SECTION 23 00 00

UTSW MECHANICAL DESIGN REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SECTION INCLUDES

A. Basic Mechanical Requirements specifically applicable to Division 23 Sections, in addition to Division 01 General Requirements.

B. This document address design criterion not specifically covered by the Mechanical Code (UMC), American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) or set requirements that may exceed the minimum requirements of both.

1.3 APPLICABILITY

A. This Specification applies to all HVAC projects designed and constructed by facilities management personnel, outside Architect/Engineering (A/E) firms, and all construction contractors.

B. No deviations to the standard are acceptable without the written authorization of the Owner or Owner's Representative.

C. UNIFORM GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS, and DIVISION 1 of the Specifications apply to the work specified in this Section.

D. Work covered by this Section of these Specifications shall be accomplished in accordance with all applicable provisions of the Contract Documents and any addenda or directives which may be issued herewith, or otherwise.

1.4 GENERAL

A. The Contractor shall execute all work hereinafter specified or indicated on accompanying Drawings .

B. Contractor shall provide all equipment necessary and usually furnished in connection with such work and systems whether or not mentioned specifically herein or on the Drawings.

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

D. The mechanical, electrical, and plumbing Drawings are necessarily diagrammatic by their nature, and are not intended to show every connection in detail or every pipe or conduit in its exact location. These details are subject to the requirements of standards referenced elsewhere in these specifications, and structural and architectural conditions

E. 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

1. Work shall be organized and laid out so that it will be concealed in furred chases and suspended ceilings, etc , in finished portions of the building, unless specifically noted otherwise.
2. All exposed work shall be installed parallel or perpendicular to the lines of the building unless otherwise noted.

F. When the mechanical, electrical, and plumbing Drawings do not give exact details as to the elevation of pipe, conduit and ducts, the Contractor shall physically arrange the systems to fit in the space available at the elevations intended with proper grades for the functioning of the system involved.

G. New construction projects will be provided with a Hierarchy Drawing or sections and elevations, which clearly show the general elevations that utilities will be routed in N-S and E-W directions.

1. The contractor shall not start work until this drawing has been provided.

H. Piping, exposed conduit and the 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 manner.
   1. The drawings do not show all required offsets, control lines, pilot lines and other location details.
   2. Work shall be concealed in all finished areas.

1.5 TERMS AND DEFINITIONS

A. General Requirements: The provisions of requirements of other Division 01 Sections apply to entire work of Contract and, where so indicated, to other elements that are included in Project. Basis Contract definitions are included in the General Conditions.

B. Indicated: The term "indicated" is a cross reference to graphic representations, notes or schedules on drawings, to other paragraphs or schedules in the specifications, and to similar means of recording requirements on contract documents. Where terms such as "shown," "noted," "scheduled," and "specified" are used in lieu of "indicated," it is for the purpose of helping reader locate the cross reference, and no limitation of location is intended except as specifically noted.

C. Directed, requested, etc.: Where not otherwise explained, terms such as "directed," "requested," "authorized," "selected," "approved," "required," "accepted," and "permitted" mean "directed by Architect/Engineer," "requested by Architect/Engineer" and similar phrases. However, no such implied meaning will be interpreted to extend Architect's/Engineer's responsibility into Contractor's area of construction supervision and job safety.

D. Approve: Where used in conjunction with Architect's/Engineer's response to submittals, requests, applications, inquiries, reports and claims by Contractor, the meaning of term "approved" will be held to limitations to Architect's/Engineer's responsibilities and duties as specified in General and Supplementary Conditions. In no case will "approval" by Architect/Engineer be interpreted as a release of Contractor from responsibilities to fulfill requirements of contract documents or to extend Architect's/Engineer's responsibility into Contractor's area of construction supervision and job safety.

E. As required: Where "as required" is used in these specifications or on the drawings, it shall mean "that situations exist that are not necessarily described in detail or indicated that may cause the contractor certain complications in performing the work described or indicated. These complications entail the normal coordination activities expected of the Contractor where multiple trades are involved and new or existing construction causes deviations to otherwise simplistic approaches to the work to be performed. The term shall not be interpreted to permit an option on the part of the Contractor to achieve the end result."

F. Furnish: The term "furnish" is used to mean "supply and deliver to project site, ready for unloading, unpacking, assemble, installation, and similar operations. Where "furnish" applies to work for which the installation is not otherwise specified, "furnish" in such case shall mean "furnish and install."

G. Install: The term "install" is used to describe operations at Project Site including the actual "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.

H. Provide: The term "provide" means "to furnish and install, complete and ready for the intended use.

I. CDAS – Central Data Acquisition System (CDAS) is the campus-wide central monitoring station, which is located in the Facilities Management Office (P Building).

J. Dry Lab – Laboratories, which are not equipped with multiple utilities, but require a greater degree of electrical power and HVAC than an office area.

K. Engineer – UTSW Engineer, Owner, or Owner's designated representative.

L. Gas Cylinder Room – Any room that contains carbon dioxide, nitrogen, or argon cylinders in excess of 50 Lbs capacity.

M. Wet Lab – Any laboratory equipped with sinks, fume hoods, biological safety cabinets, or other equipment, which requires multiple utilities (such as gas, air or vacuum), and a greater degree of HVAC than a dry lab.

N. Concealed: Areas which cannot be seen by the building occupants.

O. Exposed: Areas which are exposed to view by the building occupants, including under counters, inside cabinets and closets, plus all mechanical rooms.

1.6 RELATED REQUIREMENTS

A. Section 01 77 00 - Closeout Procedures and Submittals.
B. Section 01 79 00 - Demonstration and Training.
C. Section 01 91 00 - General Commissioning Requirements.
D. Section 09 96 00 - High-Performance Coatings.
E. Section 23 00 00 - UTSW Mechanical Design Requirements.
F. Section 23 05 53 - Mechanical Identification.
G. Section 23 08 00 - Commissioning of HVAC Systems.

1.7 PERMITS, UTILITY CONNECTIONS AND INSPECTIONS

A. General: Refer to Division 01 for construction phasing and time increments.
B. Fees and Costs:
   1. If, during the course of the construction, a need arises to buy utilities, the Contractor shall pay all fees attendant thereto.
   2. If City or privately owned utility piping or electrical cable needs to be extended, relocated, or terminated, the Contractor will pay all permits and construction/inspection fees associated with that particular work.
C. All work performed on this project is under the authority of the State of Texas, therefore no local construction fees or construction permits will be required except as may be required for new service taps, or new or modified connections to City controlled services.
   1. If inspections by City personnel are specifically required by this document, then the Contractor is responsible for any fees or permits in connection to those requirements.
D. Compliance:
   1. The Contractor shall comply in every respect with all requirements of National Fire Protection Association, local Fire Department regulations, and utility company requirements.
   2. In no case does this relieve the Contractor of the responsibility of complying with these Specifications and Drawings where specified conditions are of higher quality than the requirements of the above specified authorities.
   3. Where requirements of the Specifications and Drawings are more lenient than the requirements of the above authorities having jurisdiction, the Contractor shall make installations in compliance with the requirements of the above authorities with no extra compensation.

1.8 CONTRACT DOCUMENTS

A. All dimensional information related to new structures shall be taken from the appropriate Drawings.
   1. All dimensional information related to existing facilities shall be taken from actual measurements made by the Contractor on the site.
B. The interrelation of the Specifications, the Drawings, and the schedules are as follows:
   1. The Specifications determine the nature and setting of the several materials.
   2. The Drawings establish the quantities, dimensions, and details.
   3. The schedules give the performance characteristics.
   4. If the Contractor requires additional clarification, the request shall follow the contractually prescribed information flow requirements.
C. Should the Drawings or Specifications conflict within themselves or with each other, the better quality, or greater size or quantity of work or materials shall be performed or furnished except where directed otherwise in writing by the design professional.

1.9 OWNER FURNISHED PRODUCTS

A. Products furnished to the site and paid for by Owner will be indicated as a Cash Allowance. Refer to Division 01 of the Construction Documents for information and requirements.

1.10 FUTURE WORK

A. Future work will be noted on the Drawings.

1.11 ALTERNATES

A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at the Owner`s option.
   1. Accepted Alternates will be identified in Owner Contractor Agreement.
B. Coordinate related work and modify surrounding work as required.
C. Schedule of Alternates: See "Special Conditions" and Bid Form.
D. Any Alternate Proposals are summarized in Division 01 of the Specifications.
E. The Contractor is directed to refer to all Sections of the Specifications and Drawings for this project to determine the exact extent and scope of the various Alternate Proposals as each pertains to the work of all trades.

1.12 SUBMITTALS

A. Refer to Division 01, UGC, and supplemental UGC's for specification requirements pertaining to timeliness of submission and review, quantity, and format.
B. Each specification section describes the content of the submittals and any submittals which must be approved prior to submission of others.
C. Submit shop drawings and product data grouped to include complete submittals of related systems, products, and accessories in a single submittal.
D. Submit shop drawings for OSBC review and approval where any equipment or components must coordinate with life safety elements.
   1. Submit shop drawings showing locations of smoke detectors installed in line with humidifiers to be approved by OSBC.
E. Mark dimensions and values in units to match those specified.
F. Submit Fabrication Drawings when:
   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.
   3. Where called for elsewhere in these Specifications.
   4. Where specifically requested by the Architect/Engineer.
G. Fabrication Drawings shall be made at no additional charge to the Owner or the Architect/Engineer.
   1. All required Fabrication Drawings, except as noted otherwise, shall be prepared at a scale of not less than 1/4 inch = 1 foot.
   2. Fabrication Drawings for ductwork, air handling units, and sections in Mechanical Rooms shall be drawn at a minimum scale of 3/8 inch = 1 foot.
   3. Submit Fabrication Drawing to the Architect/Engineer and UTSW Facilities Management for review in the quantity and format as specified in Division 1. The Architect/Engineer and UTSW will review the fabrication drawings and return with comments.
H. Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.

1.13 SUBSTITUTION OF MATERIALS AND EQUIPMENT

A. Refer to General Conditions for substitution of materials and equipment.
B. Should a substitution be accepted, and should the substitute material prove defective, or otherwise unsatisfactory for the service intended within the guarantee period, material or equipment shall be replaced with the material or equipment specified at no additional cost to Owner.
C. General:
   1. Within thirty days after the date of contract award or work order, whichever is later, and before purchasing or starting installation of materials or equipment, the Contractor shall submit for review, a complete list of suppliers, contractors, and manufacturers for all materials and equipment which will be submitted for incorporation into the project.
   2. The list shall be arranged in accordance with the organization of the Specifications:

a. This initial list shall include the manufacturer`s name and type or catalog number as required to identify the quality of material or equipment proposed.
b. This list will be reviewed by the Engineer and the Owner and will be returned to the Contractor with comments as to which items are acceptable without further submittal data and which items will require detailed submittal data for further review and subsequent approval.
c. The initial list shall be submitted as herein specified Materials and equipment requiring detailed submittal data shall be submitted with sufficient data to indicate that all requirements of these Specifications have been met and samples shall be furnished when requested.
d. All manufacturers' data used as part of the submittal shall have all inapplicable features crossed out or deleted in a manner that will clearly indicate exactly what is to be furnished.

D. It is not the intent of the Drawings and/or Specifications to limit products to any particular manufacturer or to discriminate against an "APPROVED EQUAL" product as produced by another manufacturer.
1. Some proprietary products are mentioned to set a definite standard for acceptance and to serve as a reference in comparison with other products.
2. When a manufacturer`s name appears in these Specifications, it is not to be construed that the manufacturer is unconditionally acceptable as a provider of equipment for this project.
3. The successful manufacturer or supplier shall meet all of the provisions of the appropriate specification(s).
4. The specified products have been used in preparing the Drawings and Specifications and thus establish minimum qualities with which substitutes must at least equal to be considered acceptable.
5. The burden of proof of equality rests with the Contractor.
6. The decision of the designer is final.

E. When requested by the Architect/Engineer, the Contractor shall provide a sample of the proposed substitute item. In some cases, samples of both the specified item and the proposed item shall be provided for comparison purposes.

F. Timeliness:
1. The burden of timeliness in the complete cycle of submittal data, shop Drawings, and sample processing is on the Contractor.
2. The Contractor shall allow a minimum of 6 weeks time frame for review of each submission by the office of the design discipline involved after receipt of such submissions by that design discipline.
3. The Contractor is responsible for allowing sufficient time in the construction schedule to cover the aforementioned cycles of data processing, including time for all re-submittal cycles on unacceptable materials, equipment, etc covered by the data submitted.
4. Construction delays and/or lack of timeliness in the above regard are the responsibility of the Contractor and will not be considered in any request for scheduled construction time extensions and/or additional costs to the Owner.

G. All equipment installed on this project shall have local representation; local factory authorized service, and a local stock of repair parts.

H. Acceptance of materials and equipment:
1. This is based on the manufacturer`s published data and will be tentative subject to the submission of complete shop Drawings indicating compliance with the contract documents and that adequate and acceptable clearances for entry, servicing, and maintenance will exist.
2. Acceptance of materials and equipment under this provision shall not be construed as authorizing any deviations from the Specifications, unless the attention of the Architect/Engineer has been directed in writing to the specific deviations.
3. Data submitted shall not contain unrelated information unless all pertinent information is properly identified.

I. Certification: The Contractor shall carefully examine all data forwarded for approval and shall sign a certificate to the effect that the data has been carefully checked, found to be correct with respect to dimensions and available space, that the equipment complies with all requirements of the Specifications. and that the product is suitable for its intended use on this project.

J. Physical Size of Equipment: Space is critical; therefore, equipment of larger sizes than shown, even though of specified manufacturer, will not be acceptable unless it can be demonstrated that ample space exists for proper installation, operation, and maintenance.

K. Materials and Equipment Lists:

1. Provide digital copies of the list of materials and equipment, the name of manufacturer, trade name, type, and catalog number shall be submitted to the Architect/Engineer in quantity and format as described in Division 01.
2. The lists shall be accompanied by digital sets of pictorial and descriptive data derived from the manufacturers` catalogs, sales literature, or incorporated in the Shop Drawings.
3. Should a substitution be accepted, and should the substitute material prove defective, or otherwise unsatisfactory for the service intended within the guarantee period, this material or equipment shall be replaced with the material or equipment specified at no additional cost to the Owner.

1.14 MATERIALS AND WORKMANSHIP

A. All materials, unless otherwise specified, shall be new, free from all defects, suitable for the intended use, and of the best quality of their respective kinds.

1. Materials and equipment shall be installed in accordance with the manufacturer`s recommendations and the best standard practice for the type of work involved.
2. All work shall be executed by mechanics skilled in their respective trades, and the installations shall provide a neat, precise appearance.
3. 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 the furnishing of the proper equipment and/or material and seeing 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 .

B. The classification shall not exceed a flame spread rating of 25 for all materials, adhesives, finishes, etc , specified for each system, and shall not exceed a smoke developed rating of 50.

1.16 REGULATORY REQUIREMENTS

A. The "Authority Having Jurisdiction" for Fire and Life Safety related compliance in accordance with the rules and regulations promulgated by the Texas State Fire Marshal as an Agency of the State of Texas is UT Southwestern Medical Center Office of Safety and Business Continuity.

B. Plan reviews, installations, inspections, and approvals shall be done as a function of the Fire and Occupational Safety program under the direction of the Director of Fire and Occupational Safety (University Fire Marshal).

C. It is required that the installation shall meet the minimum standards prescribed in the latest editions of the following listed codes and standards identified in Section 01 41 00 - Regulatory Requirements and listed in other Specification sections. Additional requirements include but not limited to:

1. All referenced codes and standards shall be those current at the date of issue of the design documents.
2. Texas Government Code Chapter 2252.001-005; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
3. National Fire Protection Association Standards (NFPA): Currently accepted edition.
4. ASHRAE 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
5. ASHRAE Std 62.1 Ventilation and Acceptable Indoor Air Quality.
6. American Gas Association Publications (AGA): Directory of Approved Gas Appliances and Tested Accessories.
7. American Society of Mechanical Engineers (ASME): Boiler and Pressure Vessel Codes.
8. Air Conditioning and Refrigeration Institute Standards (ARI): All standards related to refrigeration and air conditioning equipment and piping furnished under these Specifications.

9. Sheet Metal and Air Conditioning Contractors National Association, Inc (SMACNA): All current editions of applicable manuals and standards (See Sections 23 31 00 - Ductwork and 23 33 00 - Ductwork Accessories).
10. Air Moving and Conditioning Association (AMCA): All current editions of applicable manuals and standards.
11. American Society of Testing Materials (ASTM): All current editions of applicable manuals and standards.
12. American Water Works Association (AWWA): All current editions of applicable manuals and standards.
13. National Electrical Manufacturers` Association (NEMA): All current editions of applicable manuals and standards.
14. International Codes, current edition or as listed elsewhere in the contract.
15. Texas Occupational Safety Act: All applicable safety standards.
16. Occupational Safety and Health Act (OSHA).
17. TAS, ADA, and ANSI Standards: All work shall be in accord with all regulations and requirements of the Standards and Specifications for Handicapped and Disabled for the Construction of Public Buildings and Facilities in the State of Texas Usable by Physically Handicapped and Disabled persons, ANSI Standards, and the requirements of the American Disabilities Act.
18. All materials and workmanship shall comply with all applicable state and national codes, Specifications, and industry standards
    a. In all cases where Underwriters` Laboratories, Inc has established standards for a particular type material, such material shall comply with these standards
    b. Evidence of compliance shall be the UL "label" or "listing" under Reexamination Service.
19. The Contract Documents are intended to comply with the aforementioned rules and regulations; however, some discrepancies may occur.
    a. Where such discrepancies occur, the Contractor shall immediately notify the Architect/Engineer in writing of said discrepancies and apply for an interpretation.
    b. 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 Division 1 of these Contract Documents, providing no work of fabrication of materials has been accomplished in a manner of noncompliance.
    c. 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.

1.17 COMMISSIONING

A. Comply with project requirements for commissioning. Refer to Section 01 91 00 - General Commissioning Requirements and associated sections.

1.18 GENERAL MATERIALS AND EQUIPMENT REQUIREMENTS

A. Storage at Site: The Contractor shall not receive material or equipment at the job site until there is suitable space provided to properly protect equipment from rust, water, weather, humidity, dust damage, and vandalism.

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

C. Conformance with Agency Requirements:
    1. Where materials or equipment are specified to be approved, listed, tested, or labeled by the Underwriters` 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 this Section of the Specifications conform to such requirements.

a. The label of the Underwriters Laboratories, Inc , applied to the item will be acceptable as sufficient evidence that the items conform to such requirements.
b. The ASME stamp or the AMCA label will be acceptable as sufficient evidence that the items conform to the respective requirements.

D. Nameplates:
1. Refer to Section 23 05 53 - Mechanical Identification for requirements.
2. 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. Attachment shall be appropriate to the type of surface to ensure longevity of attachment.
3. All data on nameplates shall be legible at the time of Final Inspection.

E. Prevention of Rust:
1. Standard factory finish will be acceptable on equipment specified by model number; otherwise, surfaces of ferrous metal shall be given a rust inhibiting coating.
2. The treatment shall withstand 200 hours in salt spray fog test, in accordance with Method 6061 of Federal Standard No 141.
3. Immediately after completion of the test, the specimen shall show no signs of wrinkling or cracking and no signs of rust creep beyond 1/8 inch on either side of the scratch mark.
4. Where rust inhibitor coating is specified hereinafter, any treatment that will pass the above test is acceptable unless a specific coating is specified except that coal tar or asphalt type coating will not be acceptable unless so stated for a specific item.
5. Where steel is specified to be hot-dip galvanized, mill-galvanized sheet steel may be used provided all raw edges are painted with a zinc-pigmented paint conforming to Military Specification MIL-P-26915.

F. Protection from Moving Parts:
1. Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts shall be fully enclosed or properly guarded for personnel protection.
2. Guards shall be compliant with OSHA requirements.

G. Verification of Dimensions:
1. The Contractor shall be responsible for the coordination and proper relation of the work to the building structure and to the work of all trades.
2. 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 Architect/Engineer of any discrepancy before performing any work.
3. Adjustments to the work required in order to facilitate a coordinated installation shall be made at no additional cost to the Owner or the Architect/Engineer.

1.19 WALL, FLOOR AND CEILING PLATES

A. Except as otherwise noted, provide C P (Chrome plated) brass floor and ceiling plates around all pipes, ducts, conduits, etc , passing exposed through walls, floors, or ceilings, in any finished spaces except underfloor and attic spaces.
1. Plates shall be sized to fit snugly against the outside of the pipe or against the insulation on lines which are insulated and positively secured to such pipe or insulation.
2. Plates will not be required for piping where pipe sleeves extend 3/4 inch above finished floor.
3. All equipment rooms are classified as finished areas.
4. Round and rectangular ducts shall have closure plates (NOT chrome plated) made to fit accurately at all floor, wall and ceiling penetrations.

1.20 SLEEVES, INSERTS, AND FASTENINGS

A. General:
1. All openings through all floors, walls, and roofs, etc , regardless of material for the passage of piping, ductwork, conduit, cable trays, etc , shall be sleeved.
2. All penetrations must pass through sleeves except soil pipe installed under concrete slabs on fill.

3. Sleeves shall be set in new construction before concrete is poured, as cutting holes through any part of the concrete will not be permitted unless acceptable to the Architect/Engineer in writing.
    a. If a penetration is cored into an existing solid concrete or stone structure, then the installation of a sleeve will not be necessary.
4. Sleeves set in floors shall extend 4-inches above finished floor elevation and be sealed water tight to the floor.

B. The minimum clearance between horizontal penetrations including insulation where applicable, and sleeve shall be 1/4 inch, except that the minimum clearance shall accommodate a Link-seal by Garlock, an Enpro Company, or approved equal product, closure where piping exits the building, or penetrates a wall below ground level.

C. Contractor shall be responsible for the accurate location of penetrations in the slab for pipe, duct, etc.
1. All penetrations shall be of ample size to accommodate the pipe, duct, etc plus any specified insulation.
2. Sleeve materials shall be rigid metal of adequate strength.
3. Void between sleeve and pipe shall be filled with Nelson Flameseal Firestop or approved equal caulk or putty.

D. Sleeves:
1. Installation of sleeves in walls shall be the same as for floors.
2. Refer to the details on the project drawings.
    a. Where the details differ from these specifications, the drawings take precedence.
3. Sleeves for penetrations passing through walls or floors on or below grade shall be removed, if practical, and after the pipes have been installed, the void space around the pipe shall be caulked with a suitable material to effect a waterproof penetration.
    a. Note that the practicality of the removal of the sleeve shall be the decision of the Construction Inspector. The decision of the Inspector shall be final.

E. Inserts:
1. Where the construction schedule allows, suitable concrete inserts for pipe and equipment hangers shall be set and properly located for all pipe and equipment to be suspended from concrete construction.
2. If the inserts are later found not to be in the proper location for the placement of hangers or if the construction schedule does not allow inserts to be installed, then drilled anchors shall be installed.
3. Drilled anchors in concrete or masonry shall be submitted for approval.

F. Fasteners:
1. Fastening of pipes, conduits, etc , in the building shall be as follows:
    a. To wood members - by wood screws.
    b. To masonry - by threaded metal inserts, metal expansion screws, or toggle bolts, whichever is appropriate for the particular type of masonry.
    c. To steel - machine screws or welding (when specifically permitted or directed), or bolts.
    d. To concrete by suitable inserts anchored to reinforcing steel, and poured in place unless other means are indicated on the plans.
    e. Power-actuated fasteners (shooting) will not be acceptable under any circumstances.
    f. If it is necessary to install a method of fastening a hanger after the structure has been installed, then only clamps or drilled anchors with torque nuts and washes shall be used.
2. Note: The use of plastic anchors or plastic expansion shields is prohibited.

G. Rat proofing: The open space around all ductwork, piping, etc , passing through the ground floor and/or exterior walls shall be rat proofed in a manner acceptable to the Architect/Engineer.

H. Weatherproofing: The annular space between a pipe and its sleeve in exterior walls or through floor to below grade shall be filled with polyurethane foam rods 50 percent greater in diameter than the space as backing and fill material and made watertight with a permanent elastic polysulfide compound.
1. Seal both surfaces of wall or floor.

I. Air Plenums: The space around piping, ductwork, etc , passing through air plenums shall be made airtight in a manner acceptable to the Architect/Engineer.

J. Fireproofing:
1. Each contractor shall seal duct, etc , penetrations through roof, fire rated walls, and floors with a foam or sealant as described below or in Division 7 that will form a watertight, vermin tight barrier that is capable of containing smoke and fire up to 2,000 degrees F for two hours.
2. Refer to fireproofing and firestopping specifications in Division 07 for product requirements.

1.21 PROJECT/SITE CONDITIONS

A. Install Work in locations shown on Drawings, unless prevented by Project conditions.
B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections.
C. Obtain permission of Architect/Engineer in writing before proceeding.
D. In some cases the existing system(s) will be expanded or replaced.
1. Contractor shall thoroughly familiarize themselves with the existing system(s) and bring to the attention of the Architect/Engineer any situations, which deviate from those, indicated in the Contract Documents.

1.22 MANUFACTURER`S RECOMMENDATIONS

A. The manufacturer`s published directions shall be followed in the delivery, storage, protection, installation, piping, and wiring of all equipment and material.
1. The Contractor shall promptly notify the Architect/Engineer, in writing, of any conflict between the requirements of the Contract Documents and the manufacturers` directions.
2. The Contractor shall obtain the Architect/Engineer`s instructions before proceeding with the work.
3. Should the Contractor perform any such work that does not comply with the manufacturers` directions or such instructions from the Architect/Engineer, the Contractor shall bear all costs arising in connection with the deficiencies.

1.23 SPACE AND EQUIPMENT ARRANGEMENT

A. The size of mechanical and electrical equipment indicated on the Drawings is based on the dimensions of a particular manufacturer.
1. While other manufacturers may be acceptable, it is the responsibility of the Contractor to determine if the equipment proposed will fit in the space.
2. Fabrication Drawings shall be prepared for approval when required by the Architect/Engineer or Owner to indicate a suitable arrangement.
B. All equipment shall be installed in a manner to permit access to all surfaces.
1. All valves, motors, drives, filters, and other accessory items shall be installed in a position to allow removal for service without disassembly of another part.
C. All equipment intended for floor mounting shall be installed on housekeeping pads or grouted bases that elevate the base away from damage.
1. Housekeeping pads to be sealed to match floor waterproofing system.
2. Housekeeping pad edges to be painted Safety Yellow.
3. Once equipment is set in place, seal around base perimeter per requirements of Section 07 92 00 - Joint Sealants.

1.24 LARGE APPARATUS

A. Any large piece of apparatus which is to be installed in any space in the building, and which is too large to permit access through stairways, doorways, or shafts shall be brought to the job and placed in the space before the enclosing structure is completed.
B. Following placement in the space, such apparatus shall be thoroughly and completely protected from damage as hereinafter specified.

1.25 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.

1. This shall include the erection of all required temporary shelters and supports to adequately protect any items stored in the open on the site from the weather, the ground and surrounding work; the cribbing of any items above the floor of the construction; and the covering of items in the incomplete building with tarpaulins or other protective covering; the installation of electric heaters in electrical switchgear and similar equipment to prevent moisture damage.
2. 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.
1. All finished floors, step treads, and finished surfaces shall be covered to prevent any damage by workmen or their tools and equipment during the construction of the building.

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

D. Storage of all equipment shall be per manufacturer's recommendations.

E. All pumps, fans and motors shall be rotated by hand when received and when stored to maintain bearing lubrication.

1.26 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 on the job as may be required to facilitate the progress to the best advantage of the job as a whole.

B. Each trade, subcontractor, and/or Contractor must pursue its work promptly and carefully so as not to delay the general progress of the job.

C. This Contractor shall work in harmony with Contractors working under other contracts on the premises.

1.27 ELECTRICAL WIRING OF MOTORS AND EQUIPMENT

A. The Contractor shall note that the electrical design and Drawings are based on the equipment scheduled and indicated on the Drawings, and should any mechanical equipment be provided requiring changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.

B. The Electrical Trades shall provide all interconnecting wiring for the installation of all power.

C. The Electrical Trades shall provide all disconnect switches as required for proper operation, as indicated on the Drawings or required by applicable code.
1. All combination starters, individual starters, and other motor starting apparatus not specifically scheduled or specified as provided by the equipment manufacturer under the scope of Division 23, shall be provided under the scope of Division 26 or as directed by the General Contractor.

D. The Mechanical Trades shall provide complete wiring diagrams indicating power wiring and interlock wiring.
1. Diagrams shall be submitted for review within 30) days after the submittals for equipment have been reviewed.
2. Diagrams shall be based on accepted equipment and shall be complete full phase and interlock control Drawings, not a series of manufacturer`s individual diagrams.
3. After these diagrams have been reviewed, copies shall be transmitted to the Electrical Trades by the Contractor.
4. See Section 23 09 00 - Instrumentation and Control for HVAC for additional clarification.

1.28 SUPERVISION

A. Each Contractor and subcontractor shall keep a competent superintendent or foreman on the job at all times (Refer to the Uniform General Conditions for additional information concerning supervision).

B. It shall be the responsibility of each superintendent to study all Drawings and familiarize themselves with the work to be done by other trades.

C. Coordinate with other trades and, before material is fabricated or installed, superintendent shall ensure that the work will not cause an interference with another trade.

D. Where interferences are encountered, they shall be resolved at the job site by the superintendents involved.

E. Where interferences cannot be resolved without major changes to the design, the matter shall be referred to the A/E for ruling.

1.29 SITE OBSERVATION

A. Site observation by the Architect/Engineer is for the express purpose of verifying compliance by the Contractor with the Contract Documents, and shall not be construed as construction supervision nor indication of approval of the manner or location in which the work is being performed as being a safe practice or place.

1.30 PRECEDENCE OF MATERIALS

A. The specifications determine the nature and setting of materials and equipment.

B. The drawings establish quantities, dimensions, and details.

C. The installation precedence of materials shall generally be as follows:

1. Note that if interference is encountered, this shall guide the contractor in the determination of which trade shall be given the "Right-of-Way" This does not require elements with a lower preference to be relocated if such relocation is required to resolve interference or to provide better access.
    a. Building lines.
    b. Structural Members.
    c. Soil and Drain Piping.
    d. Vent Piping.
    e. Supply, Return, and Outside Air Ductwork.
    f. Exhaust Ductwork.
    g. HVAC Water and Steam Piping.
    h. Condensate Piping.
    i. Fire Protection Piping.
    j. Natural Gas Piping.
    k. Domestic Water (Cold and Hot).
    l. Refrigerant Piping.
    m. Electrical Conduit.

1.31 RECORDS FOR OWNER

A. Records shall comply with Section 01 77 00 - Closeout Procedures and Submittals and requirements described herein.

B. The Contractor shall maintain a set of prints in the Field Office for the sole purpose of recording "installed" conditions.

1. Daily note all changes made in these Drawings in connection with the final installation including exact dimensioned locations of all new underground utilities, services and systems and all uncovered existing active and inactive piping outside the building.

C. At Contract completion, the Contractor shall provide a set of reproducible drawings and set of specifications electronic format (PDF).

1. The contractor shall transfer the information from the prints maintained as described above, and turn over this neatly marked set of reproducible Drawings and specifications representing the "as installed" work to the Architect/Engineers for verification and subsequent transmittal to the Owner.
2. The Contractor shall refer to Division 01 of these Specifications, and to the Uniform General Conditions, for additional information.
3. These Drawings and Specifications shall include as a minimum:
    a. Addendum written drawing changes.
    b. Addendum supplementary drawings.
    c. Accurate, dimensioned locations of all underground utilities, services and systems.
    d. Identification of equipment work shown on Alternates as to whether alternates were accepted and work actually installed.

e. Change Order written drawing changes.

D. "As installed" PDF's shall bear a stamp or hand lettered title block generally located in lower right hand corner of Drawing entitled "AS INSTALLED DRAWING" with Company name of the installing trade Subcontractor and with a place for the date and the name of the responsible company representative.

E. In addition to the above, the Contractor shall accumulate, during the progress of the job, the following data in electronic format (PDF) and turn over to the Architect/Engineer for review, and subsequent delivery to the Owner:

1. All warranties and guarantees and manufacturers` directions on equipment and material covered by the Contract.
2. Operating instructions and preventative maintenance procedures for heating and cooling and other mechanical and electrical systems.
3. Valve tag charts and diagrams specified herein.
4. Approved wiring diagrams and control diagrams representing "as installed" conditions.
5. Copies of approved Shop Drawings.
6. Any and all other data and/or drawings required as submittals during construction.
7. Repair parts list of all major items and equipment including name, address and telephone number of local supplier or agent.

F. All of the above data shall be submitted to the Architect/Engineer for approval, and shall be corrected as instructed by the Architect/Engineer prior to submission of the final request for payment.

G. Refer to additional requirements in the commissioning section of Division 01.

1.32 ATTIC STOCK

A. Provide one set of filters and two sets of belts at conclusion of the project to the Owner for attic stock.

1.33 WARRANTY

A. Refer to Division 01 and to individual specification sections for warranty requirements Unless otherwise specified, a 5-year parts and labor warranty shall be provided on all systems and equipment.

PART 2 – PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment shall be acceptable to the authority having jurisdiction as suitable for the use intended.

B. Furnish products listed and classified by Underwriter's Laboratory, Inc as suitable for purpose specified and shown.

C. Unless otherwise specified materials shall be new and free from any defects.

2.2 ACCESS DOORS

A. General: This Contractor shall provide wall, floor, or ceiling access doors for unrestricted access to all concealed items of mechanical, plumbing, or electrical equipment or devices including items requiring general maintenance or access.

B. Utilize Section 08 31 13 - Access Doors and Frames for products and requirements.

C. Access doors shall be a minimum of 24 x 24 inches in size unless approved by UTSW FM in writing. Location shall provide appropriate access.

PART 3 – EXECUTION

3.1 EXISTING FACILITIES

A. The Contractor shall be responsible for loss or damage to the existing facilities caused by them and their workers, and shall be responsible for repairing or replacing such loss or damage.

1. 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, electrical, and ventilating services for the new and existing facilities.
2. The Contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing all such temporary protection upon completion of the work.

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. Where partitions, walls, floors, or ceilings of existing construction are indicated to be removed, all Contractors shall remove and reinstall in locations approved by the Architect/Engineer all devices required for the operation of the various systems installed in the existing construction.
   1. This includes but is not limited to temperature controls system devices, electrical switches, relays, fixtures, piping, conduit, etc.

E. Outages of services as required by the new installation will be permitted but only at a time approved by the Owner.
   1. Comply with notification requirements per Section 01 10 00 - Summary.
   2. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner.
   3. All costs of outages, including overtime charges, shall be included in the contract amount.

3.2 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.
   1. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage.
   2. Salvage materials shall remain the property of the Owner, and shall be delivered to such destination or otherwise disposed of as directed by the Owner.
   3. 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.
   4. The Contractor may, at their discretion, and upon the approval of the Owner, substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.

B. All items that are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated.
   1. 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.
   2. All relocations shall be performed by workers skilled in the work and in accordance with standard practice of the trades involved.

C. When items scheduled for relocation and/or reuse are found to be in damaged condition before work has been started on dismantling, the Contractor shall call the attention of the Owner to such items and receive further instructions before removal.
   1. Items damaged in repositioning operations are the Contractor's responsibility and shall be repaired or replaced by the Contractor as approved by the Owner, at no additional cost to the Owner.

D. 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.
   1. Service lines and wiring not scheduled for reuse shall be removed to the points at which reuse is to be continued or service is to remain.
   2. Such services shall be sealed, capped, or otherwise tied off or disconnected in a safe manner acceptable to the Owner.
   3. 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.
   4. Services to existing areas or facilities that must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner as hereinbefore specified.

3.3 EXCAVATION, TRENCHING AND BACKFILL

A. Excavation (See Divisions 00 and 01 for special requirements related to excavation and trenching):

1. Any excavation and digging below 1 foot around the campus bird sanctuary must be approved by OSBC. The area of the bird sanctuary is defined as the tree line surrounding it.
2. The contractor shall perform all excavations of every description, for their particular installations and of whatever substances encountered, to the depths indicated on the Drawings and/or required for the installation of piping, conduit, utility systems, etc.
    a. All exterior lines shall be installed with a minimum cover of 24 inches, unless otherwise indicated.
    b. Generally, more cover shall be provided if grade will permit.
    c. All excavation materials not required for backfill or fill shall be removed and wasted as acceptable to the Construction Inspector.
    d. All excavations shall be made only by open cut.
    e. The banks of trenches shall be kept as nearly vertical as possible and where required, shall be properly sheeted and braced.
    f. Trenches shall be not less than 12 inches wider nor more than 16 inches wider than the outside edges of the pipe to be laid therein, and shall be excavated true to line so that a clear space not less than 6 inches nor more than 8 inches in width is provided on each side of the pipe.
    g. For sewers, the maximum width of trench specified applies to the width at and below the level may be made as wide as necessary for sheeting and bracing, and the proper installation of the work.
3. The bottom of trenches shall be accurately graded to provide proper fall and uniform bearing and support for each section of the pipe on undisturbed soil or 2 inches of sand fill at every point along its entire length, except for portions of the pipe sections where it is necessary to excavate for bell holes and for the proper sealing of pipe joints.
    a. Bell holes shall be dug after the trench bottom has been graded.
    b. Where inverts are not shown, grading shall be determined by the Plumbing Code for the service intended and the size used.
    c. Bell holes for lead pipe joints shall be 12 inches in depth below the trench bottom and shall extend from a point 6 inches back of the face of the bell.
    d. Such bell holes shall be of sufficient width to provide ample room for caulking.
    e. Bell holes for sewer tile and water pipe shall be excavated only to an extent sufficient to permit accurate work in the making of the joints and to insure that the pipe, for a maximum of its length, will rest upon the prepared bottom of the trench.
    f. Depressions for joints other than bell and spigot shall be made in accordance with the recommendations of the joint manufacturer for the particular type of joint used.
    g. In general, grading for duct banks and conduits shall be from building to manhole, and from a high point between manholes to each manhole.
    h. Special pipe beds shall be provided as specified hereinafter.
4. The lower 4 inches of the pipe trenches measuring from an overhead line set parallel to the grade line of the sewer shall be excavated only a few feet in advance to the pipe laying, by workers especially skilled in this type of work.
    a. Where damage is likely to result from withdrawing sheeting, the sheeting shall be left in place
    b. Except at locations where excavation of rock from the bottom of trenches is required, care shall be taken not to excavate below the depths required.
    c. Where rock excavation is required, the rock shall be excavated to a minimum over depth of 6 inches below the trench depths specified.
    d. The over depth rock excavation and all excess trench excavation shall be backfilled with sand.
    e. Whenever wet or otherwise unstable soil is incapable of properly supporting the pipe is encountered in the trench bottom, such soil shall be removed to a depth and for the trench lengths required, and then backfilled to trench bottom grade, as hereinafter specified, with sand.

5. All grading in the vicinity of excavation shall be controlled to prevent surface ground water from flowing into the excavations.
    a. Any water accumulated in the excavations shall be removed by pumping or other acceptable method.
    b. During excavation, material suitable for backfilling shall be stacked in an orderly manner a sufficient distance back from edges of trenches to avoid overloading and prevent slides or cave-ins.
    c. Material unsuitable for backfilling shall be wasted and removed from the job site as directed by the Construction Inspector.
6. All shoring and sheeting required to perform and protect the excavations and to safeguard employees and/or adjacent structures shall be provided.
7. Excavate as required under the building in order that all piping, ductwork, etc , shall clear the ground a minimum of 12 inches for a distance of 24 inches on either side.
    a. Edges of such excavations shall slope at an angle of not over 45 degrees with the horizontal unless otherwise approved by the Construction Inspector.
    b. The bottom of such excavation shall be graded to drain in a manner acceptable to the Construction Inspector.
8. Trenches for cast iron drain, storm water and sewer lines inside the building shall be properly excavated, following, in general, the procedures set out for exterior lines
    a. Where floors are to be poured over these lines, they shall be backfilled, tamped and settled with water.
    b. Where no flooring is to cover the lines, they shall be backfilled to form a level grade.
9. All surplus materials removed in these trenching operations becomes the property of the contractor, and shall be disposed of at the expense of the contractor, at a legal disposal site, off of the campus.

B. Backfilling:
1. Trenches shall not be backfilled until all required tests are performed and until the piping, utilities systems, etc , as installed are certified by the Owner`s inspector to conform to the requirements specified hereinafter.
2. The trenches shall be carefully backfilled with sand to a depth of 12 inches above the top of the pipe.
3. The next layer and subsequent layers of backfill may be excavated materials approved for backfilling, consisting of earth, loam, sandy clay, sand and gravel, soft shale, or other approved materials free from large clods of earth or stones larger than 1-1/2 inches in diameter, flooded until the pipe has cover of not less than one foot.
4. The remainder of the backfill material shall then be thrown into the trenches, moistened, and tamped or flooded in one foot layers.
5. Blasted rock, broken concrete or pavement, and large boulders shall not be used as backfill material.
6. Any trenches improperly backfilled, or where settlement occurs, shall be reopened to the depth required for proper compaction, then refilled and mounded over, and smoothed off.
7. Backfill under concrete slabs on fill shall be as specified above, shall be gravel, or shall be other such materials more suitable for the application Installation and compaction shall be as required for compatibility with adjacent materials.

C. Opening and Re-closing Pavement and Lawns:
1. Where excavation requires the opening of existing walks, streets, drives, other existing pavement, or lawns, such surfaces shall be cut as required to install new lines and to make new connections to existing lines.
2. The sizes of the cut shall be held to a minimum, consistent with the work to be accomplished.
3. After the installation of the new work is completed and the excavation has been backfilled and flooded, the area shall be patched, using materials to match those cut out.
4. The patches shall thoroughly bond with the original surfaces and shall be level with them, and shall meet all the requirements established by the authorities having jurisdiction over such areas.

D. Excavation in Vicinity of Trees:
   1. All trees including low hanging limbs within the immediate area of construction shall be adequately protected to a height of at least 5 feet to prevent damage from the construction operations and/or equipment.
   2. All excavation within the outermost limb radius of all trees shall be accomplished with extreme care.
   3. All roots located within this outermost limb radius shall be brought to the attention of the Construction Inspector before they are cut or damaged in any way.
   4. The Construction Inspector will give immediate instructions for the disposition of same.
   5. All stumps and roots encountered in the excavation, which are not within the outermost limb radius of existing trees, shall be cut back to a distance of not less than 18 inches from the outside of any concrete structure or pipeline.
   6. No chips, parts of stumps, or loose rock shall be left in the excavation.
   7. Where stumps and roots have been cut out of the excavation, clean compacted dry bank sand shall be backfilled and tamped.

3.4 INSTALLATION METHODS

A. Where to Conceal: All pipes, conduits, etc , shall be concealed in pipe chases, walls, furred spaces, or above the ceilings of the building unless otherwise indicated.

B. Where to Expose:
   1. In mechanical rooms, janitor`s closets tight against pan soffits in exposed "Tee" structures, or storage spaces, but only where necessary, piping may be run exposed.
   2. All exposed piping shall be run in the most aesthetic, inconspicuous manner, and parallel or perpendicular to the building lines.

C. Support: All piping, ducts and conduits shall be adequately and properly supported from the building structure by means of hanger rods or clamps to walls as herein specified.

D. Maintaining Clearance:
   1. Where limited space is available above the ceilings below concrete beams or other deep projections, pipe and conduit shall be sleeved through the projection where it crosses, rather than hung below them in a manner to provide maximum above-floor clearance.
   2. Sleeves shall be as herein specified.
   3. Piping, ductwork and other installed materials shall be located so as to not obstruct maintenance clearance for mechanical components such as controls, filters and the like.
   4. Piping shall not create trip-hazards through floor-mounting but be routed in a manner overhead or below the floor.

E. Piping:
   1. Piping shall be identified with both color and labels as indicated in Section 23 05 53 - Mechanical Identification.
   2. All pipe, conduits, etc , shall be cut accurately to measurements established at the building and shall be worked into place without springing or forcing.
   3. All ducts, pipes and conduits run exposed in machinery and equipment rooms shall be installed parallel to the building lines, except that piping shall be sloped to obtain the proper pitch.
   4. Piping, ducts and conduits run in furred ceilings, etc., shall be similarly installed, except as otherwise shown All pipe openings shall be kept closed until the systems are closed with final connections.
   5. All piping not directly buried in the ground shall be considered as "interior piping."
   6. Prior to the installation of any ceiling material, gypsum, plaster, or acoustical board, the Contractor shall notify the construction inspector so that arrangement can be made for an inspection of the above ceiling area about to be "sealed" off.
      a. The Contractor shall give as much advance notice as possible but no less than 10 working days.
   7. All above ceiling areas will be subject to a formal inspection before ceiling panels are installed, or installation is otherwise concealed from view.

a. All mechanical work at and above the ceiling, including items supported by the ceiling grid, such as air inlets or outlets, shall be complete and installed in accordance with contract requirements, including power to fans and other powered items.
b. Adequate lighting shall be provided to permit thorough inspection of all above-ceiling items.
c. The inspection will include representatives of the following: General Contractor and each Subcontractor having work above the ceiling, Facilities Management, Architect/Engineer, and the Resident Construction Manager`s Construction Inspector Areas to be included and time of inspection shall be coordinated with the Construction Inspector.
d. The purpose of this inspection is to verify the completeness and quality of the installation of the air conditioning systems, the electrical systems, the plumbing systems, and any other special above ceiling systems such as pneumatic tube, vacuum systems, fire sprinkler piping and cable tray systems.
e. The ceiling supports (tee bar or metal framing) shall be in place so that access panel and light fixture locations are identifiable and so that clearances and access provisions may be evaluated.
f. No ceiling materials may be installed until the resulting deficiency list from this inspection is worked off and the Construction Inspector has given approval.

8. Proper accessibility to equipment may be required to be demonstrated by the commissioning agent or inspector.

3.5 CONNECTIONS FOR OTHERS

A. The Contractor shall rough in for and make all gas, water, steam, sewer, etc. connections to all fixtures, equipment, machinery, etc., provided by others in accordance with detailed roughing-in Drawings provided by the equipment suppliers, by actual measurements of the equipment connections, or as detailed.
B. After the equipment is set in place, the Contractor shall make all final connections and shall provide all required pipe, fittings, valves, traps, etc.
C. Shutoff Valves: In each service line connected to an item of equipment or piece of machinery, provide a shutoff valve.
D. Traps: On each drain not provided with a trap, provide a suitable trap.
E. Provide all air gap fittings required, using materials hereinbefore specified. In each service line connected to an item of equipment or piece of machinery, provide a shutoff valve. On each drain not provided with a trap, provide a suitable trap.
F. All pipe fittings, valves, traps, etc , exposed in finished areas and connected to chrome plated lines provided by others shall be chrome plated to match.
G. Provide all sheet metal ductwork, transition pieces, etc , required for a complete installation of vent hoods, fume hoods, etc , provided by others.

3.6 CUTTING AND PATCHING

A. General: Cut and patch walls, floors, etc , resulting from work in existing construction or by failure to provide proper openings or recesses in new construction.
B. Methods of cutting:
1. Openings cut through concrete and masonry shall be made with masonry saws and/or core drills and at such locations acceptable to the Architect/Engineer.
2. Impact-type equipment shall not be used except where specifically acceptable to the Architect/Engineer Openings in precast concrete slabs for pipes, conduits, outlet boxes, etc., shall be core drilled to exact size.
C. Restoration: 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. Masonry:
1. Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry.

2. Adequate supports shall be provided during the cutting operation to prevent any damage to the masonry occasioned by the operation.
3. All structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner acceptable to the Architect/Engineer.

E. Plaster:
1. All mechanical work in areas containing plaster shall be completed prior to the application of the finish plaster coat.
2. Cutting of finish plaster coat will not be permitted.

F. Special Note: No cutting, boring, or excavating which will weaken the structure shall be undertaken
1. Rebar placement shall be determined prior to floor coring operations.
2. Any rebar, which has been cut, shall be submitted in writing to the Architect/Engineer for evaluation.

3.7 ROOF PENETRATIONS AND FLASHING

A. Pipe, conduit and duct sleeves, pitch pockets, and flashings compatible with the roofing installation shall be provided and installed by a qualified contractor for all roof penetrations.

B. This shall be the responsibility of the General Contractor.

3.8 OPERATION PRIOR TO COMPLETION

A. When any piece of mechanical equipment is operable and it is to the advantage of the Contractor to operate the equipment, they may do so, providing they properly supervises the operation, and has the Construction Inspector`s written permission to do so.

B. The warranty period shall not commence until such time as the equipment is operated for the beneficial use of the Owner, or date of substantial completion, whichever occurs first.

C. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media, properly adjust, and complete all deficiency list items before final acceptance by the Owner.
1. The date of acceptance and performance certification will be the same date.

D. Air handling equipment shall only be operational with all specified filter media in place and additional filter media in place to prevent dust from entering the return and exhaust air systems.

E. Additional requirements for operation of equipment prior to completion found in the commissioning sections of Division 1 and Division 23 shall be followed.

3.9 CLEANING AND PAINTING

A. All equipment, piping, conduit, ductwork, grilles, insulation, etc , furnished and installed in the tunnel and mechanical rooms under Division 23 of these Specifications and as hereinafter specified shall be cleaned, prepared, and painted according to the following specification. Color of finish painting in Mechanical Rooms shall be painted in accordance with Color Schedule for machinery spaces using Sherwin Williams paint numbers, or approved equivalent.
1. In the event of a conflict between the specifications referenced, the provisions of this specification shall prevail only for Divisions 22, 23 and 26 work.
2. UTSW Approved paint colors: Refer to Section 23 05 53 - Mechanical Identification.
3. Paint Specification: Refer to Section 09 96 00 - High-Performance Coatings.
4. Natural gas piping shall be painted in its entirety.

B. All equipment furnished by the mechanical and electrical subcontractors shall be delivered to the job with a suitable factory protective finish and shall be painted, after installation, with the color hereinafter specified.

C. The following materials shall not be painted:
1. Materials: copper, galvanized metal, stainless steel, fiberglass, PVC, and PVDF.
2. Aluminum jacketing on insulation.
3. Nameplates on equipment shall be protected during painting to prevent damage.

D. Before painting, materials and equipment surfaces shall be thoroughly cleaned of cement, plaster, and other foreign materials, and all oil and grease spots shall be removed.
1. Such surfaces shall be carefully wiped and all cracks and corners scraped out.

2. Exposed metal work shall be carefully brushed down with the steel brushes to remove rust and other spots and left smooth and clean.

E. For painting purposes, the equipment and piping inside of built-up air handling units shall be painted the same as if they were within the walls of a Mechanical Room.

F. Scope of painting for Division 23 work in areas other than those defined as "exposed" is as follows:
   1. Underfloor spaces:
      a. All uncovered steel pipe, supports, exposed pipe and hanger rod threads, and hangers shall be cleaned and painted with two coats of black asphaltic emulsion.
      b. Galvanized steel and copper lines shall not be painted.
   2. Concealed spaces:
      a. All canvas finishes shall be painted with one sizing coat if not already sized, containing mildew resistant additive and adhesive prior to any other specified finish paint.
   3. If insulated, the piping shall be primed, only, prior to insulation, and the insulation jacketing shall be painted as specified for piping The requirements of this paragraph are "primary" and have priority over any conflicting specification or instruction, should a conflict in the Construction Documents exist.

G. In addition to painting in mechanical rooms, materials, piping, ductwork, conduit, gear, supports, foundations, equipment, and appurtenances installed by the mechanical and electrical subcontractors in exposed areas shall be finish painted with two coats enamel paint of color selected by the Architect/Engineer, refer to Section 09 96 00 - High-Performance Coatings.

H. Additional areas to be defined as "exposed" for purposes of painting, are defined on the Drawings.

I. The surfaces to be finish painted shall first be prepared as follows:
   1. On canvas finishes pretreated as specified above.
   2. Insulated surfaces having vapor barrier jacket exposed to view shall first be painted with one (l) coat of sealer.
   3. Galvanized and black steel surfaces shall first be painted with one (1) coat of P&L galvanized metal primer. Primer may be eliminated on concealed fire and gas piping.
   4. Aluminum surfaces shall first be painted with one (1) coat of P&L zinc chromate primer.
   5. Cast iron pipe shall first be primed with a "non bleed" primer.
   6. The underside of all cast iron sinks not recessed in a cabinet are included as items to be painted in exposed areas.

J. All ferrous metal surfaces without a protective finish and not galvanized in exposed and concealed areas including chases, under floor, and above ceilings shall be painted with 2 coats of P&L zinc chromate primer as the construction progresses to protect against deterioration.

3.10 CHECKING AND TESTING MATERIALS AND/OR EQUIPMENT

A. Before the work is accepted, an authorized representative of the manufacturer of the installed materials and/or equipment shall personally inspect the installation and operation of materials and/or equipment to determine that it is properly installed and in proper operating order.
   1. The qualifications of the representative shall be appropriate to the technical requirements of the installation. The qualifications of the representative shall be submitted to the owner for approval.
   2. The decision of the Owner concerning the appropriateness of the representative shall be final.
   3. Testing and checking shall be accomplished during the course of the work where required by work being concealed, and at the completion of the work otherwise In addition, the Contractor shall submit to the Architect/Engineer a signed statement from each representative certifying as follows:
      a. "I certify that the materials and/or equipment listed below have been personally inspected by the undersigned authorized manufacturer`s representative and is properly installed and operating in accordance with the manufacturer`s recommendations"

B. Check inspections shall include plumbing equipment, electrical equipment, heating, air conditioning, insulation, ventilating equipment, controls, mechanical equipment and such other items hereinafter specified or specifically designated by the Owner or the Architect/Engineer.

C. Refer to the commissioning sections of Division 1 and Division 23 for additional start-up, testing, and acceptance requirements.

3.11 TESTS

A. The Contractor shall make, at no additional cost to the Owner, any tests deemed necessary by the inspection departments having jurisdiction, and in the National Fire Protection Association, ASTM, etc. Standards listed.
   1. The Contractor shall provide all equipment, materials, and labor for making such tests.
   2. Reasonable amounts of fuel and electrical energy costs for system tests will be paid by the Owner.
   3. Fuel and electrical energy costs for system adjustment and tests which follow beneficial occupancy by the Owner will be borne by the Owner.

B. Additional tests specified hereinafter under the various Specification Sections shall be made.

C. The Construction Inspector shall be notified in writing at least 10 working days prior to each test and other Specification requirements requiring action on the part of the Construction Inspector.
   1. All equipment shall be placed in operation and tested for proper automatic control requirements before the balancing agency starts their work.

D. Maintain Log of Tests as hereinafter specified.

E. See Specifications for additional tests and requirements.

F. All testing reports shall be submitted to UTSW Facilities Management for review and approval.

3.12 LOG OF TESTS

A. All tests shall have pertinent data logged by the Contractor at the time of testing.
   1. Data shall include date, time, personnel, description, and extent of system tested, test conditions, test results, specified results, and other pertinent data.
   2. Data shall be delivered to the Architect/Engineer and UTSW Facilities Management as specified under "Requirements for Final Acceptance" in Section 01 77 00 - Closeout Procedures and Submittals.
   3. All Test Log entries shall be legibly signed by the Project Contractor or the authorized job superintendent.

3.13 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 tools, equipment and materials, and shall clean all debris from the job.

B. Upon the completion of the job, each trade shall immediately remove all tools, equipment, any surplus materials, and all debris caused by that portion of the work.

3.14 CLOSEOUT ACTIVITIES

A. As part of project punch list requirements per Section 01 77 00 - Closeout Procedures and Submittals, include UTSW Utilities / Mechanical Shop, UTSW Controls / Utilities Operations, UTSW Electrical Shop, UTSW Building Maintenance, UTSW PM, Commissioning Agent (if applicable), and other associated teams for mechanical focused review.

B. Provide revised Operation and Maintenance Data including final installed components schedule, maintenance manuals, and warranty documentation to UTSW PM and to UTSW Building Maintenance.

3.15 TRAINING

A. Refer to Section 01 79 00 - Demonstration and Training as well as individual technical Sections for specific training requirements.

B. Where training is called for in other sections provide a minimum of 8 hours on site training for Owner’s representatives.

C. Training shall be presented by a qualified instructor with training experience and technical knowledge of the product.

D. Submit a training agenda, proposed date, and instructor qualifications to the Owner for approval.

END OF SECTION 23 00 00

SECTION 23 05 13

MOTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SECTION INCLUDES

A. High-efficiency TEFC, horizontal and vertical, single-speed, squirrel cage polyphase induction motors, up to and including 500 hp, in NEMA frame sizes 143T and larger for severe duty applications (commonly referred to as severe duty motors).

1.3 RELATED REQUIREMENTS

A. Section 01 79 00 - Demonstration and Training.
B. Section 23 00 00 - UTSW Mechanical Design Requirements.
C. Section 23 05 14 - Variable Frequency Drives.
D. Section 23 21 23 - HVAC Pumps.
E. Section 23 34 13 - Axial Fans.
F. Section 23 34 16 - Centrifugal Fans.
G. Section 23 73 15 - Air Handling Units.
H. Section 23 73 24 - Indoor Modular Air Handling Units.
I. Section 23 82 19 - Fan Coil Units.
J. Section 26 24 19 - Motor Control Centers.

1.4 REFERENCE STANDARDS

A. Texas Government Code Chapter 2252.001-005; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
B. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings.
C. ABMA STD 11 - Load Ratings and Fatigue Life for Roller Bearings.
D. IEEE 112 - IEEE Test Procedure for Polyphase Induction Motors and Generators.
E. NEMA MG 1 - Motors and Generators.
F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements.
B. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
C. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than 1/2 horsepower.
D. Submit manufacturer`s installation instructions under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements.
E. Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements.
B. Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacture of electric motors for intended use, and their accessories, with minimum five years documented product development, testing, and manufacturing experience.
B. Comply with NFPA 70.
C. Provide certificate of compliance from Authority Having Jurisdiction indicating approval of high efficiency motors.
D. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.8 REQUIREMENTS

A. IEEE Standard for Petroleum and Chemical Industry Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors up to and Including 500 HP.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements.
B. Store and protect products under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements.
C. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.10 WARRANTY

A. Provide five-year manufacturer`s warranty under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements.
B. Warranty: Provide five year manufacturer warranty for motors larger than 1 horsepower.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Toshiba.
B. Baldor Electric Company/ABB Group.
C. US Motors.
D. General Electric.

2.2 GENERAL CONSTRUCTION REQUIREMENTS

A. Electrical Service: Refer to Drawing Schedules for required electrical characteristics.
B. Motors: Design for continuous operation in 40 degrees C environment, a service factor of 1 15
C. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.
D. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer`s name and model number, Service Factor, Power Factor, efficiency.
E. Electrical Connection: Conduit connection boxes, threaded for conduit For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.
F. In addition, all motors shall be provided with adequately sized electrical connection box with threaded hub for attachment of flexible conduit, unless bus duct connection is indicated.
G. Where motors are connected to driven equipment by the use of a V-belt drive, they shall be furnished with adjustable rails.
H. Single phase motors, in general, shall be less than 3/4 horsepower and shall be 120 or 208 volt, 60-hertz motors.
    1. These motors shall have built-in thermal overload protection with automatic reset, and shall be rated for temperature rise as hereinbefore specified for 3-phase motors.
I. All motors 3/4 horsepower and larger, unless smaller motors are indicated shall be supplied as 3-phase, and shall be squirrel cage premium efficiency induction type with standard NEMA frame sizes, 480 volt.

J. Motors 1 HP and larger shall have integral frames.
K. Efficiency: NEMA Premium.
L. Motors 1 HP and larger shall be provided with a copper frame-grounding lug of hydraulic compression design, for installation by the electrical subcontractor.
M. Motors 3/4 HP and larger shall have 120V space heater that is energized only when motor is idle.

2.3 STARTING EQUIPMENT

A. Each motor shall be provided with proper starting equipment.
   1. The trade furnishing the motor, unless hereinafter specified or scheduled to the contrary, shall provide this equipment.
   2. All motor starting equipment provided by any one trade shall be of the same manufacture unless such starting equipment is an integral part of the equipment on which the motor is mounted.
   3. The Mechanical Subcontractor shall furnish all starters for Division 23 work, except those starters scheduled to be provided in Section 26 24 19 - Motor Control Centers.
B. Motor starters shall conform to NEMA Standards for Industrial Control, #IC-1, latest issue, and shall be housed in NEMA Standard enclosures.
C. Control voltage in each starter shall be either 24V or 120 volts to ground (as required), with an individual control transformer provided in each starter as required.
D. Manual starters for fractional horsepower single phase motors shall be on-off or snap switch type combined with thermal overload device.
E. The switch shall be so constructed so that it cannot be held closed under a sustained motor overload.
F. Magnetic starters shall have thermal overload protection in each of the ungrounded legs and shall be solenoid operated.
G. Provide the correct size heater element to protect the motor and allow it to operate based on motor nameplate amperes and ambient temperatures anticipated for each individual motor.
H. Each starter shall be provided with a control power transformer or 120v control power circuit.
I. Pushbuttons with or without pilot lights, hand-off-automatic switches and other scheduled apparatus shall be standard duty type mounted in NEMA enclosures or in cover of starter as specified or scheduled, and shall be furnished by the trade furnishing the starter except as specifically indicated elsewhere.
J. Hand-Off-Automatic switches for equipment that could damage itself if left in the "hand" position (such as sump pumps), shall be spring return to "off" from the "hand" position.
K. Motors 75 HP and above shall be equipped with A Cutler Hammer (IT) Soft Starter if not equipped with a VFD.
L. Motors must have shaft grounding devices when equipped with VFD.
M. Motor bearings shall meet requirements for bearings in applicable equipment sections.

PART 3 - EXECUTION

3.1 APPLICATION

A. Motors drawing less than 250 Watts and intended for intermittent service may be germane to equipment manufacturer and need not conform to these specifications.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
C. Check line voltage and phase and ensure agreement with nameplate.

END OF SECTION 23 05 13

SECTION 23 05 29

SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SECTION INCLUDES

A. Pipe and equipment hangers and supports.
B. Equipment bases and supports.
C. Sleeves and seals.
D. Flashing and sealing equipment and pipe stacks.

1.3 RELATED REQUIREMENTS

A. Section 22 11 16 - Plumbing Piping.
B. Section 23 00 00 - UTSW Mechanical Design Requirements.
C. Section 23 07 13 - Ductwork Insulation.
D. Section 23 07 16 - Equipment Insulation.
E. Section 23 07 19 - Piping Insulation.
F. Section 23 21 13 - Hydronic Piping.
G. Section 23 22 13 - Steam and Steam Condensate Piping.

1.4 REFERENCE STANDARDS

A. Texas Government Code Chapter 2252.001-005; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
B. ASME B31.1 - Power Piping.
C. ASME B31 2 - Fuel Gas Piping.
D. ASME B31.5 - Refrigeration Piping.
E. ASME B31.9 - Building Services Piping.
F. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.
G. MSS SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
H. NFPA 13 - Standard for the Installation of Sprinkler Systems.
I. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems.
J. UL 203 - Standard for Pipe Hanger Equipment for Fire Protection Services.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
   2. Coordinate the work with other trades to provide additional framing and materials required for installation.
   3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
   4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
B. Sequencing:
   1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Division 03 Concrete Sections.

1.6 SUBMITTALS

A. Submit under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements.
B. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
C. Product Data: Provide manufacturers catalog data including load capacity.
D. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
E. Manufacturer`s Installation Instructions: Indicate special procedures and assembly of components.
F. Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.

1.7 REGULATORY REQUIREMENTS

A. Conform to applicable code for support of plumbing, hydronic, steam and steam condensate piping.
B. Supports for Sprinkler Piping: Shall be in conformance with NFPA 13.
C. Supports for Standpipes: Shall be in conformance with NFPA 14.

PART 2 – PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Manufacturers:
   1. Grinnell.
   2. Other acceptable manufacturers offering equivalent products.
B. Supports, hangers, anchors and guides shall be provided for all horizontal and vertical piping.
   1. Shop Drawings shall be provided, indicating locations and details of anchors, guides, expansion loops and joints, hangers, etc.
   2. The hanger design shall conform to the ASME Code for Pressure Piping.
C. All auxiliary steel required for pipe supports, anchors, guides, etc shall be provided by the Mechanical Trades unless specifically indicated to be provided by others.
D. The supports, hangers, anchors, and guides for the chilled water supply and return piping, steam piping, condensate return piping, etc of the Campus Loop System routed through utility tunnels and below buildings shall be provided as indicated on the Drawings.
E. Contractor shall review all Drawings, including Structural Drawings, for details regarding pipe supports, anchors, hangers, and guides.
   1. All pipe supports shall be of type and arrangement to prevent excessive deflection, to avoid excessive bending stresses between supports, and to eliminate transmission of vibration.
   2. This trade shall be responsible for structural integrity of all supports, anchors, guides, etc.
   3. All structural hanging materials shall have a minimum safety factor of 5 built in.
F. Anchor points as indicated on Drawings or as required shall be located and constructed to permit the piping system to take up its expansion and contraction freely in opposite directions away from the anchored points.
G. Guide points shall be located and constructed wherever required or indicated on Drawings and at each side of an expansion joint or loop, to permit free axial movement only.
H. Pipe supports, hangers, anchors, and guides shall be fastened to the structure only at such points where the structure is capable of restraining the forces in the piping system.
I. Hangers supporting and contacting brass or copper lines 3-inches in size and smaller shall be Grinnell Fig CT-99c, adjustable, copper plated, tubing ring.
J. Hangers supporting and contacting brass or copper lines 4-inches and larger shall be Grinnell Fig 260, adjustable clevis, with a nut above and below the hanger, and approved neoprene isolating material between pipe (or tubing) and hanger on the support rod.
K. For insulated copper or brass domestic water lines, hangers for all sizes of pipe shall be Grinnell Fig 300, adjustable clevis, with a nut above and below the hanger, and approved neoprene isolating material between pipe (or tubing) and hanger on the support rod Isolate all copper or brass lines from all ferrous materials with approved dielectric materials.
L. Hangers supporting and contacting plastic or glass piping shall be of equal design, but shall be padded with neoprene material or equal The padding material and the configuration of its installation shall be submitted for approval.

M. Hangers supporting insulated lines where the outside diameter of the insulation is the equivalent of 8 inch diameter pipe or smaller in size and supporting all ferrous lines 6 inch and smaller in size shall be Grinnell Fig 260, adjustable clevis, with a nut above and below the hanger on the support rod.

N. Hangers supporting and contacting ferrous lines larger than 6 inch in size and outside of insulation on lines with the outside diameter equivalent to 10 inch diameter pipe shall be Grinnell Fig 260, adjustable clevis, with a nut above and below the hanger on the support rod.

O. Glass riser clamps shall be neoprene coated

P. Other special type of hangers may be employed where so specified or indicated on the Drawings, or where required by the particular conditions. In any case, all hangers must be acceptable to the owner.

Q. Each hanger shall be properly sized to fit the supported pipe or fit the outside of the insulation on lines where specified:

1. Hangers for dual or low temperature insulation pipes shall bear on the outside of the insulation, which shall be protected by support shields as specified in Section 23 07 19- Piping Insulation.
2. Protect insulation from crushing by means of a section of rigid insulation to be installed at hanger points.
3. Hangers for high temperature insulated pipes and all insulated hot and cold domestic water pipes shall be encased in the insulation unless supported by trapezes in which case shield and rigid insulation shall be provided as specified above for low temperature insulated pipes.

R. Hangers for large diameter steam and chilled water piping shall be roller style where thermal expansion is expected.

S. Supports for vertical piping in concealed areas shall be double bolt riser clamps, Grinnell Fig 261, or other approved equal, with each end having equal bearing on the building structure, and located at each floor.

1. Two-hole rigid pipe clamps at 4 feet on center or Kindorf channels and Grinnell Fig 261 riser clamps may be used to support pipe from vertical surfaces or members where lines are not subject to expansion and contraction.
2. Where brass or copper lines are supported on trapeze hangers or Kindorf channels the pipes shall be isolated from these supports with plastic tape with insulating qualities, or strut clamps as manufactured by Specialty Products Company, Stanton, California.

T. Supports for vertical piping in exposed areas (such as fire protection standpipe in stairwells) shall be attached to the underside of the building structure above the top of the riser, and the underside of the penetrated structure.

1. The contractor shall use a drilled anchor as specified above, and use a Grinnell No 595 Socket Clamp with Grinnell No 594 Socket Clamp Washers, as a riser clamp.
2. The top riser hanger shall consist of two (2) hanger rods (sized as specified) anchored to the underside of the building structure, supporting the pipe by means of the material specified.
3. Risers penetrating floors shall be supported from the underside of the penetrated floor as specified for the top of the riser, but the hanger rods shall also include spring isolators (see Specification on Vibration Isolation for isolator specification).
4. Floor penetrations in exposed areas shall be finished using Grinnell Fig 395 "Ceiling Plates" painted to match the pipe if uninsulated; or if insulated, the penetration shall be covered using a chrome plated escutcheon.
5. Provide hangers at all changes in direction of pipe.

2.2 PIPE SUPPORTS IN CHASES AND PARTITIONS

A. Horizontal and vertical piping chases and partitions shall be supported by hangers or other suitable support.

B. Pipes serving plumbing fixtures and equipment shall be securely supported near the point where pipes penetrate the finish wall.

C. Supports shall be steel plate, angles or special channels such as Unistrut mounted in vertical or horizontal position.

D. Pipe clamps such as Unistrut P2426, P2008, P1109 or other approved clamps shall be attached to supports.

E. Supports shall be attached to wall or floor construction with clip angles, brackets, or other approved method.
F. Supports may be attached to cast iron pipe with pipe clamp, or other approved method.
G. Isolate copper or brass lines from ferrous metals with dielectric materials to prevent electrolytic action.

2.3 CONDUITS

A. Electrical conduits shall be run parallel or perpendicular to adjacent building lines.
B. Single conduits running horizontally shall be supported by "Caddy" or "Minerallac" type hangers from adequately sized rods (minimum 1/4-inch) from the building structure Where multiple conduits are run horizontally, they shall be supported on trapeze of "Unistrut" type channel suspended on rods or bolted to vertical building members.
C. Conduit shall be secured to channel with galvanized "Unistrut" type conduit clamps or stainless steel "Unistrut" type "Uni-Clips".
D. All hangers shall be fastened to the building structure in the same manner as specified above for pipe hangers.
E. Spacing of hangers shall be adequate for the weight and rigidity of the conduits involved; in any case, no greater than 8-foot centers.
F. Where feasible, conduits may be fastened to the concrete by one-hole straps thoroughly anchored to the concrete in an approved manner.
G. Flexible conduit shall also be supported in an acceptable manner so as not to interfere with the maintenance of above-ceiling equipment, and to support it from touching the ceiling system.
H. Conduit shall be located so as not to inhibit removal of ceiling tiles.
I. The suspension system for the lay-in ceiling shall not be used to support electrical conduit.
J. Vertical conduits shall be supported as often as necessary for rigidity by clamps resting on adjacent beams or floor slabs; minimum of one support per floor.
K. All support hardware shall be galvanized or cadmium plated, or stainless steel.
L. Perforated strap iron or wire will not, under any circumstances, be acceptable as hanger material.
M. Vibration Isolation:
    1. Resilient hangers shall be provided on all piping connected to rotating equipment (pumps, etc).
    2. Piping that may vibrate and create an audible noise shall also be isolated Spring hangers or supports shall be provided where indicated on the Drawings and/or specified under Section 22 05 48 - Vibration Isolation.
N. Attachment:
    1. The load and spacing on each hanger and/or insert shall not exceed the safe allowable load for any component of the support system, including the concrete, which holds the inserts.
    2. Reinforcement at inserts shall be provided as required to develop the strength required.
    3. Inserts for piping shall be of a type which will not interfere with reinforcing as shown on the structural Drawings and which will not displace excessive amounts of structural concrete.
    4. Design and install pipe supports to avoid interference with other piping, hangers, ducts, electrical conduit, supports, building structures, equipment, etc.
    5. Install piping with due regard to expansion and contraction and the type of hanger method of support, location of support, etc shall be governed in part by this Specification.
    6. Pipe hangers shall be attached to the structure as follows:
        a. Poured In Place Concrete:
            1) Where pipes and equipment are supported under poured in place concrete construction, each hanger rod shall be fitted with a nut at its upper end, which nut shall be set into an Underwriters` Laboratories, Inc. listed universal concrete insert placed in the form work before concrete is poured.
            2) Where inserts are placed in the bottom faces of concrete joists which are too narrow to provide adequate strength of concrete to hold the insert properly or where a larger insert would require displacement of the bottom joist steel, the hanger rod shall be suspended from the center of a horizontal angle iron, channel iron, I-beam, etc. spanning across two

adjacent joists.

3) The horizontal support shall be bolted to nonadjustable concrete inserts of the "spot" type, of physical size small enough to avoid the bottom joist steel.

b. Steel Bar Joists:
   1) Where pipes and loads are supported under bar joists, hanger rods may be run through the space between the bottom angles and secured with a washer and two nuts.
   2) Where larger lines are supported beneath bar joists, hanger rods shall be secured to angle irons of adequate size; each angle shall span across two or more joists as required to distribute the weight properly and shall be welded to the joists or otherwise permanently fixed.

c. Steel Beams: Where pipes and loads are supported under steel beams, approved type beam clamps shall be used.

d. Wood Framing: Where pipes and loads are supported from wood framing, hanger rods shall be attached to framing with side beam brackets or angle clips.

e. Pre-Cast Tee Structural Concrete:
   1) Hanger supports, anchors, etc. required for mechanical systems attached to the precast, double tee, structural concrete system are to be installed in accord with approved shop Drawings only.
   2) Holes required for hanger rods shall be core drilled in the "flange" of the double tee only; impact type tools are not allowed under any circumstances.
   3) Core drilling in the "stem" portions of the double tee is not allowed.
   4) Holes core drilled through the "flange" for hanger rods shall be no greater than 1/4" larger than the diameter of the hanger rod.
   5) Hanger rods shall be supported by means of bearing plates of size and shape acceptable to the Architect/Engineer, with welded double nuts on the hanger rod above the bearing plate.
   6) Cinch anchors, lead shields, expansion bolts, and studs driven by explosion charges are not allowed under any circumstances in the lower 15 inches of each stem and in the "shadow" of the stem on the top side of the "double tees".

O. Trapezes:
   1. Where multiple lines are run horizontally at the same elevation and grade, they may be supported on trapezes of Kindorf, Elcen, or approved equal, channel-suspended on rods or pipes.
   2. Trapeze members including suspension rods shall each be properly sized for the number, size, and loaded weight of the lines they are to support.

P. Finishes:
   1. All hangers on piping including clevis hangers, rods, inserts, clamps, stanchions, brackets, shall be dipped in Zinc Chromate Primer before installation.
   2. Rods may be galvanized or cadmium plated after threading, in lieu of dipping zinc chromate
   3. Universal concrete inserts shall be cadmium plated.

Q. Ductwork:
   1. Support ductwork in accordance with the SMACNA recommendation for the service involved; however, all horizontal ductwork shall be supported at intervals not to exceed 8 feet.
   2. Horizontal ducts shall be supported using galvanized steel bands extending up both sides and onto the construction above, where they shall turn over and be secured with bolts into nuts fitted in inserts set in the concrete bolted to angles secured to the construction above, or secured in another approved manner.
   3. For attaching methods for precast double tee structural concrete, refer to details on the Drawings and as specified.
   4. All ductwork over 36 inches wide shall be supported with vibration isolation integral with the hangers or supports.

R. Terminal units weighing less than 150 lbs shall be supported by four 16 gauge, 1 inch wide sheet metal straps with ends turned under bottom of box at corners and secured by one not over 3/4 inch in length, 1/4 inch diameter sheet metal screw per strap.

1. The other strap end shall be attached to the structure by 1/4 inch diameter threaded bolt into the concrete insert or into drilled-hole threaded concrete expansion anchor.
2. Boxes over 150 lbs in weight shall be supported the same as described above except two 1/4 inch diameter sheet metal screws through turned end of strap box shall be provided.
3. Where interferences occur, overhead of the box, not allowing direct vertical support by straps, provide trapezes of Kindorf, Unistrut, or Elcen channel suspended by 1/4 inch diameter galvanized threaded rods providing such channels do not block access panels of boxes.
4. Threaded rods shall be supported from structure by concrete insert or by drilled-hole threaded concrete expansion anchor.

S. Miscellaneous:
1. Provide any other special foundations, hangers and supports indicated on the Drawings, specified elsewhere herein; or required by conditions at the site.
2. Hangers and supporting structures for suspended equipment shall be provided as required to support the load from the building structure in a manner acceptable to the Architect/Engineer.

T. Standpipe Systems: All hangers and supports for fire standpipe systems and fire sprinkler systems shall be Factory Mutual and Underwriters` Laboratories, Inc listed and labeled Construction of hangers shall be as described above for common piping, except for the above mentioned requirements.

2.4 ACCESSORIES

A. Hanger Rods: Galvanized mild steel threaded both ends, galvanized threaded one end, or galvanized continuous threaded.

2.5 INSERTS

A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.6 FLASHING

A. Metal Flashing: 26 gage galvanized or stainless steel.
B. Metal Counterflashing: 22 gage galvanized or stainless steel.
C. Roofing Flashing: See specifications for Roofing, elsewhere in these Specifications.
D. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.7 EQUIPMENT CURBS

A. Fabrication: Welded 18 gage galvanized steel shell and base, mitered 3 inch cant, variable step to match roof insulation, factory installed wood nailer.
B. Paint equipment curb to match equipment paint color. Refer to Section 23 05 53 - Mechanical Identification.

2.8 CONCRETE FOUNDATIONS ("HOUSEKEEPING PADS")

A. Concrete foundations for the support of equipment such as floor mounted panels, pumps, fans, air handling units, etc , shall not be less than 3-1/2-inches high (formed by 2x4 lumber) and extend 4-inches on all sides beyond the limits of the mounted equipment unless otherwise noted and shall be poured in forms built of new dressed lumber.
1. Housekeeping pads are required for floor-mounted equipment installed in mechanical and electrical spaces.
2. Housekeeping pads to be sealed to match floor waterproofing system.
3. Housekeeping pad edges to be painted Safety Yellow.
4. Housekeeping pads for interior floor mounted air handling units and outside air hanlding units shall be poured on top of resilient isolation pads or resilient underlayment sheet material to decouple from floor structure. Provide minimum 0.2 inch static deflection with pads having nominal 0.1 inch deflection stacked with steel plate or sheet shims between.

B. Neatly chamfer corners of foundations by means of sheet metal or triangular wood strips nailed to the form.

C. Foundation bolts shall be placed in the forms when the concrete is poured, the bolts being correctly located by means of templates.
D. Each bolt shall be set in a sleeve of size to provide 1/2 inch clearance around bolt Allow 1 inch below the equipment bases for alignment and grouting.
E. After grouting, the forms shall be removed and the surface of the foundations shall be hand rubbed with Carborundum.
F. Foundations for equipment located on the exterior of the building shall be provided as indicated.
G. Foundations shall be constructed in accordance with Shop Drawings submitted by the Contractor for review by the Architect/Engineer.

2.9 TUNNEL PIPE/CONDUIT SUPPORT RACK

A. Piping and conduit routed through the utility tunnel shall be supported by hangers, rollers, or other appropriate devices mounted on a steel pipe support rack.
B. Rack shall be fabricated of welded steel tubes or shapes attached to walls, floor and roof of the tunnel with transverse members spaced no more than 10 feet apart.
C. Complete design for the rack shall be prepared and submitted to structural and mechanical engineers fro review in accordance with Section 23 00 00 - UTSW Mechanical Design Requirements and Division 01. Refer to "Pipe Hangers and Supports" article above for additional design requirements.
D. Finish shall be hot dipped galvanized after fabrication with cold galvanized field welds.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer`s instructions.

3.2 INSERTS

A. Provide inserts for placement in concrete formwork.
B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 PIPE HANGERS AND SUPPORTS

A. Support horizontal piping in accordance with recognized standard practices, minimum spacing as required by piping materials and size In addition to minimum requirements, hangers and supports must be provided at the following locations:
    1. Within 12 inches of any change in direction.
    2. Each side of 6 inches and larger valves.
    3. Each side of in-line pumps.
B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
C. Place hangers within 12 inches of each horizontal elbow.
D. Use hangers with 1-1/2 inch minimum vertical adjustment.
E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
F. Support vertical piping at every floor Support vertical cast iron pipe at each floor at hub.
G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
H. Support riser piping independently of connected horizontal piping.
I. Provide copper plated hangers and supports for copper piping.
J. Design hangers for pipe movement without disengagement of supported pipe.
K. Prime coat exposed steel hangers and supports Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed, but shall be corrosion protected with

galvanized plating.

L. Hanger Rods: (NOTE: All hanger rods shall be trimmed neatly so that no more than 1 inch of excess hanger rod protrudes beyond the hanger nut In the event a rod is intentionally but temporarily left excessively long (for sloped or insulated lines for example), the contractor shall take appropriate measures to protect the pipe or other materials from damage).

3.4 FLASHING

A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.

B. Flash vent and soil pipes projecting 3 inches minimum above finished roof surface with lead worked one inch minimum into hub, 8 inches minimum clear on sides with 24 x 24 inches sheet size.

1. For pipes through outside walls, turn flanges back into wall and caulk, metal counterflash, and seal

C. Flash floor drains in floors with topping over finished areas with lead, 10 inches clear on sides with minimum 36 x 36 inch sheet size Fasten flashing to drain clamp device.

D. Seal floor, shower, mop sink, and drains watertight to adjacent materials.

E. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer`s instructions for sound control.

F. Provide curbs for mechanical roof installations 14 inches minimum high above roofing surface.

1. Flash and counterflash with sheet metal; seal watertight.
2. Attach counterflashing mechanical equipment and lap base flashing on roof curbs.
3. Flatten and solder joints.

G. Adjust storm collars tight to pipe with bolts; caulk around top edge Use storm collars above roof jacks Screw vertical flange section to face of curb.

3.5 SLEEVES

A. Set sleeves in position in formwork Provide reinforcing around sleeves.

B. Size sleeves large enough to allow for movement due to expansion and contraction Provide for continuous insulation wrapping.

C. Extend sleeves through floors four inches above finished floor level Caulk sleeves.

D. Where piping, ductwork or conduit penetrates floor, ceiling, or wall, close space between pipe or duct and adjacent work with fire stopping insulation and caulk air tight.

1. Provide close fitting metal collar or escutcheon covers, as appropriate, at both sides of penetration.

E. Install chrome plated steel or stainless steel escutcheons at finished surfaces.

3.6 SCHEDULES

PIPE SIZE INCHES	MAX HANGER SPACING FEET	HANGER ROD DIAMETER INCHES
1/2 TO 1-1/4	6.5	3/8
1-1/2 TO 2	10	3/8
2-1/2 TO 3	10	1/2
4 TO 6	10	5/8
8 TO 12	14	7/8
14 AND OVER	20	1
PP & PPDV (ALL SIZES)	4	3/8
C I BELL AND SPIGOT (OR NO HUB) AND AT ALL jOINTS	5	5/8
GLASS AND AT ALL JOINTS	4	1/2

A. Notes: Insulated piping support spacing shall be reduced as necessary to meet the requirements of "bloc king" or insulation at the support and at all joints.

END OF SECTION 23 05 29

SECTION 23 05 53

MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SECTION INCLUDES

A. Nameplates.
B. Stencils.
C. Pipe Markers.

1.3 RELATED REQUIREMENTS

A. Section 09 91 13 - Exterior Painting.
B. Section 09 91 23 - Interior Painting.
C. Section 09 96 00 - High-Performance Coatings.
D. Section 23 00 00 - UTSW Mechanical Design Requirements

1.4 REFERENCE STANDARDS

A. Texas Government Code Chapter 2252.001-005; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
B. ASME A13.1 - Scheme for the Identification of Piping Systems.

1.5 SUBMITTALS

A. Submit under provisions of Division 01 and Section 23 00 00 - UTSW Mechanical Design Requirements.
B. Submit list of wording, symbols, letter size, and color coding for mechanical identification.
C. Obtain new equipment identification numbers from the Drawings or the Superintendent of Utilities.
D. Product Data: Provide manufacturers catalog literature for each product required.
E. Samples: Submit two of each type of label, tag, etc., of the approximate size specified or implied in the specification.
F. Manufacturer`s Installation Instructions: Indicate special procedures, and installation.
G. Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.

1.6 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Division 01 and Section 23 00 00 - UTSW Mechanical Design Requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. The Contractor shall make it possible for the personnel operating and maintaining the new equipment and systems in this project to readily identify the various pieces of equipment, major valves, piping, etc., by marking them.
   1. All items of equipment such as pumps, etc., shall be clearly marked using engraved nameplates as hereinafter specified.
   2. The item of equipment shall indicate the same number as shown on the Drawings. For example, pumps will be identified as 3A, 3B, 3C, etc.
   3. The equipment identification will be shown on the Drawings or provided by the Superintendent of Utilities.
   4. All piping shall be identified with pipe markers including pipe type, direction, and pipe diameter with colors to match UTSW requirements.

5. Color coded pipe jacketing and fitting covers (to match jacketing type) shall match UTSW colors for mechanical and piping.

2.2 MECHANICAL SPACE AND PIPING COLORS

A. UTSW Colors in mechanical and exposed spaces shall be as follows:

1. Colors shown are with Sherwin Williams paint and approved equivalent are allowed per Section 09 96 00 - High-Performance Coatings.

ITEM	COLOR	PAINT NUMBER
Structural Elements and Railing	Gray	Structural Gray SW 4031
Equipment Supports	Light Gray	Nickel SW 4030
Floor	Gray	Slate Gray SW 4026
Housekeeping Curbs (Face)	Yellow	Safety Yellow SW 4084
Equipment Curbs (Face)	Color to Match Equipment	Confirm with Utilities
Clearances and Safety Marking on Floors and Walls	Yellow	Safety Yellow SW 4084
Walls	White	Extra White LRV 86%
Gantry Crane	Yellow	Safety Yellow SW 4084
Fire Sprinkler / Fire Safety	Red	Safety Red SW 4081
Boiler (Existing)	Match Existing Equipment	Match Existing Color
Boiler (New)	Manufacturer Standard Colors	Confirm with Utilities
Steam	Aluminum Lagging	Aluminum
Condensate Return	Aluminum Lagging	Aluminum
Hot Water (Supply)	Dark Orange	International Orange SW 4082
Hot Water (Return)	Orange	Safety Orange SW 4083
Natural Gas	Yellow	Safety Yellow SW 4084
Natural Gas Vent	Yellow	Safety Yellow SW 4084
Fuel Oil	Yellow	Junction Yellow SW 4034
City Water	Light Blue	Polymer Blue SW 4055
Exterior Water	Aluminum Lagging	Aluminum Lagging with Heat Trace
Chiller (Supply)	Dark Blue	Safety Blue SW 4086
Chiller (Return)	Blue	Turbine Blue SW 4064
Chiller Refrigerant Vent	Aluminum Lagging	Aluminum
Condensing Water (Supply)	Dark Green	Safety Green SW 4085
Condensing Water (Return)	Light Green	Generator Green SW 4070
Condensing Water (Exterior)	Aluminum Lagging	Aluminum
Compressed Air	Green	Green Byte SW 4076
Refrigerant Recovery	Purple	Plumb SW 4080
Vents / Roof Vents	Gray	Galvino SW 4027
Hanger Rods	Same as Related Pipe	Confirm with Utilities
Storm Water	White	Ultra White LRV 88%
Atmospheric Relief Lines	Sames as Related Pipe	Confirm with Utilities
Ductwork, AHU, Fans, and Insulation	Aluminum Lagging	Aluminum

2.3 NAMEPLATES

A. Description: Laminated three-layer plastic with engraved black letters on light contrasting background color.

2.4 TAGS

A. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch (40 mm) diameter with smooth edges.

B. Chart: Typewritten letter size list in anodized aluminum frame.

2.5 PIPE MARKERS

A. Color: Conform to ASME A13.1.

B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches (150 mm) wide by 4 mil (0 10 mm) thick, manufactured for direct burial service.

E. PVC Jacketing and Fitting Covers: Colors to match UTSW requirements and installed as required per Section 23 07 19 - Piping Insulation.

2.6 CEILING LABELS

A. Description: 1/2 inch minimum diameter color sticker with separate clear label, identifying item above ceiling, attached to ceiling grid.. Lettering on label shall be black.

1. Color code as follows:
    a. Yellow - HVAC equipment.
    b. Red - Fire dampers/smoke dampers.
    c. Blue - Heating/cooling valves.

2.7 GENERAL

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

B. All items of equipment such as fans, pumps, etc , shall be clearly marked using engraved nameplates as specified.

C. The item of equipment shall indicate the same number as shown on the Drawings.

D. The equipment identification will be shown on the Drawings or provided by the Superintendent of Utilities.

2.8 MECHANICAL

A. Identify new mechanical equipment by the attachment of engraved nameplates constructed from laminated phenolic plastic, at least 1/16 inch thick, 3-ply, with black surfaces and white core.

B. Engraving shall be condensed Gothic, at least 1/2 inch high, appropriately spaced.

C. Nomenclature on the label shall be in accordance with UTSW standards.

1. Nomenclature shall be as described in this section Equipment to be labeled shall include but not be limited to the following:
    a. Air Handling Units.
    b. Ventilation Fans.
    c. Pumps.
    d. Exhaust Fans.
    e. Fan and Coil Units.
    f. Hot Water Generators.
    g. Condensing Units.
    h. Storage Tanks.
    i. Converters.
    j. Compressors.
    k. Air Conditioning Control.
    l. Chillers.
    m. Panels and Switches.
    n. Miscellaneous - similar and related items.

2.9 PIPING

A. Pipe markers and arrow markers also shall be provided on but not limited to the piping of the following systems affected by the project:

1. Primary Chilled Water Supply.
2. Steam Condensate.
3. Primary Chilled Water Return.
4. Secondary Chilled Water Supply.
5. Atmospheric Relief.
6. Secondary Chilled Water Return.
7. Low Pressure Steam.
8. Compressed Air.
9. Medium Pressure Steam.

2.10 MARKERS

A. In addition, pipe runs throughout the building including those above lift out ceilings, under floor, and those exposed to view when access doors or access panels are opened shall be identified by means of Seton Setmark or Brady Mechanical Pipe Markers.
B. Concealed areas, for purposes of this identification section, are those areas which cannot be seen except by demolition of the building elements.
C. In addition to the pipe markers, arrow markers shall be used to indicate direction of flow.
D. The following specific instructions shall apply to the application of these markers:
   1. Provide a pipe marker at each valve to indicate proper identification of pipe contents Where several valves exist on one header, it is necessary to mark only the header.
   2. Provide an arrow marker with each pipe marker pointing away from the pipe marker to indicate direction of flow.
   3. Provide a double ended arrow marker when flow can be in either or both directions.
   4. Provide a pipe marker and an arrow marker at every point of pipe entry or exit where line goes through a wall or service column.
   5. Provide pipe markers and arrow markers at intervals not exceeding 50 feet.
   6. Markers shall be located on the two lower quarters of the pipe where view is unobstructed.
E. Use Seton Setmark Type SNA or Brady snap-on type identification for all piping systems, 3/4 inch thru 6 inch. For piping systems larger than 6 inch, use Seton or Brady strap on markers.
F. Pipe Markers shall conform to ANSI A 13 1-1981 "Scheme for the Identification of Piping Systems"
G. Arrow markers must have same ANSI background colors as their companion pipe markers, or be incorporated into the pipe identification marker.

2.11 NOMENCLATURE

A. Building designators for the project:
   1. _____.
   2. _____.
   3. _____.
B. UTSW Energy Management system Naming and Numbering Specification: The purpose of this document is to define the standard for naming items that become part of the EMS system as well as numbering the BACnet networks and devices.
   1. Network Numbering: The UTSW BACnet configuration utilizes two of the defined Local Area Network (LAN) technologies for its interconnection of devices Ethernet is used for Management level and Integration level device communication That is to say that front-end servers and workstations (Management level devices) talk to floor and building controllers, routers, and BACnet Broadcast Management Devices (Integration level devices). The Field level controllers such as Room Controllers, Air Handler Controllers, and other building system controllers communicate to the Integration level devices via the Master Slave/Token-Passing MS/TP LAN. Including both of these LAN types, the UTSW BACnet control system can contain up to 65,535 (64K) interconnected networks each of which are required to have a unique network number At UTSW, network numbers shall be assigned as follows:
      a. NBBSS
      b. Where: N = Network Type

1) 0 = Ethernet
2) 1 = MS/TP
3) 2 = P1
4) 3 = >6 not used
5) SS = 00 to 35 for individual I/P segments in a building
6) BB = the building number
7) 00 = EB (only for JCI)
8) 01 = UH
9) 02 = WC
10) 03 = UW
11) 04 = BE
12) 05 = Unused
13) 06 = Unused
14) 07 = NTEP
15) 08 = V
16) 09 = BTEP
17) 10 = NA
18) 11 = NB
19) 12 = NC
20) 13 = ND
21) 14 = NE
22) 15 = JA
23) 16 = NF
24) 17 = NL
25) 18 = MT - Moncrief Ft. Worth
26) 19 = ZL
27) 20 = XA (2929 Stemmons/Irving)
28) 21 = HA, Annex K
29) 22 = HP, POB1
30) 23 = WA, ASC, Ambulatory Surgical Center
31) 24 = WB
32) 25 = EQ
33) 26 = WD
34) 27 = EB
35) 28 = EC
36) 29 = EF
37) 30 = HQ, POB2
38) 31 = LC - Empire Plaza
39) 32 = A
40) 33 = B
41) 34 = C
42) 35 = D
43) 36 = E
44) 37 = F
45) 38 = G
46) 39 = H
47) 40 = J
48) 41 = K
49) 42 = L
50) 43 = M
51) 44 = MA
52) 45 = P
53) 46 = N1 (Brain/Cancer Garage)

54) 47 = S
55) 48 = U
56) 49 = X
57) 50 = Y
58) 51 = CS
59) 52 = PE, STEP
60) 53 = NM Brain
61) 54 = NN
62) 55 = NP Cancer
63) 56 = NR
64) 57 = JB
65) 58 = RK
66) 59 = LD - Empire Plaza

2. For example, a BACnet Ethernet network in P building on the primary segment would be:
   a. NBBSS.
   b. 04300 or simply network number 4300.

C. Device Numbering: A BACnet control system can contain up to 4,194,303 devices each of which are required to have a unique value for the Object Identifier property of the Device object. At UTSW, device numbers shall be assigned as follows:
   1. VBBYYY
      a. Where: V = Vendor
      b. 0 = JCI Controls
      c. 1 = Alerton Controls
      d. 2 = Siemens Controls
      e. 3 = Trane
      f. 4 = not used
      g. BB = Building number as defined in Section above.
      h. YYYY = 0000 to 9999 for devices
   2. For example, for the 112th Siemens device in NB building the device number would be:
      a. 2110112
   3. Or for the 86th Alerton device in CS building the device number would be:
      a. 1490086

D. System Naming Convention: To create a consistent naming structure across legacy, proprietary, new/remodel construction, and open protocol implementations at UTSW, the following sections specify conventions for naming buildings and equipment as it relates to the EMS system Deviation from this scheme requires prior approval in writing.
   1. All buildings shall be designated by a one-letter or two-letter name Reference construction documents for the most current designation The current exception to this rule is Thermal Energy Plants, whose names can contain TEP.
   2. All items not specifically identified in this document shall be named as BB NNN…N Where BB is the one or two letter building designation and NNN…N is the industry standard designation for that equipment type For example S BBMD-01 is the name for BACnet Broadcast Management Device BBMD number 1 in S building, and described as S BBMD number one.
   3. Rooms shall be designated BBF NNN Where BB is the one or two letter designation, F is the floor number and is always a decimal value; NNN is the actual room number as designated on the official drawings and signage For example, NB10 403 is the name for room 403 on the 10th floor of NB building In the event of multiple room controllers in a large area, they shall be designated as -1, -2… and their relative positions in the room shall be described in the description For example, NB10 403-2 described as NB 10 Room 403, TEC 2 in NW corner.
      a. Environmental rooms, Refrigerators, and Freezers shall have that designation as part of the name. For example, CY3.333 Refrigerator 33 is described as CY 3 333 Refrigerator #33. Or, F5.222 Freezer #2 is described as F 5 222 UL Freezer #2, NB8.408 Warm Room is described as NB 8 408 Warm Room.

b. In a master/slave configuration of room controllers, the master and slave designations shall be added to the description, i.e., NB10.403-02 described as NB 10 Room 403, TEC 02 slaved to TEC 01 in NW corner.
c. In the event that corridors or hallways do not have a room number designated, they shall be named as follows: BBF.N Corridor. Where BB is the one or two letter building designation, F is the floor number and N is an incrementing decimal value for controllers throughout that corridor or hallway. The relative location for the controller shall be described in the description. For example, X2.3 Corridor described as X 2, Corridor TEC 3 outside room X2.100.
d. ARC rooms shall be designated as BBF.NNN ARC. For example J1.116 ARC described as J 1 116 ARC Room.

4. Air Handlers shall be designated BB.AHU-NN Where BB is the one or two letter building designation, AHU is a designation for the air handler, and NN is an incrementing decimal value that designates the air handler number in that particular building.
   a. Air Handler Fans shall be designated BBF.AHUNN Type Fan Where BB is the one or two letter building designation, F is the floor number, AHU is a designation for the air handler, and NN is an incrementing decimal value that designates the air handler number in that particular building, and Type is either Supply Air or Return Air For example, NC AHU1 Supply Air Fan shall be described as NC AHU 1 Supply Air Fan.
   b. Air Handler Valves shall be designated BBF.AHUNN Type VLV Where BB is the one or two letter building designation, F is the floor number, AHU is a designation for the air handler, NN is an incrementing decimal value that designates the air handler number in that particular building, and Type is CD for Cold Deck, HD for Hot Deck, PC for Precool, PH for Preheat or HUM for Humidity For example, NC.AHU1 CD VLV shall be described as NC AHU 01 Cold Deck VLV.
   c. Air Handler Dampers shall be designated BBF.AHUNN Type Damper Where BB is the one or two letter building designation, F is the floor number, AHU is a designation for the air handler, NN is an incrementing decimal value that designates the air handler number in that particular building, and Type is OA for Outside Air, MA for Mixed Air, RA for Relief Air or EA for Exhaust Air For example, L.AHUB2 OA Damper shall be described as L.AHU B2 Outside Air Damper.
   d. Air Handler Safeties shall be designated BB.AHUNN Type Where BB is the one or two letter building designation, AHU is a designation for the air handler, NN is an incrementing decimal value that designates the air handler number in that particular building, and Type is Freeze Stat, High Static, Low Static, Smoke, and High Duct Temp For example, NA.AHU4 Low Static shall be described as NA.AHU 4 Low Static Pressure.
   e. Air Handler Temperatures and set points shall be designated BB.AHUNN Type Where BB is the one or two letter building designation, AHU is a designation for the air handler, NN is an incrementing decimal value that designates the air handler number in that particular building, and Type is SAT for Supply Air, CD for Cold Deck, HD for Hot Deck, PH for Preheat, MAT for Mixed Air, OAT for Outside Air Temp and RAT for Return Air For example, NA AHU4 SAT shall be described as NA AHU 4 Supply Air Temperature.

5. Valves shall be designated BBF.T.FunctionVLV Where BB is the one or two letter building designation, T is Valve type such as:
   a. RHW = Reheat Water
   b. DHW = Domestic Hot Water
   c. CHW = Chilled Water
   d. HUM = Humidity
   e. SCHW = Secondary Chilled Water
   f. PCHW = Process Chilled Water
   g. CW = Condenser Water
   h. GLY = Glycol
   i. Function indicates any special purpose such as Sup for Supply, Ret for Return, BP for Bypass, ISO for Isolation. VLV is the designation for Valve. For example, NE.CHW.BPVLV shall be described as NE CHW Bypass VLV. Or, NL.HX1.1/3VLV shall be described as NL HX1 1/3

VLV.

6. Exhaust Fans shall be designated BB.Type EFNN Where BB is the one or two letter building designation, Type is EF will be used for general purpose building exhaust, L for Lab, A for Animal, MRI for MRI. EF is a designation for the exhaust fan, NN is an incrementing decimal value that designates the exhaust fan number in that particular building For example, NA AEF13 shall be described as NA Animal EF 13 NE MRIEF17 shall be described as NE MRI EF 17
7. Fire Status shall be designated BB.Fire Type Where BB is the one or two letter building designation, Type is either Fire Trouble or Fire Alarm or Fire Supervisor
8. Fire/Smoke Dampers shall be designated BBF.FSD.NN Where BB is the one or two letter building designation, F is the floor number and is always a decimal value, FSD is a designation for the fire smoke damper, NN is an incrementing decimal value that designates the smoke damper number in that particular building
9. Chillers shall be designated BB.CHLRNN Where BB is the one or two letter building designation, CHLR is a designation for the chiller, NN is an incrementing decimal value that designates the chiller number in that particular building For example, NTEP CHLR5 shall be described as NTEP Chiller #5
    a. Associated chiller information points will be prefaced with the chiller designation in the name and followed by the information type For example, PE CHLR2 TONS shall be described as PE Chiller #2 Tons, or PE-CHLR-4 GPM shall be described as PE Chiller #4 Gallons per Minute
10. Cooling Towers shall be designated BB CTNN Where BB is the one or two letter building designation, CT is a designation for the cooling tower, NN is an incrementing decimal value that designates the cooling tower number in that particular building For example, NTEP.CT2 shall be described as NTEP Cooling Tower #2
    a. Associated cooling tower information points will be prefaced with the cooling tower designation in the name and followed by the information type For example, PE.CT2.CW Flow shall be described as PE Cooling Tower #2 Condenser Water Flow, or PE.CT4.SS shall be described as PE Cooling Tower #4 Start/Stop
11. Boilers shall be designated BB BLRNN Where BB is the one or two letter building designation, BLR is a designation for the boiler, NN is an incrementing decimal value that designates the boiler number in that particular building For example, NTEP BLR1 shall be described as NTEP Boiler #1
    a. Associated boiler information points will be prefaced with the boiler designation in the name and followed by the information type For example, PE BLR2 ECON OUT WATER TEMP shall be described as PE Boiler #2 Econ Out Water Temp, or NTEP BLR4 GAS TEMP shall be described as PE Boiler #4 Gas Temperature
12. All other items shall be described as BB (ITEM DESCRIPTION) Where BB is the one or two letter building designation, (ITEM DESCRIPTION) is the complete name/description of the item For example J Control Air HI Press shall be described as J.Control Air High Pressure, or NB LAB VAC PMP STATUS shall be described as NB Lab Vacuum Pump Status

PART 3 - EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.
B. Prepare surfaces in accordance with Division 9 for stencil painting.

3.2 INSTALLATION

A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
B. Apply stencil painting in accordance with Division 09 Painting Sections.
C. Install plastic pipe markers in accordance with manufacturer`s instructions.
D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer`s instructions.
E. Install underground plastic pipe markers 6 to 8 inches (150 to 200 mm) below finished grade, directly above buried pipe.

F. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates Small devices, such as in-line pumps, may be identified with tags.
G. Identify control panels and major control components outside panels with plastic nameplates.
H. Install ceiling labes in accordance with manufacturer's instructions.

END OF SECTION 23 05 53

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SECTION INCLUDES

A. Work required to prepare the building HVAC systems for testing, adjusting and balancing indicated by the Contract Documents as follows:
   1. Responsibilities of project contractor.
   2. Preparation for balancing of air systems.
   3. Preparation for balancing of hydronic and steam systems.

1.3 RELATED REQUIREMENTS

A. Section 01 91 00 - General Commissioning Requirements.
B. Section 23 00 00 - UTSW Mechanical Design Requirements.
C. Section 23 05 94 - System Testing, Adjusting and Balancing.
D. Section 23 08 00 - Commissioning of HVAC Systems
E. Section 23 09 55 - Control Sequence.
F. Section 23 34 13 - Axial Fans.
G. Section 23 82 23 - Power Ventilators.
H. Section 23 31 00 - Ductwork.
I. Section 23 33 00 - Ductwork Accessories.
J. Section 23 36 00 - Air Terminal Devices.
K. Section 23 37 00 - Air Inlets and Outlets.

1.4 SCOPE OF WORK

A. Testing, adjusting, and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by an impartial technically qualified TAB firm selected and employed directly by the Owner, separate and apart from the Construction Contract.
   1. Preparation for and corrections necessary for the Testing, Adjusting and Balancing of these systems, as described herein, are the responsibility of the Contractor.
B. As a part of this project Construction Contract, the Contractor shall make any changes or replacements to the sheaves, belts, dampers, valves, etc required for correct balance as advised by the TAB firm, at no additional cost to the Owner.
C. The Contractor shall provide and coordinate the services of qualified, responsible Subcontractors, suppliers, and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including the testing, adjusting and balancing period.
D. In order that all systems may be properly tested, balanced, and adjusted as required by these Specifications, the Contractor shall operate said systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB This length of time shall be subject to the approval of the Owner's Representative.
E. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy.
F. The contractor shall allow adequate time for the completion of testing and balancing activities of the owner provided services, during the construction period, and prior to Substantial Completion as defined in the Uniform General Conditions of this Construction Document.

G. The Drawings and Specifications indicate valves, dampers and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the Contractor to install these devices in a manner that will leave them accessible and readily adjustable.
   1. Should any such device not be readily accessible, the Contractor shall provide access as requested by the TAB firm.
   2. Malfunction encountered by TAB personnel and reported to the Contractor or the Owner's Representative shall be corrected by the Contractor immediately so that the balancing work can proceed with the minimum of delays.

1.5 RESPONSIBILITIES OF THE PROJECT CONTRACTOR

A. The Contractor shall:
   1. Have the building and air conditioning systems in complete operational readiness for TAB work to begin.
   2. The contractor shall allow sufficient time for the TAB firm to perform the contracted work within the construction schedule.
      a. The contractor shall complete his work by systems or floors whichever is the most efficient for scheduling.
      b. After award of the contract and the contractor has developed a construction schedule, a TAB coordination meeting shall be held with the TAB firm, the general contractor and his primary subcontractors (i e mechanical, electrical, building automation etc) to develop a testing schedule for the project.
      c. The contractor shall submit copies of the proposed schedule two (2) weeks prior to this meeting to the Owner and TAB firm.
   3. Promptly correct deficiencies of materials and workmanship identified as delaying completion of TAB work.
   4. The Contractor shall be responsible for any added costs to the Owner resulting from failure to have the building and air conditioning systems ready for TAB when scheduled, or from failure to correct deficiencies promptly.

B. Complete operational readiness of the building requires that construction status of the building shall permit the closing of doors, windows, ceilings installed, etc , to obtain simulated or projected operating conditions.

C. Complete operational readiness of the air conditioning systems also requires that the following be accomplished:
   1. Air Distribution Systems:
      a. Verify installation for conformity to design All supply, return and exhaust ducts terminated and pressure tested for leakage as required by the Specification.
      b. All volume, smoke and fire/smoke dampers are properly located and functional.
      c. Dampers serving requirements of minimum and maximum outside, return and relief air shall provide tight closure and full opening, smooth and free operation.
      d. All supply, return, exhaust and transfer grilles, registers, diffusers and terminal devices installed.
      e. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc , shall be blanked and/or sealed to eliminate excessive bypass or leakage of air.
      f. All fans (supply, return and exhaust) operating and verified for freedom from vibration, proper fan rotation and belt tension; heater elements in motor starters to be of proper size and rating; record motor amperage and voltage on each phase at start-up and running, and verify they do not exceed nameplate ratings.
      g. All single and/or double duct variable and constant volume terminal units ("mixing boxes") shall be installed and functional (i e controls functioning).
   2. Water Circulating Systems:
      a. Check and verify pump alignment and rotation.

b. Open all valves to their full open position, close bypass stop valves Set mixing valves to full-flow through systems components.
c. After the system is flushed and checked for proper operation, remove and clean all strainers.
d. The Contractor shall repeat the operation until circulating water is clean.
e. Record each pump motor amperage on each phase and voltage after reaching rated speed Readings shall not exceed nameplate rating.
f. Verify that the electrical heater elements are of the proper size and rating.
g. In preparation of TAB all water circulating systems shall be full and free of air, expansion tanks shall be set for proper water level, and all air vents shall be installed at high points of systems and operating freely.
h. Systems shall be cleaned and flushed Chemicals shall be added to closed systems to treat piping and inhibit corrosion.
i. Check and set operating parameters of the heat exchangers and control devices to the design requirements.

3. Automatic Controls:
   a. The Contractor shall schedule a meeting with the Engineer, Control Contractor, TAB firm, Commissioning Provider (if applicable) and Owner`s representative for a pre-submittal review to establish that his interpretation of the sequences of operation are correct.
   b. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, dampers sequences, air and water resets, fire and freeze stats, high and low temperature thermostats, safeties, etc.
   c. Verify that all controlling instruments are calibrated and set for design operating conditions with the exception of room thermostats or sensors, which shall be calibrated at the completion of TAB services with cooperation between the TAB firm and Control Contractor.
   d. The Automatic Temperature Control Contractor and/or Energy Management System Contractor shall thoroughly check all controls, sensors, operators, sequences, etc before notifying the TAB agency that the Automatic Temperature Controls and Energy Management System are operational.
   e. The Automatic Temperature Contractor and/or Energy Management System Contractor shall provide technical support (technicians and necessary computers) to the TAB firm for a complete check of these systems.
4. Tabulated Data: The motor amperages, voltages shall be recorded showing "actual" and "nameplate" voltage and amperage and submitted and actual RPM. This applies to each piece of electrically driven air conditioning equipment in the system including supply and exhaust fans, fans of fractional horsepower, pumps, etc. Include any additional relevant start-up information or documentation.

D. Notification of System Readiness:
1. After completion of the work above, the Contractor shall notify the Owner in writing, certifying that the work has been accomplished and that the building and the air conditioning systems are in operational readiness for testing, adjusting, and balancing; include a copy of the tabulated data described above.
2. The Owner will, in turn, notify the TAB firm of the readiness for balancing and forward copies of the Contractor`s certification.
3. Should the TAB firm be notified as described above, and the TAB work commenced and the systems are found NOT to be in readiness or a dispute occurs as to the readiness of the systems, the Contractor shall request an inspection be made by duly appointed representative of the Owner, Architect, TAB firm and the Contractor.
4. This inspection will establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for TAB services.
5. Should the inspection reveal the TAB services notification to have been premature, all cost of the inspection and wasted work accomplished by the TAB firm shall be reimbursed to the appropriated parties by the Project Contractor.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 23 05 93

SECTION 23 05 94

SYSTEM TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SUMMARY

A. Testing, adjusting and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by an impartial technically qualified TAB firm selected and employed by the Owner, separate and apart from the construction contract.

B. The firm shall be capable of performing the services specified at the location of the facility described within the time specified, of preparing and submitting the detailed report of the actual field work performed, and following up the basic work as may be required.

1.3 QUALIFICATIONS

A. The Firm shall be one which is organized to provide professional services of this specified type in the State of Texas and as a minimum shall have one (1) professional engineer licensed in the State of Texas, with current registration, to perform such professional services.

1. This engineer shall be personally responsible for developing the job site data as required in the test procedures outlined in these Specifications.

B. The Firm shall have operated a minimum of five (5) years under its current Firm name, and shall be in good standing with the State of Texas, Franchise Tax Board.

C. The firm shall submit their full incorporated name, Charter Number and Taxpayer`s I D Number for proper verification of the firm`s status.

D. The Firm shall be capable of providing a performance bond, by a bonding company licensed to do business in the State of Texas, if determined by the Owner that such a bond is required.

1. The amount of the bond which may be required shall be equal to the cost of the proposal submitted, or in the case of more than one proposal, the sum of all such proposals and any awarded work in progress.

E. The Firm shall maintain current insurance coverages in the minimum amounts indicated below.

1. If the Firm normally carries such insurance coverages (minimum or higher) incident to its operation, additional insurance for the specific proposal or proposals is not required The minimum insurance coverages required are:
   a. Worker`s Compensation as required by law.
   b. General Liability for not less than $2,000,000 aggregate.
   c. Fire Damage, and Extended Coverage, Vandalism and Malicious Mischief, in the full amount of Contract.
2. The above policies shall be carried with companies satisfactory to the Owner.
3. Certificates of each of the above policies, together with a written statement by the issuing company, stating that said policy will not be canceled without ten (10) days prior written notice to the Board of Regents of the University of Texas system, shall be delivered to the Owner before any work is started.

F. All personnel used on the job site shall be either professional engineers or engineering technicians, who shall have been permanent, full time employees of the firm for a minimum of six (6) months prior to the start of work for this specific project.

G. The TAB firm shall submit biographical data on the individual proposed to directly supervise the TAB work, as well as other personnel scheduled to perform the technical work under the contract.

1. It shall also submit a background record of at least five years of specialized experience in the field of air hydronic system balancing, and shall possess properly calibrated instrumentation.
2. The supervisory personnel for the TAB firm shall be registered engineers in the mechanical field and all of the employees used in the TAB firm shall be permanent, full-time employees of the firm.

1.4 RELATED REQUIREMENTS

A. Section 01 91 00 - General Commissioning Requirements.
B. Section 23 00 00 - UTSW Mechanical Design Requirements.
C. Section 23 05 93 - Testing, Adjusting, and Balancing.
D. Section 23 08 00 - Commissioning of HVAC Systems.
E. Section 23 36 00 - Air Terminal Devices.

1.5 REFERENCE STANDARDS

A. Texas Government Code Chapter 2252.001-005; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
B. AABC (NSTSB) - National Standards for Total System Balance, seventh edition, 2007.
C. ASHRAE 90.1 - HVAC Applications Chapter 37: Testing, Adjusting and Balancing.

1.6 DOCUMENTS

A. The Owner or Owner's Representative shall arrange with the Architect to provide one set of mechanical specifications, all pertinent change orders, and the following:
   1. One complete set of Digital Drawings less the structural sheets.
   2. One digital set of mechanical floor plans of the conditioned spaces
B. Approved submittal data on equipment installed, and related changes as required to accomplish the test procedures outlined in this Specification will be available through the Owner's Representative.

1.7 RESPONSIBILITIES OF THE TAB FIRM

A. The TAB personnel shall check, adjust, and balance the components of the air conditioning system which will result in optimal noise, temperature, and airflow conditions in the conditioned spaces of the building while the equipment of the system is operating economically.
B. This is intended to be accomplished after the system components are installed and operating as provided for in the contract documents.
C. It is the responsibility of the Mechanical Contractor to place the equipment into service Variable air volume systems shall be balanced in accordance with AABC Standard 2016, Seventh Edition.
D. Liaison and Early Inspection:
   1. The TAB firm personnel on the job shall act as liaison between the Owner, Architect and Contractor The following reviews (observations) and tests shall be performed by the TAB Firm:
      a. During the early design stages of the project, review the mechanical drawings and specifications for balance-ability and provide commentary.
      b. During construction, review all HVAC submittals such as control diagrams, air handling devices, etc , that pertain to commissioning work and balance-ability.
      c. Allow for a fixed number of trips to the project site, over and above those required for testing and balancing for inspection of installation of the mechanical piping systems, sheet metal work, temperature controls and other component parts of the heating, air conditioning and ventilating systems during the construction stage.
      d. These inspections shall be made prior to and/or at the above ceiling inspection Commentary will be provided to the Owner's Representative of each observation.
      e. Test one (1) 8 inch single duct terminal box for performance capability and leakage as described in Section 23 36 00 - Air Terminal Devices. The shipment of the box to the TAB Firm's lab will be at the manufacturer's cost and the test period will be for 3 weeks from receipt of the box. Submittal data will not be approved until box testing passes. If the sample box is rejected for any reason, the subsequent testing will be at the Contractor's cost and the time allowed will restart when the box is received at the TAB Firm.

f. Test one (1) 8 inch dual duct box for performance capability and leakage as described in Section 23 36 00 - Air Terminal Devices. The shipment of the box to the TAB Firm's lab will be at the manufacturer's cost and the test period will be for 3 weeks from receipt of the box. Submittal data will not be approved until box testing passes. If the sample box is rejected for any reason, the subsequent testing will be at the Contractor's cost and the time allowed will restart when the box is received at the TAB Firm.

g. Test 10 percent of the single and dual duct boxes for casing and damper leakage when the shipment arrives at the project site.
   1) All testing (except for the initial boxes) shall be performed on site.
   2) Boxes requiring re-testing will be charged to the Contractor at the unit price provided to the Owner.

h. Test one (1) lab configuration including fume hood with air valve, general exhaust air with air valve and supply air with air valve for performance capability through a full range of inlet pressures

i. The tracking capability of the exhaust air versus the supply air will be with the submitted hood sash fully open and as the sash is closed in 2 inch increments until fully closed.

j. Track the three (3) valve`s response time in relation to sash movement and the lab differential.

k. Witness Air Handling Unit leakage and deflection testing as specified in other sections Typical for Air Handling Units 10,000 cfm and larger Provide test results to UTSW representative.

l. Witness Fan vibration testing as specified in other sections. Provide test results to UTSW representative.

m. Attend Commissioning meetings, as required, to support UTSW during all HVAC Commissioning phases.

2. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the Owner’s Representative shall be advised in writing so that the condition can be corrected by the Contractor.
   a. The written document need not be formal, but must be understandable and legible.
   b. Data from malfunctioning equipment shall not be recorded in the final TAB report.
   c. The TAB firm shall not instruct or direct the Contractor in any of the work, but will make such reports as are necessary to the Owner.

1.8 FINAL AIR BALANCE

A. General: When systems are complete and ready for operation, the TAB firm will perform a final air balance for all air systems and record the results.

B. The outside, supply, exhaust and return air volume for each air handling unit, supply fan and exhaust fan and the supply, exhaust or return air volume for each distribution device shall be adjusted to within plus or minus 5 percent of the value shown on the drawings.

C. Air handling unit and fan volumes shall be adjusted by changing fan speed and adjusting volume dampers associated with the unit.

D. Air distribution device volume shall be adjusted using the spin-in tap damper for flexible duct connected devices and the device OBD for duct connected devices.

E. Air distribution devices shall be balanced with air patterns as specified.

F. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown.

G. General scope of balancing by the TAB Consultant will include, but is not limited to, the following:
   1. Filters: Check air filters and filter media and balance only system with essentially clean filters and filter media The Division 23 Contractor shall install new filters and filter media prior to the final air balance.
   2. Blower Speed: Measure RPM at each fan or blower to design requirements Where a speed adjustment is required, the Division 23 Contractor shall make any required changes.
   3. Ampere Readings: Measure and record full load amperes for motors.
   4. Static Pressure:

a. Static pressure gains or losses shall be measured across each supply fan, cooling coil, heating coil, return air fan, air handling unit filter and exhaust fan.
b. These readings shall be measured and recorded for this report at the furthest air device or terminal unit from the air handler supplying that device.
c. Static pressure readings shall also be provided for systems which do not perform as designed.

5. Equipment Air Flow: Adjust and record exhaust, return, outside and supply air CFM (s) and temperatures, as applicable, at each fan, blower and coil.
6. Coil Temperatures:
   a. Set controls for full cooling and for full heating loads.
   b. Read and record entering and leaving dry bulb and wet bulb temperatures (cooling only) at each cooling coil, heating coil and HVAC terminal unit.
   c. At the time of reading record water flow and entering and leaving water temperatures (In variable flow systems adjust the water flow to design for all the above readings).
7. Zone Air Flow: Adjust each zone of multizone units, each HVAC terminal unit and air handling unit for design CFM.
8. Outlet Air Flow:
   a. Adjust each exhaust inlet and supply diffuser, register and grille to within plus or minus 5 percent of design air CFM.
   b. Include all terminal points of air supply and all points of exhaust.
9. Pitot Tube Traverses:
   a. For use in future troubleshooting by maintenance personnel, all exhaust ducts, main supply ducts and return ducts shall have air velocity and volume measured and recorded by the traverse method.
   b. Locations of these traverse test stations shall be described on the sheet containing the data.
10. Maximum and minimum air flow on terminal boxes.

1.9 FINAL CHILLED WATER BALANCE

A. General: When systems are completed and ready for operation, the TAB Consultant will perform a final water balance for each chilled and hot water system.

B. The general scope of balancing by the TAB Consultant will include, but not be limited to, the following:
   1. Adjusted System Tests:
      a. Adjust balancing valves at each coil for design flow, plus or minus 5 percent. Adjust balancing valves at pumps to obtain design water flow.
      b. Record pressure rise across pumps and GPM flow from pump curve.
      c. Permanently mark the balanced position for each valve (Note: If discharge valves on the pumps are used for balancing record the head being restricted by the valves).
   2. Temperature Readings:
      a. Read and record entering and leaving water temperature at each water coil.
      b. Adjust as necessary to secure design and conditions.
      c. Provide final readings at all thermometer well locations.
   3. Pressure Readings:
      a. Water pressure shall be recorded at all gauge connections.
      b. Pressure readings at coils and pumps shall be related to coil and pump curves in terms of GPM flow through flow measuring status, if provided and installed, at each air handler.
      c. The flow of water through all water coils shall be adjusted by manipulating valves until the rated pressure drops across each coil is obtained and total water flow is verified by flow measuring status.
      d. For coils equipped with 3 way valves, the rated pressure drop shall first be adjusted through the coils.
      e. The bypass valve shall then be adjusted on each coil until an equal pressure drop between supply and return connections is the same as with the flow through the coil.
   4. Ampere Readings: Reading and record full load amperes for each pump motor.

1.10 SOUND AND VIBRATION

A. Sound:
   1. Read and record sound levels at up to 15 locations in the building designated by the Engineer.
   2. All measurements shall be made using an Octave Band Analyzer.
   3. All tests shall be conducted when the building is quiet in the presence of the Engineer, if they so desires.

B. Vibration:
   1. Witness vibration testing as specified in other sections. Provide test results to UTSW Representative.
   2. Readings will be made using portable IRD (or approved equal) equipment capable of filtering out various unwanted frequencies and standard reporting forms.
   3. Maximum vibration at any point listed above, or specified, shall not exceed 1 mil on fans and 1 mil on pumps unless otherwise specified.
   4. Equipment manufacturers shall rectify all systems exceeding vibration tolerances.

1.11 TESTING OF TEMPERATURE CONTROL SYSTEMS

A. In the process of performing the TAB work, the TAB Firm shall:
   1. Work with the temperature control contractor to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.
   2. Verify that all control devices are properly connected.
   3. Verify that all dampers, valves and other controlled devices are operated by the intended controller.
   4. Verify that all dampers and valves are in the position indicated by the controller (open, closed or modulating).
   5. Verify the integrity of valves and dampers in terms of tightness of close-off and full-open positions This includes dampers in multizone units, terminal boxes and fire/smoke dampers.
   6. Observe that all valves are properly installed in the piping system in relation to direction of flow and location.
   7. Observe the calibration of all controllers.
   8. Verify the proper application of all normally opened and normally closed valves.
   9. Observe the locations of all space thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts or cold walls.
   10. Observe the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media Control Contractor will relocate as deemed necessary by the TAB Firm.
   11. Verify that the sequence of operation for any control mode is in accordance with approved shop drawings and specifications Verify that no simultaneous heating and cooling occurs.
   12. Verify that all controller setpoints meet the design intent.
   13. Check all dampers for free travel.
   14. Verify the operation of all interlock systems.
   15. Perform variable volume system verification to assure the system and it`s components track with changes from full flow to minimum flow.

B. A systematic listing of the above testing and verification shall be included in the final TAB report:
   1. Each system will be tested in accordance with written control sequence verification procedures.
   2. The written control sequence verification will document the performance of the specified control sequence and the control manufacturers as built drawings.
   3. The written control sequence verification will identify each components sequence, safety devices and alarms.
   4. The written control sequence verification will test multiple components in a manifold system.
   5. The written control sequence verification will test the systems in normal power and emergency power.

C. List all the control points of each system Verify back to the front end graphics that the point is calibrated and the graphics indicate a change in value with the correct point name.

1.12 CALIBRATION OF SECONDARY MONITORING SYSTEM (ANIMAL RESOURCE CENTER)

A. Where this system exists, confirm it aligns with the building monitoring system.

1.13 STAIRWELL PRESSURIZATION SYSTEMS

A. With all doors closed, measure the door pull to determine that the opening force required is below 30 foot-pounds.

B. With all doors closed, measure the pressure differential across each door to verify the pressure differentials at each floor.

C. Measure the air flow in the stairwell with the maximum number of doors fully open by pitot tube traverse, if traverse locations are available If traverse locations are not available, measure air flow at each outlet.

D. Verify with smoke that the smoke detector in the stair pressurization fan inlet shuts the fan down.

1.14 REPORTS

A. The activities described in this section shall culminate in a report to be provided in an electronic report to the Owner's representative. Comply with requirements in Section 01 77 00 - Closeout Procedures and Submittals.

1. Neatly type and arrange data.
2. Include with the data the date tested, personnel present, weather conditions, nameplate record of test instrument and list all measurements taken after all corrections are made to the system.
3. Record all failures and corrective action taken to remedy incorrect situation.
4. The intent of the final report is to provide a reference of actual operating conditions for the Owner`s operations personnel.
5. The report will be organized in the following manner:
    a. Title Sheet.
    b. Table of Contents (Per system).
    c. AHU Data (Numerical sequence).
    d. Air Distribution Data, Traverse Data, All Supporting Data, etc.
    e. FCU, CRAC, etc. with supporting data.
    f. Fan Data with supporting data.
    g. Chilled Water System Data (Heat Transfer Equip., Pumps, etc.).
    h. Heating Water System Data (Heat Transfer Equip., Pumps, etc.).
    i. Condenser Water System Data (Cooling Towers, Heat Transfer Equip., Pumps, etc.).
    j. Control Verification (Sequences, Sensor Calibration, Point to Point, Graphics, etc).
    k. All measurements and recorded readings (of air, water, electricity, etc) that appear in the reports must have been made onsite by the permanently employed technicians or engineers of the firm.
    l. At the option of the Owner’s Representative, all data sheets tabulated each day by TAB personnel shall be submitted for initial by the Owner’s Representative Those work sheets so initialed, or copies thereof, shall be presented as a supplement to the final TAB report.

B. Submit reports in electronic forms approved by the Owner & Engineer which will include the following information as a minimum:

1. Title Page:
    a. Company Name.
    b. Company Address.
    c. Company telephone number.
    d. Project name.
    e. Project location.
    f. Project Manager.
    g. Project Engineer.
    h. Project Contractor.
    i. Project Identification Number.
2. Instrument List:

a. Instrument.
b. Manufacturer.
c. Model.
d. Serial Number.
e. Range.
f. Calibration date.
g. What test instrument was used for.

3. Fan Data (Supply and Exhaust):
   a. Location.
   b. Manufacturer.
   c. Model.
   d. Air flow, specified and actual.
   e. Total static pressure (total external), specified and actual.
   f. Inlet pressure.
   g. Discharge pressure.
   h. Fan RPM.
4. Return Air/Outside Air Data (If fans are used, same data as for 3 above):
   a. Identification/location.
   b. Design return air flow.
   c. Actual return air flow.
   d. Design outside air flow.
   e. Return air temperature.
   f. Outside air temperature.
   g. Required mixed air temperature.
   h. Actual mixed air temperature.
5. Electric Motors:
   a. Manufacturer.
   b. HP/BHP.
   c. Phase, voltage, amperage, nameplate, actual.
   d. RPM.
   e. Service factor.
   f. Starter size, heater elements, rating.
6. V-Belt Drive:
   a. Identification/location.
   b. Required driven RPM.
   c. Driven sheave, diameter and RPM.
   d. Belt, size and quantity.
   e. Motor sheave, diameter and RPM.
   f. Center-to-center distance, maximum, minimum and actual.
7. Duct Traverse:
   a. System zone/branch.
   b. Duct size.
   c. Area.
   d. Design velocity.
   e. Design air flow.
   f. Test velocity.
   g. Test air flow.
   h. Duct static pressure.
   i. Air temperature.
   j. Air correction factor.
8. Air Monitoring Station Data:
   a. Identification/location.

b. System.
c. Size.
d. Area.
e. Design velocity.
f. Design air flow.
g. Test velocity.
h. Test air flow.

9. Air Distribution Test Sheet:
   a. Air terminal number.
   b. Room number/location.
   c. Terminal type.
   d. Terminal size.
   e. Area factor.
   f. Design velocity.
   g. Design air flow.
   h. Test (final) velocity.
   i. Test (final) air flow.
10. Pump Data:
   a. Identification/number.
   b. Manufacturer.
   c. Size/model.
   d. Impeller.
   e. Service.
   f. Design flow rate, pressure drop, BHP.
   g. Actual flow rate, pressure drop, BHP.
   h. Discharge pressure.
   i. Suction pressure.
   j. Total operating head pressure.
   k. Shut off, discharge and suction pressure.
   l. Shut off, total head pressure.
   m. Pressure differential settings.
11. Cooling Coil Data:
   a. Identification/number.
   b. Location.
   c. Service.
   d. Manufacturer.
   e. Entering air DB temperature, design and actual.
   f. Entering air WB temperature, design and actual.
   g. Leaving air DB temperature, design and actual.
   h. Leaving air WB temperature, design and actual.
   i. Water pressure flow, design and actual.
   j. Water pressure drop, design and actual.
   k. Entering water temperature, design and actual.
   l. Leaving water temperature, design and actual.
   m. Air pressure drop, design and actual.
12. Heating Coil Data:
   a. Identification/number.
   b. Location.
   c. Service.
   d. Manufacturer.
   e. Air flow, design and actual.
   f. Entering water or steam temperature, design and actual.

g. Entering air temperature, design and actual.
h. Leaving air temperature, design and actual.
i. Air pressure drop, design and actual.

13. Sound Level Report:
    a. Location (Location established by the design engineer).
    b. NC curve for eight (8) bands - equipment off.
    c. NC curve for eight (8) bands - equipment on.
14. Vibration Test on equipment having 10 HP motors or above:
    a. Location of points:
        1) Pump bearing, drive end.
        2) Pump bearing, opposite end.
        3) Motor bearing, center (if applicable).
        4) Motor bearing, drive end.
        5) Motor bearing, opposite end.
        6) Casing (bottom or top).
        7) Casing (side).
        8) Pipe after flexible connection (discharge), if applicable.
        9) Pipe after flexible connection (suction), if applicable.
    b. Test readings:
        1) Horizontal, velocity and displacement.
        2) Vertical, velocity and displacement.
        3) Axial, velocity and displacement.
    c. Normally acceptable readings, velocity and acceleration.
    d. Unusual conditions at time of test.
    e. Vibration source (if non-complying).
15. Control verification indicating date performed and any abnormalities identified:
    a. Point Location/Description.
    b. EMS Readout (Setpoint and Actual).
    c. Actual Readout.
    d. Interlocks.
    e. Safeties:
        1) VSD Normal Operation.
        2) VSD Bypass Operation.
    f. Alarms.
    g. Sequences of Operation.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION 23 05 94

SECTION 23 08 00

COMMISSIONING OF HVAC SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes commissioning process requirements for HVAC systems, assemblies, controls, and equipment.

B. This project will have selected building systems commissioned. The equipment and systems to be commissioned are specified in Section 01 91 00 - General Commissioning Requirements .

1.2 RELATED SECTIONS

A. Section 01 91 00 - General Commissioning Requirements.

B. Section 22 08 00 - Commissioning of Plumbing Systems.

C. Section 26 08 00 - Commissioning of Electrical Systems.

1.3 REFERENCE STANDARDS

A. Texas Government Code Chapter 2252.001-005; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements

1.4 DEFINITIONS

A. Refer to 01 91 00 - General Commissioning Requirements.

1.5 SUBMITTALS

A. Certificate Of Readiness, signed by the Contractor, certifying that systems, assemblies, equipment, components, and associated controls are ready for testing.

B. Manufacturer’s completed start-up reports for equipment and systems.

C. Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.

1.6 CONTRACTOR'S RESPONSIBILITIES

A. Reference Project Specification Section 01 91 00 - General Commissioning Requirements for details of HVAC contractor’s responsibilities related to commissioning.

B. Perform commissioning tests at the direction of the CxA.

C. Attend commissioning meetings.

D. Provide information requested by the CxA for functional testing and for final commissioning documentation.

E. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

F. Functional testing of systems will be carried out solely by Mechanical contractor’s personnel, under the direction of CxA. Provide experienced personnel, familiar with the systems being installed under this project.

1.7 COMMISSIONING AUTHORITY RESPONSIBILITIES

A. Reference Project Specification Section 01 91 00 - General Commissioning Requirements.

B. CxA will direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete. Review and comment on testing, adjusting, and balancing report.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 GENERAL TESTING REQUIREMENTS

A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in Division 23 Sections. Provide submittals, test data, inspector record, and certification to the CxA.
B. Reference Project Specification Section 01 91 00 - General Commissioning Requirements for detailed requirements of commissioning of Mechanical systems.
C. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
D. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
E. Tests will be performed using design conditions whenever possible.

3.2 SYSTEM START-UP

A. Contractor is solely responsible for system start-up. CxA may, at his discretion, witness start up procedures, but will not perform any Functional Testing of systems until Contractor has completed start-up and resolved all operating deficiencies, and has so certified.

3.3 TESTING PREPARATION

A. Certify that HVAC and controls systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
B. Certify that HVAC instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
C. Certify that testing, adjusting, and balancing procedures have been completed and submitted, discrepancies corrected, and corrective work approved.
D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
E. Inspect and verify the position of each device and interlock identified on checklists.
F. Check safety cutouts, alarms, and interlocks with life-safety systems during each mode of operation.
G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.4 FUNCTIONAL TESTING / GENERAL

A. Reference Project Specification Section 01 91 00 - General Commissioning Requirements for detailed requirements of commissioning of Mechanical systems.
B. Provide measuring instruments and logging devices to record test data as directed by the CxA.

3.5 CONTROLS TESTING

A. Submit to CxA all documentation and reports called for in Section 23 09 00 - Instrumentation and Control for HVAC.
    1. Verify communications interface with Central Data Acquisition System (CDAS).
    2. Verify communications interface with central operator station, all controllers on LAN, and remote communications devices, if applicable.
    3. Verify operation of web browser interface.
    4. Verify page navigation functions correctly.
    5. Verify BAS contractor has calibrated all analog sensors per specifications. Verify sensor accuracy and reasonableness.
    6. Verify correctness of graphics: schematics reflect actual installation, all specified all specified input and output points are displayed, spelling is correct, proper units (e.g., deg F, psi, etc.) are used, layout is logical and consistent, floor plans are accurate and identify locations of equipment, thermostats, etc.
    7. Verify auxiliary items (printers, screens, computers, etc.) are supplied and functioning.
    8. Verify operation of all input and output points, including all safeties, by forcing point, changing setpoints and observing reaction, etc.
    9. Verify correct operating sequences, including setpoints.
    10. Verify communications with / points display of Modbus and Bacnet controllers of stand-alone equipment items.

11. Verify that equipment alarms register at BAS, and are stored in history log.
12. Verify operation of all condensate drains.

B. Trend Logging:
1. Set up historical trend logs to record data points from any and all systems as directed by CxA. The logging frequency and duration of logging will be set up as directed by CxA, and all logged data will be permanently stored, and transmitted to CxA at intervals as directed by CxA.

3.6 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
1. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
2. Failure of an item (other than sound) includes a deviation of more than 10 percent from reported value, or other more stringent requirement if called for elsewhere in this project manual. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report.
3. Remedy the deficiency and notify CxA who will re-verify failed portions of test.

3.7 PIPING SYSTEMS

A. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 23 piping Sections. HVAC Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Include sequence of testing and testing procedures, description of equipment for flushing operations, drawings for each pipe sector, showing the physical location of each designated pipe test section, minimum flushing water velocity, and chemical treatment plan.

3.8 DEFERRED TESTING

A. Initial commissioning will be done as soon as contract work is completed, though building may not be at full occupancy and equipment may not be at full loading.

B. If adequate load may be artificially placed upon heating or cooling equipment, CxA, at his discretion, may perform functional testing during non-peak load periods. If testing cannot be carried out under these conditions to adequately verify system performance, testing will be deferred until such time as conditions are more satisfactory.
1. Contractor is to provide services of personnel and participate in deferred or seasonal testing process in the same manner as he would in non-seasonal testing.
2. If tests cannot be completed because of a deficiency outside the scope of the Mechanical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

3.9 RE-TESTING

A. Reference Project Specification Section 01 91 00 - General Commissioning Requirements for detailed requirements of re-testing of Mechanical systems.

3.10 SYSTEMS TO BE COMMISSIONED

A. Reference Project Specification Section 01 91 00 - General Commissioning Requirements for list of Mechanical systems to be commissioned.

END OF SECTION 23 08 00

SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SECTION INCLUDES

A. This Section includes control equipment for HVAC systems, components and other systems shown to be controlled by the Building Automation System (BAS), including, but not limited to, all computer software and hardware, controllers, sensors, transmission equipment, local panels, installation, engineering, supervision, commissioning, acceptance testing, training and warranty service necessary for a complete and working system.

1.3 RELATED REQUIREMENTS

A. Section 26 32 13 - Standby Power Generator Systems.

B. Section 26 33 53 - Uninterruptible Power Systems.

1.4 SCOPE OF WORK

A. The Contractor shall furnish and install a complete direct digital control (DDC) building automation system (BAS) including all necessary hardware and all operating and applications software necessary to perform the control sequences of operation as specified herein.

B. All components of the system – workstations, network controllers, local controllers, etc. shall communicate using a standard protocol, as defined by ASHRAE Standard 135-2001 and as specified herein.

1. Level 1 communication protocol shall be BACnet IP.
2. Level 2 communication protocol shall be BACnet IP, BACnet MS/TP Modbus IP or Modbus RTU, Ethernet IP.
3. Proprietary communications is allowed as an alternate based on the project with owner approval.
4. LON communication protocol is not acceptable at any level in the BAS system.

C. The BAS contractor shall review and study all HVAC drawings and the entire specification to become familiar with the equipment and system operation and to verify the quantities and types of dampers, operators, alarms, etc. to be provided.

D. All interlocking, wiring and installation of control devices associated with the equipment described in the sequence of operations, points list and control diagrams shall be provided under this Contract.

E. Provide services and manpower necessary for commissioning of system in coordination with the Commissioning Authority, HVAC Contractor, Testing and Balancing Contractor, Electrical Contractor and Owner's Representative. Refer to Section 23 08 00 - Commissioning of HVAC Systems.

F. All work performed under this section of the specifications will comply with all codes, laws and governing bodies. If the drawings and/or specifications are in conflict with governing codes, the Contractor shall submit a proposal with appropriate modifications to the project to meet code restrictions. If this specification and associated drawings exceed governing code requirements, the specification will govern. The Controls Contractor shall obtain and pay for all necessary construction permits and licenses associated with this scope of work.

1.5 REFERENCE STANDARDS

A. Texas Government Code Chapter 2252.001-005; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

B. The control system components shall be new and in conformance with the following applicable standards for products specified:

1. American Society for Testing and Materials, ASTM.

2. Institute of Electrical and Electronic Engineers, IEEE.
3. National Electrical Manufacturers Association, NEMA.
4. Underwriters Laboratory, UL (UL 916 & 864).
5. FCC Regulation, Part 15, Section 156.
6. National Fire Protection Association, NFPA.
7. Local Building Codes.

1.6 PROTECTION OF SOFTWARE RIGHTS

A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:
   1. Limiting use of software to equipment provided under these Specifications.
   2. Limiting copying.
   3. Preserving confidentiality.
   4. Prohibiting transfer to a third party.

1.7 SUBMITTALS

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

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Riser diagram of main network architecture depicting all controllers, workstations and associated network wiring.
   2. Bill of materials of equipment indicating quantity, manufacturer, and model number.
   3. Schematic flow/control diagrams showing fans, pumps, coils, dampers, valves, and control devices.
   4. Wiring Diagrams: Power, signal, and control wiring.
   5. Details of control panel faces, including controls, instruments, and labeling.
   6. Floor plans indicating control panel locations.
   7. Written description of sequence of operation.
   8. Schedule of dampers including size, leakage, and airflow characteristics.
   9. Schedule of valves including flow characteristics.

C. Schedule of airflow monitoring stations including airflow characteristics.
   1. DDC System Hardware:
      a. Wiring diagrams for control units with termination numbers.
      b. Schematic diagrams and floor plans for field sensors and control hardware.
      c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
   2. Control System Software: Graphics outline and “Print Page” examples of final product indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
   3. Controlled Systems:
      a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
      b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.

c. Written description of sequence of operation including schematic diagram.
d. Points list.

D. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE Standard 135-2001 for each protocol.

E. Samples for Initial Selection: For each type of sensor cover with factory-applied color finishes.

F. Software and Firmware Operational Documentation: Include the following:
1. Software operating and upgrade manuals.
2. Program Software Backup: On CD, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for operator workstations and control systems.

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

H. Field quality-control test report forms.

I. Operation and Maintenance Data: Include emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Maintenance instructions and lists of spare parts for each type of control device.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

J. Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.

1.8 QUALITY ASSURANCE

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

B. Warranty: Controls Contractor shall guarantee all system components and installations to be free from defects for one (1) year from the date of acceptance as determined by the Owner. Any defects found during this period shall be repaired and/or replaced at no cost to the Owner. The Controls Contractor shall provide maximum of 24-hour response time for trouble calls or maintenance.

C. Upon completion of the installation, the Contractor shall thoroughly inspect, check, adjust, calibrate, and make ready for use all devices/sensors comprising the control system and certify that they are installed in accordance with "Record" Drawings.

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

E. Data Communications Protocol: Certify that each proposed DDC system component complies with ASHRAE Standard 135-2001 for each protocol.

F. DDC system component testing: Comply with ASHRAE 135.1-2001 for all DDC controllers.

G. All controllers used to control or monitor equipment and/or field devices shall be tested, compliant with and carry a testing seal:
1. Building Controllers.
2. Advanced Application Controllers.
3. Application Specific Controllers.

H. System Software: Provide latest version of software at Project completion. Provide all software updates for one (1) year after date of acceptance as determined by the Owner.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment in other Sections, arrange for shipping of control devices to equipment manufacturer. Upon delivery the equipment manufacturer shall inspect shipment for visual damages. The Controls Contractor shall replace any damaged control equipment at no cost to the Owner.

B. Provide factory shipping containers for each piece of equipment. Provide factory applied plastic end caps on each length of pipe and tube. Maintain cartons and end caps through shipping, storage and handling as required to prevent equipment and pipe-end damage, and to eliminate dirt and moisture from equipment and inside of pipe and tube. Where possible store equipment and materials inside and protected from weather. When necessary, to store outside, elevate well above grade and enclose with durable water-proof wrapping.

1.10 WORK BY OTHERS

A. The installation of motor starters that are not factory installed, thermal overload switches, and power wiring to motors, starters, and thermal overload switches, is specified in another section. This section includes the furnishing and installing of all controls, devices, interlocks, and wiring to provide a complete operating system as outlined in the sequence of operation.

B. The following general work scope of Contractors requiring coordination by the Controls Contractor includes, but is not limited to:

1. The Piping Contractor shall:
   a. Install automatic valves, flow meters and separable wells that are specified to be supplied by the Controls Contractor.
   b. Furnish and install all necessary pressure taps, wells, as directed by the Controls Contractor.
   c. Furnish and install all necessary drain and overflow connections and piping.
   d. Furnish and install all necessary fittings and piping connections required for flow devices.
2. The Sheet Metal Contractor shall:
   a. Install all automatic dampers and provide necessary blank-off plates or transitions required to install dampers that are smaller than duct size.
   b. Assemble multiple section dampers with required interconnecting linkages and extend required number of shafts through duct for external mounting of damper motors.
   c. Furnish and install necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation. Affix and seal permanently in place once stratification problems have been eliminated.
   d. Furnish and install access doors or other approved means of access through ducts for service to control equipment.
   e. Install duct mounted airflow monitoring stations.
   f. Install AHU and duct mounted heat and smoke detectors.
3. The General Contractor shall:
   a. Provide access doors or other means of access through ceilings and walls for services to control equipment.
   b. Provide necessary housekeeping pads and, where required, concrete inertia bases.
4. Air Terminal Box Manufacturers shall.
   a. Factory mount, wire and configure the terminal box DDC controller and actuator.
   b. Furnish static pressure probes.
   c. Furnish 24 volt transformers for terminal box controller power.
5. Electrical Contractor shall:
   a. Furnish fire alarm system compatible duct mounted heat and smoke detectors and wire to Fire Alarm System. Coordinate with the mechanical contractor the exact placement of duct mounted detectors.
   b. Provide relay cabinets, required for lighting control and wiring/conduits to the EMS panels.
6. Provide dedicated 120VAC circuits in j-boxes throughout all building areas for control panel and terminal box control power.

PART 2 - PRODUCTS

2.1 ACCEPTABLE BIDDERS

A. The specifications are intended to describe the microprocessor based Energy Management System – System 600 APOGEE and Siemens Building Technologies is the acceptable manufacturer/installer.

B. Alternate bidders are acceptable with ownership approval. Any alternate bidder must be able to demonstrate to UTSW the ability to integrate with the existing Siemens Building Technologies Energy Management System prior to bidding.

2.2 NETWORKING

A. The design of the EMS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of three levels, a campus-wide (Management Level Network - MLN) Ethernet network based on TCP/IP protocol, high performance peer-to-peer Building Level Network (BLN) and Application Specific Controller Floor Level Networks (FLN) with access being totally transparent to the user when accessing data or developing control programs.

B. The design of EMS shall allow the co-existence of new DDC Controllers with existing DDC Controllers in the same network without the use of gateways or protocol converters.

C. All operator devices either network resident or connected via remote connection 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 peer-to-peer network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.

D. All Networks shall be dynamically connected to allow access to points on different BLN's simultaneously.

2.3 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
   1. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
   2. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
   3. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
   4. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
   5. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
   6. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
      a. Water Temperature: Plus or minus 1 deg F.
      b. Water Flow: Plus or minus 5 percent of full scale.
      c. Water Pressure: Plus or minus 2 percent of full scale.
      d. Space Temperature: Plus or minus 1 deg F.
      e. Ducted Air Temperature: Plus or minus 1 deg F.
      f. Outside Air Temperature: Plus or minus 2 deg F.
      g. Dew Point Temperature: Plus or minus 3 deg F.
      h. Temperature Differential: Plus or minus 0.25 deg F.
      i. Relative Humidity: Plus or minus 5 percent.
      j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
      k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
      l. Airflow (Terminal): Plus or minus 10 percent of full scale.
      m. Air Pressure (Space): Plus or minus 0.01-inch wg.
      n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
      o. Carbon Monoxide: Plus or minus 5 percent of reading.
      p. Carbon Dioxide: Plus or minus 50 ppm.
      q. Electrical: Plus or minus 5 percent of reading.

B. Graphics User Interface:
   1. Menu: Selectable for command entry, information management, network alarm management, and database management functions including, but not limited to:
      a. Configuration.

b. Data Archiving.
c. Commanding.
d. System Diagnostics.
e. Graphic Display Tree.
f. Alarm Logs.
g. Reports.
h. Schedules.

2. Graphic Display: Display graphic with current state of the art dynamic points and refresh speed. As a minimum provide the following graphics pages:
   a. Overall Building Level: Display building, building name and all exterior equipment.
   b. Floor Level: Display floor level derived from CAD drawing, active links to monitored and/or controlled equipment on that floor.
   c. AHU System Level: Similar to floor level but displaying the area of a single AHU system and embedded links for all associated equipment including, but not limited to:
      1) AHU.
      2) Terminal boxes.
      3) Exhaust fans.
      4) Dampers.
      5) Thermostats.
      6) Field sensors.
   d. Equipment Level: Display associated equipment setpoints and real-time sensor readings as defined by the Owner.
   e. Equipment Support Data: Link the following information directly from the Equipment Level graphic display or menu graphic display tree:
      1) Operation and Maintenance manual.
      2) Equipment schedules.
      3) Sequence of operations.
   f. Other graphic displays
      1) Alarm log.
      2) Energy overview: costs, consumption, production.
      3) Equipment runtimes.

2.4 OPERATOR INTERFACE EQUIPMENT (AS APPLICABLE, CONFIRM CURRENT TECHNOLOGY REQUIREMENTS)

A. Operator Workstation (OWS): One desktop in tower case with configuration commercially available three months before substantial completion:
   1. Intel Dual-Processor: 3.0 GHz (ea. processor), 2 MB L2 cache, 800 MHz (min.) front side bus, 64-bit.
   2. Random-Access Memory: 6 GB.
   3. Graphics Video Adapter: 256 MB video memory.
   4. Hard-Disk Drive: 1 TB, 7200 RPM.
   5. DVD/CD Combo Read/Write Drive: DVD+R 8X, DVD+RW 8X, DVD-RW 6X, CD-R 24X, CD-RW 16X.
   6. Communications Card: 10/100bT Ethernet, integral to motherboard or compatible with expansion slot.
   7. Audio Card: Integral to motherboard or compatible with expansion slot, 1-3.5mm microphone input, 1-3.5mm headphone output.
   8. Media Drive: Multi-in-1 (SD/XD/CF).
   9. USB Connections: 2 front side, 4 back side, version 2.0 compliant.
   10. Monitor 24 inch flat panel LCD: 1920 x 1080 (1080p) resolution, DVI & VGA input, 50,000:1 contrast ratio, 300 cd/m2 brightness, 5 ms response time. 2 per OWS.
   11. Keyboard: QWERTY, 105 keys in ergonomic shape.
   12. Mouse: Three button with scroll wheel, optical.

13. 2 kVA UPS.
14. Speakers: compatible with audio card.
15. Operating System: Microsoft Windows XP or 7.
    a. Protocol Compliance: Control units shall use BACnet or Modbus protocol.
16. Application Software:
    a. I/O capability from operator station.
    b. System security for each operator via software password and access levels.
    c. Automatic system diagnostics; monitor system and report failures.
    d. Database creation and support.
    e. Automatic and manual database save and restore.
    f. Dynamic color graphic displays with up to 10 screen displays at once.
    g. Custom graphics generation and graphics library of HVAC equipment and symbols.
    h. Alarm processing, messages, and reactions.
    i. Trend logs retrievable in spreadsheets and database programs.
    j. Alarm and event processing.
    k. Object and property status and control.
    l. Automatic restart of field equipment on restoration of power.
    m. Data collection, reports, and logs. Include standard reports for the following:
        1) Current values of all objects.
        2) Current alarm summary.
        3) Disabled objects.
        4) Alarm lockout objects.
        5) Logs.
    n. Custom report development.
    o. Utility and weather reports.
    p. Workstation application editors for controllers and schedules.
    q. Maintenance management.
17. Custom Application Software:
    a. English language oriented.
    b. Full-screen character editor/programming environment.
    c. Allow development of independently executing program modules with debugging/simulation capability.
    d. Support conditional statements.
    e. Support floating-point arithmetic with mathematic functions.
    f. Contains predefined time variables.

B. Portable Diagnostic Unit (PDU) (Laptop): Portable notebook-style, PC-based microcomputer terminal capable of accessing system data by connecting to system network via Ethernet cable.
1. System: With one integrated USB 2.0 port, integrated Intel Ethernet, integrated audio, bios, and hardware monitoring.
2. Processor: Intel 2.13 GHz, dual-core.
3. Random-Access Memory: 6 GB, DDR3.
4. Graphics: 512 MB video memory.
5. Monitor: 14 inches, LCD color.
6. Keyboard: QWERTY 105 keys in ergonomic shape.
7. Hard-Disk Drive: 500 GB, 5400 RPM.
8. Audio: Integral sound card with 1-3.5mm microphone input, 1-3.5mm headphone output.
9. Media Drive: Multi-in-1 (SD/XD/CF)
10. USB Drives: 2 side, 2 back, version 2.0 compliant.
11. DVD/CD-ROM Read/Write Combo Drive: DVD+R 8X, DVD+RW 8X, DVD-RW 6X, CD-R 24X, CD-RW 16X.
12. Pointing Device: Touch pad, 2-button.
13. Communications Card: 10/100bT Ethernet, Bluetooth 2.1, IEEE 802.11b/g/n wireless.
14. Operating System: Windows XP or 7.

C. Archive Server: Provide servers that will provide archive locations for all historical data such as trends, alarm and event histories and transaction logs.
   1. Server shall reside on the Campus Network.
   2. Equip servers with the same tool set that is located in the network level controllers for the system configuration and custom logic definition and graphic configuration.
   3. Access to all information on the server will be through the OWS.
   4. The hardware platform for servers will, at minimum, consist of:
      a. PC processor with minimum 64-bit word structure.
      b. Minimum 4.0 GHz processor speed.
      c. Minimum 8 GB RAM.
      d. Hard drive or equal high-speed data storage, minimum 50 gigabytes.
      e. OS shall be Windows 2008 Professional.
      f. Removable high-speed data storage and export device(s) such as Read/Write CD ROM or approved equal.
      g. Full ASCII keyboard and digital Mouse or equal pointing device.
      h. Full color, flat screen monitor, minimum 22 inches diagonal screen, minimum 1280 x 1024 resolution, and minimum 72 Hz refresh rate.

2.5 DDC CONTROLLERS

A. DDC Controllers shall be stand-alone, multi-tasking, multi-user, real-time digital control processors with a minimum word size of 16 bits, minimum 16MHz clock and 4MB memory consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Each controller shall support a minimum of 96 FLN Devices. Floor Level Network Controllers (FLNC) are DDC Controllers that only support 96 FLN Devices.

B. Each DDC Controller shall support its own operating system and databases, including:
   1. Control processes.
   2. Energy management applications.
   3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
   4. Historical/trend data for points specified.
   5. Maintenance support applications.
   6. Custom processes.
   7. Operator I/O.
   8. Dial-up communications.
   9. Manual override monitoring.

C. Each DDC Controller shall support any combination of industry standard inputs and outputs.

D. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

E. DDC Controllers shall be provided with one RS-232C serial data communication port for the portable laptop operator's terminal. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

F. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.
   1. Switches shall be mounted within the DDC Controllers key-accessed enclosure.
   2. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

G. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated

intensity LED's for analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door (MBC only).

H. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

J. In the event of loss of all power, there shall be an orderly shutdown of all DDC Controllers 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 100 hours.
   1. Battery Backup: Basis of Design
      a. Basis of Design: Uninterruptible Power Supply In Kit PSH850-UPS-STAT as manufacturered by Functional Devices, Inc.
      b. Product to include 850 VA UPS, 10 amp switch/circut breaker, two - 120 Vac outlets, terminals, 120 VAC input.
   2. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
   3. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via remote connection or automatically from the network workstation PC.

K. As a minimum, a separate DDC Controller shall be provided for each mechanical room. There should only be one DDC Controller for each system.

L. All DDC controllers will be provided with a UPS backup. UTSW will approve acceptable UPS products from APC / Schneider Electric.

2.6 DDC CONTROLLER RESIDENT SOFTWARE

A. General:
   1. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.

B. Control Software Description:
   1. The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:
      a. Two-position control.
      b. Proportional control.
      c. Proportional plus integral control.
      d. Proportional, integral, plus derivative control.
      e. Automatic tuning of control loops.

C. DDC Controllers shall have the ability to perform any or all the following energy management routines:
   1. Time-of-day scheduling.
   2. Calendar-based scheduling.
   3. Holiday scheduling.
   4. Temporary schedule overrides.
   5. Start-Stop Time Optimization.
   6. Automatic Daylight Savings Time Switchover.
   7. Night setback control.
   8. Enthalpy switchover (economizer).
   9. Peak demand limiting.
   10. Temperature-compensated duty cycling.

D. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network.
2. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of connection to a remote device such as a printer or pager.

E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller 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 DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
2. 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 six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs.
4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
5. In remote alert applications, operator-selected alarms shall initiate a call to a remote operator device.

F. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary.
1. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data. All trend data shall be available for use in 3rd party personal computer applications such as Excel.
2. DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.
    a. Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation or remotely using dial-in modems. For all loop-tuning functions, access shall be limited to authorized personnel through password protection.

G. DDC Controllers shall automatically accumulate and store run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O summary.

H. DDC Controllers shall be password protected. The user’s Password and Privileges shall be identical to the Password and Privileges used at the EMS Workstation.

2.7 APPLICATION SPECIFIC CONTROLLERS

A. Terminal Equipment Controllers (TEC)
1. Provide for control of each piece of equipment, including, but not limited to, the following:
    a. VAV and CAV Dual Duct Boxes.
    b. VAV Terminal Units with and without heating coils.
    c. Fan Coil Units.

2. The controllers shall include all inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be 24 volt floating.
3. Each controller performing space temperature control shall be provided with a matching room temperature sensor with a setpoint adjustment between 55 Degrees F and 95 Degrees F.
4. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the respective controller.
5. Setpoint adjustment and override function shall have the ability to be locked out, overridden, or limited as to time or temperature through software by an authorized operator at the central workstations, at the DDC Controller, or via the portable operator's terminal.
6. Each controller shall perform its primary control function independent of the DDC Controller. The controller shall receive its real-time data from the DDC Controller time clock. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All PID gains and biases shall be adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control and shall facilitate optimal occupant comfort and energy savings.
7. Provide each terminal equipment controller with sufficient memory to accommodate point databases and operating programs. All databases and programs shall be stored in non-volatile EEPROM, EPROM, and PROM. The controllers shall be able to return to full normal operation without user intervention after a power failure. Operating programs shall be selectable and may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility.
8. Controllers shall be powered from a 24 VAC source, and shall function normally under an operating range of 18 to 28 VAC (-25 percent to plus 17 percent), allowing for power source fluctuations and voltage drops. The controllers shall also function normally under ambient conditions of 32 Degrees to 122 Degree F and 10-95 percent RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.
9. Pressure independent controllers shall include differential pressure transducers that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the average differential pressure in the duct. The controller shall convert this value to actual airflow. The differential pressure transducer shall have a measurement range of 400 to 4,000 FMP and measurement accuracy of plus or minus 5 percent at 400 FPM insuring primary air flow condition shall be controlled and maintained to within plus or minus 5 percent of setpoint at the specified parameters. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift overtime. The controller requiring 24 hours a day operation shall calibrate the airflow sensor every 24 hours with the use of an auto-zero module to eliminate the requirement of closing the supply damper to calibrate the flow sensor. It shall not be necessary to remove the controller to remove the damper actuator.

B. LABORATORY CONTROLS
   1. FUME HOOD CONTROLLER (FHC)
      a. The DDC controller shall control Variable Air Volume laboratory fume hoods.
      b. The controller will maintain constant face velocity as the sash is raised and lowered.
      c. An operator display panel will provide the user the operating status of the hood, alarm horn, and emergency purge function.
      d. The hood controller will interface with the energy management system.
   2. BIO-SAFETY CABINET CONTROLLER (BSCC)
      a. Ducted bio-safety cabinets will be controlled to a constant CFM specified by the cabinet’s manufacturer.
      b. Alarms and flows will be reported to the EMS.
   3. ROOM PRESSURE CONTROLLER (RPC)
      a. The DDC controller will provide room pressurization and temperature control to rooms or labs without fume hoods where positive or negative room pressure is critical.
      b. The RPC will maintain differential flow between the supply and exhaust terminal boxes.

c. The Room Pressurization Controller shall operate as a networked component of the EMS.

4. LABORATORY ROOM CONTROLLER (LRC)
   a. The DDC controller will provide control for laboratory space pressurization and temperature control wit h control sequences for both single duct and dual duct supply systems.
   b. The controller will maintain user defined differential airflow between lab supply air and fume hood controller exhaust and general exhaust terminals by measuring the airflow and controlling the damper position of the supply and general exhaust terminals.
   c. Lab temperature control will be maintained by measuring the room temperature and controlling he reheat valve and adjusting the air flow.
   d. Closed loop PID control will be used to maintain tighter air volume and temperature control.
   e. All air flows will be reported in CFM's from physical air flow stations or flow sensors and not calculated base on valve or damper position.
   f. The Laboratory Room Controller shall operate as a networked component of the EMS. The LRC shall communicate differential pressure values, air flow values, temperature values and alarm status.
5. DIFFERENTIAL PRESSURE MONITOR (DPM)
   a. The monitor measures and displays the differential pressure between a room and its adjoining space.
   b. The Differential Pressure Monitor (DPM) shall operate as a networked component of the LCS. The DPM shall communicate alarm status, differential pressure values, and door status. The alarm setpoint shall be adjustable from the LCS Workstation.
   c. The Differential Pressure Transmitter shall have an accuracy of plus or minus 0.001 inches of water over a range of - 0.2 to + 0.2 inches of water.
6. CAV FUME HOOD MONITOR
   a. The DDC Fume Hood Monitor shall continuously monitor the fume hood face velocity.
   b. Monitor shall be mounted to accurately monitor the face velocity.
   c. Monitor will be visible to the fume hood user and display the actual face velocity.
   d. Monitor will issue an audible alarm when the face velocity is below operating parameters.
   e. The monitor will connect to the EMS system so fume hood face velocity and alarms can be monitored remotely.

2.8 VALVES, DAMPERS AND ACTUATORS

A. VALVES:

1. Water valves shall be sized by the control manufacturer to produce the required capacity at a pressure loss of 15 psi. Nominal body rating shall be not less than ANSI Class 125. However, the valve body and packing selected shall be designed to withstand the system static head plus the maximum pump head and the maximum temperature of control medium and hot water. Single-seated valves shall have close-off ratings equal to 125 percent of the system pressure encountered that is the maximum upstream pressure. The valve body and packing selected shall be designed to withstand the system static head plus the maximum pump head and the maximum temperature of control medium without leakage for hot water.
2. Two-Way and Three-Way Valves:
   a. Valves used for control of hot and chilled water shall be of the modulating globe type.
   b. Valve sizes two inch and smaller shall be screwed and supplied with union fittings. The valves shall be constructed of bronze with stainless steel trim with equal percentage flow characteristics and have a rangeability of 50:1 or greater.
   c. Valve sizes 2.5 inch and larger shall be flanged. The valves shall be constructed of cast iron ASTM A126 Class B. The trim shall be stainless steel with equal percentage flow characteristics. The valve rangeability shall be 100:1 or greater.
   d. Valves shall be of the straight-through type as required by the sequence or indicated on the drawings.
3. Low Pressure Steam Valves: Shall be rated to 338 Degrees F at a maximum inlet pressure to the valve of 100 psig. Valves for low-pressure steam shall be sized for 80 percent pressure drop of inlet pressure. Valves shall be equipped with stainless steel trim and disc with linear flow characteristics.

Applications, which require steam valves larger than 2 inches, shall utilize two valves in a 1/3 - 2/3 parallel arrangement.

4. Butterfly Valves: Where butterfly valves are indicated to be used as automatic control valves, they shall be line size and designed for motorized control operation with upper disc steam keyed or machined square for mating with the control operator's linkage. All butterfly control valves over 8 inches shall be equipped with a manual, mechanical control actuator override, gear box operator for emergency manual control of the valve position. Provide required accessories to mechanically disengage automatic control actuator linkage and engage manual gear operator without dismantling the valve stem and stem extensions during changeover. Valves 4-20 inches and larger shall be tapped, full lug, cast iron body butterfly valves with aluminum bronze discs, stainless steel stem and EPDM seat. Design must incorporate top and bottom bushings between shafts and body of material suitable to provide a bearing surface to eliminate seizing or galling. Valves 4-20 inches must provide bubble-tight seal at 150 PSIG. Liners are to be resilient material suitable for 250 Degrees F temperature.
5. Valve Constant (Cv) Charts: Control drawings shall indicate the valve constant (Cv rating) of all valves used so that the valve pressure drop may be used for balancing and performance tests. Submittal data shall also state calculated shut-off pressure for each valve size.

B. DAMPERS:

1. The Temperature Control Manufacturer shall provide control dampers of the types and sizes indicated on the drawings, including but not limited to outside air, return, relief air dampers, isolation and exhaust system bypass dampers.
2. Damper frames shall be 5 inches X 1 inch 6063T5 extruded aluminum hat channel with .125 inch minimum wall thickness with mounting holes for flange and enclosed duct mounting.
3. Dampers shall be available in two-inch size increments from 8 inches horizontal and vertical to 48 inches. Requirements over 48 inches shall be standard modules with interconnecting hardware (jack shafting).
4. All damper blades shall be 6 inches 6063T5 heavy gage extruded aluminum airfoil for high velocity performance. Blades on all dampers must be not over 6 inches wide. Blade bearing shall be molded synthetic with 1/2 inch hex plated steel shafts. All blade linkage hardware shall be of corrosion-resistant finish and readily accessible for maintenance after installation.
5. Extruded vinyl edging seals for outdoor dampers and flexible metal compressible type side seals for all dampers shall be provided.
6. Dampers and seals shall be suitable for temperature ranges of -50 Degrees F. to +250 Degrees F. at specified leakage ratings.
7. Dampers used for proportional control shall have opposed blades.
8. Leakage rates shall not exceed 6.25 CFM/Sq. Ft. at 4 inches wg. differential rated in accordance with AMCA 500.
9. Acceptable manufacturers are Ruskin, Arrow United Industries, American Warming and Ventilating, Inc. or approved equal.

C. DAMPER AND VALVE ACTUATORS:

1. Electronic actuators shall be of 0-10 VDC type. The minimum actuator impedance shall be 800 ohms even when more than one actuator is connected in parallel. Spring return shall be required for two-position (NO/NC) control sequence or for steam valve control. Non-spring return actuators shall be used for all modulating sequence of control. They shall conform to all requirements of sequence descriptions specified or scheduled. Main mechanical equipment actuators shall have a manual position dial to allow manual positioning of valve in absence of control power.
2. Valve actuators shall be of sufficient size to close valves at system pressure drop across the valve plus 50.
3. Actuators for Terminal Equipment Controllers shall be 24V floating point, 0-10Vdc or pneumatic depending on Sequence of Operation and required speed of response. Regardless of actuator type, they shall be modulating and their position shall be readable in percentage open at the Workstation.

4. Actuators for VAV Laboratory Applications shall be provided for Laboratory Supply Air Terminals, Laboratory General Exhaust Terminals and Fume Hood Exhaust Terminals. The actuators shall be maintenance free high-speed actuators capable 1.0 second from minimum flow to 90 percent of maximum flow. The actuators shall have a fail safe position based on Sequence of Operation. The actuators shall be capable of accepting either 3-position floating point or 0-10 Vdc.

2.9 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor, Temperature Sensors and Transmitters:
   1. Sensor Types: Provide one of the following:
      a. 100 ohm (plus or minus 0.12 percent) platinum resistance temperature detectors having a coefficient of resistivity of 0.00385 ohms/ohm/°C. Provide RTD temperature transducers with of 4-20 mA output signal variations of less than 0.2 percent of full scale output for supply voltage variations plus or minus 10 percent and integral and accessible zero and span adjustment.
      b. 10,000 ohm thermistor having an accuracy of .5°F at calibration point of 75°F may be used for room temperature only.
   2. Accuracy: Plus or minus 0.5°F (0.3°C) at calibration point.
   3. Wire: Twisted, shielded-pair cable.
   4. Insertion Elements: Single point in center of duct or coil face area, use where not affected by temperature stratification or where airflow cross sectional area is smaller than 9 square feet.
   5. Averaging Elements: Twice the diagonal length of coil or duct. Use where prone to temperature stratification or where airflow cross sectional area is larger than 10 square feet.
   6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches or 75 percent of pipe inside diameter, whichever is less.
   7. Room Thermostats: Off-white enclosure capable of being mounted on a standard single gang electrical back box. Provide each with:
      a. Local display of current space temperature.
      b. Local setpoint adjustment (plus or minus 5 deg F) and temporary override button, both of which can be overridden by BAS at OWS.
      c. RJ45 connection for connection to PDU.
   8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. RTDs and Transmitters:
   1. Accuracy: Plus or minus 0.2 percent at calibration point.
   2. Wire: Twisted, shielded-pair cable.
   3. Insertion Elements in Ducts: Single point; use where not affected by temperature stratification or where ducts are smaller than 9 square feet.
   4. Averaging Elements in Ducts: Use where prone to temperature stratification or where ducts are larger than 9 square feet; length as required.
   5. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2 1/2 inches.
   6. Room Sensor Cover Construction: Off-white enclosure capable of being mounted on a standard single gang electrical back box.

D. Humidity Sensors: Bulk polymer sensor element.
   1. Accuracy: 2 percent full range with linear output.
   2. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of 32 to 120 deg F.
   3. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

E. Pressure Transmitters/Transducers:
   1. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated. Accuracy of 2 percent of full scale with repeatability of 0.5 percent. Linear output of 4 to 20 mA.
      a. Building Static-Pressure Range: 0- to 0.25-inch wg.

b. Duct Static-Pressure Range: 0- to 5-inch wg.

2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 Ma.
6. Solenoid Air Valves (EP). The valve shall be a 3-way solenoid valve for two-position operation of pneumatic valve and damper actuators. Coil voltage shall be 120VAC or 24

2.10 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Low Limit Temperature Switch: Minimum 20 feet element for freeze protection. Serpentine across the face of the coil and of sufficient length or number for three passes across the width of the coil it is protecting. Connect in series with other safety devices to de-energize fans serviced when a drop in temperature below setpoint is detected.

E. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

F. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

G. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

H. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

I. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.11 GAS DETECTION EQUIPMENT

A. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 deg F; with 2 factory-calibrated alarm levels to be determined by OSBC and UTSW CDAS.

B. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output, for wall mounting.

C. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of minus 32 to plus 1100 deg F and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

2.12 AIRFLOW MEASUREMENT STATIONS (AFMS)

A. Airflow Measurement Station: Multiport, self-averaging pitot tube station.

1. Acceptable Manufacturers: Ebtron.
2. Casing: Galvanized-steel frame.
3. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.
4. Pressure loss: Less than 0.005 inch w.c. @ 2000 FPM.
5. Accuracy: plus or minus 2 percent @ 6000 FPM and plus or minus0.5 percent @ 2000 FPM.

B. Traverse Probes: Duct or fan inlet mounted.
   1. Provide airflow traverse probes mounted in the ductwork or fan inlet capable of continuously measuring the air volume.
   2. The airflow traverse probes shall contain multiple total and static pressure sensors places at concentric area centers along the exterior surface of the cylindrical probe and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the probe, nor be adversely affected by particle contamination normally present in building system airflows.
   3. The fan inlet airflow traverse probes shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings, and shall be of aluminum construction with hard anodized finish.
   4. The airflow traverse probes shall not induce a measurable pressure drop, nor shall the sound level within the system be amplified by its presence. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 2 percent of actual flow.

2.13 FLOW METERS

A. BTU Meters (Water): Meters shall be complete with integral brass body flow meter, temperature sensor and standard brass thermowell.
   1. Accuracy
      a. Flow: plus or minus 0.5 percent of reading at calibrated velocity
      b. Differential Temperature: plus or minus 0.15 deg F over calibrated temperature range
      c. Computational Error: plus or minus 0.05 percent
   2. Output Signal: Factory selectable for flow rate, energy rate or delta-T (4-20mA or 0-10V)
   3. Operating Temperature & Pressure: 32 deg F to 200 deg F.
   4. Calibration: N.I.S.T. traceable standards.

B. Thermal Mass Flow Meters (Natural Gas): Meters shall be insertion style complete with wetted materials to be stainless steel.
   1. Accuracy: plus or minus 1.0 percent of reading.
   2. Output Signal: Scalable pulse output for totalization and analog output (4-20mA)
   3. Operating Temperature & Pressure: -40 deg F to 200 deg F.
   4. Calibration: N.I.S.T. traceable standards.

C. Vortex Flow Meters (Steam): Meters shall consist of a vortex shedding mass flow measurement device, 1000 ohm platinum RTD for temperature measurement and pressure transducer for pressure measurement. Sensor bodies shall be 316 stainless steel.
   1. Accuracy: Volumetric, plus or minus 1.0 percent.
   2. Repeatability: plus or minus 0.1 percent.
   3. Output Signal: Scalable pulse output for flow rate and analog output (4-20mA)
   4. Operating Temperature & Pressure: -40 deg F to 464 deg F.
   5. Calibration: N.I.S.T. traceable standards.

2.14 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling."

2.15 LOCAL CONTROL PANELS

A. Provide control panels with suitable brackets for wall mounting, for each miscellaneous control system. Locate panel adjacent to systems served.

B. Fabricate panels of 14-gauge furniture-grade steel, or 6063-T5 extruded aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer's standard shop-painted finish and color. Provide UL listed cabinets for use with line voltage devices.

C. Panel Mounted Equipment: Include temperature controllers, relays, and other devices excluded in the sequence of operation. Mount devices with adjustments accessible through the fronts of panels.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that power supply is available to control units and OWS.

3.2 COORDINATION

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

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

C. Coordinate equipment with Division 28 Section "Access Control" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate equipment with Division 28 Section "PLC Electronic Detention Monitoring and Control Systems" to achieve compatibility with equipment that interfaces with that system.

E. Coordinate equipment with Division 26 Section "Network Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

F. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

G. Coordinate supply of conditioned electrical branch circuits for control units and OWS.

H. Coordinate equipment with Division 26 Section "Electrical Power Monitoring and Control" to achieve compatibility of communication interfaces.

I. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

J. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

K. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

3.3 INSTALLATION

A. Install software in control units and OWS. Implement all features of programs to specified requirements and as appropriate to achieve sequence of operations.

B. Connect and configure equipment and software to achieve sequence of operations specified.

C. Mount all wall thermostats, humidistats, and other exposed control sensors on dedicated electrical backboxes.

D. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

E. Install automatic dampers according to Division 23 Section "Air Duct Accessories."

F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

G. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

H. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

I. Install refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant Piping."

J. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

K. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling."

L. Air flow stations shall be installed in serviceable locations.

M. Pressure transducer must be mounted outside air stream.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Division 26, 27, & 28 Sections of these Specifications except where specifically stated in this

Section.

B. The term "control wiring" is defined to include providing of wire, conduit, and miscellaneous material as required for mounting and connecting electric or electronic control devices.

C. Install all control wiring in conduit for electric/electronic control systems. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed. UL plenum rated cable shall be allowed above accessible lift out ceiling, in air plenums, and in other areas as approved by Architect and local and NEC codes.

D. Stub conduit to above lift out ceilings. Plastic bushing shall be installed where the sensor wire exits the conduit to prevent damage.

E. Number-code or color-code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.

F. This section shall provide all line voltage power wiring required because of substitution of equipment specified in this section.

G. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

H. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

I. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."

1. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
2. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
3. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
4. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

J. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

K. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

L. Serve only one DDC controller from any 24V control power transformer.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test each point through its full operating range to verify that safety and operating control set points are as required.
4. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
5. Test each system for compliance with sequence of operation.
6. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are operating in the correct direction.
8. Check dampers. Verify that proper blade alignment, either parallel or opposed, has been provided.
9. Check DDC system as follows:
    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

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

3.6 ADJUSTING

A. Calibrating and Adjusting:
1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
    a. Check digital inputs using jumper wire.
    b. Check digital outputs using ohmmeter to test for contact making or breaking.
    c. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

3.7 AIRFLOW MONITORS

A. Setup output control signal to be derived from a 5 minute running average airflow monitor input.

3.8 SYSTEM EXCEPTANCE

A. General: The system installation shall be complete and tested for proper operation prior to acceptance testing for the Owner's authorized representative. A letter shall be submitted to the Architect requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a

mutually agreeable time within ten (10) calendar days of request. When the field test procedures have been demonstrated to the Owner's representative, the system will be accepted. The warranty period will start at this time.

B. Field Equipment Test Procedures: DDC control panels shall be demonstrated via a functional end-to-end test. Such that:
   1. All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their operation verified.
   2. All analog input channels shall be verified for proper operation.
   3. Changing the state of the field device and observing the appropriate change of displayed value shall verify all digital input channels.
   4. If a point should fail testing, perform necessary repair action and retest failed point and all interlocked points.
   5. Introducing an error into the system and observing the proper corrective system response shall verify automatic control operation.
   6. Changing the schedule and observing the correct response on the controlled outputs shall verify selected time and setpoint schedules.

C. Workstation Test Procedures: The system workstation test procedures shall be as follows:
   1. Communication with each DDC control panel shall be demonstrated.
   2. Operator commands will be explained and demonstrated.
   3. Control sequences shall be demonstrated for proper operation.
   4. All available system reports and logs shall be demonstrated at the system workstation.
   5. Correct system start-up and shutdown procedures shall be demonstrated.
   6. All controllers shall be demonstrated to operate in a standalone mode.

D. Record Documentation: After a successful acceptance demonstration, the Contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply "3" complete 11 x 17 as-built drawings sets as well as digital "pdf" copies.

E. Operation and Maintenance Manuals: Submit three copies of operation and maintenance manuals. Include the following:
   1. Manufacturer's catalog data and specifications on sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals and any miscellaneous components used in the system.
   2. An operator's manual that will include detailed instructions for all operations of the system.
   3. An operator's reference table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.
   4. A programmer's manual that will include all information necessary to perform programming functions.
   5. A language manual that will include a detailed description of the language used and all routines used by the system.
   6. Complete program listing file and parameter listing file for all programs.
   7. A copy of the warranty.
   8. Operating and maintenance cautions and instructions.
   9. Recommended spare parts list.

3.9 TRAINING

A. Contractor shall provide to the engineer a training class outline prior to any scheduled training.

B. Factory trained control engineers and technicians shall provide training sessions for the Owner’s personnel.

C. The control contractor shall conduct five six-hour training sessions on the DDC System for the designated Owner's personnel in the maintenance and operation of the Systems. The class shall be given upon system acceptance.

D. The course shall include instruction on specific systems and instructions for operating the installed system to include as a minimum:
   1. HVAC system overview.
   2. Operation DDC Systems.

3. Function of each Component.
4. System Operating Procedures.
5. Programming Procedures.
6. Maintenance Procedures.

3.10 SERVICE AND GUARANTEE

A. This system specified under this Section of the Specifications shall be guaranteed from defects in workmanship and material under normal use and service for a period of twelve (12) months from the date of acceptance. If, during the one year period, any of the factory equipment or materials provided in the system is found to be defective in materials or workmanship, it shall be replaced or repaired by the DDC Manufacturer at no additional cost to the Owner.

B. Upon completion of the installation, the Contractor shall thoroughly inspect, check, adjust, calibrate, and make ready for use all devices/sensors comprising the control system and certify that they are installed in accordance with "Record" Drawings.

END OF SECTION 23 09 00

SECTION 23 09 55

CONTROL SEQUENCE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SECTION INCLUDES

A. Control sequence is hereby defined to mean the manner in which, and methods by which, the controls function. The requirements for each type of operation are specified in this section

B. The operating equipment, devices, and system components required for the automatic control system are specified by Section 23 09 00 - Instrumentation and Control for HVAC of these specifications.

1.3 RELATED REQUIREMENTS

A. Section 23 09 00 - Instrumentation and Control for HVAC.

1.4 REFERENCE STANDARDS

A. Texas Government Code Chapter 2252.001-005; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.5 SUBMITTALS

A. Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. All HVAC systems shall be controlled with Direct Digital Control (DDC) according to the point list contained in this section of the Specifications and shall be stand-alone.

B. Additional points or software programming not listed in the point list but which are required to meet the following sequence of operation shall be provided.

PART 3 – EXECUTION -- NOT USED

END OF SECTION 23 09 55

SECTION 23 31 00

DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SECTION INCLUDES

A. Low Pressure Ducts.
B. Medium and High Pressure Ductwork.
C. Casings.
D. Kitchen Hood Ductwork.
E. Duct Cleaning.

1.3 RELATED REQUIREMENTS

A. Division 09 Section, Painting, priming or coating of metal ductwork exposed to view.
B. Section 23 00 00 - UTSW Mechanical Design Requirements
C. Section 23 05 29 - Supports and Anchors
D. Section 23 05 53 - Mechanical Identification
E. Section 23 07 13 - Ductwork Insulation
F. Section 23 33 00 - Ductwork Accessories
G. Section 23 36 00 - Air Terminal Devices
H. Section 23 37 00 - Air Inlets and Outlets
I. Section 23 05 93 - Testing, Adjusting, and Balancing

1.4 REFERENCE STANDARDS

A. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals.
B. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications.
C. ASTM A90 - Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
D. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
E. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
F. NFPA 45 - Standard on Fire Protection for Laboratories Using Chemicals.
G. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
H. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
I. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
J. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
K. SMACNA (ROUND) - Round Industrial Duct Construction Standards.
L. Texas Government Code Chapter 2252.001-005 - Texas Government Code Chapter 2252.001-005.
M. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.

1.5 DEFINITIONS

A. Duct Sizes: Inside clear dimensions. For lined ducts, maintain sizes inside lining.
B. Low Pressure: 3 inch WG positive or negative static pressure and velocities less than 1,500 fpm.
C. Medium Pressure: 6 inch WG positive static pressure and velocities greater than 1,500 fpm.
D. High Pressure: 10 inch WG positive static pressure and velocities greater than 2,500 fpm.

1.6 SUBMITTALS

A. Product Data:
   1. Provide product data for all ductwork systems to be used on project. Product data submittals shall include the following as a minimum:
      a. System name and type.
      b. Duct system design pressure.
      c. Hangers and supports, including materials, fabrication, methods for duct and building attachment.
      d. Sealant type.

B. Shop Drawings shall be submitted on all items of sheet metal work specified herein.
   1. Shop Drawings of ductwork at air units shall be submitted at a minimum scale of 3/8 inch equal to one foot.
   2. Shop drawings of ductwork located at all other locations shall be prepared at a scale of not less than 1/4 inch equal to one foot.
   3. Reproduction and submittal of the construction documents is not acceptable.
   4. Shop drawings shall include the following:
      a. Clearance dimensions between ducts and dimensions above finished floors for bottom and tops of ducts.
      b. Call out of duct materials other than galvanized including but not limited to stainless steel, aluminum, or prefabricated fire rated ductwork.
      c. Shop Drawings shall indicate location of all supply, return, exhaust and light fixtures from the approved reflected ceiling plans.
      d. Shop drawings shall identify all duct sizes, reinforcement and spacing.
      e. Penetrations through fire rated and other partitions.
      f. Show major equipment with ductwork connections.
      g. Show all dampers, turning vanes, access doors, fire dampers and all other ductwork accessories to be provided.
      h. Submit shop drawings and product data under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements

C. Submit two samples of stainless steel welded duct joint to Engineer and Owner for approval. After approval, sample shall remain at job site for reference.

D. Welding Certificates. Provide for all welders including procedures and standards of acceptance.

E. Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements.

B. Store and protect products under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements.

PART 2 - PRODUCTS

2.1 DUCTWORK GENERAL:

A. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise.
   1. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA Duct Manuals where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein.
   2. All exhaust ductwork including toilet room exhausts shall be constructed and leak tested as specified for medium pressure supply ducts at negative pressure.

B. All ductwork shown on the Drawings, specified or required for the heating, ventilating and air conditioning systems shall be constructed and erected in a first class workmanlike manner.
   1. The work shall be guaranteed for a period of 1 year from and after the date of acceptance of the job against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation.

2. After the system is in operation, should these defects occur, they shall be corrected as directed by the Architect.

C. All duct sizes shown on the Drawings are air stream sizes. Allowance shall be made for internal lining where required, to provide the required cross sectional area.

D. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for any length of time.

E. Except for special ducts specified elsewhere herein, all sheet metal used on the project shall be constructed from prime galvanized steel sheets and/or coils up to 60 inches in width.

1. Each sheet shall be stenciled with manufacturer's name and gauge.
2. Coils of sheet steel shall be stenciled throughout on 10 foot centers with manufacturer's name and must be visible after duct is installed.
3. Sheet metal must conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards."

F. Where ducts that are exposed to view (including equipment rooms), pass through walls, floors or ceilings, furnish and install sheet metal collars around the duct.

2.2 DUCTWORK LOW PRESSURE: (INCLUDES ALL EXHAUST DUCTWORK DOWNSTREAM OF FANS.)

A. The scope of low pressure ductwork is defined as all ductwork downstream of terminal units, and all exhaust ductwork downstream of fans.

1. Construction of all low pressure duct shall be in accordance with Low Velocity Duct Construction Standards as published by Sheet Metal and Air Conditioning Contractors National Association (SMACNA) and shall be sealed and tested at 3 inch static with the same test procedures as medium pressure ductwork.

B. Spiral wound round duct shall be as manufactured by United McGill Sheet Metal Company or approved equal.

C. The metal gauges listed in the 1995 SMACNA HVAC Duct Construction Standards for Metal and Flexible Duct are the minimum which shall be used for this project.

1. It shall be noted that the Contractor is responsible that the metal gauge selected is heavy enough to withstand the physical abuse of the installation.

D. Elbows:

1. Elbows shall be radius type and have a centerline radius of 1-1/2 times the duct diameter or width.
2. Elbows in round ducts may be smooth radius as described above or 5-piece 90 degree elbows and 3-piece 45 degree elbows.
3. Joints in round ducts shall be slip type with a minimum of three sheet metal screws.
4. Joints in sectional elbows shall be sealed as specified for duct sealing. 90˚ mitered elbows are not acceptable unless approved by the Architect/Engineer or Project Manager.

E. SEALANT:

1. All ductwork (except welded exhaust duct) shall be sealed with either "MP" (Multi-Purpose), Hardcast "Iron-grip 601", Polymer Adhesive "Airseal #11", or "United Duct Seal" (United McGill Corp.) water base, latex or acrylic type sealant.
2. Note that, except as noted, oil or solvent based sealants are specifically prohibited for use on this project.
3. For exterior applications, "Uni-Thane " (United McGill Corp.) polyurethane based sealant shall be used.
4. No other sealants may be used.
5. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3 inch wide open weave fiberglass tape. Sufficient additional sealant shall then be applied to completely imbed the cloth.
6. All sealants shall be UL rated at no more than flame spread of 5 and smoke developed of 0.
7. At contractor’s option, Hardcast 1602 sealant tape may be used in lap joints and flat seams.

2.3 DUCTWORK MEDIUM PRESSURE: (INCLUDES ALL EXHAUST DUCTWORK UPSTREAM OF FANS).

A. The scope of medium pressure ductwork is defined as all ductwork downstream of all air handlers, up to and including terminal units, plus all return air ductwork.

B. Construction of all ducts shall be in accordance with High Velocity Construction Standards as published by SMACNA. All round and rectangular duct construction, duct fittings, dampers, etc., are covered in this manual and it is to be adhered to.
   1. Spiral wound round duct shall be as manufactured by United McGill Sheet Metal Company or approved equal.
   2. The metal gauges are listed herein for round duct and for rectangular duct.

C. All ductwork (except welded exhaust duct) shall be sealed with either "MP" (Multi-Purpose), Hardcast "Iron-grip 601", or "United Duct Seal" (United McGill Corp.) water base, latex or acrylic type sealant. Note that, except as noted, oil or solvent based sealants are specifically prohibited for use on this project.

D. For exterior applications, "Uni-Thane" (United McGill Corp.) polyurethane based sealant shall be used. No other sealants may be used.

E. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3 inch wide open weave fiberglass tape. Sufficient additional sealant shall then be applied to completely imbed the cloth.

F. At contractor’s option Hardcast 1602 sealant tape may be used in lap joints and flat seams.

G. Oval ducts shall be spiral flat oval or welded flat oval equal to those of United McGill Sheet Metal Company with gauges and reinforcing as recommended by the manufacturer for medium pressure or the ducts may be Shop fabricated of completely welded construction of the following gauge:
   1. No. 24 gauge
   2. No. 22 gauge
   3. No. 20 gauge
   4. No. 18 gauge
   5. No. 16 gauge

H. Oval fittings shall be equal to those of United McGill Sheet Metal Company with requirements, sealing, etc., similar to that specified for round medium pressure work.

I. Oval duct reinforcing methods shall be submitted as Shop Drawings for approval. Reinforcing galvanized angles shall be of sizes specified for same size rectangular ducts. Galvanized angles shall be used where standing seams are specified for rectangular ducts. Attaching methods shall be shown on Shop Drawings and submitted for approval.

J. Testing of Medium Pressure Ductwork: (Includes from fan discharge through to the discharge of terminal units.)
   1. All medium pressure ducts shall be pressure tested according to SMACNA Chapter 10 test procedures.
      a. Design pressure for testing ductwork shall be 6 inches of water.
      b. Total allowable leakage shall not exceed 1 percent of the total system design air flow rate.
      c. When partial sections of the duct system are tested, the summation of the leakage for all Sections shall not exceed the total allowable leakage.
   2. The entire system of medium pressure ductwork shall be tested, including the VAV/Constant Volume Terminal Units (i.e. The ductwork shall be capped immediately prior to the Terminal Units, and tested as described above).
      a. After testing has proven that the ductwork is installed and performs as specified, the terminal units shall be connected to the ductwork and the connections sealed with extra care.
      b. The contractor shall inform the project inspector when the joints may be visually inspected for voids, splits, or improper sealing of the joints.
      c. If any leakage in the terminal unit connections/joints after the systems have been put into service, the leaks shall be repaired by:
         1) Complete removal of the sealing materials.
         2) Thorough cleaning of the joint surfaces.
         3) Installation of multiple layers of sealing materials.

3. At the option of the Owner, the Contractor may be allowed to eliminate the terminal units from testing by capping the supply ductwork prior to the terminal units, then inspecting the connection to the terminal units when complete. This option may only be exercised by the Resident Construction Manager, and then only if documented in writing prior to testing.

K. All exhaust ductwork, including toilet room exhausts, shall be constructed as for medium pressure ducts and shall be tested for leaks in the same manner as for medium pressure supply ducts.

L. Contractor may use DUCTMATE or Ward flanged Duct Joint system, reference SMCNA FIG. 1-4 “Transverse Joints” T-25a or T-25b on rectangular ductwork. Slip-on duct flanges are not acceptable. Contractor may at his option (where space permits) use rectangular ductwork with DUCTMATE or Ward system in lieu of oval ductwork.

M. Elbows:

1. Rectangular 90 degree elbows shall be constructed with single thickness turning vanes mounted on an integral rail.
2. Mitered 90 degree elbows are not allowed unless approved by the Engineer and Construction Manager.
3. Radius type rectangular elbows shall have a centerline radius of 1-1/2 times the duct diameter or width.
4. Elbows in round or oval ducts may be smooth long radius as described above or 5-piece 90 degree elbows and 3-piece 45 degree elbows.
5. Joints in round ducts shall be slip type with a minimum of three sheet metal screws. Joints in sectional elbows shall be sealed as specified for duct sealing.

2.4 VANES

A. Where rectangular elbows are shown, or are required for good air flow, contractor shall provide and install turning vanes.

B. Turning vanes shall be factory fabricated with integral support rail.

C. Radius elbows shall have a centerline radius of not less than one and one-half (1-1/2) times the duct width.

D. Submit Shop Drawings on factory fabricated and job fabricated turning vanes. Provide turning vanes in all rectangular radius elbows and offsets.

E. All turning vanes shall be anchored to the cheeks of the elbow in such a way that the cheeks will not breathe at the surfaces where the vanes touch the cheeks.

2.5 FLEXIBLE DUCTS

A. Low Pressure Insulated Flexible Duct may be used where shown on the drawings.

B. Duct shall be made with factory preinsulated duct supported by a corrosion resistant metal spiral, or a coated spring steel helix and solid inner liner mechanically interlocked or permanently bonded to the helix wire, covered with a minimum of 1-1/2 inch thick, 3/4 pound density fiberglass blanket sheathed in a vapor barrier of fiberglass reinforced aluminum foil and Mylar laminate.

1. The insulation shall have a minimum "K" factor of 0.29 at 60 degrees F. mean and a vapor barrier permeability rating of 0.05 per ASTM method E96-66, Procedure A.
2. The C factor shall be 0.24 to meet HUD requirements.

C. The duct shall be rated for a positive working pressure of 10 inches w.g. and a temperature of up to 250 degrees F.

D. The duct shall comply with NFPA 90A and be listed and labeled by Underwriters Laboratories, Inc., as Class I Air Duct, Standard 181, and meet GSA, FHA, and other U. S. Government standards; flame spread, not over 25; smoke developed, not over 50.

E. Flexible ducts shall be not more than 5 feet in length, shall be installed as indicated in the diffuser connection detail, and shall be Flexmaster Type 1M or approved equal.

F. Connections:

1. The terminal ends of the duct core shall be secured by compression coupling or stainless steel worm gear type clamp equal to Ideal Series 56 Snaplock.

2. The fittings on Air Devices and on sheet metal duct shall be coated with the sealant specified for low pressure ductwork, then flexible duct core slipped over duct and coupling or clamp tightened, then connection sealed with more sealant.
3. Insulation of flexible duct shall be slipped over connection to point where insulation abuts mixing box or insulation on duct.
4. These insulation connections shall be sealed by imbedding fiberglass tape in the sealant specified for medium pressure ductwork and coating with more sealant to provide a vapor barrier. (This applies to all flex connections to diffusers, grilles, etc. when allowed on the drawings.)
5. Medium and High Pressure Insulated Flexible Duct:
    a. Shall be factory applied insulation of 1 inch minimum thickness, 3/4 pound density with a permeability rating of 0.30.
    b. The duct shall be composed of dead soft, spiral wound, triple locked corrugated aluminum core covered with Ratings shall be as described for Low Pressure Duct above.
6. Flexible ducts shall be not more than 2 feet in length, used for alignment or sound/vibration purposes only, and may only be installed in straight runs.
7. Flexible duct shall NOT be used for changes of direction of air flow,and shall be Flexmaster Type TL-M or approved equal. Installation, clamps and sealing shall be the same as specified for rigid duct.

2.6 LABORATORY EXHAUST DUCTWORK

A. Applies to stainless steel ductwork indicated in specification application table for Laboratory Exhaust Systems.

B. Provide exhaust ductwork of minimum gages:

DUCT SIZE	GAGE
28-inch diameter or less	18
30-inch to 60-inch diameter	16
61-inch diameter or greater	14
Greater than 60 x 42 (rectangular or oval)	Comply with SMACNA

C. ALL LAB EXHAUST DUCTWORK SHALL HAVE LONGITUDINAL BUTT (“SOLID”) WELD SEAMS WITH BUTT WELD JOINTS. Butt-weld all joints and fittings using Gas Tungsten Arc Welding (“TIG”). Welding procedures shall meet the requirements of AWSD1.1. Welds on exposed ductwork inside the building shall be ground and polished. Duct sealant shall not be used to seal ductwork.

D. Provide required transitions from duct to equipment and make equipment connections as called out on drawings.

E. Fittings:
    1. Refer to Round and Oval Ducts and Fittings General Requirements in this specification. Transverse and longitudinal seams shall be butt welded joints.
    2. Refer to drawings for additional information.

F. Submit certification of welder’s qualifications to perform the required welding operations and all project WPS for TIG welding sheet metal. All welder certifications shall be maximum 2 years prior to date of awarding contract.

2.7 ALUMINUM DUCTWORK

A. Provide aluminum ductwork only where indicated on the drawings.

B. Duct joints shall be all soldered construction, one standard gauge heavier than for the same size galvanized steel ducts.

2.8 DUST COLLECTOR SYSTEMS

A. Duct system shall be galvanized, constructed and supported in accordance with SMACNA Industrial Round Duct Construction for Class 2, 8 inch w.g. pressure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer also to requirements included in Part 2 of this specification.
B. Obtain manufacturer's inspection and acceptance of fabrication and installation of fiberglass ductwork prior to beginning of installation.
C. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
D. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
E. Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.
F. Coat buried, metal ductwork without factory jacket with one coat and seams and joints with additional coat of asphalt base protective coating.
G. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
H. Connect terminal units to medium or high pressure ducts directly or with two feet maximum length of flexible duct. Do not use flexible duct to change direction. Allow for a minimum of 3 diameters of straight duct to the entrance of all terminal units.
I. Connect diffusers with 5 feet maximum length or troffer boots with 2 feet maximum length of flexible duct to low pressure ducts. Hold in place with strap or clamp, and seal as specified.
J. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Use stainless steel for ductwork exposed to view and stainless steel or galvanized steel for ducts where concealed.
K. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

3.2 LOW PRESSURE DUCT SUPPORTS

A. See Section 23 05 29 - Supports and Anchors

3.3 MEDIUM PRESSURE DUCT SUPPORTS:

A. See Section 23 05 29 - Supports and Anchors

3.4 DUCTWORK APPLICATION SCHEDULE

AIR SYSTEM	MATERIAL
UNTREATED OUTSIDE AIR INTAKE	GALVANIZED STEEL
MEDIUM PRESSURE SUPPLY	GALVANIZED STEEL
LOW PRESSURE SUPPLY	GALVANIZED STEEL
RETURN/RELIEF AIR	GALVANIZED STEEL
GENERAL EXHAUST AIR	GALVANIZED STEEL
SHOWER EXHAUST	316L STAINLESS STEEL
LAB HOOD/BIOSAFETY CABINET EXHAUST/WASHER EQUIPMENT CONNECTION	316L STAINLESS STEEL TO MAIN DUCT CONNECTION – SLOPED BACK TO SOURCE
ROOFTOP DUCTWORK	316L STAINLESS STEEL
EMERGENCY GENERATOR EXHAUST	DOUBLE WALL OR BLACK STEEL

3.5 CLEANING OF SYSTEMS

A. Before turning the installation over to the Owner, all ducts should be cleaned and blown free of all dust and dirt that has collected in the ducts.

END OF SECTION 23 31 00

SECTION 23 33 00

DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SECTION INCLUDES

A. Manual and Automatic Volume Control Dampers.
B. Fire Dampers.
C. Combination Fire/Smoke Dampers.
D. Backdraft Dampers.
E. Air Turning Devices.
F. Flexible Duct Connections.
G. Duct Access Doors.
H. Duct Test Openings.
I. Gravity Ventilator Hoods.

1.3 RELATED REQUIREMENTS

A. Section 01 91 00 - General Commissioning Requirements.
B. Section 23 00 00 - UTSW Mechanical Design Requirements.
C. Section 23 05 29 - Supports and Anchors.
D. Section 23 05 53 - Mechanical Identification.
E. Section 23 31 00 - Ductwork.
F. Section 23 36 00 - Air Terminal Devices.

1.4 REFERENCE STANDARDS

A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating.
B. ASHRAE Std 135 - A Data Communication Protocol for Building Automation and Control Networks.
C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
D. Bluetooth CS - Bluetooth Core Specification.
E. IEEE 802.11 - IEEE Standard for Information Technology--Telecommunications and Information Exchange between Systems - Local and Metropolitan Area Networks--Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.
F. IEEE 802.15.4 - IEEE Standard for Low-Rate Wireless Networks.
G. LonMark Interoperability Guide - LonMark Application-Layer Interoperability Guide and LonMark Layer 1-6 Interoperability Guide; Version 3.4.
H. Modbus (PS) - The Modbus Organization Communications Protocol..
I. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
J. NFPA 80 - Standard for Fire Doors and Other Opening Protectives.
K. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
L. NFPA 92 - Standard for Smoke Control Systems.
M. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
N. NFPA 105 - Standard for Smoke Door Assemblies and Other Opening Protectives.
O. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
P. Texas Government Code Chapter 2252.001-005 - Texas Government Code Chapter 2252.001-005.
Q. UL 33 - Safety Heat Responsive Links for Fire-Protection Service.
R. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.

S. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.
T. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.
U. UL 263 - Standard for Fire Tests of Building Construction and Materials.
V. UL 555 - Standard for Fire Dampers.
W. UL 555C - Standard for Safety Ceiling Dampers.
X. UL 555S - Standard for Smoke Dampers.
Y. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

1.5 SUBMITTALS

A. Product Data: Provide published literature for volume control dampers, duct access doors, duct test holes, and hardware used including dimensions, weights, capacities, ratings, gauges, and finishes of materials, and electrical characteristics and connection requirements.
B. Shop Drawings: Submit under the provisions of 23 00 00 - UTSW Mechanical Design Requirements. Submit assemblies for shop fabricated assemblies indicated including model numbers, locations, and qualities for components including volume control dampers.
C. Submit manufacturer's installation instructions under provisions of Section 23 00 00 - UTSW Mechanical Design Requirements for fire dampers and combination fire and smoke dampers.
D. Mockups: Provide mockups for all types of fire and smoke dampers in locations as directed by Owner's Project Manager and OSBC.
E. Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect dampers from damage to operating linkages and blades.

PART 2 - PRODUCTS

2.1 DAMPERS

A. Furnish and install manual volume dampers where shown on the drawings and wherever necessary for complete control of the air flow, including all supply, return and exhaust branches, "division" in main supply, return, and exhaust ducts, each individual air supply outlet and fresh air ducts.
    1. Where access to dampers through a fixed suspended ceiling is necessary, the Contractor shall be responsible for the proper location of the access doors.
B. Locations: Dampers shall be carefully fitted, and shall be controlled by locking quadrants equal.
    1. Exposed uninsulated ductwork: Provide equal to Ventlok No. 555.
    2. Exposed externally insulated ductwork: Provide equal to Ventlok No. 644.
    3. Concealed ductwork above lay-in accessible ceilings: Provide Ventlok No. 555 or No. 644 locking quadrant for splitter dampers.
    4. Concealed ductwork not above lay-in accessible ceilings: Provide equal to Ventlok No. 677 (2 5/8 inch diameter) chromium plated dover plate.
    5. When No. 555 or No. 644 regulators are used, furnish and install end bearings for damper rods on the ends opposite the quadrant.
    6. When No. 677 regulators are used, furnish and install end bearings for the damper rods on both ends.
C. Dampers larger than three (3) square feet in area shall be controlled by means of rods hinged near the leading edge of the damper with provisions for firmly anchoring the rod and with end bearings supporting the axle.

D. Manual volume dampers shall be equal to Ruskin model CD60, Greenheck model VCD-33, or approved equal.
   1. Blades shall not exceed 48 inches in length or 12 inches in width and shall be of the opposed interlocking type.
   2. The blades shall be of not less than No. 16-gauge galvanized steel supported on 1/2 inch diameter rust proofed axles.
   3. Axle bearings shall be the self-lubricating ferrule type.

E. Install all automatic control dampers, furnished by the Temperature Control Manufacturer, in strict accordance with the manufacturer's recommendations and requirements of these Specifications.

F. All adjustable dampers installed in externally insulated ductwork shall be installed with Ventlok No. 639, or equivalent elevated dial operators.
   1. Insulation shall extend under the elevated dial.
   2. All adjustable dampers installed in internally insulated ductwork shall be installed with Ventlok No. 635 or equivalent dial operators.
   3. All damper shaft penetrations in the ductwork shall be installed with Ventlok #609 end bearings.

2.2 FIRE DAMPERS AND COMBINATION FIRE/SMOKE DAMPERS

A. Furnish and install fire dampers where shown on the drawings or required by the Specifications, fire dampers meeting the following requirements.
   1. Each fire damper shall be constructed and tested in accordance with UL 555. All dampers shall possess a 1 1/2 hour or 3 hour (as appropriate for the construction shown in the architectural drawings) protection rating, 165 or 212 degree F fusible link, and shall bear a UL label in accordance with Underwriters Laboratories labeling procedures. Fire dampers shall be constructed such that the damper frame material and the curtain material shall be galvanized.
   2. Fire dampers shall be curtain blade or multi-blade type and the damper shall be so constructed that the blades are either out of the air stream or installed in an oversized sleeve to provide a 100 percent free area of the duct in which the damper is housed.
   3. The damper manufacturer's literature submitted for approval prior to the installation shall include performance data developed from testing in accordance with AMCA 500-D Standards and shall show the pressure drops for all sizes of dampers required at anticipated airflow rates. Maximum pressure drop through fire damper shall not exceed 0.05 inch water gauge.
   4. Fire dampers shall be equipped for vertical or horizontal installation as required by the locations shown in the drawings.
   5. Fire dampers shall be installed in wall and floor openings utilizing steel sleeves, angles and other material and practices required to provide an installation equivalent to that utilized by the manufacturer when the respective dampers were tested by Underwriters Laboratories.
   6. Mounting angles shall be a minimum of 1-1/2 inch by 1-1/2 inch by 14-gauge and bolted, tack welded or screwed to the sleeve at maximum spacing of 12 inches and with a minimum of two connections at all sides. Mounting angles shall overlap at least equal to the gauge of the duct defined by the appropriate SMACNA (DCS), latest edition, and as described in NFPA 90A The entire assembly, following installation, shall be capable of withstanding 6 inches water gauge static pressure.
   7. The damper installation shall be in accordance with the damper manufacturer's instructions.
   8. All fire dampers shall comply with the specification as written above and shall be one of the following:
      a. Ruskin model DIBD2 (Style C, CR or CO).
      b. Greenheck model DFD 150 or DFDR-150 (Type C, CR or CO).
      c. Pottorff model VFD-10D-A.
   9. The contractor shall completely seal the assembly to the building components using Hardcast 1602 sealant tape to allow for expansion and contraction of the sleeve and damper assembly.
   10. Dampers shall be UL labeled for use in dynamic systems. Closure reading shall be 110 percent of the maximum design airflow at the point of installation. The minimum closure pressure rating shall be 8 inch wg for airflow in either direction.

B. Combination Fire/Smoke Dampers

1. Furnish and install where shown on the drawings, or as required by the specifications, combination fire/smoke dampers meeting the following requirements.
2. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under UL 555, 4th Edition, and shall be further classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL 555S, and bear a UL label attesting to it. The damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers required by this specification. Testing and UL qualifying a single damper size is not acceptable. The leakage rating under UL 555S shall be no higher than Leakage Class I (4 cfm per square foot at one inch water gauge pressure and 8 cfm per square foot at 4 inches water gauge pressure). The maximum air pressure drop through each combination fire/smoke damper shall not exceed 0.10 inch water gauge at the design air quantity. (Note that this may require a larger damper than the connected duct size.)
3. The damper frame shall be a minimum of 20-gauge galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be integral high surface area non electrolytic materials construction to incorporate a friction free frame blade lap seal, or molybdenum disulfide impregnated stainless steel or bronze Oilite sleeve type turning in an extruded hole in the frame or an extruded frame raceway. The dampers may be either parallel or opposed blade type. The blades shall be constructed with a minimum of 14-gauge equivalent thickness. The blade edge seal material shall be able to withstand 450 degrees F. The jamb seals shall be flexible stainless steel compression type or lap seal type.
4. In addition to the leakage ratings specified herein, the combination fire/smoke dampers and their operators shall be qualified under UL 555S to an elevated temperature of 250 degrees F. Electric operators shall be installed by the damper manufacturer at the time of damper fabrication. The damper and operator shall be supplied as a single entity that meets all applicable UL 555 and UL 555S qualifications for both dampers and operators. The manufacturer shall provide a factory-assembled sleeve. The sleeve shall be a minimum of either 20-gauge for dampers where neither width nor height exceeds 48 inches or 16-gauge where either dimension equals or exceeds 48 inches.
5. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures of at least 4 inches water gauge in the closed position, and 2500 fpm air velocity in the open position.
6. Each combination fire/smoke damper shall be equipped with a UL Classified Firestat/releasing device. The Firestat/releasing device shall electrically and mechanically lock the damper in a closed position when the duct temperatures exceed 165 degrees F and still allow the appropriate authority to operate the damper as may be required for smoke control functions. The damper must be operable while the temperature is above 250 degrees F. The actuator/operator package shall include two damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One switch shall close when the damper is fully open, and the other switch shall close when the damper is fully closed. The Firestat/releasing device and position indicator switches shall be capable of interfacing electrically with the smoke detectors, building fire alarm systems, and remote indicating/control stations.
7. The damper releasing device shall be mounted within the airstream. The device shall be activated and the damper shall close and lock when subjected to duct temperatures in excess of approximately 285 degrees F.
8. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated in the plans, and shall be furnished and installed by the damper manufacturer as required by the U.L. rating mentioned above. Motors shall be electric or pneumatic to match the type of temperature control system specified elsewhere in this specification. All required relays, EP switches, wiring piping and other labor and material necessary to completely interconnect the smoke detector system shall be furnished by the Contractor.
9. Each damper shall be furnished in a square or rectangular configuration. The Contractor shall furnish and install sleeves manufactured by the approved damper manufacturer for each damper.

The sleeves shall be constructed with square or rectangular to square, rectangular, round, or oval adapters as required. Dampers shall be installed in the sleeves in accordance with manufacturers installation instructions. The entire assembly, following installation, shall be capable of withstanding 6 inches W.T. static pressure.

C. Combination fire/smoke dampers shall comply with the specification as written above and shall be one of the following:
   1. Ruskin Model FSD60.
   2. Greenheck Model FSD 331.
   3. Pottorff.

D. The contractor shall completely seal the assembly to the building components using Hardcast 1602 sealant tape to allow for expansion and contraction of the sleeve and damper assembly.

E. Dampers shall be UL labeled for use in dynamic systems. Closure reading shall be 110 percent of the maximum design airflow at the point of installation. The minimum closure pressure rating shall be 8 inches wg for airflow in either direction.

F. Submittal and Installation
   1. The air quantity and free area through each fire and combination fire and smoke damper has been noted on the drawing adjacent to the duct size or wall opening size where such damper is required.
   2. Submittal(s) for fire, smoke, and combination fire/smoke dampers shall include the following:
      a. Assign identification numbers for each damper with corresponding number noted on the drawings.
      b. Provide air quantity, size, free area of damper, pressure drop and proposed velocity through each damper.
      c. Provide manufacturer's data of damper and its accessories or options.
   3. One sample 18 inches x 12 inches damper shall be furnished for the purpose of illustrating damper operation to the Owner's operating and maintenance personnel.
   4. Doors shall open not less than 90 degrees following installation and shall be insulated type where installed in insulated ducts.
   5. Contractor shall install each damper square and true to the building. The installation shall not place pressure on the damper frame, but shall enclose the damper as required by UL 555.
   6. After each fire damper and combination fire and smoke damper has been installed and sealed in their prescribed openings and prior to the installation of the ceilings, the Contractor shall, as directed by the Construction Inspector, activate part or all the dampers as required to verify "first time" closure.
      a. Activation of the damper shall be accomplished by manually operating the resettable link, disconnecting the linkage at the fusible link of the fire damper, and manually operating the fire/smoke damper through the pneumatic or electronic controls as appropriate.
      b. Failure of the damper to close properly and smoothly on the first attempt will be cause to replace the entire damper assembly.

2.3 FLEXIBLE CONNECTIONS

A. Provide Ventglas fabric connection where flexible connections for ducts connect to fans, including roof exhausters.
   1. Fabric connection shall be fire resistant, waterproof, mildew resistant, and air tight, and shall weigh approximately 30 ounces per square yard.
   2. Provide a minimum of 1/2 inch slack in the connections, and a minimum of 2 1/2 inches distance between the edges of the ducts except that there shall also be a minimum of 1 inch of slack for each inch of static pressure on the fan system.
   3. This does not apply to Air Handling Units with internal isolation.

2.4 DUCT ACCESS DOORS

   1. Provide low, medium, and high-pressure duct access doors with gaskets/seals appropriate for designed pressures of each installation. Provide product greater than or equal to Ductmate Duct Access Door sandwich style with double thumbscrew latch.
   2. Double-skin doors with one-inch of insulation in the door required where ducts are insulated.

3. Doors shall be 18 inches by 16 inches or 18 inches in diameter minimum, dependant on duct sizing, and provide Ventlok No. 260 latches on rectangular doors.
4. Doors sized smaller than 18 inches by 16 inches shall use Ventlok No. 100 or 140 latches.
5. Doors for zone heating coils shall be minimum 10 inches by 12 inches or 12 inches in diameter Ventlok doors. Provide stamped, insulated doors, complete with latch and two (2) hinges.
6. Doors required to be round shall be Flexmaster USA "Inspector Series" spin-in type or approved equal.
7. Doors for personnel access to ductwork shall be nominal 24 inches in diameter.

B. Where these access doors are above a suspended ceiling, this Contractor shall be responsible for the proper location of the ceiling access doors.

2.5 SCREENS

A. Furnish and install screens on all duct, fan, etc., openings furnished by this Contractor that lead to, or are, outdoors.

B. Screens shall be No. 16 gauge, 1/2 inch mesh in removable galvanized steel frame.

C. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

2.6 DUCT TAPS (CONICAL FITTINGS)

A. Conical fittings shall be used for duct taps and shall include quadrant dampers on all lines to air devices (diffusers and grilles), even though a volume damper is specified for the air device. A damper is not required for medium pressure duct taps. Spin in fittings shall be sealed at the duct tap with a gasket, or compression fit, or sealed with sealant specified for medium pressure ductwork. The location of spin in fittings in the ducts shall be determined after dual or single duct terminal units are hung or the location of the light fixtures is known to minimize flexible duct lengths and sharp bends.

B. The conical fitting shall be made of at least 26-gauge galvanized sheet metal. The construction to be a two- piece fitting with a minimum overall length of 6 inches and shall be factory sealed for high pressure requirements. Average loss coefficient for sizes 6, 8, and 10 shall be less than 0.055.

C. Each fitting shall be provided with a minimum 24-gauge damper plate with locking quadrant operator and sealed end bearings. Damper blade shall be securely attached to shaft to prevent damper from rotating around shaft.

D. Provide flange and gasket with adhesive peel-back paper for ease of application. The fitting shall be further secured by sheet metal screws spaced evenly at no more than 4 inches on-center with a minimum of four screws per fitting.

E. The conical bell-mouth fitting shall be one of the following:
1. Flexmaster U.S.A., Inc. Series 3000G.
2. Buckley Air Products, Inc., 'AIR-TITE'.

2.7 GRAVITY VENTILATORS

A. Provide gravity ventilators of type, size, and capacity as scheduled on the drawings.

B. Gravity ventilators shall be low silhouette with removable hood, all aluminum with curb cap, 1/2 inch galvanized steel square mesh bird-screen, and back-draft damper. Provide motorized damper in lieu of back-draft damper as indicated on the Drawings.

C. Provide prefabricated 16-gage galvanized steel roof curb with mitered corners. Mount unit on a minimum 12 inches high curb base with 1-1/2 inch thick 3 pound density rigid fiberglass insulation adhered to inside walls between duct and curb. Provide curb with built-in cant and mounting flange for flat roof decks, and 2 inch treated wood nailer.

D. Gravity ventilators shall be coated in a factory baked enamel finish. Coordinate color of finish with the Owner/Architect.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions.

B. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Use splitter dampers only where indicated.
C. Provide balancing dampers on medium or high pressure systems where indicated.
D. Provide fire dampers, and combination fire and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
E. Demonstrate resetting of fire dampers to Owner's representative.
F. Provide backdraft dampers on exhaust fans or exhaust ducts where indicated.
G. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Cover connections to medium and high pressure fans with leaded vinyl sheet, held in place with metal straps.
H. Provide duct test holes where indicated and where required for testing and balancing purposes.

END OF SECTION 23 33 00

SECTION 23 36 00

AIR TERMINAL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 01 General Requirements, the remaining Sections of the Specifications, and the Contract Drawings are collectively applicable to this Section.

1.2 SECTION INCLUDES

A. Variable volume terminal units.
B. Dual duct terminal units.
C. Variable volume regulators.
D. Integral sound attenuator.
E. Integral damper motor operators.
F. Integral controls.

1.3 REFERENCE STANDARDS

A. Texas Government Code Chapter 2252.001-005; Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.
B. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2018
C. AHRI 880 (I-P) - Performance Radiant of Air Terminals; 2011 with Addendum 1.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Submit shop drawings under provisions of Division 01 and Section 22 00 10 - Basic Plumbing Requirements.
   2. Submit shop drawings indicating configuration, general assembly, and materials used in fabrication.
B. Product Data:
   1. Submit product data under provisions of Division 01 and Section 22 00 10 - Basic Plumbing Requirements.
   2. Submit product data indicating configuration, general assembly, and materials used in fabrication Include catalog performance ratings that indicate air flow, static pressure, and NC designation.
   3. Include schedules listing discharge and radiated sound power level for each of second through seventh octave bands at inlet static pressures of one inch w g.
   4. Submit manufacturer`s installation instructions under provisions of Division 01 and Section 22 00 10 - Basic Plumbing Requirements.
C. Samples:
   1. A sample 8 inch size production run unit shall be submitted for examination and approval by the Engineer, UTSW FM, and the Owners Testing and Balancing (TAB) Consultant.
      a. This submittal box shall be submitted, in addition to the required written submittal, well in advance of any requirement for installation of boxes, but absolutely no later than 60 days after the date of the start of construction stipulated in the Work Order letter from the Owner to the General Contractor.
      b. A minimum of three weeks shall be allowed by the Contractor for file testing of the box from the time of submittal to the time of determination of project worthiness.
      c. This period shall restart if the sample box is rejected and another box is resubmitted.
      d. If rejected for any reason, the Contractor shall expedite the corrections documented, and shall resubmit a sample box as soon as possible.
      e. Any delay in the submittal of the box for approval shall not be grounds for a claim of delay on the part of the Contractor.

f. If approved, the unit shall remain in the possession of the Owner at the job site for comparison with units as shipped to project.
g. The unit shall be installed in the project, at an accessible, marked location.
h. The unit manufacturer shall test and certify that each box used on this project has been tested as specified.

D. Provide certification of adherence and compliance with Texas Government Code Chapter 2252.001-005 Contracts with Governmental Entity requirements.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 1 and Section 23 00 00 - UTSW Mechanical Design Requirements.

B. Include manufacturer`s descriptive literature, operating instructions, maintenance and repair data, and parts lists

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five years documented experience

1.7 WARRANTY

A. Provide one-year manufacturer`s warranty under provisions of Division 01 and Section 22 00 10 - Basic Plumbing Requirements.

PART 2 -- PRODUCTS

2.1 VARIABLE OR CONSTANT VOLUME TERMINAL UNITS

A. The Contractor shall furnish and install pressure independent dual and/or single duct variable air volume control assemblies with integral attenuator (single duct units) and attenuator-mixers (dual duct units), of the sizes, capacities and configurations shown on the Drawings.

1. Casing Construction:
   a. The units shall be constructed of a minimum of 22 gauge galvanized steel and internally lined with a minimum of 1 inch thick, three pound per cubic toot density insulation.
   b. The insulation shall be foil faced with the edges and seams sealed or "captured", encapsulating all fibers of the insulation.
   c. The insulation shall be neatly installed with no rough edges to interrupt the smooth flow of air through the box.
   d. The casing shall be insulated throughout its interior.
   e. The external insulation shall be as specified in other sections of this specification for duct insulation with full vapor barrier, and shall be field installed unless coil and plenum section is furnished as an integral part of the box.
   f. All interior features of the boxes (such as mixing baffles, damper housings, etc) shall be secured within the casing to avoid excessive movement or rattling with air movement or externally generated vibration.
   g. All external features of the terminal units shall be designed not to extend beyond the ends of the unit (For example, the actuator mounting brackets, etc., shall not extend beyond the plane of the inlet "bulkhead").
      1) The only exception shall be flow sensors installed in the inlet duct connections.
      2) Note that if a separate flow station is installed within a frame within the casing, then it shall be so installed not to allow air flow to bypass the flow measurement station.
2. The terminal units shall be constructed with inlet and discharge ductwork connections.
   a. The inlet ductwork connections shall extend a minimum of 4 inches from the unit casing including an allowance for the installation of air flow station(s) or probe(s).
   b. The discharge connection shall include 1 inch extension with slip and drive connections for use by the contractor to secure the discharge ductwork or appurtenances to the unit and shall be reinforced to provide a rigid assembly.
3. Casing Leakage:

a. Assembled Units shall be so constructed and sealed to limit air leakage to the following listed quantities at 6 inch static pressure
b. Leakage curves or tables will be required as part of the submittal data The following is the maximum allowable casing leakage including all components:

Diameter(inches)	Maximum Allowed CFM (Area x 2000 fpm)	Maximum AllowableCFM Casing Leakage
4, 5, 6,	393	8.0
7 - 8	698	14.0
9 - 10	1091	22.0
11 - 12	1571	30.0
12 - 14	2138	40.0

4. Access Plenum and Door:
   a. An access panel shall be provided immediately downstream of the dampers for inspection and service of the dampers.
   b. The access plenum shall contain a minimum of a 12 inch diameter or 12 inch by 12 inch (or full width of unit if less than 12 inches) access door as manufactured by Ventlok.
   c. Door frame may be bolted, screwed or flanged and sealed to the casing.
   d. Door shall be gasketed and shall be double all construction or insulated similar to main casing
   e. Door shall be held in place with latches or other captive retainer devices.
   f. If the damper assembly is easily removed from the rear of the box, the access size can be reduced to 8 inch round or 8 inches by 8 inches for inspection only.
5. Damper Construction:
   a. The damper blades shall be an equivalent of 18 gauge galvanized steel or equal aluminum and shall be securely riveted or bolted through the damper shafts to assure no slippage of the blades.
   b. The damper shafts shall operate in rust-proof self-lubricating bearings.
   c. Damper shafts penetrating the unit casings shall be sealed against leakage, and bearings shall be installed for protection against wear in the casing penetration.
   d. Damper shafts shall be formed of, or cut from solid stock; no hollow shafts will be allowed.
   e. The dampers shall seat against gasketed stops or the dampers shall have gasketed edges.
   f. The dampers shall be so constructed to prevent "oil canning" of the damper blade.
   g. The units shall be tested for leakage in both inlets with 6 inches static pressure imposed on one inlet at a time.
   h. The maximum percent leakage from all tests shall be reported.
   i. Leakage curves as a function of pressure shall be supplied as part of the submittal data.
   j. The damper actuator linkage, if used, shall be constructed of material of sufficient strength to avoid buckling under extreme loads.
   k. Linkages shall not allow play greater than 5 degrees of damper movement.
   l. The controls for the dampers shall cause the dampers to fail in the position of last control (freeze in place), or fail to the open position.
6. Damper Leakage:
   a. The following is the maximum damper leakage allowable for the various size diameter inlets at 6 inches w g differential pressure.
      1) The damper leakage shall not exceed the values listed in the table below at 6 inches S P, following ARI 880 Testing Procedures.

Diameter (inches)	Maximum Allowed CFM (Area x 2000 fpm)	Maximum Allowable CFM Damper Leakage
4, 5, 6,	393	6.0
7 - 8	698	10.5
9 - 10	1091	16.5
11 - 12	1571	20.0

12 - 14	2138	30.0

7. Unit Pressure Drop:
   a. For dual duct units with an integral attenuator mixer, but with no other accessories, the static pressure across the assembly with an equivalent 2000 fpm inlet velocity through one inlet shall not exceed 0.50 inches water gauge, with the total flow through either inlet.
   b. Single duct unit pressure drop shall be limited to 0.15 inches water gauge under the same conditions above.
8. Certification:
   a. The unit manufacturer shall certify that each unit used on this project will perform as specified.
   b. Each unit shall bear a tag or decal listing the following specified information:
      1) Test Pressure.
      2) Leakage CFM (damper).
      3) Leakage CFM (casing).
      4) Date of Mfg.
      5) Room or area served.
      6) Unit size - 6 inches, 8 inches, etc.
      7) Calibrated CFM, i e 800 CFM.
9. Mixing:
   a. Dual duct terminal units as specified shall provide mixing within the units, and not rely upon the discharge ductwork to provide for the completion of the mixing process.
   b. The horizontal average temperature of the air as it leaves the terminal unit shall not vary more than 1 degree F for each 20 degrees F of temperature difference between the two inlet air supplies (For example, if the cold supply air is 55 degrees F and the hot supply air is 95 degrees F, the difference is 40 degrees The allowable temperature variation of the discharge air is, thus, 2 degrees F).
   c. The temperature of the discharge air shall be measured using a pattern of four vertical, evenly spaced columns, and three horizontal, evenly spaced rows.
   d. The rows and columns shall be spaced so that the resulting 12 points shall be at the centers of equal areas.
   e. The plane of the points shall be perpendicular to the direction of air flow, within 4 inches of the discharge of the terminal unit, within the discharge ductwork.
   f. The three readings in each column shall be averaged to determine compliance with the 1 inch criteria.
10. Flow Measurement:
    a. Air flow thru the unit shall be accomplished by the use of brass "T's" and a metal multi-port sensing device with a minimum of four radially distributed pick-up points connected to a center averaging chamber with adequate internal passages to prevent restrictions that can result in control "hunting".
11. Sound: (Note that the maximum sound levels listed in this paragraph refer to raw sound levels, with no credits taken for the construction).
    a. Discharge Sound:
       1) Maximum discharge Sound Power Levels at 2000 fpm primary air inlet velocity with 1.5 inch w g inlet static pressure shall not exceed that listed in the following table.
       2) No credit for lined discharge duct, branching, flow division, end reflection, room absorption or any other effects shall be allowed.

Octave Band	Center Frequency (Hz)	Sound Power Level (dB re 10^{12} Watts)
2	125	76
3	250	66
4	500	63
5	1000	58
6	2000	60

7	4000	55

b. Radiated Sound:
   1) Maximum discharge Sound Power Levels at 2000 fpm primary air inlet velocity with 1.5 inch w g inlet static pressure shall not exceed that listed in the following table.
   2) No credit for ceiling plenum, ceiling tiles, room absorption, or any other effects shall be allowed.

Octave Band	Center Frequency (Hz)	Sound Power Level (dB re 1012 Watts)
2	125	
3	250	
4	500	
5	1000	
6	2000	47
7	4000	

c. All sound power levels shall be obtained from testing in accordance with ARI-ADC Standard 880 and shall be certified at ARI-880 certification points.

12. Testing Prior to Installation:
   a. Shipment Testing:
      1) A minimum of ten percent of each size of the terminal units (but no less than one unit of each size used) may be tested for conformance to this specification, at the Owner`s discretion.
      2) The Contractor shall allow sufficient time during construction and space for the Owners TAB Consultant to perform all testing as may be required.
   b. Unit Non-Performance:
      1) If the results of the Shipment Testing show that any of the units do not perform as specified, then an additional 10 percent of each size (but no less than one unit of a size, unless 100 percent of the size has been tested) of the units shall be tested.
         (a) If this testing, in the Owner`s opinion, shows that 10 percent or more of the units tested do not perform as specified, then 100 percent of all sizes of the units shall be tested for conformance with these specifications.
         (b) The results of that testing shall be reviewed carefully between the Contractor, manufacturer, the Owner`s construction administrator(s), and the Owner`s design engineer(s).
         (c) A method of repair or replacing the units will be negotiated.
         (d) The Owner, however, shall maintain the right of final approval of any proposed solution.
      2) Should for any reason the testing described above under "Submittal" and "Shipment Testing" prove that any of the units do not perform as specified, the Contractor shall be responsible for all subsequent labor, travel, travel expenses, and incidental expenses, penalties, or other costs attendant to any additional testing as described under "Unit
         (a) Non-Performance", or as required to prove that the units perform as specified.
         (b) This shall Include, but not be limited to, the labor, travel and reasonable incidental expenses of not only the Contractor and Owner`s TAB Consultant, but also those incurred by the Owner as may be specifically required for this purpose.
         (c) The expenses to be reimbursed to the Owner shall be labor at a rate of $300 per day or any portion of a day, plus travel and travel expenses at actual cost, plus reasonable incidental expenses at actual cost.

13. Manufacturer:
   a. All Terminal Units shall be as manufactured by Titus (model DESV or DMDV), Metal*Aire (TH-500), Nailor Industries (model 3000-UT or 3200-UT) or Price Industries (models SDV-UT or DDS-UT).
   b. Note that the model and series numbers listed may differ slightly from catalogue information.

c. No other manufacturers or models are acceptable.
d. Even though specific manufacturers may be named, the material supplied by any approved manufacturer shall meet all of the provisions of this specification without exception.

14. Hot water Coils:
    a. Hot water coils installed in conjunction with single duct terminal units shall be factory installed, one or two row with a maximum of 10 aluminum fins per inch.
    b. Air side pressure drop shall be limited to 0.2 inch wg at box rated flow.
    c. Full fin collars shall be provided for accurate fin spacing and maximum fin-to-tube contact.
    d. Tubes shall be 1/2 inch diameter seamless copper with a minimum wall thickness of 0.016 inch, tested at 400 psig air pressure under water with a minimum rated burst pressure of 1500 psig.
    e. Male sweat-type water connections shall be provided.
    f. Side and end plates shall be a minimum of 18 gauge galvanized sheet metal construction.
    g. All coils shall be constructed and tested in accordance with UL and/or ARI Standards.
15. General Performance:
    a. Devices using mechanical CFM limiters will not be accepted, nor shall it be necessary to change control components to make airflow rate changes.
    b. DDC flow stations shall be furnished, mounted and adjusted by the terminal unit assembly manufacturer to assure their proper placement within the units It shall be noted that the terminal unit manufacturer shall be responsible for the workmanship and materials of the entire assembly of unit controls.
    c. The terminal unit manufacturer shall be responsible only for the construction of the terminal unit and the installation of internal control components installed at the manufacturers factory, and shall not be responsible for the installation of controls not installed at the terminal unit manufacturer`s factory, nor shall the manufacturer be responsible for the performance of the DDC controls.
    d. The terminal unit manufacturer will furnish and install the control power disconnect and control voltage transformer.
    e. The performance of DDC controls, especially in connection with terminal units, shall be the responsibility of the DDC controls manufacturer.
16. Control Performance:
    a. Assemblies shall be able to be reset to any airflow between zero and the maximum cfm shown on Drawings.
    b. To allow for maximum flexibility and future changes, it shall be necessary to make only simple screwdriver or keyboard adjustments to arrange each unit for any maximum air flow within the ranges for each inlet size as scheduled on the Drawings.
    c. The control devices shall be designed to maintain the desired flow regardless of inlet flow deflection.
    d. All terminal units shall be installed with a minimum of four diameters of straight duct directly prior to the entry into each terminal unit connection.
17. Control Sequences:
    a. The control sequence arrangements shall be as described on the Drawings, whether the controls used on this project are pneumatic or DDC, and the terminal units shall be shipped from the manufacturer with all necessary control devices to accomplish each sequence, except as may be prohibited by the controls manufacturer.
    b. The desired sequence shall be adjustable according to space usage or a change in space conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to requirements included in Part 2 of this specification.
B. Install in accordance with manufacturer`s instructions.

C. Provide ceiling access doors or locate units above easily removable ceiling components. Refer to Section 08 31 13 - Access Doors and Frames.

D. Support units individually from structure Do not support from adjacent ductwork.

E. Connect to ductwork in accordance with Section 23 31 00 - Ductwork.

F. Install heating coils in accordance with Section 23 82 16 - Air Coils.

3.2 TERMINAL UNIT SCHEDULE

A. Refer to Drawings for schedule.

END OF SECTION 23 36 00