SPECIAL SPECIFICATION

SECTION 15950S

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Testing, adjusting, and balancing of mechanical and plumbing systems.

B. Select a qualified, independent technical balancing firm and/or laboratory to provide balancing, testing and adjusting services.

1. These services will be paid for by the Contractor.

2. The responsibilities of the balancing firm and the services to be provided are included herein for information and guidance to the Contractor.

C. Perform the balancing, testing and adjusting services with Associated Air Balance Council (AABC) certified personnel or employ a qualified, independent, technical balancing firm and/or laboratory.]

D. Each section of Division 15 - Mechanical that has products or systems listed herein incorporate this section by reference and is incomplete without the required tests stated herein.

E. Coordinate with the commissioning specifications in Section 01710s and 01715S, which apply with this specification.

1.02 REFERENCES

A. AABC - National Standards for Field Measurement and Instrumentation, Total System Balance.

B. ASHRAE - 1984 Systems Handbook: Chapter 37, Testing, Adjusting and Balancing.

C. NFPA 12A - Halon 1301 Fire Extinguishing Systems.

1.03 SUBMITTALS

A. Test Reports:

1. Submit test report forms for review minimum 90 days prior to requesting final review by A/E.

2. Furnish six individually bound copies of test data. 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, both prior to and after any corrections are made to the system. Record all failures and corrective action taken to remedy incorrect situation.

3. A/E will retain one copy. Remaining copies will be returned for inclusion in operation and maintenance manuals.

4. Prior to commencing work, submit draft reports indicating adjusting, balancing and equipment data required.

5. Submit draft copies of report for review prior to final acceptance of project. Provide final copies for A/E and for inclusion in operating and maintenance manuals.

B. Include a set of reduced drawings with air outlets and equipment identified to correspond with data sheets and indicating thermostat locations.

1.04 AIR SYSTEM BALANCING

A. Quality Assurance:

1. Company specializing in the testing, adjusting and balancing of systems specified with a minimum of five years of documented experience and a member in good standing, certified to perform services, of the AABC. Perform work under supervision of AABC Certified Test and Balance Engineer.

2. Perform total system balance in accordance with AABC National Standards for Field Measurement and Instrumentation, Total System Balance.

B. General:

1. Conform to the specifications which include, but are not limited to, the following:

a. Air and water flows balanced to specified quantities.

b. Temperature regulation verification by hourly readings for three consecutive eight-hour days.

c. Three inspections within 90 days of occupancy for temperature verification.

d. Opposite season adjustment of systems.

2. Provide sufficient funds in project cost estimate and bid proposal to cover all work required for the testing, balancing and adjusting as determined by the balancing firm and/or laboratory.

3. Complete the installation and operate all systems to ensure they are operating in accordance with the requirements of these specifications and drawings, and perform all other items as described hereinafter to assist the balancing firm in performing the balancing, testing and adjusting of the systems. The items include, but are not be limited to, the following:
   a. Air Distribution Systems:
      (1) Verify installation of all supply, return and exhaust ducts for conformity to design.
      (2) Verify all volume, splitter, extractor and fire dampers are properly located and functional. Provide tight damper closure and full opening, smooth and free operation.
      (3) Air supply, return, exhaust, transfer grilles, registers, diffusers and terminal units installed and operational.
      (4) Blank and/or seal air handling systems, units and associates apparatus, such as heating and cooling coils, filter sections, access doors, etc., to eliminate excessive bypass or leakage of air.
      (5) All fans (supply, return, relief and exhaust) operating and verified for freedom from vibration, proper fan rotation and belt tension; correct overload heater elements; and clean filters installed.
   b. Water Circulating Systems:
      (1) Check and verify pump alignment and rotation.
      (2) Clean water systems and strainers by circulation for normal operation.
      (3) Check each pump motor amperage and voltage to ensure readings do not exceed nameplate rating.
      (4) Verify electrical overload heater elements to be of proper size and ratings.
      (5) Fill all water circulating systems and verify they are free of air and all vents installed at high points of systems.
      (6) Check and set operating temperatures of heat exchangers to design conditions.
   c. Automatic Controls:
      (1) Verify that all control components are installed in accordance with project requirements, including all electrical interlocks, damper sequence air and water resets, fire and freezestats. Stroke all controls through the full range.
      (2) Calibrate all controlling instruments and set for the design conditions.
   d. Cooperate with the balancing firm to provide all necessary data on the design and proper application of the system components and furnish all labor and material

required to eliminate any deficiencies. List all motors, nameplate data and size of overload heater installed. Record motor amperage during operation.

e. The drawings and specifications indicate valves, dampers, sheaves, and miscellaneous adjustment devices required to obtain optimum operating conditions to verify that all adjustment devices are accessible and readily adjustable.

f. Accurately record actual locations of balancing valves and rough setting.

C. Sequencing and Scheduling:

1. Sequence work to commence after completion of systems and prior to substantial completion of project.

2. Schedule and provide assistance in final adjustment and test of life safety, smoke evacuation and smoke control systems, with proper authorities having jurisdiction.

D. Submit reports on AABC National Standards for Total System Balance forms and include the following information:

1. Title Page:

a. Company name.

b. Company address.

c. Company telephone number.

d. Project name.

e. Project location.

f. Project A/E.

g. Project Contractor.

h. Project altitude.

2. Air Moving Equipment:

a. Location.

b. Manufacturer.

c. Model.

d. Air flow, specified and actual.

e. Return air flow, specified and actual.

f. Outside air flow, specified and actual.

g. Total static pressure (total external), specified and actual.

h. Inlet pressure.

i. Discharge pressure.

j. Fan rotations per minute.

3. Exhaust Fan and Exhaust Scrubber Systems (Acid and Ammonia) Data:

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 rotations per minute.

i. Acid/Ammonia Scrubber

4. Return Air/Outside Air Data:

a. Identification/location.

b. Design air flow.

c. Actual air flow.

d. Design return air flow.

e. Actual return air flow.

f. Design outside air flow.

g. Actual outside air flow.

h. Return air temperature.

i. Outside air temperature.

j. Required mixed air temperature.

k. Actual mixed air temperature.

l. Design outside/return air ratio.

m. Actual outside/return air ratio.

5. Electric Motors:
    a. Manufacturer.
    b. HP/BHP.
    c. Phase, voltage, amperage; nameplate, actual, no load.
    d. Rotations per minute.
    e. Service factor.
    f. Starter size, rating, heater elements.
    g. Exercise starters through its entire operating sequence.
    h. Voltage
6. V-Belt Drive:
    a. Identification/location.
    b. Required driven rotations per minute.
    c. Driven sheave, diameter and rotations per minute.
    d. Belt, size and quantity.
    e. Motor sheave, diameter and rotations per minute.
    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.
    j. Percent of design air flow.
10. Terminal Unit Data:
    a. Manufacturer.
    b. Type, constant, variable, single, dual duct.
    c. Identification/number.
    d. Location.
    e. Model.

f. Size.

g. Minimum static pressure.

h. Minimum design air flow.

i. Maximum static pressure.

j. Maximum design air flow.

k. Inlet static pressure.

11. Induction Unit Data:

a. Manufacturer.

b. Identification/number.

c. Location.

d. Model.

e. Size.

f. Design air flow.

g. Design nozzle pressure drop.

h. Final nozzle pressure drop.

i. Final air flow.

12. 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.

13. Cooling Tower:

a. Tower identification/number.

b. Manufacturer.

c. Model.

d. Rated capacity.

e. Entering air WB temperature, specified and actual.

f. Leaving air WB temperature, specified and actual.

g. Ambient air DB temperature.

h. Condenser water entering temperature.

i. Condenser water leaving temperature.

j. Condenser water flow rate.

k. Fan rotations per minute.

14. Chemical Water Treatment: Certify that chemical treatment systems are acceptable and meet requirements of local ordinances.

15. Chillers:

a. Identification/number.

b. Manufacturer.

c. Capacity.

d. Model.

e. Evaporator entering water temperature, design and actual.

f. Evaporator leaving water temperature, design and actual.

g. Evaporator pressure drop, design and actual.

h. Evaporator water flow rate, design and actual.

i. Condenser entering water temperature, design and actual.

j. Condenser leaving water temperature, design and actual.

k. Condenser pressure drop, design and actual.

l. Condenser water flow rate, design and actual.

m. Review the installation of the water chilling units, and provide a written report that related work is satisfactory for proper operation and performance of chiller. Verify proper installation of the following:

(1) Piping connections including provisions for disconnecting and servicing of chiller.

(2) Relief pipe, including dirt trap and flexible connection.

(3) Tap in condenser lines for acid cleaning.

(4) Isolation of chilled water and condenser water piping connections to chiller.

(5) Necessary balancing valves in water piping.

(6) Pipe strainers to protect chiller components and controls including pumps, automatic modulating valves and pneumatic controls.

(7) Pipe supporting and bracing independent of chiller to prevent transfer of pipe stresses to chiller components.

(8) Flow switches or pressure differential switches properly installed in horizontal piping near the chiller.

(9) Manometer installation to indicate pressure drops.

(10) All miscellaneous piping, including oil cooler.

(11) Vibration and noise provisions.

(12) Ambient room conditions.

(13) Wiring of flow switches or pressure differential switches with chiller interlock.

(14) Pressure gages and thermometers.

(15) Electrical wiring to compressor motor controller (Division 16) with interconnecting wiring to chiller control panel and unit motors from line disconnects.

(16) Electrical wiring of oil pump/starter, refrigeration transfer compressor/starter and controls.

(17) Electrical wiring of condenser water and chilled water pump starters with chiller interlock.

16. Heat Exchanger:

a. Identification/number.

b. Location.

c. Service.

d. Manufacturer.

e. Model.

f. Steam pressure, design and actual.

g. Primary water entering temperature, design and actual.

h. Primary water leaving temperature, design and actual.

i. Primary water flow, design and actual.

j. Primary water pressure drop, design and actual.

k. Secondary water entering temperature, design and actual.

l. Secondary water leaving temperature, design and actual.

m. Secondary water flow, design and actual.

n. Secondary water pressure drop, design and actual.

17. Cooling Coil Data:

a. Identification/number.

b. Location.

c. Service.

d. Manufacturer.

e. Air flow, design and actual.

f. Entering air DB temperature, design and actual.

g. Entering air WB temperature, design and actual.

h. Leaving air DB temperature, design and actual.

i. Leaving air WB temperature, design and actual.

j. Water flow, design and actual.

k. Water pressure drop, design and actual.

l. Entering water temperature, design and actual.

m. Leaving water temperature, design and actual.

n. Air pressure drop, design and actual.

18. 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.
19. Flow Measuring Station:
    a. Identification/station.
    b. Location.
    c. Size.
    d. Manufacturer.
    e. Model.
    f. Design flow rate.
    g. Design pressure drop.
    h. Actual/final pressure drop.
    i. Actual/final flow rate.
    j. Station calibrated setting.
20. Sound Level Report:
    a. Location.

b. Octave bands - equipment off.

c. Octave bands - equipment on.

21. Vibration Tests:

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).

22. Duct Leak Test:

a. Description of ductwork under test.

b. Duct design operating pressure.

c. Duct design test static pressure.

d. Duct capacity, air flow.

e. Maximum allowable leakage duct capacity times leak factor.

f. Test Apparatus:

(1) Blower.

(2) Orifice, tube size.

(3) Orifice size.

(4) Calibrated.

g. Test static pressure.

h. Test orifice differential pressure.

(1) Leakage.

23. Boilers

a. Identification/Number

b. Manufacturer

c. Capacity

d. Model

e. Entering water temperature, design, and actual

f. Leaving water temperature, design, and actual

g. Boiler pressure drop, design, and actual

h. Boiler water flow rate, design, and actual

i. Review the installation of the boilers, and provide a written report that related work is satisfactory for proper operation and performance of boiler. Verify proper installation of the following:

(1) Piping and connections including provisions for disconnecting and servicing of boiler.

(2) Relief pipe, including dirt trap, and flexible connection.

(3) Isolation of heating water and connections to boiler.

(4) Necessary balancing valves in water piping.

(5) Pipe strainers to protect components and controls including pumps, automatic modulating valves and pneumatic controls.

(6) Pipe supporting and bracing independent of boiler to prevent transfer of pipe stresses to boiler components.

(7) Flow switches or pressure differential switches properly installed in horizontal piping near the boiler.

(8) Manometer installation to indicate pressure drop.

(9) All miscellaneous piping

(10) Vibration and noise provisions

(11) Ambient room conditions.

(12) Wiring of flow switches or pressure differential switches.

(13) Pressure gages and thermometers.

(14) Electrical wiring to fan motor (Division 16) with interconnecting wiring to control panel.

24. Boiler Combustion Test: In accordance with ASTM PTC 4.1. Include the following:

a. Boiler manufacturer.

b. Model.

c. Firing rate.

d. Overfire draft.

e. Gas meter timing dial size.

f. Gas meter time per revolution.

g. Gas pressure at meter outlet.

h. Gas flow rate.

i. Heat input.

j. Burner manifold gas pressure.

k. Percent carbon monoxide (CO).

l. Percent carbon dioxide (CO_2).

m. Percent oxygen (O_2).

n. Percent excess air.

o. Flue gas temperature at outlet.

p. Ambient temperature.

q. Net stack temperature.

r. Percent stack loss.

s. Percent combustion efficiency.

t. Heat output.

1.05 PLUMBING SYSTEM

A. Submit plumbing system to operational tests to demonstrate satisfactory operation. Include the following information:

1. Title Page:

a. Company name.

b. Company address.

c. Company telephone number.

d. Project name.

e. Project location.

f. Project A/E.

g. Project Contractor.

2. Time date and duration of test for each system.

3. Water pressures at the most remote and highest fixtures.

4. Operation of each fixture and fixture trim.

5. Operation of each valve, hydrant and faucet.

6. Pump suction and discharge pressures.

7. Temperature of each domestic hot water supply.

8. Operation of each floor drain by flooding with water.

9. Operation of each vacuum breaker and backflow preventer.

10. Piping systems: Test results of all pressure tests.

11. Pumps: Field check alignment of all couplings and pump vibration.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 PREPARATION

A. Furnish proposed test procedures, recording forms, list of personnel and test equipment for A/E review.

B. Follow recommended procedures for testing as published by test equipment manufacturer.

C. Provide instruments required for testing, adjusting and balancing operations. Make instruments available to A/E to facilitate spot checks during testing.

D. Provide any additional balancing devices required for complete system balancing.

3.02 AIR SYSTEM BALANCING

A. Before commencing work, verify that systems are complete and operable. Ensure the following:

1. Equipment is operable and in a safe and normal condition.
2. Temperature control systems are installed complete and operable.
3. Proper thermal overload protection is in place for electrical equipment.
4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
5. Duct systems are clean of debris.
6. Correct fan rotation.
7. Fire and volume dampers are in place and open.
8. Coil fins have been cleaned and combed.
9. Access doors are closed and duct end caps are in place.
10. Air outlets are installed and operable.
11. Duct system leakage has been minimized.
12. Hydronic systems have been flushed, filled and vented.
13. Correct pump rotation.
14. Proper strainer baskets are clean and in place.
15. Service and balance valves are open.
16. Report any defects or deficiencies noted during performance of services to A/E.

17. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.

18. Beginning of work means acceptance of existing conditions.

19. Pretest components in the VFD. Provide factory certification of testing the entire VFD with varying induction motor loads for 24 hours prior to shipment.

B. Installation Tolerances:

1. Adjust air handling systems to scheduled values plus or minus 5 percent for supply systems and plus or minus 10 percent for return and exhaust systems.

2. Adjust hydronic systems to plus or minus 10 percent of design conditions indicated.

C. Test Procedures:

1. Adjust air handling and distribution systems to provide design supply, return, and exhaust air quantities.

2. Make air quantity measurements in ducts by pitot tube traverse of entire cross sectional area of duct.

3. Measure air quantities at air inlets and outlets.

4. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

5. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Control volume by internal duct devices such as dampers and splitters.

6. Vary total system air quantities by adjustment of sheaves. Provide drive changes required. Vary branch air quantities by damper regulation.

7. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

8. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

9. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

10. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

11. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

12. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

13. Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.

14. For variable air volume system fan powered units, set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

15. Test run fan/motor combinations, volume dampers and controls. Check sequence of operation and air flow limits at factory prior to shipment and submit test reports.

16. Base performance on tests conducted in accordance with ADC 1062.

17. Check that automatic flow controller is capable of maintaining air flow to within 5 percent of set point with inlet static pressure variations up to 2 inches.

18. Maximum Casing Leakage: 2 percent of design air flow at rated inlet static pressure.

19. Maximum Damper Leakage: 2 percent of design air flow at inlet static pressure.

20. Set volume with damper operator attached to assembly allowing modulation from 100 percent of design flow to 20 percent design flow. Set units with heating coils for minimum 35 percent design flow.

21. Provide record data that represents actually measured, or observed condition.

22. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

23. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

24. Leave systems in proper working order, replace adjustable sheaves with permanent fixed position sheaves, replace belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

25. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by A/E.

26. Check and adjust systems for opposite season performance approximately six months after final acceptance and submit report.

3.03 HYDRONIC SYSTEM BALANCING

A. Adjust water systems to provide required or design quantities.

B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.

C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

D. Balance system with automatic control valves fully open to heat transfer elements.

E. Adjust water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

G. Pressure test all chilled, condenser & heating water piping prior to insulating. Test in place with 175 pounds per square inch hydrostatic test at the low point. Maintain pressure without pumping for two hours.

H. Provide all required pipe cleaning chemicals, chemical feed equipment, materials, and labor necessary to clean and sterilize the piping as herein specified. In addition, permanently install necessary chemical injection fittings complete with stop valves.

I. After chilled water, heating hot water, and condenser water piping have been pressure tested and approved for tightness, thoroughly clean and flush as follows:

1. After pressure testing is complete, drain the system until empty.

2. Add chemical pipe cleaning compound Mogul C-641 to system simultaneously with the filling of the system so that a minimum dosage of 50 pounds of compound per 1,000 gallons of water is attained in the system.

3. The cleaning compound shall then be circulated in the system for the recommended time period, but in no case for less than 48 hours.

4. The system shall then be drained until empty.

5. Fill the system again with fresh water and flush thoroughly until clean water is obtained. Maintain continuous blow-down and make-up as required during flushing operation. A strainer element at end of drain hose shall be utilized to confirm that discharge water is free of foreign material.

6. The cleaning and flushing procedure shall be approved in writing by the chemical manufacturer. The chemical manufacturer's representative shall supervise and certify in writing the cleaning and flushing of the piping systems.

3.04 MECHANICAL EQUIPMENT

A. Cooling Tower:

1. Provide a thermal performance test. Test cooling tower under actual operating conditions in accordance with CTI ATC-105 section on Testing and Balancing. Provide test by Cooling Tower Institute, and factory representatives of the manufacturer and witnessed by A/E.

2. If cooling tower is unable to deliver 100 percent thermal performance, required modifications will be made to the cooling tower construction to achieve 100 percent thermal performance under actual operating conditions.

3. After modifications are complete, retest in accordance with CTI ATC-105. Modifications to meet the required performance will not change the appearance of the exterior of the structure.

4. Test under actual operating conditions in accordance with CTI ATC-105, the section on Testing and Balancing, and verify specified performance. The CTI test shall be by factory representatives of the manufacturer and witnessed by A/E.

B. Chillers:

1. Document all data in the test report.

2. Demonstrate system operations, and verify specified performance.

3. Except as otherwise indicated, start up chiller in accordance with chiller manufacturer's instructions.

4. Do not place chiller in sustained operation prior to initial balancing of the mechanical systems affected by chiller operations.

5. Cooperate with other trades and installers of other work during the testing, adjusting, balancing and start-up of mechanical systems.

6. Complete the report preparation, and review the report on related work prior to chiller start-up; do not start chiller until inadequacies have been corrected in manner acceptable to chiller installer.

7. Include field capacity tests to verify the compliance of the installed equipment with the Contract Documents. Provide factory trained representative that is qualified to supervise the testing operations, and to obtain test data required to enable the water chilling unit manufacturer to certify the capacity of the units based on field tests. Conduct tests in accordance with methods prescribed by ARI Standard 550-88, with the exception that test quality evaporator and condenser pressure gages may be used. Brush clean the water sides of the condensers and evaporators immediately prior to the test. Assume the water side fouling factor to be 0.00025 during the test. Certify that the units can produce at least the specified cooling capacity with a maximum kilowatt per ton input not to exceed 105 percent of the specified value. Provide all necessary instruments, thermometers, gages, manometers, etc., required for the tests.

C. Refrigeration System:

1. Clean lines of scale, direct and foreign matter before making connections and purge with dry nitrogen to prevent oxidation during brazing.

2. After completion, pressure the high and low pressure sides of the piping system at the test pressures specified in ASHRAE 15 for the refrigerant type to be used. Leak test with a bubble solution followed by a Halide torch test. Repair any leaks and repeat tests until no further leaks are found and the system passes a static leak test pressure for a duration of 24 hours.

3. After the pressure tests are completed, exhaust the system including the coils by a suitable vacuum pump connected to the liquid line. After 2.5 mm of mercury absolute pressure is obtained, continue the evacuation for 72 hours. Check the vacuum by a suitable mercury column gage.

4. After the dehydration of the system is thus completed, charge the system with refrigerant and put into operation.

5. Follow the general test guidelines of ASHRAE 15 for the tests of the refrigerant piping system.

6. Test refrigeration system in accordance with ASME B31.5.

7. Provide written test report detailing methods, materials, and results.

3.05 FIRE PROTECTION

A. Fire Protection System:

1. Hydrostatically test all fire protection piping in accordance with NFPA. Test all standpipe fire protection and all sprinkler piping with 200 pounds per square inch hydrostatic test at the lowest level with pressure maintained without loss for two hours.

2. Submit certified laboratory performance test curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH when applicable.

3. Conduct a field acceptance test in accordance with NFPA 20. Provide notice to the pump manufacturer's engineer and A/E so that they can be present during the field test.

4. Submit written report indicating the results of the test, certified by those present that test was performed and that system performance was acceptable.

5. Schedule test to allow A/E to witness. Give written notice of the date of test a minimum of three working days in advance.

6. Upon completion of test, prepare Contractor's Material and Test Certificate and submit to A/E. Furnish copies to the authority having jurisdiction.

3.06 PLUMBING EQUIPMENT

A. Compressed Air System:

1. Apply pressure to piping system equal to 1 and 1/2 times the operating pressure, 150 pounds per square inch-gage minimum, with oil free dry air or gaseous nitrogen and hold while testing all joints with a soap solution. Repair all leaks. Maintain pressure in piping system for a period of 15 minutes.

2. With air compressor(s) activated and attached to piping system, record compressed air readings at each compressor and at each outlet.

3. 3. Provide services of a factory trained representative for two consecutive days to test, supervise pre-start checkout, initialize start-up, place into operation and review operating instructions. Provide certification in writing that this work was accomplished.

B. Natural Gas:

1. Apply pressure equal to 1-1/2 times the operating pressure with 50 pounds per square inch-gage as a minimum. Utilize oil free dry air or gaseous nitrogen and hold pressure for one hour with no drop in pressure. Repair all leaks.

2. Record natural gas reading at entrance to building on main line with valves to equipment shutoff. Read each indicating instrument at 1/2 hour intervals for a period of four hours and a final reading at the end of 24 hours.

C. Sanitary Waste, Vent and Storm Drainage Systems: Test systems throughout upon completion of the rough work and without fixtures connected. Test underground lines with not less than 15 feet hydrostatic head and prove leak free for one hour. After storm drainage piping is complete, plug all openings, except tops of stacks, and fill system with water and prove leak free for one hour. Plug and test sanitary system by floors and prove leak free for one hour. Flush floor drains for proper operation.

D. Domestic Water System:

1. Test all hot and cold water piping prior to being insulated. Test in place with 125 pounds per square inch hydrostatic test at the low points and maintain pressure without pumping for one hour.

2. Completely flush water circulating system with water with strainers removed. Fill system with water with strainer installed and circulate water for 48 hours minimum with a 1 inch open bleed valve or until bleed water is clear. After completing this operation, chemically treat system, clean strainer and open to central system.

3. Thoroughly flush all domestic water piping and tanks and then treat and sterilize with HTH or a liquid chlorine gas and water solution, or a direct chlorine gas placed in the upstream side in amounts to give a dosage of 50 ppm chlorine calculated on the volume of water the piping will contain. A minimum residual of 5 ppm chlorine shall remain in all parts of the system for a minimum of 24 hours. After sterilizing, flush all lines thoroughly. The foregoing shall be considered minimum requirements. The sterilization shall be in accordance with local utility company requirements.

4. Under no circumstances shall the Contractor permit the use of any portion of the domestic water system until it has been properly sterilized and certified same by the local water department.

5. Test results of disinfection of water piping system.

END OF SECTION