Section 25 60 00

Laboratory Control System

KAUST Standards

This standard will serve as specific engineering requirements in the design and construction of all KAUST facilities within KAUST vicinity to address electrical, civil/structural, integrated automation, plumbing, HVAC, fire suppression, electronic safety and security aspects.

The standard is a “live” and on-going document that is to be updated as the need arises. It is governed by KAUST procedure SAP-P-007-2015 and related forms for initiating updates and approving any waiver requests developed by E&PM.

SECTION 25 60 00 – LABORATORY CONTROL SYSTEMS

PART 1 – GENERAL

1.1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary conditions and Division 01 Specification Sections, apply to this Section.

B. All related referenced codes and standards in this section corresponds to IBC 2009 edition.

1.2. SUMMARY

A. This Section includes control equipment for laboratory control systems and components.

B. Related Sections include the following:

1. Division 23 Section "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.

1.3. DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. Lon Works: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

H. VAV: Variable air volume

I. CV: Constant Volume

1.4. SYSTEM PERFORMANCE

A. Manufacturers Requirements

1. Provide the services of control manufacturer’s representative to be on site during the entire time that the start-up, testing and balancing procedures, detailed in Part 3 of this specification, takes place. Representative shall be part of manufacturer’s service organization and shall be skilled in the adjustment and calibration of all control devices as well as being capable of modifying and for checking system software.
2. Certify maintenance of local office within 80 Km radius of job site, staffed with factory-trained engineers capable of providing instructions to Owner's personnel and performing routine and emergency maintenance on ALL system components .Upon Architect's request, submit list of personnel staffing field office and their professional disciplines.
3. Provide laboratory control system supplier's warranty of performance of entire system, including pneumatic components, as required by Contract documents. Performance and components requirements are established by control sequences and diagrams on Drawings and by this Paragraph.

4. Supplier to make available all necessary system protocol and point data to the site-wide systems integrator so as to allow integration of the system onto the KAUST Integrated Automation System.
5. Supplier shall provide all necessary network hardware such as gateways, routers, hubs, or other equipment, including software and configuration to support integration of the supplier's system onto a BAC net/IP/Ethernet backbone or any other universal protocol that can communicate with all the automations systems available in the Building and Campus/KAUST.
6. Supplier to provide suitably qualified personnel to support the site-wide Systems Integrator so as to allow integration of the supplier's system onto the KAUST Integrated Automation System.

1.5. SEQUENCE OF OPERATION

A. Refer to Mechanical Division 23 Control Drawings for all sequence of operations.

1.6. SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and start up instructions for each type of product indicated.
   1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for interface equipment control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
   2. Control System Software: Include technical data for operating system software, operator interface, colour graphics, and other third-party applications.
   3. Controlled Systems: Instrumentation list with element name, type of device manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
   2. Schematic flow diagrams showing dampers, valves, and control devices.
   3. Wiring Diagrams: Power, signal, and control wiring.
   4. Details of control panel faces, including controls, instruments, and labelling.
   5. Written description of sequence of operation.
   6. Schedule of valves including size, leakage, and flow characteristics.
   7. DDC System Hardware:
      a. Wiring diagrams for control units with termination numbers
      b. Schematic diagrams and floor plans for field sensors and control hardware.

c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

8. Control System Software: List of Colour graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
9. Controlled Systems:
    a. Schematic diagrams of each controlled system with control points labelled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135 or Lon Works as appropriate for the proposed system.

D. Software and Firmware Operational Documentation: Include the following:
    1. Software operating and upgrade manuals.
    2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
    3. Device address list.
    4. Printout of software application and graphic screens.
    5. Software license required by and installed for DDC workstations and control systems.

E. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For laboratory instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section "Operation and Maintenance Data," include the following:
    1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
    2. Interconnection wiring diagrams with identified and numbered system components and devices.
    3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
    4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
    5. Calibration records and list of set points

Projection Table should be attached with all the submittals

Sample Projection Table:

Projection Table

Project:	***: King Abdullah for Science & Technology (KAUST)***		
Building	***: UNXXXX***		
Drawing Ref.	***: UNXXXX dated XX-XX-XXXX (UNXXXX XXX-IMXXX Bulletin XXXX Issue No. X)***		
Level	***: X***	***Area***	***: XX***
LAB	***: LFO-XXX***		
Room No	***: LXXXX - XXXX***		

Size & Orientation		12" H				12"V				
Sash Position	**Thermostat Mode**	**GEX-XXXX EAV_XXXX**	**TOT1**	**+ve Offset**	**Exhaust +Offset**	**SUP-XXXX-SAV_XXXX**	**TOT2**	**-ve Offset**	**Supply +Offset**	**Note**
	%	**100%**				**#DIV/0!**				
-	**Min Cool/heat**									
-	**COOL MAX**									
-	**Occupied**									
-	**Unoccupied**									
Calculated	**Min Clamp:**	**0**				**0**				
	Max Clamp:	**0**				**0**				
HOK - Schedule	**Min Clamp:**	**0**				**0**				
	Max Clamp:	**0**				**0**				

Rooms with inwards air flow is under negative pressure: Exhaust = Supply + |Offset|
Rooms with outwards air flow is under positive pressure: Supply = Exhaust + |Offset|

Total Room EA (L/S)	Schedule	Calculated
UNOccupied Min EA (L/S):	0 L/S	0 L/S
Occupied Min EA (L/S):	0 L/S	0 L/S
Occupied Max EA (L/S):	0 L/S	0 L/S

1.7. QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

B. Electrical Components, Devices, and Accessories: Listed and labelled as defined in NFPA 70, Article 100, 2014 edition, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with ASHRAE 135 for DDC system components as appropriate for proposed system.

1.8. DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.9. COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 28 Section "Intrusion Detection" to achieve compatibility with equipment that interfaces with that system and with building master clock.

C. Coordinate equipment with Division 28 Section "Access Control" to achieve compatibility with equipment that interfaces with that system.
D. Coordinate equipment with Section "Clock Systems" to achieve compatibility with equipment that interfaces with that system.
E. Coordinate equipment with Division 28 Section "PLC Electronic Detention Monitoring and Control Systems" to achieve compatibility with equipment that interfaces with that system.
F. Coordinate equipment with Division 26 Section "Network Lighting Controls" to achieve compatibility with equipment that interfaces with that system.
G. Coordinate equipment with Division 28 Section "Digital, Addressable Fire-Alarm Systems" to achieve compatibility with equipment that interfaces with that system.
H. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.
I. Coordinate equipment with Division 26 Section "Electrical Power Monitoring and Control" to achieve compatibility of communication interfaces.
J. Coordinate equipment with Division 26 Section "Panel boards" to achieve compatibility with starter coils and annunciation devices.
K. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.
L. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

1.10. EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
B. Replacement Materials: One replacement diaphragm or relay mechanism for each unique pneumatic damper motor, valve motor, controller, thermostat, and positioning relay.

PART 2 – PRODUCTS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection

2.1. CONTROL SYSTEM

A. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic Colour graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.2. LABORATORY CONTROL SYSTEM

A. Laboratory airflow control system shall be provided to control the airflow into and out of laboratory rooms as indicated on the drawings. The exhaust volume of a laboratory fume hood shall be precisely controlled by an Adaptive Face Velocity controller to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on actual hood usage. The laboratory control unit shall vary the amount of air into the room to maintain temperature control, minimum ventilation, airflow balance, and laboratory pressurization in relation to adjacent spaces (positive or negative). All laboratory airflow control systems devices shall be by a single manufacturer.

B. Warranty shall commence upon the date of acceptance and extend for a period of thirty six months whereupon any defects in materials or system performance shall be repaired by the manufacturer at no cost to the owner.
C. The manufacturer shall provide to the owner during and after the warranty period, at no additional cost, five (5) years of preventative maintenance for products that incorporate airflow sensors (e.g., Pitot tube, flow cross, air bar, hot wire, vortex shedder, etc.) and flow transducers. The laboratory controls manufacturer shall remove the airflow sensors quarterly during the five year period to inspect and clean them as to prevent inaccuracies due to long term build-up from corrosion, lab tissues, wet or sticky particles, or other materials that foul the sensor. The transducer shall be checked and recalibrated to insure long term accuracy.
D. System Performance Requirements:
    1. The laboratory airflow control system shall be fully stand-alone for each individual laboratory. The system shall not use or rely on information from controllers in other laboratory areas to control the functions within its laboratory.
    2. The laboratory airflow control system shall employ individual Face Velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hoods exhaust airflow in a variable volume mode to maintain a constant face velocity over a minimum range of 20 to 100% at full sash opening. Response time shall be less than one second with no more than a 5% volume deviation within one second of the sash reaching 90% of its final value with a full height sash movement of one second.
    3. The laboratory airflow control system shall also maintain intersystem stability within one second of a change in pressure and/or flow to eliminate hunting, system oscillations, and crosstalk between airflow controllers.
    4. The laboratory airflow control system shall use volumetric offset control to maintain room pressurization and auxiliary fume hood make-up air tracking. The system shall respond and maintain room pressurization (negative or positive) within one second of a change in room/system conditions.
    5. The laboratory airflow control system shall maintain specific airflow (±5% of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change airflow change or quantity of airflow control devices on the manifold (within 15.24 mm to 76.2 mm wc).
    6. The laboratory airflow control system shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure.

Systems using differential pressure measurement or velocity measurement to control room pressurization are unacceptable.

7. The laboratory airflow control system shall maintain specific airflow (±5% of signal) with a minimum 16 to 1 turndown to insure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.
8. Experience
    a. The laboratory airflow control system supplier shall provide a list of at least three similar laboratory airflow control systems installed in the state or province as part of this proposal.
    b. The laboratory airflow control system supplier shall provide the names, addresses, and the telephone numbers of the consulting engineer and the owner's representative for each of these installations. It is understood that these individuals may be contacted regarding timely delivery, the quality of installation, the operation and performance of the equipment and the service requirements for each installation. Unsatisfactory performance or inability to provide references shall be grounds for rejection.
9. Performance Verification
    a. In the event a substituted manufacturer is to be considered the laboratory airflow control system supplier shall demonstrate a typical laboratory space that includes multiple fume hoods, a general exhaust, and supply airflow control device for the purpose of verifying the laboratory airflow control system's ability to meet the performance requirements indicated in this specification. All travel and lodging costs to witness the performance verification shall be the responsibility of the laboratory airflow control system supplier.

E. Compliance Schedule
1. Any alternate laboratory airflow control system supplier shall provide a separate compliance schedule, which shall include the section, paragraph, and subparagraph of these specifications and direct statement to indicate compliance or noncompliance with the requirements. For all areas of noncompliance the supplier shall describe what specific and alternative approach has been taken and document the impact this will have on the sizing of the air delivery systems, the required cooling and heating capacities, energy costs and maintenance of building.
2. The alternate laboratory airflow control system supplier shall furnish a letter of compliance to the engineer, signed by a corporate office of the laboratory system manufacturer, certifying the compliance and noncompliance items as stated above 10 days prior to the bid.

F. Fume Hood Sash Components
1. A vertical sash sensor shall be provided to measure the height of each vertically moving fume sash consisting of a potentiometer wheel and cable. Cable shall be stainless steel with 3 mils of epoxy coating. Sensor potentiometer shall have proof of testing and life span of a million cycles or more. A horizontal sash sensor shall be provided for each pair of horizontal or overlapping sashes that are located on

horizontal, combination, California, walk-in, or distillation type fume hoods. Sensors shall be magnetic bar type with bridge diodes and contacts. All wiring shall be provided with a retractable cable and hidden from view. Control systems employing side-wall mounted velocity sensors are unacceptable.

2. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow set points to maintain a constant face velocity throughout this range. A minimum volume shall be set to insure flow through the fume hood even with the sash totally closed.

G. Fume Hood Monitor (with LED or Numerical Display)

1. A fume hood monitor shall be provided to receive the sash opening signal from the vertical and or horizontal sash sensors. The monitor shall compute the total open sash area and then output an exhaust airflow control signal to the appropriate volume control device (valve or drive).
2. The face velocity and minimum exhaust flow level of the fume hood shall be set at the fume hood monitor via trim pot adjustments. Accurate adjustment of the face velocity shall be provided at two (2) different sash positions.
3. An emergency exhaust capability shall be provided to override the sash sensor and command maximum exhaust airflow. A push to start, push to stop, and pushbutton switch shall initiate this mode.
4. A night energy waste alert circuit employing a light level sensor shall be included in the monitor to sense the combination of a darkened laboratory room and a fume hood that has its sash left up.
5. Fume hood monitor shall include and LED display or numerical velocity display] to indicate a relative measure of hood face velocity, visual indication for normal operation, visual and audible alarm for an unsafe alert and visual and audible alarm to indicate emergency exhaust operation. Equal to the [FHM 310 model for analogue display of energy use or FHM-610 model for numerical LED display of [face velocity].
6. A push-button switch shall be provided to mute the audible alarm. The mute mode is automatically reset when the alarm condition ceases.

H. Zone Presence Sensor

1. A zone Presence Sensor shall be provided to detect the motion and presence of an operator or inanimate object (e.g., gas cylinder) and index the fume hood control system from a normal operating face velocity (e.g., .51 m/sec) to a standby face velocity (e.g., .30 m/sec) and vice versa. The sensor location shall be located in the front top of the hood according to Manufacturer's instructions.
2. The sensor shall have optics to define a detection zone of 610 mm directly in front of the fume hood, and within six inches of the width of the fume hood. For fume hoods over 1.83 meters wide, multiple sensors shall be provided. If the sensor sees no motion and presence in its detection zone, it shall index the fume hood control system to the user adjustable standby face velocity. When the sensor sees motion and presence, it shall index the fume hood control system to the normal face velocity in less than one second upon detection of an

operator in its zone. The fume hood monitor shall visually alert the operator as to whether the fume hood is in normal or standby mode by means of an LED display.

3. The Zone Presence Sensor shall have a control circuit that adapts to its specific surroundings and automatically adjusts for inanimate objects placed within its detection zone. It shall adaptively map the area into memory and, after a period of time, nullify the inanimate object and to return to a standby mode. Operators shall enter and leave the zone with the unit automatically adjusting between normal and standby mode. If the inanimate object is moved or taken out of the zone the unit shall automatically re-map the area within a 5 minute period.
4. The Zone Presence Sensor shall mount on any style or type of fume hood and require no special tools. Field calibration shall not be required.
5. Traditional area motion or presence detectors are totally unacceptable, unit shall be by a single manufacture provided as an integrated part of the laboratory system.

I. Airflow Control Device - General

1. The airflow control device shall be a venture valve equal to the Phoenix Controls Accell II model.
2. The airflow control device shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a man folded system.
3. The airflow control device shall maintain accuracy within ±5% of signal over an airflow turndown range of no less than 16 to 1.
4. Minimum entrance or exit duct diameters shall be required to ensure accuracy and / or pressure independence.
5. The airflow control device shall be constructed of one of the following three types:
   a. Class A-The airflow control device for non-corrosive airstreams such as room/lab supply and general exhaust shall be constructed of 16 gauge aluminum. The device’s shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be spring-grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, or polyester, or PPS (polyphenylene sulphide) composite.
   b. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. Refer to project schedule for compliance of external sound attenuator devices.
   c. Class B-The airflow control device for corrosive airstreams such as fume hoods and bio-safety cabinets shall have baked-on corrosion resistant phenolic coating. The device’s shaft shall be

made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of Teflon or PPS (polyphenylene sulphide) composite.

   d. Class C-The airflow control device for highly corrosive airstreams shall be constructed as defined in Paragraph D.2 and, in addition, shall have no exposed aluminum or stainless steel components. Shaft support brackets, pivot arm, integral mounting link, and pressure independent springs shall have a baked on corrosion resistant phenolic coating in addition to the materials defined in paragraph D.2. The internal nuts, bolts, and rivets shall be titanium or phenolic coated stainless steel. Only devices clearly defined as “High Corrosion Resistant” on project drawings will require this construction.

6. The controller for the airflow control devices shall be microprocessor based and operate using a peer-to-peer control architecture. The room level airflow control devices shall function as a standalone network.
7. The room level control network shall utilize a BAC net or any universal protocol that can communicate with all the automation systems in the Building.
8. There shall be no reliance on external or building level control devices to perform room level control functions. Each laboratory control system shall have the capability of performing; fume hood control, pressurization control, temperature control, humidity control, and implement occupancy and emergency mode control schemes.
9. The laboratory airflow control systems shall have the option of digital integration with the BMS.
10. Pneumatically-actuated two positions or VAV operation, a pneumatic actuator shall be factory mounted on the valve. Loss of pneumatic main air or control power shall cause normally open valves to fail to maximum position, and normally closed valves to fail to minimum position.
11. Certification
    a. Each airflow control valve shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of at least +1% of signal over the entire range of measurement.
    b. All airflow valves shall be individually marked with valve specific, factory calibration data. As a minimum, it should include: valve tag number, serial number, model number, eight point valve characterization information (electronic valves), and quality control inspection numbers. All information shall be stored on computer diskette in ASCII format for future retrieval or for hard copy printout to be included with as-built documentation.

J. Exhaust and Supply Airflow Control Device with Peer to Peer Architecture
    1. The airflow control device shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feed-back signal that represents its airflow.
    2. The airflow control device shall store its control algorithms in non-volatile, rewritable memory. The device shall be able to stand alone or be able to network with other room level digital airflow control devices over a 375k baud network.
    3. The airflow control device shall use industry standard 24 vac power with required step down transformers.
        a. The airflow control device shall have a local EIA-232 port for connection to a notebook PC commissioning tool.
        b. The airflow control device shall accommodate a universal point expansion module to address fume hood control, temperature control, and non-network sensors.
        c. The airflow control device shall meet FCC Part 15 Subpart J Class A, and be UL916 listed.

K. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic Colour graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

L. Clean Space Shielded Static Pressure Sensors
    1. Static pressure sensors serving the Advanced Fabrication laboratory shall be suitable for recessed or surface mount. Sensors shall have multiple sensing ports, pressure impulse suppression chamber and airflow shielding with 3mm (nom) connection.
    2. Materials of Construction: 316 Stainless Steel
    3. Probes shall be capable of sensing static pressure within 1% of actual pressure value while being subjected to a maximum 0.5m/s airflow velocity from a 360 degree source.
    4. Shielded static pressure sensors shall be as manufactured by Air Monitor, Model: S.A.P. /R or approved equal.

M. Clean Space Particle Counter
    1. Furnish and provide particle sensor/transmitter for each clean space within the Advanced Fabrication Suite as follows.
        a. Enclosure: Stainless Steel.
        b. Minimum Sensitivity: 0.5micro-m.
        c. Output Signal: 4-20ma, scale to particulate count/concentration.
        d. Vacuum Pump: Integral and sized for associated operation of equipment.
        e. Particle Counters shall be as manufactured by Clemet, Model CI-3100 or approved equal.

PART 3 - EXECUTION

3.1. EXAMINATION

A. Verify that standby power supply is available to control units and operator workstation.
B. Verify that pneumatic piping and duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2. INSTALLATION

A. Install software in control units. Implement all features of programs to specified requirements and as appropriate to sequence of operation.
B. Connect and configure equipment and software to achieve sequence of operation specified.
C. Verify location of thermostats, humidistats, and other exposed control sensors with drawings and room details before installation. Install devices at mounting heights in accordance with Americans with Disabilities Act (ADA), or as otherwise directed by the Architect.
D. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."
E. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling."

3.3. PNEUMATIC PIPING INSTALLATION

A. Install piping in mechanical equipment rooms inside mechanical equipment enclosures, in pipe chases, or suspended ceilings with easy access.
  1. Install copper tubing with maximum unsupported length of 915 mm, for tubing exposed to view.
  2. Install polyethylene tubing in metallic raceways or electrical metallic tubing. Electrical metallic tubing materials and installation requirements are specified in Division 26 Section "Raceway and Boxes for Electrical Systems."
B. Install terminal single-line connections, less than 460 mm in length, with copper or polyethylene tubing run inside flexible steel protection.
C. In concealed locations such as pipe chases and suspended ceilings with easy access, install copper, polyethylene bundled and sheathed, or polyethylene tubing in electrical metallic tubing. Electrical metallic tubing materials and installation requirements are specified in Division 26 Section "Raceway and Boxes for Electrical Systems."
D. In concrete slabs, furred walls, or ceilings with no access, install copper or polyethylene tubing in electrical metallic tubing or vinyl-jacketed polyethylene tubing.
  1. Protect embedded-copper and vinyl-jacketed polyethylene tubing with electrical metallic tubing extending 150 mm above finished slab and 150 mm into slab. Pressure test tubing before and after pour for leak and pinch.
  2. Install polyethylene tubing in electrical metallic tubing extending 150 mm above floor line; pull tubing into electrical metallic tubing after pour.
E. Install tubing with sufficient slack and flexible connections to allow for vibration of piping and equipment.
F. Purge tubing with dry, oil-free compressed air before connecting control instruments.
  1. Bridge cabinets and doors with flexible connections fastened along hinge side; protect against abrasion. Tie and support tubing.

G. Number-code or color-coded control air piping for future identification and service of control system, except local individual room control tubing.
H. Pressure Gages or Test Plugs: Install on branch lines at each receiver controller and on signal lines at each transmitter, except individual room controllers.

3.4. ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems." 24V control transformers are to be provided by the supplier.
B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
C. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."
    1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
    2. Install exposed cable in EMT raceway.
    3. Install concealed cable in EMT raceway.
    4. Bundle and harness multi conductor instrument cable in place of single cables where several cables follow a common path.
    5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
    6. Number-code or color-coded conductors for future identification and service of control system, except local individual room control cables.
    7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
F. Electrical Wiring: Wiring and connections required for temperature control system shall be provided under this Section, unless shown otherwise on Drawings, and shall comply with applicable requirements of Division 26, Electrical. Necessary normal and emergency power wiring to control devices shall be provided under this section. Electrical circuits for all controls shall be dedicated only to the control system. Wiring from the including dedicated circuit breakers to the point of use shall be a part of the work.

3.5. FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
B. Perform the following field tests and inspections and prepare test reports:
    1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest
    2. Test and adjust controls and safeties.
    3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

4. Pressure test control air piping at 207 kPa or 1.5 times the operating pressure for 24 hours, with maximum 35-kPa loss.
5. Test calibration of pneumatic and electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
6. Test each point through its full operating range to verify that safety and operating control set points are as required.
7. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
8. Test each system for compliance with sequence of operation.
9. Test software and hardware interlocks.

C. DDC Verification:
1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check DDC system as follows:
    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.6. ADJUSTING

A. Calibrating and Adjusting:
1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analogue instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

4. Control System Inputs and Outputs:
    a. Check analogue inputs at 0, 50, and 100 percent of span.
    b. Check analogue outputs using mill ampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating start up procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.7. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain laboratory instrumentation and controls.

B. Refer to Division 01 Section "Demonstration and Training."

3.8. COMMISSIONING

A. As per Division 23 requires the engagement of a Commissioning Agent to document the completion of the mechanical, electrical, plumbing, fire protection, and laboratory control system for the project. Division 23 defines the roles of each member of the Commissioning Team. Comply with the requirements of Division 23 for the commissioning of the various building systems and the laboratory control system.

B. Laboratory Control System Contractor Commissioning Responsibilities
   1. Completely install and thoroughly inspect start up, test, adjust, calibrate and document systems and equipment for Laboratory Control System.
   2. Provide laptop computer, software and training to accommodate TAB Contractor in system balancing.
   3. Maintain database of control parameters submitted by TAB Contractor subsequent to field adjustments and measurements.
   4. Provide control systems start up schedule and coordinate with CxPM so that CxA may witness the control system point-to-point "check-out" and document completion. Provide on-site technician skilled in software programming and hardware operation to demonstrate control system point-to-point "check-out" tests to CxA.
   5. Provide on-site technician skilled in software programming and hardware operation to exercise sequences of operation and to correct control deficiencies identified during functional performance testing including opposed season/deferred testing.
   6. Provide, for use during commissioning, instrumentation, computer, software and communication resources necessary to demonstrate total operation of building systems during point-to-point "check-out", functional performance testing, and opposed season testing of control system equipment.
   7. Attend commissioning kick-off meeting and other commissioning team meetings.
   8. Attend Owner training kick-off meeting conducted by CxA.
   9. Prepare training plans with CxPM and execute training as specified in Division 23 and 25 of these specifications. Attend Owner training kick-off meeting and other coordination meetings as required to complete training plans.
   10. Maintain comprehensive system calibration and checkout records. Submit records to CxA.
   11. Set up trend logs as required by CxA to substantiate proper systems operation.
   12. Participate in two warranty review meetings with the Owner and O&M staff to review the commissioning systems performance 3 months and 10 months into the warranty period.

END OF SECTION 25 60 00