UT Health

HOUSTON, TEXAS

Jesse Jones Library - 2nd Floor Build-out

Construction / Bid Issuance

Construction Documents
Project Manual

04/20/18

HDR Project No. 445163

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DIVISION 23

HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

SECTION 23 09 23
DIRECT DIGITAL CONTROL SYSTEMS (DDC)

PART 1 GENERAL

1.00 The following sections are to be included as if written herein:

A. Section 23 00 00 – Basic Mechanical Requirements

B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors

C. Section 23 05 53 – Mechanical Identification

1.01 SECTION INCLUDES

A. Control Equipment

B. Software

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 23 21 00 - Hydronic Piping: Installation of control valves, flow switches, temperature sensor sockets, gauge taps, flow meters.

B. Section 23 22 00 - Steam and Steam Condensate Piping: Installation of control valves, flow switches, temperature sensor sockets, gauge taps, flow meters.

C. Section 23 33 00 - Ductwork Accessories: Installation of automatic dampers, smoke detectors. Connection of damper end switches.

1.03 BACNET DDC SYSTEM INTEGRATION TO THE ENTERPRISE BAS

A. Contractor shall furnish and install a totally Native BACnet DDC control system for the building, as indicated on the project drawings. All associated software, System Controllers, High Level Interfaces, Application Controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135–2012. Building system shall communicate with the Owner's existing Enterprise Building Automation System (BAS) using ASHRAE Standard 135 – 2012: BACnet®, as it's protocol. Contractor shall provide full cooperation and assistance in the overall integration of the building DDC system in to the Owner's Enterprise BAS.

B. Communication shall be established by presenting all data points in BACnet IP format, to the Enterprise BAS. The IP connection to the building network, will be provided by UT Health IT department. Contractor shall be responsible for verifying that all building data points are "discoverable" and accessible via the Enterprise BAS Operator Workstation. This includes all values and attributes, including schedules, alarms, I/O, variables, PID controllers, trend logs, and all other data points required for the operator to fully control the system from the Enterprise BAS operator workstation.

C. Provide all necessary BACnet compliant BTL (BACnet Testing Laboratories) listed hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for all system hardware and software. Contractor is to provide:

1. BACnet Testing Laboratory (BTL) Certificates of Compliance for all hardware
2. BACnet Data Communications Protocol Certificates

D. Contractor shall provide and enable all BACnet functionality. Contractor shall program all BACnet schedules, BACnet trends, and BACnet alarms that are required for the control system. The owner's System Integrator will integrate these into the Enterprise BAS as BACnet objects, rather than recreating these within the Enterprise BAS database. Functionality shall include:

1. monitor and command BACnet objects
2. establish BACnet schedules and calendars
3. receive and acknowledge BACnet alarms, and
4. establish and read BACnet trend logs.

E. Integration of Building BACnet DDC System into the Enterprise BAS:

1. Control system performance requirements shall be satisfied when monitoring and controlling the building control system can be accomplished via the Enterprise BAS operator workstation.
2. Operator shall be able to upload, download, monitor, alarm, report, trend, control and program every input and output point in the building DDC system from existing Enterprise BAS operator workstation. Interface of control system I/O points into Enterprise BAS shall be transparent to the BAS operator.

F. UT Health's Enterprise BAS integrator will provide the following services:

1. Enterprise BAS expansion and development of graphics, logs, reports, trends and other operational capabilities of Enterprise BAS for I/O being added to DDC control system for use by Enterprise BAS operator.

G. Contractor will assist Owner's Enterprise BAS system integrator, with the following services:

1. Provide full cooperation with UT Health's Enterprise BAS system integrator during commissioning to accomplish complete integration of the building DDC system with the Enterprise BAS, including graphics, logs, reports, trends and other operational capabilities of the enterprise system, for all I/O being added to DDC system.
2. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability.
3. Data Presentation: On the Enterprise operator workstation, demonstrate graphic display capabilities.

1.04 RELATED SECTIONS

A. Section 23 09 93 - Sequence of Operation

B. Section 26 00 00 - Equipment Wiring Systems

1.05 REFERENCES

A. ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, Air Conditioning

B. ASME MC85.1 - Terminology for Automatic Control

C. NEMA EMC1 - Energy Management Systems Definitions

1.06 DEFINITIONS

A. NA

1.07 SYSTEM DESCRIPTION

A. Automatic temperature control field monitoring and control system using native BACnet field programmable micro-processor based units, with communications to the Owner's existing Building Management System.

B. Remote hardware, software, and interconnecting wire and conduit. Central hardware is furnished by the Owner's System Integration vendor.

C. Terminal unit controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, pneumatic or electric unless indicated otherwise.

D. Electronic Damper Motors and Valve Operators.

1.08 SUBMITTALS

A. N/A

B. Shop Drawings:

1. Trunk cable schematic showing programmable control unit locations, and trunk data conductors.

2. List of connected data points, including connected control unit and input device.

3. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.

4. System configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

5. Descriptive data and sequence of operation of operating, user, and application software.

C. Product Data: Provide data for each system component and software module.

D. Manufacturer's Installation Instructions: Include for all manufactured components.

1.09 PROJECT RECORD DOCUMENTS

A. Revise shop drawings to reflect actual installation and operating sequences.

B. Include data specified in "Submittals" in final "Record Documents" form.

1.10 OPERATION AND MAINTENANCE DATA

A. Include interconnection wiring diagrams complete field installed system with identified and numbered, system components and devices.

1.11 QUALIFICATIONS

A. Manufacturer: Schneider Electric, Johnson Controls, or Siemens.

B. Installer: Provision and installation of the control system shall be accomplished by the Factory branch of the manufacturer. No distributors are approved.

1.12 PRE-INSTALLATION CONFERENCE

A. N/A

1.13 COORDINATION

A. N/A

B. Ensure installation of components is complementary to installation of similar components in other systems.

C. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

D. Ensure system is completed and commissioned.

1.14 WARRANTY

A. Provide one year warranty.

B. Warranty: Include coverage for all equipment provided.

1.15 MAINTENANCE SERVICE

A. N/A

1.16 EXTRA MATERIALS

A. N/A

1.17 PROTECTION OF SOFTWARE RIGHTS

A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:

1. Limiting use of software to equipment provided under these specifications.

2. Limiting copying.

3. Preserving confidentiality.

4. Prohibiting transfer to a third party.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Schneider Electric – Factory branch

B. Johnson Controls – Factory branch

C. Siemens – Factory branch

D. Substitutions: See requirements under General Provisions of the specification.

2.02 LOCAL OPERATOR ACCESS AND DISPLAY PANEL

A. Provide local display and adjustment panel. Panels shall be a portable laptop or tablet device that is capable of operating and/or adjusting any point data within the control system. Display and adjust:

1. Input/output point information.

2. Controller set points.

3. Controller tuning constants.

4. Program execution times.

5. High and low limit values.

6. Limit differential.

7. Time, date, year.

2.03 OPERATOR STATION

A. Operator Computer workstation/printer:

1. These Computer workstation and printer devices are not a part of this scope of work. They are to be provided by the Owner's System Integrator.

2.04 CONTROL UNITS

A. Units: Modular in design and consisting of processor board with programmable RAM memory, local operator access and display panel, and integral interface equipment.

B. Battery Backup: For minimum of 100 hours for complete system including RAM without interruption, with automatic battery charger.

C. Provide the following functions:

1. Mathematical: Absolute value, calculate, square root, power, sign, average, totalize.

2. Logic: OR, AND, compare negate.

3. Fixed Formula: High and low select, span, rate, ramp, enthalpy, wet bulb, dew point, relative humidity, humidity ratio, and filter.

4. Data Manipulation: Store, file and set.

5. Display Panel: Display adjust, override, time, day, date, year, alarm scan, override scan.

6. Control Routines: Proportional, integral, lead lag, hysteresis correction and incremental control.

7. Energy Management: Duty cycling, load shed, optimal run time, holiday and daylight savings time correction.

D. Provide self-test procedure for checking digital display and computer. Display advisories for maintenance, performance, or software problems. Identify variables as reliable or unreliable. Variables identified as unreliable will flash when displayed and calculation will use default.

E. Indicate alarms and deviations. Alarm scan shows alarms and identification. Continue alarm indication until acknowledged and alarm condition is corrected.

F. Provide two communication interface ports permitting communication between processor, process interface equipment, other processors, and the Owner's existing central processing unit.

2.05 DATA INTERFACE UNITS

A. Provide equipment required to connect all sensors, transducers and interface relays required to monitor and control equipment in sequence of operation.

2.06 INPUT/OUTPUT SENSORS

A. Temperature:

1. Resistance temperature detectors with resistance tolerance of plus or minus 0.1 percent at 21 degrees C, interchangeability less than plus or minus 0.2 percent C, time constant of 13 seconds maximum for fluids and 200 seconds maximum for air.

2. Measuring current maximum 5 MA with maximum self-heat of 0.017 degrees C/MW in fluids and 0.008 degrees C/MW in fluids and 0.008 degrees C/MW in air.

3. Provide 3 lead wires and shield for input bridge circuit.

4. Use insertion elements in ducts not affected by temperature stratification or smaller than one square meter. Use averaging elements where larger or prone to stratification sensor length 2.5 m or 5 m as required.

5. Insertion elements for liquids shall be with brass socket with minimum insertion length of 2-1/2 inches (60 mm).

6. Supply room sensors with locking cover.

7. Provide outside air sensors with watertight inlet fitting, shielded from direct rays of sun.

B. Humidity Sensors:

1. Elements: Accurate within 5 percent full range with linear output.

2. Room Sensors: With locking cover, span of 10 to 60 percent relative humidity.

3. Duct and Outside Air Sensors: With element guard and mounting plate, range of 0 - 100 percent relative humidity.

C. Static Pressure Sensors:

1. Undirectional with ranges not exceeding 150 percent of maximum expected input.

2. Temperature compensated with typical thermal error or 0.06 percent of full scale in temperature range of 40 to 100 degrees F.

3. Accuracy: One percent of full scale with repeatability 0.3 percent.

4. Output: 0 - 5 vdc with power at 12 to 28 vdc.

D. Equipment Operation Sensors:

1. Status Inputs for Fans: Differential pressure switch with adjustable range of 0 to 5 inches wg (0 to 1250 Pa).

2. Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 8 to 60 psi (50 to 400 kPa).

3. Status Inputs Where Differential Pressure Sensing is Impractical: Current sensitive relay with current transformers, adjustable and set to 175 percent of rated motor current.

E. Digital to Pneumatic Transducers: N/A

F. Damper Position Indication: Potentiometer mounted in handbox enclosure with adjustable crank arm assembly connected to damper to transmit 0 - 100 percent damper travel.

2.07 OPERATING SYSTEM SOFTWARE

A. System Format:

1. Divide points of control or monitoring by system.

2. Identify points with unique, structured point identifier reflecting "specific area" or "specific system", and "specified point".

B. Input Process:

1. Select, from menu, one of four general types of commands based upon password clearance, command points, information points, build parameters, and modify parameters. Commands not available by password clearance shall be deleted from video display.

2. Enter memory changes through keyboard.

3. Select entry modes, Aid or Direct, based on operator's degree of capability and familiarity with system.

4. Aid Mode shall prompt operator through each step indicating available options.

5. Direct Mode shall allow experienced operator to input command string directly.

6. Enter commands as alpha/numeric character strings. Where commands require data for limits, setpoint, and time, enter value in same engineering units as controlled variable.

7. Operator input shall not inhibit alarm reporting. Echo input on associated output device, to either execute or abort.

C. Operator Access Control: Restrict any operator commands through use of software password.

D. Information Access: Obtain point status information from any designated output device with access command. Point status consists of point identification, numerical value (analog points) and associated engineering units, and individual function label indicating that point is on or off or in Alarm Normal condition. Output includes date and time of execution.

E. Point Display: Video display includes status of single point or group of points with high and low limits (if applicable). Refresh display at least every 20 seconds.

F. Alarm summary includes status of points in Alarm condition.

G. Off-normal summary includes status of points in Off-Normal condition.

H. Alarm Reporting:

1. Alarm outputs contain descriptor, point identification, point data, engineering units, and date and time.

2. Print on line changeable message, up to 60characters in length, for each alarm point specified, immediately.

3. Display alarm reports on video. Display multiple alarms in order of occurrence.

4. Inhibit reporting of associated analog and binary alarms upon HVAC system shutdown. Upon restart, inhibit alarm reporting for operator pre-determined time.

5. Operator specifies if alarm required acknowledgement.

I. Advisories:

1. Lockout summary which contains status of points in locked out condition.

2. Continuously interrogate system hardware and programmable control units for failure or tampering and report if operational or not operational.

3. Power failure detection, time and date.

4. System communication failure with operator device, field interface unit, point, programmable control unit.

J. Data Base Save/Restore:

1. Provide program which allows saving or restoring of operating data.

2. Data includes:

a. Analog limits and differentials

b. Start-stop times

c. Access/secure times

d. Lockout/unlock times

e. Setpoint values and adjustment times

f. Limits and differential values

g. Totalization points, limits, and current values

h. Alarm messages and their assignments

i. Load control program operational parameters

j. HVAC control program operational parameters

K. Power Failure Motor Restart: Provide program to restore systems to normal operating conditions following power outage, and to enforce emergency operating conditions during power outage. Automatically restart loads to correct operating condition if normal or emergency power is available.

2.08 BASIC OPERATING FEATURES

A. Binary Capabilities:

1. Monitor binary sensors, continuously storing present contact condition in memory.

2. Indicate if point is off-normal, in alarm, or off-line.

3. Program output points for Open/Closed, Test/Reset, Start/Stop.

4. Feedback Start/Stop points. Employ point unique, feedback delay timer to temporarily suppress alarm reporting after input to allow time for response.

5. Output advisory message if response is not as commanded.

6. Hold points in present operating condition if controls power failure occurs.

B. Analog Capabilities:

1. Measure, transduce, transmit and display analog values.

2. Express analog point values in proper engineering units/

3. Have sensor to readout accuracy of plus or minus [one degree F (0.56 degrees C).] [0.5 degrees F (0.28 degrees C).]

4. Use English system of measurement.

5. Provide for operator designated ranges either linear, series of linear approximations, split ranges, or square root extractions of exponential functions.

6. Compare analog read to high and low limits and annunciate Alarm or Off-Normal condition.

7. Output alarm, including point identification current value and associated engineering units, high or low value, and time and date.

8. Automatically disable alarm reporting upon associated system shutdown. Allow sufficient time to return to normal operating conditions before allowing alarm reporting.

9. Provide limit and differential summary.

C. Analog Point Adjust:

1. Remotely adjust controller set points or dampers. Automatically adjust points based upon preselected time or value.

2. Employ feedback so that if point fails to respond, responds with wrong value, or drifts from set point value by plus or minus 2 percent, output alarm message. Employ feedback delay timer to temporarily suppress alarm reporting after input to allow time for response.

3. Hold points in present operating condition if controls power failure occurs.

D. Automatic Alarm Lockout: Automatically inhibit alarm reporting of analog and binary points upon associated system shutdown. Inhibit reporting for operator predetermined time, upon restart of HVAC systems.

2.09 LOAD CONTROL PROGRAMS

A. General:

1. Provide means to reduce electrical energy usage, using control algorithms designed for electrical energy control.

2. Apply algorithms to other energy sources, such as steam or natural gas.

3. Support English units of measurement.

B. Demand Limiting:

1. Monitor total power consumption per power meter and shed associated loads automatically to reduce power consumption to an operator-presettable maximum demand level.

2. Use floating window type demand determination to monitor demand and compare to target value.

3. Automatically shed loads throughout the demand interval selecting loads with independently adjustable on and off time of between one and 255 minutes.

4. Output advisory if loads are not available to satisfy required shed amount, advise shed requirements.

5. Operator commands:

a. Add/delete demand meter point

b. Define load point

c. Define load priority target

d. Define control target

e. Begin new billing period

f. Lock/unlock program

g. Activate/inactivate/restore load

h. Request load control system control summary

i. Request load control system load summary

6. Load control system summary:

a. Demand interval

b. Current kW power and measured demand

c. Projected load limit

d. Total energy available from HVAC system

e. Maximum, average, and current expendable load

f. Maximum, average and current deferrable load

g. Demand limit status, target value, and recent control action

h. Duty cycle status, target value, and recent control action

i. Covergence time

j. Restore bandwidth

7. Load summary:

a. Load priority

b. Expendable/deferrable load type

c. Point type, ID, status

d. Load rating

e. Minimum off, maximum off, and minimum on times

C. Duty Cycling:

1. Periodically turn selected loads off to evenly reduce power consumption to target value, selecting loads with independently adjustable on and off time of between one and 255 minutes.

2. Operator commands:

a. Define load point

b. Define control target

c. Activate/inactivate/restore load

d. Request load control system load summary

2.10 HVAC CONTROL PROGRAMS

A. General:

1. Support English units of measurement

2. Identify each HVAC Control system

B. Optimal Run Time:

1. Start-up and shutdown times of HVAC equipment for both heating and cooling.

2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.

3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.

4. Use outside air temperature to determine early shut down with ventilation override.

5. Analyze multiple building mass sensors to determine seasonal mode and worse case condition for each day.

6. Operator commands:

    a. Define time schedule

    b. Add/delete fan status point

    c. Add/delete outside air temperature point

    d. Add/delete mass temperature point

    e. Define heating/cooling parameters

    f. Define mass sensor heating/cooling parameters

    g. Lock/unlock program

    h. Request optimal run time control summary

    i. Request optimal run time mass temperature summary

    j. Request HVAC point summary

    k. Request HVAC saving profile summary

7. Control summary:

    a. HVAC Control system begin/end status

    b. Optimal run time lock/unlock control status

    c. Heating/cooling mode status

    d. Optimal run time schedule

    e. Start/stop times

    f. Selected mass temperature point ID

    g. Optimal run time system normal start times

    h. Occupancy and vacancy times

    i. Optimal run time system heating/cooling mode parameters

8. Mass temperature summary:

    a. Mass temperature point type and ID

    b. Desired and current mass temperature values

    c. Calculated warm-up/cool-down time for each mass temperature

    d. Heating/cooling season limits

e. Break point temperature for cooling mode analysis

f. Linear compensation factor for heating mode analysis

9. HVAC point summary:

a. Control system identifier and status

b. Fan status point ID and status

c. Outside air temperature point ID and status

d. Mass temperature point ID and status

e. Calculated optimal start and stop times

f. Period start

C. Supply Air Reset:

1. Monitor heating and cooling loads in building spaces, terminal reheat systems, both hot deck and cold deck temperatures on dual duct and multizone systems, single zone unit discharge temperatures.

2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:

a. Raising cooling temperatures to highest possible value.

b. Reducing heating temperatures to lowest possible level.

3. Operator commands:

a. Add/delete fan status point

b. Lock/unlock program

c. Request HVAC point summary

d. Add/Delete discharge controller point

e. Define discharge controller parameters

f. Add/delete airflow rate

g. Define space load and load parameters

h. Request space load summary

4. Control summary:

a. HVAC control system status (begin/end)

b. Supply air reset system status

c. Optimal run time system status

d. Heating and cooling loop

e. High/low limits

f. Deadband

g. Response timer

h. Reset times

5. Space load summary:

a. HVAC system status

b. Optimal run time status

c. Heating/cooling loop status

d. Space load point ID

e. Current space load point value

f. Control heat/cool limited

g. Gain factor

h. Calculated reset values

i. Fan status point ID and status

j. Control discharge temperature point ID and status

k. Space load point ID and status

l. Air flow rate point ID and status

D. Enthalpy Switchover:

1. Calculate outside and return air enthalpies using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.

2. Operator commands:

a. Add/delete fan status point

b. Add/delete outside air temperature point

c. Add/delete discharge controller point

d. Define discharge controller parameters

e. Add/delete return air temperature point

f. Add/delete outside air dew point/humidity point

g. Add/delete return air dew point/humidity point

h. Add/delete damper switch

i. Add/delete minimum outside air

j. Add/delete atmospheric pressure

k. Add/delete heating override switch

l. Add/delete evaporative cooling switch

m. Add/delete airflow rate

n. Define enthalpy deadband

o. Lock/unlock program

p. Request control summary

q. Request HVAC point summary

3. Control summary:

a. HVAC control system begin/end status

b. Enthalpy switchover optimal system status

c. Optimal return time system status

d. Current outside air enthalpy

e. Calculated mixed air enthalpy

f. Calculated cooling cool enthalpy using outside air

g. Calculated cooling cool enthalpy using mixed air

h. Calculated enthalpy difference

i. Enthalpy switch over deadband

j. Status of damper mode switch

2.11 CHILLER CONTROL PROGRAMS

A. N/A

2.12 PROGRAMMING APPLICATION FEATURES

A. Trend Point:

1. Sample all analog and status points, real or computed, at intervals specified in minutes, hours, days, or month.

2. Output trend logs as line graphs or bar graphs. Output graphic on terminal, with each point for line and bar graphs designated with a unique pattern or color, vertical scale either actual values or percent of range, and horizontal scale time base. Print trend logs up to 12 columns of one point/column.

B. Alarm Messages:

1. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totalized point's warning limit, and hardware elements advisories.

2. Output assigned alarm with "message requiring acknowledgement".

3. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.

C. Weekly Scheduling:

1. Automatically initiate equipment or system commands, based on preselected time schedule for points specified.

2. Provide program times for each day of week, per point, with one minute resolution.

3. Automatically generate alarm output for points not responding to command.

4. Provide for holiday scheduling.

5. Operator commands:

a. System logs and summaries.

b. Start of stop point.

c. Lock or unlock control or alarm input.

d. Add, delete, or modify analog limits and differentials.

e. Adjust point operating position.

f. Change point operational mode.

g. Open or close point.

h. Enable/disable, lock/unlock, or execute interlock sequence or computation profile.

i. Begin or end point totalization. - Modify totalization values and limits.

j. Access or secure point.

k. Begin or end HVAC or load control system.

l. Modify load parameter.

m. Modify demand limiting and duty cycle targets.

6. Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.

D. Interlocking:

1. Permit events to occur, based on changing condition of one or more associated master points.

2. Binary contact, high/low limit of analog point or computed point shall be capable of being utilized as master. Same master may monitor or command multiple slaves.

3. Operator commands:

a. Define single master/multiple master interlock process.

b. Define logic interlock process.

c. Lock/unlock program.

d. Enable/disable interlock process.

e. Execute terminate interlock process.

f. Request interlock type summary.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install electrical work in accordance with Section 26. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

C. The Electrical contractor in Division 26 is to provide a 120v AC, 15 amp dedicated emergency power circuit to each programmable control unit.

3.02 MANUFACTURER'S FIELD SERVICES

A. Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

B. Provide service engineer to instruct Owner's representative in operation of systems plant and equipment for 2 day period.

C. Provide basic operator training for 2 persons on data display, alarm and status descriptors, requesting data, execution of commands and request of logs. Include a minimum of 16 hours dedicated instructor time.

3.03 DEMONSTRATION

A. Demonstrate complete and operating system to Owner.

3.04 INPUT/OUTPUT SCHEDULE

A. See project drawings for a partial listing of the input and output points. Provide all points required to accomplish a fully functioning system for specified equipment sequences, provided below.

3.05 SEQUENCE OF OPERATION

A. Terminal units:

1. Minimum Airflow Percentages for Variable Volume Air Terminal Units

   a. As indicated on room schedule.

   b. The minimum air flow percentage for VVR-# units shall be 30 PCT or as scheduled.

   c. The minimum air flow percentage for VV-# units shall be 30 PCT or as scheduled.

2. Unoccupied Mode Determination:

   a. Unless indicated otherwise, unoccupied mode for each air terminal unit shall be individually programmable by Owner via time schedule. This includes spaces requiring 24 HR operation for occupied mode, as space may be temporarily placed out of service by Owner.

3. Air System Balancing:

   a. Each air handling system shall have ability to set air terminal operation to "automatic" or "design" operation for balancing purposes. This shall be accomplished by a single, password protected command through the BMS at the operator workstation.

   b. During the "automatic" mode, all air terminal units shall function as normal.

   c. During the "design" mode, all air terminal units shall operate at their maximum airflow setting to simulate design condition.

4. Provide each terminal unit with discharge air temperature sensor for monitoring purposes.

B. Single duct, constant volume unit with reheat (CVR-#), direct digital controls:

1. Occupied cooling and heating mode:

   a. Modulate hot water control valve(s) for reheat coil and as required to maintain room sensor set point and uniform space temperature throughout the room.

   b. Modulate damper as required to maintain constant air volume.

2. Unoccupied cooling mode:

a. For rooms which are not exhausted or pressurized, the supply air volume shall modulate as required to maintain a minimum space temperature of 85 DEGF (adj.). The minimum airflow setting during unoccupied mode shall be 30 PCT of actual maximum airflow. Room set point adjustment on sensor shall be inactive.

b. For rooms which are exhausted (i.e. negative), the minimum supply air volume shall remain at 100 PCT of design value during unoccupied mode to ensure that pressure relationship is maintained. Examples of such spaces are restrooms, etc.

3. Unoccupied heating mode:

a. When air terminal unit is at it unoccupied mode minimum airflow setting, modulate hot water control valve(s) for reheat coil to maintain minimum room temperature of 65 DEGF (adj.).

C. Single duct variable volume with or without reheat (VVR-#, VV-#), direct digital controls:

1. Occupied cooling mode:
   a. Room sensor, through DDC controller, shall modulate damper between maximum and minimum airflow settings as required to maintain set point. Minimum airflow percentage shall be as indicated on air terminal unit equipment schedule.

2. Occupied heating mode (units with reheat coil):

a. When air terminal unit is at its minimum airflow setting, modulate hot water control valve(s) for reheat coil as required to maintain room sensor set point and uniform space temperature throughout the room.

3. Unoccupied cooling mode:

a. The supply air volume shall modulate as required to maintain a minimum space temperature of 85 DEGF (adj.). The minimum airflow setting during unoccupied mode shall be 30 PCT of actual maximum airflow. Room set point adjustment on sensor shall be inactive.

4. Unoccupied heating mode:
   a. When air terminal unit is at it unoccupied mode minimum airflow setting, modulate hot water control valve(s) for reheat coil as required to maintain minimum room temperature of 65 DEGF (adj.).

D. Direct digital control for constant volume reheat (CVR-#) serving spaces requiring negative pressure.

1. Occupied cooling and heating mode:

    a. Modulate hot water control valve(s) for reheat coil as required to maintain room sensor setpoint and uniform space temperature throughout the room.

    b. Modulate damper for CVR-# as required to maintain constant air volume.

2. Unoccupied cooling and heating mode:

    a. Modulate hot water control valve(s) for reheat coil as required to maintain a minimum room temperature of 65 DEGF.(adj).

    b. Modulate damper for CVR-# as required to maintain constant air volume.

E. Smoke damper verification:

1. Provide each smoke and fire smoke damper with end switch to indicate position to BMAS. This is to verify proper damper position during fire alarm system testing and to alarm facility staff when smoke damper actuator fails. At installer's option, the actuator may be furnished with integral end switch. Coordinate with Section 23 31 13.

END OF SECTION

SECTION 23 21 13
HYDRONIC PIPING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Hydronic Piping Systems, as indicated, in accordance with provisions of Contract Documents.

B. Systems and Products Included:
   1. Systems:
      a. Heating water piping.
   2. Products:
      a. Air vents.
      b. Pressure and temperature test stations, combination.
      c. Strainers.
      d. Valves.
      e. Water flow measurement devices.

C. Work installed but not furnished:
   1. Automatic valves: Furnished in Section 25 50 00.
      a. Provide fittings and reducers required for installation of automatic valves.
   2. Electronic flow measurement devices: Furnished in Section 25 50 00.

D. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Outside Utilities: Section 20 10 10.

B. Piping standards: Section 20 11 00.

C. Manual valve standards: Section 20 05 23 (for valves with "V" prefix).

1.3 SUBMITTALS

A. Product Data:
   1. Air vents.
   2. Pressure and temperature test stations, combination.
   3. Strainers.
   4. Valves, constant flow control.
   5. Valves, manual.
   6. Valves, pressure reducing.
   7. Valves, pressure relief.
   8. Water flow measurement devices.

B. Contract Closeout Information:
   1. Operation and Maintenance Data for items requiring operational instructions or periodic maintenance such as: air vents, constant flow control valves, pressure relief valves, triple duty valves, water flow measurement devices, water treatment system, glycol feed systems, etc.
   2. Field test reports.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Automatic High Capacity Air Vents:

1. Base:
    a. Armstrong International.
2. Optional
    a. Hoffman Specialty.
    b. Metraflex.
    c. Thrush.

B. Automatic Low Capacity Air Vents:
1. Base:
    a. Bell & Gossett, ITT.
2. Optional:
    a. Armstrong International.
    b. Hoffman Air & Filtration Systems.
    c. Taco.
    d. Thrush.

C. Manual Air Vents:
1. Base:
    a. Crane Valves.
2. Optional:
    a. Jenkins.
    b. Johnston.
    c. OIC.
    d. Powell.
    e. Stockham Valves & Fittings.

D. Pressure/Temperature Test Stations, Combination P/T Plug.
1. Base:
    a. Pete's Plug by Peterson Equipment Company.
2. Optional:
    a. Fairfax.
    b. P/T Plugs and Flex Connectors by Sisco.
    c. Super Seal.

E. Strainers, Air Separator/Strainers:
1. Base:
    a. Bell & Gossett, ITT.
2. Optional:
    a. Armstrong Machine Works.
    b. Taco.
    c. Thrush.

F. In-line Wye Strainer and Valve Combination Strainers:
1. Base:
    a. Flow Design Inc.
2. Optional:
    a. Griswold Controls.
    b. Nexus Valve.

G. Single Basket and Tee Strainers:
1. Base:
    a. Spirax Sarco.
2. Optional:
    a. Armstrong Machine Works.
    b. Hoffman Specialty, ITT.
    c. Keckley, OC.
    d. Metraflex.
    e. Mueller Steam Specialty.

f. Spence Engineering.
g. Tate.
h. Victaulic of America.

H. Suction Diffuser Strainers:
1. Base:
a. Bell & Gossett, ITT.
2. Optional:
a. Armstrong Pumps.
b. Mueller Steam Specialty.
c. Taco.
d. Victaulic of America.

I. Constant Flow Control Valves:
1. Base:
a. Flow Design Inc.
2. Optional:
a. Griswold Controls.
b. Nexus Valve.

J. Water Flow Measurement Devices:
1. Base:
a. Victaulic of America.
2. Optional:
a. Barco USA.
b. Data Industrial.
c. Dynasonics.
d. Gerand Engineering.

K. Other manufacturers desiring approval comply with Section 00 26 00.

2.2 MATERIALS

A. Pipe And Fittings
1. Pipe and fittings - General:
a. The following are not permitted:
1) Plain end, pressure fit type fittings.
2) Hole cut mechanical tee or saddle fittings.
2. Fittings: galvanized where galvanized piping is used.
3. Condensate and cooling-coil-drain piping:
a. Copper, type M or L, and soldered joints.
b. Galvanized steel with cast iron drainage type fittings.
4. Heating water piping, above grade:
a. Copper, type L, with soldered joints, and wrought copper or cast brass fittings.
1) Optional fittings:
a) Ring seal crimped fitting system: 2 IN and smaller where approved by authority having jurisdiction.
b. Black steel, with welded joints.
1) For 2-1/2 IN and larger: Use butt welding fittings.
2) For 2 IN and less: Use socket welding fittings, 2000 PSI class, malleable or cast iron threaded fittings.
3) Weld-o-let or thread-o-let type fittings may be used in lieu of tees for branch connections, provided main is one size larger than takeoff. Couplings or half couplings are not acceptable except for non-flow connections such as thermometers or gauges.

B. Air Vents:
1. High Capacity, automatic:
a. 300 PSI rated test pressure, minimum.

b. Maximum working pressure: 150 PSIG.
c. Maximum temperature: 212 DEGF.
d. Body and cover material: Cast iron, ASTM-A126, Class B.
e. Seat material: Stainless steel-T303, ASTM-A276 or Viton.
f. Float and float arm material: Stainless steel-T304, ASTM-A240.

2. Low Capacity, automatic:
a. 150 PSI rated, minimum.
b. Maximum working pressure: 100 PSIG.
c. Maximum temperature: 212 DEGF.
d. Cast bronze, chrome plated, body with renewable valve and seat.
e. Synthetic rubber disc.

C. Pressure And Temperature Test Stations, Combination
1. Pressure/temperature test station, combination:
a. Station to receive either a 1/8 IN OD temperature or pressure probe.
b. Fitting: Solid brass, 1/4 IN NPT, with 2 valve cores of neoprene (maximum 200 DEGF at 500 PSI) or Nordel (maximum 275 DEGF at 500 PSI).
c. Provide extension at locations with pipe insulation. Extension length shall match or exceed insulation thickness.
d. Provide with color coded and marked cap with gasket, rated at 1000 PSI at 140 DEGF.

2. Pressure and temperature test kit:
a. Range: 0-100 PSI, 0-230 FT WG.
b. 1/8 IN OD probe and 5 IN stem pocket testing thermometers.
c. No. 500 gauge adapter with 1/8 IN OD probe.
d. Protective carrying case.

D. Strainers
1. Strainers, air separator/strainers:
a. ASME code construction.
b. Removable stainless steel air collector tube.
c. NPT tappings for vent and blowdown connections.
d. Stainless steel strainer with 3/16 IN diameter perforations.
1) Free area: Not less than 5 times cross sectional area of connecting pipe.
e. Working pressure: 125 PSIG at 350 DEGF.

2. Strainers, in-line wye strainer and valve combination:
a. One piece configuration consisting of O-ring union, P/T plug, blow down and ball valve with handle.
b. Strainer valves 1-1/4 IN and smaller: Limit passage of particles larger than 500 microns.
c. Strainer valves 1-1/2 IN and larger: Limit passage of particles 1000 microns and larger.
d. Bronze body construction with threaded or sweat connections.
1) Internal parts: Brass and stainless steel.
2) Ball valve:
a) Ball and stem: 316 stainless steel.
b) Port size: standard.
c) Blowout proof stems.
d) Reinforced Teflon (PTFE) seats.
e) Teflon (PTFE) seals.
f) Adjustable packing.
g) Extended necks and stems that isolate moving valve parts from insulation.
e. Provide valves with unions to allow field exchange of internal components without removing valve body from pipeline.
f. Provide metal ID taps permanently marked to show direction of flow, strainer mesh and model number.

3. Strainers, single-basket type.

a. Screwed or flanged.
b. Body: Cast iron, flanged ends, bolted access cover.
c. Coating: Rust inhibiting.
d. Working pressure, non shock: 150 PSIG.
e. Screens: Bronze, monel or stainless steel.
1) 2 IN and less: 3/64 IN perforations.
2) 2-1/2 IN and larger: 1/8 IN perforations.

4. Strainers, suction diffusers:
a. Angle cast iron body type with inlet vanes and combination diffuser-strainer-orifice cylinder.
b. Provide with disposable 16 mesh strainer for system start-up.
c. Orifice cylinder with 3/16 IN diameter openings.
1) Designed to withstand pressure differential equal to pump shutoff head.
2) Free area equal to 5 times cross-section area of pump suction opening.
d. Vane length: Not less than 2-1/2 times pump suction opening.
1) Provide with adjustable support foot to carry weight of suction piping.

5. Strainer, tee-pattern type.
a. Grooved ends.
b. Body: One-piece ductile iron casting conforming to ASTM-A536 or malleable iron conforming to ASTM-A47.
c. Coating: Rust inhibiting.
d. Working pressure rating: 300 PSI.
e. Basket screen: 304 stainless steel 0.041 IN wire in a woven No.6 mesh wire screen with 0.126 IN opening.
f. Vertical down flow or horizontal flow.
g. Cleaning access through blank end cap.

6. Strainers, wye:
a. See Section 20 05 19, Piping Specialties.

E. Valves
1. Constant flow control valves:
a. Factory calibrated, direct acting, automatic pressure compensating.
b. Control flow rates within 4 PCT of flow rating over operating pressure differential range.
1) Set flow rating to match the maximum flow required by device served.
c. Pressure differential range:
1) 2-32 PSID.
d. Threaded-brass or copper-sweat body with stainless-steel internal parts.
e. Provide a metal identification tag with chain for each installed valve.
1) Identify valve model number, rated GPM, direction of flow, and differential pressure range.
f. Provide with integral unions to allow field exchange of internal components without removing valve body from pipeline.
g. Provide as indicated.

2. Manual valves:
a. Angle valves:
1) 2 IN and smaller: V-17.
2) 2-1/2 IN and larger: V-18.
b. Balancing valves:
1) 2 IN and smaller: V-64.
2) 2-1/2 IN to 12 IN: V-65.
3) 8 IN and larger:
a) Plug valve: V-37 with memory stop.
b) Provide venturi waterflow measuring device.
4) Ball type balancing valves/circuit setters shall not be used.
c. Isolation valves (Ball valves):

1) 2 IN and smaller: V-13 or V-14.
d. Isolation valves (Butterfly valves):
1) 2 IN and smaller: not used.
2) 2-1/2 IN and larger: V-34 or V-35.
e. Boiler blowdown valves: Plug, globe, angle and check.
1) Rated for 250 PSIG and 400 DEGF.
f. Boiler feedwater valves: Plug, globe, angle and check.
1) Rated for 250 PSIG and 400 DEGF.
g. Check valves, pump discharge:
1) 2 IN and smaller: V-25 or V-26.
2) 2-1/2 IN and larger: V-28, V-29, or V-30.
h. Check valves, other:
1) 2 IN and smaller: V-25.
2) 2-1/2 IN and larger: V-28 or V-29.
i. Isolation valves (Gate valves):
1) 2 IN and smaller: not used.
2) 2-1/2 IN and larger: V-3.
j. Globe valves:
1) 2 IN and smaller: V-6 or V-7.
2) 2-1/2 IN and larger: V-8.
k. Plug valves:
1) 2 IN and smaller: V-36.
2) 2-1/2 IN and larger: V-37.
3. Pressure reducing valves:
a. Water type, diaphragm operated with low inlet pressure check valve and built-in strainer.
b. Construction:
1) Body: Brass.
2) Diaphragm: EPT.
3) Check valve: Rubber.
4) Seat: Brass.
5) Stem: Brass with Buna N insert.
6) Strainer: Brass.
c. Maximum working pressure: 100 PSIG.
d. Adjustable pressure range: 25-60 PSIG.
4. Pressure relief valves, water:
a. ASME-approved, tight-shutoff, self-closing.
b. 2-1/2 IN and less: Screwed.
c. 3 IN and larger: Flanged.
d. Ten percent over pressure.
e. Test lever.
f. Capacity: Same BTUH as equipment served. See schedules.
g. Relief setting: 125 PSIG unless indicated otherwise**.**

F. Water Flow Measurement Devices
1. Differential water pressure meter:
a. Portable type with 6 IN round dial, 270 degree indication.
b. Range: 0-100 IN WG as specified.
c. Provide purge valves and hoses, minimum of 20 FT.
d. Meter assembly rated at 250 PSI and 250 DEGF.
e. Arrange tubing for multi-station measurement.
2. Venturi waterflow measuring device:
a. Accuracy: Plus/minus 1 PCT at design flow.
b. Maximum pressure drop: 0.8 FT.
c. Provide safety shut-off valves, sensing taps, nipples and quick connection couplings.
d. Identify with metal tag on chain indicating:

1) Size.
2) Location.
3) GPM.
4) Meter reading for GPM specified.

e. Sizes 1/2 IN through 2 IN brass, screwed.
f. Sizes 2-1/2 IN and over steel, flanged or butt welded.

2.3 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 GENERAL

A. Excavation and backfilling: Section 20 10 10.

B. Reaction anchorage: Section 20 10 10.

C. Piping more than 5 FT outside building: Section 20 10 10.

D. Install in accordance with Section 20 11 00 and Section 20 05 00.

E. Connect equipment.

3.2 PIPE AND FITTINGS

A. Threaded joints in glycol-water piping:
1. Remove pipe cutting oil from threads by scrubbing in Portland cement.
2. Coat dry threads with Rectorseal No. 7 or "Permatex High Temperature thread sealant product No. 59235 or No. 59225 IN pipe compound prior to assembly.

B. Do not insulate or conceal piping until testing is completed.

3.3 AIR VENTS

A. Automatic Air Vents:
1. Provide shut off valve ahead of vent.
2. Provide copper relief line from valve to drain or drip pan.
3. Provide at locations indicated on equipment and piping schematic drawings.

B. Air vents, manual:
1. Vents shall prevent air binding in systems.
2. Vent valves:
a. Provide at trapped high points of closed cooling and heating piping systems.
b. Provide at coil headers in air handling units unless an automatic air vent is indicated at that location on equipment or piping schematic drawings.
3. Coin operated vents:
a. May be used in lieu of vent valves at coil headers for terminal units with piping connections 1-1/4 IN and smaller.

3.4 PRESSURE AND TEMPERATURE TEST STATIONS, COMBINATION

A. Provide at locations indicated on equipment and piping schematic drawings.

3.5 STRAINERS

A. Provide full line size strainers ahead of control valves (motor operated), regulating valves, pumps, and as indicated.

B. Provide strainer types as indicated:
1. Heating water: Single-basket, tee, or wye type.

C. Connections to suit piping.

D. Provide blow-down va
   1. Strainers 6 IN and larger: 1-1/2 IN blow-down valve.
      a. Pipe blow down to drain.
   2. Strainers 2 to 5 IN: 1 IN blow-down valve with 3/4 IN hose end connection.
   3. Strainers 1-1/2 IN and smaller: 1/2 IN blow-down valve with 3/4 IN hose end connection.

3.6 VALVES

A. Heating and cooling pipe risers:
   1. Provide isolation valves at main feed points to risers.
   2. Provide isolation valves at branch take-offs from risers.

B. Install pressure relief valves on heat exchangers' piping between exchanger and isolation valves.

C. Provide drain piping at pressure relief valves and valves with test levers.
   1. Extend piping to within 6 IN of floor.

D. System Drains: See Section 20 05 19.

E. 3-valve Manifold:
   1. Provide at each differential pressure sensor.
   2. Coordinate locations and quantities of sensors with Controls Contractor.

3.7 WATER FLOW MEASUREMENT DEVICES

A. Provide as indicated.

3.8 CONDENSATE DRAINS

A. Pipe condensate drains for all equipment (i.e. air handling units, fan coil units, kitchen condensing units, etc.) and route to nearest floor drain, mop sink, etc. Coordinate final location with architect.

3.9 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

3.10 TESTING

A. Test heating and cooling piping upon completion of a section or of entire system.
   1. Test hydrostatically to pressure not less than 50 PCT in excess of maximum pressure to which pipe will ordinarily be subjected, but in no case less than 150 PSI.
   2. Repair or replace leaks or defective pipe disclosed by tests.
   3. Repeat tests until piping indicates tight.

3.11 CLEANING OF HEATING WATER SYSTEMS

A. Do not valve in or operate system pumps until after system has been cleaned.

B. At system completion, make temporary connection to domestic water system, and flush system until clear water is visible from drain connection.
   1. Drain system after flushing.

C. At project completion, clean systems:
   1. Thoroughly flush system with a recommended hot solution (160-180 DEGF) of alkaline cleaning chemical to remove oil and grease that may be present.
      a. Thorough flushing includes eliminating air from system.
      b. Drain systems, and rinse completely with clean water.
      c. Measure and record volume of each system for purpose of chemical treatment.
   2. Add water and acid solution, and circulate through systems as recommended by manufacturer to remove rust and scale.
      a. Circulate solution through systems at a minimum velocity of 10 FPS.
      b. Drain systems, and rinse completely with clean water.
         1) Rinse system at a minimum velocity of 10 FPS.

3. Check drain water for pH level.
4. If drain water is acidic, neutralize system by thoroughly reflushing with alkaline-type material as indicated above.

D. After cleaning is complete, and just before start-up, clean strainers.

3.12 START-UP

A. After cleaning is complete, and water pH is acceptable to manufacturer of water treatment chemicals, add manufacturer-recommended amount of chemicals to systems.

B. Provide monthly testing for the first six months after start-up to verify that the correct chemical concentrations are present in each system.

END OF SECTION

SECTION 23 31 13
AIR DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Air Distribution System, as indicated, in accordance with provisions of Contract Documents.

B. Systems Included:
   1. High and low pressure ductwork, fittings and accessories.
   2. Dampers.
   3. Fire and smoke dampers.
   4. Diffusers, registers and grilles.
   5. Duct access doors.
   6. Control dampers less actuators.
      a. Actuators for control dampers: See Section 25 50 00.

C. Definitions:
   1. Low and high pressure ductwork:
      a. See Article 2.2 of this section.
   2. Gage:
      a. Steel sheet and wire: U S Standard Gage.
      b. Aluminum sheet: Browne & Sharpe Gage.
      c. Steel wire: Washburn and Moen Gage.
   3. Concealed insulated surfaces:
      a. Piping, ductwork and equipment in walls, partitions, floors, pipe chases, pipe shafts, duct shafts and above suspended ceilings.
   4. Exposed insulated surfaces:
      a. Piping, ductwork and equipment located in mechanical rooms, tunnels and rooms without suspended ceilings.

D. Duct sizes indicated are based upon internal dimensions.

E. Location of diffusers, registers and grilles are indicated on Architectural Reflected Ceiling Plans.

F. Drawings indicate tentative arrangement of partitions, diffusers and lights.
   1. Owner reserves right to rearrange rooms, lights and diffusers prior to actual installation to suit needs.

G. Control Dampers Installed in Air Handling Units:
   1. Furnished in Section 25 50 00, Controls and Instrumentation.
   2. Deliver to air handling unit manufacturer and factory mount in unit.

H. Dampers:
   1. Factory built and assembled.

I. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE):
   1. ASHRAE Handbook - HVAC Systems and Equipment: Current chapter on duct construction.
   2. ASHRAE Standard 70-72, Method of Testing for Rating the air flow performance of outlets and inlets.

B. Air Diffusion Council (ADC):
   1. ADC Standard 1062: GRD-84, Test Code for Grilles, Registers and Diffusers.

2. ADC Test Code FD 72-R1, Flexible Air Duct Test Code.

C. Air Movement and Control Association International (AMCA):
   1. AMCA Standard 210, Test Code for Air Moving Devices.

D. National Fire Protection Association (NFPA):
   1. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems, current edition.
   2. NFPA 96 Standard for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment, current edition.
   3. NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials

E. Sheet Metal & Air Conditioning Contractors National Association (SMACNA):
   1. SMACNA HVAC Duct Construction Standard - Metal and Flexible, Current Edition.
   2. SMACNA Duct Cleanliness for New Construction, Current Edition.

F. ASTM International (ASTM):
   1. ASTM A109 Standard Specification for Steel, Strip Carbon (0.25 Maximum Percent), Cold-Rolled.
   2. ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvanealed) by the Hot-Dip Process.
   3. ASTM B23 Standard Specification for White Metal Bearing Alloys (Known Commercially as Babbit Metal).
   4. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials.
   5. ASTM E96 Standard Test Methods for Water Vapor Transmission of Materials.

G. Underwriters Laboratories (UL):
   1. UL 181A Closure Systems for Use with Rigid Air Ducts.
   2. UL 181B Closure Systems for Use with Flexible Air Ducts and Air Connectors.
   3. UL 723 Standard for Test for Surface Burning Characteristics of Building Materials

1.3 SUBMITTALS

A. Shop Drawings:
   1. Ductwork layout at 1/4 IN to 1 FT scale.
      a. Layout drawings to include sign-off from balancing contractor indicating the contractor has reviewed the documents to ensure volume damper installation is in compliance with the requirements of this section.
      b. Shop drawings may not be copied, traced, or any other reproduced version of the construction documents.
      c. Shop drawings should show progress from coordination with other trades, ductwork elevations, fittings, joints, sheet metal gauges, and any other pertinent information related to the layout, installation, or construction of the ductwork.

B. Product Data:
   1. Ductwork and fittings.
   2. Dampers.
   3. Diffusers, registers and grilles.

C. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. Including but not limited to fire and smoke dampers, control dampers and combination louvers.
      b. See Section 01 78 23.
   2. Test reports.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. High Pressure Flat Oval and Round Spiral Ductwork:
   1. Base:
      a. United McGill Airflow Corporation.
   2. Optional:
      a. Semco Incorporated.
      b. Sheet Metal Connectors, Inc.
      c. Eastern Sheet Metal, Inc.
      d. Spiral Pipe of Texas.

B. Factory Fabricated Duct Connection Systems:
   1. Base:
      a. Ductmate Industries.
   2. Optional:
      a. Nexus.
      b. Ward Industries, Inc.

C. Sealants, Mastics and Adhesives:
   1. Base:
      a. Hardcast.
   2. Optional:
      a. United McGill Airflow Corporation.
      b. Foster (Division of HB Fuller).

D. Turning Vanes:
   1. Base:
      a. Aerodyne Controls.
   2. Optional:
      a. Airsan.
      b. Tuttle & Bailey.
      c. Titus.
      d. VentProducts.

E. Flexible Fan Connections:
   1. Base:
      a. Ventfabrics.
   2. Optional:
      a. Duro-Dyne.
      b. Elgin.

F. Preinsulated Flexible Duct:
   1. Base:
      a. Atco.
   2. Optional:
      a. Flexible Technologies, Thermaflex.
      b. Hart and Cooley.
      c. Flexmaster.

G. Access Doors, Low Pressure:
   1. Base:
      a. Ruskin Manufacturing.
   2. Optional:
      a. Air Balance.
      b. Nailor-Hart Industries, Inc.
      c. Ventfabrics.
      d. CESCO products.

e. Safe-Air of Illinois.

H. Access Doors, Low and High Pressure:
1. Base:
a. Ductmate.
2. Optional:
a. Ward Industries.
b. United McGill Airflow Corporation.
Blender Products.

I. Other manufacturers desiring approval comply with Section 00 26 00.

2.2 MATERIALS

A. Sheet Metal:
1. Galvanized steel (G90): ASTM A653/A653M.
2. Black steel: ASTM A109.

B. Duct Sealer:
1. NFPA rating of "Non-Combustible".
2. Flame spread rating: 25 or lower, in dry condition.
3. Smoke developed rating: 50 or lower, in dry condition.
4. Resistant to water and water vapors.
5. Pressure rupture rating: 16 IN WG , minimum.
6. Durkee-Atwood Permatite Class I Duct Sealer; Hardcast Iron Grip 601 and Duct Seal 321; or United McGill Sheet Metal Uni-Mastic 181 Duct Sealer and United Duct Sealer.

C. Solder:
1. Grade-50B per ASTM B23.

D. Duct Sealing Tape:
1. NFPA rating of "Non-Combustible".
2. Flame spread rating: 25 or lower, in dry condition.
3. Smoke developed rating: 50 or lower, in dry condition.
4. Adhesive: Specifically compounded for maximum adhesion to galvanized and stainless steel.
5. Listings/Labels: UL 181A or UL 181B.

: United McGill UnitGrap and Uni-Tack
http://www.mcgillairseal.com/textDocs/products/uniGrab.htmDuct Liner Adhesive and Mastic:
1. NFPA rating of “Non-Combustible”.
2. Flame spread rating: 25 or lower, in dry condition.
3. Smoke developed rating: 50 or lower, in dry condition.
4. Compounded for maximum adhesion to galvanized and stainless steel ductwork.
5. Listings/labels: UL 181A or UL 181B

F. RTV Foam:
1. UL listed room temperature vulcanized silicone rubber foam.

G. Ductwork:
1. Maintain full areas and suitable shapes at every point.
2. Shapes may be changed to fit unusual space conditions.
a. Cross sectional area to be maintained.
b. Modifications increasing system pressure drop require Architect approval.
c. Modifications increasing aspect ratio beyond 5:1require Architect approval.
3. Provide necessary transitions and offsets to complete systems.
4. Ductwork, Low Pressure, Sheet Metal:
a. Construct in accordance with SMACNA HVAC Duct Construction Standard per appropriate SMACNA table.
1) Ductwork for systems operating between 2 IN WG and 3 IN WG static pressure, positive or negative:

a) Rectangular duct.
b) Round spiral seam duct.
2) Ductwork systems operating under 2 IN WG positive or negative:
a) Rectangular duct.
b) Round duct: spiral or longitudinal seam.
b. Low pressure ductwork includes but is not limited to:
1) Supply ductwork on outlet side of single and dual duct air terminal units.
2) Return, relief air, and outside air ductwork.
3) Exhaust air ductwork from air inlets to air terminal units (e.g. isolation exhaust system).
4) Exhaust air for other exhaust systems operating less than 3 IN WG static pressure, positive or negative.
5) Supply ductwork for constant volume systems without air terminal units.
c. Transverse joints, rectangular:
1) Ducts with longest side 36 IN and longer:
a) Use factory fabricated flanged duct connection systems (e.g. Ductmate 35/25 slide on systems).
b) Non-proprietary SMACNA defined T-22 or T-24 flanged connections
c) Seal transverse flanged duct connections with pressure sensitive, high density, closed cell, neoprene or polyurethane tape gasket.
2) Ducts with longest side shorter than 35 IN :
a) Flanged duct connection systems as defined above are optional.
b) Refer to SMACNA HVAC Duct Construction Standard for proper duct construction.
d. Longitudinal seam: Use Pittsburgh lock seam only.
e. Seal low pressure ducts to Seal Class A requirements.
f. Runouts to diffusers, register and grilles:
1) Flexible duct.
2) Provide rigid ductwork where ducts pass through smoke or fire rated walls, floors or ceilings.
3) Maximum flexible duct length: 3 FT .
4) Minimum turning radius:
a) As recommended by manufacturer.
b) Do not kink, bend or restrict free area of duct.
5. Ductwork, High Pressure:
a. Construct in accordance with SMACNA HVAC Duct Construction Standard per following:
1) Rectangular duct: Table 1-X, X IN WG static pressure, positive or negative.
2) Round duct: Table 3A & Fig. 3-1, X IN WG static pressure.
3) Flat oval duct: Table 3-4, X IN WG static pressure.
b. Transverse joints, rectangular:
1) Use factory fabricated flanged duct connection systems (e.g. Ductmate 35/25 slide on systems).
2) Non-proprietary SMACNA defined T-22 or T-24 flanged connections
3) Seal transverse flanged duct connections with pressure sensitive, high density, closed cell, neoprene or polyurethane tape gasket.
c. Longitudinal seam: Pittsburgh lock seam.
d. High pressure ductwork includes:
1) Supply ductwork from air handling unit discharge to connection with single and dual duct air terminal units.
2) Exhaust ductwork between suction side of exhaust fan and air terminal units (e.g. isolation exhaust system).
3) Exhaust or return ductwork for other exhaust systems operating over 3 IN WG static pressure.
e. Runouts to air terminal units: Rigid or flexible ductwork.
1) Maximum flexible duct length: 3 FT .

2) Minimum turning radius:
a) As recommended by manufacturer. Do not kink, bend or restrict free area of duct as to generate additional pressure drop or noise.
3) Provide rigid ductwork on units located in rated corridors or corridors requiring smoke tight construction, where ducts pass through smoke or fire rated walls, floors or ceilings, and connections to air terminal units for exhaust or return systems.

f. Seal high pressure duct to seal Class A requirements.

H. Duct Hangers and Supports:
1. High and low pressure sheet metal ductwork:
a. SMACNA HVAC Duct Construction Standard.

I. Duct Fittings and Joints:
1. Low Pressure Systems:
a. Radius elbows without vanes:
1) Radius ratio (R/W) of 1.5 and greater.
b. Connections to diffusers, grilles and registers: Fitted securely to necks or collars provided behind diffuser, grille, or register face area.
c. Branch connections:
1) Round: Factory built short cone or bellmouth type. Air scoops are not acceptable.
2) Rectangular: 45 degree entry type or radius elbow.
d. Provide necessary transition pieces and duct collars to make connections to ductwork from neck sizes scheduled or indicated on drawings.
e. Where building walls, floor and ceilings form portions of duct or plenum, provide gasketed angles or channels at junction points, securely bolted to building structure.
2. High Pressure Systems:
a. Elbows 3-8 IN diameter: Die stamped, for minimum air friction loss, with continuous corrosion resistance welds.
b. Elbows over 8 IN diameter: Welded segment type, not less than 5 pieces for 90 degree elbows, and not less than 3 pieces for 45 degree elbows, using corrosion resistant welds.
c. Tees: "Low loss, short cone type", unless specifically detailed otherwise for space limitations.
d. "Y's" 45 degree type. 60 degree type may be used if space conditions dictate.
e. Install "Y's" as indicated.
f. Where tees are indicated, "Y's" may be substituted if space is available.
g. "Y's": Straight sided type (no cone).
h. Takeoffs from air handling unit plenums: Standard Bellmouth fittings.
1) Construct in accordance with SMACNA HVAC Duct Construction Standards.
i. "Y" takeoffs from horizontal ceiling mounted ducts to serve boxes: May be straight sided, shop fabricated type by accurately cutting and welding "Y's" into spiral ducts without use of fittings.

J. Turning Vanes, Square Elbows:
1. Velocities up to 2500 FPM : Single vane, runner Type 2, with 3/4 IN trailing edge, 2 IN vane radius and 1.5 IN vane spacing, minimum 24 GA.
a. For widths over 36 IN install vanes in 2 or more sections or use tie rods to limit unbraced vane length.
2. Where inlet and outlet dimensions of elbows are not equal, set 2 or more sections at 45 DEG angle to give optimum turning.
3. Radius elbows without vanes: Radius ratio (R/W) of 1.5 and greater.
4. Radius elbows with vanes: Radius ratio (R/W) less than 1.5; use where space limitations occur.
a. R/W = 0.75 to 1.0: Provide 3 vanes in elbow.
b. R/W = 1.0 to 1.25: Provide 2 vanes in elbow.
c. R/W = 1.25 to 1.5: Provide 1 vane in elbow.

d. Provide vane spacing per SMACNA HVAC Duct Construction Standards.

5. Where square elbows are indicated or required, provide with turning vanes.

K. Flexible Fan Connections:
1. Material: Neoprene double coated closely woven glass fabric flexible connections.
2. Fasten fabric to sheet metal duct work and to fan collar extension with 3/16 IN rivets spaced not more than 5 IN OC.
3. Locate in inlet and outlet of fans, as close to fan as possible.
4. Provide at ducts crossing building expansion joints and as indicated on drawings.
5. Connections shall not be under tension.
6. Provide minimum separation distance of 1 IN across the connection.

L. Flexible Ducts, Preinsulated:
1. Low pressure construction:
a. Liner: Steel wire helix encapsulated with chlorinated polyethylene (CPE) film.
b. Insulation:
1) 1 IN x 3/4LB/CF fiberglass insulation, minimum resistance of R-4.2.
c. Jacket:
1) Bi-directional metalized polyester.
2) Permeability: Not to exceed 0.05 perms when tested in accordance with ASTM E96 Procedure A.
2. High pressure construction:
a. Liner: Heavy gauge corrugated aluminum with watertight continuous lock seams.
b. Insulation: 1 IN x 3/4LB/CF fiberglass insulation, minimum resistance of R-4.2.
c. Jacket:
1) Bi-directional metalized polyester.
2) Permeability: Not to exceed 0.05 perms when tested in accordance with ASTM E96 Procedure A.
3) Flex duct must also meet any other local or state requirements for flexible duct construction and performance.
3. Rated working pressure:
a. Low pressure duct: Positive 4 IN WG minimum; negative 1 IN WG minimum, for return or exhaust air connections.
b. High pressure duct: Positive 8 IN WG minimum; negative 8 IN WG minimum for return or exhaust air connections
4. Fire resistant, self extinguishing, UL-181, Class 1, with flame spread of 25 or less and smoke development not to exceed 50.
5. Thermal conductance(C): 0.23 BTU/ h-FT^2-F .
6. Low pressure connections:
a. Secure duct to collar or sleeve with screws, or metal or nylon clamps or bands.
b. Seal connection with 2 wraps of duct tape.
7. High pressure connections:
a. Secure duct to collar or sleeve with duct sealer and 1/2 IN aluminum or galvanized steel bands or clamps.
b. Secure insulation jacket with 2 wraps of duct tape.
8. Turn radius: Not less than R/D equal to 1.0.
9. Provide flexible duct supports in accordance with SMACNA HVAC Duct Construction Standards.
10. As applicable, all products or assemblies to meet local or state code requirements.

M. Access Doors:
1. Provide at fire dampers, smoke dampers, fire and smoke dampers, duct mounted automatic dampers, duct mounted coils (except air terminal unit reheat coils) and where indicated on Drawings.
2. Position access doors to permit easy visual inspection and allow maintenance and resetting of device served.
3. Increase duct dimensions at devices when necessary to accommodate required access.

4. Install access doors above accessible lay-in ceilings.
5. Where access doors are installed above gypsum wall board ceilings or within shafts, provide access panels per Section 20 05 00.
6. Access doors at low pressure ductwork:
    a. Minimum Sizes:
        1) Access doors in ducts less than 600 MM 24 IN wide: 300 MM X 300 MM 12 IN X 12 IN.
    b. To install doors in round ducts or rounded side of flat oval duct, provide duct boot.
        1) Ruskin ADC22.
7. Low and high pressure ductwork:
    a. Access doors:
        1) Removable, double wall construction.
        2) 1 IN thick fiberglass insulation.
        3) Closed cell neoprene gasket and attachment bolts.
        4) Air tight seal to static pressures of 20 IN WG.
    b. Sizes:
        1) For ducts 18 IN and under, the minimum door size shall be 10 IN X 6 IN.
        2) For ducts 19 IN to 24 IN, the minimum door size shall be 16 IN X 12 IN.
        3) For ducts over 24 IN the minimum door size shall be 24 IN X 18 IN.
    c. Provide duct boot to install doors in round ducts or rounded side of flat oval duct.

N. Dampers:
1. Sizes and types: As indicated.
2. Locate as indicated.
3. Factory built and assembled dampers.
4. Dampers Manual, Rectangular and Square:
    a. Opposed blade type, fitted with shank bolts, marked for direction (open/closed).
    b. Provide locking hand quadrant, with 2 IN standoff bracket.
    c. Construction:
        1) Greater than 36 x 12 IN :
            a) Frame: 16 GA galvanized steel formed into structural shape.
            b) Blades: 16 GA galvanized steel, equipped with brass pin running on stainless steel pivot for vertical axis.
            c) Axles: Continuous, steel 1/2 IN hex.
            d) Basis of design: Ruskin MD35.
        2) 36 IN x 12 IN and less:
            a) Frame: 22 GA galvanized steel, flat or angle.
            b) Blades: 22 GA galvanized steel, equipped with brass pin running on stainless steel pivot for vertical axis.
            c) Axle: Continuous, steel 3/8 IN hex.
            d) System pressure and velocity rating: 2.5 IN WG and 1500 FPM .
            e) Basis of design: Ruskin MD25 or MD15.
5. Dampers Manual, Round:
    a. Butterfly type with circular blade mounted to shaft.
    b. Frame: Minimum 20GA galvanized steel 7 IN segment duct.
    c. Blade: Minimum 20 GA galvanized steel.
    d. Shaft: Continuous, Steel 3/8 IN hex.
    e. System pressure and velocity rating: 2.5 IN water gauge and 1500 FPM.
    f. Hand quadrant: Locking type with 2 IN standoff bracket.
    g. Bearings: Self-lubricating nylon or stainless steel sleeve.
    h. Basis of design: Ruskin MDRS25.
6. Dampers, Backdraft, Low Pressure:
    a. Counterbalanced, gravity operated.
    b. Fabricate of aluminum.
    c. Blades: Provided with common linkage rod and felt seals.
7. Dampers, Control:

a. Frame:
   1) 16 GA galvanized steel, 16 gauge stainless steel or extruded aluminum.
b. Blades:
   1) Airfoil shaped, 6 IN wide.
   2) Two layers of 22 GA galvanized steel mechanical joined sheets or extruded aluminum.
c. Seals:
   1) Extruded vinyl blade edge.
   2) Flexible metal compressible jamb seals.
d. Bearings:
   1) Aluminum frame construction: synthetic bearings.
   2) Galvanized or stainless steel construction: Stainless steel sleeve or ball bearing.
e. Temperature rating
   1) -40 to 200 DEGF .
f. Pressure and velocity rating:
   1) 4 IN WG pressure differential at 2000 FPM .
g. Blade arrangement:
   1) Opposed blade, except outside air and return air control dampers shall be parallel blade and arranged to promote mixing.
h. Actuators:
   1) See Section 25 50 00.
i. Example:
   1) Aluminum frame construction: Ruskin CD50.
   2) Galvanized frame construction: Ruskin CD60.

O. Fire Dampers:
1. UL labeled, 1-1/2 HR rated unless otherwise indicated.
2. Fire dampers shall have 165 DEGF 74 DEGC fusible link, except as follows:
   a. For exhaust and return systems, which are part of a smoke control system, the fusible link temperature shall be 285 DEGF . The following exhaust and return systems are part of a smoke control system: _____.
   b. Fire dampers in dishwasher and cartwash exhaust systems shall have 285 DEGF fusible link.
3. Fire dampers shall be dynamic type.
4. Provide as indicated and as required by NFPA and local regulations.
5. Provide with mounting angles and sleeves.
6. For curtain-type fire dampers, blades must be out of air stream (Type B fire damper), except as follows:
   a. Fire dampers with blades in the airstream (Type A fire damper): where dampers are installed at a wall mounted grille and ductwork is not installed on both sides of the wall penetration.
   b. For ducts where the smallest dimension is 8 IN or less : Type C fire dampers shall be 1 IN larger in each dimension and both the frame and the blades must be out of the air stream. This is not required at locations where fire dampers are installed at wall mounted grilles.
7. On round or flat oval ductwork, provide dampers in enclosure with round or oval connections on each side.
   a. Fire Dampers in Low Pressure Ducts:
      1) Provide curtain type damper, Ruskin Model DIBD2.
         a) Rated up to 2000 FPM at 4 IN WG for vertical mounted applications.
         b) Rated up to 2000 FPM at 4 IN WG for horizontal mounted applications.
   b. Fire Dampers in High Pressure Ducts:
      1) For vertical mounted applications: curtain type damper, Ruskin Model DIBDX2.
         a) Rated up to 4000 FPM at 8 IN WG .
      2) For horizontal mounted applications: curtain type damper, Ruskin Model DIBD2.
         a) Rated up to 2000 FPM at 4 IN WG .

c. Fire Dampers for Stainless Steel Ductwork Systems:
   1) Provide as specified above except with type 304 stainless steel construction.
   2) Provide as specified above except with type 316 stainless steel construction.
d. Ceiling Fire Dampers:
   1) UL listed specifically for floor/ceiling assemblies.
   2) Provide Ruskin CFD Series radiation damper suitable for type of diffuser, register, and grille.
   3) Provide mineral wool thermal insulating blanket for back side of diffuser, register, or grille as required by the manufacturer to comply with listing of damper.

P. Smoke Dampers:
1. UL classified as a leakage rated damper for use in smoke control systems under UL555S, latest edition, and bear a UL label attesting to same.
2. Suitable for velocity and pressure of system.
3. Jamb seals: Stainless steel flexible metal compression type.
4. Provide in ductwork adjacent to smoke partition (not in wall) with actuator in accessible location and visible for inspection.
5. Provide dampers and actuators as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators as a rated assembly.
6. Frame: 16 GA galvanized steel, minimum.
   a. Loss through wide open damper based on AMCA Test Figure 5.3:
   b. 12 IN x 12 IN duct size: Not more than 1.25 IN WG at 3000 FPM face velocity.
   c. 24 IN x 24 IN duct size: Not more than 0.45 IN WG at 3000 FPM face velocity.
   d. 36 IN x 36 IN duct size: Not more than 0.3 IN WG at 3000 FPM face velocity.
7. Provide factory supplied caulked sleeve.
8. Smoke Dampers, Low Pressure:
   a. Parallel blade type with blades hinged together for operation in unison and bearings arranged for automatic operation.
   b. UL555S Leakage Rating: Class I (4 CUFTM/ SF at 1 IN WG).
      1) Ruskin Model SD37.
   c. Blades: Single or double thickness type.
      1) Single thickness type: 16 GA steel, minimum.
      2) Double thickness type: 18 GA steel.
   d. Blade width: Not more than 6 IN .
   e. Single blade dampers may be used for up to 8 IN wide blade, or up to 12 IN round.
9. Smoke Dampers, Square or Rectangular, High Pressure:
   a. Parallel or opposed blade type with linkage for automatic operation.
   b. UL555S Leakage Rating: Class I (8 CUFTM/ SF at 4 IN WG).
      1) Ruskin Model SD60 or SD50.
   c. On round or flat oval ductwork:
      1) Provide dampers in an enclosure with round or oval connections on each side.
10. Smoke Dampers, Round or Flat Oval, High Pressure:
   a. Single blade type with encompassed blade edge seal.
   b. UL555S Leakage Rating: Class I (8 CUFTM/ SF at 4 IN WG).
      1) Ruskin Model SDRS25.
11. Damper actuator:
   a. Pneumatic type, factory installed.
      1) Two-position type operating on 0 to 20 PSIG air pressure.
      2) Spring return fail closed.
      3) UL listed at 250 DEGF .

Q. Combination Fire-Smoke Dampers:
1. Fire-Smoke Dampers, Combination:
   a. UL classified as a Leakage Rated damper under UL555S, latest edition, bearing a UL label attesting to same.
   b. UL555 fire rating: 1.5 Hour.

c. Suitable for velocity and pressure of system.
d. Compressible metal jamb seals.
e. Operator installed per UL requirements, in accessible location and visible for inspection.
f. Provide dampers and actuators as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators as a rated assembly.
g. Frame: 16 GA galvanized steel, minimum.
h. Loss through wide open damper:
i. Loss through wide open damper based on AMCA Test Figure 5.3:
1) 12 IN x 12 IN duct size: Not more than 1.25 IN WG at 3000 FPM face velocity.
2) 24 IN x 24 IN duct size: Not more than 0.45 IN WG at 3000 FPM face velocity.
3) 36 IN x 36 IN duct size: Not more than 0.3 IN WG at 3000 FPM face velocity.
j. Provide factory supplied caulked sleeve.

2. Fire-Smoke Dampers, Combination, Low Pressure:
a. Parallel blade type with blades hinged together for operation in unison and bearings arranged for automatic operation.
b. May be used in lieu of separate fire and smoke dampers.
c. UL555S Leakage Rating: Class II (10 CUFTM/ SF at 1 IN WG).
1) Ruskin FSD36.
d. Fusible link: 165 DEGF melting point.

3. Fire-Smoke Damper, Combination, High Pressure:
a. Parallel blade type.
b. May be used in lieu of separate fire and smoke dampers.
c. UL555S Leakage Rating: Class I (8 CUFTM/ SF at 4 IN WG).
1) Ruskin Model FSD60 .
d. Fusible link: 165 DEGF melting point.

4. Actuators, Fire-Smoke Damper:
a. Electric type, factory installed.
b. Two-position.
c. 120 VAC.
d. Spring return fail closed.

5. Diffusers:

R. Diffusers, Registers and Grilles:
1. Diffusers, Ceiling:
a. Square type.
b. Size, type and manufacturer: As scheduled.
c. Finish of steel units: Factory applied, baked or electrocoated enamel; color as selected by Architect or as indicated.
d. Finish of aluminum units: Satin anodized.
e. Provide sponge rubber gasket for ceiling diffusers.
f. Provide necessary screws, duct collars, transitions and air pattern deflectors.

2. Air Grilles and Registers:
a. Size, type and manufacturer as scheduled.
b. Finish of steel units:
1) Factory applied, baked or electrocoated enamel.
2) Color as selected by Architect or as indicated.
c. Finish of aluminum units: Satin anodized.
d. Provide sponge rubber gasket for ceiling and wall units.
e. Provide necessary screws, duct collars and transitions.
f. Provide opposed blade dampers in registers where indicated.

Acoustic Performance Requirements

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine structure, substrates, and conditions under which work is to be installed.

B. Correct deficiencies.

C. Installation constitutes acceptance of responsibility for performance.

D. Install air flow measuring stations specified in Section 25 50 00 IN accordance with manufacturer's installation instructions and as specified.

3.2 INSTALLATION OF DUCTWORK

A. Ductwork Cleanliness:
   1. Reference Standard:
      a. SMACNA – Duct Cleanliness for New Construction.
   2. Basic Level:
      a. Under this level of ductwork cleanliness it is acknowledged that ductwork leaving the premises of the manufacturer will include some or all of the following:
         1) Internal and/or external self-adhesive labels or marking for parts identification.
         2) Exposed mastic sealant.
         3) Light zinc oxide coating on the metal surface.
         4) A light coating of oil on machine formed ductwork.
         5) Minor protrusions into the airway of rivets, screws, bolts and other jointing devices.
         6) Internal insulation and associated fasteners.
         7) Discoloration marks from plasma cutting process.
      b. The internal surfaces of ductwork shall be wiped to remove excess dust immediately prior to installation.
   3. Intermediate Level:
      a. Under this level of ductwork cleanliness it is acknowledged that ductwork leaving the premises of the manufacturer will include some or all of the following:
         1) Internal and/or external self-adhesive labels or marking for part(s) identification.
         2) Exposed mastic sealant.
         3) Light zinc oxide coating on the metal surface.
         4) A light coating of oil on machine formed ductwork.
         5) Minor protrusions into the airway of rivets, screws, bolts and other jointing devices.
         6) Internal insulation and associated fasteners.
         7) Discoloration marks from plasma cutting process.
      b. Site storage: The area provided for storage shall be clean, dry and exposure to dust minimized.
      c. The working area should be clean and dry and protected from the elements.
      d. The internal surfaces of ductwork shall be wiped to remove excess dust immediately prior to installation.
      e. Open ends on completed ductwork and overnight work-in-progress shall be sealed.
   4. Advanced Level:
      a. In addition to the provisions of the Intermediate level the following requirements apply:
         1) All self-adhesive labels for part identification are to be applied to external surfaces only.
         2) To maintain cleanliness during transportation, all ductwork shall be sealed either by blanking or capping duct ends, bagging small fittings, surface wrapping or shrink wrapping.
      b. Site Storage:
         1) A clean and dry environment where the ductwork is protected from dust must be provided for the storage of ductwork prior to installation.

2) All sealed ends shall be visually examined and if damaged resealed with an appropriate material.

c. The working area shall be clean, dry and the ductwork protected from dust. Protective coverings shall only be removed immediately before installation and inspected to determine if additional wipe down is necessary.

5. Duct Cleanliness levels by space type:
   a. Basic Level:
      1) Ductwork systems serving mechanical or electrical equipment rooms.
   b. Advanced Level:
      1) All Hospital or Medical Office Building areas providing direct patient care or patient care support (examples: Central Sterile, Kitchen, Surgery Suites, Patient Floors, Exam and Treatment Areas): Advanced Level.
      2) All Laboratory areas.
      3) Computer, telephone equipment rooms, Data Centers and similar areas housing high tech equipment or fabrication processes.
   c. Intermediate Level:
      1) All building areas not covered under Advanced or Basic Level duct cleanliness (i.e. general office and administration areas, cafeterias, meeting rooms, etc.)

B. Install generally as indicated.

C. Conceal ductwork in finished spaces unless indicated otherwise.

D. Do not install ductwork in or allow to enter or pass through electrical rooms, elevator machine rooms, or spaces housing switchboards, panelboards or distribution boards, except ductwork that serves electrical rooms, elevator machine rooms, or spaces.

E. Exercise special care to provide tight fitting well fabricated, well braced ductwork systems.

F. Field assemble rectangular, round or flat oval ductwork as follows:
   1. Use duct joint sealer applied slip joints.
   2. Use Ductmate Spiralmate or Ovalmate systems.
   3. Isolate dissimilar metals with elastomeric sealant tape or fiber gaskets, and gaskets and washers for bolts.
   4. Install TDC flanged duct connection systems in accordance with SMACNA construction standards.

G. In high pressure ductwork, do not use 2 piece mitered 90 degree elbows with or without vanes unless approved by Engineer.

H. Fabricate duct connections for hoods, openings, fans, and other devices.

I. Where ducts pass thru fire rated and smoke rated construction, maintain rating indicated.
   1. Where fire dampers are not used, seal around duct with firestopping.
   2. See Section 07 84 00 for materials.

J. Do not kink, bend or otherwise restrict the free area of flexible ductwork.

K. Ductwork Hangers:
   1. Install per SMACNA Duct Construction Standards but in no case shall ductwork hangers or ductwork be directly supported to or supported off of other ductwork.

3.3 INSTALLATION OF MANUAL DAMPERS

A. Provide volume dampers, to facilitate air balancing, in the following locations whether shown on the plans or not:
   1. Run-outs to individual room terminal devices (i.e. supply grilles and diffusers, return and exhaust grilles). Locate damper as close to the run-out take off as possible.
   2. Lateral duct take-offs from a return or exhaust main riser for systems serving multiple floors.

B. Provide additional branch main volume dampers required by the balancing contractor, refer to Section 20 08 00.

3.4 INSTALLATION OF FIRE AND SMOKE DAMPERS

A. Install in accordance with manufacturer's instructions and UL requirements.
   1. See Section 07 84 00.

B. Floor mounted dampers may be installed in a concrete floor curb.

3.5 CLEANING

A. At substantial completion, clean work installed under this section.

3.6 EQUIPMENT DEMONSTRATION

A. At substantial completion, inspect and test, and operate satisfactorily, in presence of Engineer and representative of Owner, operation of each piece of equipment and its accessories.

B. If inspection or test indicates defects, replace defective work or material.

C. Repeat inspections and tests until defects are eliminated.

END OF SECTION

SECTION 23 36 00
AIR TERMINAL UNITS AND INDUCTION UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish all labor, materials, tools, equipment, and services for Air Terminal Units and Induction Units, as indicated, in accordance with provisions of Contract Documents.

B. Systems Included:
   1. Air terminal units.

C. Operators and controllers:
   1. Operators and controllers for air terminal units: Provided in Section 25 50 00.

D. Definitions:
   1. Low pressure ductwork:
   2. High pressure ductwork: refer to section 23 31 13.

E. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Design and installation standards:
   1. ASHRAE Guide and Data Book – Systems and Equipment, current chapter on duct construction.
   2. Air Diffusion Council, ADC Standard 1062R2, Air Diffusing Equipment Test Code.
   3. Air Moving and Conditioning Association, AMCA Standard 210, Test Code for Air Moving Devices.
   4. ASHRAE Standard 70-72, Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.
   5. NFPA-90A, Standard for the Installation of Air Conditioning and Ventilating Systems, current edition.
   6. SMACNA HVAC Duct Construction Standard - Metal and Flexible current edition.
   7. UL Publication No.181, Erosion Test Methods.
   8. ARI 885-98: Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.

1.3 SUBMITTALS

A. Product Data:
   1. Air Terminal units.

B. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction report.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Air terminal units:
   1. Base:
      a. Titus.
   2. Optional:
      a. Krueger.
      b. Metalaire.
      c. Trane.

B. Other manufacturers desiring approval comply with Section 00 26 00.

2.2 MATERIALS

A. Air Terminal Units
   1. Air terminal units - general: Factory assembled.
      a. Configured for pressure independent control.
      b. Capacity: As indicated.
      c. Noise level: Based on ARI 885-98. Refer to plans for scheduled values.
      d. Operators: Furnished in Section 25 50 00.
         1) Factory or field installed on units.
         2) Provide two operators per air terminal unit for dual duct applications.
      e. Acoustical fiberglass liner:
         1) Comply with NFPA-90A for fire resistivity and UL Standard 181 for erosion.
         2) Insulation shall consist of 1 IN thick non-porous foil faced rigid fiberglass insulation secured by full length galvanized steel z-strips which enclose and seal all edges, eliminating tape and adhesives.
      f. Provide multi-point velocity pressure sensors with external pressure taps.
      g. Provide static pressure tube(s).
      h. Valve adjustment: Field adjustable.
      i. Set air terminal units to air flow rates indicated.
      j. Casing leakage: 5 PCT, maximum, of nominal rated capacity at 3.0 IN WG internal pressure.
   2. Heating and cooling coils for air terminal units: ARI certified, continuous plate or spiral fin type, leak tested at 300 PSI.
      a. Capacity: As indicated, based on scheduled entering water temperature.
      b. Headers: Copper or brass.
      c. Fins: Aluminum, maximum 8 fins per IN.
      d. Tubes: Copper, arrange for counter-flow of heating water.
      e. Water velocity: 8 FPS maximum with head loss not greater than indicated.
      f. Provide 20 GA galvanized steel casing with slip and drive construction for attachment to metal ductwork.
      g. Provide vent and drain connection at high and low point, respectively, of each coil.
      h. Coils guaranteed to drain.
   3. Inlet air valves for air terminal units: Corrosion resistant, self-seating type.
      a. Frame, links and levers may be of zinc coated steel or aluminum.
      b. Vanes, pivots, hinged or knuckle joints: Aluminum or other non-ferrous metal.
      c. Leakage: Not greater than 3 PCT of maximum rated capacity when closed against inlet static pressure of 4.0 IN WG.
      d. Equip with suitable linkage and motor mounting platform to accommodate control operators.
      e. Use resilient sealing members to prevent leakage.
      f. Provide direct reading air flow rate scale and external adjustment.
   4. Air terminal units, single duct, with coils: Constant or variable volume, high velocity unit with reheat coil, as indicated.
      a. Construction: 22 GA galvanized steel or 0.040 IN aluminum, minimum.

B. Terminal Air Valves
   1. Air valves, flow control:
      a. Airflow control device shall be a venturi valve.
      b. Pressure independent over a 0.6 IN WG – 3.0 IN WG drop across valve.
      c. Volume control accurate to plus or minus 5 PCT of airflow over an airflow turndown range of 16 to 1. No minimum entrance or exit duct diameters shall be required to ensure accuracy or pressure independence.
      d. Response time to change in command signal and duct static pressure less than one second.

e. 16 gauge spun aluminum valve body and control device with continuous welded seam and 316 stainless steel shaft and shaft support brackets. Pressure independent springs shall be stainless steel. Shaft bearing surfaces shall be Teflon or polyester.
f. 316 stainless steel continuous welded seam valve body, control device, shaft, shaft support bracket, pivot arm and internal mounting link. The control device shall have a baked on corrosion resistant phenolic coating. The shaft shall have a Teflon coating and all shaft bearing surfaces shall be made of Teflon. The pressure independent springs shall be made of stainless steel.
g. The airflow device shall have no exposed aluminum or stainless steel components. The shaft support brackets, pivot arm, internal mounting link, and pressure independent springs shall have a baked-on corrosion resistant phenolic coating. Internal nuts, bolts, and rivets shall be titanium or phenolic coated stainless steel.
h. Constant volume units:
    1) Internal spring compresses to maintain constant volume of air.
    2) As static pressure decreases internal spring expands to increase annular area to maintain constant volume of air.
i. Variable volume units:
    1) Actuator to be factory mounted to the valve.
    2) Closed loop control of airflow by way of flow feedback signal with less than 1 second response time.
    3) Shaft positioned using direct potentiometer measurement to produce a linearized factory calibrated feedback.
j. Certification:
    1) Control device: factory calibrated to airflows detailed on plans using NIST traceable air stations and instrumentation having a combined accuracy of plus or minus 1 PCT of signal over the entire range of measurement.
    2) Electronic airflow control devices: further calibrated and their accuracy verified to plus or minus 5 PCT of signal at a minimum of eight different airflows across the full operating range of the device.
    3) All airflow control devices: individually marked with device specific, factory calibration data to include: tag number, serial number, model number, eight point characterization information (for electronic devices), and quality control inspection numbers.

2. Airflow control devices that are not venturi valves, and airflow measuring devices (e.g., pitot tube, flow cross, air bar, orifice ring, vortex shedder, etc.) are acceptable provided:
    a. They meet the performance and construction characteristics stated throughout this section of the specification.
    b. Suppliers of airflow control devices or airflow measuring devices requiring minimum duct diameters: provide revised duct layouts showing the required straight duct runs upstream and downstream of these devices.
    c. Supplier of the airflow control system: submit coordination drawings reflecting these changes and include static pressure loss calculations as part of submittal.
    d. All costs to modify the ductwork, increase fan sizes and horsepower, and all associated electrical changes: borne by the airflow control supplier and the contractor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units as indicated and in accordance with manufacturer's recommendations and instructions and as specified.

END OF SECTION

SECTION 23 81 26
UNITARY SPLIT AIR CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Unitary Split Air Conditioners, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Units factory tested.

1.3 SUBMITTALS

A. Shop Drawings:

B. Product Data:

C. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction report.
   3. Test report.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Unitary split air conditioners:
   1. Base:
      a. Carrier.
      b. Lennox Inds.
      c. Bryant Air Conditioning.

B. Humidifiers:
   1. Base:
      a. Research Products.
      b. Walton Labs.
      c. Lennox Inds.
      d. Carrier.
      e. Bryant Air Conditioning.

C. Other manufacturers desiring approval comply with Section 00 26 00.

2.2 MATERIALS

A. Unitary Split Air Conditioner - General
   1. Air conditioner: Unitary, split type, heating and cooling unit with outdoor condensing unit, indoor gas furnace with evaporator and humidifier.
      a. Sizes and capacities: As indicated.

B. Condensing Unit
   1. Condensing unit: Air-cooled condensing unit, factory assembled, consisting of compressor, condenser coil and fan, and casing.
      a. Units: CSA and UL approved; conforming to ARI Standard 210.
      b. Operating range: 40-120 DEGF outdoor ambient.
      c. Factory installed filter drier.

2. Compressor: Hermetic, welded shell-type.
    a. Motor: Wide operating range, dual voltage.
    b. Internal spring isolation and 2-stage sound isolation.
    c. Winding thermostat and current overload device coupled with pressure limiting valve.
    d. Internal protection devices for:
        1) Motor overload.
        2) Locked rotor.
        3) Extreme voltage supply.
        4) Excessive winding temperatures.
        5) Extreme pressures.
        6) Loss of refrigerant charge.
        7) Compressor cycling.
    e. Off cycle crankcase heater.
3. Coil, condenser: Seamless aluminum tubes, 3/8 IN OD, with aluminum fins mechanically bonded.
    a. Two row.
    b. Factory pressure and leak tested at 600 PSI.
    c. Provide heavy duty protective grille on every side.
4. Fan, condenser: Aluminum, aerodynamically designed, statically balanced.
    a. Motor: Two-speed, single phase, direct drive, heavy duty, permanently lubricated, with built in thermal overload protection.
    b. Mount fan and motor support to cabinet top.
    c. Provide grille to protect fan.
5. Casing, condensing unit: 18 GA galvanized steel.
    a. Finish: Phosphatized; epoxy resin primer; acrylic finish coat.
    b. Removable end panel for access to components and connections.
    c. Standard base size.
    d. Mounting rails: Die formed; integral with base.
    e. Drain holes in base pan.
    f. Electrical and refrigeration connections in same location on units.

C. Electric Furnace
1. Furnace, electric: Suitable for upflow, downflow or horizontal operation without equipment changes; consisting of heating elements, fan, filter, evaporator coils, controls and casing.
    a. UL approved as heating units; for installation in confined spaces with reduced clearances to combustible materials.
    b. Wiring: Complete at factory.
        1) Internal wiring: 105 DEGC rated.
        2) Low voltage wiring terminal strip.
        3) Low and high voltage connections made from either side.
2. Heating elements, electric: Open type nickel-chromium alloy.
    a. UL approved.
    b. Cover 70 PCT, minimum, of air outlet area, minimize bypass air and reduce coil surface temperatures.
    c. Design in 5 KW, maximum, increments.
3. Fan, furnace: Forward curved, centrifugal type, with locked blades.
    a. Motor: Multi-speed, direct drive, permanently lubricated, separately isolated.
    b. Capacity: As required for heating and cooling.
    c. Assembly mounted on furnace casing slide rails for easy access and removal.
4. Filter, furnace: Throwaway type, mounted inside unit; sized to handle maximum CFM.
5. Casing, furnace: 22 GA steel, one piece wrap around, welded construction.
    a. Finish: Cleaned and phosphatized, primed and baked enamel finish coat.
6. Controls, furnace:
    a. Heating elements:
        1) Provide thermal sequencers control 10-40 SEC time delay between increments.
        2) Each increment: Automatic resetting thermal overload.

b. Fan:
1) Control by bonnet temperature.
2) Operate after 30 SEC regardless of bonnet temperature.
3) Two-speed relay for automatic heating/cooling changeover.
c. Cooling: 50 VA transformer.
d. Thermostat: Heating/cooling, for remote mounting.

7. Coil, evaporator: Seamless copper tubes, 3/8 IN OD, with aluminum fins mechanically bonded.
a. Three row; fin design to permit airflow from any direction without moisture carryover.
b. Casing: 20 GA steel.
1) Finish: Baked enamel.
2) Lined with 1/2 IN thick, 1/2 PCF density neoprene coated insulation.
3) Drain pan with 3/4 IN connection.
4) Adjustable inlet and outlet panels.
c. Quick-connect models: Provide:
1) Male couplers.
2) Capillary tube expansion device or thermal expansion valve.
3) Operating charge of R-22.
d. Sweat-connect models: Provide:
1) Thermal expansion valve.
2) Holding charge.
3) Copper tube stubs for field piping.

D. Blower Unit
1. Blower unit: Factory assembled; consisting of fan, filters, evaporator coil, controls and casing.
2. Fan, blower: Centrifugal type, direct drive.
a. Motor: Two-speed, permanent split capacitor, with built in thermal overload protection and run capacitor.
3. Filter, blower: Throwaway type, slide-in/slide-out.
4. Casing, blower unit: 20 GA steel.
a. Finish: Baked enamel.
b. Lined with . 1/2 IN thick, 1/2 PCF density neoprene coated insulation.
c. Removable access panels with quarter-turn fasteners.
5. Coil, evaporator: Seamless copper tubes with aluminum fins mechanically bonded.
a. Quick-connect male couplers.
b. Expansion valve expansion device.
c. Operating charge of R-22.
6. Controls, blower unit:
a. Fan relay.
b. 50 VA transformer.
c. Thermostat: Cooling, for remote mounting.

E. Humidifier
1. Humidifier: Power type, designed for warm air plenum installation.
a. Motor and fan accomplish air movement necessary for evaporation.
b. Solenoid valve for positive water shut-off.
c. Replaceable evaporator pad.
d. Capacity: As indicated.
e. Provide humidistat suitable for remote mounting in finished space.

2.3 REFRIGERANT PIPING AND ELECTRICAL WORK

A. Piping, refrigerant for quick-connect installations: Pre-charged, factory assembled, in standard lengths.
1. Female couplings.
2. Suction line: Foam plastic insulated.

3. Provide gauge ports at condenser.

B. Piping, refrigerant, for field assembled piping: See Section 23 23 00.

C. Control wiring: Provide wiring between components for control functions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions and recommendations.

B. Connect piping, wiring and control wiring.

END OF SECTION