**Company Name:**

_____

**TARRANT COUNTY**
PURCHASING DEPARTMENT

**MELISSA LEE, C.P.M., A.P.P.**
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# RFP NO. 2023-077

# REQUEST FOR PROPOSALS FOR TARRANT COUNTY CORRECTIONS CENTER BUILDING AUTOMATION SYSTEM (BAS) REPLACEMENT PROJECT

## PROPOSALS DUE MARCH 6, 2023 2:00 P.M. CST

## VOLUME 2

RFP NO. 2023-077

BAIRD, HAMPTON & BROWN

building partners

## Scope Summary

To: Bidders

From: Les Brown, PE

Date: January 17, 2023

Subject: Tarrant County Corrections Center Replace Building Automation System

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Remove existing Building Automation System and replace with new Building Automation System per the Drawings and Specifications.

1. The Building Automation System (BAS) Contractor for this project will be the Prime Contractor and will be responsible for ALL work on the project. The BAS Vendor will need to acquire ALL required subcontractors that are needed to complete all elements of the work. This will include, but not be limited to: Electrical work and General Construction work.

2. This contract to replace the Building Automation System will be performed concurrently with a separate contract to replace the existing Air Handling Unit equipment. The work for this contract will need to be performed in close coordination with the Air Handling equipment Contractor so that it will be installed as if one seamless project.

3. This Contractor will furnish certain control devices to the Air Handling Unit equipment replacement Contractor who will install them. This will include chilled water and heating water control valves and automatic control dampers and fire/smoke dampers.

4. The Building Automation System replacement work, and related Air Handling equipment replacement work (performed under separate contract) will be performed on a Quadrant-by-Quadrant basis. When one Quadrant is down for replacement, all functions on the remaining 3 Quadrants must remain fully functional.

5. The First, Second, Third Floors and portion of the Fifth Floor will remain occupied during the duration of the project and will need to have Heating and Air Conditioning maintained at all times. Provisions for using temporary ductwork from other units while these units are replaced is indicated on the drawings. Provide temporary controls as required.

6. Perform all work in accordance with all applicable National and Local Codes and Code Authorities.

7. Submit electronic copy of Shop Drawings for all materials furnished under this work.

8. Secure and pay for all necessary permits, licenses and inspections required by Law for the completion of the work. Secure and pay for all certificates of approval that are required and deliver them to the Engineer before final acceptance of the work.

9. Examine the project site and make allowances in the Bid to accommodate existing conditions.

10. All material shall be new, UL listed, and free from defects, unless existing material is specifically shown to be reused. Install all material in accordance with good workmanship standards.

11. Substitutions of specified material must be approved in writing by the Engineer prior to bidding.

12. Provide factory finish on all material furnished to the jobsite and touch up finishes which have been damaged.

13. Schedule for removing existing BAS equipment and installation of replacement BAS equipment shall be carefully coordinated with Tarrant County Facilities Management prior to any work.

14. All equipment and accessories will be new.

15. Provide all electrical work required to support the new BAS equipment in conformance with NEC requirements.

16. Most ceilings in the secure areas are ¾" security cement plaster on metal lath. The Contractor will make any required ceiling openings for equipment access, install new access door and repair ceiling.

17. All Testing and Balancing work will be provided by the County's TAB Contractor, Air Balancing Company, and will not be included in the bid.

18. As part of the proposal for this project, the Contractor shall include a list of similar projects of this type, and also a list of projects within jail facilities. Provide a minimum of (2) references, with contact information, that can verify previous work within jail facilities.

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1/17/23

SECTION 23 00 10

BASIC MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS AND SUPPLEMENTAL GENERAL PROVISIONS

A. The "General Conditions" and "Supplementary Conditions" are by reference made a part of this section and shall apply to each and every heading as though included herein.

B. In the event of conflict, the requirements of the "General Conditions" and "Supplementary Conditions" will take precedence over these "General Requirements".

C. The "General Conditions" are reference for understanding of the Basic Mechanical Requirements for the simultaneous replacement Air Handling Unit replacement project.

1.2 GENERAL

A. This contract to replace the existing Building Automation System (BAS) shall be performed concurrently with a separate project to replace the existing Air Handling Units. The work for this contract shall be performed in close coordination with the Air Handling Unit contractor so that it will be installed as if one seamless project, and shall fully comply with all Owner directed scheduling and phasing of work.

B. The Contractor shall provide all plans, labor, equipment, appliances and materials, and shall perform all operations in connection with the installation of the mechanical work in accordance with the specifications, applicable drawings, and the conditions specified above.

C. Contractor shall furnish and install all equipment required to provide a complete and operable system, whether or not specifically mentioned or specifically indicated on the drawings.

1.3 INSPECTION OF THE SITE

A. The Contractor shall visit the site, verifying all existing items indicated on drawings and/or specified, and familiarize himself with the existing work conditions, hazards, grades, actual formations, soil conditions, and local requirements. The submission of bids shall be deemed evidence of such visits.

B. All proposals shall take these existing conditions into consideration, and the lack of specific information on the drawings shall not relieve the Contractor of any responsibility.

C. In the event that equipment specified and/or reviewed is not compatible with the existing conditions, the trade furnishing the equipment shall be responsible for notifying the Contractor prior to ordering it.

1.4 PERMITS, UTILITY CONNECTIONS, AND INSPECTIONS

A. Refer to other sections of the specifications for construction phasing and time increments.

B. The Contractor shall obtain and pay for all required utility connections, utility extensions and/or relocations and shall pay all costs and inspection fees for all work included herein.

1.5 APPLICABLE CODES AND STANDARDS

A. The installation shall meet the minimum standards prescribed in the latest editions of the following listed codes and standards, which are made a part of the Specifications, except as may be hereinafter modified in these Specifications and associated drawings.

B. Latest edition of the National Fire Protection Association Standards (NFPA):

1. NFPA No. 70 National Electrical Code
2. NFPA No. 90A Installation of Air Conditioning and Ventilating systems
3. NFPA No. 91 Exhaust systems of Air Conveying of Gases, etc.
4. NFPA No. 101 Safety to Life from Fire in Buildings and Structures
5. NFPA No. 255 Test of Surface Burning Characteristics of Building Materials

C. United States of America Standards Institute (ASA) Standards:

1. A40.8 National Plumbing Code
2. B31.1 & B31.1a Code for Pressure Piping

D. American Society of Mechanical Engineers (ASME): Boiler and Pressure Vessel Codes.

E. Air Conditioning and Refrigeration Institute Standards (ARI): All standards related to refrigeration and air conditioning equipment and piping furnished under these Specifications.

F. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA) 1985: All applicable manuals and standards.

G. Air Moving and Conditioning Association (AMCA): All applicable manuals and standards.

H. American Society of Testing and Material (ASTM): All applicable manuals and standards.

I. American Water Works Association (AWWA): All applicable manuals and standards.

J. National Electrical Manufacturer's Association (NEMA): All applicable manuals and standards.

K. City Fire Department as applicable to construction of this site.

L. City and State Building Codes.

M. State of (Texas) Occupational Safety Act: Applicable safety standards.

N. Occupational Safety and Health Act (OSHA).

O. State of (Texas) Energy Conservation Construction Code.

P. All work shall be in accordance with all regulations and requirements of the State of Texas Architectural Barriers Act (TAS).

Q. Refer to Specifications sections hereinafter bound for additional codes and standards.

R. All materials and workmanship shall comply with all applicable state and national codes, specifications, and industry standards. All material shall be listed by the Underwriter's Laboratories, Inc., as conforming to its standards and so labeled in every case where such a standard has been established for the particular type of material in question.

S. All equipment provided and all installation methods shall meet all applicable requirements of the Fort Worth Energy Code or International Energy Conservation Code.

T. The Contract Documents are intended to comply with the aforementioned rules and regulations; however, some discrepancies may occur. Where such discrepancies occur, the Contractor shall immediately apply for an interpretation. Should the discovery and notification occur after the execution of a contract, any additional work required for compliance with said regulations shall be paid for as covered by other specifications of the Contract Documents, providing no work or fabrication of materials has been accomplished in a manner of non-compliance. Should the Contractor fabricate and/or install materials and/or workmanship in such a manner that does not comply with the applicable codes, rules and regulations, the Contractor who performed such work shall bear all costs arising in correcting these deficiencies to comply with said rules and regulations.

1.6 CONTRACT DOCUMENTS

A. These specifications are accompanied by drawings of the building and details of the installations indicating the locations of equipment, piping, ductwork, outlets, switch controls, circuits, lines, etc. The drawings and these specifications are complementary to each other, and what is required by one shall be as binding as if required by both.

B. If the Contractor deems any departures from the drawings necessary, details of such departures and the reasons therefore shall be submitted to the Engineer for review. No departures shall be made without prior written acceptance.

C. There are intricacies of construction that are impractical to specify or indicate in detail; however, in such cases the current rules of good practice and applicable specifications shall govern.

D. It is the Contractor's responsibility to properly use all information found on the Mechanical and Electrical drawings where such information affects his work.

E. All dimensional information related to new structures should 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.

F. The interrelation of the specifications, the drawings, and the schedules is as follows: The specifications determine the nature and setting of the several materials, the drawings establish the quantities, dimensions and details, and the schedules give the performance characteristics.

G. Should the drawings or specifications disagree within themselves, or with each other, the better quality of greater quantity of work or materials shall be estimated upon, and unless otherwise directed by the Engineer in writing, shall be performed or furnished. Figures indicated on drawings govern scale measurements and large-scale details govern small-scale drawings.

1.7 SPACE AND EQUIPMENT ARRANGEMENT

A. The size of mechanical, and electrical equipment indicated on the drawings is based on the dimensions of the manufacturer used as basis of design. While other manufacturers may be acceptable, it is the responsibility of the Contractor to determine if the equipment he proposes to furnish will fit in the space. Shop drawings shall be prepared to indicate a suitable arrangement.

B. All equipment shall be installed in a manner that will allow required access.

C. Maintain all code required clearances for equipment access.

1.8 FABRICATION DRAWINGS

A. Contractor shall submit shop drawings whenever (1) equipment proposed varies in physical size and arrangement from that indicated on the drawings, thus causing rearrangement of equipment space, (2) where tight spaces require extreme coordination between ductwork, piping, conduit and other equipment, and (3) where called for elsewhere in these specifications.

B. All required shop drawings, except as hereinafter specified, shall be prepared at a scale of not less than 1/8 in. equal to 1 ft. for floor plans and 1/4 in. equal to 1 ft. for mechanical rooms.

1.9 SUPERVISION

A. Each contractor shall keep a competent superintendent or foreman on the job at all times necessary for the timely and proper completion of the work.

B. It shall be the responsibility of each superintendent to study all drawings and familiarize himself with the work to be done by other trades. He shall coordinate this work with other trades, and before material is fabricated or installed, make sure that his work will not cause an interference that cannot be resolved without major changes to the drawings. If a conflict between trades arises that cannot be resolved at the jobsite, the matter shall be referred to the Architect for his ruling.

1.10 EXISTING FACILITIES

A. The Contractor shall be responsible for loss or damage to the existing facilities caused by any workers, and shall be responsible for repairing or replacing such loss or damage. The Contractor shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and in-service maintenance of all plumbing, heating, air conditioning, and ventilating services for the new and existing facilities. The Contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, and remove all such temporary protection upon completion of the work. All barricades and safety devices shall be in compliance with OSHA.

B. The Contractor shall provide temporary or new services to all existing facilities as required to maintain their proper operation when normal services are disrupted as a result of the work being accomplished under this project.

C. Where existing construction is removed to provide working and extension access to existing utilities, Contractor shall remove doors, piping, conduit, outlet boxes, wiring, light fixtures, air conditioning ductwork and equipment, etc., to provide this access and shall reinstall same upon completion of work in the areas affected.

D. Outages of services, as required by the new installation, will be permitted only at a time approved by the Owner.

1.11 DEMOLITION AND RELOCATION

A. The Contractor shall modify, remove and/or relocate all materials and items so indicated on the drawings or required by the installation of new facilities. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operative condition.

B. All items that are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The Contractor shall clean and repair and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore to good operative order. All relocations shall be performed by workmen skilled in the work and in accordance with standard practice of the trades involved.

C. Service lines and wiring to items to be removed, salvaged, or relocated shall be removed to points indicated on the drawings, specified, or acceptable to the Owner. Service lines and wiring not scheduled for reuse shall be removed and sealed, capped, or otherwise tied-off or disconnected in a safe manner acceptable to the Engineer. All disconnections or connections into the existing facilities shall be done in such a manner as to result in minimum interruption of services to adjacent occupied areas. Services to existing areas of facilities, which must remain in operation during the construction period, shall not be interrupted without prior specific approval of the Engineer as hereinbefore specified.

D. All equipment and materials indicated to be removed and not be re-used shall be disposed of by the Contractor.

1.12 OPERATING AND MAINTENANCE INSTRUCTIONS

A. The Contractor shall prepare, in triplicate for the Owner's Manual, complete sets of operating and maintenance instructions, system piping, valving, control and interlock diagrams, manuals, parts lists, etc., for each item of equipment. Include copies of all equipment warranties.

B. In addition, the Contractor shall provide the services of a competent certified technician acceptable to the Engineer to instruct a representative of the Owner in the complete and detailed operation of all equipment and systems. These instructions shall be provided for a period of not less than 8 hours to fully accomplish the desired results. Upon completion of these instructions, a letter of release will be required, stating the dates of instruction and the personnel to whom instructions were given. The Contractor shall be responsible for proper maintenance until the instructions have been given to the Owner's maintenance personnel.

1.13 GUARANTEE

A. All work and equipment shall be guaranteed for a period of one year from the date of substantial completion.

B. Guarantee shall be for all labor and materials.

1.14 MATERIALS AND WORKMANSHIP

A. All materials, unless otherwise specified, shall be of current U.S. manufacture, new, free from all defects, and of the best quality of their respective kinds. Materials and equipment shall be installed in accordance with the manufacturer's recommendations and the best standard practice for the type of work involved. All work shall be executed by mechanics skilled in their respective trades, and the installations shall present a neat, workmanlike appearance. Materials, and/or equipment damaged in shipment, or otherwise damaged prior to installation, shall not be repaired at the job site, but shall be replaced with new materials and/or equipment.

B. The responsibility for furnishing the proper equipment and/or material, and to see that it is installed as intended by the manufacturer rests entirely upon the Contractor, who shall request advice and supervisory assistance from the representative of specific manufacturers during the installation.

1.15 FLAME SPREAD PROPERTIES OF MATERIALS

A. Materials and adhesives incorporated in this project shall conform to NFPA 255, latest edition. The classification shall not exceed No. 2, with the range of indices between 0 to 25 for these Classifications as listed in the Federal Specifications. Modifications shall be made to insulating materials, etc., as required to comply with the Federal Specification.

1.16 SLEEVES, INSERTS AND FASTENINGS

A. Pipes passing through concrete or cinder walls and floor or other corrosive material shall be protected by a protective sheathing or wrapping or by sleeves, as required to meet the local code. Annular spaces between sleeves and pipes shall be filled or tightly caulked in an approved manner. Annular spaces between sleeves and pipes in fire-resistance-rated assemblies shall be filled or tightly caulked in accordance with the local code.

B. The minimum clearance between horizontal penetrations including insulation where applicable, and sleeves shall be 1/4 in., except that the minimum clearance shall be 2 in. where piping contacts the ground. Sleeves through walls and partitions shall be installed flush with exposed surfaces. Sleeves through floors shall be extended 2 in. above finished floor.

C. Fastening of pipes, conduits, etc., in the building shall be as follows: To wood members - by wood screws; to masonry - by threaded metal inserts, metal expansion screws, or toggle bolts, whichever is appropriate for the particular type of masonry; to steel - machine screws or welding (when specifically permitted or directed), or bolts, and to concrete by suitable inserts anchored to reinforcing steel, and poured in place unless other means are acceptable for general use, and will only be permitted where specifically acceptable to the Architect.

D. Under no circumstances will the use of plastic anchors or plastic expansion shields be permitted for any purpose whatsoever.

E. The space around piping, ductwork, etc., penetrating walls, ceilings and floors that define air plenums shall be sealed airtight in an acceptable manner. Ceiling plenums used for return air are considered air plenums.

1.17 ACCESS DOORS

A. This Contractor shall provide wall or ceiling access doors for unrestricted access to all concealed shutoff or service valves, dampers, VAV box access, and other items of concealed mechanical equipment. All access door locations are not shown on the drawings. It is the Contractor's responsibility to provide access doors at all locations required.

B. Access Doors in Concrete Ceiling:

1. Flat frame 10 gauge steel security access door.
2. Frame: 2 in. x 2 in. x 3/16 in. angle frame with 2 in. flange, welded at corners.
3. Door: 10 gauge plate steel door mounted on two heavy-duty detention hinges welded to frame. Size as required, with minimum 18" X 18" size.
4. Finish: Grey powder coat paint.
5. Lock: In lieu of locks, secure door with (8) stainless steel Torx security screws evenly distributed around 3 sides. Verify compatibility with Owner's current security screws.
6. Equal to SP Series by JL Industries.

C. Access Doors in Sheet Rock Ceiling:

1. Frame: 16 gauge steel with 1in well flange.
2. Door: 16 gauge steel access door mounted with a 90° continuous, concealed hinge. Size as required, with minimum 18" x 18" size.
3. Finish: Grey power coat paint.
4. Lock: In lieu of locks, secure door with (8) stainless steel Torx security screws evenly distributed around 3 sides. Verify compatibility with Owner's current security screws.
5. Equal to TM Series by JL Industries.

1.18 CONSTRUCTION REQUIREMENTS

A. The Mechanical and Electrical plans and specifications including the General Provisions, Supplemental General Provisions, and other pertinent documents issued by the Engineer, are a part of these specifications and the accompanying mechanical drawings, and shall be complied with in every respect. All the above is included in the Contract Documents, and shall be examined by all bidders. Failure to comply shall not relieve the Contractor of responsibility or be used as a basis for additional compensation due to omission of architectural, structural and electrical details from the mechanical drawings.

B. It is the intent of the Contract Documents to provide an installation complete in every respect. In the event that additional details or special construction may be required for

work indicated or specified in this section or work specified in other sections, it shall be the responsibility of the Contractor to provide same as well as to provide material and equipment usually furnished with such systems or required to complete the installation, whether mentioned or not.

C. The Contractor shall be responsible for fitting all material and apparatus into the building and shall carefully lay out all work at the site to conform to the structural conditions, to avoid all obstructions, to conform to the details of the installation supplied by the manufacturer of the equipment to be installed and thereby to provide an integrated satisfactory operating installation.

D. The mechanical and associated drawings are necessarily diagrammatic in character and cannot show every connection in detail or every pipe or equipment in its exact location. These details are subject to the requirements of ordinances and also structural and architectural conditions. The Contractor shall carefully investigate structural and finish conditions and shall coordinate the separate trades in order to avoid interference between the various phases of work. Work shall be laid out 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. All work shall be installed parallel or perpendicular to the lines of the building unless otherwise noted.

E. When the mechanical drawings do not give exact details as to the elevation of pipe, ducts, etc., physically arrange the systems to fit in the space available at the elevations intended with the proper grades for the functioning of the system involved. Piping and duct systems are generally intended to be installed true and square to the building construction, and located as high as possible against the structure in a neat and workmanlike manner, and the plans do not show all required offsets, control lines, pilot lines and other location details. Work shall be concealed in all finished areas. Piping specified to be insulated shall be supported in a manner that will allow the insulation to be installed without gaps. Insulated piping in concealed areas shall be offset with fittings as necessary to permit installation of insulation. Bending of pipes or installing pipes in a strain in order to insulate will not be permitted.

1.19 MECHANICAL SUBMITTALS

A. Refer to the Conditions of the Contract (General and Supplementary) and Division 01 Section: "SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES" for submittal definitions, requirements, and procedures.

B. Submittal of Shop Drawings, product data, and samples will be accepted only when submitted by The Contractor. Data submitted from Subcontractors and material suppliers directly to the Architect will not be processed.

C. Submit Shop Drawings, product data, and samples on items indicated in the individual sections.

D. Shop Drawings and submittal data shall not be used as requests or proposals for alternate equipment or materials. Refer to Item "Product Options and Substitutions" elsewhere in this section.

1.20 PRODUCT OPTIONS AND SUBSTITUTIONS

A. Refer to the Instructions to Bidders and the Division 01 Section "PRODUCTS AND SUBSTITUTION" for requirements in selecting products and requesting substitutions.

B. Standards for Materials:

1. These specifications indicate a standard for all materials incorporated into the work, with manufacturer's names and catalog numbers used to establish a grade and quality of materials and equipment. The manufacturer listed on the equipment schedules, or named first in the specifications, is the one on whose equipment the layout is based. Other named manufacturers must meet the indicated performance and space requirements.

2. The "approved equal" clause used in these specifications is to permit the proposal of unnamed manufacturer's products for the work, and the Engineer decision concerning equal products is final.

3. Considerations as to determination of equal products include, but are not limited to, the following:

| | |
|---|---|
| Materials | Physical size |
| Workmanship | Weight |
| Gauges of Materials | Appearance |
| Available Local Service Personnel | Performance |
| Previous successful installations | Capacity |
| Delivery Schedules | Required Equipment Clearances |

C. Requests for substitutions of equipment, materials and apparatus listed in Division 23 Sections must be submitted in writing as a question during the prescribed timeframe for submitting questions. Refer to the instructions for bidders for timeframe. Such requests must be accompanied by complete data to permit proper evaluation.

D. BIDS SHALL NOT BE BASED ON UN-APPROVED MATERIALS, EQUIPMENT, OR APPARATUS. UNAPPROVED MATERIAL, EQUIPMENT OR APPARATUS WILL NOT BE ACCEPTED.

E. Should electrical or other similar requirements for alternate equipment, whether named in the specifications or approved as a substitution, be different from requirements for the products used in laying out the project, such changes shall be the responsibility of the Contractor, and shall not result in extra charges to the Owner or Engineer.

1.21 RECORD DOCUMENTS

A. Refer to the Division 01 Section: "CLOSEOUT PROCEDURES" for requirements. The following paragraphs supplement the requirements of Division 01.

B. Mark Drawings to indicate revisions to controls component locations and similar units requiring periodic maintenance or repair; actual equipment locations, concealed equipment, with control devices located and with items requiring maintenance located; Change Orders.

C. Mark Specifications to indicate approved substitutions; Change Orders; actual equipment and materials used.

1.22 PAINTING

A. Protection of Factory-applied Finishes:

1. Factory-applied finishes on equipment and apparatus installed on the project shall be carefully protected.

2. At the conclusion of the work, and prior to final acceptance of the project, equipment and apparatus shall be thoroughly cleaned of all construction dirt, oil and grease smears, temporary labels, debris, paint droppings, etc.

3. Damaged factory finishes shall be restored to their original condition using procedures, materials and application techniques as set forth in Division 09 found elsewhere in these specifications.

1.23 CLEANING

A. Refer to the Division 01 Section: "CLOSEOUT PROCEDURES" for general requirements for final cleaning.

B. Name Plates:

1. All nameplates shall be protected from damage during the construction process.

2. At the conclusion of the work, the nameplates shall be carefully cleaned and left in a fully legible condition.

C. Removal of Rubbish: Each Contractor is responsible for the timely removal of rubbish and trash generated by his work, such as empty cartons, containers, materials crates, etc., from the project site. Particular attention is called to residue that may present a potential tripping or injury hazard.

PART 2 - PRODUCTS

2.1 GENERAL MATERIALS AND EQUIPMENT REQUIREMENTS

A. The manufacturer's published instructions shall be followed for preparing, assembling, installing, erecting, and cleaning manufacturer's materials or equipment, unless otherwise indicated. The Contractor shall promptly notify the Engineer in writing of any conflict between the requirements of the Contract Documents and the manufacturer's directions and shall obtain the Engineer instructions before proceeding with the work. Should the Contractor perform any such work that does not comply with the manufacturer's directions or such instructions from the Engineer, he shall bear all costs arising in connection with the deficiencies.

B. The Contractor shall not receive material or equipment at the jobsite until there is suitable space provided to properly protect equipment from rust, drip, humidity, and dust damage.

C. Capacities shall be not less than those indicated but shall be such that no component or system becomes inoperative or is damaged because of start-up or other overload conditions.

D. Where materials or equipment are specified to be approved, listed, tested, or labeled by the Underwriter's Laboratories, Inc., or constructed and/or tested in accordance with the standards of the American Society of Mechanical Engineers or the Air Moving and Conditioning Association, the Contractor shall submit proof that the items furnished under these sections of the specifications conform to such requirements. The ASME stamp or the AMCA label will be acceptable as sufficient evidence that the items conform to the respective requirements.

E. Each major component of equipment shall have the manufacturer's name, address, and catalog number on a plate securely attached to the item of equipment. All data on nameplates shall be legible at the time of Final Observation.

F. The Contractor shall be responsible for the coordination and proper relation of all work to the building structure and to the work of all trades. The Contractor shall visit the premises and become thoroughly familiar with all details of the work and working conditions, to verify all dimensions in the field, and to advise the Engineer of any discrepancy before performing any work. Adjustments to the work required, in order to facilitate a coordinated installation, shall be made at no additional cost to the Owner.

2.2 PROTECTION

A. The Contractor shall at all times take such precautions as may be necessary to properly protect all materials and equipment from damage from the time of delivery until the completion of the work. Failure on the part of the Contractor to comply with the above will be sufficient cause for the rejection of the items in question.

B. Take particular care not to damage the building structure in performing work. All finished floors, steel treads, and workmen or their tools and equipment shall cover finished surfaces to prevent any damage during the construction of the building.

C. Equipment and materials shall be protected from rust both before and after installation. Any equipment or materials found in a rusty condition at the time of final observation must be cleaned of rust and repainted as specified elsewhere in these specifications.

2.3 **COOPERATION BETWEEN TRADES AND WITH OTHER CONTRACTORS**

A. **EACH TRADE, SUBCONTRACTOR AND/OR CONTRACTOR MUST WORK IN HARMONY WITH THE VARIOUS OTHER TRADES, SUBCONTRACTORS, AND/OR CONTRACTORS ONTHE JOB AS MAY BE REQUIRED TO FACILITATE THE PROGRESS TO THE BEST ADVANTAGE OF THE JOB AS A WHOLE. EACH TRADE, SUBCONTRACTOR, AND/OR CONTRACTOR MUST PURSUE HIS WORK PROMPTLY AND CAREFULLY AS NOT TO DELAY THE GENERAL PROGRESS OF THE JOB. THE CONTRACTOR SHALL WORK IN HARMONY WITH CONTRACTORS WORKING UNDER THE OTHER CONTRACTS ON THE PREMISES.**

2.4 PRECEDENCE OF MATERIALS

A. These specifications and the accompanying drawings are intended to cover systems which will not interfere with the structural design of the building, which will fit into the available space, and which will insure complete and satisfactory systems. Each Contractor shall be responsible for the proper fitting of his material and apparatus into the building.

B. Each Contractor shall so harmonize all work with the work of the other trades so that it may be installed in the most direct and workmanlike manner without hindering, interfering, or restricting the other trades. Piping interferences shall be handled by giving precedence to pipelines that require a stated grade for proper operation.

PART 3 - INSTALLATION

3.1 INSTALLATION METHODS

A. All cabling shall be concealed in pipe chases, walls, furred spaces, or above the ceiling, unless otherwise indicated.

B. Cabling may be run exposed in mechanical rooms, janitors' closets, or storage spaces, but only where necessary. All exposed cabling shall be run in the neatest, most inconspicuous manner, and parallel or perpendicular to the building lines.

C. All cabling shall be adequately and properly secured to the building structure.

D. Where limited space is available above the ceilings and below concrete beams or other deep projections, cabling and conduit shall be sleeved through the projection where it crosses, in a manner to provide maximum above-floor clearance. Sleeves shall only be placed in locations that do not compromise structural integrity of any structural member.

E. The Contractor shall study all construction documents and carefully lay out all work in advance of fabrication and erection in order to meet the requirements of the extremely limited spaces. Where conflicts occur, the Contractor shall meet with all involved trades and the Engineer and resolve the conflict, prior to erection of any work, in the area involved.

3.2 CUTTING AND PATCHING

A. Cut and patch openings through walls, floors, etc., resulting from work in existing construction or by failure to provide proper openings or recesses in new construction.

B. Openings cut through concrete and masonry shall be made with masonry saws and/or core drills at locations acceptable to the Engineer. Impact-type equipment will not be used, except where specifically acceptable to the Engineer. Openings in Precast concrete slabs for pipes, conduits, outlet boxes, etc., shall be core drilled or cast to exact size.

C. All openings shall be restored to "as-new" condition under the appropriate Specification Section for the materials involved, and shall match remaining surrounding materials and/or finishes.

D. Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry. Adequate supports shall be provided during the cutting operation to prevent any damage to the masonry occasioned by the operation. All structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner acceptable to the Engineer.

E. No cutting, boring, or excavating, which will weaken the structure, shall be undertaken. NO STRUCTURAL MEMBER MAY BE CUT WITHOUT THE WRITTEN APPROVAL OF THE ENGINEER.

3.3 IDENTIFICATION AND LABELING

A. The Contractor shall make it possible for the personnel operating and maintaining the equipment and systems in this project to readily identify the various pieces of equipment, valves, piping, etc., by marking them.

B. All items of mechanical and electrical equipment shall be identified by the attachment of engraved nameplates constructed from laminated phenolic plastic, at least 1/16 in. thick, 3-ply, with black surfaces and white core. Engraving shall be condensed gothic, at least 1/2 in. high, appropriately spaced. Nomenclature on the label shall include the name of the item, its mark number, area, space, or equipment served, and other pertinent information. Equipment to be labeled shall include, but not be limited to, the following:

1. HVAC control panels and switches
2. Miscellaneous similar and/or related items.

3.4 TESTS AND INSPECTIONS

A. The Contractor shall, during the progress of the work and upon its completion, test his work and make all tests as required by the specifications, state, municipal and other authorities having jurisdiction of the work. Tests shall be made in the presence of authorities requiring tests. The Contractor shall pay all costs, inspection charges and fees required for the tests of his work.

B. The Contractor shall provide all apparatus, etc., required for tests. The Contractor shall take all due precautions to prevent damage to the building or its contents incurred by such tests. The Contractor shall repair and make good at his own expense any damage caused by failures or leaks during the tests.

C. All equipment shall be placed in operation and tested for proper automatic control before the final balancing of the system is started.

D. All tests shall have pertinent data logged by the Contractor at the time of testing. Data shall include date, time, personnel, description, and extent of system tested, test condition, test results, specified results, and any other pertinent data. Data shall be delivered to the Engineer.

3.5 COOPERATION AND CLEANUP

A. It shall be the responsibility of each trade to cooperate fully with the other trades on the job to help keep the job site in a clean and safe condition. At the end of each day's work, each trade shall properly store all of his tools, equipment and materials and shall clean his debris from the job. Upon the completion of the job, each trade shall immediately remove all of his tools, equipment, any surplus materials and all debris caused by his portion of the work.

3.6 CLEANING AND PAINTING

A. This Contractor shall thoroughly clean the finish on all parts of the materials and equipment with factory applied finishes. Exposed parts in equipment rooms, above crawl space slabs, and all other spaces except sealed chases and attics shall be thoroughly cleaned of cement, plaster and other materials, and all oil and grease spots shall be removed. Such

surfaces shall be carefully wiped and all cracks and corners scraped out. If the finish has been damaged, the Contractor shall re-paint to the satisfaction of the Engineer.

B. No nameplates on equipment shall be painted, and suitable protection shall be afforded to the plates to prevent their being rendered illegible during painting operation.

3.7 ELECTRICAL PROVISIONS FOR BUILDING AUTOMATION SYSTEM (BAS)

A. The extent of electrical provisions to be provided as part of BAS work is indicated in other mechanical sections of the specifications, on the drawings and as further specified in this section.

B. Wherever possible, match the elements of the electrical provisions of BAS work with similar elements of the electrical work specified in electrical sections of the specifications.

C. Standards:

1. For electrical equipment and products, comply with applicable NEMA standards, and refer to NEMA standards to definitions of terminology herein.

2. Comply with National Electrical Code (NFPA No. 70) for installation requirements.

3. Comply with National Electrical Contractors Association (NECA) "Standard of Installation".

3.8 EQUIPMENT INSTALLATION REQUIREMENTS

A. All mechanical equipment shall be furnished and installed complete and ready for use.

B. All mechanical equipment and appliances shall be installed in a manner that all Code required access and services space is provided. Coordinate exact position of equipment and appliances with routing of new ductwork and piping, and with all existing conditions to provide required clearances.

1. Ensure that a minimum of 30” deep and 30” wide working space is provided in front of the control side of each appliance and cabinet.

END OF SECTION

SECTION 23 09 23

BUILDING AUTOMATION SYSTEM (BAS)

PART 1 - GENERAL

1.1 GENERAL

A. All work shall be in accordance with Division 01 and Section 23 00 10 "BASIC MECHANICAL REQUIREMENTS".

B. **THIS CONTRACT TO REPLACE THE EXISTING BUILDING AUTOMATION SYSTEM SHALL BE PERFORMED CONCURRENTLY WITH A SEPARATE PROJECT TO REPLACE THE EXISTING AIR HANDLING UNITS. THE WORK FOR THIS CONTRACT SHALL BE PERFORMED IN CLOSE COORDINATION WITH THE AIR HANDLING UNIT CONTRACTOR SO THAT IT WILL BE INSTALLED AS IF ONE SEAMLESS PROJECT, AND SHALL FULLY COMPLY WITH ALL OWNER DIRECTED SCHEDULING AND PHASING OF WORK.**

C. The successful Building Automation System contractor shall be selected based on price and evaluation criteria as determined by the Owner.

D. The new Building Automation System shall be equal in quality, functionality and performance to the Reliable Controls system which is currently utilized by the Owner in other Tarrant County facilities. It is desirable that the BAS shall connect and communicate to the Reliable Control virtual server located in the Owner's off site centralized data center.

E. Reliable Control is used as the basis of design.

1.2 SCOPE OF WORK

A. Furnish all labor, materials, tools, equipment, and services for a fully integrated Building Automation System (BAS) as indicated, in accordance with the Contract Documents.

B. The BAS shall fully integrate third-party manufacturers control subsystems (i.e., boilers, chillers, etc.), which shall be capable of operating in a standalone mode, while being software integrated to comprise the complete BAS.

C. Deliver the following features, hardware, and functions as a minimum:

1. Operator Workstation(s) – Equal to Web-based Reliable Controls RC-Webview Complete with Microsoft Windows 10 based operating system.

2. One Network Control Panel (NCP) for each major piece of equipment such as chillers, boilers, cooling towers, etc.

3. One Application Specific Controller (ASC) for each air-handling unit, packaged rooftop unit, make-up air unit, fan coil unit, etc.

4. Integration to third-party manufacturers’ microprocessor controllers, as specified herein.

5. Furnish and install all sensors, transducers, and controlled devices per this specification.

6. Furnish all automatic control valves and control dampers for installation by the Mechanical Installer. Furnish and install all control damper and control valve actuators.

7. All monitoring, controlling, optimizing, interfacing, reporting, archiving, operator interface and information formulation and other special packages as required by the Contract Documents, including but not limited to the following:
   a. Scheduled stop/start.
   b. Optimum start/stop.
   c. Run time totalization.
   d. Duty cycling.
   e. Power demand control.
   f. Load restoration following a fire alarm.
   g. Automatic alarm lockout.
   h. Password access control.
   i. Graphics display.
   j. Dynamic graphical trending.
   k. Historical data recording and reporting.

## 1.3 CONTRACTOR QUALIFICATIONS

A. An integrated BAS will only be considered for acceptance from companies that are able to demonstrate that hardware and software they provide are equal in quality and performance to the Tarrant County standard BAS provider - Reliable Controls.

1. Johnson Controls
2. Schneider Electric
3. Siemens Building Technologies
4. Reliable Controls
5. Honeywell
6. Delta Controls
7. Climatec

B. The BAS shall be installed by competent mechanics and commissioned by competent technicians regularly employed by the equipment vendor.

C. Provide installation, calibration, and check-out of the stand-alone subsystems; as well as the complete operation of the integrated BAS, including graphics generation, implementation of point history feature and energy management applications.

D. Maintain local support facility with technical staff, spare parts inventory, and all necessary test diagnostic equipment.

## 1.4 REFERENCED STANDARDS, CODES, AND ORDINANCES

A. It is the responsibility of the Contractor to be familiar with all codes, rules, ordinances, and regulations of the authority having jurisdiction and their interpretations that are in effect at the site of the work.

B. All controllers that are utilized as part of smoke control functions shall comply with UL864.

C. All newly installed systems equipment, components, accessories, and installation hardware shall be new and free from defects and shall be UL listed where applicable. All components shall be in current production and shall be a standard product of the system or device manufacturer. Refurbished or reconditioned components are unacceptable. Each component shall bear the make, model number, device tag number (if any), and the UL label as applicable. All system components of a given type shall be the product of the same manufacturer.

1.5 SUBMITTALS

A. Provide submittal data as referenced in Division 01 and Section 23 00 10 of these Contract Documents.

B. Shop drawings shall include the installation details for all equipment to be furnished or provided under this Contract. At minimum, the shop drawings shall include details of:

1. BAS architecture schematic (riser diagram).
2. Interconnection and installation drawings and schedules, including bill of materials and sequences of operation.
3. Field panel layout, plan location and interconnection drawings and specification sheets.
4. Proposed panel loading and spare capacity.
5. Location and sizes for sleeves in walls and floors.
6. Instrumentation locations marked on Mechanical Drawings.
7. Schematic of monitored/controlled systems indicating device locations.
8. Device installation details.
9. Other documentation as appropriate.

C. Product data submittals shall include the specifications for all equipment and software to be furnished or provided under this Contract. In addition, the submittals shall include details of:

1. Software and special packages.
2. Computer equipment and terminal specification sheets.
3. Field sensors and instrumentation specification sheets.
4. Damper, valve and actuator specifications sheets.
5. Proposed graphic schematics of mechanical and other systems.
6. Wiring specifications.
7. Format of point/function log sheet.
8. Other documentation as appropriate.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

A. The BAS shall be capable of integrating multiple building functions including equipment supervision and control, alarm management, energy management, lighting control, information management, and historical data collection and archiving as well as trending.

B. The BAS shall consist of the following:

1. Network Control Panels (NCPs)
2. Application Specific Controllers (HVAC, TUC, etc.)
3. Portable Operator Terminals
4. PC-Based Operator Workstations

C. System shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Network Control Panels, and operator devices.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each NCP and ASC shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection as well as trending. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

E. Network Control Panels shall be able to access any data from, or send control commands and alarm reports directly to, any other controller on the network without dependence upon a central processing device, such as a central file server. Network Control Panels shall also be able to send alarm reports to multiple operator workstations, terminals, and printers without dependence upon a central processing device or file server.

2.2 NETWORKING/COMMUNICATIONS

A. The design of the BAS shall network Operator workstations (fixed and portable) and Network Control Panels. Inherent in the system’s design shall be the ability to expand or modify the network.

B. Local Area Network

1. Workstation/Network Control Panel Support. Operator workstations and NCPs shall directly reside on a single shared high-speed local area network such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.
2. Dynamic Data Access. All operator devices, either network resident or connected via the internet, shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.
3. General Network Design. Network design shall include the following provisions:
   a. High-speed data transfer rates for alarm reporting, quick report generation from multiple controllers, and upload/download efficiency between network devices.

b. Support of any combination of controllers and Operator workstations directly connected to the local area network.
c. Detection and accommodation of single or multiple failures of workstations, NCP, or the network media. The network shall include provisions for automatically reconfigure itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.
d. Message and alarm buffering to prevent information from being lost.
e. Error detection, correction, and re-transmission to guarantee data integrity.
f. Default device definition to prevent loss of alarms or data and to ensure alarms are reported as quickly as possible in the event an operator device does not respond.
g. Automatic synchronization for the real-time clocks in all NCPs and ASCs shall be provided.

C. Remote Access Communications.

1. Equal to Reliable Controls RC-Remote Access with 256-bit encryption.

2.3 NETWORK CONTROL PANELS

A. Network Control Panels shall be microprocessor-based, multi-tasking, multi-user, real-time digital control processors. Each NCP shall consist of modular hardware with plug-in enclosed processors, communication, controllers, power supplies, and input/output modules. A sufficient number of controllers shall be provided to fully meet the requirements of this specification and the attached point list. A 20% installed spare capacity of each point type (AI, AO, DI, DO) shall be provided at each NCP as part of the base bid. The BCS point capacity shall be capable of being expanded by 200% by the addition of NCPs and ASCs. The BAS shall also support an additional two workstations above those specified herein.

B. Each NCP shall have sufficient memory to support its own operating system and databases including:

1. DDC and other control Processes
2. Energy Management Applications
3. Alarm Management
4. Historical/Trend Data for all points
5. Maintenance Support Applications
6. Custom Processes
7. Operator I/O
8. Network Communications
9. Manual Override Monitoring

C. Each NCP shall support the following types of point inputs and outputs:

1. Digital inputs for status/alarm contacts.
2. Digital outputs for on/off equipment control.
3. Analog inputs for temperature, pressure, humidity, flow, and position measurements.

4. Analog outputs for valve and damper modulation, and capacity control of primary equipment.

5. Pulse inputs for pulsed contact monitoring.

D. The BAS shall be modular in nature and shall permit expansion through the addition of software applications, workstation hardware, field controllers, sensors, and actuators. The system architecture shall support 200% expansion capacity of all types of DDC panels and all point types included in the initial installation.

E. Network Control Panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of operator I/O devices such as industry standard printers, laptop workstations, PC workstations, modems and portable operator terminals.

F. Surge and transient protection shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients consistent with UL 1449.

G. In the event of the loss of normal power, there shall be an orderly shutdown of all Network Control Panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours. Upon restoration of normal power, the NCP shall automatically resume full operation without manual intervention.

H. Provide UPS with a 4 hour runtime.

## 2.4 SYSTEM SOFTWARE FEATURES

A. General

1. All necessary software to form a complete operating system as described in this specification shall be provided.

2. The software programs specified in this section shall be provided as an integral part of the NCP or ASC and shall not be dependent upon any higher-level computer for execution.

B. Control Software Description

1. Control Algorithms. The NCP and ASC shall have the ability to perform the following control algorithms:
   a. Two-Position Control
   b. Proportional Control
   c. Proportional plus Integral Control
   d. Proportional, Integral, plus Derivative Control
   e. Adaptive Control Loop Tuning

2. Equipment Cycling Protection. Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period. Minimum equipment cycle times shall be coordinated with the equipment manufacturer.

3. Equipment Delays. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to electrical loads.

4. Powerfail Motor Restart. Upon the resumption of normal power, the NCP and ASC panels shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

C. Energy Management and Control Applications

1. NCP and ASC panels shall have the ability to perform the following energy management and control routines:
   a. Scheduled stop/start
   b. Optimum start/stop.
   c. Run time totalization.
   d. Duty cycling.
   e. Power demand control.
   f. Night Setback Control.
   g. Enthalpy or Dry Bulb Economizer.
   h. Chilled Water Reset.
   i. Heating/Cooling Interlocks.
   j. Supply Air Temperature Reset.
   k. Hot Water Reset.
   l. Smoke Control.

2. All programs shall be executed automatically without the need for operator intervention and shall be flexible to allow operator customization. Programs shall be applied to building equipment as described in the Execution portion of this specification and in the I/O point sheets.

D. Custom Process Programming Capability. NCP and ASC shall be able to execute custom, job-specific processes defined by the operator to automatically perform calculations and special control routines.

1. Process Inputs and Variables. It shall be possible to use any of the following in a custom process:
   a. Any system-measured point data or status
   b. Any calculated data
   c. Any results from other processes
   d. User-defined constants
   e. Arithmetic functions (+, -, *, /, square root, exponential, etc.)
   f. Boolean logic operators (and, or, exclusive or, etc.)
   g. On-delay/Off-delay/One-shot timers

2. Process Triggers. Custom processes may be triggered based on any combination of the following:
   a. Time interval
   b. Time of day
   c. Date
   d. Other processes
   e. Time programming
   f. Events (e.g., point alarms)

E. Alarm Management. Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each NCP and ASC shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the NCP or ASC panel's ability to report alarms be affected by either operator

activity at a PC workstation or local I/O device, or communications with other controllers on the network.

1. Point Change Report Description. All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.

2. Prioritization. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of five priority levels shall be provided.

3. Report Routing. Alarm reports, messages, and files will be directed to a user-defined list of operator devices or PC disk files used for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

4. Alarm Messages. In addition to the point's descriptor and the time and date, the user shall be able to print, display, or store an 80-characer alarm message to more fully describe the alarm condition or direct operator response.

5. Transaction Logging. Operator commands and system events shall be automatically logged to disk in personal computer industry standard database format. Operator commands initiated from direct-connected workstations, dial-up workstations and portable Operator workstation shall all be logged to this transaction file. This data shall be available at the Operator workstation(s).

F. Historical Data and Trend Analysis. A variety of historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways:

1. Continuous Point Histories. Network Control Panels shall store point history files for all analog and digital points. Sufficient memory shall be provided within each NCP and ASC to accommodate all historical data collection described in this section.

2. The point history routine shall continuously and automatically sample the value of all analog inputs at intervals determined by the Operator. Samples for all points shall be stored for the past 24 hours to allow the user to immediately analyze equipment performance and all problem-related events for the past day. Point history files for all points shall include a continuous record of the last ten status changes or commands for each point.

3. Extended Sample Period Trends. Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 2 hours shall be provided. Each NCP, ASC and portable Operator workstation shall have dedicated memory buffers/hard disk space for trend data.

4. Data Storage and Archiving. Trend data shall be stored at the Network Control Panels and uploaded to hard disk storage when archival is desired.

G. Runtime Totalization. Network Control Panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this specification.

H. Analog/Pulse Totalization. Network Control Panels shall automatically sample, calculate, and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

I. Event Totalization. Network Control Panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.

2.5 APPLICATION SPECIFIC CONTROLLERS

A. HVAC Controllers.

1. Each Network Control Panel shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

2. Each ASC shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, and real-time digital control processor.

3. Each ASC shall have sufficient memory to support its own operating system and data bases including:
   a. Control Processes
   b. Energy Management Applications

4. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation or portable Operator's workstation connected to any NCP in the network.

5. Powerfail Protection. All system set points, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

6. Configuration Upload and Download. The ASCs shall have the capability of receiving configuration and program loading by all of the following: 1) locally, via a direct connect portable laptop service tool, 2) over the network, from the portable laptop service tool; and 3) from the Operator Workstation(s), via the communication networks.

7. Continuous Zone Temperature Histories. Application Specific Controllers shall have the capability to automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored in the ASC or shall be uploaded to the associated NCP or Operator Workstation.

B. Terminal Unit Controllers

1. Provide a terminal unit controller (TUC) for each terminal unit identified on the mechanical drawings.

2. Terminal unit controllers shall comply with the requirements specified above for Application Specific Controllers.

3. The terminal unit manufacturer shall provide the following components to ensure that each terminal unit is provided with a pressure independent control system.
   a. Multi-point flow averaging sensor for primary airflow rate monitoring.
   b. Flow rate calibration curves.
   c. 24 Vac transformer for terminal unit controller power supply.
   d. 24 Vac relay for on/off control of fan (as applicable).
   e. 24 Vac relay(s) for electric heating coil control (as applicable).
   f. Interlocks between the fan motor and the electric heating coil (as applicable).
   g. Manual fan speed adjustment (as applicable).
   h. Sheetmetal DDC controller enclosure.

i. Terminal unit primary air dampers.

4. Furnish and field install the following terminal unit control components:
   a. Terminal unit DDC controller.
   b. Damper motors for the primary air damper.
   c. Hot water coil control valve (as applicable).

5. Field calibrates the differential pressure transducer used to monitor the terminal unit primary airflow rate. Coordinate calibration with the balancing of the air distribution systems. Ensure overall primary air flow measurement accuracy of +/- 5% for primary air velocities in the range of 400 ft. per minute to 3000 ft. per minute.

6. Control of the primary air dampers and heating coils (electric or hot water, as applicable), shall be by direct digital control using a proportional plus integral control algorithm, at minimum. Maintain the space temperature set point to within +/- 1ºF, when either in the heating or cooling mode.

7. All terminal unit communication cabling shall be routed through cable rings to avoid cable damage due to ductwork, hangers, etc. Communication cabling shall be provided with a heavy insulation jacket and shall be orange or another unique color. Coordinate cable jacket color with all other trades.

8. The sequences of operation shall be resident at the TUC or in the supervisory NCP for the various modes of operations:
   a. Normal occupied mode.
   b. Night setback mode.
   c. Morning warm-up mode.
   d. Morning cool-down mode.

9. The controller shall incorporate the necessary input subsystems to enable monitoring of the following parameters:
   a. Space temperature.
   b. Primary airflow rate. Flow rate shall be displayed at the BAS Operator terminals (including the hand held terminal) in c.f.m.

10. The controller shall incorporate the necessary output subsystems to enable control of the following terminal unit parameters:
    a. Damper modulation. For morning warm-up, terminal unit primary air damper shall be fully closed. For morning cool down the primary air damper shall be open to the maximum flow rate position.
    b. Electric heating coil control (where applicable).

## 2.6 INTEGRATION WITH THIRD-PARTY MANUFACTURER CONTROLLERS

A. Interoperability With Equipment Controllers.

1. The BAS shall be capable of interoperating with multiple building systems supplied by different manufacturers. The BAS shall be able to receive, react to, and send information from/to multiple equipment controllers.

2. The system shall allow the custom generation of third-party vendor code on a local level to permit any system to be fully integrated into the BAS network.

3. Input and output points from the third-party controllers shall have real-time interoperability with BAS software features such as Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis, Totalization, and Dial-Up and Local Area Network Communications, as described previously in the contract documents.

B. Networking/Communications.

1. The BAS shall support any combination of third-party controllers (if more than one third-party manufacturer is being integrated) on a single network.

2. A minimum of 100 third-party controllers shall be supported on a single network, or as dictated by the third party system architecture.

3. Integration shall be by RS-232 or RS-485 technologies.

C. Verify and diagnose communication messages and point information between third-party controllers and the BAS.

D. The BAS shall be able to monitor and control third-party controller point inputs and outputs as defined in the I/O point schedule.

## 2.7 OPERATOR INTERFACE

A. Basic Interface Description.

1. Operator workstation interface software shall minimize Operator training through the use of English language prompting, English language point identification, and industry standard PC application software. The system shall utilize any one of the following operating systems:
   a. Microsoft Windows
   b. Any system that utilizes a DOS operating system will not be acceptable.

2. At the option of the user, portable and permanent workstations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all operator devices.

3. The Operator Interface shall provide simultaneous viewing of several different types of system displays in a windowing environment to speed facility operation and analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air-handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze system performance.

4. Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display, and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.
   a. A minimum of five levels of access shall be supported.
   b. Operators shall be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel mounted devices, and shall be limited to only those items defined for the access level of the password used to log-on.
   c. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

5. Reports shall be generated automatically or manually and directed to workstation displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:
   a. A general listing of all points in the network
   b. List all points currently in alarm
   c. List of all off-line points
   d. List all points currently in override status
   e. List of all disabled points

f. List all points currently in alarm lockout
g. List all weekly schedules
h. List all holiday programming
i. List of limits and dead bands

6. Third-party interface system data, including transactions, alarms totalization files, etc., shall be stored on the portable workstation disk drive in an industry standard database format (e.g., dBase IV, SQL) such that it is compatible with off-the-shelf third-party database and spreadsheet programs.

7. The BAS shall interface to off-the-shelf personal computer software programs (e.g., Microsoft Word for Windows, Microsoft Excel, Lotus, etc.). This interface shall conform to Dynamic Data Exchange (DDE) protocols and standards. The user shall have the ability to "link" the computer programs directly to live, real-time BCS data values. Systems that offer data exchange using only historical, disk-resident information shall not be acceptable. BAS data value "reads" and "writes" shall both be permissible.

8. The BAS software shall allow multiple users to use the system simultaneously.

B. Provide Dynamic Color Graphic Displays as follows:

1. System schematics (for each piece of mechanical equipment including air handling units, chilled water systems, and hot water boiler systems).

2. Site plans showing all lighting systems controlled by the BAS.

3. Floor plan of each building floor showing terminal unit and temperature sensor locations. The points displayed on the mechanical system graphic displays shall be based on the I/O point sheets included as part of these Contract Documents.
   a. System Selection/Penetration. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.
   b. Dynamic Data Displays. Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention. Values of each analog output shall be indicated on the associated mechanical system graphic display.
   c. Windowing. The windowing environment of the Operator workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

C. System Configuration and Definition. All temperature and equipment control strategies and energy management routines shall be definable by the Operator. System definition and modification procedures shall not interfere with normal system operation and control.

D. Operator Workstation:

1. Provide one (1) Operator Workstation which shall be provided for command entry, information management, network alarm management, and database management functions. All real-time control functions shall be resident in the Network Control Panels and Application Specific Controllers to facilitate greater fault tolerance and reliability.

2. The Workstation shall be general purpose, commercially available personal computers having the following minimum specifications:
   a. Processor: Intel i7
   b. Quad Core

c. 1 TByte Hard Drive
d. 16 GByte RAM
e. 24X CD-Rom
f. 23 in. 1920 x 1080 LED Monitor
g. Integral 10/100/1000 Mbaud Networking Interface
h. EIA-232 port or USB adapter for direct connection
i. Microsoft Windows 10 (x64)

E. Portable Operator Workstation:

1. Each NCP and ASC shall be capable of supporting a portable notebook Operator workstation or Portable Operator Terminal (POT) for local command entry, instantaneous and historical data display, and program additions and modifications.

2. The operator functions provided by the Portable Workstation shall include, but not be limited to, the following:
   a. Start and Stop Points
   b. Modify Set points
   c. Modify PID Loop Set points
   d. Override PID Control
   e. Change Time/Date
   f. Add/Modify Start/Stop Weekly Scheduling
   g. Add/Modify Set point Weekly Scheduling
   h. Enter Temporary Override Schedules
   i. Define Holiday Schedules
   j. View Analog Limits
   k. Enter/Modify Analog Warning Limits
   l. Enter/Modify Analog Alarm Limits
   m. Enter/Modify Analog Differentials
   n. View Point History Files

3. The Portable Operator Workstation or POT shall provide access to all real or calculated points in the controller to which it is connected (NCP or ASC) or any other controller in the network. This capability shall not be restricted to a set of predefined “global points,” but shall provide totally open exchange of data between the Operator workstation or POT and any controller in the network.

4. Operator access at the Portable Workstation or POT shall be identical to the Operator workstations. Any password changes shall automatically be downloaded to all controllers on the network.

5. The Portable Workstation or POT shall provide English language prompting to eliminate the need for the operator to remember command formats or point names. Prompting shall be provided consistent with a user’s password clearance and the types of points being displayed, to eliminate the possibility of Operator error.

F. Hand Held Terminal

1. Provide four (4) HP Elite x360 14 inch G9 2-in-1 Notebook PC (with Windows 10).

2. The Operator shall be able to execute control and monitoring functions for a terminal unit via plug in connection of the Hand Held Terminal at the TUC and at the wall mounted temperature sensor for that terminal unit. The Operator shall not be required to disconnect the temperature sensor cable to plug the hand Held Terminal into the Terminal unit controller. Provide all required adapter and interfaces required to meet this requirement. It is not a requirement that the Operator be able to undertake monitoring and control functions with the Hand held Terminal on one terminal unit

while connected to the control system of another terminal unit control systems are on the same communications network.

3. The Operator shall undertake the following functions for a terminal unit control system from the hand held terminal or POT:
   a. Set terminal unit to occupied mode.
   b. Change occupancy schedules.
   c. Modulate primary air damper to minimum flow rate position.
   d. Modulate primary air damper to closed position.
   e. Modulate primary air damper to maximum flow rate position.
   f. Modulate primary air damper to fully open position.
   g. Change heating space temperature set point.
   h. Change cooling space temperature set point.
   i. Change minimum occupied primary airflow rate.
   j. Change minimum unoccupied primary airflow rate.
   k. Change maximum primary airflow rate.
   l. Change night setback (unoccupied) space temperature set point.
   m. Change control algorithm constants.
   n. Set terminal unit to night setback mode of operation.
   o. Set terminal unit to electrical demand reduction mode.
   p. Set terminal unit to morning warm-up mode.
   q. Set terminal unit to morning cool-down mode.

4. The Operator shall monitor the following parameters with the hand held terminal:
   a. Primary airflow rate in c.f.m.
   b. Space temperature.

5. Handheld tool shall provide English language operator interface.

G. Provide (2) sets of software, cables and any other devices necessary to completely calibrate, adjust and operate BAS system to the Owner's Testing, Adjusting, Balancing, and Commissioning Firm.

## 2.8 INSTRUMENTATION

A. Temperature Sensors/Transducers.

1. Provide only one of the following temperature sensor types throughout:
   a. 1000-ohm, (0.2%) thin film platinum.
   b. 100-ohm, (0.2 ohm) platinum.
   c. 1000-ohm, (0.2%) nickel.
   d. Thermistor (100 or 100000 ohm)

2. All temperature sensors shall be constructed as follows:
   a. Shielded cable with a single end grounded.
   b. Waterproof sensor to sheath seal.
   c. Strain minimizing construction.

3. All sensors provided shall meet the following overall end-to-end accuracy requirements whether or not temperature transducers are provided, under all normal building ambient conditions:
   a. Temperatures less than 100ºF shall be reported by the BAS with an accuracy of 0.5ºF.
   b. Temperatures greater than 100ºF shall be reported by the BAS with an accuracy of 1.0ºF.
   c. Averaging temperature sensors shall be reported by the BAS with an accuracy of 1.0ºF.
   d. Drift shall not exceed the accuracy requirements over a 5-year period.

4. Thermowell mount elements shall meet the following additional requirements.
   a. Stainless steel sheath suitable for the pressure rating of the system.
   b. Length shall be suitable for application.
   c. Furnish thermowells and all other accessories required for the temperature sensor. The Mechanical Installer shall supply Wells for installation. Thermowells shall be stainless steel or chrome plated brass construction of size to suit sensor and pipe and shall be rated for the maximum pressure imposed on the various water systems. Verify and certify that the material of construction will not cause any galvanic corrosion.
   d. Each chilled or hot water supply temperature sensor shall be matched to within 0.2ºF over the range of 32ºF to 68ºF with the associated return water temperature sensor.

5. Outside air temperature sensor shall meet the following additional requirements:
   a. Complete with non-corroding outdoor shield designed to minimize the effect of solar heating on the temperature sensor element.
   b. Water proof seal.
   c. Threaded fittings for mating to conduit.
   d. Outside air temperature sensors shall be wired to different NCP. If one sensor or the associated NCP fails the other shall automatically take its place so that sequences of operation that are dependent on this parameter continue to be executed. Sensors shall be located as approved by the Architect/Engineer.

6. Duct mounted temperature sensors shall meet the following additional requirements:
   a. Copper sheathed construction.
   b. Length shall be such that the element is between 1/3 and 2/3 the distance across the duct from all sides.
   c. Ascertain the recommended location of supply air temperature sensors from the air handling unit manufacturer.

7. Space temperature sensors for non-public spaces shall meet the following additional requirements:
   a. Wall mounted, white protective enclosure LCD. Setpoint adjustment.

8. Space temperature sensors for all lobbies, public spaces and mullions shall meet the following additional minimum specifications:
   a. Sensor shall be flush mounted button type.
   b. The Owner shall approve color of sensor.
   c. Equal to Reliable Controls SSE3 Sensors.
   d. Provide tamper proof cover where installed in public access areas. Wall mounted enclosures shall be subject to Owner's approval where installed in public areas.

9. Provide averaging temperature sensors where duct mounted temperature sensors are used to sense mixed air temperature or coil discharge temperature and the cross-sectional area of the duct is 12 square ft. or greater. Averaging temperature sensors shall meet the following requirements:
   a. Copper sheathed construction. Standard conduit box termination. Lead connections shall be rugged.
   b. Probe shall have a minimum-bending radius of 12 in.
   c. Probe shall have a minimum immersion length of 12 ft. or a minimum length of one foot per square foot of duct, whichever is greater.
   d. Probe shall be single continuous sensing RTD or shall be multiple RTD or thermistor sensors spaced no further apart than 6 in.
   e. Provide suitable supports at all bends and elsewhere as necessary to ensure that the sensor is held firmly in position and will not incur damage from vibration in the air stream. Support shall be provided, at minimum, every 24 in. in addition to support at bends.

10. If required, RTD temperature transducers to be provided having the following minimum specifications:
    a. Input circuit to accept resistance detectors as specified above.
    b. Output signal of 4-20mA into maximum of 500-ohm load. Output signal shall be proportional to the engineering range detailed in the Point Sheets.
    c. Output short circuit and open circuit protection.
    d. Input short circuit and open circuit protection.
    e. Output variation of less than 0.2% of full-scale output for supply voltage variations of 10%.
    f. Combined non-linearity, repeatability and hysterisis effects not to exceed 0.5% of full-scale output.
    g. Maximum current to sensor not to exceed manufacturers suggested rating.
    h. Integral, accessible zero and span adjustments.
    i. Long term output drift of equal to or less than 0.50% of full-scale output per year.
    j. Shock and vibration protection as necessary.

B. Humidity Sensors/Transducers

1. Provide outside air, space and duct mounted relative humidity sensors and transducers having the following minimum specifications:
    a. Range of 0 - 100% RH.
    b. Combined “end-to-end” accuracy of sensor and transducer, 5% RH between 20% and 80% RH and 6% RH over full range.
    c. Maximum sensor non-linearity of 5% RH with defined curve. Transducer to provide linearized output.
    d. Output from transducer shall be 4-20 mA into a maximum of 500-ohm load.
    e. Output variations of less than 0.2% of full-scale output for supply variations of 10%.
    f. Maximum output linearity error of 1% if full scale output.
    g. Integral accessible zero and span adjustments.
    h. Long term output drift of less than 0.25% of full-scale output per 6 months.
    i. Dustproof housing.
    j. Outside air sensor shall be complete with non-corroding outdoor shield designed to minimize the effect of wind or solar heating on the RH sensing element (outdoor only).
    k. Suitably sized conduit to be provided for any lead wires external to the building or passing through the wall of the building (outdoor only).
    l. Duct mounted sensor shall have a minimum 8 in. probe.

C. Control Relays

1. Provide interposing control relays having, at minimum, the following specifications:
    a. Pickup rating time and hold rating as required for individual applications.
    b. Input operating voltage to be compatible with the BAS digital output equipment.
    c. Shock and vibration protection as necessary.
    d. Rated for a minimum of ten (10 million mechanical operations and a minimum of 500,000 electrical operations.

2. The control relays shall be located in the NCP or other local panels as provided by the BAS Installer.

3. The relays shall provide complete isolation between the motor starter, damper actuator or valve actuator, control circuit and the associated BAS digital output.

4. Select control relays such that they meet the following requirements.
    a. The malfunction of an NCP/ASC component shall cause the motor to fail on or off or maintain previous status as identified in the Sequences of Operation.

b. Following the resumption of power after power interruption to a motor, the motor shall not restart until commanded to do so by the BAS in accordance with a predetermined start-up procedure.
c. If a motor is detected by the BAS to have failed, i.e. its BAS monitored and commanded status differ, then the BAS shall shut down the motor and restart shall only be possible (when the HOA switch is in the “Auto”) by a manually entered restart command at the BAS.

5. Where hand-off-auto (HOA) switches are provided, the BAS digital output shall be wired such that control of the motor is from the BAS in the auto position only.

6. Other interlocks providing safety control, e.g. shutdown on high temperature/vibration detection, etc., shall not be overridden by the BAS control relays or the installation of the control relays.

D. Differential Pressure Transducer - Air Service

1. Provide supply static differential pressure transducers as follows:
a. Pressure transducers shall monitor the difference supply duct static pressure and space static pressure. The sensing point in the duct shall be as identified in the sequences of operations. The sensor shall be mounted adjacent to the sensing point in the duct.
b. Internal materials of the transducer shall be suitable for the application.
c. Output signal of 4-20mA proportional to input pressure, into a 500 ohm load.
d. Input range of 0 to 5 in.
e. Output variations of less than 0.3% full scale for supply voltage variations of 10% W.C.
f. End-to-end accuracy not to exceed 1.0% over entire range.
g. Integral, accessible zero and span adjustment.
h. Over pressure input protection to a minimum of five times rated input.

E. Differential Pressure Transducer – Water Service

1. Provide a differential pressure transducer meeting the requirements detailed herein to monitor the differential pressure across the supply and return lines of the chilled water and hot water systems.

2. The differential pressure transducers shall meet the following specifications:
a. Internal materials of the transducer shall be suitable for the application.
b. Output signal of 4-20mA proportional to input pressure, into a 500 ohm load.
c. Input range of 0.50 psig.
d. Output variations of less than 0.3% full scale for supply voltage variations of 10%.
e. End-to-end accuracy not to exceed 1.0% over entire range.
f. Integral, accessible zero an span adjustment.
g. Over pressure input protection to a minimum of five (5) times rated input.
h. The differential pressure transducer shall be rated to withstand the maximum rated pressure of the chilled water or hot water system in which it is installed.
i. The Mechanical Installer shall install valved tappings. Furnish the valves to the Mechanical Installer.

F. Electromagnetic Flowmeter

1. Provide electromagnetic flow meters meeting the following requirements:
a. Minimum turndown ratio of 30:1
b. Combined linearity and repeatability not to exceed 1.5%.
c. Pulse or 4 to 20mA output proportional to flow rate.
d. Integral digital converter.
e. Insertion type.

f. Suitable for maximum flow rate in line.
g. Rated 150 psig service or as necessary to withstand the maximum pressure of the system whichever is the greater.
h. Negligible pressure drop.
i. Suitable for services in chilled water or hot water lines.
j. End-to-end accuracy of 1.0% over full turndown ratio.
k. Suitable for a minimum flow velocity of 0.5 ft. per second.
l. Local flow rate indicator showing instantaneous flow rate.
m. Capable of bi directional reading (chilled water bypass only).

2. Install the electromagnetic flow meter in the valve in accordance with the manufacturer's instructions.

G. Differential Pressure Switches - Air Service

1. Provide differential pressure air switches as follows:
   a. SPDT switch action or two (2) SPST switches rated for 10 amps minimum at 120 Vac.
   b. Set point trip adjustment over, at minimum, of operating range. Dead band adjustment down to, at maximum, 10% of operating range.
   c. Operating range of 1.0 in. W. C. to 3.0 in. W. C. for fans with a total static pressure rating of 2.5 in. W. C. or less and 2.0 in. W. C. to 6.0 in. W. C. for fans having a total static pressure rating of greater than 2.5 in. W. C. Operating range of 0 to 1.0 in. W. C. for filter status applications.
   d. Shock and vibration protection as necessary.
   e. Materials and construction suitable for application.
   f. Manual reset shall be provided for air differential pressure switches used in high positive and negative pressure output applications. High differential pressure switches shall be provided for all VAV AHU.
   g. Air differential pressure switches used in filter status applications shall be equipped with an analog gauge. Gauge shall indicate actual differential pressure and differential pressure set point of switch.

2. High differential pressure switches shall be wired in series with other safety devices to the respective motor starter.

H. Thermostats

1. Provide as applicable, line voltage (120 Vac) or, low voltage wall mounted thermostats for equipment as identified on the Mechanical Drawings. Install thermostats as located on the Mechanical Drawings.

2. Each thermostat shall be for single stage with a variable set point 65º to 85ºF and shall initially be set up to control space temperature as designated in the sequences of operation.

3. Provide a 3°F dead band.

4. The thermostats shall be complete with bases and sub-bases.

5. The thermostats shall be rated for the application, and shall contain sufficient relay contacts to control valves, fans and dampers.

6. Thermostats controlling equipment in hazardous locations shall meet all applicable codes and requirements regarding the respective hazard.

I. Freezestats

1. Provide freezestats with a minimum 20-ft. vapor tension element, which shall serpentine, the inlet face on all air handling unit cooling which receive unconditioned outside air. One or more of these devices shall be provided and wired in series in order to provide one linear foot of coil surface area.

2. The freezestats shall have a manual reset. It shall not be possible for the switch to reset until the duct temperature has increased by at least 10ºF above the set point.

3. Hardwire interlock to the associated fan so that fan will shut down when HOT switch is in Hand or Auto position. Provide time delay relays with minimum two (2) minute time delay duration to minimize nuisance freezestats trips.

4. Cut out temperature shall be adjustable in the range of, at minimum, 32ºF to 40ºF.

J. Current Sensing Relays

1. Provide current sensing relays as follows:
   a. Solid core current transducer.
   b. Switching range suitable for the application.
   c. Self-powered transducer.
   d. Normally open status contacts.
   e. Hysteresis amperage of no less than 0.2 amps.

K. Fan Inlet Velocity Sensors/ Duct and Plenum Probes

1. Sensors shall be of the thermal dispersion type with true average, independent multi-point sensing capability. Sensors shall be totally constructed from non-corrosive materials, with 304 stainless steel sensor bodies, 304 stainless steel mounting brackets, adjustable cadmium-plated muting rods and “bead in glass” thermistor sensors. Each fan airflow monitoring system shall incorporate at least two sensor probes with four thermistors each.

2. Fan Inlet Performance Requirements – The individual sensor accuracy for airflow shall be better than ±0.15ºF (±0.1ºC) over the entire operating range.

3. Fan Inlet Sensor Operating Ranges – Airflow: 0 to 10,000 FPM; Temperature: -20ºF to + 160ºF; Relative Humidity: 0 to 99% (non-condensing).

4. Transmitter shall be constructed of an aluminum chassis designed to operate between minus 20ºF and 120ºF. Transmitter shall be equipped with a 12-bit A/D converter with a minimum reading accuracy of 2%. Transmitter shall output a 4-20 mAdc or 0-10 Vdc signal proportional to air velocity.

5. Approved manufacturers and equipment shall be only the following:
   a. Ebtron Advantage III Gold Series probes, combination airflow/ temperature sensors with GTx116-F (Duct and Plenum Probe) or GTx108-F (Fan Inlet Sensor) transmitter as appropriate.
   b. Approved equal.

## 2.9 AUTOMATIC VALVES - GENERAL

A. Furnish all valves shown on the Drawings and/or described in the sequences of operation as automatic control valves. The Mechanical Contractor for the Air Handling Unit Replacement project shall install valves. All other valves such as manually operated valves, etc. shall be furnished and installed by the Mechanical Installer. Provide details of the manufacturer’s installation requirements to the Mechanical Installer. Refer to the mechanical drawings for the design conditions on which to base sizing and ratings of the valves and their actuators.

B. Valves up to 2 in. in size shall have screwed ends. Valves 2.5 in. and larger shall have flanged ends. Flanged valves shall be furnished complete with companion flanges, gaskets and bolting materials. Flanges, gaskets and boiling materials shall meet the requirements of ASME/ANSI B16.3, B16.5, B16.9, B16.11 and all other relevant standards. Coordinate with the Mechanical Contractor

C. Control valves shall be selected so that cavitation does not occur over the full operating range of the valve at the system differential pressures. The control valve assembly shall be capable of tight shut-off when operating at system pressure with the system pump operating at shut-off head.

D. Valve schedules shall be submitted for review and shall clearly show the following for each valve:

1. Associated system.
2. Manufacturer and model number.
3. Size.
4. Flow rate, flow coefficient – (CV) and pressure drop at design conditions.
5. Valve configuration (e.g. two way, three way, butterfly).
6. Leakage rate.
7. Maximum pressure shut-off capability.
8. Actuator manufacturer and model number.
9. Valve body pressure and temperature rating.
10. Normally open/closed and failure positions.

E. Control Valves

1. Two-way control valves shall be straight pattern single seat globe type suitable for chilled and hot water service. These valves shall meet the following minimum requirements:
   a. Modulating design to provide equal percentage flow characteristics.
   b. Leakage rate shall not exceed 0.01% of the value flow coefficient (CV) at pump shut-off head.
   c. The valves shall be rated at minimum for the working pressures indicted in the valves schedules.
   d. Valves shall be suitable for continuous throttling.
   e. Valve body material shall be cast iron, or carbon steel, with stainless steel trim for working pressures below 300 psig.
   f. Valve seats shall be metal, ceramic filled PTFE or equivalent and must assure tight seating.
2. Three-way valves shall be suitable for chilled water and hot water service and shall meet the following minimum requirements.
   a. Modulating design with V-port parabolic or linear plug and stainless steel trim.
   b. Leakage rate shall not exceed 0.01% of the valve CV from inlet to an outlet port at pump shut-off head when this valve is closed to flow through that outlet port.
   c. Valve body material shall be cast iron or carbon steel with stainless steel trim.
   d. Valve seats shall be metal, ceramic filled PTFE or equivalent and must assure tight seating.

3. Pressure drop through modulating control valves shall not exceed 8 psig.

F. Butterfly Valves

1. Butterfly valves shall be the full lug type. Semi-lug valves and water valves are not acceptable.
2. The pressure drop across modulating butterfly valves shall not exceed 8 psig. Butterfly valves for isolation service shall be line size and the pressure drop across the valve at maximum design flow shall not exceed 5 psig.
3. The butterfly valve manufacturer shall certify compliance with bubble tight shut-off requirements at a differential pressure not less than the full rated design working pressure and temperature specified with the downstream flange removed with flow in either direction.
4. Valve body shall be carbon steel, 316 stainless steel, cast iron or ductile iron.
5. Shaft shall be 316 stainless steel or 17-4PH stainless steel. Guarantee zero leakage to the shaft.
6. Seat shall be replaceable with a stainless steel, titanium, Inconel or equivalent metal retaining ring. Seat material shall be Teflon (PTFE), reinforced Teflon (RTFE) or resilient elastomer (EPDM).
7. Butterfly Valves shall be as manufactured by Belimo, Siemans, Kele, or approved equal.

G. Valve Actuators

1. All valves shall be provided with electric actuators. Actuators shall be sized to meet the shut-off requirements when operating at the maximum system differential pressure and with the installed system pump operating at shut-off head. Actuators shall control against system maximum working pressures.
2. All two-way control valves on heating coils shall fail closed upon a loss of power, or as indicated in the Sequences of Operation. The three-way control valves shall fail closed to flow through the coil. Butterfly valves shall fail in the previous position.
3. Actuators shall have visual mechanical position indication, showing output shaft and valve position. The actuator shall be capable of operating the valve from the fully closed to the fully open position and vice versa in less than two minutes.
4. Actuators shall be constructed to withstand high shock and vibration without operations failure. The actuator cover shall be die cast aluminum or material of equivalent strength and have captive bolts to eliminate loss of bolts when removing the cover from the base. Materials of construction shall be non-corroding.
5. Actuators and valves shall be mounted and installed only in the positions approved by the manufacturer. Shop drawings shall clearly indicate the acceptable positions.
6. Valve actuators shall be of the magnetic or motor driven type. Valve stem position shall be adjustable in increments of one (1) percent or less of full stem travel.
   a. Motor driven actuators shall have an integral self-locking gear train, mechanical travel stops and two adjustable travel limit switches with electrically isolated contacts; gear assembly shall be made of hardened steel. Motor drive actuators shall be rated for continuous duty and have an input voltage of 120 Vac, 60 Hz. Disassembly of the gears shall not be required to remove the motor. Actuator motor shall be fully accessible for ease of maintenance.

b. Magnetic actuators shall be rated for continuous duty and shall have a control signal compatible with the analog output subsystem.

7. Valve actuators shall be as manufactured by Belimo, Siemans, Kele, or approved equal.

2.10 DAMPERS - GENERAL

A. Furnish all automatic dampers (AD), smoke dampers (SD) and fire smoke dampers (FSD) as indicted on the Drawings. Manual dampers (MD) for balancing, back draft dampers (BD) and dampers which are specified as part of a factory built air handling unit or terminal unit are not furnished by the BAS Contractor. The Mechanical Contractor for the Air Handling Unit Replacement project shall install all dampers. Provide details of the manufacturer's installation requirements to the Mechanical Contractor.

B. Provide damper actuators for all dampers that are furnished as part of this Contract. Where practical actuators shall be factory mounted.

C. Dampers incorporating multiple sections shall be controlled in unison. Where more than one actuator serves a damper, then the actuators shall be driven in unison and the control wiring shall be provided accordingly. Damper sections shall not exceed sixteen (16) square ft. in face area. Damper jackshafts are not acceptable for controlling multiple damper sections.

D. Dampers incorporating multiple sections shall be designed in such a way that the actuators, whether externally or internally mounted, are accessible without difficulty. Under no circumstances shall it be necessary to remove damper sections, or structural or other fixtures to facilitate removal of damper motors. Provide access doors where necessary to meet this requirement. In particular ensure that where in-air stream actuators are provided they are readily accessible.

E. For all AD, FSD, and SD that are interlocked to a fan motor(s), the BAS Installer shall wire between the MCC or local starter and the damper actuator. Dampers interlocked to fan motors shall be driven open and spring closed unless otherwise indicated in the Contract Documents. The 120 Vac power supply originating from the MCC or local starter shall be used to power the damper where possible. If the damper is indicated to be spring open and driven closed or requires a separate power source then the BAS Installer shall provide the necessary interposing relays and shall obtain the power supply to hold the damper closed from the nearest available power panel. The BAS Installer shall wire between the AD, FSD or SD position indicator switch, whose contacts shall be rated for a load up to 10 amps at 120 Vac, and the MCC or local starter. The damper position indicator switch contacts shall be closed when the damper is fully open and open when the damper is not fully open. The Fire Alarm System control of interlocked dampers shall be via the fan motor starter.

F. Automatic Dampers

1. Automatic Dampers (AD) shall be factory fabricated.

2. Damper frames shall be constructed of 16-gauge thick welded galvanized steel channel, or 1/8 in. thick extended aluminum channel. Frames in excess of 3 ft. by 3 ft., shall have corner braces or equivalent means of strengthening to ensure squareness and rigidity. Channel dimensions shall be a minimum of 5 in. by 1 in. Frames shall be constructed for flanged ductwork connection. "Slip-In" (insertion) type dampers shall not be acceptable. Frames shall be sized to match the final dimensions of the ducts including allowance where applicable, for the duct lining materials. Coordinate required installation details with Mechanical Installer. The BAS Installer

shall be responsible for coordination of correct sizing for damper assemblies furnished as part of this Contract. Blade stops shall not extend more than 1/2 in. into the air stream.

3. Damper blades shall be constructed of:
   a. Galvanized sheet steel of minimum 21-gauge thickness with a minimum of four (4) breaks running the entire length of the blade.
   b. Double galvanized sheet steel of minimum 22-gauge thickness per sheet. Sheets shall be formed with a minimum of four (4) breaks in each sheet running the entire length of the blade. Sheets shall be spot welded together, or
   c. Airfoil shaped double skin-galvanized steel constructed from minimum 14-gauge thick galvanized sheet steel.
   d. Airfoil shaped double skin-extruded aluminum constructed from minimum 16-gauge thick sheet.

4. Maximum width for galvanized steel blades shall not exceed 8 in. and for aluminum shall not exceed 6 in. Maximum blade length shall not exceed 48 in.

5. Blade edge seals shall be field replaceable and shall be one of the following:
   a. Neoprene
   b. Vinyl
   c. Polyurethane
   d. Silicone rubber
   e. Synthetic elastomer

6. Blade end (side) seals shall be one of the following:
   a. Continuous spring stainless steel strip
   b. Synthetic elastomer
   c. Flexible aluminum compression type.

7. Damper sections shall be installed such that the blades are horizontal.

8. Damper axles shall be constructed of:
   a. Minimum 1/2 in. square zinc plated steel with non-slip between blade and axle.
   b. Minimum 1/2 in. hexagon zinc plated steel with non-slip locking between blade and axle.
   c. Minimum 1/2 in. diameter zinc plated steel fastened to the blades with bolts through the axle, rivets or welds to ensure non-slip locking between blade and axle.

9. Damper axle bearings shall be one of the following:
   a. Oil impregnated sintered bronze
   b. Stainless steel sleeve

10. Linkage that interconnects blades shall be corrosion resistant steel and shall be located on the face of the damper in the air stream or shall be concealed in the frame. Linkages shall be readily accessible for maintenance.

11. Control shaft shall be as specified above and shall extend beyond the frame as necessary to match up with actuator or actuator linkage as applicable.

12. Multiple section dampers shall be of the opposed blade type. Two position dampers shall be of either the parallel or opposed blade type.

13. Multiple section dampers shall bolt together to form a rigid structure free from twisting or bending.

14. The two diagonal measurements from upper to lower opposite corners of the installed damper assembly, including multiple section dampers, shall not differ by more than 0.15 in. or 0.2 percent, whichever is greater.

15. The free area ratio, i.e. the open area in a damper assembly, including in-air stream actuators, divided by the total duct area shall not be less than 0.75 for velocities above 1500 fps and 0.6 for velocities below 1500 fps. This shall apply to both single and multiple damper section assemblies.

16. Maximum leakage rate through a 48 in. by 48 in. closed automatic damper shall not exceed 10 CFM per square foot of overall damper face area at 4 in. W.C. pressure differential with a maximum closing torque not exceeding that applied by the actuator provided for the damper. The leakage rate of the field-installed damper shall not exceed the rate specified above. Dampers shall be rated for the maximum air stream face velocity that they will experience during normal operation.

17. Damper schedules shall be submitted for review and shall clearly indicate the following for each damper:
    a. Associated system.
    b. Manufacturer and model number.
    c. Mechanical drawing reference.
    d. Damper size for each section.
    e. Parallel or opposed blade configuration.
    f. Actuator manufacturer and model number for each section.
    g. Ratio of anticipated air stream velocity to the manufacturer's maximum recommended velocity rating.
    h. Free area ratio.

18. If the automatic damper complies with these specifications, one of the following manufacturers will be acceptable:
    a. Greenheck
    b. Pottorff
    c. Ruskin

G. Fire Smoke Damper (FSD)

1. Fire Smoke Dampers (FSD) shall be factory fabricated.

2. Damper frames shall be constructed of minimum 16 gauge welded galvanized steel channel. Frames in excess of 36 in. height shall have corner braces or equivalent means of strengthening to ensure squareness and rigidity. Frames shall be constructed for flanged ductwork connection. "Slip In" (insertion) type dampers shall not be acceptable. Frames shall be sized to match the final dimensions of the ducts including allowance where applicable, for the duct lining materials. Coordinate required installation details with Mechanical Installer. BCS Installer shall be responsible for coordination of correct sizing for damper assemblies furnished as part of this Contract. Blade stops shall not extend more than 1/2 in. into the air stream.

3. Damper blades shall be constructed of:
    a. Galvanized sheet steel of minimum 16 gauges with a minimum of three (3) breaks running the entire length of the blade.
    b. Airfoil shaped double skin-galvanized steel constructed from minimum 14-gauge sheet.

4. Maximum width for galvanized steel blades shall not exceed six (6) in. Maximum blade length shall not exceed 48 in. for airfoil blades and 36 in. for grooved blade.

5. Blade end (side) seals shall be one of the following:
    a. Silicone rubber.
    b. Flexible metal compression type.

6. Damper sections shall be installed such that blades are horizontal.

7. Damper axles shall be constructed of:
   a. Minimum of 1/2 in. square in. zinc plated steel with non-slip between blade and axle.
   b. Minimum 1/2 in. hexagonal zinc plated steel with non-slip locking between blade and axle.
8. Bearings shall be stainless sleeve type.
9. Linkage that interconnects blades shall be corrosion resistant steel and shall be concealed in the frame. Linkages shall be readily accessible for maintenance.
10. Control shaft shall be as specified above and shall extend beyond the frame as necessary to match up with actuator or actuator linkage as applicable.
11. Multiple section dampers shall be of the opposed type. Two position dampers shall be of either the parallel or opposed blade type.
12. Modulating dampers shall bolt together to form a rigid structure free from twisting or bending per the manufacturer's approved methods.
13. Measurements diagonally from upper to lower opposite corners of the installed damper assembly, including multiple section dampers shall not differ by more than 1/8 in. or 0.2%, whichever is greater.
14. The free ratio, i.e., the open area in a damper assembly divided by the total duct area shall not be less than 0.8. This shall apply to both single and multiple damper section assemblies.
15. Maximum leakage shall be as for UL 555S Class 1 low-leakage type. Maximum leakage rates shall not exceed the Class 1 UL rating. The FSD shall meet UL555, UL555S, NFPA 90A and NFPA 92A requirements in all respects including size limitations. The FSD shall be one and one half (1 ½) hour fire rated and listed under UL standard 555. The damper and damper actuator shall be furnished as an integral unit and shall be equipped with a UL classified and listed fire stat meeting the elevated temperature qualification of UL 555S at 250ºF.
16. Provide damper position indicator switches that shall be an integral part of the damper actuator or shall be linked directly to the damper blades for indication of the fully open and fully closed position when required by the sequence of operation or the FAS. The damper position indicator switches shall be factory mounted and adjusted by the damper manufacturer. When FSD are associated with a fan these damper position indicator switches shall be hardwire interlocked to inhibit motor start-up. The motor start-up shall be inhibited when the HOT switch is in both the "hand" and "auto" positions. Where damage can result to mechanical components (fans, dampers, etc.). If a damper fails to open prior to fan start-up, then the interlock between the fan and damper shall not be overridden by the fire control system. The BAS Installer shall install the hardwire interlocks.
17. Dampers shall be rated by the manufacturer for normal operations, for the maximum face velocity that will be imparted by the air stream in which the damper is installed.
18. Damper schedules shall be submitted for review and shall clearly indicate the following for each damper:
   a. Associated system.
   b. Manufacturer and model number.
   c. Mechanical Drawing reference.
   d. Damper size for each section.
   e. Parallel or opposed blade configuration.
   f. Actuator manufacturer and model number for each section.
   g. Normally open/closed and failure positions.

h. Damper end switch interlock.
i. High temperature closing devices.
j. Ratio of anticipated air stream velocity to the manufacturer’s maximum recommended velocity rating.

19. If the FSD complies with these specifications, one of the following manufacturers will be acceptable:
    a. Ruskin
    b. Pottorff
    c. Greenheck

H. Smoke Dampers (SD)

1. Smoke dampers (SD) shall be factory-fabricated.

2. Damper frames shall be constructed of minimum 16 gauge welded galvanized steel channel. Frames in excess of 36 in. height shall have corner braces or equivalent means of strengthening to ensure squareness and rigidity. Frames shall be constructed for flanged ductwork connection. "Slip In" (insertion) type dampers shall not be acceptable. Frames shall be sized to match the final dimensions of the ducts including allowance where applicable, for the duct lining materials. Coordinate required installation details with Mechanical Installer. BCS Installer shall be responsible for coordination of correct sizing for damper assemblies furnished as part of this Contract. Blade stops shall not extend more then 1/2 in. into the air stream.

3. Damper blades shall be constructed of:
    a. Galvanized sheet steel of minimum 16 gauge with a minimum of three (3) breaks running the entire length of the blade.
    b. Airfoil shaped double skin-galvanized steel constructed from minimum 14-gauge sheet.

4. Maximum width for galvanized steel blades shall not exceed six (6) in. for grooved blade.

5. Blade end (side) seals shall be one of the following:
    a. Silicone rubber.
    b. Flexible metal compression type.

6. Damper sections shall be installed such that blades are horizontal.

7. Damper axels shall be constructed of:
    a. Minimum of 1/2 in. square inch zinc plated steel with non-slip between blade and axle.
    b. Minimum 1/2 in. hexagonal zinc plated steel with non-slip locking between blade and axle.

8. Bearings shall be stainless sleeve or oil impregnated sintered bronze type.

9. Linchage that interconnects blades shall be corrosion resistant steel and shall be concealed in the frame. Linkages shall be readily accessible for maintenance.

10. Control shaft shall be as specified aboce and shall extend beyond the frame as necessary to match up with actuator or actuator linkage as applicable.

11. Modulating dampers shall be of the opposed blade type. Two position dambers shall be of either the parallel or opposed blade type.

12. Multiple section dampers shall bolt together to form a rigid structure free from twisting or bending per the manufacturer's approved methods.

13. Measurements diagonally from upper to lower opposite corners of the installed damper assembly, including multiple section dampers shall not differ by more than 1/8 in. or 0.2% wichever is the greater.

14. The free-area ratio, i.e., the open area in a damper assembly divided by the total duct area shall not be less than 0.8. This shall apply to both single and multiple damper section assemblies.

15. Maximum leakage shall be as for UL 555S Class 1 low leakage type. Maximum leakage rates shall not exceed 8 CFM per sq. ft. of overall damper face area at 4.0-in. wg. differential pressure. The leakage rate of the field-intalled damper shall not exceed the Class 2 UL rating. The SD shall meet UL 555S, NFPA 90A and NFPA 92A requirements in all respects including size limitations.

16. Provide damper position indicator switches that shall be an integral part of the damper actuator or shall be linked directly to the damper blades for indication of the fully open and full closed position when required by the sequence of operation or the FAS. The damper position indicator switches shall be factory mounted and adjusted by the damper manufacturer. When SD is associated with a fan these damper position indicator switches shall be hardwire interlocked to inhibit motor start-up. The motor positions. Where damage can result to mechanical components (fans, dampers, etc.) If a damper fails to open prior to fan start-up, then the interlock between the fan and damper shall not be overridden by the fire control system. The BCS Installer shall install the hardwire interlocks.

17. Dampers shall be rated by the manufacturer for normal operations, for the maximum face velocity that will be imparted by the air stream in which the damper is installed.

18. Damper schedules shall be submitted for review and shall clearly indicate the following for each damper:
    a. Associated system.
    b. Manufacturer and model number.
    c. Mechanical drawing reference.
    d. Damper size of each section.
    e. Parallel or opposed blade configuration.
    f. Actuator manufacturer and model number for each section.
    g. Normally open/closed and failure positions.
    h. Damper end switch interlocks.
    i. Ratio of anticipated air stream velocity to the manufacturer's maximum recommended velocity rating.

19. If the SD compiles with these specifications, one of the following manufacturers will be acceptable:
    a. Greeheck
    b. Ruskin
    c. Pottorff

## 2.11 DAMPER ACTUATOR

A. Damper Actuators.

1. Provide damper actuators for all automatic control dampers, including those furnished as part of a packaged air-handling unit.

2. Electric damper actuators used for two-position service shall be of the spring return type. Modulating dampers shall be motorized in both directions with spring return to the failure (de-energized) position. Unless stated otherwise in these Contract Documents dampers shall fail to the closed position on loss of power. Damper

actuators shall have a service life, at minimum, of 60,000 fully closed to fully open to fully closed operations. In addition the modulating damper actuators shall have a service life of, at minimum, 1000 spring operations on loss of power.

3. Actuators shall stroke by the rotating motion of a reversible, overload-protected synchronous motor or shall be direct-coupled rotary type actuators.

4. The actuators shall be protected against overload by an integral magnetic clutch that shall allow the motor to continue running when, for example, the actuator is stalled at the end of its stroke or by a jammed damper. Alternatively, stall protection shall be by non-overloading impedance protected motor.

5. Provide sufficient quantity of additional damper actuators to meet the damper leakage requirements for the installed damper assembly. At minimum the torque provided shall be such as to meet the maximum close-off leakage requirements.

6. Provide mounting brackets suitable for extended shaft mounting or direct damper drive shaft mounting. The actuator housing shall be rugged and non-corrosive.

7. Damper actuator shall be fully accessible for ease of maintenance. Shop drawings shall clearly indicate motor locations on multiple section damper assemblies.

8. The actuators shall stroke two position dampers from fully closed to fully open in less than two (2) minutes. Modulating dampers shall be driven from fully closed to fully open and vice versa in less than two (2) minutes. This time shall not include the initial period following the availability of power, not to exceed 200 seconds, which is required to tension the spring.

9. Actuator for Smoke Dampers shall open or close damper in less than 75 seconds or as required to comply with UL 555S.

10. The control signal to the modulating damper actuators shall be compatible with the BCS analog output subsystem e.g. 4-20 mA, 0 to 10 Vdc, etc.

11. Actuators shall be as manufactured by Belimo, Siemans, Kele, or approved equal.

2.12 SMOKE DETECTORS

A. The existing duct mounted smoke detectors will remain and be re-used.

PART 3 - EXECUTION

3.1 GENERAL

A. All grounding, wiring, selection of components and installations shall conform to the National Electrical Code with amendments to the date of issue of this specification.

B. The installation shall conform to each manufacturer’s recommended procedures and to all applicable codes, statutes and ordinances and to the Contract Documents. In each and every instance of application, the code, regulation, statute, by-law or specification having the most stringent requirements shall apply.

C. All installations to be performed by skilled and certified technicians.

D. All equipment installed shall be mechanically stable and, as necessary, fixed to wall or floor. Provide anti-vibration mounts, if required, for the proper isolation of the equipment.

E. Install equipment so as to allow for easy maintenance access. Install equipment such that it does not interfere in any way with across to adjacent equipment and personnel traffic in the surrounding space.

F. Install equipment in locations providing adequate ambient conditions for its specified functioning, allowing for adequate ventilation and with no condensate traps.

G. All components placed in areas of high humidity or potentially high humidity must be adequately protected.

H. The existing smoke detectors will remain and be re-used.

3.2 CONDUIT, WIRING, CABLING AND FITTINGS

A. The installation shall conform to the Division 23 and 26 Contract Documents for this project.

B. All wires and cables for powering the BAS as provided shall be:

1. Ninety-eight (98) percent conductivity copper.
2. A minimum of #12 AWG for branch 120 VAC power circuits.
3. A minimum of #14 AWG for DO motor control circuits.
4. A minimum of #18 AWG for sensing, transmitter, DO (except motor control circuits) and AO control circuits. Where manufacturers recommend a heavier conductor, then the BAS Installer shall comply with the manufacturer's recommendation.
5. A minimum of #20 AWG for communication trunk, shielded and grounded at a single end.
6. Stranded copper conductors throughout for #18 AWG and smaller diameter wire.
7. Continuously color coded insulation in accordance with Section 26 05 19 entitled "Wire and Cable".

C. All cabling shall be plenum rated cable and shall be as specified above with the following additional requirements:

1. All plenum rated wire and cable shall be a minimum of #18 AWG and shall be shielded.
2. Cable jacket shall have a minimum thickness of 0.015 in. and shall be bright orange, red, yellow or other bright, distinctive color. Coordinate jacket color with other trades.
3. Plenum wiring and cabling shall be routed through cable rings. Cable rings shall be suitably spaced to properly support plenum cabling and shall be attached to ductwork hangers or structure as applicable.
4. Plenum cable shall be as manufactured by Belden, Kynar, Dekoron or approved equal.

D. Smaller gauge wiring shall be acceptable if certified by the equipment manufacturer. If complications arise, however, due to wiring size, replace the wire at no additional cost to the Owner.

E. The sizing and provision of conduit and type of wire for the main BAS trunk wiring are the design responsibility of the BAS Installer.

F. Obtain and pay for all electrical inspection fees related to the work of this section.

G. Perform circuit tests using qualified personnel only. Provide necessary instruments and equipment to demonstrate that:

1. All circuits are continuous and free from short circuits and grounds.

2. All circuits are free from unspecified grounds; that resistance to ground of all circuits is no less than 50 megohms.

H. Provide complete testing for all wiring installed or utilized as part of this work. Provide all equipment, tools, and personnel as necessary to conduct these tests.

I. Provide complete grounding of all power and signal wiring so as to ensure system integrity of operation.

J. NCP/ASC shall not be mounted in-line with vertical conduit but shall be connected off to the side of the vertical conduit by suitably pitched conduit such that any condensed moisture in the vertical conduit cannot enter the NCP/ASC enclosures.

K. All analog and digital input points and communication cables shall have shielded wiring. Non-shielded wiring may only be provided upon certification from the manufacturer that non-shielded wiring will not cause degradation of system performance and will not render the system more susceptible to damage. However, if complications arise from the use of non-shielded wiring, replace the wiring at no additional cost to the Owner.

L. BAS wiring shall not run in the same conduit as power wiring of any voltage.

M. All control cable supporting smoke control functions shall be routed in conduit.

N. Suitably coated wire may be used in ceiling spaces and in tenant wall partitions without conduit where local codes permit and the cable jacks and insulation have been accepted under the provisions of the National Electrical Code and have been classified by UL, Inc. For use without conduit in air plenums. Elsewhere use Electrical Metallic Tubing (EMT).

O. Sleeves shall be provided by the BCS Installer where required and shall meet the requirements detailed in the Division 26 Contract Documents for this project.

P. All wiring shall be marked in accordance with the National Electrical Code. Provide the labeling of wire at every termination. Each wire shall be identified which uniquely identifies each wire and which corresponds to the shop Drawings and as-built Drawings provided under this Contract.

3.3 EQUIPMENT, INSTALLATION

A. Temperature sensing wells.

1. Provide list with shop drawing of well locations to Mechanical Installer.

B. Locate temperature sensors, humidity sensors, thermostats, and humidistat for room control immediately as shown on the mechanical drawings. Prior to installation, coordinate sensor and/or thermostat locations with the Owner and Architect.

1. Prior to installation, coordinate sensor and/or thermostat locations with Owner's Representative.

C. Mount local control panels on at convenient locations adjacent to equipment served.

1. Mount all relays, etc., internal to the temperature control panels.

2. Tag each instrument corresponding to symbols used on control diagrams.

D. Mounting of controllers on air handling units shall not be allowed.

E. Furnish all control valves (globe and butterfly, as applicable) to the Mechanical Installer for the Air Handling Unit Replacement project. Mechanical Installer to install control valves per the valve manufacturer's recommendations.

3.4 COMMISSIONING

A. BAS shall be installed and commissioned by factory-trained technicians skilled in the setting and adjustment of BAS equipment used in this project. This technician is to be experienced in the type of systems associated with this BAS,

B. Perform a complete and detailed calibration and operational check for each individual point and for each individual function as contained within the BAS. These checks shall ensure that all equipment, software, network elements, modules and circuits as provided under the terms of this contract are functioning as per the Contract Documents. Such checks shall be carried out with the use of point/function log sheets. Point/function sheets are to be prepared by the Contactor and submitted to the Engineer for the approval of content and format. Such calibration and operation checks shall be performed prior to the commencement of final tests on completion for any relevant system part. The point/function logs shall, at minimum, include the following:

1. Identification of each point by BAS point name and expanded descriptor.

2. Indication of BAS value/status, field-tested value/status, and deviation between the BAS and field-tested value/status.

3. Confirmation of system safeties operation.

4. Confirmation of proper failure modes of motors, dampers, valves, etc.

5. Confirmation of proper tuning of PID control loops.

6. Confirmation of proper sequence of operation performance.

7. Manufacturer, model number and accuracy of test instruments used.

8. Date of testing/verification and name of individuals performing the tests.

C. All system commissioning will be performed in conjunction with the air balancing/commissioning company that will be provided by Tarrant County and not part of this contract.

D. At time of final observation, demonstrate the sequence of operation for each system to the Owner's Representative, Engineer and Owner's Commissioning Agent. Perform system demonstration as directed by Owner's Representative, Engineer and Owner's Commissioning Agent.

E. The Owner's Commissioning Agent will provide the testing criteria and will perform sequence of operation function tests with the assistance of a BAS technician familiar with the project.

3.5 TRAINING

A. Provide a minimum of 40 hours of instructions to Owner’s personnel in the operation and maintenance of the control system. Provide training after the system has been installed and commissioned. Training shall be on-site, using the installed BAS as the basis for training. Provide Training Manuals and O&M Manuals for students attending on-site training.

3.6 WARRANTY

A. It is the Owner's intent to accept completion of the project on a quadrant-by-quadrant basis. Warranty period will begin at substantial completion date for each quadrant

B. At completion of final test of installation and acceptance by Owner, provide any service incidental to proper performance for a period of one year.

C. Equipment shall be warranted for one year (including defects in workmanship and material) under normal use and service. During warranty period supplier shall also replace or repair, free of charge, any equipment proven to be defective in workmanship or material.

D. Certain electronic devices not manufactured by the BAS supplier such as computers, etc., shall carry the original manufacturer’s warranty. Pass any registration and warranty documents and warranty rights to the Owner.

E. All software upgrades, enhancements or revisions that are initiated by the BAS manufacturer up to the time of expiration of the warranty period shall be provided at no additional cost to the Owner.

3.7 SOFTWARE AND FIRMWARE UPDATES

A. The Buildidng Automation System (BAS) manufacurers shall furnish and install system software and firmware updates whenever they are issued by the manufacurers for the life of the system, at no additional cost to the Owner.

END OF SECTION

SECTION 23 09 93

SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 specifications, apply to this section as well as Section 23 00 10 "BASIC MECHANICAL REQUIREMENTS".

1.2 DESCRIPTION OF WORK

A. The work required by this Section shall include the provision of all labor, materials, documentation and services as required by the Contract Documents for those aspects of the BAS installation relating to:

1. The implementation of the sequences of operation as detailed herein.

1.3 GENERAL

A. In the descriptions of the sequences of operation to be executed by the BAS, the following shall apply:

1. Where modulation of a valve or damper is referred to then it shall mean the direct digital control of the valve or damper based on a control algorithm resident in the BAS software at the NCP. Unless noted otherwise the control algorithm shall be PID control. Choose the control constants so as to provide optimum loop response.

2. An Operator having the required level of password access shall be able to modify the Operator changeable or definable parameters on-line from an I/O device such that the monitoring and control functions of the BAS shall not be affected during the period of the change. The mechanism by which the change is made shall be simple and shall be adequately described in the Operator's manuals. Where setpoints for control parameters such as temperature, humidity, Operator selection of lead/lag equipment, and modes of operation are referred to in this Section they shall be Operator changeable on-line on the associated VDU graphic.

3. Where the sequences refer to the start/stop of a system this shall be initiated either by an Operator manually entered command or automatically by a software routine such as "Optimum Stop/Start", "Power Demand Control", "Programmed Stop/Start", etc. or by way of an interlock in the sequences of operation to other equipment or events.

4. When the motor controller provided by Division 23 or Division 26 is equipped with a HOA, the motors shall only be controlled by the BAS when the HOA switch is in the auto position.

5. High differential pressure switches, smoke and fire detectors and interlocked dampers (motorized control damper, smoke damper or combination fire/smoke damper) shall be wired to shut down motors when the HOA switch is in both the hand and auto positions. It shall not be possible for the BAS to override these or any other safety devices or any fire alarm system control functions.

6. Refer to the Point Definition Sheets, which form part of these Contract Documents, to facilitate the interpretation of the sequences of operation as defined in this Section.

7. Provide additional I/O points and instrumentation, whether or not such points are indicated in the Point Definition Sheets, if they are required in order to attain the requirements of the Contract Documents.

8. Where fans and dampers (control dampers, smoke dampers or combination fire/smoke dampers) are to be interlocked, provide hardwire interlocks between the motor starter and damper or software interlocks such that the damper shall be driven open when the motor is required to start. Motor start up shall not occur until the damper end switch indicates the damper is in the full open position.

9. The BAS shall open the BAS motor control relay where the BAS commanded and monitored status of the motor differ.

10. On air handling systems that are equipped with heating and cooling coils, the heating and cooling setpoints shall be selected to avoid simultaneous heating and cooling.

11. Where there are fans not identified within the sequence of operation or point definition sheets that provide supply and/or exhaust air that are not controlled by way of a thermostat, they shall be hardwire interlocked to the controlling device as indicated in the Division 23 or Division 26 Contract Documents. The supply fans shall be hardwire interlocked with their associated exhaust fan (if applicable) to operate simultaneously. The dampers (control damper, smoke damper or combination fire/smoke damper) shall be hardwire interlocked with the fans by way of end switches such that the fans cannot operate when the damper is not fully open. The damper status shall not be monitored by the BAS.

## PART 2 - PRODUCTS

### 2.1 AIR HANDLING UNITS – AH-1E-6E, AH-1W-6W

A. During normal operation, the supply fan will be started and stopped through the BAS. Duct static pressure will be maintained at setpoint through static pressure sensor by adjusting the supply fan speed.

B. When the fan is running, the outside air damper will open to an adjustable minimum position. The outside air damper will fully close when the fan is off.

C. When the outside air temperature is above 55 degrees (adjustable) the BAS will modulate the cooling coil valve and the heating coil valve in sequence to maintain space temperature setpoint at sensor. The discharge temperature at sensor will have a low limit of 55 degrees (adjustable).

D. When the outside air temperate is below 55 degrees (adjustable) the mechanical cooling will be locked out (cooling coil valve closed) and the BAS will modulate the mixed air dampers and the heating coil valve in sequence to maintain space temperature setpoint. The discharge temperature at sensor will have a low limit of 55 degrees (adjustable). Coordiante exact temperature setpoint with commissioning company. Final adjustment will be determined by Air Balancing Company.

E. The BAS will modulate open the cooling coil valve in sequence for dehumidification if the return air humidity at humidity sensor is above 50% setpoint (adjustable).

F. Duct mounted smoke detectors will shut down the supply fan and signal the fire alarm system if smoke is detected in return air or supply air. Static pressure limit switches will shut down the fan if excessive pressures are detected.

G. Current Transformer CT will provide fan status to the BAS. Differential pressure switch will provide a non-critical alarm at the BAS of dirty filter indication.

H. The BAS will fully open the heating coil valve to flow to the coil if the supply air temperature falls below 50 degrees (adjustable) for freeze protection. Coordinate exact temperature setpoint with commissioning company.

I. Smoke control operation. The unit will enter the smoke control mode upon signal from the fire alarm system, indicating that a zone which has a common return air duct or plenum with this unit is in alarm. The outside air damper will fully open, and the return air damper will fully close. The cooling coil valve will open to fully bypass the cooling coil. The heating coil valve will modulate to maintain space temperature setpoint or minimum discharge temperature at sensor. Hardwired safety devices will continue to function. Duct static pressure will remain constant as the BAS modulates the fan speed to compensate for dampers opening and/or closing. (See paragraph 2.16 for cell damper operation)

2.2 AIR HANDLING UNITS: AH-7E(1), 8E(1), 7W(2), 8W(2)

A. During normal operation, the supply fan will be started and stopped through the BAS.

B. When the fan is running, the outside air damper will open to an adjustable minimum position. The outside air damper will fully close when the fan is off.

C. When the outside air temperature is above 55 degrees (adjustable) the BAS will modulate the cooling coil valve and the heating coil valve in sequence to maintain space temperature setpoint at sensor. The discharge temperature at sensor will have a low limit of 55 degrees (adjustable).

D. When the outside air temperature is below 55 degrees (adjustable) mechanical cooling will be locked out (cooling coil valve closed) and the BAS will modulate the mixed air dampers and the heating coil valve in sequence to maintain space temperature setpoint. The discharge temperature at sensor will have a low limit of 55 degrees (adjustable). Coordinate exact temperature setpoint with commissioning company.

E. The BAS will modulate open the cooling coil valve in sequence for dehumidification if the return air humidity at humidity sensor is above 50% setpoint (adjustable).

F. Duct mounted smoke detectors will shut down the supply fan and signal the fire alarm system if smoke is detected in return air or supply air. Static pressure limit switches will shut down the fan if excessive pressures are detected.

G. CT will provide fan status to the BAS. Differential pressure switch will provide a non-critical alarm at the BAS for dirty filter indication.

H. The BAS will fully open the heating coil valve to flow to the coil if the supply air temperature falls below 50 degrees (adjustable) for freeze protection. Coordinate exact temperature setpoint with commissioning company.

I. Smoke Control Operation. The unit will enter the smoke control mode upon signal from the fire alarm system, indicating that a zone which has a common return air duct or plenum with this unit is in alarm. The outside damper will fully open and the return air damper will fully close. The cooling coil valve will fully close. The heating coil valve will modulate to

maintain space temperature setpoint for minim discharge temperature at sensor. Hardwired safety devices will continue to function. Duct static pressure will remain constant as the BAS modulates fan speed to compensate for dampers opening and/or closing. (See Paragraph 2.16 for day room damper operation)

2.3 AIR HANDLING UNITS AH-7E(2), 8E(2)3, 7W(1), 8W(1)

A. During smoke purge operation, the supply fan will be started and stopped through BAS. It will run when any day room in the associated quadrant is in alarm.

B. When the fan is running, the outside air damper will fully open. When the fan is shut down, the outside air damper will fully close.

C. Duct static pressure will be maintained at setpoint through static pressure sensor by adjusting the supply fan speed.

D. Hot Water Valve will be open to the heating coil when the discharge temperature is below 55 degrees (adjustable) and in bypass when above 55 degrees.

E. Duct mounted smoke detectors will shut down the fan and signal the fire alarm system if smoke is detected. Differential Pressure Switches will shut down the fan if excessive pressures are detected.

F. CT will report fan status to the BAS. Differential Pressure Switch will provide a non-critical alarm at the BAS for dirty filter indication.

G. See Paragraph 2.16 for day room purge damper operation.

2.4 AIR HANDLING UNITS: AH-10, 11, 13, 14

A. During normal operation, the supply fan will be started and stopped through the BAS by relay. Duct static pressure will be maintained at setpoint through sensor by adjusting the supply fan speed.

B. When the fan is running, the outside air damper will open to an adjustable minimum position. The outside air damper will fully close when the fan is off.

C. When the outside air temperature is above 55 degrees (adjustable) the BAS will modulate the cooling coil valve and the heating coil valve in sequence to maintain discharge temperature setpoint at sensor.

D. When the outside air temperature is below 55 degrees (adjustable) mechanical cooling will be locked out (cooling coil valve closed) and the BAS will modulate the mixed air dampers and the heating coil valve in sequence to maintain discharge temperature setpoint.

E. Duct mounted smoke detectors will shut down the supply fan and signal the fire alarm system if smoke is detected in return air or supply air. Static pressure limit switches will shut down the fan if excessive pressures are detected.

F. CT will provide fan status to the BAS. Differential Pressure Switch will provide a non-critical alarm at the BAS for dirty filter indication.

G. The BAS will fully open the Heating Coil Valve to flow to the coil if the supply air temperature falls below 50 degrees (adjustable) for freeze protection.

H. BAS will reposition the associated smoke purge system dampers when purge is in operation.

I. See below for smoke control sequence of operation.

1. Administrative Area, Level 1 (AH-14):
   a. On detection of smoke within the Administration area, the return air damper for AH-14 closes in the 4th level mechanical room, and the fresh air damper for AH-14 opens fully.
   b. Smoke Exhaust Fan SEF-5 (Col. H-8) is energized.
   c. Return air dampers for all AH Fans on floors 2 through 13M which open into the return air/smoke removal shaft at column H-8 are closed.
   d. Smoke is exhausted from the Administrative area, including main corridor and corridor to courts building through the roof by SEF-5.
   e. The return air damper for AH-13 (second level) closes in the 4th level mechanical room, and the fresh air damper opens fully to pressurize the second level.

2. Second Level (AH-13)
   a. Administrative Area:
      1) On detection of smoke, the damper in the return air duct in the 4th level mechanical room is closed, and the fresh air damper is fully opened.
      2) Smoke Exhaust Fans SEF-2 (COL. D-1) and SEF-3 (COL. E-1) are energized.
      3) Air Terminal Units for cell and holding areas remain in the normal cooling (or heating) mode.
      4) Return Air Dampers for all AH Fans on Floors 3 through 13M which open into the return air/smoke removal shafts at Columns D-1 and E-1 are closed. Smoke is exhausted through the roof by Smoke Exhaust Fans SEF-2 and SEF-3.
   b. Cell and Holding Area.
      1) The Air Terminal Units serving the cell and holding areas will be opened to the full purge condition.
      2) The Return Air Dampers for AH Units on the first and third levels close in the 4th level mechanical room, and the fresh air dampers open fully.

3. Third Level (AHU-10)
   a. Administrative Area:
      1) On detection of smoke, the damper in the return air duct is closed, fresh air damper is fully opened, and the supply fan goes to full ventilation cycle.
      2) Smoke Exhaust Fan SEF-2 (COL. D-1) is energized.
      3) Air Terminal Units for Administrative Areas go to the full open, or purge position.
      4) Return Air Dampers for all AH Fans on all floors through 13M which open into the return air/smoke removal shaft at column D-1 are closed. Smoke is exhausted through the roof by Smoke Exhaust Fan SEF-2.
   b. Cell and Holding Areas:
      1) Operational sequence is the same as described for the Administrative Area.
   c. AHU-12 and AHU-14 (1st level administrative and cells) remain in normal operation.
   d. The return air damper in the 4th level mechanical room for AH-13 closes and the fresh air damper opens fully to pressurize the second level.

4. Level 5 and 6

a. Medical area ( Level 5, AH-11 )
   1) On detection of smoke, a damper in the return air duct in the 4th level mechanical room is closed, and the fresh air damper for AH-11 opens fully.
   2) Smoke Exhaust Fans SEF-1 (Col. A-1), SEF-2 (Col. D-1), SEF-7 (Col. D-8) and SEF-8 (Col. 1-8) are energized.
   3) Air terminal units for medical ward and cell areas, and the sixth-floor library/administrative areas remain in the normal cooling (or heating) mode.
   4) Return air dampers located in the 4th level mechanical room for all AHU fans which open into the return air/smoke removal shaft at columns D-1, E-1, D-8, and A-8, as well as all return air dampers from cell and day room area which open into these shafts, are closed.
   5) Smoke is exhausted through the roof by Smoke Exhaust Fans SEF-1, SEF-2, SEF-7, and SEF-8.
   6) Isolating smoke dampers located at the ceiling level of the interstitial level in the above smoke removal shafts are closed.

b. Medical wards and bed areas:
   1) On detection of smoke, a damper in the return air duct in the 4th level mechanical room is closed, and the fresh air damper for AHU-11 open fully.
   2) Smoke Exhaust Fans SEF-1 (Col. A-1), SEF-2 (Col. D-1), SEF-7 (Col. D-8), and SEF-8 (Col. A-8) are energized.
   3) Air terminal units for administrative areas remain in the normal cooling (or heating) mode.
   4) Return air dampers located in the 4th level mechanical room for all AHU fans which open into the return air/smoke removal shaft at columns listed above, as well as all return air dampers from cell and day room areas which open into these shafts, are closed.
   5) Smoke dampers for the purge system open fully to the corner duct shafts listed above.
   6) Smoke is exhausted through the roof by Smoke Exhaust Fans SEF-1, SEF-2, SEF-7, and SEF-8.

c. Library/Administrative area, Level 6 (AHU-11):
   1) Smoke removal of this area is accomplished in the same manner as described above for the 5th level medical area, except there are no prisoner holding areas on this level.

## 2.5 AIR HANDLING UNIT: AH-12

A. Supply Fan Off: When the fan is off, cooling and heating coil valves are closed to the coils. The outside air damper is closed. The return air damper is open. If a low temperature condition is detected by the mixed air temperature sensor located in the air handler the cooling and heating valves shall fully open to the coil and the fan shall start with the outdoor air damper closed and the return damper open. Once the temperature in the unit reaches 55°F. The unit shall return to normal operation.

B. Supply Fan Operating: The supply fan runs continuously during occupied mode. The modulating outside air and return air dampers open to maintain a constant outdoor air CFM as indicated on the air handler schedule. The cooling or heating coil valves modulate to maintain the unit discharge air temperature setting of 55°F.

C. Space Temperature Control: The thermostat or temperature sensors associated with each vav box shall control the vav air valve, electric heater and, where applicable, the parallel fan.

   1. Valve only vav box - the air valve shall modulate to maintain the space cooling setpoint. Upon a drop is space temperature with the air valve in the minimum position the vav box shall go through a 5°F deadband between the heating and cooling mode

of operation. Once the space temperature drops below the heating setpoint the air valbe shall adjust to a minimum of 50% of the cooling supply air CFM and the electric heater shall engage to maintain the heating setpoint. The reverse shall occur upon a rise in space temperature.

2. Parallel fan vav box - the air valve shall modulate to maintain the space cooling setpoint. Upon a drop in space temperature with the air valve in the minimum position the vav box shall go through a 5°F deadband between the heating and cooling mode of operation. Once the space temperature drops below the heating setpoint the papallel fan shall engage. Upon a further drop in space temperature the electric heating coil shall engage to maintain the heating setpoint. The reverse shall occur upon a rise in space temperature.

D. Safety shutdown of the fan. The control system shuts down the fan if smoke is detected or if a high static pressure condition is detected.

1. Smoke detection: A duct smoke detector shall stop the fan whenever the presence of smoke is detected. To restart the fan, the smoke detectors and the control panel must be manually reset.

2. High static pressure: A detection of high static pressure by the high limit pressure sensor in the air handler supply plenum shall stop the fan. To restart the fan the control panel must be manually reset.

2.6 AIR HANDLING UNIT: AH-9

A. During normal operation. the supply fan will be started and stopped through the BAS.

B. When the fan is running, the outside air damper will open to an adjustable minimum position. The outside air damper will fully close when the fan is off.

C. When the outside air temperature is below 55 degrees (adj.) mechanical cooling will be locked out (cooling coil valve closed) and the BAS will modulate the mixed air dampers and the heating coil valve in sequence to maintain space temperature setpoint.

D. Duct mounted smoke detectors will shut down the supply fan and signal the fire alarm system if smoke is detected in return air or supply air. Static pressure limit switches will shut down the fan if excessive pressures are detected.

E. CT will provide fan status to the BAS. Differential Pressure Switch will provide a non-critical alarm at the BAS for dirty filter indication.

F. The BAS will fully open the heating coil valve to flow to the coil if the supply air temperature falls below 50 degrees (adj.) for freeze protection.

G. Elevator Lobby (Fan AH-9)

1. On detection of smoke in any elevator lobby from the 5th level through level 13M the return air damper adjacent to the fan unit in the elevator penthouse area closes, and the fresh air damper opens fully.

2. Return air dampers into the return air/smoke exhaust shaft close on all floors, pressuring all elevator lobbies.

2.7 FAN POWERED BOXES

A. Upon a call for cooling the air valve on the VAV Terminal will modulate open. As the temperature decreases in the space, the air valve will be modulated closed. When the air valve is approximately 80% closed (adjustable from the BAS system), the fan will be energized to draw plenum air into the terminal unit. ON a continued drop in temperature the air valve will completely close, and the hot water valve on the heating coil will open. The revers sequence will occur as the temperature begins to rise.

B. Cooling Only Boxes:

1. The control valve will modulate toward the closed position upon sensing a drop in space temperature. As the space temperature begins to rise, the air valve will be modulated open.

C. Cooling with Hot Water Reheat:

1. The air valve will modulate toward minimum position upon a decreased call for cooling. Upon a call for heating, the system will hold the air valve at minimum position and cycle the Heating Coil Valve.

D. All Units:

1. A pushbutton on the face of the space temperature sensor will override the unoccupied setpoint and return the unit to the occupied setpoint for a period established by the Building Engineer.

2.8 TOILET EXHAUST FANS

A. During normal operation the fans will be started remotely through the BAS.

B. High Limit Thermostat will shut down the fan and signal the fire alarm system if inlet air temperature exceeds setpoint.

C. CT will provide fan status for the BAS.

2.9 HOLDING CELL SMOKE PURGE

A. When Holding Cell Smoke Purge is initiated, AH-12 is off, purge exhaust fan PEF-HC is on, and purge supply fan is on after 5 second time delay.

2.10 SALLYPORT VENTILATION

A. During normal operation exhaust fan (VSE-1) will be started remotely through the BAS System. Supply Fan (VSS-1) will run when VSE-1 is running.

B. CT will report fan status to the BAS.

C. High Limit Thermostats will shut down their respective fans and signal the fire alarm system if inlet air temperature exceeds setpoint.

2.11 BUS SALLYPORT, TRUCK DOCK VENTILATION, MEDICAL EXHAUST FAN, HOLDING CELL EXHAUST

A. During normal operation the fans will be started remotely through the BAS.

B. High Limit Thermostat (HL-1) will shut down the fan and signal the fire alarm system if inlet air temperature exceeds setpoint.

C. CT will provide fan status to the BAS.

2.12 STAIRWELL PRESSURIZATION

A. During automatic operation the stairwell fans will be started by the BAS upon signal from the fire alarm system.

B. High Limit Thermostats (HL-2) will shut down the fan signal the fire alarm system if inlet air temperature exceeds setpoint.

C. CT will provide fan status to the BAS.

2.13 HEATING WATER SYSTEM

A. During normal operation the heating water system will be activated when the outside air temperature is below 65 degrees.

B. Upon start-up the combustion air dampers will fully open. When the combustion air dampers are open as indicated by damper end switch, the primary pump (selectable) will start. Isolation valve (VP-9) will close and (VP-10) will open. Boilers 2, 3, and 4 will be enabled when flow switch contacts make. Mixing valve (VP-8) will modulate to maintain heating water supply temperature at setpoint as reset by outside air temperature.

C. If the primary pump fails or does not start, the BAS will go into alarm after a short time delay and start the secondary pump.

D. Operation of Boiler 1 will be initiated by manual command through the BAS, or whenever Boilers 1, 2 and 3 are not able to maintain HWS temperature setpoint, Boilers 2, 3 and 4 will be disabled, isolation valve (VP-9) will open and (VP-10) will close. Boiler 1 will be enabled when flow switch contacts make. Mixing valve (VP-7) will modulate to maintain heating water supply temperature at setpoint as reset by outside air temperature.

E. Schedule Boiler 1 to automatically run for 30 minute test period once per month during October to March. The BAS shall notify operator when test period is initiated and indicate alarm if boiler does not come on.

2.14 CHILLED WATER SYSTEM

A. The chiller water system consists of two (2) chillers and two (2) primary chilled water pumps piped in parallel, with one (1) standby primary chilled water pump with two automated isolation valves.

B. Start/stop control of the chillers and the primary chilled water pumps shall be possible from the BAS by on-line Operator command or automatically by the chiller sequencing program for normal operation. The automatic/manual mode of operation shall be on-line selectable by the Operator. The chillers shall operate in an Operator defined lead-lag sequence to distribute run time. Lead-lag selection shall be selectable on the associated VDU graphic display.

C. The chiller shall start when flow through the condenser and evaporator is proven for the Operator defined time period. Two differential pressure switches provided per chiller, one for the condenser and one for the evaporator for proof of water flow. Interlock each chiller with their respective flow safety devices.

D. Interlock the chillers to the associated chilled water pump such that the chilled water pump is operating prior to the chiller start. An alarm shall be generated by the BAS if a chiller is operating and either of the associated chilled water or condenser water pumps is not operating.

E. The chilled water supply temperature setpoint shall be determined by Operator entry or by BAS automatic sequence. Upon start-up following power failure, commissioning of equipment, etc., the chilled water supply temperature setpoint shall have an initial value of 42°F.

F. De-energized mode.

1. The chillers shall be de-energized.
2. The chilled water pumps shall be de-energized.

G. Normal operation mode.

1. The chillers and the associated primary chilled water pumps shall be staged to maintain the chilled water supply temperature setpoint, initially set at 42°F. The chillers shall be staged as follows:
   a. Chiller CH-1 shall be the lead machine. After start-up of CH-1 and primary pump P-6, if flow is measured in the chilled water bypass line from the supply line to the return line that is less than 10 percent of the capacity of P-6 and CH-1 is operating above 90 percent fully ampacity, then the chiller CH-2 and primary pump p-8 shall be energized to operate in conjunction with chiller CH-1 and primary pump P-6.
   b. When both chillers are operating simultaneously, and flow is measured in the chilled water bypass line from the return line to the supply line that is 110% of the capacity of the on-line primary chilled water pumps, and the chillers are operating at an Operator defined percentage of load, then the lag chiller and the associated primary chilled water pump shall be de-energized.
   c. When both chillers operating simultaneously, and the chilled water supply temperature setpoint is being maintained and the chillers are at an Operator defined reduced percentage of load, then the lag chiller and the associated primary chilled water pump shall be de-energized.
2. Provide Operator definable time out sequences to prevent excessive staging/cycling of chillers.
3. The chillers shall operate in an Operator defined lead-lag sequence to equalize equipment runtimes.

H. BAS component failure mode.

1. The chillers shall be de-energized.

2. The chilled water pumps shall be de-energized.

I. The chiller manufacturer has provided a chiller control system including unit control panels (UPC) and system control panels (SCP) for interface to the BAS. Refer to the chiller control panel specifications to ascertain all the necessary details. Provide any wiring, conduit, etc. required from the UCP to the SCP and from the SCP to the BAS.

J. Flowmeter will monitor flowrate in the chilled water supply, after the bypass connection.

2.15 CONDENSER WATER SYSTEM

A. The condenser water system consists of two cooling towers, each equipped with two variable speed fans, one modulating condenser water bypass valve, electric basin heaters and high and low basin level switches. The condenser water system also consists of two constant speed condenser water pumps and one standby constant speed condenser water pump with four condenser water isolation valves.

B. When a chiller is commanded to run, the associated condenser pump shall operate. By positioning automated isolation valve and starter H-O-A switches, it should be possible to operate any chiller with the standby condenser pump rather than the pump normally associated with that chiller. Provide all wiring and software necessary for these interlocks.

C. The fans of an enables cooling tower shall be sequenced to maintain the condenser water supply temperature setpoint. When the condenser water supply temperature rises above setpoint, all fans shall be enables and operate on low speed. If the condenser water supply temperature continues to rise above setpoint, the enabled cooling tower fans shall ramp up from low speed to high speed. The condenser water supply temperature setpoint shall initially be in the range of 82°F to 85°F and shall be reset as a function of ambient wet bulb temperature and chiller loading to optimize chiller plant energy efficiency. The reset of the condenser water supply temperature setpoint shall be limited to a minimum temperature as recommended by the chiller manufacture.

D. Whenever the condenser water supply temperature drops below setpoint, the condenser water bypass valve will modulate open as needed to maintain setpoint temperature.

E. The number of starts for any cooling tower fan shall not exceed the manufacturer’s recommendation. Obtain written confirmation from the cooling tower manufacture of this restriction and ensure that details are incorporated into all operations manuals.

F. Provide level switches in each cooling tower sump. High alarm and low alarm setpoints shall be on-line Operator definable.

G. Interlock the cooling tower cell fans to their associated vibration switches as recommended by the cooling tower manufacturer, to shutdown the cooling tower fans in the event of a vibration alarm condition. The BAS shall monitor these vibration switches.

H. The cooling tower cell fans, and condenser water bypass valve shall maintain their current status in the event of a BAS component failure.

## 2.16 CELL/DAY ROOM SMOKE CONTROL

A. The Cell/Day Room smoke control system provides a means for purging smoke from effected areas, isolating non effected areas, and pressurizing non effected areas to prevent smoke migration.

B. If the Cell zone in a quadrant goes into alarm the following will occur:

1. The Cell supply air dampers will open from the preset 800 CFM position to the preset 2400 CFM position. The cell supply fans will change speed as required to maintain supply duct static pressure.

2. All return dampers and Combination Fire/Smoke Damper in the effected quadrant chases will close (for floor pressurization and isolation) except the Cell return dampers for the cell zone in alarm.

3. The associated chase smoke exhaust fans will start and maintain a negative pressure (-0.5” adjustable) to draw smoke from the alarm zone.

4. The return air dampers on air handling units receiving return air from the two effected chases will fully close, and the outside air dampers will fully open.

C. If the day room zone in a quadrant goes into alarm the following will occur:

1. All return dampers and Combination Fire/Smoke Damper in the effected quadrant chases will close (for floor pressurization and isolation) except the Day room return dampers for the day room zone in alarm.

2. The associated chase smoke exhaust fans will start and maintain a negative pressure (-0.5” adjustable) to draw smoke from the alarm zone.

3. The return air dampers on air handling units receiving return air from the two effected chases will fully close, and the outside air dampers will fully open.

4. The purge fan for the effected quadrant will start and maintain positive supply duct static pressure and both purge supply dampers will open to the effected area. All other will remain closed.

D. Provide smoke damper testing screen that indicates fire alarm status, smoke damper status, and smoke exhaust fan status for each quadrant. Provide information similar to sample screen image at the end of this section.

## 2.17 DOMESTIC HOT WATER HEATING SYSTEM

A. Boiler system will activate via a manual or automatic command from the BAS control system. In automatic control, each boiler will be enabled/disabled by the control system. Each boiler will operate through its own controller.

B. Respective heating water return pump will prove flow before boiler is fired

C. The boiler factory control panel will modulate/stage burner as required to maintain a heating water loop temperature of 180°F as sensed by HWR temp sensor.

D. Upon system start up (or any time loop water temperature is below 140°F boiler (DFB-1) is provisioned with a three way valve to protect the boiler from receiving cold or condensing water temperatures upon start up. The three way valve will modulate to maintain 140°F

minimum entering water temperature to boiler. Leaving water temperature set point will be controllable (reset) by the BAS control system. Boiler firing rate will be based on a leaving water temperature.

E. Upon notification by the utility company of a natural gas curtailment, a manual command by the operator at the front end will shut down boilers 2A, 2B, 3A, 3B (if they are running), switch the fuel source for boiler DFV-1 from natural gas to fuel oil and initiate DFB-1 start sequence as described above (manual command from BAS).

F. Heating water return temperature to each boiler, circulating pump status, boiler run status, boiler alarm, boiler firing rate and valve position will be monitored and available for display at the operator workstation.

G. The low temperature protection 3-way valve for Boiler DFB-1 will close to the bypass (open to the boiler) when the dedicated boiler circulation pump is disengaged.

H. Boiler will shut down or not fire if its respective pump indicates a no flow condition, if the boiler combustion/ventilation air system is not operating, a low water condition is detected or high temperature limit is detected. When the boiler receives a signal to engage, the dedicated boiler pump will engage. After the boiler disengages, the dedicated boiler pump will disengage.

I. Selector switch at each boiler will select if temperature sensors in 3000 gallon tank or in 1500 gallon tank will be used for boiler control.

2.18 AIR COOLED SYSTEM CHILLER

A. Chiller start up - the controls system will start and stop system water pump and chiller. Upon an automatic command from the control system or a manual command from the front end, the chilled water system will be engaged. The dedicated chilled water punp for the chiller will start and prove flow through the chiller evaporator via the flow switch. The chiller will start only after flow has been proven through the evaporator.

B. The chiller will adjust its capacity to maintain a leaving water temperature of 42°F (adj.).

C. When shutting down, the chiller will be de-energized first, and then the pump will be de-energized.

D. Chiller supply temperature control - during normal operation the chiller will codulate it compressor(s) to maintain a supply water temperature of 42°F (adj.).

E. Chiller shutdown - the chiller load will be calculated via the equation: Tons - 12,000 X 500 X FS01 X (TS02-T01). When the chiler tons falls below 12.5% of capacity, the chiller will disengage.

F. Chiller staging upon unit failure - in the event of a chiller failure, an alarm will sound at the control panel. The chiller and primary chilled water pump will be de-energized. The chiller will have to be manually reset at the BAS control panel. The control system will then energize the chiller per the sequence above.

2.19 FAN COIL UNITS

A. Supply fan off - when the supply fan is off, the chilled water valves will be closed to the coils.

B. Supply fan operating - the supply fan runs continuously unless the the system is shut down by the BAS system. The cooling coil valve modulates to maintain the space temperature set point.

C. Safety shutdown of the unit - the BAS system will shutdown the unit if there is water detected in the overflow or emergency drain pan An alarm will be generated and sent to the BAS control panel.

PART 3 - INSTALLATION - NOT USED

END OF SECTION

SECTION 26 05 10

GENERAL REQUIREMENTS FOR ELECTRICAL WORK

PART 1 - GENERAL

1.1 SUMMARY

A. Provide all labor, materials, supervision, tools, services, equipment and incidentals necessary for complete and operational systems as specified under this division and as shown on the Contract Drawings.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Division.

1.2 DRAWINGS AND SPECIFICATIONS

A. Prior to submitting a bid:

1. Examine the Drawings.

2. Read the Specifications and other Contract Documents, including Addenda and referenced material.

3. Visit the site of the work, in accordance with directions from Purchasing Department.

4. Become informed prior to bidding as to existing conditions and limitations of the project.

B. Bring exceptions and inconsistencies in Drawings, specifications, addenda, referenced material, other Contract Documents and site conditions to the attention of the Purchasing Department in writing during the question period of the County bidding process; otherwise be responsible for changes and additions that become necessary during construction.

C. Interpretation or correction of the Contract Documents will be made by Addendum and official responses to submitted questions and will be posted on the Tarrant County website.

D. Location of material, equipment, devices and appliances shown in the Contract Drawings are approximate and are subject to such revisions as may be necessary or desirable at the time the work is installed. Install the work in relation to existing conditions and be responsible for the correctness of the work with reference to finish elevations and surrounding conditions.

E. The Contract Documents show the general arrangements of the work. After contract award, should project conditions require any rearrangement, or if equipment or accessories can be installed to better advantage in a different manner, the Contractor may, before proceeding with the work, prepare and submit five copies of shop drawings of the proposed rearrangement for the Engineer's review.

F. If the Contractor proposes to install equipment requiring space conditions other than those shown, he shall assume responsibility for the rearrangement of the space and shall have the Engineer review the change before proceeding with the work. The request for such changes shall be accompanied by shop drawings of the space affected.

G. The accompanying Drawings do not indicate the existing electrical installations other than to identify modifications and extensions thereto. Visit the site in accordance with directions from Purchasing Department and ascertain the conditions to be met and the work to be accomplished in removing and modifying the existing work, and installing the new work. Failure to comply with this shall not constitute grounds for any additional payment in connection with removing or modifying any part of the existing installations and/or installing any new or temporary work under this Division.

1.3 CODES AND STANDARDS

A. Execute the work in accordance with local, state and national codes, ordinances and regulations having jurisdiction or authority over the work. Make any and all adjustments required by these agencies without further cost to the Owner. In addition, conform to the applicable provisions and recommendations of the following standards:

1. National Electrical Manufacturer Association (NEMA)
2. American Society for Testing and Materials (ASTM)
3. National Fire Protection Association (NFPA)
4. National Electrical Safety Code (NESC)
5. Institute of Electrical and Electronic Engineers (IEEE)
6. National Electrical Code (NEC)
7. Underwriters' Laboratories (UL)
8. American National Standards Institute (ANSI)
9. International Building Code (IBC)
10. Occupational Safety and Health Administration (OSHA)
11. Americans with Disabilities Act (ADA)
12. Applicable utility companies
13. Texas Accessibility Standards (TAS)
14. International Energy Conservation Code (IECC)

B. Execute the work in accordance with the most current codes and standards in effect at the time of bidding.

C. In the event standards and codes conflict with each other, the most stringent shall apply.

D. Conform to National Electrical Code rules. Provide material and equipment, which is approved by Underwriter's Laboratories, bears UL label and is acceptable to Factory Mutual.

E. It is specifically understood, however, that in those instances where capacities, sizes, etc., of electrical equipment, devices or material as designated in these Specifications or on the Drawings are in excess of the minimum requirements of the National Electrical Code, such designated capacities shall prevail.

PART 2 - PRODUCTS

2.1 SHOP DRAWINGS AND SUBMITTALS

A. Submit Shop Drawings for all material furnished under this division of the work. Refer to the General Requirements for additional requirements. In addition to the quantity of Shop Drawing copies required by the General Requirements, furnish one additional copy for the Electrical Engineer's file. No material shall be fabricated, delivered to the jobsite, or installed which the Engineer through Shop Drawing submittals has not approved.

B. The submittals shall include sufficient descriptive material, such as catalog cuts, diagrams, and other data published by the manufacturer, as well as evidence of compliance with safety and performance standards, to demonstrate conformance to the specification requirements; catalog numbers alone will not be acceptable. The data shall include the name and address of the nearest service and maintenance organization that regularly stocks repair parts.

C. Deliver Shop Drawings to the Engineer in sufficient time to avoid delay of the project. Group Division 26 submittals as identified below, submit sections not included in these groupings separately. The Electrical Contractor shall acknowledge receipt of all Division 23 mechanical equipment submittals and confirm the overcurrent protection requirements of the project specific HVAC equipment has been coordinated with the distribution equipment prior to submitting for approval. All proposed changes to the overcurrent protection devices shall be clearly identified in the distribution equipment submittal.

1. Distribution Equipment – Low Voltage

D. Submit samples for approval when requested by the Engineer.

E. Before submitting Shop Drawings for review, examine them and verify that they correctly represent the material or equipment intended for this project. The Contractor's review of Shop Drawings is not intended to take the place of the review of the Engineer, and Shop Drawings which have not been reviewed by the Engineer shall not be used in fabricating or installing any work.

F. List deviations and exceptions from the specified equipment in writing. Failure to do so will be cause for rejection of submittals. Contractor agrees that if deviations, discrepancies, or conflicts between Shop Drawing submittals and the Contract Documents are discovered either prior to or after Shop Drawing submittals are reviewed by the Engineer, the Contract Documents shall control and shall be followed, unless deviations have been specifically approved by the Engineer and Owner.

G. The review of Shop Drawings or catalog data by the Engineer shall not relieve the Contractor from responsibility for deviations from plans and specifications unless the contractor has, in writing, specifically called attention to such deviations at the time of submission and has obtained the permission of the Engineer thereon; nor shall it relieve the contractor from responsibility for error of any kind in Shop Drawings. When the Contractor does call such deviations to the attention of the Engineer, they shall state in their letter whether or not such deviations involve any extra cost. If this is not mentioned, it will be assumed that no extra cost is involved for making the change.

H. Contractor agrees that Shop Drawing submittals reviewed by the Engineer are not change orders; that the purpose of Shop Drawing submittals by the Contractor is to demonstrate to

the Engineer that the Contractor understands the design concept, that the contractor demonstrates their understanding by indicating which equipment and material they intends to furnish and install and by detailing the fabrication and installation methods they intends to use.

2.2 STANDARDS FOR MATERIALS

A. It is the intention of these specifications to indicate a standard of quality for all materials incorporated in this work. Manufacturer's names and catalog numbers are used to designate the item of equipment or material as a means of establishing grade and quality. Where several manufacturers are named, only the named manufacturer's products will be considered and the Contractor's bid shall be based on their product. Substitutions may be submitted for approval during the bidding process.

B. Where the phrase 'or approved equivalent' or 'or equivalent' or 'equivalent to' or 'accepted substitute' is used in these specifications, the names or name mentioned are to be used as a basis of quality. Other manufacturers will be considered if the quality of the proposed material is equivalent to that of materials named, in the opinion of the Engineer.

C. Basis of quality shall include material, workmanship, weight, finishes, and gauges of material, appearances, capacity and performance. Manufacturer's representation as to availability of equipment, replacement parts and service personnel in the area will be a factor in consideration of submittals.

D. All materials shall be fully warranted.

E. Furnish standard products and manufacturers regularly engaged in production of such equipment.

F. Furnish manufacturer's latest standard design.

G. All equipment shall conform with applicable IEEE, UL, ANSI and/or NEMA Standards.

H. Obtain manufacturer's recommendations and instructions for all installed equipment including installation instructions, preparation cleaning, tests and preservice checks, and then ensure all have been performed prior to completion of work.

2.3 SUBSTITUTIONS

A. The Engineer prior to installation shall approve substitutions of equipment. Substitution of equipment shall be in accordance with Division 01 of the specifications.

B. Requests for substitutions of equipment, materials and apparatus listed in Division 26 Sections must be submitted in writing as a question during the prescribed timeframe for submitting questions. Refer to the instructions for bidders for timeframe. Such requests must be accompanied by complete data to permit proper evaluation.

C. When alternate or substitute materials and equipment are used, the Contractor shall be responsible for space requirements, configurations, performance, changes in bases, supports, structural members and openings in structure, and other apparatus and trades that may be affected by their use.

D. Contractor shall bear all additional costs resulting from the use of substituted materials. Such changes shall be at no additional cost to the Owner.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate and direct the work under this division of the specifications with the work under other divisions of the specifications. Examine the Contract Documents and report any discrepancies between divisions of the work to the Engineer and obtain written instructions for changes necessary in the work.

B. Before installation, make proper provisions to avoid interferences with the work under other divisions of the specifications. Changes required in the work of the Contractor caused by their neglect to do so shall be made by them at their at his own expense.

C. Harmonize the work under this division with the work under other divisions of the specifications such that it may be installed in the most direct and workmanlike manner without hindering, or conflicting with the work under other divisions of the specifications. Piping interferences shall be handled by giving precedence to pipelines that require a stated grade for proper operation.

3.2 PERMITS AND FEES

A. Secure and pay for all necessary permits, licenses and inspections required by law for the completion of the Work. Secure and pay for all certificates of approval that are required and deliver them to the Engineer before final acceptance of the Work.

3.3 QUALITY ASSURANCE

A. Use adequate quantities of skilled workmen who are trained and experienced in their crafts and who are familiar with the specified requirements and methods needed to perform the work in this division.

B. Install materials and equipment based upon actual dimensions and conditions at the project site. Field measure for materials or equipment requiring exact fit.

C. Be responsible for the proper location and sizes of all slots, holes or openings in the building structure pertaining to the work in this division, and for the correct location of pipe sleeves.

D. Perform work in accordance with good commercial practice. The good appearance of the finished work shall be of equivalent importance with its operation.

E. Isolate all conduit, transformers and motors to insure an acceptable noise level free from objectionable vibration for all systems.

3.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Follow the manufacturer's directions in the delivery, storage and handling of equipment and materials.

B. Equipment and materials shall be tightly covered and protected against dirt, water, chemical or mechanical injury and theft. Damaged equipment will not be accepted.

C. After materials are installed, protect the installation until the work is completed and accepted by the Owner.

3.5 CLEANING UP

A. Remove all shipping labels, dirt, paint, grease and stains from all equipment under this division of the Work. Remove debris as it accumulates. Upon completion of the Work, clean all electrical equipment and the entire electrical installation in order to present a first class electrical installation suitable for occupancy. No loose parts, scraps, tools nor debris shall be left on the premises.

3.6 CUTTING AND PATCHING

A. Be responsible for the cost of cutting and patching required in connection with the work under this division of the specifications.

B. Coordinate the work to eliminate unnecessary cutting of construction. Where it becomes necessary to cut through walls, floors, ceilings and other construction to permit installation of the work, or to repair defective work under this division, the costs for such cutting and patching shall be included in this division of the work. Comply with other applicable divisions of the specifications concerning the quality of cutting and patching.

C. Where openings are cut through masonry walls, provide lintels or structural supports to protect the remaining masonry. Provide adequate support during the cutting operation to prevent any damage to the affected masonry.

D. Cutting of structural members is not permitted unless the Engineer grants specific written permission.

3.7 FLASHINGS, SLEEVES, INSERTS

A. Be responsible for maintaining the integrity of the waterproofing of conduit penetrations through roofs, exterior walls and floors.

B. Be responsible for the installation of counterflashing of roof penetrations to provide a weatherproof installation.

C. Install 22 gauge galvanized sheet iron sleeves for each conduit passing through floors. Extend sleeves 1-1/2 in. above the floor slab and cement watertight. The sizes of sleeves shall be installed to permit the subsequent insertion of the proper size conduits or raceways.

D. Install galvanized wrought iron pipe sleeves around conduits and raceways that pass through concrete beams or walls and masonry exterior walls. The inside diameter of these sleeves shall be at least 1/2 in. greater than the outside diameters of the service pipes. After the pipes are installed in these sleeves, fill the annular space between pipes and sleeves with mastic. The completed installation shall be watertight.

E. Be responsible for maintaining the fire rating of penetrations through walls, floors and ceilings.

F. Waterproofing and fireproofing work shall conform to the requirements of other applicable sections of the specifications.

3.8 PAINTING

A. Maintain original factory finish on all material and equipment installed under this division of the work unless specifically noted otherwise within the Contract Documents. Should the finish be marred in transit or during installation, it shall be re-finished to present a neat, workmanlike appearance. Leave equipment clean and free from any grease, dirt and rust and in a suitable condition for painting.

3.9 IDENTIFICATION OF ELECTRICAL EQUIPMENT

A. Identify electrical equipment in accordance with the NEC, local authorities and in accordance with the requirements of the Contract Documents.

B. Use laminated three-ply, engraved plastic nameplates with black surface and white interior core, at least 1/16 in. thick. Engraved lettering shall be condensed gothic at least 1/4 in. high and properly spaced for legible and easy reading. Attach plates to equipment with chromium-plated screws. Adhesive attachment is not acceptable. Identify the following items with engraved nameplates, located as follows:

1. Each switch/fuse unit or circuit breaker in each main panel and each distribution panel - adjacent to switch/fuse unit or circuit breaker.
2. Spares shall be labeled 'Spare'.
3. Each branch circuit panel - on panel trim cover immediately above panel door.
4. Each safety switch, relay cabinet, time clock - on outside of cover. Include the power source on safety switches.
5. Each motor starter - on outside of cover.
6. Each motor starter in motor control center on outside of cover.
7. Any switch for load that cannot be seen from the control point - custom engraved on outside of switch coverplate.

C. Custom engraving on cover plates for items noted above shall be equivalent to custom engraving as performed by Hubbell, or accepted substitute.

D. Install adhesive arc flash warning labels on all equipment as required by the latest NFPA 70E. Each label shall show specific and correct information for specific equipment based on its arc flash calculations. Labels shall show the followings:

1. Nominal system voltage.
2. Equipment/bus name, date prepared, and preparer's name and address.
3. Arc flash boundary.
4. Available arc flash incident energy and the corresponding working distance.

5. Minimum arc rating of clothing.

6. Site-specific level of PPE.

E. Branch circuit panelboard directories shall be completely and properly typewritten, including room numbers. Room numbers and names shall be as finally designated at the jobsite.

F. Refer to other sections of the specifications for conductor color-coding requirements.

G. Refer to Section 26 05 33 for identifying of underground electrical work.

3.10 RECORD DOCUMENTS

A. Job set: Promptly following receipt of the Owner's Notice to Proceed, secure from the Engineer at no charge to the Contractor, one complete set of all Documents comprising the Contract.

B. Final Record Documents: At a time nearing the completion of the work, secure from the Engineer at no charge to the Contractor one complete set of sepia transparencies of all Drawings in the Contract.

C. Maintenance of Job Set: Immediately upon receipt of the job set described in paragraph above, identify each of the Documents with the title, "RECORD DOCUMENTS - JOB SET".

D. Preservation:

1. Considering the Contract completion time, the probable number of occasions upon which the job set must be taken out for the new entries and for examination, and the conditions under which these activities will be performed, devise a suitable method for protecting the job set to the approval of the Engineer.

2. Do not use the job set for any purpose except entry of new data and for review by the Engineer, from start of transfer of data to final Project Record Documents.

3. Maintain the job set at the site of Work where the Engineer designates that site.

E. Making Entries on Drawings:

1. Using an erasable colored pencil (not ink or indelible pencil), clearly describe the change by graphic line and note as required.

2. Date all entries.

3. Call attention to the entry by a 'cloud' drawn around the area or areas affected.

4. In the event of overlapping changes, use different colors for the overlapping changes.

5. All equipment shall be clearly indicated in its installed location. Exposed items or those easily accessible, as above lay-in ceilings, may be located to scale. Concealed items not readily accessible, such as underground piping, shall be located by dimension.

F. Transfer of Data to Final Project Documents:

1. Approval of recorded data prior to transfer:

a. Following receipt of the transparencies described above, and prior to beginning transfer of recorded data thereto, secure the Engineer's approval of all recorded data.
b. Make required revisions.

2. Transfer of Data to Drawings:
a. Carefully transfer change data shown on the job set of Record Drawings to the corresponding transparencies, coordinating the changes as required.
b. Clearly indicate at each affected detail and other drawing a full description of changes made during construction, and the actual location of items described above.
c. Call attention to each entry by drawing a 'cloud' around the area or areas affected.
d. Make changes neatly, consistently, and with the proper media to assure longevity and clear reproduction.

G. Review and Submittal:

1. Submit the completed set of Project Record Documents to the Engineer as described above.

2. Participate in review meetings as required.

3. Make required changes and promptly deliver the final Project Record Documents to the Engineer.

3.11 OPERATIONS AND MAINTENANCE DATA

A. Accumulate, as the job progresses, the following data, in duplicate, prepared in a neat brochure or packet folder, and deliver to the Engineer for checking and subsequent delivery to the Owner.

1. Manufacturers' warranties, guarantees, service manuals, and operating instructions for equipment and materials covered by this division of the specifications.

2. Copies of approved Shop Drawings.

3. Any and all other data and/or Drawings required during construction.

4. Repair parts list of all major items and equipment including name, address, and telephone number of local supplier and agent.

3.12 INSTRUCTION OF OWNER'S PERSONNEL

A. Provide the services of competent technicians acceptable to the Engineer to instruct representatives of the Owner in the complete and detailed operation of each item of equipment, and each system. These instructions shall be provided for whatever periods may be necessary to accomplish the desired results. Upon completion of these instructions, the Contractor shall obtain a Letter of Release, acknowledged by the Owner or his Authorized Representative, stating the dates on which the various kinds of instruction were given, and the personnel to whom the instructions were given.

B. Be responsible for proper maintenance of equipment and systems until the instructions have been given to the Owner's personnel and the letter of release acknowledged.

C. In providing the instructions to the Owner's personnel, follow the written operating and maintenance manuals in all instances, and familiarize the Owner's personnel with such

manuals. Operating and maintenance manuals used for instructions shall include wiring diagrams, manufacturers' operation and maintenance manuals, parts lists (with sources identified), and other data as appropriate for each system, and as required elsewhere in the Specifications to be furnished to the Owner prior to final acceptance of the project.

3.13 LOCAL PARTS AND SERVICE

A. Each item of equipment furnished on this project shall have local representation, factory-authorized service, and an adequate stock of repair parts. "Local" shall be defined, for this purpose, as "within 150 miles of the project site".

3.14 INSTALLATION INSPECTIONS AND CERTIFICATIONS

A. Obtain timely inspections of the installation by the constituted authorities. Remedy any deficiencies to the satisfaction of the inspection authority.

B. Upon final completion of the Work, obtain certificates of acceptance from the constituted authorities. Deliver the certificates to the Engineer for transmission to the Owner.

3.15 OPERATION PRIOR TO ACCEPTANCE

A. When any equipment is operable, and it is to the advantage of the Contractor to operate the equipment, the Contractor may do so provided that the Contractor properly supervises the operation and retains full responsibility for the equipment operated. Regardless of whether or not the equipment has or has not been operated, clean the equipment properly; make required adjustments, and complete punch list items before final acceptance by the Owner.

B. The date of acceptance by the Engineer, for beneficial use by the Owner, shall be the beginning date of the warranty period.

3.16 ACCEPTANCE OF THE WORK

A. The Work, when completed, will be accepted in a finished, perfect and undamaged state only. Provide for protection of the Work during its progress, and if damaged, do all patching or replacing necessary to its full and satisfactory completion.

3.17 WARRANTY

A. Furnish a written certificate, guaranteeing all materials, equipment and labor to be free of all defects for a period of one year from the date of final acceptance by the Owner of the Work, and guarantee that if any defects appear within the stipulated guarantee period, such work shall be replaced without charge.

B. This guarantee shall be extended to include the capacity and integrated performance of all component parts of the various systems.

3.18 FINALLY

A. It is the intention that this Specification provide a complete installation. Include all accessory construction and apparatus necessary to the operation and testing of the work under this division. The omission of specific reference to any part of the work necessary for such complete installation shall not relieve this Contractor from furnishing and installing such parts.

END OF SECTION

SECTION 26 05 11

WORK IN EXISTING BUILDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Refer to Section 26 05 10 - GENERAL REQUIREMENTS FOR ELECTRICAL WORK.

B. Furnish all labor, materials, services, equipment, and appliances required in conjunction with the work in existing buildings as indicated in the Contract Documents.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use materials to match existing construction unless specified elsewhere in these Contract Documents. Materials shall comply with local codes, be UL listed, and be properly applied for their intended function.

PART 3 - EXECUTION

3.1 EXISTING CONDITIONS

A. It is recommended that the Contractor inspect the jobsite prior to bidding and be familiar with all existing conditions. Include the cost of the work required to accommodate the existing conditions in the bid proposal.

B. Obtain data related to existing facilities from existing documents, measurements, notations, photographs, surveys and other observations at the site.

C. Relocate existing items as required to accommodate the new construction. Remove, relocate and reconnect equipment and accessories that are to be reused.

D. Coordinate the Work with other divisions of the specifications. Determine which items and equipment are to remain, to be relocated or be removed, and perform all work consistent with the Scope of Work.

E. Loads that exist and are to remain shall be connected to the new distribution system as shown on the Drawings or as required to maintain their proper operation.

F. Refer to other divisions of the specifications and determine equipment that requires power to be disconnected, or power to be relocated and disconnect power and relocate power to this equipment.

G. Remove all conductors and exposed conduit rendered unused back to the source of supply.

H. Perform splices as required to maintain circuit continuity to existing devices or equipment to remain in service.

3.2 DISRUPTION OF EXISTING FUNCTIONS

A. Access: Access to and use of the existing facilities and site will be restricted, and shall be under the direction and control of the Owner.

B. Disruptions: Maintain existing electrical, communications, alarm, and other existing systems, and maintain existing functions in service except for scheduled disruptions. Where existing functions to remain in use are disrupted, they shall be fully restored after disruption, in full compliance with this division of the specifications for new work.

C. Scheduling of Disruptions: Seek and obtain approval two weeks in advance of the event date. Indicate date of event, starting time, and duration of each required disruption.

D. Notice of Disruption: Date, time and duration of each disruption shall be subject to the Owner's prior approval, and shall include the following information in the form of a memorandum submitted by the Contractor to the Engineer for approval by the Owner:

| FACILITY/SYSTEM | STARTING DATE | TIME | DURATION |
|---|---|---|---|

E. Emergency Disruptions: When circumstances preclude obtaining advance approval as specified above, make request immediately upon knowledge of the requirement, and perform work so as to cause the minimum amount of disruption, for the minimum duration.

F. Notification: Notify the Engineer and the Owner immediately by telephone and then in writing, as changes and additions to the scheduled disruption requirements become known.

G. Duration: Complete as large a portion of the work as possible before initiating disruption and perform only that work necessary so as to minimize duration of disruption. Maintain adequate personnel, supplies, materials, equipment, tools, and other resources at job site to avoid unnecessary delay in resumption of normal service.

3.3 SALVAGE, DEMOLITION AND RELOCATION

A. General

1. Modify, remove, or relocate materials and items indicated in the Contract Documents and required by the installation of new facilities.

2. Working jointly with the work under other divisions of the specifications establish and mark salvage and demolition items before commencing work; report items scheduled for relocation, reinstallation or reuse, which are found to be in damaged condition; await further instructions from the Owner's Representative and/or the Engineer before commencing with work.

3. Owner shall have first right of refusal for all material and equipment. Deliver salvaged material accepted by the Owner to destinations on the premises as directed and remove material rejected by the Owner from the site.

B. Relocations

1. Make minor relocations necessitated by the conditions at the site or as directed by the Engineer, without additional cost to the Owner.

2. Repair and restore to good functional condition equipment, materials and items scheduled for relocation, which are damaged during dismantling or reassembly operations.

3. New materials and items of similar design and quality may be substituted for materials and items indicated to be relocated upon approval of shop drawings, product data, and samples.

4. Remove carefully, in reverse order to original assembly or placement, items that are to be relocated.

5. Protect items until relocation is complete.

6. Clean and repair items to be relocated, and provide new materials, fittings, and appurtenances required to complete the relocations and to restore items to good operating order.

7. Perform the relocation work in accordance with applicable sections of these specifications, utilizing skilled workers.

C. Relocating Devices: Remove and reinstall, in locations designated by the Owner's Representative and the Engineer, temperature control system devices, relays, wire, conduit, fixtures, equipment and other devices required for the operation of the various systems that are installed in existing-to-be-removed construction.

3.4 EXISTING RACEWAYS

A. Reuse raceways where possible and where permitted by local codes. Rework raceways to meet code requirements. Secure all raceways that are not properly supported. Paint raceways when exposed to view to match surroundings if existing finish is damaged or soiled.

B. Fasten existing boxes and raceways securely to provide proper support.

3.5 NEW RACEWAYS

A. Provide new raceways where required to provide wiring as indicated in the Contract Documents.

B. Where raceways must be exposed to view, use wiremold, securely fastened, and painted to match surroundings. Provide number of coats of paint as required to cover prime coat of original finish of wiremold.

3.6 EXISTING WIRING DEVICES

A. Inspect existing wiring devices, which are to be reused, for damage and replace as necessary.

B. Clean existing wiring devices, to be reused, to a "like- new" condition.

C. Replace damaged wiring devices cover plates with new cover plates that match the existing.

D. Tighten wire terminations at reused wiring devices.

E. Replace existing lighting switches rated 15 amperes with new switches rated 20 amperes when the load to be controlled exceeds 12 amperes.

F. Replace existing receptacles rated 15 amperes with new receptacles rated 20 amperes when the load to be connected exceeds 12 amperes.

3.7 EXISTING LIGHTING FIXTURES

A. Service existing lighting fixtures as follows:

1. Clean reflective surfaces, lenses, and sight exposed portions.
2. Re-lamp with new lamps of the same types removed.
3. Repair or replace lamp holders, ballasts, wiring, and door latching and hinging mechanisms.
4. Reconnect to branch circuit wiring, tighten connections.

B. Existing lighting fixtures may be replaced with new fixtures in lieu of the actions required by Paragraph 3.8 A above, if, in the Contractor's opinion, costs to the Owner would be lower.

3.8 EXISTING CEILINGS

A. Provide a typewritten list of existing damaged ceilings and ceiling tiles. Disregard rooms in which ceilings are to be repaired and replaced. Correlate list to room numbers indicated on drawings.

B. Mark damaged ceilings and ceiling tiles with easily removable red "stick-on" labels, minimum size two square in.

C. Submit list prior to commencing work. Do not start work until Engineer and Owner review list; otherwise repair and replace damaged ceilings and ceiling tiles.

3.9 EXISTING PANELBOARDS

A. Service existing panelboards to be reused as follows:

1. Clean interiors and exteriors.
2. Touch-up damaged finishes with manufacturer's matching touch-up paint.
3. Inspect for component damage and repair or replace as necessary.
4. Tighten conduit and wire terminations.
5. Verify panelboards and panelboard feeders are of adequate capacity for loads to be served as follows:
   a. Activate loads connected to panelboards to simulate 100 percent demand.
   b. Measure and record amperage readings of phase and neutral conductors of panelboards feeders.
   c. Provide typewritten record of recorded measurements to the Engineer for review.
6. Rebalance loads as specified in other sections of the specifications to provide for evenly balanced phases.
7. Provide new typewritten circuit directories.

8. Provide new panelboard identification labels if panelboard designation changes or if no labels exist.

3.10 EXISTING WIRING

A. Inspect existing wiring to be reused for damage. Repair or replace damaged wiring.

B. Secure and label existing wiring that is to be disturbed.

C. Tighten existing wiring terminations and connections.

3.11 EXISTING FOUNDATIONS AND FLOORS

A. Prior to coring, penetrating or cutting of existing foundations or floors, the Contractor shall notify the Engineer in writing and request all as-built and building record drawings showing the location of post tension cables in slabs and subsequent floors. In the event post tension cables do exist in the building, the Contractor shall X-ray the area to be cut, cored or penetrated. Two copies of the X-ray shall be forwarded to the Engineer and written approval issued to the Contractor prior to proceeding with the work.

B. If no as-built or record building drawings are available, then the Contractor shall X-ray the area to be cut, cored or penetrated. Two copies of the X-ray shall be forwarded to the Engineer and written approval issued to the Contractor prior to proceeding with the work.

END OF SECTION

SECTION 26 05 19

WIRES AND CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Refer to Section 26 05 10 - GENERAL REQUIREMENTS FOR ELECTRICAL WORK.

B. Provide labor, materials, services, equipment and appliances required in conjunction with the installation of wire and cable systems as indicated in the Contract Documents.

1.2 SUBMITTALS

A. Manufacturer's Data: Submit copies of manufacturer's specifications for products to be used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide conductors made of soft-drawn-annealed copper with conductivity not less than that of 98 percent pure copper. Conductors #12 gauge and smaller shall be solid. Conductors No. 10 gauge and larger shall be stranded.

B. Utilize conductors with insulation rated at 600 volts and insulated with type 'THHN' insulation in dry locations and type "THWN" in wet locations . Wire in fixture channels and other special locations shall be as specifically rated for temperature in Article 300 in the NEC.

C. Minimum wire sizes shall be in accordance with other requirements of the specifications and as follows: For 20 ampere branch circuits #12 gauge, except that home runs greater than 50 ft. from the panel to the first outlet box on 120/208 volt shall be #10 gauge. Where home runs are greater than 100 ft. from the panel to the first outlet box, on 277-volt circuits wire shall be #10 gauge.

D. All wire shall be color-coded. Mark conductors on each end with a 1 in. band of colored pressure-sensitive plastic tape or by the use of brilliant waterproof lacquer, applied according to manufacturer's instructions. Colors for each phase and the neutral shall be consistent throughout the system in accordance with the requirements of this section.

E. Conductor sizes shown on the Contract Documents are selected based upon use with 75 degrees C terminations. Furnish terminations, which are UL listed for 75°C, or derate conductors for use at 60°C. Use of 90°C terminations is acceptable, but conductor must be sized at the 75°C rating. Do not use 90°C rating for conductors.

F. Armored cable types AC and BX are specifically not allowed.

G. Armored cable type MC is specifically not allowed.

PART 3 - EXECUTION

3.1 GENERAL WIRING METHODS

A. Place an equivalent number of conductors for each phase, neutral and ground of a circuit in same raceway or cable.

B. Do not share neutral conductors between branch circuits connected to single pole circuit breakers unless shown otherwise on drawings.

C. Splice only in junction or outlet boxes.

D. Neatly train and lace wiring inside boxes, equipment, and panelboards.

E. Make conductor lengths equal for parallel circuits.

F. Pull all conductors into a raceway at the same time. Use UL listed wire pulling lubricant for pulling #4 gauge and larger wires.

G. When inserting conductors in raceways, comply with the following:

1. Raceways shall first be installed as a complete raceway system without conductors.
2. Do not install pull wires and conductors until the raceway system is in place.
3. Do not use cleaning agents and lubricants that have a deleterious effect on the conductors.
4. Completely and thoroughly swab raceway system before installing conductors.

3.2 PHASING

A. Identify wire and cable for feeders and branch circuits for general power and lighting with a visible color code in accordance with the requirements of this section as follows:

| 120/208 Volt | 277/480 Volt |
|---|---|
| Phase A - Black | Phase A - Brown |
| Phase B - Red | Phase B - Orange |
| Phase C - Blue | Phase C - Yellow |
| Neutral - White | Neutral - Gray |
| Ground - Green | |

B. Provide green or bare grounding conductor identification for grounding conductors. Identification of all ungrounded conductors at junction boxes, wireways, and/or terminations may be by means of colored tape or painting when color-coded conductors as specified above are not available.

C. Phasing of the complete electrical installation shall be connected and maintained the same throughout the power distribution system. Where the project is an addition or modification to an existing facility, the electrical distribution system phasing shall be made the same as the existing.

D. Switchgear, safety switches, motor starters, plug-in type bus duct, lighting and power panels and power receptacles shall have all the same phase arrangements throughout the facility.

3.3 INSTALLATION

A. Install conductors in a neat and workmanlike manner to meet code requirements and make runs continuous without weld, splice, or joint between boxes. Do not install wires in conduit unless the entire system of conduit and outlet boxes is permanently in place. Pull conductors using a UL approved wire lubricant.

B. Provide conductors continuous from outlet to outlet with no splices except at outlets. Leave sufficient wire at all outlets to make connections without straining.

C. Deliver cable and wire to the project in original packages. Conductors with insulation showing deterioration within one year after final completion and acceptance of the Work shall be removed and replaced at no cost to Owner.

D. Thoroughly clean wires before installing lugs and connectors.

E. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

F. Terminate spare conductors with electrical tape.

G. Torque test conductor connections and terminations to manufacturer's recommended values.

H. Where outlets only are indicated, leave 48-in. leads of conductors, for connection to equipment. Identify all conductors' circuit numbers with Brady tape at terminals and junctions.

I. Where more than three current-carrying conductors are installed in a raceway, use larger size conductor and appropriate larger size raceway to comply with Article 310 of the National Electrical Code.

J. Where conductor is installed in an environment where the ambient temperature will exceed 86°F, use larger size conductor and appropriate larger size raceway to comply with Article 310 of the National Electrical Code.

K. Test all circuits for grounds. Prove and test energy available at the load side of disconnect switches and at the final point of connection to driven equipment. Make all necessary and reasonable tests as required by the Engineer to prove the integrity of work and leave the complete electrical installation ready for operation.

END OF SECTION

SECTION 26 05 20

WIRE CONNECTION AND DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Refer to Section 26 05 10 - GENERAL REQUIREMENTS FOR ELECTRICAL WORK.

B. Provide labor, materials, services, equipment and appliances required in conjunction with the installation of wire connections and devices systems as indicated in the Contract Documents.

1.2 SUBMITTALS

A. Manufacturer's Data: Submit copies of manufacturer's specifications for products to be used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Make cable and wire connections for splicing or terminating with compression deforming type connectors as manufactured by Burndy Corp., Thomas & Betts Co., Inc., Dossert Manufacturing Corp., Ilsco Corp., or accepted substitute. Connectors for cable sizes 250 Kcmil and larger shall be the long barrel type for double indentation. Soldered connections will not be permitted. Twist-on insulated connectors, of proper size, and resistant to vibration, may be used. Use twist-on connectors as manufactured by Minnesota Mining and Manufacturing Co., Thomas & Betts Co., Inc., Ideal Industries, Inc., or approved equivalent.

B. Provide terminal connectors with the hole sizes and spacing in accordance with NEMA standards. Provide terminal connectors with two holes in tongue for use on conductor sizes 250 Kcmil and larger. Terminal connectors are not required for connections to the circuit breakers in the lighting and/or receptacle panels.

C. Insulate connections made with non-insulated connectors with three layers of plastic tape, each layer being half-lapped. Use No. 35+ plastic tape as manufactured by Minnesota Mining and Manufacturing Co., or similar and equivalent plastic tape as manufactured by Plymouth Rubber Co.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Make all electrical power and control connections to equipment furnished under other divisions of the specifications and furnish wiring, conduit, outlet boxes, disconnect switches, etc., as required for same. Check General Construction, Controls, Plumbing, Heating, and Air Conditioning, etc. plans and specifications to determine the amount of such wiring required and include cost of same in bid. Verify locations, horsepower, voltages, etc., of all

equipment as the job progresses. If a conflict arises in wiring, ask the Engineer immediately for clarification.

B. Provide branch circuits and connections to all motors furnished to this project. Provide all disconnect switches as shown and where required by national or local codes. In general, all wiring shall be in conduit, with a short section of flexible conduit at each motor. Securely attach conduit to flexible conduit. When the motor is an integral part of equipment, isolate with a short section of flexible metal conduit to prevent vibration and/or noise amplification to the building structure. If the motor is adjustable, an additional length of flexible metal conduit shall be installed at the motor. Connect a ground wire from the conduit termination to the motor frame on the inside of the flexible conduit. Use approved grounding lugs or clamps on the conduit connection.

C. Branch circuits and connections to all electrically operated equipment are included in this contract, whether or not specifically mentioned. Check, on the job, for further details on Plumbing, Heating, and Air Conditioning equipment as project progresses. Ground equipment in an approved manner.

D. Major equipment furnished under the mechanical and other sections of the specifications may require different rough-in requirements than indicated on the plans due to the 'or equivalent' equipment clause. Secure detailed drawings from the trade furnishing the equipment to determine actual rough-in locations, conduit and conductor requirements.

E. Before connecting equipment, check the nameplate data against the information shown on the Drawings. Call any discrepancies to the attention of the Engineer.

END OF SECTION

SECTION 26 05 26

GROUNDING

PART 1 - GENERAL

1.1 SUMMARY

A. Refer to Section 26 05 10 - GENERAL REQUIREMENTS FOR ELECTRICAL WORK.

B. Furnish all labor, materials, services, equipment and appliances required in conjunction with the installation of a grounding system as indicated in the Contract Documents.

PART 3 - EXECUTION

2.1 INSTALLATION

A. Ground electrical work in accordance with NEC Article 250, local codes as specified herein, and as shown on the Drawings.

B. Use rigid metal conduit and electrical metallic tubing as equipment grounding conductors. Make-up couplings wrench tight. Install grounding conductor in nonmetallic raceways and under floor ducts.

C. Install equipment-grounding conductors in nonmetallic raceways. Install equipment grounding conductors in metallic raceways where noted on the drawings.

D. Where connections are made to motors or equipment with flexible metal conduit, grounding conductor shall be stranded copper conductor within the conduit, bonded to the equipment and to the rigid metal raceway system. Size conductor in accordance with NEC, Article 250.

E. At each convenience outlet, install a grounding clip attached to the outlet box and leave a sufficient length of No. 12 wire with green colored insulation to connect to the grounding terminal of the receptacle. Grounding clip shall be equivalent to Steel City Type G. This requirement may be deleted if automatic grounding clip receptacle meeting NEC Article 250.

2.2 COORDINATION

A. Coordinate the work under this section with the work under other divisions of the specifications.

END OF SECTION

SECTION 26 05 29

SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Refer to Section 26 05 10 - GENERAL REQUIREMENTS FOR ELECTRICAL WORK.

B. Furnish all labor, materials, services, equipment and appliances required in conjunction with installation of supporting devices as indicated in the Contract Documents.

1.2 SUBMITTALS

A. Product Data:

1. Manufacturer's engineering brochures.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Kindorf

B. Unistrut

C. Superstrut

D. Powerstrut

2.2 MATERIALS

A. Continuous slotted channel: 12 gauge steel with electro-galvanizing and gold zinc dichromate barrier bases and dimensions as required for application.

B. Hanger rods: Continuous thread, electro-galvanized, steel, with gold zinc dichromate barrier, sizes as required for loads imposed.

C. Hex head cap screws and nuts: No. H-113 and No. 114, respectively.

D. One-hole pipe straps: Series HS-100, galvanized steel.

E. Single bolt channel pipe straps: Steel, with machine screw and nut, Series C-105 and Series C-106.

F. Lay-in pipe hanger: Series C-149.

G. Conduit and pipe hanger: Series 6H.

H. Beam clamps: Series 500, RC, EC and PC as applicable.

I. Concrete inserts, spot: Series D-256 or D-255.

J. Concrete inserts, channel: Series D-980 or Series D-986.

K. Riser clamps: Series C-210.

L. Cable supports: O.Z./Gedney Type S.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Carefully lay out supporting devices to coordinate with the work under other divisions of the specifications.

B. Securely fasten and support conduits and raceways to the building structure.

C. Suspend horizontal runs of conduits and raceways from the floor and roof construction by rod hangers spaced 10 ft. or less on centers for sizes 2-1/2 in. and greater, and 9 ft. or less on centers for 2 in. and smaller.

D. Fasten single runs of conduit to the structure with one-hole pipe straps and beam clamps or hang on rod hangers.

E. Support multiple runs of conduit and raceways from continuous channel inserts or from trapeze hangers constructed of rod hangers and channels.

F. Fasten single conduits to rod hangers with adjustable lay-in pipe hangers or for conduits of sizes 2 in. and smaller with Series 6H pipe hangers.

G. Fasten conduits to channels with pipe channel straps.

H. Support conduits and raceways within 3 ft. of each bend, of each termination, and at other intervals to maintain horizontal and vertical alignment without sag and deformation.

I. Do not use cable, strap, or wire hangers and fasteners.

J. Provide riser clamps for conduits at floor lines. Provide wire and cable supports in pull boxes for risers in accordance with NEC.

K. Install supports to permit equivalently distributed expansion and contraction of conduits and raceways with expansion joints. Use guides consisting of saddles, U-bolts and anchors designed for equivalent effectiveness for both longitudinal and transverse thrusts. Submit complete details for review.

L. Do not support conduits and raceways from equipment connections.

M. Provide special supports with vibration dampers to minimize transmission of vibrations and noises, where required.

N. Provide hangers, racks, cable cleats, and supports for wires and cables in cable chambers and other locations to make a neat and substantial installation.

O. Provide steel angle and channel supports to the floor and structure for panelboards, cabinets, pull and junction boxes. Provide independent support from entering conduits and raceways.

P. Provide supports as specified for conduits and raceways for outlet boxes and pull boxes 100 cubic in. and smaller.

Q. Paint all cuts, breaks, welds and other points where the rust inhibiting coating of supports is damaged.

R. Provide supports sized for the ultimate loads to be imposed.

S. Anchor supporting devices with:

1. Wood screws on wood.
2. Toggle bolts on hollow masonry.
3. Bolts and expansion anchors in concrete or brick.
4. Machine screws, threaded rods and clamps on steel.

T. Provide supports with hot-dipped galvanized finish in outdoor and wet locations.

U. Pipe and conduit supports:

1. Single run pipe and conduits, 2-1/2 in. O.D. and less, shall have Type SS-8R/SS-8C as manufactured by Portable Pipe Hangers, Inc., or approved equivalent, spaced at maximum eight ft. on center and installed on roof pads if required by the roofing manufacturer.
2. Multiple run pipe and conduits larger than 2-1/2 in. O.D. shall have Type PS, PSE, PP-10 with Roller, or PP-10 with Bar, as manufactured by Portable Pipe Hangers, Inc., or approved equivalent, spaced at maximum eight ft. on center and installed on roof pads if required by the roofing manufacturer. All conduits shall be held in place with clips on bars.

END OF SECTION

SECTION 26 05 32

PULL AND JUNCTION BOXES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Refer to Section 26 05 10 - GENERAL REQUIREMENTS FOR ELECTRICAL WORK.

B. Provide labor, materials, services, equipment and appliances required in conjunction with the installation of pull and junction boxes as indicated in the Contract Documents.

1.2 SUBMITTALS

A. Manufacturer's Data: Submit copies of manufacturer's specifications for products to be used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pull boxes and junction boxes used on concealed runs of conduit in walls and over ceilings shall be of code gauge galvanized steel with sheet steel covers. Pull boxes in floors shall be of galvanized malleable cast iron, with gasketed covers. Exposed pull boxes or junction boxes installed outdoors shall be weatherproof and shall be provided with watertight gasketed covers fastened with corrosion resistant screws.

B. Pull Boxes and Junction Boxes: Metal construction conforming to National Electrical Code, with screw-on or hinged cover. Use hinged cover for boxes larger than 12 in. in any dimension.

C. Flush-Mounted Pull Boxes: Provide overlapping covers with flush-head cover retaining screws, prime coated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Use separate pull boxes and junction boxes for electric power, control, lighting, computer and communication systems.

B. Install pull boxes and junction boxes where required by the National Electrical Code and wherever required to overcome mechanical difficulties.

C. Install pull boxes in interior conduit at not more than 100 ft. apart when junction or outlet boxes do not break conduit runs.

D. Size pull boxes and junction boxes to best meet the needs of the particular situation and/or location and to comply with the National Electrical Code.

E. Coordinate the work in this section with the work under other divisions of this specification.

END OF SECTION

SECTION 26 05 33

CONDUITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Refer to Section 26 05 10 - GENERAL REQUIREMENTS FOR ELECTRICAL WORK.

B. Provide labor, materials, services, equipment, and appliances required in conjunction with the installation of conduit systems as indicated in the Contract Documents.

1.2 SUBMITTALS

A. Manufacturer's Data: Submit copies of manufacturer's specifications and product data for products to be used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Rigid Metal Conduit: Heavy-wall, mild steel tube with metallic corrosion-resistant coating on interior and exterior, hot-dipped galvanized, free from defects and manufactured in accordance with ANSI standards, and UL listed.

B. PVC Coated Rigid Metal Conduit:

1. Hot dip galvanized inside and out. Factory-cut threads shall be protected with hot galvanized threads and a clear urethane coating. Thread protectors shall be used on the exposed threads. The PVC coating must have been investigated by UL as providing the primary corrosion protection for the rigid galvanized steel conduit. The PVC coating shall be gray, 40 mils in thickness, continuous over the entire length of the conduit except at the threads, and be free of blisters, bubbles, or pinholes and manufactured in accordance with UL 6 Standard for Safety, Rigid Metal Conduit.

C. Electric Metallic Tubing (EMT): Welded steel tubing formed of low carbon steel, electro-galvanized exterior, inside coated with a thick, baked, tough elastic low-friction coating of enamel, and UL approved.

D. Intermediate Metal Conduit (IMC): Manufactured in accordance with UL 1242 with interior coating of silicone epoxy ester lubricant.

E. Flexible Metal Conduit: Single strip helically wound interlocking galvanized steel, UL listed; provide liquid tight with extruded polyvinyl jacket in damp and wet locations and in kitchens.

F. Rigid Nonmetallic Conduit:

1. Direct buried - Schedule 40, UL listed.

2. Concrete encased - Schedule 20, UL listed.

G. Elbows and Bends:

1. Rigid nonmetallic conduit systems - PVC coated rigid metal conduit.
2. Other conduit systems - same material as the conduit with which they are installed.

H. Bushings:

1. 1-1/4 in. and smaller - high-impact thermosetting phenolic insulation, 150°C, O-Z/Gedney Type A.
2. 1-1/2 in. and larger - hot-dipped galvanized with thermosetting phenolic insulation, 150°C, O-Z/Gedney Type B.

I. Locknuts:

1. 1-1/4 in. and smaller - zinc-plated heavy stock steel, O-Z/Gedney.
2. 1-1/2 in. and larger - cadmium-plated malleable iron, O-Z/Gedney.

J. Hubs: Cadmium-plated malleable iron, tapered threads, neoprene 'O' ring, insulated throat, O-Z/Gedney.

K. EMT Connectors: Compression type, zinc-plated steel body, cadmium-plated malleable iron nut, insulated throat, O-Z/Gedney.

L. EMT Couplings: Compression type, zinc-plated steel body, O-Z/Gedney.

M. Liquid tight Conduit Connectors: Cadmium-plated malleable iron body and nut, cadmium plated steel ferrule, insulated throat, integrally-cast external ground lug, O-Z/Gedney Type 4QL.

N. Through-Wall and Floor Seals: Malleable iron body, oversize sleeves, sealing rings, pressure clamps and hex-head cap screws, O-Z/Gedney Type FSK.

O. End Bells: Hot-dipped galvanized, threaded, malleable iron, O-Z/Gedney Type TNS.

P. Expansion Fittings: Hot-dipped galvanized, malleable iron with bonding jumpers.

1. Linear - O-Z/Gedney Type AX or TX.
2. Linear with deflection - O-Z/Gedney Type AXDX.

Q. Escutcheons: Chrome-plated sectional floor and ceiling plates, Crane No. 10.

R. Accessories: Reducers, bushings, washers, etc., shall be cadmium-plated, malleable iron of the forms and dimensions best suited for the application.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Size conduits as indicated on the Contract Drawings and as required by the National Electrical Code for the quantity and sizes of wires to be installed in the conduit. Do not use conduit sized less than 1/2 in. unless specified otherwise.

B. No more than one, three-phase circuit or three, single phase circuits may be placed in a single conduit, unless specifically noted on the drawings as such.

C. Conceal conduits from view in all areas except mechanical and electrical rooms and crawl spaces. Should it appear necessary to expose any conduit:

1. Bring it to the attention of the Engineer immediately and obtain Engineer's approval for location of exposed conduit.

2. Rearrange the work to facilitate an approved installation.

D. Install conduits at elevations to maintain headroom and at locations to avoid interference with other work requiring grading of piping, the structure, finished ceiling, walls, access panels, etc. Avoid crossing other work.

E. To prevent displacement, securely support conduits to be concealed in the building structure and installed in advance of other work. Carefully lay out conduits installed within the structure, such as floors, beams, and walls to avoid densities excessive for the construction.

F. Install conduits imbedded in structural slabs in the middle of the slab below the top and above the bottom reinforcing steel. Maintain a minimum 1-1/2 in. concrete cover except where penetration into the slab is made. Do not install conduit larger than 1 in. in slabs.

G. Ream, remove burrs, and swab inside conduits before pulling in conductors.

H. Cap or plug conduits with standard manufactured accessories as soon as the conduits have been permanently installed in place.

I. Make bends and offsets in 1 in. and smaller conduits with approved bending devices. Do not install conduits, which have had their walls crushed, deformed or their surface finish damaged due to bending.

J. Where space conditions prohibit the use of standard ells, elbows, and conduits, use cast ferrous alloy fittings of such forms and dimensions as best suited for the application.

K. Make conduit joints mechanically tight, electrically continuous, and watertight. Pitch conduits in areas where moisture may subsequently be present in a manner to avoid creating moisture traps; where unavoidable, provide junction box with drain fitting at conduit low point.

L. Install insulated throat threaded hubs on conduits entering enclosures without threaded hubs in wet and damp locations.

M. Install and neatly rack exposed conduits parallel with and perpendicular to building walls. Provide space for 25% additional conduit. Do not install exposed diagonal conduit runs.

N. Route and suspend conduits crossing expansion joints to permit expansion, contraction, and deflection utilizing approved fittings to prevent damage to the building, conduits, and supporting devices.

O. Do not install conduits exposed on the roof unless approval is obtained prior to installation.

P. Route conduit through roof openings for piping and duct-work where possible; otherwise, route through roof penetration system as specified in Section 26 05 27 - SEALING OF PENETRATIONS.

Q. Do not place conduits in close proximity to equipment, systems and service lines, such as hot water supply and return lines, steam pipes, which could be detrimental to the conduit and its contents. Maintain a minimum of 3 in. separation, except in crossing, which shall be a minimum 1 in.

R. Connect motors, equipment containing motors, equipment mounted on isolated foundations, transformers and other equipment and devices which are subject to vibration and which require adjustment, with flexible metallic conduit from the device to the conduit serving it. Restrict length of flexible conduit to 6 ft. maximum unless specifically instructed in writing otherwise by the Engineer. Provide secure supports at the points of attachment on each side of the connection. Use bonding jumpers as directed by the National Electrical Code and other sections of these specifications.

S. Install escutcheons on sight exposed conduits passing through interior floors, walls, and ceilings in finished spaces

T. Install fire seals on conduits passing through fire-rated partitions, floors and ceiling.

U. Install through-wall seals on conduits passing through exterior walls or use standard galvanized steel pipe sleeves, diameters 1/2 in. greater than the outside diameter of the sleeved conduit and fill the annular space with mastic.

V. Install sleeves for conduits passing through interior floors.

W. Install insulated throat grounding bushings on conduits stubbed through slabs and foundations into electrical enclosures.

X. Provide grounding of conduits, fittings and accessories. Refer to grounding section of specifications.

Y. Feeder Circuits:

1. Install rigid metal conduit in damp and wet locations, in concrete slabs, and where exposed in mechanical and electrical equipment rooms and crawl spaces.
2. Install flexible metal conduit where specified above and where permitted by the authorities having jurisdiction. Use liquid tight flexible metal conduit in damp and wet locations, where exposed in mechanical and electrical equipment rooms, and in kitchen and shop areas.
3. Exterior to the building and above grade, use rigid steel conduit and for elbows and bends greater than 30 degrees.

Z. Branch Circuits:

1. Install rigid metal conduit in damp and wet locations, in concrete slabs, and where exposed in crawl space.
2. Install electrical metallic tubing where concealed by building structure and where exposed in mechanical and electrical equipment rooms.

3. Exterior to the building and above grade, use rigid steel conduit and for elbows and bends greater than 30 degrees.

4. Install flexible metal conduit where specified above and where permitted by the authorities having jurisdiction. Use liquid tight flexible metal conduit in damp and wet locations, where exposed in mechanical and electrical equipment rooms, and in kitchen and shop areas. Limit flexible conduit to a length of 6 ft. maximum unless specifically instructed otherwise, in writing, by the Engineer.

END OF SECTION