

# **DIVISION 23**

HEATING,  
VENTILATING, AND AIR  
CONDITIONING



## SECTION 23 00 00 - MECHANICAL GENERAL PROVISIONS

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. Except as modified in this Section, General Conditions, Special Conditions, applicable provisions of Division 01, General Requirements, and other provisions and requirements of the contract documents apply to work of Division 23.
- B. Applicable provisions of this Section apply to all Sections of Division 23 HVAC.
- C. Contract drawings are diagrammatic only and do not give fully dimensioned locations of various elements of work. Determine exact locations from field measurements and provide coordination drawings.
- D. All work in these Sections shall be installed by craftsmen skilled in their trade.
- E. Unsightly, inadequate, or sloppy work will not be acceptable and shall be removed and replaced as necessary to achieve an acceptable installation.

## 1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, un-air-conditioned spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within un-air-conditioned shelters.
- F. Furnish: The term "furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations.
- 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.

#### 1.4 CODE REQUIREMENTS AND PERMITS

- A. Perform work in accordance with applicable statutes, ordinances, codes, and regulations of governmental authorities having jurisdiction.
- B. Resolve any code violation discovered in contract documents with the Engineer prior to award of the contract. After award of the contract, make any correction or addition necessary for compliance with applicable codes at no additional cost to Owner.
- C. Obtain and pay for all permits and inspections.
- D. The following building codes are applicable to this project.
  - 1. 2015 International Mechanical Code
  - 2. 2015 International Building Code
  - 3. 2015 International Energy Conservation Code
  - 4. State Energy Conservation Office (SECO) mandated state building compliance with ASHRAE 90.1-2013

#### 1.5 REFERENCES

- A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, AWWA Specifications, Federal Standards or other standard specifications must comply with latest editions except where specified otherwise in individual Sections, revisions, amendments, or supplements in effect on date bids are received.
- B. Requirements in reference specifications and standards are minimums for all equipment, materials and work. In instances where capacities, size or other features of equipment, devices, or materials exceed these minimums, meet listed or shown capacities.

#### 1.6 SUBMITTALS

- A. Equipment and Materials submittals must show sufficient data to indicate complete compliance with contract documents as follows:
  - 1. Proper sizes and capacities.
  - 2. That the item will fit in the available space in a manner that will allow proper service.
  - 3. Construction methods, materials, and finishes.
- B. Material and Equipment List: Within 30 days after award of the contract and before orders are placed or shop drawings are submitted, submit a list of equipment and principal materials specified. Give names of manufacturers, catalog and model numbers, and such other supplementary information as necessary for identification.
- C. Material and Equipment Shop Drawings: Submit all detailed shop drawings, descriptive literature, physical data, and performance data for review for items of equipment and for principal materials proposed for installation. HVAC controls may be submitted separately provided the controls submittal is complete and coordinated with all other applicable trades. Include identifying symbols and equipment numbers used in plans and specifications, with reference to specification paragraphs, and drawing numbers of all equipment and material submitted.
- D. Final Submittal: In addition to number of copies of shop drawings and other data required for review submittals, maintain a separate file of final approved copies of such material. Deliver approved copies in a hard-back binder for the Owner's use. Incorporate changes and revisions made throughout construction period. Delivery of approved copies is a condition of final acceptance for the project.

- E. Contractor's Check: Shop drawings will be submitted only by the Contractor. Indicate by signed stamp that the drawings have been checked, that the work shown on the drawings is in accordance with contract requirements and that dimensions and relationship with work of other trades have been checked. If drawings are submitted for approval that have not been checked and signed by the Contractor, they will be returned for checking before being considered by the Architect/Engineer.
- F. Refer to Section 01 33 00 for additional submittal requirements

#### 1.7 COORDINATION DRAWINGS

- A. Prior to starting work, the Contractor shall provide coordination drawings for all areas of the building. The Contractor shall submit the coordination drawing for confirmation of the coordination process. The Contractor is responsible for all trade confirmation.
- B. CAD. Provide 1/4 inch scale 2D coordination drawings.
  - 1. Drawings shall show all equipment, ductwork, cable trays, fire protection system, coil pull spaces, chilled water, heating water and condensate piping and trap, electrical conduit, electrical and control panels, etc. installed in mechanical room to verify space allocation and coordination of trades.
  - 2. Provide plan and elevation views detailing installation.
  - 3. Contractor may not proceed with construction of MEP systems until trade coordination process has been demonstrated to be completed by the Contractor to the Architect, Engineer and Owner.

#### 1.8 INTERFERENCE DRAWINGS

- A. Interference drawings are drawings that indicate conflict between the various systems and other components of the building such as beams, columns, walls, etc. They shall be drawn to scale and shall include plans, elevations, sections and other details as required to clearly define the interference and to indicate the contractor's proposed solution.
- B. They shall be submitted for approval whenever job measurements and an analysis of the drawings and specifications by the contractor indicate that the various systems cannot be installed without significant deviation from the intent of the contract. When such interference is encountered, work shall cease in the general area of the conflict until a resolution to the question has been approved.

#### 1.9 GUARANTEE

- A. Guarantee work for one year from the date of final acceptance of the project. During that period make good any faults or imperfections that may have arisen due to defects or omissions in materials or workmanship.

#### 1.10 SERVICE

- A. Perform service work required during the guarantee period including lubrication of bearings. Perform manufacturer's recommended monthly service and provide Owner with written report. Cleaning of air filters and pipe strainers is not included.

#### 1.11 RESOLUTION OF CONFLICTS

- A. Where conflicts may exist between and/or within the drawings and/or specifications, the contractor shall contact the A/E to clarify. The Contractor shall notify the A/E for resolution of the issue prior to executing the work in question.

## PART 2 - PRODUCTS

## 2.1 MATERIALS AND EQUIPMENT

- A. Furnish new and unused materials, pipes, pipe fittings, and equipment of domestic manufacture, where available. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer.

## 2.2 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers are listed in individual Sections of Division 23. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer.
- B. Manufacturers' names and catalog numbers specified under Sections of Division 23 are used to establish standards of design, performance, quality and serviceability and not to limit competition.
- C. Equipment of similar design, equal to that specified, manufactured by a manufacturer named in the acceptable manufacturers' list will be acceptable on approval.
- D. Substitutions:
  - 1. If the Contractor desires to substitute a material or method as an equal to the specified item, he shall request permission from the Architect/ Engineer, in writing, and shall include such literature, samples, etc., deemed necessary to establish the equal quality of his proposal.
  - 2. If the Architect/Engineer deems it necessary in order to establish the equality between two or more products, he may require laboratory testing at the Contractor's expense in order to obtain information upon which to base a decision.
  - 3. The Architect/Engineer will not give approval to material salesmen or subcontractors, and only in writing to the successful Contractor after the project has been awarded.
  - 4. For each proposed substitution product, clearly show how the proposed product meets the requirements of the specifications, including performance.
  - 5. No substitution will be considered unless it is presented in writing within that number of days after Notice to Proceed equal to 15 percent of the contract time.
  - 6. Proposers of substitute products shall present samples, literature, test and performance data, record of other installations, names of Owners, architects, engineers, contractors and subcontractors as references, statement of current financial condition, and other technical information applicable to their products, to aid in determining the worth of the substitute product offered in relation to the material and work specified from the standpoint of the Owner's best interest. Substitute materials and products shall be used only if approved in writing by the Architect/Engineer in advance.
  - 7. Approval of substitute materials offered shall not be a basis for contingent extra charges because of changes in other work or related work, such as roughing-in, electrical, structural or architectural, which may result from the substitution.
  - 8. For any Contractor initiated substitutions or changes, Contractor shall be responsible for achieving results equal to or better than the product or design originally specified.
- E. Basis of Design: Where a basis of design is indicated (i.e., scheduled products), that product was used for the purposes of established space requirements, structural design for the building, utility connections, etc. If the contractor elects to furnish a product other than the basis of design product (either another named acceptable manufacturer or via substitution) the contractor is responsible for any construction or design costs associated with the non-basis of design product.

## 2.3 NOISE AND VIBRATION

- A. Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions without cost to the Owner. If the item of equipment is judged to produce objectionable noise or vibration, demonstrate (without cost to the Owner) that equipment performs within designated vibration limits indicated in the specifications, or as specified by manufacturer.
- B. Seal all wall and partition penetrations (the penetration opening shall be one inch larger than penetrating member) by ducts and piping by stuffing the annular void with fiberglass insulation and then caulking over fully with a non hardening acoustical caulking applied to both sides of wall or partition.

## 2.4 AIR FILTERS AND PIPE STRAINERS

- A. Immediately prior to final acceptance of project, inspect, clean and service hydronic system strainers and replace disposable type air filters.
- B. Turn over to Owner additional sets of spare filters and other spare parts as specified.

## 2.5 ACCESS DOORS

- A. Provide access doors for all walls or ceiling locations as required for access to valves, controls, regulating devices, water arresters, fire dampers, air distribution boxes, and other concealed equipment requiring maintenance adjustment or operation. Coordinate location with General Contractor.
- B. Refer to architectural Sections for access door requirements.

## 2.6 FLAME SPREAD PROPERTIES OF MATERIALS

- A. Materials and adhesives incorporated in this project shall conform to NFPA Standard 255, "Method of Test of Surface Burning Characteristics of Building Materials" and NFPA 90. 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.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Cooperation with Other Trades: Cooperation with trades of adjacent, related, or affected materials or operations and of trades performing continuations of work under subsequent contract is considered a part of this work in order to effect timely and accurate placement of work and to bring together in proper and correct sequence the work of such trades.
- B. Workmanship: Work must be performed by workmen skilled in their trade.
- C. Installation of all equipment and materials must be complete. Installation shall meet requirements of specifications and manufacturer's recommendations.
- D. Electrical Wiring of Motors and Equipment. The Contractor shall note that the electrical design was based upon the mechanical equipment indicated on the mechanical construction documents and specifications. If Contractor proposes any mechanical equipment that requires changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.

### 3.2 SPACE REQUIREMENTS

- A. Consider space limitations imposed by contiguous work, including clearances required for service, in selection and location of equipment and material. Do not provide equipment or material which is not suitable in this respect.
- B. The following space allocation and coordination shall be followed, unless otherwise indicated on the construction drawings:
  - 1. Gravity-fed plumbing and roof drain line shall take priority over all other systems.
  - 2. Light fixtures and cable tray arrangements shall take priority in spatial layout. In areas with ceilings, other systems shall be routed above the light fixtures, and offset from above cable tray allowing for access and maintenance clearance.
  - 3. Install HVAC ductwork as close to the bottom of structural framing as possible while allowing clearance for installation of insulation wrap. Install ductwork to be accessible from the ceiling plane.
  - 4. Install HVAC chilled/hot water piping in the plane directly below HVAC ductwork unless indicated otherwise on drawings.
  - 5. Install fire sprinkler piping in the plane directly beneath the HVAC chilled/hot water piping. Do not install sprinkler piping directly below equipment requiring maintenance.
  - 6. Install domestic hot and cold water in the plane directly above the light fixtures.
  - 7. Refer to Division 26 for electrical and control wiring requirements.
  - 8. Install piping to permit removal of coils at air handling units and to permit access to all terminal unit components.

### 3.3 OBSTRUCTIONS

- A. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.
- B. Before any cutting or trenching operations are begun, verify with Owner's Representative, utility companies and other interested parties that all available information has been provided. Verify locations given.
- C. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.
- D. Assume total responsibility for and repair any damage to existing utilities or construction.

### 3.4 OPENINGS

- A. Framed, cast or masonry openings for ductwork, equipment and piping are specified under other divisions. However, drawings and layout work for exact size and location of all such openings are included under this division.

### 3.5 ACCESS DOORS

- A. Coordinate location of access doors for ease of operation and maintenance of concealed equipment.

### 3.6 DELIVERY, STORAGE AND HANDLING

- A. Adequately protect work, equipment, fixtures and materials from damage during storing, installation, start-up and testing.
- B. Cover all equipment stored exposed to elements with waterproof tarps, provide adequate ventilation.



- C. At work completion, all work must be clean and in like new condition.
- D. Storage of all mechanical equipment, piping materials and ductwork shall be in strict accordance with manufacturers written installation instructions.
- E. Rotate air handler fans and pump shafts on routine basis.
- F. Provide factory installed pipe caps for all pipes to be installed on the project.
- G. Provide covers over all openings in ductwork stored or installed on the project.
- H. Energize motor heaters with temporary power as soon as the motor is received on site.
- I. Air Handling Units shall not be used as storage containers

### 3.7 LUBRICATION AND OIL

- A. Provide a complete charge of correct lubricant and/or oil for each item of equipment requiring lubrication. Contractor shall lubricate per manufacturers requirements until equipment is turned over to the owner.

### 3.8 PAINTING

- A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections for Interior Painting and Exterior Painting.
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.
- C. Paint mechanical items located outdoors, in building equipment rooms, in tunnels and on roof. Painting of mechanical systems includes preparing, painting, and color coding work.
- D. Preparation and application shall be in accordance with Division 09 Painting Sections.
- E. Mechanical items to be painted include, but are not limited to, piping, pipe hangers, heat exchangers and tanks, mechanical equipment, insulation, equipment supports, motors, and ductwork.
- F. Thoroughly clean surfaces receiving paint of dirt, grease, oil, rust, and scale.
- G. Unless otherwise specified, paint using three coats of selected colors. Mix and use exactly as specified by manufacturer. Allow each coat to dry thoroughly before applying succeeding coats. Painting may be done by spraying where feasible.
- H. Upon completion of painting, remove all scaffolds, surplus material, rags, and trash to leave spaces neat and clean.
- I. Machinery and Equipment: Paint motors, compressors, tanks, air handling units, and other similar equipment according to the following requirements:
  - 1. First Coat: Rust inhibitive primer (not required if factory painted). Use galvanized iron primer where applicable.
  - 2. Second Coat: Machinery enamel. Factory finished items require matching touch up only.
  - 3. Third Coat: Machinery enamel.
- J. Piping and Ductwork:
  - 1. First Coat: Rust inhibitive primer. Use galvanized iron primer where applicable. Omit first coat on pre-sized insulated pipe.
  - 2. Second Coat: Enamel.

3. Third Coat: Enamel.

K. Pipe Coding:

1. Paint all piping white. Each line shall receive pipe marker as specified.
2. Paint pipe in accordance with the following painting schedule:

<b>PAINTING SCHEDULE</b>	
<b>Color Code – Finish Coats</b>	
<b>Item</b>	<b>Color</b>
Treated Water	Federal Safety White
Drain and Exhaust	Navy Gray
Caustic	Federal Safety Red
Acid and Chemical	Federal Safety Purple
Chilled Water	Cascade Green
Condenser Water	Federal Safety Green
Air	Marlin Blue
Anything Hot	Federal Safety Orange

3.9 CUTTING AND PATCHING

- A. General: Cut and patch walls, floors, etc., resulting from work or by failure to provide proper openings or recesses in new construction.
- B. Methods of cutting: 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.
  1. Do not use impact-type equipment except where specifically acceptable to the Architect/Engineer.
  2. Core drill openings in precast concrete slabs for pipes, conduits, outlet boxes, etc., to exact size.
- C. Restoration: Restore all openings to "as-new" condition under the appropriate Specification Section for the materials involved
- D. Match remaining surrounding materials and finishes.
- E. Masonry: Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry.
- F. Provide adequate support during cutting operation to prevent any damage to the masonry occasioned by the operation. All structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner acceptable to the Architect/Engineer.
- G. Special Note: No cutting, boring, or excavating which will weaken the structure shall be undertaken.

3.10 OPERATING TESTS

- A. After all mechanical systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation witnessed by Owner's Representative.
- B. Prove operations of control systems and all safeties, freezestats and alarms.
- C. Make adjustments as required to ensure proper functioning of all systems.
- D. Special tests on individual systems are specified under individual Sections.

## 3.11 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. Furnish copies of commercially available standard operation and maintenance data, including operating instructions, maintenance instructions and parts listings in accordance with Specification 01 78 32. Detailed requirements for these items are as follows:
  - 1. Information required for the preparation of O&M manuals may be furnished in the form of manufacturers' standard brochures, schematics, and other printed instructions. Clearly distinguish between information which applies to the equipment and information which does not apply. Data shall include as a minimum the following items:
    - a. Recommended procedures and frequencies for preventive maintenance; inspection, adjustment, lubrication, cleaning, etc.
    - b. Special tools and equipment required for testing and maintenance.
    - c. Parts lists reflecting the true manufacturer's name, part number and nomenclature.
    - d. Recommended spares by part number and nomenclature and spare stocking levels.
    - e. Integrated mechanical and electrical system schematics and diagrams to permit operation and troubleshooting after acceptance of the system.
    - f. Troubleshooting, checkout, repair and replacement procurement procedures.
    - g. Operating instructions including start up and shutdown procedures.
    - h. Safety considerations including load limits, speed, temperature and pressure.
  - 2. Provide O&M manuals for all HVAC equipment.

## 3.12 PROJECT RECORD DOCUMENTS

- A. Maintain at the job site a separate set of white prints of the contract drawings for the sole purpose of recording the "as-built" changes and diagrams of those portions of work in which actual construction is significantly at variance with the contract drawings.
- B. Mark the drawings with a colored pencil.
- C. Prepare, as the work progresses and upon completion of work, drawings clearly indicating locations of various lines, valves, ductwork, traps, equipment, and other pertinent items, as installed.
- D. Record underground and underslab piping installed, dimensioning exact location and elevation of such piping.
- E. At conclusion of project, obtain without cost to Owner, reproducibles of original mechanical drawings and transfer as-built changes to these.
- F. Delivery of as-built prints and reproducibles is a condition of final acceptance.

END OF SECTION 23 00 00



## SECTION 23 05 93 – SYSTEM TESTING, ADJUSTING AND BALANCING

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 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 as part of General Contractors scope of work.
- 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. 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 it's current Firm name, and shall be in good standing with the State of Texas, Franchise Tax Board. The firm shall submit their full incorporated name, Charter Number and Taxpayer's I.D. Number for proper verification of the firm's status.
- C. 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. 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.
- D. The Firm shall maintain current insurance coverages in the minimum amounts shown below. If the Firm normally carries such insurance coverages (minimum or higher) incident to it's operation, additional insurance for the specific proposal or proposals is not required. The minimum insurance coverages required are:
  - 1. Worker's Compensation as required by law.
  - 2. General Liability for not less than \$1,000,000 aggregate refer to Division 01, General Conditions.
  - 3. Fire Damage, and Extended Coverage, Vandalism and Malicious Mischief, in the full amount of Contract. The above policies shall be carried with companies satisfactory to the Owner. 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.

- E. 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.
- F. 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. 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. 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.
- G. The scope of the TAB work as defined herein is indicated in order that the Mechanical Contractor will be advised of the coordination, adjustment and system modification which will be required under the project work in order to complete the Owner's requirements for final TAB. The General Contractor shall engage one of the certified TAB firms from the approved list below:

Engineered Air Balance, Inc. - (713)873-7084

Technical Air Balance, Inc. - (281) 651-1849

Precision Air of Texas - (281) 449-0961

Air balance work shall be done by one of the above approved contractors and not by the Mechanical Contractors own forces.

#### 1.4 REFERENCES

- A. National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems, Fifth Edition 1989.
- B. ASHRAE - 1991 HVAC Applications Chapter 34: Testing, Adjusting and Balancing.
- C. ANSI/ASHRAE Standard 111-1988 - Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

#### 1.5 DOCUMENTS

- A. The TAB firm shall, as a requirement of the TAB contract, arrange with the Architect to compile one set of mechanical specifications, all pertinent change orders, and the following:
  - 1. One complete set of Drawings less the structural sheets.
  - 2. One set of mechanical floor plans of the conditioned spaces. These Drawings shall be ozalid type (blue or black on light background) reproductions to facilitate marking.
- B. Approved submittal data on equipment installed, and related changes as required to accomplish the test procedures outlined in Paragraphs 1.6 through 1.10 of this Specification will be available through the Construction Inspector.

#### 1.6 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. This is intended to be accomplished after the system components are installed and operating as provided for in the contract documents. 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 1989 Standard, Fifth Edition.

- B. 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 Agency:
    - a. [\_\_\_\_\_] Model [\_\_\_\_\_].
    - b. During construction, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to commissioning work and balance ability.
    - c. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the Construction Inspector shall be advised in writing so that the condition can be corrected by the Mechanical Contractor. The written document need not be formal, but must be understandable and legible. Data from malfunctioning equipment shall not be recorded in the final TAB report. 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.

### 1.7 FINAL AIR BALANCE

- A. General: When systems are complete and ready for operation, the TAB Consultant will perform a final air balance for all air systems and record the results. 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 +5% of the value shown on the drawings. Air handling unit and fan volumes shall be adjusted by changing fan speed and adjusting volume dampers associated with the unit. 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. Air distribution devices shall be balanced with air patterns as specified. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown. The 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: 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. 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. 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: Set controls for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb temperatures (cooling only) at each cooling coil, heating coil and HVAC terminal unit. 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: Adjust each exhaust inlet and supply diffuser, register and grille to within +5% of design air CFM. Include all terminal points of air supply and all points of exhaust. Note: For Labs and Rooms that are negative exhaust air flow shall be set to design +10% and supply to design -5%. Positive areas will have opposite tolerances.
  9. Pitot Tube Traverses: 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. Locations of these traverse test stations shall be described on the sheet containing the data.
  10. Maximum and minimum air flow on terminal boxes.

## 1.8 FINAL CHILLED AND HEATING HOT 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. The general scope of balancing by the TAB Consultant will include, but not be limited to, the following:
1. Adjusted System Tests: Adjust balancing valves at each coil and heat exchanger for design flow, +5%. Adjust balancing valves at pumps to obtain design water flow. Record pressure rise across pumps and GPM flow from pump curve. 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: Read and record entering and leaving water temperature at each water coil, converter and heat exchanger. Adjust as necessary to secure design and conditions. Provide final readings at all thermometer well locations.
  3. Pressure Readings: Water pressure shall be recorded at all gauge connections. 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. 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. For coils equipped with 3 way valves, the rated pressure drop shall first be adjusted through the coils. 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.

## 1.9 TESTING OF TEMPERATURE CONTROL SYSTEMS

- A. In the process of performing the TAB work, the TAB Agency 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 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 Agency.
  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 set points 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.



## 1.10 [STAIRWELL PRESSURIZATION SYSTEMS

- A. With all doors closed, measure the door pull to determine that the opening force required is below 30 #/ft.
- 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.]

## 1.11 REPORTS

- A. The activities described in this section shall culminate in a report to be provided in quadruplicate (4) individually bound to the RCM. Neatly type and arrange data. 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. Record all failures and corrective action taken to remedy incorrect situation. The intent of the final report is to provide a reference of actual operating conditions for the Owner's operations personnel.
- B. All measurements and recorded readings (of air, water, electricity, etc.) that appear in the reports must have been made onsite by the permanently employed technicians or engineers of the firm.
- C. At the option of the Construction Inspector, all data sheets tabulated each day by TAB personnel shall be submitted for initial by the Construction Inspector. Those work sheets so initialed, or copies thereof, shall be presented as a supplement to the final TAB report.
- D. Submit reports on 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. Water flow, design and actual.
  - g. Water pressure drop, design and actual.
  - h. Entering water or steam temperature, design and actual.
  - i. Leaving water temperature, design and actual.
  - j. Entering air temperature, design and actual.
  - k. Leaving air temperature, design and actual.
  - l. 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) Fan bearing, drive end.
    - 2) Fan bearing, opposite end.
    - 3) Motor bearing, center (if applicable).
    - 4) Motor bearing, drive end.
    - 5) Motor bearing, opposite end.
    - 6) Casing (bottom or top).
    - 7) Casing (side).
    - 8) Duct after flexible connection (discharge).
    - 9) Duct after flexible connection (suction).
  - 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.

END OF SECTION 23 05 93