

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

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

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

1.03 REFERENCE STANDARDS

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

1.04 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.01 GENERAL

- A. None used.

PART 3 - EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION

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

3.03 SYSTEMS VERIFICATION

A. Air Distribution Systems:

- 1. Verify installation for conformity to the Contract Documents. All supply, return, and exhaust ducts shall be terminated and pressure tested for leakage as required by the Contract Documents.
- 2. All volume, smoke and fire/smoke dampers are properly located and functional. Dampers serving requirements of minimum and maximum outside, return, and relief air shall provide tight closure and full opening, smooth and free operation.
- 3. All supply, return, exhaust and transfer grilles, registers, diffusers and terminal devices are installed and airflow at each device shall be verified.
- 4. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be sealed or blanked-off to eliminate excessive uncontrolled bypass or leakage of air.
- 5. All fans (supply, return and exhaust) operating and verified for freedom from vibration, with proper fan rotation and belt tension. Heater elements in motor starters are of proper size and rating. Record motor amperage and voltage on each phase at Start-up and running, and verify they do not exceed nameplate ratings.
- 6. Duct systems and air handling units and coils are clean and free of debris.
- 7. Air systems are pressure independent and can be tested by floor, riser, system, etc. but once the all systems are installed, the total flows and system tracking will require final testing, adjusting and balancing.

B. Water Circulating Systems:

- 1. Check and verify pump alignment and rotation.
- 2. Open all valves to their full open position, close bypass stop valves. Set mixing valves to full-flow through systems components. After the system is flushed and checked for proper operation, remove and clean all strainers. Repeat the operation until circulating water is clean.

3. Record the amperage of each pump motor on each phase and voltage after reaching rated speed. Readings shall not exceed nameplate rating.
4. Verify that the electrical heater elements are of the proper size and rating.
5. 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. Systems shall be cleaned and flushed. Chemicals shall be added to closed systems to treat piping and inhibit corrosion.
6. Check and set operating temperatures and other parameters of the heat exchangers and control devices to the design requirements.
7. Installation and system verification of condenser water, hot water, and chilled water systems must be 100 percent complete prior to balancing.

C. Building Automation System (BAS):

1. Verify that all control components are installed in accordance with the Contract Documents and that all control components are functional, including all electrical interlocks, damper sequences, air and water resets, fire and freeze stats, high and low temperature thermostats, safeties, etc.
2. 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 BAS Provider.
3. BAS Provider shall thoroughly check all controls, sensors, operators, sequences, etc. before notifying the TAB Firm that the building automation system is operational. The BAS Provider shall provide technical support, including technicians and necessary computers, to the TAB Firm for a complete check of these systems.
4. BAS Provider shall assist the Contractor with functional performance testing and point-to-point testing back to the main graphics.
5. BAS Provider, if requested by Owner, shall set-up controls on sample fan powered terminal units at TAB Firm's office.

END OF SECTION 23 05 90

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

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Testing, adjusting, and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by a technically qualified TAB Firm.
- B. TAB Firm shall be capable of performing the TAB services as specified in accordance with the Contract Documents, including the preparation and submittal of a detailed report of the actual TAB Work performed.
- C. TAB Firm shall check, adjust, and balance components of the air conditioning system which will result in optimal noise, temperature, and airflow conditions in the conditioned spaces of the building while the system equipment is operating economically and efficiently. This is intended to be accomplished after the system components are installed and operating as specified in the Contract Documents. It is the responsibility of the Contractor to place the equipment into service. Variable air volume systems shall be balanced in accordance with AABC Standard, Latest Edition or NEBB Standards for Testing, Adjusting, Balancing of Environmental Systems (Latest Edition).
- D. TAB Firm shall check, adjust, and balance all hydronic systems including pumps, water distribution systems, chillers, cooling towers, boilers, heat exchangers, coils, and related equipment.
- E. Liaison and Early Field Inspection:
 - 1. TAB Firm shall act as a liaison between the Owner, Architect and Contractor. TAB Firm shall perform the following reviews (observations) and tests:
 - a. During construction, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to the ability to satisfactorily balance systems.
 - 2. During the balancing process, as the TAB Firm discovers abnormalities and malfunctions of equipment or components, the TAB Firm shall advise the Contractor in writing so that the condition can be corrected by the Contractor prior to finishing the TAB scope of Work. Data from malfunctioning equipment shall not be recorded in the final TAB report.

1.03 REFERENCE STANDARDS

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

- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. AABC - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.
 - 2. NEBB - National Environmental Balancing Bureau, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
 - 3. ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.
 - 4. ANSI/ASHRAE Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.
 - 5. CTI - Cooling Technology Institute CODE ATC-105.

1.04 QUALITY ASSURANCE

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

1.05 SUBMITTALS

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

D. Submit reports on electronic forms approved by the Owner and Architect/Engineer which will include the following information as a minimum:

1. Title Page:

- a. Company name.
- b. Company address.
- c. Company telephone number.
- d. Project name.
- e. Project location.
- f. Project Manager.
- g. Project Engineer.
- h. Project Contractor.
- i. Project identification number.

2. Instrument List:

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

3. Fan Data (Supply and Exhaust):

- a. Identification and location.
- b. Manufacturer.
- c. Model.
- d. Air flow, specified and actual.
- e. Total static pressure (total external), specified and actual.
- f. Inlet pressure.
- g. Discharge pressure.

- h. Fan RPM.
- 4. Electric Motors:
 - a. Manufacturer.
 - b. Horsepower/brake horsepower.
 - c. Phase, voltage, amperage, nameplate, actual.
 - d. RPM.
 - e. Service factor.
 - f. Starter size, heater elements, rating.
- 5. 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. Pressure independent control valve water pressure drop, design and actual.
 - l. Entering water temperature, design and actual.
 - m. Leaving water temperature, design and actual.
 - n. Air quantity CFM design, and CFM actual.
 - o. Air pressure drop, design and actual.
 - p. Sensible Btu/hr design, and actual.
 - q. Total Btu/hr design, and actual.
- 6. Heat Exchanger Data:
 - a. Identification and location.

- b. Service.
 - c. Manufacturer.
 - d. Steam flow rate, design and actual.
 - e. Water flow rate, design and actual.
 - f. Water pressure drop, design and actual.
 - g. Pressure independent control valve water pressure drop, design and actual.
 - h. Entering steam temperature and pressure, design and actual.
 - i. Entering water temperature, design and actual.
 - j. Leaving water temperature, design and actual.
 - k. Electric heat, full load kW, number of stages, kW per stage – specified and actual (if applicable).
7. Sound Level Report:
- a. Location (Location established by the Engineer).
 - b. Baseline background NC curve for eight (8) bands – with equipment off.
 - c. Operating NC curve for eight (8) bands – with equipment on.
 - d. Test readings:
 - 1) Horizontal, velocity and displacement.
 - 2) Vertical, velocity and displacement.
 - 3) Axial, velocity and displacement.
 - e. Normally acceptable readings, velocity and acceleration.
 - f. Unusual conditions at time of test.
 - g. Vibration source (if non-complying).
8. Control verification indicating date performed and any abnormalities identified:
- a. Point Location/Description.
 - b. EMS Readout (Setpoint and Actual).
 - c. Actual Readout.
 - d. Interlocks.
 - e. Safeties:

- 1) VSD Normal Operation.
 - 2) VSD Bypass Operation.
 - f. Alarms.
 - g. Sequences of Operation.
9. Include in the appendix all submittals for air handling units, pumps, fans, heat exchangers, energy recovery units control system, etc.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 AIR BALANCE

- A. When systems are installed and ready for operation, the TAB Firm shall perform an air balance for all air systems and record the results. The 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 percent 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 opposed blade damper (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.
- B. The general scope of balancing by the TAB Firm shall include, but is not limited to, the following:
 1. Blower Speed: Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required, the Contractor shall make any required changes.
 2. Ampere Readings: Measure and record full load amperes for motors.
 3. Static Pressure: Static pressure gains or losses shall be measured across each 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.
 4. Equipment Air Flow: Adjust and record exhaust, return, outside and supply air CFM(s) and temperatures, as applicable, at each fan, blower and coil.
 5. 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 reheat coil at each VAV 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).

6. Outlet Air Flow: Adjust each exhaust inlet and supply diffuser, register and grille to within + 5 percent 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 percent and supply to design - 5 percent. Positive areas will have opposite tolerances.
7. Pitot Tube Traverses: For use in future troubleshooting by Owner, 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.

3.02 HYDRONIC SYSTEM BALANCE

- A. When systems are installed and ready for operation, the TAB Firm shall perform water balance for each chilled and heating hot water system.
- B. The general scope of balancing by the TAB Firm shall include, but not be limited to, the following:
 1. Adjusted System Tests: Adjust pressure independent control valves at each coil and heat exchanger for design flow, +/- 5 percent, in accordance with valve manufacturer's published commissioning procedure. Pressure independent valve manufacturer will provide service tool and/or service software for use in this commissioning process, and provide training in its use. 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 design conditions. Provide final readings at all thermometer well locations.
 3. Test cooling towers in accordance with CTI Code ATC – 105.
 4. 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 pressure independent control valves, in accordance with valve manufacturer's published commissioning procedures until the rated pressure drops across each coil is obtained and total water flow is verified by flow measuring status. Verify required pressure drop across each pressure independent control valve. 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.
 5. Ampere Readings: Reading and record full load amperes for each pump motor.

3.03 SOUND VIBRATION AND ALIGNMENT

- A. Sound: Read and record sound levels at up to fifteen (15) locations per floor in the building as designated by the Architect/Engineer. All measurements shall be made using an Octave Band Analyzer. All tests shall be conducted when the building is quiet and in the presence of the Architect/Engineer, at the Architect/Engineer's option.
- B. Vibration: Read and record vibration for all water circulating pumps, air handling units, and fans which have motors larger than 10 horsepower. Include equipment vibration, bearing housing vibration, foundation vibration, building structure vibration, and other tests as directed by the Architect/Engineer. Readings will be made using portable IRD (or approved equal) equipment capable of filtering out various unwanted frequencies and standard reporting forms. Maximum vibration at any point listed above, or specified, shall not exceed one mil on fans and one mil on pumps unless otherwise specified. Equipment manufacturer shall rectify all systems exceeding vibration tolerances.

3.04 BUILDING AUTOMATION SYSTEMS

- A. In the process of performing the TAB Work, the Contractor shall:
 - 1. Work with the Building Automation System (BAS) Provider and Owner to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.
 - 2. Verify that all control devices are properly connected.
 - 3. Verify that the intended controllers operate all dampers, valves and other controlled devices.
 - 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 all duct-mounted dampers, dampers in terminal units, and fire/smoke dampers.
 - 6. Observe that all valves are properly installed in the piping system in relation to direction of flow and location. Observe that all pressure independent control valves are properly installed in accordance with manufacturer's published installation instructions.
 - 7. Observe the calibration and operation 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. BAS Provider will relocate sensors as deemed necessary by the TAB Firm or Contractor.
 - 11. Verify that the sequence of operation for any control mode is in accordance with approved Shop Drawings and Specifications. Verify that no demand for simultaneous heating and cooling occurs at the terminal units.

12. Verify that all controller setpoints meet the Contract Documents.
13. Check all dampers for free travel.
14. Verify the operation of all interlock systems.

END OF SECTION 23 05 93

SECTION 23 21 13 – HYDRONIC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Furnish and install all labor, materials, equipment, tools and services and perform all the operations required in connection with, or associated with, the construction of complete hydronic piping systems, including process and heating hot water piping, condenser water piping process or hot water piping, condensate drain piping and generator cooling water piping systems as indicated on the Drawings.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. ANSI/ASME Sec 9 - Welding and Brazing Qualifications.
 - 2. ASTM A53 – Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless.
 - 3. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings Class 150 and 300.
 - 4. ANSI/ASME B16.9 – Factory-Made Wrought Butt welding Fittings.
 - 5. ANSI/ASME B16.23 – Cast Copper Alloy Solder Drainage Fitting – DWV.
 - 6. ANSI/ASME B16.29 – Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings – DWV.
 - 7. ANSI/ASME B31.9 - Building Services Piping.
 - 8. ASME B36.1 – Standardization of dimensions of welded and seamless wrought steel pipe for high or low temperatures and pressures.
 - 9. ANSI/AWS D1.1 - Structural Welding Code.

10. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless, for Ordinary Uses.
11. ASTM A105 – Standard Specification for Carbon Steel Forgings for Pipe Applications.
12. ASTM A106 Grade B, Seamless or Electric Resistance Welded (ERW) piping.
13. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
14. ASTM A312 – Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipe.
15. ASTM A536 – Standard Specification for Ductile Iron Castings.
16. ASTM B88 – Standard Specification for Seamless Copper Water Tube.

1.04 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating shall be clearly marked on the outside of the valve body.
- B. Welding Materials and Procedures: Conform to Chapter V, ASME/ANSI B31.9 and applicable state labor regulations.
- C. Welders Certification: Furnish in accordance with AWS D10.12 and ASME B31.9.
- D. Each threaded fitting shall be stamped as specified by ANSI B16.3.
- E. Each welded fitting shall be stamped as specified by ANSI B31.9.

1.05 SUBMITTALS

- A. Product Data:
 1. Submit product data on pipe materials, pipe fittings, valves, and accessories. Clearly indicate make, model, type, size, and pressure rating for each device.
 2. Submittal data for all fittings shall include a letter signed by an official of the manufacturing company certifying compliance with these Specifications.
- B. Record Documents:
 1. Include welder's certification of compliance in accordance with Chapter V, ASME/ANSI B31.9.

PART 2 - PRODUCTS

2.01 GENERAL

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

1. All threaded fittings shall be USA factory made, wrought carbon or alloy steel threaded fittings conforming to ASTM A234 or malleable iron threaded fittings conforming to ASME B16.3.
2. Acceptable manufacturers: Grinnell, Tube Turn, Weld Bend Hackney, Taylor Forge or Ladish Company.

C. Flanges:

1. All 150 lb. and 300 lb. ANSI flanges shall be weld neck and shall be domestically manufactured, forged carbon steel, conforming to ANSI B16.5 and ASTM A-191 Grade I or II or A-105 as made by Tube Turn, Hackney or Ladish Company. Slip on flanges shall not be used. Complete test reports may be required for any fitting selected at random.
2. Flanges shall have the manufacturer's trademark permanently identified in accordance with MSS SP-25. Contractor shall submit data for firm certifying compliance with these Specifications.
3. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard Heavy dimensions. All-thread rods will not be an acceptable substitute for flange bolts. Bolts shall have a tensile strength of 60,000 psi and an elastic limit of 30,000 psi.
4. All flanges shall be gasketed. Place gasket between flanges of flanged joints. Gaskets shall fit within the bolt circle on raised face flanges and shall be full face on flat face flanges. Gaskets shall be cut from 1/16 inch thick, non-metallic, non-asbestos gasket material suitable for operating temperatures from -150 degrees F to +750 degrees F, Klingenseal C-4400, Manville Style 60 service sheet packing or accepted substitution. Gaskets must be compatible with flowing fluid, temperature, and pressure of system.

D. Copper Fittings:

1. Mechanically formed, drilled and extruded tee-branch connections shall not be permitted.

2.02 PIPE

A. CONDENSER PROCESS PIPING

1. Steel:
 - a. Pipe 2 inches and smaller: Black steel ASTM A106, Grade A or B, seamless, Schedule 40.
 - 1) Fittings: Screwed, malleable iron, Class 150.
 - 2) Joints: Screwed.
 - 3) Unions: Forged steel, ASTM A105, screwed with stainless steel seats.
 - 4) Fittings:
 - a) ASTM A234 carbon steel welding type, long radius type elbows unless specified otherwise SOFT on the Drawings.

- 5) Joints:
- 6) Flange: ANSI B16.5 Class 150, forged carbon steel.
2. Steel ERW Pipe (Not to be used on HW systems):
 - a. 2 inches and smaller Black Steel ASTM A106 Gr. A or B – Schedule 40.
 - 1) 2" and under ASTM A47, malleable iron, 150 lb.
 - 2) Joints screwed
 - 3) Unions: Forged steel, ASTM A105, screwed with stainless steel seats.
 - b. Fittings: ASTM A234 Carbon steel welding type.
 - c. Joints: Butt welded.
 - d. Flange: ANSI B16.5 Class 150, forged carbon steel.
3. Copper:
 - a. Pipe 2 inches and smaller; Copper Tubing: ASTM B 88, Type L, hard drawn. All brass and bronze piping components shall have no more than 15 percent zinc content.
 - 1) Fittings: ASME B16.18, cast bronze, or ASME B16.22 wrought copper and bronze.
 - 2) Joints: ASTM B 32, solder, Grade 95TA (lead free).
4. Joints:
 - a. Flange: ANSI B16.5 Class 150, forged carbon steel.
5. Joints:
 - a. Grooved mechanical couplings.
6. Flange: ANSI B16.5 Class 150, forged carbon steel.
7. Coat exterior condenser water pipe, valves, and fittings, with minimum 8 mil thick coal tar epoxy.
- B. Equipment Drains and Overflows:
 1. Pipe: Galvanized steel ASTM A53, Schedule 40.
 - a. Fittings: Galvanized cast iron, ductile iron, steel, or ATM B16.3 malleable iron.
 2. Tubing: Copper ASTM B88, Type L, hard drawn.
 - a. Fittings: ASME B16.23 cast brass, or ASME B16.29 solder wrought copper.

2.03 VALVES

A. General

1. All valves used in 150 psi circulating systems shall be ANSI Class 150. All valves in 300 psi systems shall be Class 300 valves and shall be constructed of all ASTM B-61 or B-584 composition. All gate, globe and angle valves shall be screw-over-bonnet design. Metal used in the stems of all bronze gate, globe and angle valves shall conform to ASTM B371 Alloy 694, ASTM B99 Alloy 651 or other corrosion resistant equivalents. Secure written approvals by Owner for the use of alternative materials.
2. The following manufacturers are acceptable: Milwaukee, NIBCO, Keystone, KITZ, Crane, Dezurik, Daniels, Williams, Velan Vogt, Victaulic and Anvil.
3. All iron body valves shall have the pressure containing parts constructed of ASTM designated of A536 grade 65-45-12 ductile iron or A126 class B iron. Stem material shall meet ASTM A582 or A564 stainless steel, B16 Alloy 360, or ASTM 371 Alloy 876 silicon bronze or its approved equivalent model by listed manufacturers.
4. All cast steel body valves shall have the pressure containing parts constructed of ASTM designation A-216-GR-WCB carbon steel. Stems shall meet ASTM designation A-186-F6 chromium stainless steel. Seat ring shall be hard faced carbon steel or 13[^] chromium A-182-F6 stainless. Handwheels shall be A47 grade 35018 malleable iron or ductile iron ASTM A536.
5. All forged steel body valves shall have the pressure containing parts constructed of ASTM 105, Grade 2 forged carbon steel. Seat and wedges shall meet ASTM-A-182-F6 chromium stainless steel. Seat rings shall be hard faced. Valves shall conform to ANSI B16-34 pressure-temperature rating.
6. All gate valves, globe valves, angle valves and shutoff valves shall have malleable iron hand wheels, except iron body valves 2-1/2 inches and larger which may have either malleable iron or ASTM A-126 Class B, gray iron hand wheels.
7. Packing for all valves shall be free of asbestos fibers and selected for the pressure-temperature service of the valve. It is incumbent upon the manufacturer to select the best quality, standard packing for the intended valve service.
8. Provide stem extensions on all insulated valves.
9. Valve chain operators shall be of cast iron or malleable iron and designed to provide positive grip on wheel. Provide chain guide to prevent chain from slipping or jumping on wheel. Employ rustproof chain complete with closing link of sufficient length to operate at 6 feet-6 inches above floor level.
10. Provide valves suitable for connection to adjoining pipe as specified for pipe joints above. Use valves that are full size of pipe in which installed.

B. Ball Valves:

1. Threaded pipe 2 inches and smaller: KITZ 68M with ISE Stem Extension and built in memory stop device, Milwaukee BA400-SXM for 3" Milwaukee BA100-SXM, NIBCO T 585-70-66-LL. For threaded pipe 2-1/2 inches to 3 inches: Crane 9303-S or approved equivalent model by listed manufacturers.
 - a. Threaded full port two-piece bronze body (ASTM-B584 Alloy 844, ASTM B61, or ASTM B62 (ASTM Approved Alloys" only).
 - b. Stainless steel ball and stem, blowout proof stem with stem extension made of non-thermal conducting material and having an adjustable memory stop after insulation is installed.
 - c. Ball valves shall be provided with SS lockable handles and locking devices or KITZ 68M Stem Extension and built in memory stop device.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. After completion, fill, clean, and treat systems.

3.02 PIPING STORAGE REQUIREMENT

- A. All ERW and seamless piping shall be clearly identified and stored on separate construction pipe racks to prevent the intermixing of piping.
- B. Shop fabricated piping spool and pup pieces of ERW and seamless pipe shall be clearly identified and separated in the lay down yard to prevent the intermixing of piping.

3.03 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All valve installations shall be in accordance with manufacturer's published recommendations.
- C. Pipe Installation:
 1. All the various piping systems shall be made up straight and true and run in orderly manner, plumb and parallel to building structural. Install piping to conserve building space. Coordinate location with other trades and do not interfere with use of space for other work.
 2. Piping shall follow as closely as possible the routes shown on Drawings which take into consideration conditions to be met at the Site.

3. Should any unforeseen conditions arise, lines shall be changed or rerouted after proper approval has been obtained.
4. All piping shall be installed with due regard to expansion and contraction and so as to prevent excessive strain and stress in the piping, in connections, or in equipment to which the lines are connected.
5. Group piping whenever practical at common elevations.
6. Slope piping and arrange system to drain at low points. Use eccentric reducers where applicable to maintain the bottom of pipe level.
7. Branch tap connections are to be from the top to horizontal position of pipe run.
8. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
9. Provide and install Pete's plugs adjacent to thermo wells for electronic temperature sensors, to electronic pressure sensors and install Pete's plugs adjacent where shown or noted on piping drawings or drawing details. The piping taps for the Pete's plugs, permanently mounted pressure gauges, and instruments sensors shall be a minimum size of ½ inch schedule 40 pipe and be able to isolate them with a ½ inch stainless steel ball valve. Systems provided with pressure independent control valves shall be provided with a Pete's plug downstream of the control valve, to facilitate verification of the valve manufacturer's recommended water pressure drop across the pressure independent control valve.
10. Provide clearance for installation of insulation, and access to valves and fittings.
11. Prepare pipe, fittings, supports, and accessories for finish painting. Process water piping insulated with cellular glass does not require finish painting.
12. All piping shall be clean when it is installed. Before installation it shall be checked to assure it is the correct material to be used on the piping system, upended, swabbed if necessary, and all rust or dirt from storage or from lying on the ground shall be removed.
13. Where leaks occur, the pipe shall be repaired and the tests repeated. No leaks shall be corrected by peening. Defective piping and joints shall be removed and replaced.
14. Procedure of Assembling Screw Pipe Fittings: All screw joints shall be made with taper threads, properly cut. Joints shall be made tight with Teflon tape or Teflon-based compound appropriate to the medium, material and temperature range of the system. Compound shall be applied to the pipe threads only and not to fittings. When threads are cut on pipes, the ends shall be carefully reamed to remove any burrs. Before installing pipe that has been cut and threaded, the lengths of pipe shall be upended and hammered to remove all shavings and foreign material.

D. Valve Installation:

1. Locate all valves such that the removal of their bonnets is possible. All flanged valves shown in horizontal lines with the valve stem in a horizontal position shall be positioned so the valve stem is inclined one bolt hole above the horizontal position.

2. Screw pattern valves placed in horizontal lines shall be installed with their valve stems include at an angle of a minimum of 30 degrees above the horizontal position.
3. Pressure independent control valves shall be installed in accordance with valve manufacturer's published installation instructions, with regard to orientation, clearances, and lengths of straight pipe upstream and downstream of the valve.
4. All valves must be true and straight at the time the system is tested and inspected for final acceptance.
5. Valves shall be installed as nearly as possible to the locations indicated in the Drawings. Any change in valve location must be so indicated on the Record Drawings.
6. Provide line shut-off valves at locations required for proper operation, servicing and troubleshooting of the HVAC hydronic distribution systems and connected components. Locations shall include but not be limited to the following; at each piece of equipment, at each branch take-off from mains, at the base of each riser, where recommended by equipment manufacturers and at strategic locations to allow sectional isolation while limiting disruption of services to large portions of the system.
7. All valves must be of threaded or flanged type. No solder connected valves shall be used on this Project.
8. Equipment, valves, expansion joints, relief devices, strainers, etc., must be removed or isolated during the test if the pressure/force ratings of the devices are not as high as that specified for the test. Piping shall be drained and protected any time ambient temperature is below freezing.
9. Where leaks occur, the pipe shall be repaired and the tests repeated. No leaks shall be corrected by peening. Defective piping and joints shall be removed and replaced.
10. All threaded valves installed in copper piping shall be provided with copper or bronze male adapters on each side of valves. Sweat solder adapters to pipe before installing valves.
11. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with architectural drawings.
12. Install valves with stems upright or horizontal, not inverted.
13. All manually operated shutoff valves to equipment that are 2-1/2 inches and larger located 8 feet (Bottom of pipe) or higher above finished floor or stationary platform in mechanical rooms and accessible pipe chases or as noted on Project Drawings shall be chain wheel operated. Chains shall be installed and secured to allow clear passage at walk through areas.

3.04 TESTING

A. System Pressure Tests:

Line	Testing Medium	Testing Pressure (psig)	Time (hours)
Condenser Water	Water	1-½ times working pressure, minimum 125	24

1. Refer to the Drawings for system design pressure.

3.05 HOT TAP PROCEDURE

- A. Contractor shall provide MD ANDERSON drawings with the location of all hot taps shown 10 days prior to scheduled start of work. Contractor shall also clearly identify all locations in the field.
- B. Upon receipt of drawings MD ANDERSON will field verify abatement requirements. MD ANDERSON will also identify and coordinate, through the building mission groups, the impact of potential system shut downs, Owner requirements and will issue a notice to proceed.
- C. Upon MD ANDERSON's issuance of a notice to proceed the Contractor shall perform the following hot tap procedures:
 1. Preparation
 - a. Remove insulation at identified and approved hot tap locations and save for reinstallation as noted below.
 - b. Ultra-sound pipe at each weld location to verify pipe thickness. If pipe fails to pass ultra-sound follow procedure outlined in paragraph A to establish new tap location.
 - c. Temporarily reinstall pipe insulation upon completion of ultra-sound to prevent condensation.
 - d. Repeat above listed steps on all approved hot tap locations.
 2. Installation
 - a. Remove insulation as required for installation of scheduled hot tap.
 - b. Weld saddle sleeve to pipe. All welds shall be made as per 15510-1.06-B
 - c. Install new valve on saddle sleeve.
 - d. Install blind flange on valve to prevent accidental opening.
 - e. Pressure test valve/seating to one and a half (1-1/2) times design operating pressure for 24 hours. MD ANDERSON representative shall witness this test.
 - f. Upon passing pressure test and prior to hot tapping pipe:
 - 1) Verify that MD ANDERSON has staff ready to perform emergency shut-off procedures.

- 2) Verify emergency patch is on location and sized to match pipe being tapped.
- 3) Verify cleaning company is on call with portable shop vacuum(s).
 - g. Hot tap pipe, remove plug and wire to valve handle.
 - h. Clean all strainers in pipes affected by hot taps made that day.
 - i. Reinsulate pipe.
 - j. Repeat above listed steps for all remaining taps.
- D. Unless approved by Owner all hot taps in horizontal lines shall be made at or above center line of pipe.

3.06 TRAINING

3.07 APPLICATION

- A. Install valves and unions at equipment connections. Install unions on equipment side of valves. Provide dielectric isolation only where non-ferrous components connect to ferrous components.
- B. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.
- C. Install ball valves in piping 2 inches and smaller and butterfly valves in piping 2-1/2 inches and larger for throttling, bypass or manual flow control services. Under this application, throttling valves are not to be used for shutoff, and additional valves shall be installed for isolation.
- D. Use plug valves for throttling service where indicated on Drawings.
- E. Provide gate or ball drain valves at main shutoff valves, low points of piping, bases of vertical risers and at equipment. Pipe to nearest drain.

3.08 FLUSHING AND CLEANING OF PIPING SYSTEMS

- A. MD ANDERSON Systems:
 - 1. When constructing minor piping modifications or additions verify with Owner if the Owner's pumps and strainers can be used for flushing and chemical cleaning operations. When the flushing and cleaning operations are complete, the contractor shall insure the strainer baskets and screens installed in the piping systems permanent strainers replaced with clean elements. Keep temporary strainers in service until the equipment has been tested, then replace straining element with a new strainer and clean and deliver the old straining elements to Owner. Fit the Owners strainers with a line size blowoff valve.

END OF SECTION 23 21 13

SECTION 23 21 30 HYDRONIC SPECIALITIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Perform all Work required to provide and install air vents, pressure gauges, thermometers, strainers, air separators, expansion tanks, relief valves, water flow measuring and balancing systems, and water flow integrating meters as indicated by the Contract Documents with supplementary items necessary for their proper installation and operation.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. ANSI/ASME Boilers and Pressure Vessel Code, Section VIII, Division 1 Design and Fabrication of Pressure Vessels.

1.04 QUALITY ASSURANCE

- A. Manufacturer: For each product specified, provide components by the same manufacturer throughout.

1.05 SUBMITTALS

- A. Product Data:
 - 1. Submit Shop Drawings and product data, including component sizes, rough-in requirements, service sizes, and finishes.
 - 2. Submit manufacturer's installation instructions.

1.06 EXTRA MATERIALS

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

PART 2 - PRODUCTS

2.01 GENERAL

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

2.02 Manufacturers

- A. Circuit Balancing Valves: Armstrong, Tour & Anderson.
- B. Coil Package Valve Sets: Nexus, Tour and Anderson
- C. Integrating Flowmeters: Panametrics, Balance Master, Controlotron, EMCO.
- D. Pressure Gauges: Ashcroft, Dwyer, Weksler, Marsh Instrument, H.O. Terice, Moeller Instrument Co, Weiss.
- E. Thermometers: Ashcroft, Dwyer, Marsh Instrument, Weksler, Moeller Instrument, H.O. Terice, Weiss, Controlotron Corporation.
- F. Strainers: Keckley, Mueller, Muessco, Strainers, Inc., Victaulic, Anvil.

2.03 MANUAL AIR VENTS

- A. Provide air vents at the highest points of the hydraulic piping systems and on the uppermost connections to all hydraulic coils; 125 psig pressure rating. Provide shutoff valves to facilitate maintenance of air vents.
- B. Locate all air vents and their discharge lines in accessible locations, preferably clustered.
- C. Route discharge lines to nearest floor drain without air traps.

2.04 Coil Circuit Balancing Valves

- A. Install in chilled and hot water piping systems and elsewhere where shown on Drawings per manufacturer's recommendation and installation instructions. Balance valves shall not be required on systems provide with pressure independent control valves. Balance valves shall be rated to operate and perform their intended design function at the system's operating temperature and maximum design pressure. The valve body shall be a wye pattern, globe-style, and provide two pressure/temperature metering ports (PT Ports), and digital handwheel. Balancing valve handle shall have a integral memory stop for locking the valve position after the system is balanced.
- B. Valves may also be furnished with precision machined venturi built into the valve body to provide highly accurate flow measurement and flow balancing. The venturi shall have two, 1/4" threaded brass metering ports and gasketed caps located on the inlet side of the valve.

2.05 FLEXIBLE HOSE

- A. Furnish and install Amber-Booth Metalflex flexible hose connectors or accepted substitution. Hose and braid shall be bronze and male fittings shall be steel.

- B. Install connector in a straight line without offset. Piping shall be supported so that connector does not carry pipe load.
- C. Install in line without twisting connector.
- D. For pipe sizes ½ inch to 2 inches only. Model BR-SM.

2.06 PRESSURE GAUGES

- A. Application: Provide pressure gauges as indicated on Drawings; 4-½ inch face diameter with 0.5 percent accuracy of full span, Grade 2A, ANSI B40.1.
- B. Gauge Ranges:
 - 1. Provide 0 - 160 psi gauges for 150 psi chilled/hot water service.
 - 2. Provide 0 – 300 psi gauges for 300 psi, chilled/hot water service.
 - 3. Provide 0 - 200 psi gauges for domestic cold water service.
 - 4. Provide 0 – 150 psi gauges for condenser water and generator cooling water service.
 - 5. Provide liquid glycerin filled compound pressure gauges with a graduation ratio of 30 psi to 30 inches of mercury across basket strainer at suction of condensing water pump.
- C. For each gauge, provide bronze gauge lock and globe type bleed valve:
 - 1. Similar to Jenkins 750, Crane 362E, Stockham B-66, Powell 120 or accepted substitution of the pressure rating for the system installed.

2.07 THERMOMETERS

- A. Placement: Provide, where shown on Drawings and as indicated below, thermometers of suitable range for the service required. Provide thermometers on the inlet and outlet sides of all coils, heat exchangers, and heat generators.
 - 1. Condenser water:
 - a. Range: 0 to 120 degrees F.
 - b. Division: 1 degrees F.
- B. Sockets: Provide thermometer sockets at all thermometer locations. Provide thermometer sockets only, fitted with plug and chain and conforming to the requirements specified for thermometers. Install all sockets vertical or at a 45-degree vertical angle to permit filling with conducting liquid for tests.
- C. Construction: Provide thermometers that are 9 inches long with an etched glass enclosed scale of 2-degree increments, a cast aluminum case, and red reading mercury. Furnish an adjustable, angle-type scale with a swivel nut connection into ¾-inch brass separable sockets. Use a 3-1/2 inch stem length for all pipe sizes up through 8 inches, a 6-inch stem length for 10 inch pipe size, and a 9-inch stem length for pipe sizes larger than 10 inches.
- D. Extensions: Where thermometers are installed in insulated lines, use extension-neck separable sockets.
- E. Remote Thermostats: Furnish remote bulb thermometers where specified and shown. Provide thermometers with corrosion-resistant movements set in cast aluminum cases with black enamel finish.

1. Furnish dials 4-½ inches in diameter, with black numbers on white dials.
2. Use copper capillary tubing protected by a spiral or double-braided bronze armor.

2.08 STRAINERS

- A. 2 inches and smaller: Screwed brass or iron body, Y pattern with 1/32 inch stainless steel perforated screen. 150 psi or 300 psi pressure rating to match system pressure.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Flush and clean expansion tanks prior to delivery to the Project Site, and keep sealed during construction.

3.02 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Provide manual air vents at system high points and as indicated.
- D. Provide manual air vents at entrance to all heating hot water coils, with a "cane" shaped discharge tube, positioned to permit draining to a portable receptacle.
- E. Provide valved drain and hose connection on strainer blow down connection.

END OF SECTION 23 21 30