

THE UNIVERSITY OF TEXAS

MD Anderson ~~Cancer~~ Center

MD ANDERSON STAIR PRESSURIZATION
Project #17-0228

THE UNIVERSITY OF TEXAS
MD ANDERSON CANCER CENTER
1515 HOLCOMBE BLVD.
HOUSTON, TX 77030



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**Issued for Construction
PROJECT MANUAL**



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SECTION 20 05 13 – MOTORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install high efficiency single- and three-phase electric motors required for equipment supplied under this division of Work as indicated by the Contract Documents, with supplementary items necessary for proper installation. Refer to Electrical Drawings for motor starter sizes. Disconnect switches to be furnished in Division 26.
- B. The Fire Suppression, Plumbing and HVAC Subcontractor shall furnish starters for Fire Suppression, Plumbing and HVAC Work. Motor starters shall be provided in accordance with Division 26 Specifications. Some motors furnished in mechanical equipment rooms shall have starters furnished and installed as part of Division 26 (as per Specification Section 26 29 14, Motor Starters). Coordinate with Division 26.
- C. Motors rated at less than 190 Watts and intended for intermittent operation need not conform to these Specifications.
- D. ECM (Electronically Commutated Motor) motors on terminal units, fan-coil units, and computer room air conditioning units are except from specification requirements that can not apply due to different electrical design characteristics.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and Workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings.
 - 2. AFBMA 11 – Load Ratings and Fatigue Life for Roller Bearings.
 - 3. EISA - The Energy Independence & Securities Act 2007.
 - 4. ANSI/EEE 112 – Test Procedure for Polyphase Induction Motors and Generators.

5. ANSI/NEMA/ MG 1 – Motors and Generators Part 31.
6. NFPA 70 – National Electrical Code.
7. ANSI C19 – Industrial Control Apparatus.
8. NEMA ICS – Industrial Control and Systems.
9. NEMA RV 3 - Application and Installation Guidelines for Flexible and Liquidtight Flexible Metal and Nonmetallic Conduits
10. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
11. NEMA FB 2.20 - Selection and Installation Guidelines For Fittings for Use With Flexible Electrical Conduit and Cable
12. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
13. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports
14. NEMA OS 3 - Selection and Installation Guidelines for Electrical Outlet Boxes
15. UL 508 – Industrial Control Equipment.
16. ANSI/IEEE 117 – Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random Wound AC Electric Machinery.
17. ANSI/NEMA MG 2 – Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors.
18. ANSI/UL 674 – Electric Motors and Generators for Use in Hazardous (Classified) Locations.
19. ANSI/UL 1004 – Electric Motors.

1.04 QUALITY ASSURANCE

- A. Motors associated with variable frequency drives (VFD) shall be inverter-duty rated, and provided with grounded shaft or ceramic bearings to insulate shaft, and Class F 105 degrees C rise insulation. Ref. NEMA MG1 Part 31.
- B. Conform to NFPA 70.

1.05 SUBMITTALS

- A. All motors provided by the Contractor shall be of the same manufacturer unless they are an integral part of the piece of equipment to which they are attached.
- B. Product Data: Provide the following information for each motor:
 1. Manufacturer.
 2. Rated full load horsepower.

3. Rated volts.
 4. Number of Phases.
 5. Insulation Class.
 6. Frequency in Hertz.
 7. Full load amperes (FLA).
 8. Locked rotor amperes (LRA) at rated voltage or NEMA code letter.
 9. Nominal speed at full load (rpm).
 10. Service factor.
 11. NEMA design letter.
 12. NEMA machine type (ODP, WP-I, TEFC, etc.).
- C. For motors one horsepower and larger, include the following additional information:
1. NEMA frame size.
 2. NEMA insulation system classification. For motors required to be installed outdoors, include information showing compliance for outdoor application.
 3. Maximum ambient temperature for which motor is designed.
 4. Time rating.
 5. Bearing size and type data.
 6. Guaranteed efficiency and power factor at full load, 75% load, 50% load, 25% load and 0% load.
- D. For motors 20 horsepower and larger, include the following additional information:
1. No load amperes.
 2. Safe stall time.
 3. Guaranteed efficiency and power factor at full load, 75% load, 50% load, 25% load and 0% load.
 4. Motor manufacturer's recommended maximum power factor correction capacitor (kvar) that can safely be switched with the motor.
 5. Expected value of corrected power factor at no load, 50 percent, 75 percent and full load.
 6. Full load amperes with corrected power factor.
 7. Maximum guaranteed slip at full load.
- E. Operation and Maintenance Data:

1. Submit operation and maintenance data including assembly Drawings, bearing data including replacement sizes, and lubrication instructions.

F. Alternate Motors:

1. If a motor horsepower rating larger than indicated is offered as a substitute and accepted, provide required changes in size of conductors, conduits, motor controllers, overload relays, fuses, circuit breakers, switches and other related items at no change in the Contract price.

1.06 WARRANTY

- A. Provide minimum one-year manufacturer's warranty including coverage for motors one horsepower and larger.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Electrical Service: Refer to Drawing schedules for required electrical characteristics.
- C. Design for continuous operation in 40 degrees C environment and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, Service Factor and motor enclosure type.
 1. Totally Enclosed Motors: Design for a service factor of 1.00 and an 80 degrees C maximum temperature rise in the same conditions.
 2. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.
- D. Visible Stainless Steel Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency.
- E. Electrical Connection: Provide adequately sized metal electrical connection box for conduit connection. For fractional horsepower motors where connection is made directly, provide metal electrical box for conduit connection.
- F. Motors shall be built in accordance with the latest ANSI, IEEE and NEMA Standards and shall be fully coordinated with the equipment served, shall be of sizes and electrical characteristics scheduled and of approved manufacturer as listed below or of the same manufacturer as the equipment which they serve. Nameplate rating of motors shall match the characteristics scheduled.
- G. All motors shall be designed for normal starting torque unless the driven machine requires high starting torque and shall be selected for quiet operation, free from magnetic hum.

- H. All motors shall be provided with adequately sized electrical connection box for attachment of flexible conduit. Paragraph 1.03 of this specification refers to the NEMA standards and publications relevant to applications and use of both metal and liquid tight flexible conduit. When motors are connected to driven equipment by the use of a V-belt drive, they shall be furnished with adjustable rails.
- I. All air handling unit motor(s) with single and fan array arrangements, exhaust fan motors, chilled and hot water pump motors shall be compatible with variable frequency drive controllers. Equipment manufacturer shall coordinate with VFD manufacturer to ensure compatibility. Characteristics of motors furnished on equipment shall be furnished to VFD manufacturer for review, prior to installing motor on equipment. VFD's shall be furnished with driven equipment and shall be run tested as an equipment unit at factory prior to shipment. Submit run test report prior to shipping. F.O.B. of motors to factory shall be by the equipment manufacturer.
- J. Motors shall be open drip-proof type, except where specified or noted otherwise on the construction drawing.
- K. Motors $\frac{1}{4}$ to $\frac{3}{4}$ hp shall be Subtype II and meet the minimum requirements of EPA92 for minimum NEMA nominal efficiency motors.
- L. Motors 1 to 200 hp shall be Subtype I and meet the minimum requirements of NEMA Table 12-12 for NEMA premium efficiency motors.

2.02 MANUFACTURERS

- A. Manufacturer: Company specializing in the manufacture of electric motors for HVAC and plumbing equipment use, and their accessories, with minimum three (3) years documented product development, testing and manufacturing experience.
 - 1. Baldor - Super E – NEMA Premium Efficiency.
 - 2. Marathon - NEMA Premium Efficiency.
 - 3. Siemens – NEMA Premium Efficiency U.S. Electrical – NEMA Premium Efficiency.

2.03 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- A. Starting Torque: Less than 150 percent of full load torque.
- B. Starting Current: Up to seven times full load current.
- C. Breakdown Torque: Approximately 200 percent of full load torque.
- D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
- E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

- F. Single phase motors, shall be less than 3/4 horsepower and shall be permanent split phase, capacitor start, induction run, 120 volt, 60 hertz motors with dripproof enclosures except as hereinafter specified. These motors shall have built-in thermal overload protection and shall be rated for temperature rise as hereinbefore specified for 3-phase motors.

2.04 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

- A. Starting Torque: Exceeding one fourth of full load torque.
- B. Starting Current: Up to six times full load current.
- C. Multiple Speed: Through tapped windings.
- D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum Service Factor as specified herein, prelubricated sleeve or ball bearings, automatic reset overload protector.
- E. Single phase motors shall be less than 3/4 horsepower and shall be permanent split phase, capacitor start, induction run, 120 volt, 60 hertz motors. These motors shall have built-in thermal overload protection with automatic reset and shall be rated for temperature rise as hereinbefore specified for 3-phase motors.

2.05 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A. Starting Torque: Three times full load torque.
- B. Starting Current: Less than five times full load current.
- C. Pull-up Torque: Up to 350 percent of full load torque.
- D. Breakdown Torque: Approximately 250 percent of full load torque.
- E. Motors: Capacitor in series with starting winding; capacitor-start/capacitor-run motors shall have two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- F. Enclosures shall be of the open dripproof type with a service factor as specified herein and Class B insulation rated at 90 degrees C temperature rise measured above 40 degrees C room ambient condition at full load, unless otherwise noted.
- G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.
- H. Single phase motors, in general, shall be less than 3/4 horsepower and shall be permanent split phase, capacitor start, induction run, 120 volt, 60 hertz motors. These motors shall have built-in thermal overload protection and shall be rated for temperature rise as hereinbefore specified for 3-phase motors.

2.06 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Enclosures shall be of the open drip proof type with a service factor as specified herein and Class B insulation rated at 90 degrees C temperature rise measured above 40 degrees C room ambient condition at full load, unless otherwise noted.

- B. All motors 3/4 horsepower and larger, unless smaller motors are indicated to be supplied as 3-phase, shall be 3-phase and shall be squirrel cage high efficiency induction type with standard NEMA frame sizes.
- C. Three phase motors not connected to variable frequency drives are to be protected for phase loss and phase unbalance protection.
- D. Motors 1 HP and larger shall have integral frames.
- E. Starting Torque: Between one and one and one-half times full load torque.
- F. Starting Current: Six times full load current.
- G. Power Output, Locked Rotor Torque, Breakdown or Pullout Torque: NEMA Design B characteristics.
- H. Design, Construction, Testing and Performance: Conform to ANSI/NEMA MG 1 for Design B motors.
- I. Insulation System: NEMA Class B or better.
- J. Testing Procedure: In accordance with ANSI/IEEE 112, Test Method B. Load test motors to determine freedom from electrical or mechanical defects and compliance with performance data.
- K. Motor Frames: NEMA standard T-frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- L. Bearings:
 - 1. Ball or roller type, double shielded with continuous grease relief to accommodate excessive pressure caused by thermal expansion or over lubrication.
 - 2. All motor bearings shall be factory prepacked with a nondetergent lubricant and shall be provided with lubrication fitting arranged to provide easy access when installed on the driven apparatus except as noted hereinafter.
 - 3. Permanently lubricated factory-sealed motors may be provided in fractional horsepower sizes only where they are an integral part of a piece of approved apparatus.
 - 4. All bearings shall be designed for L-10, 40,000 hour minimum life hours of continuous service. Calculate bearing load with NEMA minimum V-belt pulley with belt centerline at end of NEMA standard shaft extension. Direct driven fans may require specific bearings other than ball type, verify equipment specification where motor may be used where bearing life requirement may exceed L-10 rating. Stamp bearing sizes on nameplate.
- M. Sound Power Levels: Refer to ANSI/NEMA MG 1.
- N. Part Winding Start (Where Indicated): Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel. Bearings shall be double shielded with waterproof non-washing grease.

- O. Nominal Efficiency and Power Factor: Meet or exceed values as scheduled at load and rated voltage when tested in accordance with ANSI/IEEE 112.
- P. Motors one horsepower and larger shall be provided with a copper frame grounding lug of hydraulic compression design, for installation by the electrical subcontractor.

2.07 STARTING EQUIPMENT

- A. Each motor shall be provided with proper starting equipment. Starting equipment shall be furnished by this Division.
- B. Relays and equipment supplied by this Contractor shall be integral with electrical equipment supplied.

2.08 RATING

- A. Speed and Size: Speed and approximate horsepower ratings are specified in equipment Specification Sections or are indicated on the Drawings. Furnish motors sufficiently sized for the particular application and with full-load rating not less than required by the driven equipment at specified capacity. Size motors so as not to overload at any point throughout the normal operating range.
- B. Voltage:
 - 1. Single phase: 115 volts for 120-volt nominal system voltage.
 - 2. Three phase: 200 volts for 208-volt nominal system voltage.
 - 3. Three phase: 230 volts for 240-volt nominal system voltage.
 - 4. Three phase: 230/460 volts for 240/480-volt nominal system voltage.
 - 5. Three phase: 460 volts for 480-volt nominal system voltage.
- C. Frequency: 60 Hertz.
- D. Efficiency: Provide energy-efficient motors meeting the requirements of NEMA MG1-12.55A, Table 12Y and MG 1.41.3. Efficiency to be determined by testing in accordance with NEMA MG 112.53 using IEEE 112A – Method B.
- E. Service Factor: According to NEMA MG 1-12.47 but not less than those indicated per the Table below.
- F. Table: NEMA Open Motor Service Factors:

<u>Horsepower</u>	<u>3600 RPM</u>	<u>1800 RPM</u>	<u>1200 RPM</u>	<u>900 RPM</u>
1/6 – 1/3	1.35	1.35	1.35	1.35
1/2	1.25	1.25	1.25	1.15
3/4	1.25	1.25	1.15	1.15
1	1.25	1.15	1.15	1.15
1.5-150 and above	1.15	1.15	1.15	1.15
150				

Horsepower 3600 RPM 1800 RPM 1200 RPM 900 RPM

PART 3 - EXECUTION

3.01 APPLICATION

- A. Single-phase motors for shaft mounted fans shall be split phase type.
- B. Single-phase motors for shaft mounted fans or blowers shall be permanent split capacitor type.
- C. Single-phase motors for fans shall be capacitor start, capacitor run type.
- D. Motors located in exterior locations and in direct drive axial fans, roll filters, humidifiers and draw-through air units shall be totally enclosed weatherproof epoxy-sealed type.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Properly install and align motors after installation on the driven equipment.
- D. Motor feeders shall be free of splices. In special cases when splice-free feeders are impractical, splices may be allowed given prior written approval from the Owner.
- E. Use crimp-on, solderless copper terminals on the branch circuit conductors. For motors 20 horsepower and larger, use 5300 Series 3M motor lead splicing kit or approved equal.
- F. When the motor and equipment are installed, the motor's nameplate must be in full view.

3.03 TESTING

- A. General: Provide all necessary instruments, labor and personnel required to perform motor inspection and testing.
- B. Inspection: Inspect all motors for damage, moisture absorption, alignment, freedom of rotation, proper lubrication, oil leaks, phase and rotation and cleanliness, and report any abnormalities to Owner before energizing.
- C. Tests: Motor full load current and full load voltage shall be measured. Motor phase loss and phase unbalance protection shall be tested. Motor Test Report forms included at the end of this Section shall be completed and submitted prior to Substantial Completion.
- D. Energizing: After installation has been thoroughly checked and found to be in proper condition, with thermal overloads in motor controllers properly sized and all controls in place, energize the equipment at system voltage for operational testing.
- E. Motor Test Report Form:

DATE _____

SHEET ___ OF _____

PROJECT NAME _____

PROJECT NO. _____

MOTOR DESIGNATION _____, LOCATION _____

HP _____, FLA _____, LOCATION _____

PHASE LOSS AND PHASE UNBALANCE PROTECTION _____

INSULATION CLASS _____

SERVED FROM PANEL/MCC _____

MEASURED CONDITIONS

TEMPERATURE: _____ degrees F

RELATIVE HUMIDITY: _____ %

CURRENT (AMPS): ØA _____, ØB _____, ØC _____

VOLTAGE (VOLTS): ØB _____, ØBC _____, ØCA _____

ØAN _____, ØBN _____, ØCN _____

END OF SECTION 20 05 13

SECTION 23 05 13 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install a complete variable frequency motor drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor.
- B. The drive manufacturer shall supply the drive and all necessary controls as specified.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. Standard 519, IEEE Guide for Harmonic Content and Control.
 - 2. ANSI/UL Standard UL508C, Underwriter's Laboratories.
 - 3. ICS 7.0, AC Adjustable Speed Drives, National Electrical Manufacturer's Association (NEMA).
 - 4. IEC 16800 Parts 1 and 2.

1.04 QUALITY ASSURANCE

- A. Company specializing in manufacturing the products specified in this Section with minimum three (3) years experience.
- B. VFD and options shall be UL listed as a complete assembly. VFD's that require the customer to supply external fuses are not acceptable.
- C. VFD and options shall be tested to ANSI/UL Standard 508 and listed by a nationally recognized testing agency such as UL or ETL.

- D. VFD and options shall comply with applicable requirements of the latest Standards of ANSI/UL, IEEE, and the NEC.

1.05 SUBMITTALS

A. Product Data:

1. Submit product data for components and accessories.
2. All VFD's for this Project shall be supplied by one manufacturer.
3. Submit Shop Drawings indicating outline dimensions, enclosure construction, lifting and supporting points, electrical one-line diagram, equipment electrical ratings, noise levels (including driven equipment) and total harmonic distortion (voltage and current).
4. Manufacturer shall provide terminal block to terminal block wiring diagrams coordinated with the Owner to provide a complete and functional operating system. Furnish detailed Drawings showing construction, dimensions, wiring diagrams, and installation procedures for Engineer's approval.

B. Operation and Maintenance Data:

1. Submit manufacturer's written installation instructions.
2. Submit training outline.
3. Furnish harmonic analysis verifying compliance with specified distortion levels.
4. Furnish a list of recommended spare parts.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to the Project Site under provisions of Division 01 and Division 20.
- B. Accept products on Site in factory-fabricated protective container with factory installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures and finish.

1.07 EXTRA MATERIALS

- A. Refer to Section 01 78 46 for Maintenance Material Requirements.

1.08 WARRANTY

- A. VFD shall be unconditionally warranted by the manufacturer for two (2) years from the date of Substantial Completion, not to exceed 30 months from date of shipment.
- B. Warranty shall include all parts, labor, shipping, field service or technician time, labor or travel expenses, and verbal or written correspondence with the VFD manufacturer or VFD manufacturer's representatives. Include correspondence which might be incidental to the proper installation and operation of the equipment.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Furnish complete VFD controllers that convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor derating.
- C. Contractor shall check equipment schedules on the Contract Drawings to determine if the VFD "bypass" switch option is required to allow the motor to run if the controller malfunctions. If the "bypass" switch option is not required, articles and statements in this section do not apply, and the Contractor shall provide one spare VFD for each equivalent horsepower motor or equipment power load indicated on the Contract Drawings.
- D. VFD manufacturer shall verify compatibility of motor furnished on equipment. One controller shall control the speed of one motor with the exception being a wall fan technology system.
- E. VFD shall convert 3 phase, 60 Hz utility power to adjustable voltage and frequency, 3 phase AC power for stepless motor speed control from 10 percent to 100 percent of the motor's 60 Hz speed. Input voltage characteristics are 480 volts, 3 phase, 60 Hz.
- F. VFD shall include a converter section. The converter section shall convert fixed frequency and voltage AC utility power to a variable DC voltage. VFD's that use silicon controlled rectifiers in the converter bridge shall also include 5 percent reactors. Isolation transformers are not acceptable in lieu of line reactors.
- G. VFD shall include an inverter section. The inverter section shall invert the variable DC voltage into a PWM wave form; adjustable voltage and frequency output for stepless motor speed control.
- H. Individual or simultaneous operation of VFD's shall not add more than 5 percent total harmonic voltage distortion and no more than 5 percent total harmonic current distortion (per IEEE 516-1992) to the normal bus.
 - 1. VFD manufacturer shall perform harmonic analysis based on the electrical one-line diagram.
 - 2. The VFD manufacturer shall provide calculations specific to this installation, showing total harmonic voltage distortion is less than 5 percent.
 - 3. Input line filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE Standard 519. All VFD's shall include a minimum of 5 percent impedance reactors, no exceptions.
- I. VFD shall include a coordinated AC transient protection system consisting of 4-120 joule rated MOV's (phase to phase and phase to ground), a capacitor clamp, and 5 percent impedance reactors.

J. Alternate Harmonics Specification:

1. Input line reactors and DC Bus filtered chokes (factory installed and wired in the drive enclosure) shall be provided to allow reliable operation on a typical commercial power distribution system and to minimize harmonics reflected onto the input line.
 - a. Shall not interfere with computer and other electronic systems in the building.
 - b. If not inherently protected, provide a suitable isolation transformer.
 - c. The system shall not produce spikes on the incoming line.
2. Any inverter that generates sufficient electrical line noise to interfere with operation of sensitive building equipment shall be field modified or replaced by the inverter supplier at no additional cost to the Owner.

K. EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product Standard EN 61800-3 for the First Environment restricted level.

L. Low voltage logic and 115V control circuits shall be electrically isolated from the power circuits. Signal circuit common shall be grounded.

M. VFD shall include a power ride-through feature to allow continuous operation up to a three-cycle line loss.

N. Two independently adjustable accel and decel ramps with 1 to 1800 seconds adjustable time ramps. Extended time periods are also acceptable.

O. VFD shall have full function output current limit adjustable from 10 to 100 percent. At the factory with compatible motor, provide at least three lock-out ranges (50 rpm maximum each), two of which can be used to correct any run test problems.

P. Components shall be pretested and complete VFD shall have full burn-in under full load for a minimum of 12 hours. Provide at least three lockout ranges (50 rpm maximum), two of which can be used to correct run test problems.

Q. Ambient noise generated by the VFD shall be limited to an amount equal to the system noise level as designated by the latest ASHRAE noise level guidelines for such equipment at each octave band. Noise level criteria at different octave bands and mid-frequencies shall be furnished with the submittal data.

R. VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.

2.02 MANUFACTURERS

- A. Danfoss Graham.
- B. ABB.
- C. Yaskawa Electric.

2.03 ENCLOSURE

- A. VFD shall be enclosed in a UL Listed Type 12 enclosure. Enclosure shall be UL listed as a plenum rated VFD. The VFD tolerated voltage window shall allow operation from a line of +30 percent nominal, and -35 percent nominal voltage as a minimum.
- B. Environmental operating conditions: 0 to 40 degrees C continuous. VFD's that can operate at 40 degrees C intermittently (during a 24-hour period) are not acceptable and must be oversized. Altitude from 0 to 3300 feet above sea level, less than 95 percent humidity, non-condensing. VFD's without these ratings are not acceptable.
- C. The following operator controls shall be located on the front of the enclosure:
 1. Bypass Hand-Off-Auto.
 2. Drive mode selector.
 3. Bypass mode selector.
 4. Bypass fault reset.
 5. Provide the following indicating lights (LED type). In addition, provide test mode or push to test feature:
 - a. Power-on (ready).
 - b. Run enable (safeties) open.
 - c. Drive mode select damper opening.
 - d. Bypass mode selected.
 - e. Drive running.
 - f. Bypass running.
 - g. Drive fault.
 - h. Bypass fault.
 - i. Bypass H-O-A mode.
 - j. Automatic transfer to bypass selected.
 - k. Safety open.
 - l. Damper opening.
 - m. Damper end-switch made.
 6. Provide the following relay (form C) outputs from the bypass:
 - a. System started.

- b. System running.
 - c. Bypass overttide enabled.
 - d. Drive Fault.
 - e. Bypass fault (motor overload or underload-broken belt).
 - f. Bypass H-O-A position.
- D. Digital inputs for the system shall accept 24V or 115VAC (selectable).
- E. Customer Interlock Terminal Strip: Provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in Hand, Auto, or Bypass modes (not functional in fireman's override 2). The remote start/stop contact shall operate in VFD mode.
- F. Dedicated digital input that will transfer motor from VFD mode to bypass mode upon dry contact closure for fireman's override. Two modes of operation are required:
- 1. The first mode forces the motor to bypass operation and overrides both the VFD and bypass H-O-A switches and forces the motor to operate across the line (test mode). The system will only respond to the digital inputs and motor protections.
 - 2. The second mode operates as the first, but will also defeat the overload and singe-phase protection for bypass and ignore all keypad and digital inputs t the system 9run until destruction).
- G. Include a "run permissive circuit" that will provide a normally open contact whenever a run command is provided (local or remote start command in VFD or bypass mode). The VFD system (VFD or bypass) shall not operate the motor until it receives a dry contact closure from a damper or valve end-switch. When the VFD system safety interlock (fire detector, freezestat, high static pressure switch, etc) opens, the motor shall coast to a stop and the run permissive contact shall open, closing the damper or valve.
- H. Include Class 20 or 30 (selectable) electronic motor overload protection.

2.04 BYPASS

- A. Furnish where indicated on the Drawings, a complete factory wired and tested bypass system consisting of an output contactor and bypass contactor. Overload protection shall be provided in both drive and bypass modes.
- B. Bypass to be furnished, built, and mounted by the VFD manufacturer.
- C. Provide an internal switch to select manual or automatic bypass.
- D. Provide an adjustable current sensing circuit for the bypass to provide loss of load indication (broken belt) when in the bypass mode.
- E. Door interlocked, padlockable disconnect that will disconnect all input power from the drive and all internally mounted options.

- F. Fused VFD only disconnect (service switch). Fast acting fuses exclusive to the VFD – fast acting fuses allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection, maintaining bypass capability. Bypass designs, which have no such fuses, or that incorporate fuses common to both the VFD and the bypass will not be accepted. The following contactor bypass schemes are not acceptable.
 - 1. Door interlocked main input disconnect switch.
 - 2. Power on light.
 - 3. “Drive-off-bypass” manual mode selector switch.
- G. The bypass shall incorporate an internally sourced power supply and shall not require an external power source.

2.05 DISPLAY / KEYPAD

- A. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three (3) operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):
 - 1. Output frequency.
 - 2. Motor speed (RPM, percent, or engineering units).
 - 3. Motor current.
 - 4. Calculated motor torque.
 - 5. Calculated motor power (kW).
 - 6. DC bus voltage.
 - 7. Output voltage.
- B. Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). The keypad shall use the following assistants:
 - 1. Start-up assistants.
 - 2. Parameter assistants.
 - 3. Maintenance assistant.
 - 4. Troubleshooting assistant.
- C. VFD shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. Keypad shall be removable, capable of remote mounting and shall allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFD's.

- D. Keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate “bumpless transfer” of speed reference when switching between “Hand” and “Auto” modes. There shall be fault reset and “Help” buttons on the keypad. The Help button shall include “on-line” assistance for programming and troubleshooting.
- E. Provide a built-in time clock with battery back-up in the VFD keypad. The time clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power up. The time clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock (when in the off mode) for a programmable time frame. There shall be four (4) separate, independent timer functions that have both weekday and weekend settings.

2.06 SERIAL COMMUNICATION

- A. VFD shall have the capability of communicating with the building automation system (BAS) via an RS-485 serial port.
- B. VFD shall be provided with protocol information specific to the selected BAS Provider and shall be pre-configured at the factory to provide automatic communications without the need for field programming.
- C. VFD shall continue to provide serial communications regardless of how inverter is being controlled (“manual” mode via keypad, “automatic” mode via BAS, or “stopped” mode via either keypad or automatic BAS start/stop signal).
- D. Serial communications capabilities shall include, but not be limited to:
 - 1. Run/stop control speed set adjustment.
 - 2. Proportional/integral or PID control adjustments.
 - 3. Current limit.
 - 4. Accel/decel time adjustments.
- E. VFD shall have the capability of allowing the BAS to monitor the following feedback signals:
 - 1. Process variable.
 - 2. Output speed/frequency.
 - 3. Current.
 - 4. Torque.
 - 5. Power (kW).
 - 6. Operating hours.
 - 7. Kilowatt hours (kWh).
 - 8. Relay outputs.

9. Diagnostic warning and fault information.

- F. VFD shall allow the BAS to control the drive's digital and analog outputs and monitor all drive digital and analog inputs via the serial interface.
- G. VFD shall be capable of providing the BAS with status signals for bypass operation and external safety trips via serial interface.

2.07 SYSTEM OPERATION

- A. Selector switch in the "off" position: controller run circuit shall be open and the system shall not operate.
- B. Selector switch in the "manual" position: motor speed shall be controlled by the manual speed potentiometer.
- C. Selector switch in the "auto" position: operation shall be via input 0 to 10 VDC or 4-20 mA signal with strategy output speed proportional to the input signal. If required into the controls strategy, VFD manufacturer shall furnish a pressure transducer mounted in the drive enclosure to convert a 3 to 15 psi pressure signal to a 0 to 10 VDC signal or 4-20 mA signal.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Verify that surfaces are ready to receive Work.
- B. Verify that field measurements are as shown on Shop Drawings and as instructed by manufacturer.
- C. Verify that required utilities are available, in the proper location, and ready for use.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Power wiring shall be completed by the Electrical Contractor in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.03 TESTING

- A. Manufacturer shall provide a factory trained technician to inspect, test and start-up the VFD and associated equipment and place the VFD into operation.
- B. A harmonic test verifying the distortion level shall be included as part of Start-up and forwarded to the Owner. Any additional equipment, installation and equipment floor space required to meet the distortion level as set forth in the Specification, shall be borne by the VFD manufacturer.

3.04 TRAINING

- A. Manufacturer shall provide for and present to the Owner, at no cost to the Owner, a training and troubleshooting course at the Owner's location. Provide one (1) hour orientation/start-up operation training for a minimum of two (2) people.

END OF SECTION 23 05 13

SECTION 23 05 48 – VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Open-spring isolators.
 - 2. Spring hangers.
 - 3. Snubbers.

1.02 SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
- C. Welding certificates.
- D. Field quality-control reports.

1.03 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.01 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.

- g. Vibration Isolation.
- h. Vibration Mountings & Controls, Inc.
- 2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
- 3. Size: Factory or field cut to match requirements of supported equipment.
- 4. Pad Material: Oil and water resistant with elastomeric properties.
- 5. Surface Pattern: Smooth pattern.
- 6. Infused nonwoven cotton or synthetic fibers.
- 7. Load-bearing metal plates adhered to pads.

2.02 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

- 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. Vibration Mountings & Controls, Inc.
- 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
- 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
- 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.03 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Ace Mountings Co., Inc.
2. California Dynamics Corporation.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.
5. Vibration Eliminator Co., Inc.
6. Vibration Isolation.
7. Vibration Mountings & Controls, Inc.
8. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
9. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
10. Minimum Additional Travel: 50 percent of the required deflection at rated load.
11. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
12. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
13. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
14. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
15. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.04 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Kinetics Noise Control, Inc.
 2. Mason Industries, Inc.
 3. Vibration Mountings & Controls, Inc.
- B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 3. Maximum 1/4-inch air gap, and minimum 1/4-inch thick resilient cushion.

PART 3 - EXECUTION

3.01 APPLICATIONS

- A. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static loads within specified loading limits.

3.02 VIBRATION CONTROL DEVICE INSTALLATION

- A. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- B. Equipment Restraints:
 1. Install snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- E. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- G. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.03 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
 - 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 - 5. Test to 90 percent of rated proof load of device.
 - 6. Measure isolator restraint clearance.
 - 7. Measure isolator deflection.
 - 8. Verify snubber minimum clearances.

- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.04 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.05 VIBRATION ISOLATION SCHEDULE

- A. Boilers – Elastomeric Isolation Pad, 0.15” deflection
- B. Fans Floor Mounted – Open Spring Isolators, 1-1/2” deflection.
- C. Fans (Suspended) – Spring Hangers, 1-1/2” deflection

END OF SECTION 23 05 48

**SECTION 23 05 90 – CONTRACTOR COORDINATION WITH TESTING, ADJUSTING, AND
BALANCING**

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to prepare the building HVAC systems for testing, adjusting, and balancing (TAB) Work indicated by the Contract Documents, including the following:
 - 1. Preparation of air systems for testing, adjusting and balancing.
 - 2. Providing materials and labor to assist TAB Firm in meeting testing, adjusting and balancing requirements.
- B. Testing, adjusting and balancing of the air systems and related ancillary equipment will be performed by a technically qualified TAB Firm. The preparation for and corrections necessary for the testing, adjusting and balancing of these systems, as described herein, are the responsibility of this Contractor.
- C. Make any changes or replacements to the sheaves, belts, dampers and valves required for correct balance as advised by the TAB Firm, at no additional cost to the Owner.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AABC: National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems.
 - 2. AABC: Testing and Balancing Procedures.
 - 3. ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.
 - 4. ANSI/ASHRAE Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

1.04 QUALITY ASSURANCE

- A. Provide and coordinate the services of qualified, responsible Subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including during the testing, adjusting and balancing period.
- B. In order that systems may be properly tested, adjusted, and balanced, the Contractor shall operate systems at Contractor's expense for the length of time necessary to properly verify the systems' completion and readiness for TAB.
- C. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. Allow adequate time for the testing and balancing activities during the construction period and prior to Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL

- A. None used.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Contractor shall be responsible to prepare the stair pressurization systems ready for TAB when scheduled.
- B. Operational readiness requires that construction status of the building will permit the closing of doors, windows, ceilings installed, etc., to obtain simulated or projected operating conditions.
- C. Notification of System Readiness:
 - 1. Upon completion of the system installation Work, the Contractor shall notify the Owner and TAB Firm in writing, certifying that the Work has been accomplished and that the air conditioning systems are in operational readiness for testing, adjusting, and balancing.
 - 2. TAB Firm shall notify the Contractor of TAB Firm's readiness for balancing.
 - 3. Should the TAB Firm be notified as described above, and the TAB Work commenced and the systems are found NOT to be in readiness or a dispute occurs as to the readiness of the systems, the Contractor shall request an inspection be made by a duly appointed representative of the Owner, Architect, TAB Firm and the Contractor. This inspection will establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for TAB services. Should the inspection reveal the TAB services notification to have been premature, all cost of the inspection and wasted Work accomplished by the TAB Firm shall be the responsibility of the Contractor.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Allow sufficient time for the TAB Firm to perform TAB Firm's Work within the Project schedule. Complete installation Work by system or floor, whichever is the most efficient for scheduling. Develop the Project schedule in close coordination with the TAB Firm.
- D. The Drawings and Specifications indicate dampers, variable frequency drives, and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions. Install these devices in a manner that will leave the devices accessible and readily able to be adjusted. Immediately correct any malfunction encountered that the TAB Firm reports so that the balancing Work can proceed with minimal delay.
- E. Contractor shall promptly correct deficiencies of materials and workmanship identified as delaying completion of TAB Work.

3.03 SYSTEMS VERIFICATION

A. Air Distribution Systems:

- 1. Verify installation for conformity to the Contract Documents. All ducts shall be terminated and pressure tested for leakage as required by the Contract Documents.
- 2. All dampers are properly located and functional. Dampers shall provide tight closure and full opening, smooth and free operation.
- 3. All fans operating and verified for freedom from vibration, with proper fan rotation and belt tension. Heater elements in motor starters are of proper size and rating. Record motor amperage and voltage on each phase at Start-up and running, and verify they do not exceed nameplate ratings.
- 4. Duct systems are clean and free of debris.

B. Building Automation System (BAS):

- 1. Verify that all control components are installed in accordance with the Contract Documents and that all control components are functional, including all interlocks, damper sequences, safeties, etc.
- 2. Verify that all controlling instruments are calibrated and set for design operating conditions.
- 3. BAS Provider shall thoroughly check all controls, sensors, operators, sequences, etc. before notifying the TAB Firm that the building automation system is operational. The BAS Provider shall provide technical support, including technicians and necessary computers, to the TAB Firm for a complete check of these systems.

4. BAS Provider shall assist the Contractor with functional performance testing and point-to-point testing back to the main graphics.

END OF SECTION 23 05 90

SECTION 23 05 93 – SYSTEM TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Testing, adjusting, and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by a technically qualified TAB Firm.
- B. TAB Firm shall be capable of performing the TAB services as specified in accordance with the Contract Documents, including the preparation and submittal of a detailed report of the actual TAB Work performed.
- C. TAB Firm shall check, adjust, and balance components of the stair pressurization system which will result in optimal airflow conditions. This is intended to be accomplished after the system components are installed and operating as specified in the Contract Documents. It is the responsibility of the Contractor to place the equipment into service. Variable air volume systems shall be balanced in accordance with AABC Standard, Latest Edition or NEBB Standards for Testing, Adjusting, Balancing of Environmental Systems (Latest Edition).
- D. Liaison and Early Field Inspection:
 - 1. TAB Firm shall act as a liaison between the Owner, Architect and Contractor. During construction, review all HVAC submittals that pertain to the ability to satisfactorily balance systems.
 - 2. During the balancing process, as the TAB Firm discovers abnormalities and malfunctions of equipment or components, the TAB Firm shall advise the Contractor in writing so that the condition can be corrected by the Contractor prior to finishing the TAB scope of Work. Data from malfunctioning equipment shall not be recorded in the final TAB report.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:

1. AABC - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.
2. NEBB - National Environmental Balancing Bureau, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
3. ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.
4. ANSI/ASHRAE Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

1.04 QUALITY ASSURANCE

- A. TAB Firm shall have operated a minimum of five (5) years under TAB Firm's current name and shall be in good standing with the State of Texas, Franchise Tax Board. TAB Firm shall submit full incorporated name, Charter Number, and Taxpayer's I.D. Number for proper verification of TAB Firm's status.
- B. TAB Firm's personnel performing Work at the Project Site shall be either professional engineers or certified air and water balance technicians, who shall have been permanent, full time employees of the TAB Firm for a minimum of six (6) months prior to the start of Work for this Project.
- C. TAB firm shall have a background record of at least five (5) years of specialized experience in the field of air and hydronic system balancing and shall possess properly calibrated instrumentation.

1.05 SUBMITTALS

- A. The activities described in this Section shall culminate in a report to be provided in quadruplicate (4), individually bound and also provided electronically to the Contractor to be presented to the Owner. Neatly type and arrange data. Include with the data, the dates tested, personnel present, weather conditions, nameplate record of test instrument and list all measurements taken after all corrections are made to the system. Record all failures and corrective action taken to remedy incorrect situation. The intent of the report is to provide a reference of actual operating conditions for the Owner's operations personnel.
- B. All measurements and recorded readings (of air, water, electricity, etc.) that appear in the report must have been made at the Project Site by the permanently employed technicians or engineers of the TAB Firm.
- C. At the Owner's option, all data sheets tabulated each day by TAB Firm personnel shall be submitted for review and sign-off by the Owner's Construction Inspector. Those data sheets, as initialed by Owner's Construction Inspector, shall be presented as a supplement to the final TAB report.
- D. Submit reports on electronic forms approved by the Owner and Architect/Engineer which will include the following information as a minimum:
 1. Title Page:
 - a. Company name.

- b. Company address.
 - c. Company telephone number.
 - d. Project name.
 - e. Project location.
 - f. Project Manager.
 - g. Project Engineer.
 - h. Project Contractor.
 - i. Project identification number.
2. Instrument List:
- a. Instrument.
 - b. Manufacturer.
 - c. Model.
 - d. Serial number.
 - e. Range.
 - f. Calibration date.
 - g. What test instrument was used for.
3. Fan Data:
- a. Identification and location.
 - b. Manufacturer.
 - c. Model.
 - d. Air flow, specified and actual.
 - e. Total static pressure (total external), specified and actual.
 - f. Inlet pressure.
 - g. Discharge pressure.
 - h. Fan RPM.
4. Electric Motors:
- a. Manufacturer.
 - b. Horsepower/brake horsepower.

- c. Phase, voltage, amperage, nameplate, actual.
 - d. RPM.
 - e. Service factor.
 - f. Starter size, heater elements, rating.
5. V-Belt Drive:
- a. Identification and location.
 - b. Required driven RPM.
 - c. Driven sheave, diameter and RPM.
 - d. Belt, size and quantity.
 - e. Motor sheave, diameter and RPM.
 - f. Center-to-center distance, maximum, minimum and actual.
6. Duct Traverse:
- a. System zone/branch.
 - b. Duct size.
 - c. Area.
 - d. Design velocity.
 - e. Design air flow.
 - f. Test velocity.
 - g. Test air flow.
 - h. Duct static pressure.
 - i. Air temperature.
 - j. Air correction factor.
7. Vibration Test on equipment having 10 horsepower motors or greater:
- a. Location of points:
 - 1) Fan bearing, drive end.
 - 2) Fan bearing, opposite end.
 - 3) Motor bearing, center (if applicable).
 - 4) Motor bearing, drive end.

- 5) Motor bearing, opposite end.
- 6) Casing (bottom or top).
- 7) Casing (side).
- 8) Duct after flexible connection (discharge outlet).
- 9) Duct after flexible connection (suction inlet).
- b. Test readings:
 - 1) Horizontal, velocity and displacement.
 - 2) Vertical, velocity and displacement.
 - 3) Axial, velocity and displacement.
- c. Normally acceptable readings, velocity and acceleration.
- d. Unusual conditions at time of test.
- e. Vibration source (if non-complying).
8. Control verification indicating date performed and any abnormalities identified:
 - a. Point Location/Description.
 - b. EMS Readout (Setpoint and Actual).
 - c. Actual Readout.
 - d. Interlocks.
 - e. Safeties:
 - 1) VSD Normal Operation.
 - 2) VSD Bypass Operation.
 - f. Alarms.
 - g. Sequences of Operation.
9. Include in the appendix all submittals for fans, etc.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 AIR BALANCE

- A. When systems are installed and ready for operation, the TAB Firm shall perform an air balance for all air systems and record the results. The air volume for each fan shall be adjusted to maintain the minimum differential pressures between the stair and the corridor and the maximum door pull force to open the stair door indicated on the drawings. Fan volumes shall be adjusted by changing fan speed and adjusting volume dampers associated with the system. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown.
- B. The general scope of balancing by the TAB Firm shall include, but is not limited to, the following:
 - 1. Blower Speed: Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required, the Contractor shall make any required changes.
 - 2. Ampere Readings: Measure and record full load amperes for motors.
 - 3. Static Pressure: Static pressure gains or losses shall be measured across each fan. Static pressure readings shall also be provided for systems.
 - 4. Equipment Air Flow: Adjust and record air CFM(s), as applicable, at each fan.
 - 5. Pitot Tube Traverses: For use in future troubleshooting by Owner, all ducts shall have air velocity and volume measured and recorded by the traverse method. Locations of these traverse test stations shall be described on the sheet containing the data.

3.02 VIBRATION AND ALIGNMENT

- A. Vibration: Read and record vibration for all fans which have motors larger than 10 horsepower. Include equipment vibration, bearing housing vibration, foundation vibration, building structure vibration, and other tests as directed by the Architect/Engineer. Readings will be made using portable IRD (or approved equal) equipment capable of filtering out various unwanted frequencies and standard reporting forms. Maximum vibration at any point listed above, or specified, shall not exceed one mil on fans and one mil on pumps unless otherwise specified. Equipment manufacturer shall rectify all systems exceeding vibration tolerances.

3.03 BUILDING AUTOMATION SYSTEMS

- A. In the process of performing the TAB Work, the Contractor shall:
 - 1. Work with the Building Automation System (BAS) Provider and Owner to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.
 - 2. Verify that all control devices are properly connected.
 - 3. Verify that the intended controllers operate all dampers and other controlled devices.

4. Verify that all dampers are in the position indicated by the controller; open, closed, or modulating.
5. Verify the integrity of all dampers in terms of tightness of close-off and full-open positions.
6. Observe the calibration and operation of all controllers.
7. Observe the locations of all sensors to determine whether their position will allow them to sense only the intended pressures. BAS Provider will relocate sensors as deemed necessary by the TAB Firm or Contractor.
8. Verify that the sequence of operation for any control mode is in accordance with approved Shop Drawings and Specifications.
9. Verify that all controller setpoints meet the Contract Documents.
10. Check all dampers for free travel.
11. Verify the operation of all interlock systems.
12. Perform variable volume system verification to assure the system and system components track with changes from full flow to minimum flow.

3.04 STAIRWELL PRESSURIZATION SYSTEMS

- A. With all doors closed, measure the door pull to determine that the opening force required is less than or no greater than 30 pound-force.
- B. With all doors closed, measure the pressure differential across each door to verify the pressure differentials at each floor. Pressure differential shall not exceed 0.15 inches w.g. and shall be greater than 0.05 inches w.g.
- C. Measure the airflow in the stairwell with the maximum number of doors fully open by pitot tube traverse, if traverse locations are available. If traverse locations are not available, TAB Firm shall measure air flow at each outlet.
- D. Verify with smoke that the smoke detector in the stair pressurization fan inlet shuts down the fan.

END OF SECTION 23 05 93

SECTION 23 07 13 – DUCTWORK INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install ductwork insulation and jackets indicated by the Contract Documents with supplementary items necessary for proper installation.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
 - 2. ASTM C168 - Terminology Relating to Thermal Insulation Materials.
 - 3. ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
 - 4. ASTM C553 - Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - 5. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.
 - 6. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
 - 7. ASTM C1104 - Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
 - 8. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
 - 9. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
 - 10. ASTM C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.

11. ASTM E84 - Surface Burning Characteristics of Building Materials.
12. ASTM E96 - Water Vapor Transmission of Materials.
13. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
14. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
15. NFPA 255 - Surface Burning Characteristics of Building Materials.
16. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
17. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.
18. UL 723 - Surface Burning Characteristics of Building Materials.
19. ASTM E2336 - Standard for Grease Ducts.
20. ASTM D5590 - - Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay

1.04 QUALITY ASSURANCE

- A. All ductwork requiring insulation shall be insulated as specified herein and as required for a complete system. In each case, the insulation shall be equivalent to that specified and materials applied and finished as described in these Specifications.
- B. All insulation, jacket, adhesives, mastics, sealers, etc., utilized in the fabrication of these systems shall meet NFPA for fire resistant ratings (maximum of 25 flame spread and 50 smoke developed ratings) and shall be approved by the insulation manufacturer for guaranteed performances when incorporated into their insulation system, unless a specific product is specified for a specific application and is stated as an exception to this requirement. Certificates to this effect shall be submitted along with Contractor's submittal data for this Section of the Specifications. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.
- C. Application Company Qualifications: Company performing the Work of this Section must have minimum three (3) years experience specializing in the trade.
- D. All insulation shall be applied by mechanics skilled in this particular Work and regularly engaged in such occupation.
- E. All insulation shall be applied in strict accordance with these Specifications and with factory printed recommendations on items not herein mentioned. Unsightly, inadequate, or sloppy Work will not be acceptable.

1.05 SUBMITTALS

- A. Product Data:

1. Provide product description, list of materials, "k" value, "R" value, mean temperature range, and thickness for each service and location.
 - B. Record Documents:
 1. Submit under provisions of Division 01.
 - C. Operation and Maintenance Data:
 1. Samples: When requested, submit three (3) samples of any representative size illustrating each insulation type.
 2. Manufacturer's Installation Instructions: Indicate procedures that ensure acceptable standards will be achieved. Submit certificates to this effect.
- 1.06 DELIVERY, STORAGE AND HANDLING
- A. Deliver, store, protect, and handle products to the Project Site under provisions of Division 01 and Division 20.
 - B. Deliver materials to Site in original factory packaging, labeled with manufacturer's identification including product thermal ratings and thickness.
 - C. Store insulation in original wrapping and protect from weather and construction traffic. Protect insulation against dirt, water, chemical, and mechanical damage.
 - D. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulation cements.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. Unifrax 1 LLC. (FyreWrap)
- B. 3M Fire Protection Products (Fire Barrier Duct Wrap 615+)
- C. Type D4 2-Hour: Fire Rated Duct Insulation (High Temperature Flexible Blanket); refractory grade fibrous fire barrier material with minimum service temperature design of 2,000 degrees F; aluminum foil laminated on both sides; with a minimum 'k' value of 0.25 and a minimum density of 6 lbs/cu ft; containing no asbestos. Listed by a nationally recognized testing laboratory (NRTL) UL to meet ASTM E119, and with flame spread/smoke minimum rating of 25 / 50 when tested as per ASTM E84/UL 723.

2.03 INSULATION ACCESSORIES

- A. Adhesives: Waterproof vapor barrier type, meeting requirements of ASTM C916; Childers CP-82 or Foster 85-20/85-60.
- B. Weather Barrier: Breather Mastic:, Childers CP-10/CP-11 or Foster 46-50 White..

- C. Vapor Barrier Coating: Permeance - ASTM E 96, Procedure B, 0.08 perm or less at 45-mil dry film thickness, tested at 100F and 50%RH; Foster 30-65 or Childers CP-34
 - 1. When higher humidity levels may be of concern, only specify the following fungus/mold resistant coating: Foster 30-80 AF (anti fungal). Coating must meet ASTM D 5590 with 0 growth rating**
- D. Reinforcing Mesh: 10x10 or 9x8 glass mesh; Foster Mast a Fab or Childers #10
- E. Jacket: Pre-sized glass cloth, minimum 7.8 oz/sq yd.
- F. Type D4 Insulation Adhesive: Fire resistive to ASTM E84, Childers CP-82 or Foster 85-20.
- G. Impale Anchors: Galvanized steel, 12 gage self-adhesive pad.
- H. Joint Tape: Glass fiber cloth, open mesh.
- I. Tie Wire and Wire Mesh: Annealed steel, 16 gage.
- J. Stainless Steel Banding: 3/4-inch wide, minimum 22 gage, 304 stainless.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Verify that ductwork has been tested before applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.
- C. Maintain required ambient temperature during and after installation for a minimum period of 24 hours.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Extend duct insulation without interruption through walls, floors, and similar penetrations, except where otherwise indicated.
- D. Insulation (Type D4) application for exterior of ducts:
 - 1. External duct wrap system to provide 2-hour rating and, flexible wrap shall be overlapped to provide an effective fire barrier. The barrier is installed in 24-inch or 48-inch wide sections. Insulation pins are welded in certain locations to maintain the fire barrier material up against the duct.
 - 2. Install duct wrap as tested per manufacturer's instructions to assure the duct wrap is mechanically attached per the manufacturer's spacing of bands or weld pins.

3. Vertical and horizontal members of the support hanger system shall be wrapped with one layer of the insulation. Vertical and horizontal portions shall be wrapped independent of one another. The horizontal hanger shall be removed from the vertical support rods and wrapped and then immediately replaced so that an adjacent horizontal support can be removed, wrapped, and reinstalled. The end of the threaded vertical rod shall extend 6-inch past the horizontal member at the beginning of the installation.
4. Penetrations: Where ducts penetrate fire rated walls, floors and roofs, the duct wrap shall be used in conjunction with a firestop system that is listed by a nationally recognized laboratory and rated for penetration of a rated wall or floor by the fire rated grease duct system used.
- E. All ductwork, accessories, and all plenums including metal and masonry construction, etc., shall be insulated as indicated on the Drawings, as specified herein and as required for a complete system. In each case, the insulation shall be equal to that specified and materials applied and finished as described in these Specifications.
- F. Where vapor barriers are required, the vapor barrier shall be on the outside. Extreme care shall be taken that the vapor barrier is unbroken. Joints, etc., shall all be sealed. Where insulation with a vapor barrier terminates, it shall be sealed off with the vapor barrier being continuous to the surface being insulated. Ends shall not be left raw.
- G. Extreme care shall be taken in insulating high and medium pressure ductwork including all ductwork between the fan discharge and all mixing boxes to ensure the duct is not pierced with sheet metal screws or other fasteners. All high and medium pressure ducts in these Specifications are classified as high velocity ductwork.
- H. Where canvas finish is specified use lagging adhesive/coating to prevent mildew in securing canvas. Do not use wheat paste. Use only anti fungal lagging adhesive that adheres to ASTM D 5590 with 0 growth rating. (Foster 30-36AF, Childers CP-137AF). In addition, cover all exterior canvas-covered insulation with a fire retardant weather barrier mastic.
- I. All supply ductwork in the Project shall be insulated; all exhaust and fume hood exhaust ductwork shall not be insulated, unless used for energy recovery purposes or noted on drawings.
- J. Flexible round ducts shall be factory insulated.

3.03 INSPECTION

- A. Visually inspect the completed insulation installation per manufacturers recommended materials, procedures and repair or replace any improperly sealed joints.
- B. Where there is evidence of vapor barrier failure or "wet" insulation after installation, the damaged insulation shall be removed, duct surface shall be cleaned and dried and new insulation shall be installed.

3.04 DUCTWORK INSULATION APPLICATION AND THICKNESS SCHEDULE

Ductwork System	Application	Insulation Type	Insulation Thickness
Stairwell Pressurization Duct	All Outside of Rated Room	D4	Must meet 2 Hr Rating

END OF SECTION 23 07 13

SECTION 23 31 00 – DUCTWORK

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Provide materials and installation for complete first class HVAC systems; install ductwork, flexible duct, hangers, supports, sleeves, flashings, vent flues, and all necessary accessories as indicated in the Contract Documents. Provide any supplementary items necessary for proper installation that make the systems operable, code compliant and acceptable to the authorities having jurisdiction.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. ASHRAE - Handbook of Fundamentals; Duct Design.
 - 2. ASHRAE - Handbook of HVAC Systems and Equipment; Duct Construction.
 - 3. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.
 - 4. ASTM E 96 - Standard Test Methods for Water Vapor Transmission of Materials.
 - 5. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - 6. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
 - 7. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.
 - 8. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
 - 9. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.

10. SMACNA – HVAC Duct Construction Standards.
11. SMACNA – Rectangular Industrial Duct Construction Standards.
12. SMACNA – Round Industrial Duct Construction Standards.
13. SMACNA – HVAC Air Duct Leakage Test Manual.
14. UL 181 - Factory-Made Air Ducts and Connectors.
15. Engineering Design Manual for Air Handling Systems, United McGill Corporation (UMC).
16. Assembly and Installation of Spiral Ducts and Fittings, UMC.
17. Engineering Report No. 132 (Spacing of Duct Hangers), UMC.
18. AWS D1.1 American Welding Society Structural Welding Code.

1.04 INSTALLER QUALIFICATIONS:

- A. Company shall have minimum three years documented experience specializing in performing the work of this section.
- B. Installation of HVAC systems shall be performed by qualified Journeyman.

1.05 DEFINITIONS

A. Low Pressure

1. 2 inch W.G. Pressure Class: Ductwork systems up to 2 inch w.g. positive or negative static pressure with velocities less than or equal to 1500 fpm.

B. Medium Pressure

1. 3 inch W.G. Pressure Class: Ductwork systems over 2 inch w.g. and up to 3 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
2. 4 inch W.G. Pressure Class: Ductwork systems over 3 inch w.g. and up to 4 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
3. 6 inch W.G. Pressure Class: Ductwork systems over 4 inch w.g. and up to 6 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.

C. High Pressure

1. 10 inch W.G. Pressure Class: Ductwork systems over 6 inch w.g. and up to 10 inch w.g. positive or negative static pressure with velocities greater than 2500 fpm.

1.06 SUBMITTALS

A. Product Data:

1. Provide the following information for each sheet metal system furnished on the Project:

- a. System name and type.
- b. Duct system design pressure.
- c. Duct material.
- d. Duct gage.
- e. Transverse joint methods.
- f. Longitudinal seam type.
- g. Sealant type.
- h. SMACNA rectangular reinforcement type.
- i. SMACNA intermediate reinforcement type.
- j. SMACNA transverse reinforcement type.

B. Record Documents:

1. Submit Shop Drawings on all items of ductwork, plenums, and casings including construction details and accessories specified herein in accordance with Division 01. Ductwork construction details and materials used for duct sealant, flexible connections, etc. shall be submitted and approved prior to the fabrication of any ductwork.
2. Draw ductwork Shop Drawings on minimum 1/4 inch equal to one foot scale building floor plans and shall indicate duct sizes, material, insulation type, locations of transverse joints, fittings, ductwork bottom elevation, offsets, ductwork specialties, fire and fire/smoke dampers, and other information required for coordination with other trades. Clearly designate the following on the Shop Drawings:
 - a. Clearance dimensions between ducts and or location dimensions from walls, floors, columns, beams and large bore piping.
 - b. Duct materials i.e., stainless steel, galvanized steel, prefabricated fire rated ductwork pressure class ratings of ducts as defined within this specification.
 - c. Duct materials i.e., stainless steel, galvanized steel, prefabricated fire rated ductwork.
 - d. Fire and fire/smoke partitions.
3. Detail Drawings for mechanical rooms and air handling unit locations shall be submitted at a minimum scale of 1/4 inch equal to one foot shall also be included within the Shop Drawings.
4. Coordinate with all other trades and building construction prior to submitting Shop Drawings for review. Indicate location of all supply, return, exhaust, and light fixtures from approved reflected ceiling plans on Shop Drawings.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to the Project Site and store and protect products under provisions of Division 01 and Division 20.
- B. Protect materials from rust both before and after installation.

1.08 WARRANTY

- A. All ductwork shown on the Drawings, specified or required for the air conditioning and ventilating systems shall be constructed and erected in a first class workmanlike manner.
- B. The Work shall be guaranteed for a period of one (1) year from the Project Substantial Completion date against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation. After the system is in operation, should these defects occur, they shall be corrected as directed by the Owner at Contractor's expense.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 APPLICATION

- A. Ductwork systems shall be constructed in accordance with the following Materials as a minimum standard. Refer to Drawings for any deviation from this Table.

AIR SYSTEM	MATERIAL	MINIMUM PRESSURE CLASSIFICATION ⁽¹⁾
Supply and Return Systems:		
Untreated Outside Air Intake (Louver) to AHU Plenum	304 Stainless Steel	Low Pressure

- B. Notes to Table:

- 1. Positive pressure unless noted otherwise in Table.

2.03 DUCTWORK MATERIAL AND CONSTRUCTION

- A. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise on Drawings. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein.
- B. Ductwork shall be constructed of 304 Stainless Steel.
- C. Minimum gage of round, oval or rectangular ductwork shall be 26 gage per SMACNA Standards.

- D. All duct sizes shown on the Drawings are clear inside dimensions.
- E. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for future connections/phases, otherwise plastic covers are acceptable.
- F. Sheet metal must conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards."
- G. Where ducts are exposed to view (including equipment rooms) and where ducts pass through walls, floors or ceilings; furnish and install sheet metal collars around the duct.
- H. Duct Sealing: All ductwork, regardless of system pressure classification, shall be sealed in accordance with Seal Class A, as referenced in SMACNA Standards. All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed.
 - 1. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3 inches wide open weave fiberglass scrim tape. Sufficient additional sealant shall then be applied to completely embed the cloth.
 - 2. Sealant shall be water based latex UL 181A-M sealant with flame spread of 0 and smoke developed of 0. Sealants shall be Hard Cast Iron Grip 601, Ductmate Pro Seal, Foster 32-19, Childers CP-146 or Design Polymerics DP 1010.
 - 3. Scrim tape shall be fiberglass open weave tape, 3 inches wide, with maximum 20/10 thread count, similar to Hardcast FS-150.
 - 4. Sealer shall be rated by the manufacturer and shall be suitable for use at the system pressure classification of applicable ductwork.
 - 5. Except as noted, oil or solvent-based sealants are specifically prohibited.
 - 6. For exterior applications, "Uni-Weather" (United McGill Corporation), solvent-based sealant, or Foster 32-19 shall be used.

2.04 RECTANGULAR AND ROUND DUCTWORK

- A. Metal gages listed in SMACNA HVAC Duct Construction Standards, Metal and Flexible Duct, are the minimum gages which shall be used. Select metal gage heavy enough to withstand the physical abuse of the installation. In no case shall ductwork be less than 26 gage per SMACNA Standards.
- B. All longitudinal seams for rectangular duct shall be selected for the specified material and pressure classification. Seams shall be as referenced in SMACNA Standards.
- C. All transverse joints and intermediate reinforcement on rectangular duct shall be as shown in SMACNA Standards. Transverse joints shall be selected consistent with the specified pressure classification, material, and other provisions for proper assembly of ductwork.

- D. Spiral round duct and fittings shall be as manufactured by United McGill Sheet Metal Company or approved equivalent. All fittings shall be factory fabricated, machine formed and welded from galvanized sheet metal.
- E. Joints in spiral duct and fittings shall be assembled, suspended, sealed, and taped per manufacturer's published assembly and installation instructions.
- F. Contractor may use DUCTMATE or Ward Industries coupling system, as an option, on rectangular ductwork. The DUCTMATE or Ward Industries system shall be installed in strict accordance with manufacturer's recommendations.
- G. Rectangular ductwork field fabricated offsets shall not exceed 30 degrees.

2.05 CASINGS AND PLENUMS - 2 INCH W.G. PRESSURE CLASS

- A. All 2-inch w.g. pressure class casings and plenums for mixed air plenums shall be constructed in accordance with SMACNA Standards.
- B. All casings shall enclose the filter and automatic dampers as shown on the Drawings. Casings shall be fabricated of galvanized sheet metal erected with three-foot center maximum standing seams reinforced with ¼-inch bars. The casing shall be stiffened on three-foot centers maximum with angle irons tack welded in place.
- C. All openings to the casing shall be properly sealed to prevent any air leakage. Access doors shall be installed as indicated on the Drawings and shall be air tight, double skin insulated construction with frames welded in place. Doors shall be rubber gasketed with #390 Ventlok gasketing and equipped with fasteners equal to Ventlok #310 latches and #370 hinges that can be operated from both the inside and the outside.
- D. Casings shall be anchored by the use of angle irons sealed and bolted to the curb and floor of the apparatus casing. Casings shall be tested and provided tight at a pressure of three inches water column.
- E. Insulate per Section 23 07 13.

2.06 CASINGS AND PLENUMS – 6 INCH W.G. PRESSURE CLASS

- A. Shall enclose filters and automatic dampers at air handling unit systems. Casings shall be constructed of cellular, standing seam panels with 3 inch deep reinforced "hat" sections as manufactured by metal deck manufacturers and as described in SMACNA Standards.
- B. All openings to the casing shall be properly sealed to prevent air leakage. Install access doors for easy access to equipment. Access doors shall be air tight, double skin insulated construction with frames welded in place. Doors shall be rubber gasketed with #390 Ventlok gasketing and equipped with fasteners equal to Ventlok #310 latches that can be operated from both the inside and outside. Hinges shall be equivalent to Ventlok #370.
- C. Anchor casing by the use of galvanized angle irons sealed and bolted to the curb and floor of the apparatus casing as indicated in SMACNA Standards.

- D. A fan discharge diffuser plate shall be located on the fan discharge and shall be constructed of 10 gage steel perforated plate installed in 6 inch channel iron frames (8.2#) rigidly supported to withstand the fan discharge velocity. Perforations shall be 3/8 inch (0.375 inch) staggered on 11/16 inch centers (27 percent open area). One section shall be hinged to provide an access door between the discharge side of the fan and the entering side of the coils. After fabrication of the diffuser plate, coat with rust-resistant paint. After installation, touch up diffuser plate and paint channel iron frames with rust-resistant paint.
- E. Provide sufficient access openings to allow access for maintenance of all parts of the apparatus. Access door size shall be as large as feasible for the duty required.
- F. Insulate per Section 23 07 13.

2.07 ELBOWS RECTANGULAR DUCTS

- A. Construct elbows as follows in order of preference:
 - 1. Long radius, unvaned elbows.
 - 2. Short radius, single thickness vaned elbows.
 - 3. Rectangular, double thickness vaned elbows.
- B. Long radius elbows shall have a centerline radius of not less than one and one-half (1-1/2) times the duct width. Short radius elbows shall have a centerline radius of not less than one times the duct width.
- C. Contractor shall have the option to substitute short radius vaned elbows, but shall request the substitution at the time of submittal of Product Data.
- D. Provide turning vanes in all rectangular elbows and offsets.
- E. Job fabricated turning vanes, if used, shall be fabricated of the same gage and type of material as the duct in which they are installed. Vanes must be fabricated for same angle as duct offset. Submit Shop Drawings on factory fabricated and job fabricated turning vanes.
- F. All turning vanes shall be anchored to the cheeks of the elbow in such a way that the cheeks will not breathe at the surfaces where the vanes touch the cheeks. In most cases, this will necessitate the installation of an angle iron support on the outside of the cheek parallel to the line of the turning vanes.
- G. In 90-degree turns that are over 12 inches wide in the plane of the turn, provide and install double thickness vanes on integral side rails. For ducts under 12 inches in width, use single thickness vanes. The installation of the turning vanes shall be as described for single thickness vanes. On other types of turns or elbows, single thickness trailing edge vanes shall be used.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Cleanliness:
 - 1. Before installing ductwork, wipe ductwork to a visibly clean condition.
 - 2. During construction, provide temporary closures of metal or taped polyethylene on open ductwork and duct taps to prevent construction dust or contaminants from entering ductwork system. Seal ends of ductwork prior to installation to keep ductwork interior clean. Remove closures only for installation of the next duct section.
 - 3. For ductwork supplying Clean Rooms, Operating Rooms and other Critical Care areas, sanitize ductwork with a biocidal agent EPA approved for HVAC systems immediately prior to sealing ductwork.
 - 4. During duration of construction, maintain the integrity of all temporary closures until air systems are activated.
- D. Provide openings in ductwork where required to accommodate thermometers, controllers and other devices. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring. Sleeve of pitot tube opening shall be no more than one inch long. Opening shall be one inch wide to accept pitot tube.
- E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- F. Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.
- G. Coat buried, metal ductwork without factory jacket with one coat and seams and joints with additional coat of asphalt base protective coating.
- H. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
- I. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Use stainless steel for ductwork exposed to view and stainless steel for ducts where concealed.
- J. All visible welds in ductwork between biosafety cabinets, canopy hoods and fume hoods and the ceiling shall be ground and polished.
- K. Slope duct toward grilles for moisture-laden ducts. Provide drain and trap at elbow of main moisture exhaust duct system.

- L. Project inspector shall be notified to inspect all field fabricated offsets before cover-up or external insulation is applied.
- M. Hangers and Supports:
 - 1. All ductwork supports shall be in accordance with Table 4-1 (rectangular duct) and Table 4-2 (round duct) of the SMACNA Standards, with all supports directly anchored to the building structure.
 - 2. Rectangular duct shall have at least one pair of supports on minimum 8'-0" (eight feet) centers. All horizontal round and flat oval ducts shall have ducts hangers spaced 10'-0" (ten feet) maximum.
 - 3. Lower attachment of hanger to duct shall be in accordance with Table 4-4 of the SMACNA Standards.
 - 4. Vertical ducts shall be supported where they pass through the floor lines with 1-1/2 inch x 1-1/2 inch x 1/4 inch angles for duct widths up to 60 inches. Above 60 inches in width, the angles must be increased in strength and sized on an individual basis considering space requirements.
 - 5. Hanger straps on duct widths 60 inches and under shall lap under the duct a minimum of 1 inch and have minimum of one fastening screw on the bottom and two on the sides.
 - 6. Hanger straps on duct widths over 60 inches shall be bolted to duct reinforcing with 3/8 inch bolts minimum.

3.02 DUCTWORK SYSTEM CLEANING

- A. If the system has been operated without scheduled filters or if the integrity of temporary closures has been compromised, Contractor shall have ductwork cleaned according to National Air Duct Cleaners Association (NADCA) Standards by a Certified Regular Member of the NADCA.
- B. Before turning the installation over to the Owner, Contractor shall certify that the air handling systems have only been operated with scheduled filters in place. Otherwise, Contractor shall present evidence that the ductwork was cleaned as required above.

3.03 TESTING

- A. All medium and high pressure duct systems (positive or negative) shall be pressure tested according to SMACNA test procedures (HVAC Air Duct Leakage Test Manual). Notify Owner minimum seven (7) calendar days in advance of leakage testing.
 - 1. Design pressure for testing ductwork shall be determined from the maximum pressure generated by the fan at the nominal motor horsepower selected.
 - 2. Total allowable leakage shall not exceed 1 percent of the total system design airflow rate.
 - 3. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
 - 4. Leaks identified during leakage testing shall be repaired by:

- a. Complete removal of the sealing materials.
 - b. Thorough cleaning of the joint surfaces.
 - c. Installation of multiple layers of sealing materials.
5. The entire ductwork system shall be tested, excluding connections upstream of the terminal units (i.e. ductwork shall be capped immediately prior to the terminal units, and tested as described above).
 6. After testing has proven that ductwork is installed and performs as specified, the terminal units shall be connected to ductwork and connections sealed with extra care. Contractor shall inform the Owner when joints may be visually inspected for voids, splits, or improper sealing of the joints. If any leakage exists in the terminal unit connections/joints after the systems have been put into service, leaks shall be repaired as specified for other leaks.
 7. Fixed flow measurement devices (i.e. orifice tubes, nozzles, etc.) shall have current calibration documentation showing that the device was verified to a National Institute Of Standards and Technology (NIST) standard within the previous five years or as recommended by the manufacture and be accurate to at least +/- 2% of reading.
 8. Pressure measurement instrumentation (i.e. manometer) shall have current calibration documentation showing that the device was verified to a NIST standard within the previous year or as recommended by the manufacture. Instrumentation shall have an accuracy of at least +/- 2% of reading and have a resolution of 2:1 with respect to the measured pressure (i.e. resolution of 0.01 measured 0.1).
- B. All low-pressure duct systems (positive or negative) shall be inspected for visible and audible signs of leakage.
1. Leaks identified by inspection shall be repaired by:
 - a. Complete removal of the sealing materials.
 - b. Thorough cleaning of the joint surfaces.
 - c. Installation of multiple layers of sealing materials.
 2. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.
- C. Ductwork leakage testing and/or inspection shall be performed prior to installation of external ductwork insulation.

END OF SECTION 23 31 00

SECTION 23 33 00 – DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install the following ductwork accessories indicated by the Contract Documents with supplementary items necessary for proper installation.
 - 1. Flexible duct connections.
 - 2. Duct access doors.
 - 3. Screens
 - 4. Duct test holes.
 - 5. Guy wire systems.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AMCA 500D – Laboratory Method of Testing Dampers for Rating.
 - 2. AMCA 500L – Laboratory Method of Testing Louvers for Rating.
 - 3. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
 - 4. NFPA 101 - Life Safety Code.
 - 5. SMACNA - HVAC Duct Construction Standards.
 - 6. UL 33 - Heat Responsive Links for Fire-Protection Service.
 - 7. UL 555 – Standard for Fire Dampers.
 - 8. UL 555C – Standard for Ceiling Dampers.

9. UL 555S – Standard for Smoke Dampers.

1.04 SUBMITTALS

A. Product Data:

1. Provide product data for shop fabricated assemblies including, but not limited to, volume control dampers, duct access doors, and duct test holes. Provide product data for hardware used.

PART 2 - PRODUCTS

2.01 GENERAL

- ##### A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

A. Dampers:

1. Greenheck.
2. Louvers and Dampers, Inc.
3. Nailor Industries.
4. Prefco.
5. Ruskin.
6. Portorff

B. Regulators, Locking Quadrants:

1. Ventfabrics
2. Mercer Rubber

2.03 FLEXIBLE CONNECTIONS

- ##### A. Where ducts connect to, flexible connections shall be made using "Flexmaster TL-M" or "Ventglas" fabric that is temperature-resistant, fire-resistant, waterproof, mildew-resistant and practically airtight, weighing approximately thirty ounces (30 oz.) per square yard. Ventglas is good for connections for inside building environments where ultra-violet light is not present.
- ##### B. Material used outdoors shall be resistant to ultra-violet sunrays. There shall be a minimum of one-half inch (1/2-inch) slack in the connections, and a minimum of two and one-half inches (2-1/2-inch) distance between the edges of the. This does not apply to air handling units with internal isolation. A more rugged flexible material that is resistant to ultra violet rays needs to be used when connecting an exhaust fan or exhaust air plenum to ductwork. Mercer Rubber supplies a more durable flex connection for outdoor use.

C. Connections to Chemical Fume Hoods

1. Flexible connections shall be made using a coupling with stainless steel bands as manufactured by Fernco, Inc.

2.04 ACCESS DOORS

- A. Furnish and install in the ductwork, hinged rectangular, pressure relief, or round "spin-in" access doors to provide access to all fire dampers, mixed air plenums, steam reheat coils (install upstream), automatic dampers, etc.
- B. Where ductwork is insulated, access doors shall be double skin doors with one inch (1") of insulation in the door.
- C. Where duct size permits, doors shall be eighteen inches (18") by sixteen inches (16"), or eighteen inches in diameter, and shall be provided with Ventlok No. 260 latches (latches are not required in round doors).
- D. Latches for rectangular doors smaller than 18 inch x 16 inch shall be Ventlok No. 100 or 140.
- E. Doors for zone heating coils shall be Ventlok, stamped, insulated access doors, minimum 10 inch x 12 inch, complete with latch and two (2) hinges, or twelve inches (12") in diameter.
- F. Round access doors shall be "Inspector Series" spin-in type door as manufactured by Flexmaster USA.
- G. Grease duct access doors shall be as manufactured by Dura Systems Barriers Inc.
- H. Doors for personnel access to ductwork shall be nominal twenty-four inches (24") in diameter. Doors may be fabricated in a local approved sheet metal shop in accordance with SMACNA Standards.
- I. Where access doors are installed above a suspended ceiling, this Contractor shall be responsible for the proper location of ceiling access doors.

2.05 SCREENS

- A. Furnish and install screens on all duct, fan, etc., openings furnished by this Contractor which lead to, or are located outdoors.
- B. Screens shall be No. 16 gage, one-half inch (1/2") mesh in removable galvanized steel frame.
- C. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

2.06 GUY WIRE SYSTEM

- A. Provide 1/4-inch diameter American Aircraft Steel Cable (plastic coated) with clip for vertical stack off utility fans on roof, with eyebolts for attachment to anchor systems on the roof.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Provide all dampers furnished by the BAS Provider in strict accordance with manufacturer's written installation instruction and requirements of these Specifications.
- D. Flex connectors are not required at equipment with internally isolated fans. Cover connections to medium and high pressure fans with leaded vinyl sheet, held in place with metal straps where noted on the Owner's drawings.
- E. Provide duct access doors for inspection and cleaning before and after automatic dampers and in the ductwork.
- F. Provide duct test holes where indicated and where required for testing and balancing purposes.
 - 1. Furnish and install Ventlok No. 699 instrument test holes in the return air duct and in the discharge duct of each fan unit.
 - 2. Install test holes in locations as required to measure pressure drops across each item in the system, e.g., outside air louvers, filters, fans, coils, intermediate points in duct runs, etc.

END OF SECTION 23 33 00

SECTION 23 34 13 – INLINE FANS

PART 1 - GENERAL

1.01 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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install the following fans indicated by the Contract Documents with supplementary items necessary for proper installation.
 - 1. Mixed flow.
 - 2. Motors and drives.
 - 3. Fan accessories.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
 - 2. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
 - 3. AMCA 99 - Standards Handbook.
 - 4. ACMA 203 - Fan Application Manual - Field Performance Measurements.
 - 5. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
 - 6. AMCA 301 - Method of Calculating Fan Sound Ratings from Laboratory Test Data.
 - 7. ACMA 803 - Site Performance Test Standard - Power Plant and Industrial Fans.
 - 8. NEMA MG1 - Motors and Generators.
 - 9. NFPA 70 - National Electrical Code.
 - 10. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

1.04 QUALITY ASSURANCE

- A. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.
- B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.
- C. Fabrication: Conform to AMCA 99.
- D. Performance Base: 50 feet above sea level.
- E. Temperature Limit: Maximum 300 degrees F.
- F. Static and Dynamic Balance: Eliminate vibration or noise transmission to occupied areas.

1.05 SUBMITTALS

A. Product Data:

- 1. Submittal data for approval for all fans of every description furnished under this Section of these Specifications.
 - a. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gages and finishes of materials, electrical characteristics and connection requirements.
 - b. Fan curves with specified operating point clearly plotted. The recommended range of operation shall be stable.
 - c. Fans shall be capable of operating stably at reduced loads imposed by means of variable speed drives, inlet guide vanes or controlling pitch of fan blades.
 - d. Data on sound power levels for both fan inlet and outlet at rated capacity.
 - e. Data on special coatings and construction where applicable.
 - f. Electrical characteristics and connection requirements.
 - g. All data on fan accessories.

B. Operation and Maintenance Data:

- 1. Manufacturer's installation instructions and operating and maintenance data.
 - a. Submit under provisions of Division 01.
 - b. Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to the Project Site under provisions of Division 01 and Division 20.

- B. Accept products on Site in factory-fabricated protective containers or coverings, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- D. Check and maintain equipment on a monthly basis to ensure equipment is being stored in accordance with manufacturer's recommended practices. Additionally, during each check, fans and motors shall be rotated and greased and shafts shall be left approximately 180 degrees from that of previous month. Maintain storage records that indicate these maintenance requirements have been met.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Fans shall be either belt or direct drive as scheduled on the Drawings.
- C. Select fans such that they do not increase motor size, increase noise level, or increase tip speed by more than 10 percent, or increase inlet air velocity by more than 20 percent, from specified criteria. Provide fans capable of accommodating static pressure variations of plus or minus 10 percent.
- D. Statically and dynamically balance fans to eliminate vibration or noise transmission to occupied areas.
- E. Coat all parts of fan housing, blades, etc., exposed to corrosive air stream with specified material to handle environmental conditions.
- F. Motors and Drives: Provide motors and drives as required in this Section and as scheduled on Drawings.
- G. Finishes: Provide finishes as required in this Section for manufacturer and Site-applied as scheduled on Drawings.
- H. Accessories: Provide with accessories as require in this Section and as scheduled on Drawings.

2.02 MANUFACTURERS

- A. Chicago.
- B. Greenheck.
- C. Loren-Cook.
- D. Peerless.
- E. Woods.

2.03 MIXED FLOW

- A. Mixed flow-type fan wheel, mounted in a tubular housing with guide vanes for ducted, un-ducted inlet or discharge, or roof-mounted application. Direct-drive or belt-drive as scheduled on Drawings.
- B. Wheel: Mixed flow-type, steel construction with wheel cone, spherical backplate and single thickness cambered blades. Smooth curved, inlet cone specifically matched to the wheel. Hub shall be steel construction keyed and locked to the shaft.
- C. Housing: Heavy gage steel, continuously welded for all AMCA 99 designated Classes. Provide continuously welded vanes to straighten discharge air flow and continuously welded, pre-punched integral inlet and discharge flanges. For belt drive fans, isolate the drive components from the air stream by a continuously welded belt tunnel and a removable bearing cover. Housing shall be adequately braced, designed to minimize turbulence with spun inlet bell. Housing and bearing supports shall be welded structural steel construction designed to prevent vibration and rigidly support the shaft and bearings.

2.04 MOTORS AND DRIVES

- A. Motors: As indicated, in total compliance with Section 20 05 13 - Motors.
- B. Bearings: L-10 life at 200,000 hours self-aligning, grease-lubricated ball or roller bearings.
- C. Shafts: Hot rolled steel, ground and polished, with key-way, protectively coated with lubricating oil. Provide 316 stainless steel shafts for fume hood or corrosive applications.
- D. V-Belt Drives: All v-belt drives shall be designed for a minimum of 50 percent overload. Cast iron or steel sheaves, dynamically balanced, keyed. Variable and adjustable pitch sheaves for motors 15 horsepower and under, selected so required rpm is obtained with sheaves set at mid-position. Fixed sheave for 20 horsepower and over. Where more than one belt is required, matched sets shall be used. Include an additional set of drives for each fan to be used for final adjustments. After correct speed has been determined with variable sheave, provide fixed sheaves.
- E. Belt Guards: All belt drives shall be furnished with belt guards. Fabricate to SMACNA Low Pressure Duct Construction Standards; of 12 gage 3/4-inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.05 FACTORY-APPLIED FINISHES

- A. Wheels and Impellers: Steel components shall be finished with a thermally fused polyester coating. Other finishes as required on Drawings.
- B. Housings:
 - 1. Interior Fans: Thermally fused polyester coating for steel. Prime coating is not required for aluminum housings.

2. Exterior (Outdoor) Fans: Prior to assembly with minimum 6 mil saltwater-resistant, thermally-fused polyester coating (color selected by Architect). Coating is not required for aluminum housings.

2.06 ACCESSORIES

- A. Inlet Bell: Bell mouth inlet fabricated of steel with flange.
- B. Outlet Cones: Fabricated of steel with flanges, outlet area/inlet area ratio of 1.5/1.0, with center pod as recommended by manufacturer.
- C. Dampers: Welded steel construction consisting of two semi-circular vanes pivoted on oil retaining bearings in short casing section, finished by hot dip galvanizing. Provide motor actuation.
- D. Thrust Restraints: Provide thrust restraints where thrust exceeds fan weight for vane and axial fans.
- E. Inlet/Outlet Screens: Galvanized steel welded grid. Provide where inlet or outlet are unducted.
- F. Access Doors: Shaped to conform to housing with quick opening latches and gaskets.
- G. Cover: Provide weatherproof cover for motor and drive where fans are exposed to the weather.
- H. Extended Wiring: Provide extended wiring for electrical connection at the exterior of the unit for all direct drive applications.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. Install in accordance with manufacturer's instructions. Do not operate fans for any purpose until ductwork is clean, filters in place, bearings lubricated and fan has been test run under observation.
- C. Install fans with resilient mountings and flexible electrical leads. Refer to Section 20 05 48.
- D. Install flexible connections specified in Section 23 33 00 between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one-inch flex between ductwork and fan while running.
- E. Install fan restraining snubbers as required. Refer to Section 20 05 48. Adjust snubbers to prevent tension in flexible connectors when fan is operating.
- F. Provide safety screen where inlet or outlet is exposed.

3.02 PAINTING

- A. Provide fans with factory finish in accordance with the manufacturer's standard. Touch up scratches and marks from handling and placement of equipment with masking enamel to match manufacturer's color.
- B. Where fans are required to have epoxy or Heresite coating, have units factory finished with required number of coats prior to shipping to the Project Site.
- C. Refer to Division 09 for Site-applied finishes.

END OF SECTION 23 34 13

SECTION 25 00 10 – BUILDING AUTOMATION SYSTEMS (BAS) GENERAL - RETROFIT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Section includes:
 - 1. Description of Work.
 - 2. Quality Assurance.
 - 3. System Architecture.
 - 4. Distributed Processing Units/Quantity and Location.
 - 5. Demolition and Reuse of Existing Materials and Equipment.
 - 6. Sequence of Work.
- B. Furnish and install a direct digital control and building automation system (BAS). The new BAS shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves (except where noted otherwise) to perform control sequences and functions specified. The BAS for this Project will generally consist of monitoring and control of systems described herein. Reference shall also be made to control Drawings, Sequence of Operation, and points lists.
- C. The HVAC systems being controlled are the stair pressurization system. System shall be listed for use as a life safety system. System shall be installed in accordance with NFPA 101 and NFPA 92.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

2. ASHRAE 135: BACnet - A Data Communication Protocol for Building Automation and Control Networks. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. and all current addenda and annexes.
3. Electronics Industries Alliance:
 - a. EIA-709.1-A-99: Control Network Protocol Specification.
 - b. EIA-709.3-99: Free-Topology Twisted-Pair Channel Specification.
 - c. EIA-232: Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
 - d. EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes.
 - e. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.
 - f. EIA-472: General and Sectional Specifications for Fiber Optic Cable.
 - g. EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.
 - h. EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications.
 - i. EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.
4. NEMA Compliance:
 - a. NEMA 250: Enclosure for Electrical Equipment.
 - b. NEMA ICS 1: General Standards for Industrial Controls.
5. NFPA Compliance:
 - a. NFPA 90A: "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
 - b. NFPA 70: National Electrical Code (NEC).
6. Institute of Electrical and Electronics Engineers (IEEE):
 - a. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
 - b. IEEE 802.3: CSMA/CD (Ethernet – Based) LAN.
 - c. IEEE 802.4: Token Bus Working Group (ARCNET – Based) LAN.
 - d. IEEE 519: Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.

1.04 QUALITY ASSURANCE

- A. Reserved.
- B. Apogee Product Line Demonstrated History: The product line being proposed for the Project must have an installed history of demonstrated satisfactory operation for a length of one (1) year since date of final completion in at least ten (10) installations of comparative size and complexity. Documents with references shall be submitted verifying this requirement has been met at Owner's request.
- C. Siemens Installers Field Coordinator and Sequence Programmer Qualifications: Individual(s) shall specialize in and be experienced with control system installation for not less than five (5) years. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than two (2) projects of similar size and complexity. Installer shall submit the names of the proposed individual and at least one alternate for each duty at Owner's request. Proposed individuals must show proof of the following training:
 - 1. Product Line Training: Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training offered by the manufacturer on that product line for installation and configuration.
 - 2. Programming Training: Individuals involved with programming the Site-specific sequences shall provide evidence of the most advanced programming training offered by the vendor of the programming application offered by the manufacturer.
- D. The BAS and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.
- E. The BAS shall be listed by Underwriters Laboratories (UUKL 864) for Supervised Smoke Control.

1.05 SUBMITTALS

- A. General: Submit documents under provisions of Division 01. Two (2) copies of the materials shall be delivered directly to MD ANDERSON Monitoring Services staff, in addition to the copies required by other Sections. In addition, an electronic version of the completed materials shall be provided on CD or DVD. Refer to Section 25 08 10 for additional Commissioning submittal requirements.
- B. Electronic Submittals: While all requirements for hard copy submittal apply, control submittals and operation and maintenance (O&M) information shall also be provided in electronic format as follows:
 - 1. Drawings and Diagrams: Shop Drawings shall be provided on electronic media as an AutoCAD drawing per Owner's CAD standards. All 'x reference' and font files must be provided with AutoCAD files.
 - 2. Other Submittals: All other submittals shall be provided in Adobe Portable Document Format.
- C. Product Data: Submit manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Include installation and start-up instructions.

D. Record Documents:

1. Siemens shall submit separately and directly to Owner a pricing breakdown of all cost associated to Project for review. This is to include but not be limited to material quantity, description, unit list price, multiplier, cost, extended cost, material costs adjustment less Owner's discount price, outside material price totaled and itemized, itemized subcontract price associated to Project, and total Project support price.
 - a. Siemens labor hours quantities shall be itemized by mechanical labor, electrical labor, and design and management labor. Hour quantities shall be itemized by journeyman rate, technician rate and design/management rate with quantity of hours listed separately.
 - b. All estimated overtime shall be disclosed. Profit for Project shall be disclosed. Total Project price shall not exceed the sum of the listed itemized costs.
 - c. Provide an accurate spreadsheet breakdown of physical point counts of all analog inputs, analog outputs, digital inputs, digital outputs, building controllers and application specific controllers. The total point count for the project shall be itemized in a logical manner to allow the owner to confirm point count accuracy. Below is an example.

Project Physical Point Count	Drawing M-006	Drawing M-007	Drawing M-008	Drawing M-010	Drawing M-014	Drawing M-015
Physical Digital Input(s)						
Physical Digital Output(s)						
Physical Analog Input(s)						
Physical Analog Output(s)						
Building Controller(s)						
Application Specific Controller(s)						
TOTALS						

- d. All subcontracts greater than \$10K shall be competitively priced by a minimum of two owner approved subcontractors. Both subcontract proposals shall be fully disclosed.
 - e. This pricing summary, including any attachments, is intended only for the Owner and contains confidential and/or privileged information. Any unauthorized review; use, disclosure or distribution is prohibited.
2. Qualifications: Manufacturer, installer, and key personnel qualifications as indicated for the appropriate item above.

3. Shop Drawings: Submit Shop Drawings electronically on AutoCAD software for each control system, including a complete drawing for each air handling unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Shop Drawings shall contain the following information:
 - a. System Architecture and System Layout:
 - 1) One-line diagram indicating schematic locations of all control units, workstations, LAN interface devices, gateways, etc. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the diagram.
 - 2) Provide floor plans locating all control units, workstations, servers, LAN interface devices, gateways, etc. Include all WAN and LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans. Wiring routing conditions shall be maintained accurately throughout the construction period and the Record Drawings shall be updated to accurately reflect accurate, actual installed conditions.
 - b. Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include written description of sequence of operation.
 - c. All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.
 - d. With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number). If this information is not available at the time of Shop Drawings submittals, furnish with O&M manual documentation for Owner review and approval. See Section 25 15 10 for additional requirements.
 - e. Label each control device with setting or adjustable range of control.
 - f. Label each input and output with the appropriate range.
 - g. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.
 - h. With each schematic, provide valve and actuator information including size, Cv, design flow, design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of spring return valves and dampers.

- i. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination Drawings on separate Drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that is existing, factory-installed and portions to be field-installed.
 - j. Details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.
 - k. Sheets shall be consecutively numbered.
 - l. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.
 - m. Table of Contents listing sheet titles and sheet numbers.
 - n. Legend and list of abbreviations.
 - o. Record copies of product data, as built control Shop Drawings and final sequence of operation updated to reflect the final installed condition.
 - p. Provide network architecture Record Drawings showing all nodes including a description field with specific controller identification, description and location information.
 - q. Provide record riser diagram showing the location of all controllers. Indicate device instance, MAC address and drawing reference number.
- E. Operation and Maintenance Data:
- 1. Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessory.
 - 2. Submit BAS User's Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripherals.
 - 3. Submit BAS advanced Programming Manuals for each controller type and for all workstation software.
 - 4. Manufacturer's Certificates: For all listed and/or labeled products, provide certificate of conformance.
 - 5. Product Warranty Certificates: Submit manufacturer's product warranty certificates covering the hardware provided.

1.06 SYSTEM ARCHITECTURE

- A. The communication speed between the controllers, LAN interface devices, CSS, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. Contractor shall submit guaranteed response times with Shop Drawings including calculations to support the guarantee. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall modify their BAS control design as necessary to accomplish these performance requirements. Generally requirements do not apply when a remote connection must be established via modem:
1. 5 seconds between a Level 1 (critical) alarm occurrence and enunciation at operator workstation.
 2. 10 seconds between a Level 2 alarm occurrence and enunciation at operator workstation.
 3. 20 seconds between a Level 3-5 alarm occurrence and enunciation at operator workstation.
 4. 10 seconds between an operator command via the operator interface to change a set point and the subsequent change in the controller.
 5. 5 seconds between an operator command via the operator interface to start/stop a device and the subsequent command to be received at the controller.
 6. 10 seconds between a change of value or state of an input and it being updated on the operator interface.
 7. 10 seconds between an operator selection of a graphic and it completely painting the screen and updating at least ten (10) points.
- B. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other BAS nodes on the network. If a LAN is severed, two (2) separate networks shall be formed and communications within each network shall continue uninterrupted.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

1.08 WARRANTY

- A. Contractor shall warranty all products and labor for a period of [insert Warranty Period] after Substantial Completion.

- B. The Owner reserves the right to make changes to the BAS during the Warranty Period. Such changes do not constitute a waiver of warranty. Contractor shall warrant parts and installation work regardless of any such changes made by Owner, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS. Any disagreement between Owner and Contractor on such matters shall be subject to resolution through the Contract 'Disputes' clause.
 - 1. At any time during the Warranty Period that Contractor is on the Project Site for maintenance, emergency, or normal service, Contractor shall notify Owner via MD ANDERSON Monitoring Services and the local building operating personnel.
 - 2. Contractor shall notify said personnel of all work anticipated being involved for the service work. In addition, no work affecting system operation shall commence until express permission is granted.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. The BAS and digital control and communications components installed as Work of this Contract shall be an integrated distributed processing system of the following manufacturer or communication protocol. No other products will be considered as substitutions.
 - 1. Siemens Building Technologies - APOGEE: Provide control products and systems that completely integrate and operate from the existing APOGEE system currently in operation at the institution. All access, programming, alarming, and system configuration shall be utilized from the existing system software and database without any third party programs or gateways.
 - 2. Substitutions: None

2.03 MATERIALS AND EQUIPMENT

- A. Materials shall be new, the best of their respective kinds without imperfections or blemishes, and shall not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where Drawings or Specifications specifically allow existing materials to remain in place.

2.04 UNIFORMITY

- A. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Fasteners requiring explosive powder (shooting) or pneumatic-driven actuation will not be acceptable under any circumstances.
- D. Refer to additional requirements in other Sections of this Specification.

3.02 SURGE PROTECTION

- A. Contractor shall furnish and install any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BCs, AAC/ASCS operator interfaces, printers, routers, gateways and other hardware and interface devices. All equipment shall be capable of handling voltage variations 10 percent above or below measured nominal value, with no affect on hardware, software, communications, and data storage.

3.03 CONTROL POWER SOURCE AND SUPPLY

- A. BAS Provider shall extend all power source wiring required for operation of all equipment and devices provided under Division 25 and the Drawings if not specified under Division 26.
- B. General requirements for obtaining power include the following:
 - 1. All control power for a given stand alone controller and all associated controls for this stand alone controller shall originate from the same circuit.
 - 2. All mechanical equipment which is supplied with emergency power shall have the DDC controller supplied with emergency power.
 - 3. Provide an uninterruptible power supply (UPS) as indicated on the Drawings or as necessary. UPS shall protect against blackouts, brownouts, surges and noise.
 - a. UPS shall include LAN port and modem line surge protection.
 - b. UPS shall be sized for a 7-minute full load runtime, 23-minute 1/2 load runtime, with a typical runtime of up to 60 minutes. Transfer time shall be 2-4 milliseconds.
 - c. UPS shall provide a 480-joule suppression rating and current suppression protection for 36,000 amps and provide 90 percent recharge capability in 2-4 hours. Suppression response time shall be instantaneous. UPS low voltage switching shall occur when supply voltage is less than 94 volts.
 - d. Provide a Maintenance Bypass Switch that allows input voltage to bypass the UPS and directly power the connected equipment if an abnormal condition prevents the UPS from supporting the load, or if the UPS is required to be taken out of service.

- e. Provide all software, cables, peripherals etc. for a complete system.

END OF SECTION 25 00 10

SECTION 25 08 10 – BAS COMMISSIONING - RETROFIT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Section includes:
 - 1. BAS and equipment testing and Start-up.
 - 2. Validation of proper and thorough installation of BAS and equipment.
 - 3. Functional testing of control systems.
 - 4. Documentation of tests, procedures, and installations.
 - 5. Coordination of BAS training.
 - 6. Documentation of BAS Operation and Maintenance materials.
- B. This Section defines responsibilities of the Contractor to commission the BAS.
- C. The term "Owner" shall include a representative from MD ANDERSON Building Automation Services but is not limited to represent the Owner exclusively. Coordinate all activities to include all of the Owner's representatives.
- D. Commissioning is the process of ensuring that all building systems are installed and perform interactively according to the design intent, the systems are efficient and cost effective and meet the Owner's operational needs, the installation is adequately documented, and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.
- E. The Contractor shall direct, coordinate, and oversee the Commissioning process and witness functional performance tests.
- F. The Owner's TAB Firm may write the Owner approved control sequence verification sheets for functional performance tests and develop forms using the BAS Provider's point log to test each point back to the graphical interface. The BAS Provider shall furnish the Contractor with an estimated time to complete this task, which Contractor will incorporate in the Project Schedule. In the event Owner's TAB Firm is not under contracted for the Project, the Contractor shall write the Owner approved sequence verification sheets for functional performance tests.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within all references.

1.04 CONTRACTOR RESPONSIBILITIES

- A. Completely install and thoroughly inspect, startup, test, adjust, balance, and document all systems and equipment.
- B. Assist Owner and/or TAB Firm in verification and functional performance testing. This will generally include the following:
 - 1. Attend Commissioning progress and coordination meetings.
 - 2. Prepare and submit required draft forms and systems information.
 - 3. Establish trend logs of system operation as specified herein.
 - 4. Demonstrate system operation.
 - 5. Manipulate systems and equipment to facilitate testing.
 - 6. Provide instrumentation necessary for verification and performance testing.
 - 7. Manipulate control systems to facilitate verification and performance testing.
 - 8. Train Owner as specified in this Section.
- C. Compensation for Retesting: Contractor shall compensate Owner for Site time necessitated by incompleteness of systems or equipment at time of functional performance testing. All testing failures, which require on-Site time for retesting, will be considered actual damages to the Owner. All parties under Contract with the Owner who are affected by the retesting shall be included in the Contract modification.

1.05 SUBMITTALS

- A. The following list outlines the general sequence of events for submittals and commissioning:
 - 1. Submit product data and Shop Drawings, and receive approval.
 - 2. Submit BAS logic documentation, and receive approval.
 - 3. Submit background graphic screens, and receive approval.
 - 4. Submit Start-Up Checklists and manufacturer's start-up procedures for all equipment provided by the Contractor.

5. Install BAS.
6. Submit BAS Start-Up Test Agenda and Schedule for review.
7. Receive BAS Startup Test Agenda/schedule approval.
8. Submit Training Plan.
9. Simulate sequencing and debug program off-line to the extent practical.
10. Place systems under BAS control where applicable during a scheduled outage.
11. Perform BAS Startup where applicable during a scheduled outage.
12. Prepare and initiate trend log data storage and format trend graphs.
13. Submit completed BAS Start-Up Reports and initial draft of the Operating and Maintenance (O&M) Manuals.
14. Receive BAS Startup Report approval and approval to schedule Demonstrations and Commissioning.
15. Demonstrate systems to Owner.
16. Submit Trend Logs in format specified.
17. Receive demonstration approval and approval to schedule Acceptance Period.
18. Train Owner on BAS operation and maintenance.
19. Substantial Completion.
20. Begin Acceptance Phase.
21. Two-week Operational Test.
22. Perform Functional Performance Testing including point to point verification to graphical interface.
23. Receive Acceptance Period approval, which is Functional Completion for the BAS.
24. Train Owner on final sequences and modes of operation.
25. Install framed control Drawings.
26. Provide Level 1 password access to the Owner.
27. Revise and re-submit Record Drawings and O&M Manuals.
28. Manager of Building Automation Services sign-off required.
29. Final Acceptance.
30. Begin Warranty Phase.

31. Schedule and begin Opposite Season acceptance period.
32. Receive Opposite Season acceptance period approval.
33. Submit Record Drawings and O&M Manuals.
34. Update framed control Drawings.
35. Complete Owner Training.
36. End-of-Warranty date/period.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 INSTRUMENTATION

- A. Instrumentation required to verify readings and to test the system and equipment performance shall be provided by Contractor and made available to Owner. Generally, no testing equipment will be required beyond that required to perform Contractor's Work under these Contract Documents. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

2.03 TAB AND COMMISSIONING PORTABLE OPERATORS TERMINAL

- A. For new Projects, Contractor shall provide portable operators terminal or hand held device to facilitate Testing, Adjusting, and Balancing (TAB) and calibration. This software or device shall support all functions and allow querying and editing of all parameters required for proper calibration and Start-up.
- B. Connections shall be provided local to the device being calibrated. For instance, for terminal units, connection of the operator's terminal shall be either at the sensor or at the terminal unit. Otherwise a wireless system shall be provided to facilitate this local functionality.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.

3.02 BAS START-UP TESTING, ADJUSTING, CALIBRATION

- A. Work and/or systems installed under this Division shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below:
1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
 2. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
 3. Verify integrity/safety of all electrical connections.
 4. Coordinate with Owner's TAB Firm to obtain control settings that are determined from balancing procedures. Record the following control settings as obtained from Owner's TAB Firm, and note any TAB deficiencies in the BAS Start-Up Report:
 5. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BAS display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5 percent accurate, test equipment shall be +/-0.25 percent accurate over same range). Record the measured value and displayed value for each device in the BAS Start-up Report.
 6. Check and set zero and span adjustments for all transducers and transmitters.
 7. For dampers:
 - a. Check for adequate installation including free travel throughout range and adequate seal.
 - b. Where loops are sequenced, check for proper control without overlap.
 8. For actuators:
 - a. Check to ensure that device seals tightly when the appropriate signal is applied to the operator.
 - b. Check for appropriate fail position, and that the stroke and range is as required.
 - c. For sequenced electronic actuators, calibrate per manufacturer's instructions to required ranges.
 9. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the Operator Interface display. Record the results for each device in the BAS Start-Up Report.
 10. For outputs to reset other manufacturer's devices (for example, VSDs) and for feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.

11. Verify proper sequences by using the approved checklists to record results and submit with BAS Start-Up Report. Verify proper sequence and operation of all specified functions.
12. Verify that all safety devices trip at appropriate conditions. Adjust setpoints accordingly.
13. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BAS Start-up Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):
 - a. Space Pressurization (on active control systems): Between 0.05"-0.1" wg with no doors open on the low end and a 30 lb force to open all the doors to the stairwell on the high end.
14. For interface and DDC control panels:
 - a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the Record Drawings.
 - b. Ensure that terminations are safe, secure and labeled in accordance with the Record Drawings.
 - c. Check power supplies for proper voltage ranges and loading.
 - d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
 - e. Check for adequate signal strength on communication networks.
 - f. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
 - g. Ensure that all outputs and devices fail to their proper positions/states.
 - h. Ensure that buffered and/or volatile information is held through power outage.
 - i. With all system and communications operating normally, sample and record update/annunciation times for critical alarms fed from the panel to the Operator Interface.
 - j. Check for proper grounding of all DDC panels and devices.
15. For Operator Interfaces:
 - a. Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
 - b. Output all specified BAS reports for review and approval.

- c. Verify that the alarm printing and logging is functional and per requirements.
 - d. Verify that trends are archiving to disk and provide a sample to the Owner for review.
 - e. Verify that paging/dial-out alarm annunciation is functional.
 - f. Start-up and check out control air compressors, air drying, and filtering systems in accordance with the appropriate section and with manufacturer's instructions.
 - g. Verify proper interface with fire alarm system.
- B. Submit Start-Up Test Report: Report shall be completed, submitted, and approved prior to Substantial Completion.

3.03 SENSOR CHECKOUT AND CALIBRATION

- A. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2 degrees F of each other for temperature and within a tolerance equal to 2 percent of the reading of each other for pressure. Tolerances for critical applications may be tighter.
- B. Calibration: Calibrate all sensors using one of the following procedures:
1. Sensors Without Transmitters - Standard Application: Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gauge or BAS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20 percentage of the expected range.
 2. Sensors With Transmitters - Standard Application: Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until the ammeter reads 4 mA. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gauge or BAS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.
- C. Sensor Tolerance: Sensors shall be within the tolerances specified for the device. Refer to Section 25 11 10.

3.04 COIL VALVE LEAK CHECK

- A. Verify proper close-off of the valves. Ensure the valve seats properly seat by simulating the maximum anticipated pressure difference across the circuit. Demonstrate to the Owner the verification of zero flow by measuring the coil differential pressure. If there is pressure differential, close the isolation valves to the coil to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.

3.05 BAS DEMONSTRATION

- A. All BAS Demonstration shall take place on the main Control Systems Server and MD ANDERSON WAN. Schedule to add system to main Control Systems Server and MD ANDERSON WAN with Owner at least two (2) weeks in advance to the demonstration. At the time of request, provide all documentation that the following criterions are met:
 - 1. Updated BAS submittals in electronic and hard copy to Owner including the updated riser diagram for the system.
 - 2. Reports on verification of Network Layout Verification including but not limited to Building Controller locations, cable routes with length of cable between controllers and any trunk extenders or trunk isolators.
 - 3. Reports on verification of electrical characteristics of BAS network, communications and electrical integrity of Building Controllers.
 - 4. Reports on verification of traffic on BAS Network including but not limited to COVs between Building Controllers, point commands by the operator, point commands by program across the network, alarm reporting on the network, any unresolved points in the system, integrity of the ports on any Building Controller isolator/extender and results of Building Controller tests running at selected baud rate.
 - 5. Demonstrate to Owner the updates of databases without errors or faults between the temporary Control Systems Server and Building Controllers. If there is no temporary server, demonstrate to Owner after system is added to main Control Systems Server.
 - 6. Reports on verification of system log files, interruption of log files of system traffic and overall acceptable operation of the system where a temporary Control Systems Server is utilized.
- B. Demonstrate the operation of the BAS hardware, software, and all related components and systems to the satisfaction of the Owner. Schedule the demonstration with the Owner seven (7) calendar days in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved. If the Work fails to conform to the Contract Documents, so as to require scheduling of additional Site visits by the Owner for re-demonstration, Contractor shall reimburse Owner for costs of subsequent Site visits.
- C. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the Project Site.

- D. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner.
- E. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:
 - 1. Demonstrate that required software is installed on BAS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
 - 2. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
 - 3. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.
 - 4. Demonstrate correct calibration of input/output devices using the same methods specified for the Start-Up Tests. A maximum of 10 percent of I/O points shall be selected at random by the Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by Owner for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
 - 5. Demonstrate that all DDC and other software programs exist at respective field panels. The Direct Digital Control (DDC) programming and point database shall be as submitted and approved.
 - 6. Demonstrate that all DDC programs accomplish the specified sequence of operation.
 - 7. Demonstrate that the panels and DDC network of panels automatically recover from power failures within five (5) minutes after power is restored.
 - 8. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
 - 9. Identify access to equipment selected by the Owner. Demonstrate that access is sufficient to perform required maintenance.
 - 10. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.
- F. BAS Demonstration shall be completed and approved prior to Substantial Completion.
- G. Any tests successfully completed during the demonstration will be recorded as passed for the functional performance testing and will not have to be retested.

3.06 BAS ACCEPTANCE PERIOD

- A. After approval of the BAS Demonstration and prior to Contract Close Out Acceptance Phase shall commence. Acceptance Period shall not be scheduled until all HVAC systems are in operation and have been accepted, all required cleaning and lubrication has been performed.

- B. Operational Test: At the beginning of the Acceptance Phase, the system shall operate properly for two (2) weeks without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these Specifications. At the end of the two weeks, Contractor shall forward the trend logs to the Owner for review. Owner shall determine if the system is ready for functional performance testing and document any problems requiring Contractor's attention.
1. If the systems are not ready for functional performance testing, Contractor shall correct problems and provide notification to the Owner that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time for an additional one-week period.
 2. This process shall be repeated until Owner issues notice that the BAS is ready for functional performance testing.
- C. During the Acceptance Period, the Contractor shall maintain a hard copy log of all alarms generated by the BAS. For each alarm received, Contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the Contractor's opinion, the cause of the alarm is not the responsibility of the Contractor, Contractor shall immediately notify the Owner.

3.07 BAS OPERATOR TRAINING AND O&M MANUALS

- A. Provide up to four (4) complete sets of the approved Operations and Maintenance (O&M) Manuals (hard copy and one electronic copy) to be used for training.
- B. Contractor shall submit a Training Plan for the scope of training for which BAS Provider is responsible. Training Plan shall be forwarded to the Contractor who will compile, organize, format, and forward to the Engineer for review.
1. Coordinate requirements of Training with the MD ANDERSON Monitoring Services Department.
- C. On-Site Training: Provide services of BAS Provider's qualified technical personnel for 8-hour days to instruct Owner's personnel in operation and maintenance of BAS. Instruction shall be in classroom setting at the Project Site for appropriate portions of the training. Training may be in non-contiguous days at the request of the Owner. The Owner shall notify Contractor seven (7) calendar days in advance of each day of requested training. The Contractor's designated training personnel shall meet with the Engineer and Owner for the purpose of discussing and fine-tuning the training agenda prior to the first training session. Training agenda shall generally be as follows:
1. Basic Operator Workstation (OWS) Training – For all potential users of the OWS:
 - a. Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of controller portable and built-in operator interface device display capabilities.
 - b. Brief overview of the various parts of the O&M Manuals, including hardware and software programming and operating publications, catalog data, controls installation Drawings, and DDC programming documentation.

- c. Demonstration of workstation login/logout procedures, password setup, and exception reporting.
 - d. Demonstration of workstation menu penetration and broad overview of the various workstation features.
 - e. Overview of systems installed.
 - f. Present all Site-specific point naming conventions and points lists, open protocol information, configuration databases, back-up sequences, upload/download procedures, and other information as necessary to maintain the integrity of the BAS.
 - g. Overview of alarm features.
 - h. Overview of trend features.
 - i. Overview of workstation reports.
2. BAS Hardware Training – For Maintenance and Control Technicians:
- a. Review of installed components and how to install/replace, maintain, commission, and diagnose them.
3. BAS Technician Training:
- a. Introduction to controller programming and overview of the programming application interface.
 - b. General review of sequence of operation and control logic for the Project Site, including standalone and fail-safe modes of operation.
 - c. Uploading/downloading and backing up programs.
 - d. Network administration.
 - e. Review of setpoint optimization and fine-tuning concepts.
- 3.08 WARRANTY PHASE BAS OPPOSITE SEASON TRENDING AND TESTING
- A. Trending: Throughout the Warranty Phase, trend logs shall be maintained. Contractor shall forward archive trend logs to the Owner for review upon Owner request. Owner will review these and notify Contractor of any warranty work required.
 - B. Opposite Season Testing: Within twelve (12) months of Substantial Completion, Contractor shall schedule and conduct with Owner, Opposite Season functional performance testing. BAS Provider shall participate in this testing and remedy any deficiencies identified.

END OF SECTION 25 08 10

SECTION 25 11 10 – BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS (RETROFIT)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Section Includes:
 - 1. Wiring.
 - 2. Control Dampers and Actuators.
 - 3. Control Panels.
 - 4. Sensors.
 - 5. Electric Control Components (Switches, EP Valves, Thermostats, Relays, etc.).
 - 6. Transducers.
 - 7. Current Switches.
 - 8. Nameplates.
 - 9. Testing Equipment.
- B. Refer to Section 25 00 10 for general requirements.
- C. Refer to other Division 20 and Division 23 Sections for installation of dampers in mechanical systems; not Work of this Section.
- D. Provide the following electrical Work as Work of this Section, complying with requirements of Division 26 sections:
 - 1. Control wiring between field-installed controls, indicating devices, and unit control panels.
 - 2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.
 - 3. Wiring associated with annunciator and alarm panels (remote alarm panels) and connections to their associated field devices.
 - 4. All other necessary wiring for fully complete and functional control system as specified.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within all references.

1.04 WORK BY OTHERS

- A. Control Dampers furnished under this Section shall be installed under the applicable air distribution or air handling equipment Section under the direction of the BAS Provider who will be fully responsible for the proper operation of the damper.
- B. Variable Frequency Drives furnished under section 23 05 13 shall be provided with serial communication protocol information specific to the selected BAS Provider. BAS Provider shall be fully responsible to interface and make available VFD information in the building automation system as monitor only information. Control of the VFD shall meet controller standalone requirements of Section 25.
- C. Controlled Equipment Power Wiring shall be furnished and installed under Division 26. Where control involves 120 volt (V) control devices controlling 120V equipment, Division 26 Contractor shall extend power wiring to the equipment. BAS Provider shall extend it from the equipment to the control device.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MATERIALS AND EQUIPMENT

- A. General: Provide electronic and electric control products in sizes and capacities indicated, consisting dampers, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.
- B. Communication Wiring and BAS low voltage wiring/cables: All wiring shall be in accordance with the latest edition of the National Electrical Code and Division 26. Wiring/cables shall be provided in a customized color jacketing material. Material color shall be as specified in section 27 05 53 (Identification for Low-Voltage Cables).
 - 1. Contractor shall supply all communication wiring between Building Controllers, Routers, Gateways, AAC's, ASC's and local and remote peripherals outside the MD ANDERSON IT infrastructure. (e.g., operator workstations, printers, and modems).

2. Local Supervisory LAN: For any portions of this network required under this Section of the Specification, Contractor shall comply with Division 27 Communication specifications. Network shall be run with no splices and separate from any wiring over thirty (30) volts.
 3. Secondary Controller LANs: Communication wiring shall be individually 100 percent shielded pairs per manufacturer's recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over thirty (30) volts. Shield shall be terminated, and wiring shall be grounded as recommended by building controller manufacturer.
 - a. Wet / Damp Locations – Wiring in underground raceways or raceways which are subject to moderate degrees of moisture shall be listed for installation in wet locations. Direct burial wiring without a raceway is prohibited.
- C. Signal Wiring: Contractor shall run all signal wiring in accordance with the latest edition of the National Electrical Code and Division 26.
1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be twisted, 100 percent shielded pair, minimum 18-gage wire, with PVC cover. Signal wiring shall be run with no splices and separate from any wiring above thirty (30) volts.
 - a. Wet / Damp Locations – Wiring in underground raceways or raceways which are subject to moderate degrees of moisture shall be listed for installation in wet locations. Direct burial wiring without a raceway is prohibited.
 2. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.
- D. Low Voltage Analog Output Wiring: Contractor shall run all low voltage control wiring in accordance with the latest edition of the National Electrical Code and Division 26.
1. Low voltage control wiring shall be 18-gage. Wiring size for RJ-11 and RJ-45 connectors shall be 22-gage, twisted pair, 100 percent shielded, with PVC cover, Class 2 plenum-rated. Low voltage control wiring shall be run with no splices separate from any wiring above thirty (30) volts.
 - a. Wet / Damp Locations – Wiring in underground raceways or raceways which are subject to moderate degrees of moisture shall be listed for installation in wet locations. Direct burial wiring without a raceway is prohibited.
- E. Control Panels: Provide control panels with suitable brackets for wall mounting, unless noted otherwise, for each control system. Locate panel adjacent to systems served. Mount center of control panels [60 inches – confirm with Owner] above finished floor or roof.
1. Interior: Fabricate panels of 16-gage furniture-grade steel, totally enclosed on four sides, with removable perforated backplane, hinged door and keyed lock, with manufacturer's standard shop-painted finish and color. Panel / enclosure shall be sized to provide adequate mounting space for all components plus a minimum of 25% spare backplane capacity. All components shall have a minimum of 2 inch clearance from the four sides of the panel unless factory wired and designed otherwise.

2. Provide UL-listed cabinets for use with line voltage devices.
3. Control panel shall be completely factory wired and piped, and all electrical connections made to a terminal strip. Wire nuts are not acceptable in exposed area of panel. High and low voltage cables shall be isolated from each other.
4. All gauges and control components shall be identified by means of nameplates or Owner approved equivalent.
5. Provide a 6 inch x 6 inch minimum wireway (metal wiring/tubing) trough across the entire width of the panel mounted to the top of the panel with close nipples of sufficient size for additional 50 percent wiring and tubing capacity. Wireways shall not be less than 24 inches in length. Control panel wiring shall be installed and distributed in the wireway to minimize routing of wiring and tubing within the control panel. Wireway construction to be the same as the associated control panel.
6. Complete wiring and tubing termination Drawings shall be mounted in, and a second set mounted adjacent to, each panel in a frame with lexan cover of sufficient size to be easily readable.

2.03 CONTROL DAMPERS

- A. General: Provide factory fabricated automatic control dampers of sizes, velocity and pressure classes as required for smooth, stable, and controllable airflow. Provide parallel or opposed blade dampers as recommended by manufacturer's sizing techniques. For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close-off pressure, and recommended by damper manufacturer for fan discharge damper service. Control dampers used for smoke dampers shall comply with UL 555S. Control Dampers used for fire dampers shall comply with UL 555.
- B. For general isolation and modulating control service in rectangular ducts at velocities not greater than 1500 feet per minute (fpm) (7.62 m/s), differential pressure not greater than 2.5 inches w.c. (622 Pa):
 1. Performance: Test in accordance with AMCA 500.
 2. Frames: Galvanized steel, 16-gage minimum thickness, welded or riveted with corner reinforcement.
 3. Blades: Stainless steel in lab exhausts and galvanized steel elsewhere, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts with set screws, 16 gage minimum thickness.
 4. Blade Seals: Synthetic elastomer, mechanically attached, field replaceable.
 5. Jamb Seals: Stainless steel.
 6. Shaft Bearings: Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.
 7. Linkage: Concealed in frame.

8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
 9. Leakage: Less than one percent based on approach velocity of 1500 fpm. (7.62 m/s) and 1 inches wg. (249Pa).
 10. Maximum Pressure Differential: 2.5 inches wg. (622 Pa).
 11. Temperature Limits: -40 to 200 degrees F (-40 to 93 degrees C).
 12. Where opening size is larger than 48 inches (1219 mm) wide or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames and jackshafts appropriate for installation.
- C. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6 inches w.c. (1493 Pa):
1. Performance: Test in accordance with AMCA 500.
 2. Frames: Galvanized steel, 16-gage minimum thickness, welded or riveted with corner reinforcement.
 3. Blades: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts, 14 gage minimum extrusion thickness.
 4. Blade Seals: Synthetic elastomeric, mechanically attached, field replaceable.
 5. Jamb Seals: Stainless steel.
 6. Shaft Bearings: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.
 7. Linkage: Concealed in frame.
 8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
 9. Leakage: Less than 0.1 percent based on approach velocity of 4000 fpm. (20.3 m/s) and 1 inches wg. (249Pa).
 10. Maximum Pressure Differential: 6 inches wg. (622 Pa).
 11. Temperature Limits: -40 to 200 degrees F (-40 to 93 degrees C).
 12. Where opening size is larger than 48 inches (1219 mm) wide or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames and jackshafts appropriate for the installation.
- D. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm, differential pressure not greater than 12 inches w.c.:
1. Performance: Test in accordance with AMCA 500.

2. Frames: Galvanized steel, 12-gage minimum thickness, welded or riveted with corner reinforcement.
 3. Blades: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 3/4 inch (19 mm) shafts with set screws.
 4. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
 5. Linkage: 10-gage minimum thickness galvanized steel clevis type crank arms, 3/16 inch x 3/4 inch (4.76 mm x 19 mm) minimum thickness tie rods.
 6. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
 7. Leakage: Less than 0.2 percent based on approach velocity of 4000 fpm (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
 8. Maximum Pressure Differential: 12 inches wg. (2984 Pa).
 9. Temperature Limits: -40 to 300 degrees F (-40 to 149 degrees C).
 10. Where opening size is larger than 48 inches (1219 mm) wide or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames and jackshafts appropriate for the installation.
- E. For general isolation and modulating control service in round ducts up to 40 inches in size at velocities not greater than 2500 fpm (12.7 m/s), differential pressure not greater than 4 inches w.c. (994 Pa):
1. Performance: Test in accordance with AMCA 500.
 2. Frames: Rolled 12 gage steel strip for sizes 6 inch and smaller, rolled 14 gage steel channel for larger sizes, galvanized or aluminum finish.
 3. Blades: Steel construction, 12 gage minimum thickness for dampers less than 18 inches (457 mm) in size, 10 gage minimum thickness for larger dampers.
 4. Blade Seals: Full circumference neoprene.
 5. Shaft: 1/2 inch (12.7 mm) diameter zinc or cadmium plated steel.
 6. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
 7. Leakage: Less than 0.2 percent based on approach velocity of 4000 fpm. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
 8. Maximum Pressure Differential: 4 inches wg. (994 Pa).
 9. Temperature Limits: -40 to 300 degrees F (-40 to 149 degrees C).

- F. For general isolation and modulating control service in round ducts up to 60 inches in size at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6 inches w.c. (1492 Pa):
1. Performance: Test in accordance with AMCA 500.
 2. Frames: Rolled 10-gage steel channel for sizes 48 inch and smaller, rolled 3/16 inch (4.76 mm) thick steel channel for larger sizes, galvanized or aluminum finish.
 3. Blades: Steel construction, 10-gage minimum thickness for dampers not greater than 48 inches in size, 1/4 inch (6.35 mm) minimum thickness for larger dampers.
 4. Blade stops: 1/2 inch x 1/4 inch (12.7 mm x 6.35 mm) full circumference steel bar.
 5. Blade Seals: Full circumference neoprene.
 6. Shaft: Zinc or cadmium plated steel, angle reinforcing as necessary.
 7. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
 8. Leakage: Less than 0.4 percent based on approach velocity of 4000 fpm (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
 9. Maximum Pressure Differential: 6 inches wg. (1492 Pa).
 10. Temperature Limits: -40 to 250 degrees F (-40 to 121 degrees C).

2.04 ACTUATORS

- A. General: Size actuators and linkages to operate their appropriate dampers or valves with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied.
- B. Actuators:
1. Ambient Operating Temperature Limits: -10 to 150 degrees F (-12.2 to 66 degrees C).
 2. Two Position Electric Actuators: Line voltage (120 volt, 24 volt) with spring return. Provide end switches as required.
 3. Modulating Electronic Actuators: Provide actuators with spring return for 0-5 Vdc, 0-10 Vdc, 2-10Vdc, and 4-20 mA on valves greater than 1 inch. 3-point floating actuators for terminal units are to fail in place unless specified otherwise. Actuators shall travel full stroke in less than 150 seconds. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL listed. Provide stroke indicator. Actuators shall have positive positioning circuit where indicated. [Parallel actuators on a single valve are allowed only if written approval is given by Owner]. Actuators shall have current limiting motor protection. Actuators shall have manual override. Modulating actuators for valves shall have minimum rangeability of 40 to 1.

- a. Close-Off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off pressure for two-way water valve applications shall be the shutoff head of associated pump. Required close-off rating of steam valve applications shall be design inlet steam pressure plus 50 percent for low pressure steam, and 10 percent for high pressure steam. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent.
- b. Subject to compliance with requirements, approved manufacturers are as follows:
 - 1) Siemens.
 - 2) Automated Logic.
 - 3) Belimo.
 - 4) Johnson Controls.
 - 5) Delta.
 - 6) Substitutions: By written approval from Owner.

2.05 GENERAL FIELD DEVICES

- A. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers and as required for proper operation in the system.
- B. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.
- C. Field devices specified herein are generally 'two-wire' type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, is not designed to work with 'two-wire' type transmitters, if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide 'four-wire' type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.
- D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy and repeatability equal to, or better than, the accuracy and repeatability listed for respective field devices.
- E. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, nonrepeatability and hysteresis.

2.06 VFD SERIAL COMMUNICATION

- A. VFD Serial communications shall include, but not be limited to monitor the following feedback signals:

1. Process variable.
2. Output speed/frequency.
3. Current
4. Torque
5. Power (kW)
6. Operating hours
7. Kilowatt hours (kWh)
8. Relay outputs
9. Diagnostic warning and fault information

2.07 DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

A. Liquid, Steam and Gas:

1. General: Two-wire smart DP cell type transmitter, 4-20 mA linear output, adjustable span and zero, stainless steel wetted parts.
2. Ambient Limits: 0 to 175 degrees F.
3. Process Limits: 0 to 175 degrees F.
4. Accuracy: Less than 0.3 percent.
5. Output Damping: Time constant user selectable from 0 to 36 seconds.
6. Vibration Effect: Less than ± 0.1 percent of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.
7. Electrical Enclosure: NEMA 4, 4X, 7, 9.
8. Approvals: FM, CSA.
9. Acceptable Manufacturers: Setra, Rosemount Inc. 3051 Series, Foxboro, Johnson-Yokagawa.

B. General Purpose Low Pressure Air: Generally for each measurement of duct pressure, filter differential pressure or constant volume air velocity pressure measurement where the range is applicable. Sensor shall be in range at all times.

1. General: Loop powered two-wire differential capacitance cell-type transmitter.
2. Output: Two wire 4-20 mA output with zero adjustment.
3. Overall Accuracy: Plus or minus 1 percent.

4. Minimum Range: 0.1 inches w.c.
5. Maximum Range: 10 inches w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Units shall be Setra,
8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.

2.08 DIFFERENTIAL PRESSURE SWITCHES (DPS)

- A. General Service Auto Reset - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing. Acceptable Manufacturer - Dwyer Series 1900 or approved equal.
- B. General Service Manual Reset - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Manual reset shall be readily accessible in reach of personnel installed at height not to exceed 5 feet above finished floor. Provide manufacturer's recommended static pressure sensing tips and connecting tubing. Acceptable Manufacturer - Dwyer Series 1900 or approved equal. The High Static Pressure Safety Switch shall alarm to the Building Automation System upon activation.
- C. General Service - Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range and 0 degrees F to 160 degrees F operating temperature range.

2.09 PRESSURE SWITCHES (PS)

- A. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150 percent of rated pressure.
- B. Acceptable Manufacturers: Siemens, Square D, ITT Neo-Dyn, ASCO, Penn, Honeywell, and Johnson Controls.

2.10 CURRENT SWITCHES (CS)

- A. Clamp-On Design Current Operated Switch (for Motor Status Indication):
 1. Range: 3.5 to 135 amps.
 2. Trip Point: Adjustable.
 3. Switch: Solid state, normally open, 0.1A @ 30VAC/DC.
 4. Trip Indication: LED.
 5. Approvals: UL, CSA.
 6. Maximum Cable Size: 350 MCM.

7. Manufacturers: Veris Industries H-608, H-904, H-908.
 - a. Veris Model Number H-608 restricted to constant speed motors rated 40 horsepower or less.
 - b. Veris Model Number H-904 required on VFD motors.
- B. Variable Speed Status: Contractor shall utilize programmable status contacts from the VSD where applicable.

2.11 CURRENT TRANSFORMERS (CT)

- A. Clamp-On Design Current Transformer (for Motor Current Sensing)
 1. Range: 1-10 amps minimum, 20-200 amps maximum.
 2. Trip Point: Adjustable.
 3. Output: 0-5 VDC.
 4. Accuracy: ± 0.2 percent from 20 to 100 Hz.
 5. Acceptable Manufacturers: KELE SA100.

2.12 ELECTRIC CONTROL COMPONENTS

- A. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley.
- B. Low Temperature Detector ('Freezestat') (FZ): Low temperature detector shall consist of a 'cold spot' element which responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8 inch x 20 feet (3.2mm x 6.1m), junction box for wiring connections and gasket to prevent air leakage or vibration noise, DPDT (4 wire, 2 circuit) with manual reset. Manual reset shall be readily accessible in reach of personnel installed at height not to exceed 5 feet above finished floor. Temperature range 15 to 55 degrees F (-9.4 to 12.8 degrees C), factory set at 38 degrees F. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each five square feet of cooling coil/duct face area. The Low Temperature Detector shall alarm to the Building Automation System upon activation
- C. High Temperature Detectors ('Firestat') (FS): High temperature detector shall consist of 3-pole contacts, a single point sensor, junction box for wiring connections and gasket to prevent air leakage of vibration noise, triple-pole, with manual reset. Temperature range 25 to 215 degrees F (-4 to 102 degrees C).
- D. Surface-Mounted Thermostat: Surface-mounted thermostat shall consist of SPDT contacts, operating temperature range of 50 to 150 degrees F (10 to 65 degrees C), and a minimum 10 degrees F fixed setpoint differential.

- E. Low Voltage Wall Thermostat: Wall-mounted thermostat shall consist of SPDT sealed contacts, operating temperature range of 50 to 90 degrees F (10 to 32 degrees C), switch rating of 24 Vac (30 Vac maximum), and both manual and automatic fan operation in both the heat and cool modes.
- F. Control Relays: All control relays shall be UL listed, with contacts rated for the application.
1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
 - a. Pilot light indication of power-to-coil. Pilot light shall be visible from a standing position of 5 feet AFF.
 - b. Coil rated for 50 and 60 Hz service.
 - c. Relays shall be labeled in a professional manner to identify the function or purpose. Coordinate with owner for approved verbiage of labels
 - d. Acceptable Manufacturers: Relays shall be Functional Devices (RIB), Potter Brumfield, Model KRPA or approved equal.
 2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 horsepower, and 1/3 horsepower, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC or approved equal.
 3. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.
 4. All safety circuits shall be installed to operate individual interposing relays located in the associated equipment control panel. Each safety device (i.e. freezestat, DP safety, smoke detector, firestat, etc.) wiring circuit shall be installed with individual homeruns back to the associated control panel. See control Drawings for details.
- G. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA 1 enclosure. Manufacturer shall be Square 'D', Cutler-Hammer or Westinghouse.
- H. Control Transformers: Furnish and install control transformers as required. Control transformers shall be machine tool type and shall be US and CSA listed. 120/24 VAC transformers shall be fused in accordance with the NEC. Transformer shall be properly sized for application and mounted in minimum NEMA 1 air vented enclosure. Multiple transformers in a single enclosure shall have fan aided ventilation whenever ambient temperature exceeds 140 deg F
1. Transformers shall be manufactured by Westinghouse, Square 'D', Jefferson or approved equal.
- I. Time Delay Relays (TDR): TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a NEMA 1 enclosure.

1. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.
 2. TDRs shall be UL and CSA listed, Crouzet type.
- J. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley or approved equal.
- K. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley or approved equal.
- L. Alarm Horn: Panel-mounted audible alarm horn shall be continuous tone, 120 Vac Sonalert solid-state electronic signal, as manufactured by Mallory or approved equal.
- M. Electric Selector Switch (SS): Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen-Bradley or approved equal.

2.13 NAMEPLATES

- A. Provide engraved phenolic or micarta nameplates for all equipment, components, and field devices furnished. Nameplates shall be 1/8 inch thick, black, with white center core, and shall be minimum 1 inch x 3 inch, with minimum ¼ inch high block lettering. Nameplates for devices smaller than 1 inch x 3 inch shall be attached to adjacent surface.
- B. Each nameplate shall identify the function for each device.

2.14 TESTING EQUIPMENT

- A. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is ±0.5 percent accurate, test equipment shall be ±0.25 percent accurate over same range).

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.

- C. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in Drawings and details shown on Drawings. Install electrical components and use electrical products complying with requirements of the latest edition of the National Electrical Code and all local codes.
- D. Control Wiring: The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connection of electric control devices.
1. Wiring System: Install complete wiring system for electric control systems. Conceal wiring exposed in mechanical rooms and areas where other conduit and piping are exposed. Installation of wiring shall generally follow building lines. Install in accordance with the latest edition of the National Electrical Code and Division 26. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.
 2. Control Wiring Conductors: Install control wiring conductors, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with the latest edition of the National Electrical Code and Division 26.
 3. Communication wiring, signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.
 4. All WAN and LAN patch cords shall be approved and installed as directed by owner.
 5. BAS low voltage wiring/cables: All cables shall have legible printed sleeve identification labels at each device and the panel termination.
 - a. Labels shall be Brady PermaSleeve TM, part number - "BPSPT-187-175-WT" or owner approved equivalent.
 - b. Each label shall be identified with the entire BAS point name utilized in the BAS database and the point address.
 - c. Install RJ11 modular jack plates for the Owner's spare alarm connection points specified on the drawing. The entire point address printed with black text on 1/2" high white labels shall be installed to identify each port of the RJ11 modular jack plate. Contractor shall confirm exact wall location with the Owner prior to installing.
 6. Terminate all control wiring internal to panels to screw terminals connections or owner approved wire connection equivalent. Wire nuts and/or splices are not allowed in panels. When terminating a wire cable, the cable jacket, cable shielding wire, and cable shielding material shall be finished in a neat consistent workmanlike manner.
 7. Install all control wiring external to panels in electric metallic tubing or raceway. Installation of wiring shall generally follow building lines. Provide steel type connectors. Install wiring in galvanized rigid steel conduit at all exterior locations and where subjected to moisture. Install in PVC Schedule 40 conduit if encased in concrete. All conduits penetrating partitions, walls or floors shall be sealed with a submitted and approved fire/smoke sealant to prevent migration of air through the conduit system.

8. Communication wiring, signal wiring and low voltage control wiring may be run without conduit in concealed, accessible locations if noise immunity is ensured.
 - a. Contractor shall be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.
 - b. Accessible locations are defined as areas inside mechanical equipment enclosures, such as heating and cooling units, instrument panels etc.; in accessible pipe chases with easy access, or suspended ceilings with easy access. Installation of wiring shall generally follow building lines.
 - c. Run in a neat and orderly fashion, bundled where applicable, and completely suspended (strapped to rigid elements or routed through wiring rings) away from areas of normal access. Tie and support conductors neatly with suitable nylon ties and not to exceed five (5) foot intervals.
 - d. Conductors shall not be supported by the ceiling system or ceiling support system. Conductors shall be pulled tight and be installed as high as practically possible in ceiling cavities. Wiring shall not be laid on the ceiling or duct.
 - e. Conductors shall not be installed between the top cord of a joist or beam and the bottom of roof decking.
9. Secondary LAN Communication cabling shall be provided in an Owner approved color dedicated to the BAS.
10. Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation Drawings..

END OF SECTION 25 11 10

MD Anderson Cancer Center										
Steam Control Valve Specification Sheet (Globe Body)										
Project Name				REVISIONS				SHEET		xx of xx
				NO.	BY	DATE	DESCRIPTION	SPEC. NO.		REVISION
				1				15951		*
				2				CONTRACT		DATE
				3				X		mm/dd/yy
				4				PROJECT NUMBER		
				5				XXXX.XX		
				6				BY	CHECKED	APPROVED
7				XYZ	XYZ	XYZ				
GENERAL	Tag Number		*							
	Service Description		*							
	P&ID Sheet Number		*							
	Line No. or Vessel No.		*							
	Line Size / Mat'l / Sch.		*							
	Electrical Class	Power Supply	*			*				
PROCESS DATA	Fluid	Fluid State	SATURATED STEAM <125 PSIG			VAPOR				
	Operating Condition		Units	Minimum	Normal	Maximum	Other			
	Flow Rate		LB/HR	*	*	*	*			
	Inlet Pressure		PSIG	*	*	*	*			
	Outlet Pressure		PSIG	*	*	*	*			
	Temperature		DEG F	*	*	*	*			
	Mol. Wt.									
	Sp. Wt	Sp. Grav								
	Viscosity	Sp Heat								

SECTION 25 14 10 – BAS FIELD PANELS - RETROFIT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Section includes:
 - 1. Building Controller (BC).
 - 2. Advance Application Specific Controller (AAC).
 - 3. Application Specific Controller (ASC).
- B. Furnish and install DDC Control units and/or Smart Devices required to support specified building automation system functions.
- C. Refer to Section 25 00 10 for general requirements.
- D. System shall be listed for controlling a Stair Pressurization system.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within all references.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 STAND-ALONE FUNCTIONALITY

- A. General: These requirements clarify the requirement for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone functionality is specified with the controller and for each Application Category specified in this Section. This item refers to acceptable paradigms for associating the points with the processor.
- B. Functional Boundary:
1. Provide controllers so that all points associated with and common to one unit or other complete system/equipment shall reside within a single control unit. The boundaries of a standalone system shall be as dictated in the Contract Documents.
 2. Systems specified for the Application Category will dictate the boundary of the standalone control functionality. See related restrictions below.
 3. When referring to the controller as it pertains to the standalone functionality, reference is specifically made to the processor.
 4. One processor shall execute all the related I/O control logic via one operating system that uses a common programming and configuration tool.
- C. The following configurations are considered acceptable with reference to a controller's standalone functionality:
1. Points packaged as integral to the controller such that the point configuration is listed as an essential piece of information for ordering the controller (having a unique ordering number).
 2. Controllers with processors and modular back planes that allow plug in point modules as an integral part of the controller.
 3. I/O point expander boards, plugged directly into the main controller board to expand the point capacity of the controller.
- D. The following configurations are considered unacceptable with reference to a controller's standalone functionality:
1. I/O point expansion devices connected to the main controller board via wiring and as such may be remote from the controller and that communicate via a sub LAN protocol.
 2. Multiple controllers enclosed in the same control panel to accomplish the point requirement.

2.03 BUILDING CONTROLLER (BC)

- A. The BC(s) shall provide fully distributed control independent of the operational status of the OWSs and CSS. All necessary calculations required to achieve control shall be executed within the BC independent of any other device. All control strategies performed by the BC(s) shall be both operator definable and modifiable through the Operator Interfaces.

- B. BCs shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices and perform all necessary mathematical and logical functions.
- C. BCs shall share information with the entire network of BCs for full global control directly without requiring other BCs, LAN devices, Local Supervisory LAN gateways, routers etc. to assist, perform, or act as an intermediate device for communicating.
- D. Each controller shall permit multi-user operation from multiple workstations and portable operator terminals connected either locally or over the Primary Controller LAN. Each unit shall have its own internal RAM, non-volatile memory, microprocessor, battery backup, regulated power supply, power conditioning equipment, ports for connection of operating interface devices, and control enclosure.
- E. BCs shall be programmable from an operator workstation, portable operator terminal, or hand held operating device. BC shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.
- F. BCs shall be connected to a controller network that qualifies as a Primary Controlling LAN.
- G. All BCs shall be protected from any memory loss due to a loss of power, power surge, or unstable power by one or a combination of the following:
 - 1. Volatile RAM shall have a battery backup using a lithium battery with a rated service life of fifty (50) hours, and a rated shelf life of at least five (5) years. Self-diagnostic routine shall report an alarm for a low battery condition.
 - 2. EEPROM, EPROM, or NOVRAM non-volatile memory.
- H. In addition, BCs shall provide intelligent, standalone control of HVAC functions. Each BC shall be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar and voltage transient and lightning protection devices. Refer to standalone functionality specified above.
- I. For systems requiring end-of-line resistors those resistors shall be located in the BC.
- J. Input-Output Processing:
 - 1. Digital Outputs (DO):
 - a. Outputs shall be rated for a minimum 24 Vac or Vdc, 1 amp maximum current. Each shall be configurable as normally open or normally closed.
 - b. Each output shall have an LED to indicate the operating mode of the output and a manual hand off or auto switch to allow for override. Provide feedback to remotely indicate the HOA is not in the Auto position. If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure.
 - c. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.

2. Analog Inputs (AI):
 - a. AI shall be 0-5 Vdc, 0-10 Vdc, 0-20 Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input.
 - b. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise).
 - c. A/D converters shall have a minimum resolution of twelve (12) bits.
3. Digital Inputs (DI):
 - a. Monitor dry contact closures.
 - b. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board.
4. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
5. Electronic Analog Outputs (AO):
 - a. Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection.
 - b. Pulse Width Modulated (PWM) analog via a DO and transducer is acceptable only with Owner approval (Generally these will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops.).
 - c. Where these are allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturers board is unacceptable).
 - d. D/A converters shall have a minimum resolution of ten (10) bits.
6. Analog Output Pneumatic (AOP), 0-20 psi:
 - a. Pneumatic outputs via an I/P transducer, or digital to pneumatic transducer are acceptable.
 - b. Multiplexed digital to pneumatic transducers are acceptable provided they are supplied as a standard product and part of the BC and provide individual feedback.
 - c. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.
7. Pulsed Inputs:
 - a. Capable of counting up to eight (8) pulses per second with buffer to accumulate pulse count.
 - b. Pulses shall be counted at all times.

K. BC Power Loss:

1. Upon a loss of power, power surge, or unstable power to any BC, the other units on the primary controlling network shall not in any way be affected.
2. Upon a loss of power, power surge, or unstable power to any BC, the battery backup shall ensure that the energy management control software, the Direct Digital Control software, the database parameters, and all other programs and data stored in the RAM are retained for a minimum of fifty (50) hours. An alarm diagnostic message shall indicate that the BC is under battery power.
3. Upon restoration of power within the specified battery backup period, the BC shall resume full operation without operator intervention. The BC shall automatically reset its clock such that proper operation of any time dependent function is possible without manual reset of the clock. All monitored functions shall be updated.
4. Should the duration of a loss of power exceed the specified battery back-up period or BC panel memory be lost for any reason, the panel shall automatically report the condition (upon resumption of power) and be capable of receiving a download via the network, and connected computer. In addition, the Owner shall be able to upload the most current versions of all energy management control programs, Direct Digital Control programs, database parameters, and all other data and programs in the memory of each BC to the operator workstation via the local area network, or via the telephone line dial-up modem where applicable, or to the laptop PC via the local RS-232C port.

L. BC Failure:

1. Building Controller LAN Data Transmission Failure: BC shall continue to operate in stand-alone mode. BC shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value. Peer BCs shall recognize the loss, report alarm and reconfigure the LAN.
2. BC Hardware Failure: BC shall cease operation and terminate communication with other devices. All outputs shall go to their specified fail position.

M. BCs may include LAN communications interface functions for controlling secondary controlling LANs Refer to Section 25 30 10 - BAS System Communications Devices for requirements if this function is packaged with the BC.

N. All BC naming conventions shall adhere to the format as established by the Owner's Standard Acronyms document.

O. I/O Point Expansion Devices communicating to BC via a sub LAN protocol:

1. Utilizing any point from a point expansion device communicating to BC via a sub LAN protocol to support the BC's Stand Alone Functionality requirement is not allowed.
2. Point expansion devices shall be mounted in packaged equipment enclosures, or locking wall mounted enclosure in a readily accessible location. Identify panel enclosure with the entire point address of point expansion device(s) on an engraved phenolic or micarta nameplate.

3. The owner shall approve the location of point expansion devices mounted above finished ceiling prior to installation. An owner approved ceiling tag shall identify the specific location of the point expansion device location.
4. Each point expansion device shall be identified in the database with the location of where the device is physically installed to allow the owner to service these devices when needed. The owner shall approve the final method identifying the locations with the available software options.

2.04 ADVANCED APPLICATION SPECIFIC CONTROLLER (AAC) AND APPLICATION SPECIFIC CONTROLLER (ASC)

A. General Requirements:

1. AACs and ASCs shall provide intelligent, standalone control of HVAC equipment. Each unit shall have its own internal RAM, non-volatile memory and will continue to operate all local control functions in the event of a loss of communications on the ASC LAN or sub-LAN.
2. AACs and ASCs shall include sufficient memory to perform the specific control functions required for its application and to communicate with other devices.
3. Each AAC and ASC must be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, minimum eight (8) bit A to D conversion, voltage transient and lightning protection devices. All volatile memory shall have a battery backup of at least fifty (50) hours with a battery life of five (5) years.
4. All point data; algorithms and application software within an AAC /ASC shall be modifiable from the Operator Workstation.
5. AAC and ASC Input-Output Processing:
 - a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each DO shall be discrete outputs from the AAC/ASC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
 - b. Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10Vdc, 0-20Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of eight to ten bits depending on application.
 - c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board.
 - d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
 - e. Electronic Analog Outputs (AO) as required by application:

- 1) Voltage mode, 0-5VDC and 0-10VDC; current mode (4-20 mA). Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO and transducer is acceptable only with Owner approval (Generally, PWM will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops.).
- 2) Where PWM is allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturers board is unacceptable).
- 3) D/A converters shall have a minimum resolution of eight (8) bits.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. All Division 25 installation including but not limited to, cable and wiring, grounding, raceway and conduit, electrical circuit and panel identifications, wiring devices, and lighting shall comply with Division 26 installation requirements. In addition to the Division 26 requirements, contractor shall label panel board name and circuit number in an owner approved manner at each BAS field panel, control cabinet, or point of termination in which a 120VAC control circuit is utilized.

3.02 HARDWARE APPLICATION REQUIREMENTS

- A. General:
 1. The functional intent of this Specification is to allow cost effective application of manufacturers standard products while maintain the integrity and reliability of the control functions.
 2. A Building Controller as specified above is generally fully featured and customizable whereas the AAC/ASC refers to a more cost-effective unit designed for lower-end applications. Specific requirements indicated below are required for the respective application. Manufacturer may apply the most cost-effective unit that meets the requirement of that application.
- B. Standalone Capability:
 1. Each Control Unit shall be capable of performing the required sequence of operation for the associated equipment.

2. All physical point data and calculated values required to accomplish the sequence of operation shall originate within the associated CU with only the exceptions enumerated below. Listed below are functional point data and calculated values that shall be allowed to be obtained from or stored by other CUs or SDs via LAN.
- C. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.
- D. Application Category 0 (Distributed Monitoring):
 1. Applications in this category include the following:
 - a. Monitoring of variables that are not used in a control loop, sequence logic, or safety.
 2. Points on BCs, AACs, and ASCs may be used in these applications as well as SDs and/or general-purpose I/O modules.
 3. Where these points are trended, Contractor shall verify and document that the network bandwidth is acceptable for such trends and is still capable of acceptable and timely control function.
- E. Application Category 1 (Application Specific Controller):
 1. Applications in this category include the following:
 - a. Fan Coil Units.
 - b. Airflow Control Boxes (VAV and Constant Volume Terminal Units).
 - c. Miscellaneous Heaters.
 - d. Unitary equipment <15 tons (Package Terminal AC Units, Package Terminal Heat Pumps, Split-System AC Units, Split-System Heat Pumps, Water-Source Heat Pumps).
 - e. Induction Units.
 - f. Dual Duct Zone Dampers.
 2. Standalone Capability:
 - a. Provide capability to execute control functions for the application for a given setpoint or mode, which shall generally be occupied mode control.
 - b. Only the following data (as applicable) may be acquired from other controllers via LANs. In the event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the ASC shall use the last value obtained before the fault occurred.
 - c. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Value
Scheduling Period	Normal

Physical/Virtual Point	Default Value
Morning Warm-Up	Off (cold discharge air)
Load Shed	Off (no shedding)
Summer/Winter	Winter
Trend Data	N/A

3. Mounting:

- a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use.
- b. ASCs that control equipment mounted in a mechanical room may either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
- c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.
- d. BAS Provider may furnish ASCs to the terminal unit manufacturer for factory mounting.

4. LAN Restrictions: For networks operating at 38.4 kbps or less, limit the number of nodes on the network to meet all system performance criteria and to no more than 80 percent of the maximum recommended by the manufacturer. For networks operating at greater than 38.4 kbps limit the number of nodes on the network to meet all system performance criteria up to the maximum recommended by the manufacturer.

F. Application Category 2 (General Purpose Terminal Controller):

1. Applications in this category include the following:

- a. Unitary Equipment \geq 15 tons (Air Conditioners, Heat Pumps, Packaged Heating/Cooling Units, and similar).
- b. Small, Constant Volume Single Zone Air Handling Units.
- c. Constant Volume Pump Start/Stop.
- d. Miscellaneous Equipment (Exhaust Fan) Start/Stop.
- e. Miscellaneous Monitoring (not directly associated with a control sequence and where trending is not critical).

2. Standalone Capability:

- a. Only the following data (as applicable) may be acquired from other ASCs via LANs.
- b. In the event of a loss of communications with any other ASCs, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC/ASC shall use the last value obtained before the fault occurred.
- c. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Delay Time	Default Value
Outside Air Temperature	3 minutes	80°F
Outside Air Humidity	3 minutes	60% RH
Outside Air Enthalpy	3 minutes	30 Btu/lb
Trend Data		N/A
Cooling/Heating Requests	3 minutes	None

3. Mounting:

- a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment and shall be rated for plenum use.
 - b. ASCs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the Contractor) or in a near by mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.
4. LAN Restrictions: Limit the number of nodes servicing any one of these applications on the AAC/ASC LAN to 80 percent capacity on new installed LANs.
5. LAN Restrictions: Comply with Part Two requirements, Stand-Alone Functionality.

3.03 CONTROL UNIT REQUIREMENTS

- A. Refer to Section 25 00 10 for requirements pertaining to control unit quantity and location.

END OF SECTION 25 14 10

SECTION 25 15 10 – BAS SOFTWARE AND PROGRAMMING - RETROFIT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Section includes:
 - 1. Point Structuring.
 - 2. Alarm.
 - 3. Point Structuring.
 - 4. Graphics.
- B. Fully configure systems and furnish and install all software, programming and dynamic color graphics for a complete and fully functioning system as specified.
- C. Refer to Section 25 00 10, Building Automation System (BAS) General - Retrofit for general requirements as well as requirements for interface with Owner's WAN.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within all references.

PART 2 - PRODUCTS

2.01 POINT STRUCTURING AND NAMING

- A. General:
 - 1. The intent of this Section is to require a consistent means of naming points across the Owner's WAN. Configure the systems from the perspective of the Owner's WAN, not solely the local Project.

2. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, and the like.
3. The convention is tailored towards the Owner's WAN and as such, the interface shall always use this naming convention.
4. Native BACnet systems shall also use this naming convention. For non-BACnet systems, the naming convention shall be implemented as much as practical, and any deviations from this naming convention shall be approved by the Owner.
5. Each controller shall have English language descriptors for all system points, variables, parameters etc. located and accessible from the controller memory. All point naming shall match between all system files and record documents.

B. Point Summary Table:

1. The BAS Provider shall coordinate with the Owner's Building Automation System department to compile and submit a proposed Point Summary Table for review prior to any object programming or project startup. The Contractor shall support and not impede direct negotiations between the BAS Provider and the Owner to allow the customizing necessary for structuring the BAS point names to meet the Owner's needs. The MD ANDERSON Manager of Building Automation will provide the format form of the Point Summary Table to be submitted to the BAS Provider upon request. Contactor shall ensure final BAS point names have the approval of the Owner's Manager of Building Automation System prior to any object programming or project startup.
2. The Point Summary Table shall be kept current throughout the duration of the Project by the Contractor as the Master List of all points for the Project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the Owner the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.

C. Point Naming Convention

1. All proposed point names shall reference the existing MD ANDERSON BAS Acronym Standards which can be located and viewed on the Apogee BAS Server.

D. Device Addressing Convention:

1. BACnet network numbers and Device Object IDs shall be unique throughout the network.
2. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner.
3. Coordinate with the Owner or a designated representative to ensure that no duplicate Device Object IDs occur.
4. Alternative Device ID schemes or cross project Device ID duplication if allowed shall be approved before Project commencement by the Owner.

PART 3 - EXECUTION

3.01 SYSTEM CONFIGURATION

- A. Contractor shall thoroughly and completely configure BAS system software, supplemental software, network communications, CSS, OWS, remote operator workstation, portable operators terminal, printer, and remote communications.

3.02 SITE-SPECIFIC APPLICATION PROGRAMMING

- A. Provide all database creation and Site-specific application control programming as required by these Specifications, national and local standards and for a fully functioning system. Provide all initial Site-specific application programming and thoroughly document programming. Generally meet the intent of the written sequence of operation. It is the Contractor's responsibility to request clarification on sequence issues that require such clarification.
- B. All Site-specific programming shall be fully documented and submitted for review and approval, both prior to downloading into the panel, at the completion of functional performance testing, and at the end of the Warranty Period. Programs shall utilize comment lines which will also reside in the field panel.
- C. All programming, graphics and data files must be maintained in a logical system of directories. All file names shall adhere to the naming convention format as established in the Owner's Standard Acronyms documentation. All files developed for the Project will be the property of the Owner and shall remain on the workstation(s)/server(s) at the completion of the Project.

3.03 ALARMS

- A. This Section supersedes and over rules all references to building automation alarms in the Contract Documents, including all sequences of operations and other sections of the BAS Specification in regards to alarms. The Contractor shall support and not impede direct negotiations between the BAS Provider and the Owner to allow the customizing necessary for customizing alarms and alarm parameters to meet the Owner's needs.
- B. The BAS Provider is required to submit a point summary to confirm building automation point names as specified herein The BAS Provider shall submit this point summary with the addition of identifying all alarms which includes detail information on the alarm parameters to the MD ANDERSON Manager of Building Automation for approval prior to the beginning of any commissioning process of the building automation system.
- C. The MD ANDERSON Manager of Building Automation will provide the format form to the BAS Provider upon request. The Owner shall grant approval of alarms to be verified through commissioning by issuing the approved alarms to the Contractor. The approved alarms issued to the Contractor shall be used for the Functional Test Procedures alarms tested. The Contractor shall initiate the start of this process immediately after building automation submittal have been approved and monitor the progress to ensure the construction schedule is not delayed.
- D. Analog Input Alarms:

1. All other Analog Inputs:

- a. BAS Provider shall utilize their expertise and recommend not less than three (3) analog input alarms which protect the Owner's best interests.
- b. Submit at Priority 3 with recommended alarm parameters.
- c. Identify recommended alarms in submittal.
- d. Owner will confirm alarm.

E. Digital Inputs Alarms:

1. Proofs (current sensor, air flow switches, water differential pressure switches etc).
 - a. Digital inputs paired with BAS digital output will have the ability to alarm at all times @ Priority 3.
 - b. Alarm will delay for the reason time needed when the state of the digital output changes to prevent nuisance alarms.
 - c. Point is in alarmed condition when the value of the digital input does not equal the value of the digital output after the time delay.
 - d. Point is in the Normal condition when the value of the digital input equals the value of the digital output after the time delay.
 - e. Digital input proofs without a paired digital output shall not alarm and be for monitoring purposes only.
2. Safeties (high static cutout, freeze condition, excessive vibration, high humidity cutout, VFD fault, etc.).
 - a. The digital input shall be always ready to alarm without delay.
 - b. The digital input shall display "ALARM" at Priority 3 at the Alarm screen when activated.
 - c. The digital input shall display "NORMAL" at the Alarm screen when deactivated.
3. Monitoring Digital Inputs (auxiliary drain pan alarm, Liebert Unit general alarm, water detector, etc) the exception is air filter differential pressure switch.
 - a. All digital inputs which "deactivated" is the normal state of planed operations shall alarm when the normal state of planed operation changes.
 - b. The digital input shall display "ALARM" at Priority 3 at the Alarm screen when activated.
 - c. The digital input shall display "NORMAL" at the Alarm screen when deactivated.

F. Analog Outputs Alarms:

1. All Analog Outputs:

- a. BAS Provider shall utilize their expertise and recommend any analog output alarms which protect the Owner's best interests.
 - b. Identify recommended alarms in submittal.
 - c. Owner will confirm any alarms.
- G. Digital Outputs Alarms:
1. Refer to digital inputs paired with digital outputs as specified herein.
 2. All Digital Outputs:
 - a. BAS Provider shall utilize their expertise and recommend any digital output alarms which protect the Owner's best interests.
 - b. Identify recommended alarms in submittal.
 - c. Owner will confirm any alarms.
- H. All alarms shall be enhanced to alarm and display the alarm Priority level at the alarm screen table of the specific Owner approved BAS workstations
- I. Priority 2 Critical Alarms: All incubator temperature alarms, ultra low temperature alarms, and any other alarm that the Owner deems critical shall report to the Owner specified destinations as a Priority 2 alarm. The Contractor, with Owner approved time delays and triggered points, shall enhance the alarm to prevent nuisance alarming.
- J. Priority 3 Mechanical Critical Alarms: All mechanical equipment alarms, which has been identified by the Owner and is achievable with the I/O point available in the Project, shall report to the Owner specified destinations as a Priority 3 alarm. The Contractor, with Owner approved time delays and triggered points, shall enhance the alarm to prevent nuisance alarming.
- K. Priority 4 Mechanical Alarms: Dirty air filters alarms and non critical alarms, which has been identified by the Owner and is achievable with the I/O point available in the Project, shall report to the Owner specified destinations as a Priority 4 alarm. The Contractor, with Owner approved time delays and triggered points, shall enhance the alarm to prevent nuisance alarming.
- L. Nuisance Alarms: All alarms which have been identified by the Owner as a nuisance alarm due to numerous times in and out of alarm shall be addressed and corrected by the Contractor in a manner that the Owner has approved.
- M. Contractor shall review Owner's current and typical BAS existing alarms. The Contractor shall use this data as a guideline in identifying all alarmable points for this Project. The Contractor shall submit all virtual and physical points involved in the Project with all alarmable points identified for the Owner to review. Contractor is responsible for complying with all alarming requests by the Owner that is achievable with the I/O point available in the Project, with existing BAS database, and with the creation of any necessary virtual points.

3.04 GRAPHIC SCREENS

- A. Background resolution shall be 1280 x 1024 for all graphics.
- B. Floor Plan Screens: The Contract Document Drawings will be made available to the Contractor in AutoCAD LT 2002 format upon request. These Drawings may be used only for developing backgrounds for specified graphic screens; however the Owner does not guarantee the suitability of these Drawings for the Contractor's purpose. Graphic Screens shall be submitted for approval.
 1. Provide graphic floor plan screens for each floor [wing] [tower] [other] of each building.
 - a. Indicate the location of all equipment that is not located on the equipment room screens.
 - b. Indicate the location of temperature sensors associated with each temperature-controlled zone (i.e., VAV terminals, fan-coils, single-zone AHUs, etc.) on the floor plan screens.
 - c. Display the space temperature point adjacent to each temperature sensor symbol. Use a distinct line symbol to demarcate each terminal unit zone boundary. Use distinct colors to demarcate each air handling unit zone.
 - d. Mechanical floor plan Drawings will be made available to the Contractor upon request for the purpose of determining zone boundaries. Indicate room numbers as provided by the Owner.
 - e. Provide a drawing link from each space temperature sensor symbol and equipment symbol shown on the graphic floor plan screens to each corresponding equipment schematic graphic screen.
 - f. The Owner may approve the substitution of tabular graphics in lieu of floor plan graphics as circumstances apply. Contractor shall verify with Owner whether to create tabular or floor plan graphics.
 2. If multiple floor plans are necessary to show all areas, provide a graphic building key plan. Use elevation views and/or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.
 3. Provide a graphic for each system of the Project. Contact Owner to identify all systems requiring a graphic. An example of the AHU system is:
 - a. Provide graphic screens for each air handling system to include but not limited to describe area served and any information the Owner has identified as pertinent.
 - b. Link screens for air handlers to the heating system and cooling system graphics.
 - c. Link screens for supply and exhaust systems if they are not combined onto one screen.

4. Provide a graphic for each system of the Project. Contact Owner to identify all systems requiring a graphic. An example of the CHW system is:
 - a. Provide a cooling system graphic screen showing all points associated with the chillers, cooling towers and pumps.
 - b. Indicate outside air dry-bulb temperature and calculated wet-bulb temperature.
 - c. Link screens for chilled water and condenser water systems if they cannot fit onto one cooling plant graphic screen.
5. Link graphic screens to all pertinent graphics and/or pertinent data/ information the Owner has requested.
 - a. Link the appropriate sequence of operations to graphics. (.rtf format).
 - b. Link approved schematic control Record Drawing to graphic. (.pdf format)
6. Submit all graphics per Section 25 00 10 for Owner approval.

END OF SECTION 25 15 10

SECTION 25 30 10 – BAS COMMUNICATION DEVICES - RETROFIT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Section includes:
 - 1. Local Supervisory LAN Gateways/Routers.
 - 2. Variable Frequency Drives (VFD's).
- B. Provide all interface devices and software to provide an integrated system connecting BCs, AACs, ASCs and Gateways to the Owner's Wide Area Network (MD ANDERSON WAN).

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within all references.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 LOCAL SUPERVISORY LAN GATEWAYS/ROUTERS

- A. The Supervisory Gateway shall be a microprocessor-based communications device that acts as a gateway/router between the Supervisory LAN CSSs or OWS and the Primary LAN.
- B. The Gateway shall perform information translation between the Primary LAN and the Local Supervisory LAN, which is 100 Mbps Ethernet TCP/IP and shall use BACnet over IP.

- C. The gateway shall contain its own microprocessor, RAM, battery, real-time clock, communication ports, and power supply as specified for a BC in Section 25 14 10. Each gateway/router shall be mounted in a lockable enclosure unless it is a PC that also serves as an OWS.
- D. The gateway/router shall allow centralized overall system supervision, operator interface, management report generation, alarm annunciation, acquisition of trend data, and communication with control units. It shall allow system operators to perform the following functions from the CSS, OWSs, and POTs:
 - 1. Configure systems.
 - 2. Monitor and supervise control of all points.
 - 3. Change control setpoints.
 - 4. Override input values.
 - 5. Override output values.
 - 6. Enter programmed start/stop time schedules.
 - 7. View and acknowledge alarms and messages.
 - 8. Receive, store and display trend logs and management reports.
 - 9. Upload/Download programs, databases, etc. as specified.
- E. Upon loss of power to the Gateway, the battery shall provide for minimum 100 hour backup of all programs and data in RAM.
- F. The Gateway shall be transparent to control functions and shall not be required to control information routing on the Primary LAN

PART 3 - EXECUTION

3.01 PREPARATION

- A. Examine areas and conditions under which control systems are to be installed. Do not proceed with Work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Provide all interface devices and software to provide an integrated system.

- D. Closely coordinate with the Owner, or designated representative, to establish IP addresses and communications to assure proper operation of the building automation system with Owner's WAN.

END OF SECTION 25 30 10

SECTION 26 01 00 - BASIC ELECTRICAL REQUIREMENTS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Drawings are necessarily diagrammatic by their nature and are not intended to show every connection in detail or every pipe or conduit in its exact location. Carefully investigate structural and finish conditions and coordinate the separate trades in order to avoid interference between the various phases of Work. Organize and lay out Work so that it will be concealed in furred chases and suspended ceilings, etc., in finished portions of the building, unless specifically noted to be exposed. Install all Work parallel or perpendicular to building lines unless otherwise noted.
- B. The intent of the Drawings is to establish the types of systems and functions; not to set forth each item essential to the functioning of the system. Install the Work complete, including minor details necessary to perform the function indicated. Review pertinent Drawings and adjust the Work to conditions shown. Where discrepancies occur between Drawings, Specifications, and actual field conditions, immediately notify the Owner's Project Manager for Owner's interpretations.
- C. Coordinate the actual locations of electrical outlets and equipment with building features and equipment as indicated on architectural, structural, mechanical, and plumbing Drawings. Review any proposed changes in electrical wiring devices or equipment location with the Owner's Project Manager. Owner may direct relocation of outlets before installation, up to five (5) feet from the position indicated, without additional cost. Remove and relocate outlets placed in an unsuitable location when requested by the Owner, at no additional cost to the Owner.
- D. All dimensional information related to new structures shall be taken from the appropriate Drawings. All dimensional information related to existing facilities shall be taken from actual measurements made by the Contractor on the Site.
- E. Existing Structures: The building floor slabs, structure, and outer walls are generally existing to remain. The only existing penetrations are openings where indicated on the Drawings. This Contract requires the Contractor to core drill all other floor or wall penetrations as required. All floor penetrations shall include a sleeve that extends two (2) inches above the floor. Bus duct penetrations shall have a minimum 4-inch high curb as per NEC requirement or per drawing, whichever is higher.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the Contract Documents.

1.04 DEFINITIONS

- A. Concealed: Concealed areas are those areas that cannot be seen by building occupants.
- B. Exposed: Exposed areas are all areas that are exposed to view by building occupants, including areas below counter tops, inside cabinets and closets, inside all equipment rooms, and areas outside the building exterior envelope, exposed to the outdoors.

1.05 QUALITY ASSURANCE

- A. Regulations: Work, materials and equipment shall comply with the latest rules and regulations specified in National Fire Protection Association (NFPA).
- B. Discrepancies: The Drawings and Specifications are intended to comply with listed codes, ordinances, regulations and standards. Where discrepancies occur, immediately notify the Owner's Project Manager in writing and ask for an interpretation. Should installed materials or workmanship fail to comply, the Contractor is responsible for correcting the improper installation at no additional cost to the Owner. Additionally, where sizes, capacities, or other such features are required in excess of minimum code or standards requirements, provide those specified or shown.
- C. Contractor Qualifications: An acceptable Contractor for the Work under this Division must have personnel with experience, training and skill to provide a practical working system. The Contractor shall furnish acceptable evidence of having installed not less than three systems of size and type comparable to this Project. All personnel installing equipment under this Division shall possess valid City of Houston and State of Texas licenses for their skill level. Each Journeyman shall supervise no more than two apprentice helpers. Refer also to Owner's Special Conditions.

1.06 SUBMITTALS

- A. Product Data: Provide coordination Drawings with submittals as required by Division 01.
- B. Record Documents: In addition to hard copy format, all material submitted as final record products, including approved Shop Drawings and submittals, shall be submitted to the Owner in its original electronic file format on compact disc or DVD. Material may be scanned into electronic file format where necessary.

1.07 DELIVERY, STORAGE AND HANDLING

- A. All equipment and materials shall be delivered to the Project Site clean and sealed for protection.
- B. Moisture: During construction, protect switchgear, transformers, motors, control equipment, and other items from insulation moisture absorption and metallic component corrosion by appropriate use of strip heaters, lamps or other suitable means. Apply protection immediately upon receiving the products and maintain continually.

- C. Damage: Take such precautions as are necessary to protect apparatus and materials from damage. Failure to protect materials is sufficient cause for rejection of the apparatus or material in question.
- D. Finish: Protect factory finish from damage during construction operations until acceptance of the Project. Restore any finishes that become stained or damaged to Owner's satisfaction.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Equipment and control systems should match, integrate, communicate or cooperate with Owner's existing systems, such as power monitoring systems, building automation, fire alarm, motor control centers, switchgears, breakers, transformers, and lighting dimming systems.
- C. Conditions: Provide new products of manufacturers regularly engaged in production of such equipment. Provide the manufacturer's latest standard design for the type of product specified. Products shall be U.S. made. Owner reserves the right to approve or disapprove foreign-made products.
- D. NEC and UL: Products shall conform to requirements of the National Electrical Code. Where Underwriters' Laboratories have set standards, listed products and issued labels, products used shall be listed and labeled by UL.
- E. Space Limitations: Equipment selected shall conform to the building features and shall be coordinated with all components. Do not provide equipment that will not meet arrangement and space limitations. Contractor shall submit room layouts with submitted items shown drawn to scale. Submittals will be rejected without floor plan Drawings showing submitted items.
- F. Factory Finish: Equipment shall be delivered with a hard surface, factory-applied finish so that no additional field painting is required except for touch-up.
- G. Common Source: Equipment specified in Sections 26 22 13, 26 23 00, 26 24 16, 26 24 19, 26 28 17, 26 29 14, 26 43 13 shall be provided by the same manufacturer.
- H. Series Ratings: Overcurrent devices shall have fully rated interrupting capacity. Series rating of devices is unacceptable.

2.02 EQUIPMENT AND DEVICE MARKING

- A. Externally mark all equipment, devices, conduits for feeders, branch circuits and similar devices using the same circuit designations as indicated on construction drawings and final Record Documents. Conduit marks shall be made at the point of origin and destination of the conduits, using permanent marker.
- B. Nameplates shall be black laminated rigid phenolic with white core. Emergency nameplates shall be red laminated phenolic with white cores. Nameplate minimum size shall be 1 inch high by 3 inches long with 3/16 inch high engraved white letters. Supply blank nameplates for spare units and spaces.

- C. Nameplate Fasteners: Fasten nameplates to the front of equipment only by means of stainless steel self-tapping screws. Stick-ons or adhesives are not acceptable unless the NEMA enclosure rating is compromised, then only epoxy adhesive shall be used to attach nameplates.
- D. Nameplate Information: The general naming convention shall consist of the following segments:
1. Building name in abbreviated form where equipment is located;
 2. Building floor where electrical equipment is located;
 3. Electrical system type: NP (normal power), EP (emergency power), LS (life safety branch), CB (critical branch), EB (equipment system branch);
 4. System voltage: M (medium voltage), H (277/480V) or L (120/208V);
 5. Individual equipment identification: A, B, C, etc.
- E. In general, provide the following information for the types of electrical equipment as listed:
1. Switchgears, Switchboards, Distribution Panels and Motor Control Centers: On mains, identify the piece of equipment, the source, and voltage characteristics (i.e., 480/277V 3PH 4W). For each branch circuit protective device, identify the load served.
 2. Transformers, Individual Starters, Contactors, Disconnect Switches, Transfer Switches and Similar Equipment: Identify the device designation, voltage characteristics source and load served.
 3. Panelboards: Identify panelboard designation, voltage characteristics, and source designation.
- F. Panelboards: Prepare a neatly typed circuit directory printed on 80 weight paper. This directory shall be installed behind clear heat-resistant plastic in a metal frame tack welded to the inside of the door for each panelboard. Identify circuits by equipment served and by building room numbers where room numbers exist. Indicate spares and spaces with light, erasable pencil marking. Adhesive mounted directory pocket is not acceptable. Removing and attaching panel schedules from the Drawings is not acceptable.
- G. Panelboards, Pull, Junction and Outlet Boxes:
1. With ½ inch high permanent lettering, identify conduits connected to panelboards, pull, junction and outlet boxes with the complete circuit number of the conductors contained therein. Neutral conductors shall be identified by wire marker tags in the panelboards, pull, junction and outlet boxes. Where multiple circuits are contained in a box, identify the circuit conductors with permanent tags which indicate circuit designation.
 2. Emergency circuit junction boxes and their covers shall be painted red. Circuit identification shall be marked on the junction box cover.
 3. Fire alarm circuits (only) shall be marked with half red covers and "Fire Alarm" marked on the face.

- H. Equipment and raceways over 600 Volts: Provide "WARNING - HIGH VOLTAGE - KEEP OUT" signs on all equipment. With 2 inch-high lettering, mark all exposed raceways containing conductors operating in excess of 600 volts every 100 feet and at each wall or floor penetration with the words "WARNING - HIGH VOLTAGE".
- I. Power receptacles, wall switches and dedicated outlets. Identify circuits as per Specification Section 26 27 26.
- J. Dedicated outlets: Dedicated is understood to be specific equipment listed by equipment number in the panel schedules or identified on the Drawings. Dedicated also includes computer outlets.
- K. Remote Ballasts: For remote ballasts not within five (5) feet of their associated lighting fixture, provide appropriate permanent lettering on both the ballasts and the light fixture to identify which are mated to the other.

2.03 INDUSTRIAL CONTROL PANELS

- A. The scope of the work does not intend to cover the Integrated Automation System, neither the design for a functional process control system. It is not intended to apply to the wirings that form an integral part of the equipment, such as motors, controllers, or factory assembled control equipment or listed utilization equipment. It intends to provide the guideline for constructing Industrial Control Panels defined by NFPA 70 Article 409.
- B. The electrical requirements pertaining to, but not limited to, branch circuits, luminaires, motor circuits and controllers, air-conditioning and refrigerating equipment, hazardous locations, short-circuit and ground-fault protection, overcurrent/overload protection, industrial machinery, etc. shall be in accordance with the applicable requirements from the specific articles in NFPA 70 Article 409 Table 409.3.
- C. Industrial Control Panels shall be built in accordance with the requirements of Division 25 Integrated Automation System, and shall utilize components that are UL listed, UL recognized, or specified by MDACC specifications. Component manufacturers shall have an established network of product distribution for parts replacement. The nearest distribution point shall be within 50 miles of the Project Site.
- D. Multi-section industrial control panels shall be bonded together with an equipment grounding conductor or an equivalent equipment grounding bus sized in accordance with NFPA 70 Article 250. Equipment grounding conductors shall be connected to this equipment grounding bus or to equipment grounding termination point provided in a single-section industrial control panel.
- E. NFPA 70 Article 110 Table 110.20 shall be used as the basis for selecting industrial control panel enclosures for use in specific locations other than hazardous (classified) locations. Industrial control panel enclosures shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to other switches or overcurrent devices or other equipment, unless the conductors fill less than 40 percent of the cross-sectional area of the wiring space.
- F. The phase arrangement on 3-phase horizontal common power and vertical buses shall be A, B, C from front to back, top to bottom, or left to right, as viewed from the front of the industrial control panel.
- G. Spacing between live bare metal parts in feeder circuits shall not be less than specified in NFPA 70 Article 430 Table 430.97.

- H. Control panel internal wiring shall be installed neatly in panduit system.

PART 3 - EXECUTION

3.01 DEMOLITION

- A. Unless otherwise noted, remove all electrical materials and equipment from areas indicated for demolition. Removal of equipment shall not interfere with existing operations.
- B. Remove conduit and wire back to panelboards or to nearest junction box that is not being removed and needs to remain in service. Wire shall be removed back to point of origin. Turn off circuit breakers or switches serving abandoned circuits and tag breaker or switch and label in panel schedule as "Spare".
- C. Materials and equipment to be removed, except items specifically noted to be relocated or delivered to the Owner, become property of the Contractor and shall be immediately removed from the Project Site. If the Owner identifies other items during construction, those items become Owner property and will be turned over to the Owner.
- D. Electrical services and controls to items being removed shall be disconnected and removed from the Project Site.
- E. All fluorescent lighting fixtures being removed from the Project Site that will not be turned over to the Owner shall have any PCB-containing ballasts removed from the fixtures for environmental disposal. Ballasts shall remain intact with wire leads at least twelve (12) inches long.
- F. Contractor shall ensure that light switches within the Work area remain operational. Where temporary 120 volt light strings are installed, a switch shall be provided for the light strings near the Project entry door.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. Installation shall be in accordance with manufacturer's published recommendations.
- C. Fasteners requiring explosive powder (shooting) or pneumatic-driven actuation will not be acceptable under any circumstances.
- D. Cooperation with Other Trades: Cooperate with trades of adjacent, related or affected materials or operations, and with trades performing continuations of this Work in order to effect timely and accurate placing of Work and to coordinate, in proper and correct sequence, the Work of such trades.
- E. Workmanship: Work shall be performed by competent workers skilled in their trade. This installation must be complete.
- F. Housekeeping Pads: Unless otherwise noted. Install 3 1/2 inch thick concrete foundation pads for indoor floor-mounted equipment, except where direct floor mounting is required. Pour pads on roughened floor slabs, sized so that outer edges extend a minimum of 3 inches beyond equipment. Trowel pads smooth and chamfer edges to a 1 inch bevel. Secure equipment to pads as recommended by the manufacturer.

- G. Setting of Equipment: Equipment must be leveled and set plumb. Sheet metal enclosures mounted against a wall must be separated from the wall not less than 1/4 inch by means of corrosion-resistant spacers or by 3 inches of air for freestanding units. Use corrosion resistant bolts, nuts and washers to anchor equipment. Provide Drawings and layout Work showing exact size and location of sleeves, openings or inserts for electrical equipment in slabs, walls, partitions and chases in sufficient time to be coordinated with Work under other divisions.
- H. Sealing of Equipment: Seal openings into equipment to prevent entrance of animals, birds and insects.
- I. Motors: Electrical Work includes the electrical connection of all motors, except those that are wired as a part of equipment.
- J. Concealed Work: Conceal all electrical Work in walls, floors, chases, under floors, underground, and above ceilings except:
1. Where shown or specified to be exposed. Exposed is open to view.
 2. Where exposure is necessary to the proper function.
 3. Where size of materials and equipment preclude concealment.
- K. Application: Unless otherwise indicated, power will be utilized as follows:
1. 480 volts, three phase: Motors $\frac{3}{4}$ horsepower and larger and electric heating equipment.
 2. 120 volts, single phase: Motors $\frac{1}{2}$ horsepower and smaller.
 3. 120 volts, single phase: Incandescent lighting and fluorescent task lighting.
 4. 277 volts, single phase: Fluorescent and high-intensity-discharge lighting and electric heating equipment.
 5. 120 volts, single phase: Convenience outlets.
 6. 208 volts, single and three phase: Power outlets.
- L. Transformers: Use transformers to change the service to the required utilization voltages.
- M. Provide final electrical connections to equipment furnished under other divisions and by the Owner. Furnish detailed Shop Drawings of equipment indicating the exact number and location of rough-in points. Such final Shop Drawings may indicate adjustments in total number and exact location of rough-in points, and in equipment dimensions. Making adjustments to field conditions is considered a part of the Work required.
1. Roughing-in: When roughing-in electrical branch circuits to various items of equipment, terminate at proper points as indicated on detailed equipment Shop Drawings or as directed by Owner. Do not rely on Drawings accompanying these Specifications for rough-in locations, only for general routing of circuiting.
 2. Final Connections: Laboratory casework, medical equipment, and food service equipment will include service fittings such as switches, duplex receptacles, lighting fixtures, etc., on the casework or equipment. Provide branch circuit connections to meet service fitting requirements.

- N. Refer to Divisions 07 and 09 for sealing and firestopping requirements where raceways penetrate smoke, fire, and sound rated walls.
- O. All unused openings such as but not limited to, knockouts on panels and boxes, surface wireway openings, busway openings, circuit breaker empty slots shall be covered with approved cover plates.
- P. Temporary power equipment and distribution for construction shall not occupy building spaces or block pathways that are designated for permanent installation of other trades according to design drawings.

3.03 TESTING

A. Test Conditions:

- 1. Place circuits and equipment into service under normal conditions, collectively and separately, as may be necessary to determine satisfactory operation. Perform specified tests in the presence of the Owner's representative(s). Furnish all instruments, wiring, equipment and personnel required for conducting tests. Demonstrate that the equipment operates in accordance with requirements of the Contract Documents. Special tests on certain items are specified hereinafter.
- 2. Testing shall be performed by an independent testing company that is Owner approved, and National Electrical Testing Association (NETA) certified. Submit copies of test reports.
- 3. Prior to testing, Contractor shall submit to Owner for approval, installation verification Prefunctional Checklists and Functional Performance Test procedures. These shall be used for documentation as part of the commissioning process.
- 4. All instruments required for conducting the tests shall be NIST (National Institute for Standard and Technology) certified or traceable, and calibrated at the time of testing.

B. Test Dates: Schedule final acceptance sufficiently in advance of the Contract date to permit completion of any necessary adjustment or alterations within the number of days allotted for completion of the Contract. Provide written notification to Owner at least fourteen (14) calendar days in advance of Functional Performance Test dates.

C. Retests: If retesting is required due to initial failure, conduct retests of such time duration as may be necessary to assure proper functioning of adjusted or altered parts or items of equipment. Any resultant delay as a result of such necessary retests does not relieve the Contractor of Contractor's responsibility under this Contract.

D. Circuit Verification: All 120-volt single-phase circuits shall be verified to match the Drawings and panel schedules by "ringing out" each circuit in the presence of the Owner's representative(s).

E. Refer to Commissioning Specification Sections for additional start-up, pre-functional and operational checkout, and for functional performance test procedures.

END OF SECTION 26 01 00

SECTION 26 05 19 – CABLE, WIRE AND CONNECTORS, 600 VOLT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. This Section specifies the requirements for 600-volt cable, wire and connectors. It consists of but is not limited to power distribution circuitry, control system circuitry, lighting circuitry, appliance, equipment and motor-branch circuitry and outdoor power and lighting circuitry.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. NEMA WC 3: Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - 2. NEMA WC 5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - 3. Where application of National Electrical Code, appears to be in conflict with the requirements of this section, the Owner shall be asked for an interpretation.

1.04 SUBMITTALS

- A. Product Data:
 - 1. Submit manufacturer's data on cable and wire connectors.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Provide factory-wrapped waterproof flexible barrier material for covering wire and cable wood reels, where applicable; and weather resistant fiberboard containers for factory-packaging of cable, wire and connectors, to protect against physical damage in transit. Damaged cable, wire or connectors shall be removed from the Project Site.
- B. In their factory-furnished coverings, store cable, wire and connectors in a clean, dry indoor space which provides protection against the weather.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
- B. Provide factory-fabricated wire of the size, rating, material and type as indicated for each service. Where not indicated, provide proper selection as required to comply with installation requirements and with NEC standards. The minimum size wire to be used for power or lighting circuits shall be #12 copper stranded with insulation as noted below. Minimum size for control circuits shall be #14 copper stranded.

2.02 MANUFACTURERS

- A. Interstate Wire Company.
- B. American Insulated.
- C. Okonite.
- D. Southwire.
- E. Encore Wire.

2.03 BUILDING WIRE

- A. NEMA WC 70 – Nonshielded 0-2kV Cables
- B. Feeders and Branch Circuits all sizes: 98 percent conductivity copper, stranded conductor, 600-volt insulation, THHN/THWN. Use XHHW insulation for all isolated power circuits.
- C. Control Circuits: 98 percent conductivity copper, stranded conductor, 600 volt insulation, THHN, THWN.
- D. Color Coding:
 - 1. Branch Circuit and Feeders:

	<u>280Y/120 Volts</u>	<u>480Y/277 Volts</u>	<u>120/240 Volts</u>
Phase A	Black	Yellow	Black
Phase B	Red	Brown	Red
Phase C	Blue	Orange	---
Neutral	White with tracer	Gray with tracer	White with tracer
Ground	Green	Green	Green

- 2. The above colors shall be used unless requirements of code require different colors. When connecting to existing circuits, existing color coding shall be utilized. The neutral tracer color shall match the phase conductor color that it is associated with. Lighting circuits with shared grounding conductor are not required to have tracer colors on the wire.
- 3. Secondary conductors from isolation transformers shall be: Conductor 1-orange and conductor 2-brown.

4. Conductors No. 8 AWG and larger shall be identified by colored plastic tape that matches the circuit phase color at all visible points when colored insulation is unavailable. Colored tape shall be located and of such a quantity to readily indicate the conductor phase.
- E. Type AC and MC cable assemblies shall be permitted only with proper cable management via cable trays and with Owner's prior written approval.

2.04 REMOTE CONTROL AND SIGNAL CABLE

- A. Control Cable for Class 1 Remote Control and Signal Circuits: 98 percent conductivity copper conductor, 600-volt insulation, rated 60 degrees C, individual conductors twisted together, shielded and covered with a PVC jacket.
- B. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits: 98 percent conductivity copper conductor, 300-volt insulation, rated 60 degrees C, individual conductors twisted together, shielded and covered with a nonmetallic jacket; UL listed for use in air handling ducts, hollow spaces used as ducts, and plenums.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Installer must examine the areas and conditions under which cable, wire and connectors are to be installed and notify the Contractor and Owner in writing of conditions detrimental to the proper and timely completion of the work.
- B. Inspect wire and cable for physical damage. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. General wiring methods:
 1. Install electrical cable, wire and connectors as indicated. All installations, temporary or permanent, shall be in accordance with the manufacturer's written instructions, the applicable requirements of NEC, and as required ensuring that products serve the intended functions.
 2. Coordinate cable and wire installation work with electrical raceway and equipment installation work, as necessary for proper interface.
 3. Cables shall be selected on the basis of their purpose and UL listing. Generally, use Types THWN, XHHW and THNN in building interiors and other dry locations. Outdoors and in underground in raceways, use Type THWN or THHN. Conductors subject to abrasion, such as in lighting poles, shall be Type THWN or THHN.

4. No conductor smaller than No. 12 wire shall be used for branch circuit wiring. In the case of "homeruns" over 50 feet in length (100 feet for 277 volt), no conductor smaller than a No. 10 wire shall be used. The tap conductor from the J-box in the ceiling to the receptacle may be No. 12. Each 120-volt phase conductor shall have a neutral conductor of the same size. The sizing of all wire except remote control wire shall be accomplished in the case of both feeder and branch circuits by conforming to the following provisions.
 - a. 480 Volt Branch Circuits: The voltage drop in the case of 277/480 volt circuits shall not exceed 1.0 percent at maximum load and 70.0 percent power factor.
 - b. 120/208 Volt Branch Circuits: The voltage drop in the case of 120/208 volt circuits shall not exceed 2.0 percent at maximum load and 70.0 percent power factor.
5. Remote control wires shall be no smaller than No.14 AWG stranded copper conductors and shielded with drain. Control wires shall be run in separate conduits. Departures from the sizes so determined shall be made only in those cases in which the National Electrical Code requires the use of larger conductors. The sizes as determined from these tables shall be regarded as the acceptable minimum under all other circumstances. In no case, however, shall there be a voltage drop greater than that specified in any feeder or branch circuit. This voltage drop shall be based on the full load, 70 percent power factor, the total impedance drop with 60-hertz alternating current and with the reactance drop in the respective metal conduits duly considered. The Contractor may, if Contractor deems it necessary or advisable, use larger sized conductors than those shown. Under no circumstances, however, shall the Contractor use any conductors sized in a manner which does not conform to the above mentioned tables without having first secured the written approval of the Owner's duly authorized representative.

D. Wiring Installation Raceways:

1. Wire and cable shall be pulled into clean dry conduit.
2. Pull conductors together where more than one is being installed in a raceway.
3. Use UL listed pulling compound or lubricant, when necessary; compound must not deteriorate conductor and insulation. No pulling compound shall be used when pulling isolated power circuits utilizing XHHW insulation.
4. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed. Wires with damaged insulation shall be replaced at no cost to the Owner.
5. Place an equal number of conductors for each phase of a circuit in same raceway.
6. No more than three phase conductors shall be installed in same conduit. Line conductors shall not share the same conduit with load conductors.

E. Wiring Connections and Terminations:

1. Splicing cable or wire is not allowed unless it is explicitly designed by the Engineer, or for equipment connection per equipment manufacturer's recommendation. Where splices are to be implemented, approval of the Owner must be obtained before installation is made. Provide electrical boxes where splices are made.
2. Thoroughly clean wires before installing lugs and connectors.

3. Terminate indoor spare conductors with electrical tape in a box.
4. Conductors installed outdoors or in garages, whether in use or spare, shall be installed in conduits and terminated in boxes that are rated for outdoor use with listed connectors that are rated for watertight/rain tight applications. The use of indoor wire nuts with electrical tape is prohibited for installations outdoors or in garages.

F. Field Quality Control:

1. Torque test conductor connections and terminations to manufacturer's recommended values.
2. Perform continuity test on all conductors. Verify proper phasing connections and phase rotation, where applicable.
3. Conductors in vertical conduits or raceways shall be supported in the manner set forth in the appropriate section of the latest revision of the National Electrical Code. Lighting fixtures shall not be used for raceways for circuits other than series wiring of fixtures.
4. Conductors may be run parallel on sizes 1/0 to 500 kCMIL inclusive provided all parallel conductors are the same size manufacturer, length and type of insulation. Except as otherwise shown on Drawings, no more than three (3) conductors may be run in parallel, and they shall be so arranged and terminated as to ensure equal division of the total current between all conductors involved. Where parallel connection is contemplated, approval of the Owner must be obtained before installation is made.

3.03 TESTING

- A. Before final acceptance, the Contractor shall make voltage, insulation and load tests, necessary to demonstrate to the Owner the satisfactory installation and proper performance of all feeder circuits.
- B. Test feeder conductors to determine the conductors are clear of faults, high resistance connections and megger test same at 600 volts DC. Test results below 30 mega ohms shall be cause for rejection of the wiring installation. Replace and retest all such rejected conductors.

END OF SECTION 26 05 19