University Contact: Energy & Engineering Group
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SECTION 23 05 93_TESTING AND BALANCING FOR HVAC SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes
1.1 Testing and Balancing of Ducted Air Systems
1.2 Testing and Balancing of Hydronic Cooling and Heating Systems

B. The intent of these standards are to provide input to the design team on the University's preference of manufacturers, design, material options and quality assurance to maintain the longevity of its assets.

C. Testing and Balancing contractor shall check, adjust and balance all components of the HVAC and exhaust systems which will result in optimal noise, temperature and airflow conditions in the conditioned spaces of the building while the systems are operating economically and efficiently.

1.2 REFERENCES

A. Common Work for HVAC Systems 23 05 00

B. Common Requirements for HVAC Systems 23 05 01

C. Hydronic Pumps 23 22 13

D. Hydronic Piping Systems 23 21 13.23

E. Air Distribution Systems, Section 23 30 00

F. Fans 23 34 00

G. Air Terminal Units 23 36 00

H. Air Handling Units 23 73 00

I. Terminal Heating and Cooling Units 23 82 00

1.3 QUALITY ASSURANCE

A. All TAB Contractors performing work on the University of Delaware Newark Campus must be certified by either the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB). TAB Contractor must have 10 years of experience

with projects of similar scope and size. TAB Contractor shall provide documentation of successful completion of 10 projects with similar scope and size.

B. All TAB work at the University of Delaware shall be performed by technicians with either AABC or NEBB certification. All TAB technicians performing work at the University of Delaware Newark Campus must have at least 5 years of experience with projects of similar scope and size. TAB Contractor shall provide documentation that technicians performed at least 5 recent projects of similar scope and size.

C. All TAB work shall be supervised by licensed professional engineer registered in the State of Delaware.

D. All TAB shall be performed as per American Society of Heating Air Conditioning and Refrigeration Engineers (ASHRAE) standard 111 – Measurement, Testing, Adjusting and Balancing of Building HVAC Systems.

E. All TAB shall be performed as per American Society of Heating Air Conditioning and Refrigeration Engineers (ASHRAE) standard 113 – Method of Testing Room Air Diffusion.

F. All ducted laboratory fume hoods shall be certifies as per American Society of Heating Air Conditioning and Refrigeration Engineers (ASHRAE) standard 110 – Method of Testing Performance of Laboratory Fume Hoods.

1.4 SUBMITTALS

A. Preliminary Submittals

1. Qualifications of the Test and Balance Agency and of personnel assigned to the project.

2. Detailed Procedures for the project.

3. Report forms that will be used on the project

4. List of instruments to be used on the project including certification for all instruments.

5. Submit reports of pre-construction plan check and periodic mechanical construction review prior to commence of work.

B. Intermediate Submittals

1. Provide appropriate deficiency information to the project team as TAB work progresses. Deficiency information shall be sufficient to facilitate resolution to the deficiencies.

2. Prepare a written report describing deficiencies or components that do not function properly. Describe actions taken to resolve deficiencies. Document that the deficiencies have been resolved to the satisfaction of the TAB contractor.

C. Final Submittals

1. Upon completion of work, submit testing, adjusting and balancing reports bearing the seal and signature of the Certified Test and Balance Supervisor/Technician. The reports are: certified proof that the systems have been tested, adjusted and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed and are operating; and, are an accurate record of all final quantities measured to establish normal operating values of the systems.

2. Submission: Submit six (6) complete sets of reports. If information is incomplete or further testing, adjusting and balancing is deemed necessary, resubmit six (6) final complete sets. Distribution of submittals will be:

Owner	Four (4) copies
Owner Representative	One (1) copy
Mechanical engineer	One (1) copy

3. Format: Bind report forms in three-ring binders or portfolio binders. Label edge and binder front cover with label identifying project name, project number and descriptive title of contents. Divide the contents of the report into the below listed divisions, separated by divider tabs:
    a) General Information (title page and instrument list)
    b) Summary
    c) Air Systems
    d) Water Systems
    e) Special Systems

Title Page:

a) Company name
b) Company address
c) Company telephone number
d) Name, signature, and registration number of each technician
e) Project name
f) Project location
g) Project Architect
h) Project Engineer
i) Project Contractor

j) Project altitude
k) Date of report
l) Balancing methodology (Ratio or Herman Method)

Instrument List:

a) Instrument
b) Manufacturer
c) Model
d) Serial number
e) Range
f) Calibration histories

Summary page(s) to include:

a) Provide sheet describing mechanical system deficiencies.
b) Describe objectionable noise or drafts found during testing, adjusting and balancing.
c) Provide recommendations for correcting deficiencies and unsatisfactory performances and indicate whether modifications required are: within the scope of the contract; design related; or installation related.

The remainder of the report shall contain the appropriate forms for each respective item and system. Fill out forms completely. Indicate on form when information cannot be obtained or is not applicable.

For air systems, the forms shall, at a minimum, include:

a) Names and initials of personnel performing the balancing (on each form)
b) Dates balancing was performed (on each form)
c) Weather conditions at the time of the test or balance (outdoor temperature, barometric pressure, outdoor relative humidity…etc.)
d) All motor rated data: voltages, amps, RPM, HP, manufacturer, starter and overload protective device sizes
e) All motor operating data (before and after adjustments) voltages, amps, RPM, HP, BHP, and sheave size/rating and manufacturer
f) All fan data (design and operating): supply and return CFM, operating static pressures (suction, discharge, and fan static), fan sheave, belt size, fan RPM
g) All drive changes necessitated to obtain design capacities
h) List actual minimum and maximum outside air volumes measured for each system and the corresponding control setpoint
i) All supply and return air outlet/inlet CFM readings. Include velocity measurements and A_K factors where applicable. Include initial and final CFM readings at each outlet/inlet. Record the throw for each outlet.
j) For VAV systems, record static pressure at each terminal box as well as static pressure at static pressure sensor (for temperature control system). Record initial and final minimum and maximum CFM readings.

k) Measured building static pressure at building static pressure sensor and five other locations.
l) Measured room pressurization for all spaces requiring negative or positive pressurization with regard to adjacent spaces.
m) Heating and cooling coil entering and leaving air temperatures during test (as a reference).
n) Design and As-Built fan system curves for each fan.
o) Schematic layout of each system with all fans, VAV terminals, inlets and outlets. Inlets and outlets shall be labeled with the inlet and outlet number. Inlet and outlets shall be labeled to which room they occupy.
p) ASHRAE 110 Laboratory Fume Hood Certification (If Required)

For water systems, the forms shall, at a minimum, include:

a) Names and initials of personnel performing the balancing (on each form)
b) Dates balancing was performed (on each form)
c) All motor operating data (design and operating): voltages, amps, RPM, HP, BHP, starter and overload protective device sizes/rating
d) All pump data (design and operating): GPM, RPM, discharge pressure (no flow and full flow), suction pressure (no flow and full flow), total head pressure (no flow and full flow), impeller size, (ensure that pump curves are in O&M manuals)
e) Flow levels for each unit served (design and operating)
f) Heating and cooling coil water entering and leaving temperatures
g) Record minimum and maximum water flows for the system and at all heating and cooling coils.
h) Design and As-Built pump system curves for each pump.

Detailed data collection requirements for specific HVAC systems are in Appendix TAB1.

Any deficiencies that could not be resolved should be provided in writing and a possible explanation of the problem provided.

Test and Balance Contractor will provide Control Contractor with:

1) Static pressure and CFM values at each fan system
2) Static pressure and CFM values at each terminal box
3) Static pressure at static pressure sensor (that ensures adequate static pressure at all terminal boxes) and at AHU static pressure sensor.
4) For each fan system, outside air damper position that provides required minimum outside air.
5) Flow rates and pressures for each hydronic system
6) Pipe pressure at pressure sensor (that ensures adequate pressure at all coil valves) and at pump pressure sensor.

1.5 CLOSE OUT SUBMITTALS

Not Applicable

1.6 PRE-BALANCING SERVICES

A. Perform a pre-balancing review of the following documents:
   1) Contract drawings – Verify all minimum/maximum air and water flows sum to the quantities listed on the design documents.
   2) Contract specifications
   3) Addenda
   4) Submittal data
   5) Shop drawings
   6) Automatic control drawings
   7) Determine if there are sufficient amount of balancing devices. Offer suggestions to where balancing devices are needed.
   8) Prepare a report of the pre-construction review that lists recommended changes that allow for the most effective balancing of all mechanical systems.

B. Examine HVAC systems and equipment installation to verify that indicated balancing devices such as test ports, guage cocks, flow-control devices, balancing valves and fittings, control dampers and manual balancing dampers are installed and that their locations are accesssible and appropriate for effective balancing and for effective equipment operation. Report all inaccesible or inappropriate balancing devices to project team for corrective action.

C. Perform construction review, coordinated with General Contractor and Owner Representative, during the installation of the mechanical systems. Purpose for the review is to:
   1) Identify potential problems for performing balancing
   2) Identify modifications that will aid balancing
   3) Schedule and coordinate balancing with other work
   4) Prepare a report of construction review

D. TAB contractor shall make special note wherever abnormal installed conditions (such as crimped flexible ducts, tight offsets and unusual tap-ins or fittings) do not permit a proper air balance without increasing main duct static pressure or fan speed. Abnormal conditions shall be reported as early as possible, preferably during preliminary observations, and submitted with static pressure and airflow measurements that will permit analysis and identification of necessary corrective actions.

E. Prior to beginning testing, adjusting and balancing, schedule and conduct a conference with the Architect/Engineer, Owner Representative, and the Mechanical/Control system installing Contractors. The conference objective is final coordination and verification of system operation and readiness for testing, adjusting and balancing procedures and scheduling procedures with the above mentioned parties. Indicate work required to be completed prior to testing, adjusting, and balancing and identify the party responsible for completion of that work.

F. Contact the Control Contractor for assistance in operation and adjustment of controls during testing, adjusting and balancing procedures. Include in report any deficiencies found in the temperature control system as they relate to testing and balancing.

G. Identify TAB Locations: After rough-in of ducts, piping and equipment is complete, identify traverse locations. Drill all test holes in duct required for temperature, pressure and velocity readings. Install test hole caps equal to Ventlock model 699 in each hole.

PART 2 - PRODUCTS

2.1 Instrumentation

A. Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements to be in accordance with the requirements of Reference Standards and instrument manufacturer's specifications.

B. All instruments used for measurements shall be accurate and calibrated. Calibration and maintenance of all instruments to be in accordance with the requirements of Reference Standards.

C. Provide all necessary tools, scaffolding and ladders and other necessary instruments.

PART 3 – PROJECT TEAM RESPONSIBILITY TO TAB CONTRACTOR

3.1 Provide TAB Contractor with the latest set of contract documents (drawings, specifications, approved submittals…etc.) including all approved change orders/contract modifications.

3.2 Develop a project schedule with input from the TAB contractor that coordinates the work of other disciplines and provides adequate time to allow for successful completion of the TAB work.

3.3 Ensure the building enclosure is complete, including but not limited to all structural components, windows and doors installed, door hardware complete, stairs, elevators and mechanical shafts complete, roof systems complete, ceilings are in place and all plenums sealed.

3.4 Ensure that all necessary mechanical work is complete including hydrostatic testing. The piping systems shall be flushed, filled, vented and chemically treated. The duct systems have been cleaned.

3.5 Complete the installation of permanent electrical power systems serving HVAC equipment and systems.

3.6 Complete the installation of all HVAC equipment and systems.

3.7 Perform the start up of all HVAC equipment and systems in accordance with the manufacturer's recommendations.

3.8 Complete installation, programming (including design parameters and graphics) calibration and start up of all building control systems.

3.9 Require that BAS firm provide access to hardware, software and onsite technical support required to assist the TAB effort.

PART 4 - EXECUTION

4.1 Daily Reports

A. Submit to Owner Representative daily work activity reports for each day on which testing and balancing work is performed. Reports shall include description of day's activities and description of any system deficiencies.

4.2 Preliminary Procedures

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. Volume (balancing and terminal units) dampers are in place and open.
    8. Fire dampers are in place and open.
    9. Coil fins have been cleaned and combed.
    10. Access doors are closed and duct end caps are in place.
    11. Air outlets are installed and connected.
    12. Duct system leakage has been minimized.
    13. Proper strainer baskets are clean and in place.
    14. Correct pump rotation.
    15. Hydronic systems have been flushed, filled, and vented.
    16. Service and balance valves in water distribution system are in place and open.
    17. Operating voltage on fan and pump motors do not exceed motor's nameplate maximum voltage rating.
    18. 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.

4.3 Duct Leak Test

A. All air ducted systems installed at the University of Delaware Newark Campus shall be fabricated for a maximum leakage of 1%. TAB contractor shall air leak test all ducted systems and document that the ducted systems passed or failed the leak test. If HVAC air ducts failed the leak test, TAB contractor shall make recommendations for modifications to the ducts so that they will pass the leak test.

4.4 Performing Testing, Adjusting and Balancing on Air Systems

A. Perform testing, adjusting and balancing procedures on each system identified in drawing, in accordance with the detailed procedures outlined in the referenced standards except as may be modified below.

B. In areas containing ceilings, remove ceiling tile to accomplish balancing work. Replace tile when work is complete and provide new tile for any tile that was damaged by this procedure. If the ceiling construction is such that access panels are required for the work of this section and the panels have not been provided, inform the owner representative.

C. Cut insulation, ductwork and piping for installation of test probes to the minimum extent necessary for adequate performance of procedures. Patch to maintain system integrity and pressure rating of systems.

D. In air systems employing filters, blank off sufficient filter area to simulate a pressure drop that is midway between that of a clean filter and that of a dirty filter.

E. Test and Balance Contractor shall set outlets/diffusers flow rate (volume) by adjusting dampers installed in the ductwork. Do not use volume dampers that are integral with the outlets/diffusers to set outlet/diffuser volume.

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

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

H. All Air Systems shall be balanced using a procedure, which results in minimum restrictions being imposed. At completion of balancing:
   1) Supply/exhaust fan RPM shall be set so that the static pressure at the terminal that is most difficult to maintain is adequate, but not excessive.

I. Measure and record system measurements at the fan to determine total flow. Adjust equipment as required to yield specified total flow at ventilation unit and at terminals. Proceed taking measurements in mains and branches as required for final terminal balancing. Perform terminal balancing to specified flows after balancing branch dampers, deflectors, extractors and valves.

J. Provide fan and motor drive sheave adjustments necessary to obtain design performance. Once drive sheave diameters have been established, replace all adjustable sheaves with solid pulleys (at Test and Balance Contractor Cost). Include in scope of services drive changes specifically noted on drawings, if any. If work indicates that any drive or motor is inadequate for the application, advise the owner representative by giving the representative properly sized motor/drive information (in accordance with manufacturers original service factor and installed motor horsepower requirements). Any changes shall keep the duct system within its design limitations with respect to the speed of the device and pressure classification of the distribution system. Material costs for sheave changes as well as time and material for motor changes will be considered a reimbursable expense and will require an itemized cost breakdown of all time and motor/drive changes submitted to owner representative; prior authorization is needed before this work is started.

K. If variable frequency drives (VFD's) are used to control motor speed, adjust fan speed via VFD's to obtain HVAC system performance as per the design documents. Set minimum and maximum fan speed with VFD and lock the minimum and maximum settings on the VFD. Record minimum and maximum fan & motor speed, VFD frequency and motor amperes.

L. Measure and record static air pressure conditions across fans, coils, terminals and filters. Indicate in report if cooling coil measurements were made on a wet or dry coil and if filter measurements were made on a clean or dirty filter.

M. Adjust outside air, return air and relief air dampers for design conditions at both the minimum and maximum settings and record both sets of data (and test methodology). If necessary, Test and Balance Contractor should return when an adequate temperature difference between the return air and outside air temperatures exists in order to determine minimum outside air damper position.

N. Balance modulating dampers at extreme conditions and record both sets of data. Balance variable air volume systems at maximum air flow rate (full cooling) and minimum flow rate (full heating) and record all data.

O. Adjust register, grille and diffuser vanes and accessories to achieve proper air distribution patterns (including diffuser throw and outlet velocity), uniform space temperatures, areas free from objectionable noise and drafts — that are within the capabilities of the installed system.

P. Final air system measurements to be within the following range (unless directed otherwise by Engineer) of the specified CFM:

Fans	-5% to +5% of design value
Supply grilles, registers, diffusers	-5% to +5% of design value
Return/exhaust grilles, registers	-5% to +5% of design value
Room pressurization air	-5% to +5% of design value

Q. Permanently mark equipment settings including damper positions, valve positions, and control settings. Set and lock memory stops.

R. Leave systems in proper working order by replacing belt guards, closing access doors and electrical boxes, and restoring temperature controls to normal operating settings.

S. Develop fan system curves for each fan in the HVAC systems using the data developed during the balancing process.

T. Perform room and building pressurization measurements to verify that lobbies, stairwells, laboratories, odorous rooms, clean spaces and other sensitive areas have correct air balance and pressure relationships. With all doors closed, measure the door pull to determine that the operating force required to open or close the door is less than or no greater than 30 pound-force.

U. Certify all laboratory fume hoods in accordance with ASHRAE Standard 110. This includes all new, re-used and relocated hoods.

4.5 Performing Testing, Adjusting and Balancing on Water Systems

A. Perform testing, adjusting and balancing procedures on each system identified in drawing, in accordance with the detailed procedures outlined in the referenced standards except as may be modified below.

B. Unless specifically instructed in writing, all work in this specification section is to be performed during the normal workday.

C. Document type and placement of expansion tank within piping system. Indicate tank water level. Indicate the pneumatic pressure within the expansion tank.

D. Document valve type and its ability to fully regulate flow during various conditions (different flow, temperature, and control conditions).

E. Provide motor and impeller adjustments necessary to obtain design performance. Include in scope of services changes specifically noted on drawings, if any. If work indicates that any impeller or motor is inadequate for the application, advise the owner representative by giving the representative properly sized motor/impeller information (in accordance with manufacturers original service factor and installed motor horsepower/impeller requirements). Any changes shall keep the piping system within its design limitations with respect to the speed of the device and pressure classification of the distribution system. Material costs for impeller changes as well as time and material for motor changes will be considered a reimbursable expense and will require an itemized cost breakdown of all time and motor/impeller changes submitted to owner representative; prior authorization is needed before this work is started.

F. If variable frequency drives (VFD's) are used to control motor speed, adjust pump speed via VFD's to obtain HVAC system performance as per the design documents. Set minimum and maximum pump speed with VFD and lock the minimum and maximum settings on the VFD. Record minimum and maximum pump & motor speed, VFD frequency and motor amperes.

G. Measure and record pressure across pump during no flow and full flow conditions.

H. All Hydronic Systems shall be balanced using a procedure, which results in minimum restrictions being imposed

I. Final water system measurements to be within the following range (unless directed otherwise by Engineer) of the specified gpm:

Pumps	-5% to +5%

J. Document if balancing was accomplished using valves or by trimming impeller. Document energy savings due to trimmed impeller.

K. If parallel pumps are designed to operate together, then measure:
   1) Both pumps at no flow
   2) Both pumps at full flow
   3) Each pump at full flow (while the other pump is off)

L. Measure and record design and actual pressure conditions prior and after coils, heat exchangers, and strainers.

M. Permanently mark equipment settings including valve positions, and control settings. Set and lock memory stops.

N. Leave systems in proper working order by closing access doors and electrical boxes and systems to normal operating settings.

O. Develop pump system curves for each pump in the HVAC systems using the data developed during the balancing process.

4.6 Building Automation System (BAS) Coordination

A. In the process of performing TAB work, the TAB contractor shall:

1. Work with the BAS provider to ensure the most effective total system operation within the design limitations and to obtain mutual understanding of the intended control performance.

2. Verify all control devices are properly connected.

3. Verify the intended controllers operate all dampers, valves and other controlled devices. Verify the controllers and thermostats operate the correct control devices.

4. Verify that al 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 close-off and full-open positions. This includes all duct mounted dampers, dampers in terminal units and air handling units and fire/smoke dampers.

6. Observe the calibration and operation of all controllers.

7. Check all dampers for free travel.

8. Verify the operation of all interlock systems

9. Perform variable volume system verification to assure the system and system components track with changes from full flow to minimum flow.

4.7 Sound Vibration and Alignment

A. Sound: Read and record sound levels at up to fifteen (15) locations per floor in building as designated by the Owners Representative (Commissioning Agent). 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 Owner's Representative.

B. Vibration: Read and record vibration for all pumps, fans and air handling units which have motors larger than 10 horsepower. Include equipment vibration, bearing housing vibration, foundation vibration and building structure vibration. Readings shall be made using portable

IRD (or approved equal) equipment capable of filtering out various unwanted frequencies and standard reporting forms.

4.8 Seasonal Adjustments

A. Within one year, the TAB contractor shall return during a period, in the winter and summer, when the outdoor conditions are representative of design conditions. The TAB contractor shall sample conditions in 50% of the HVAC systems (air flows, water flows, space temperature, building and space temperature…etc.) to determine if the HVAC systems are within design requirements. TAB contractor shall prepare a report documenting its findings and make recommendations for adjustments and modifications needed to bring HVAC systems within specified performance.

4.9 Commissioning

A. All testing and balancing shall be performed to the satisfaction of the Commssioning Agent prior to the acceptance of the testing and balancing report as meeting the requirements of this document.

B. If the Test and Balance Contractor fails to demonstrate proper compliance with this standard, the Engineer's, Owner Representative's or Commissioning Agent's costs for witnessing and reviewing three or more spot checks will be assigned to the Test and Balance Contractor by the Owner as a deduct to their contracted price. Note: The Test and Balance Contractor will not be responsible for costs related to poor design or to other factors beyond their control, though it is expected to call any design concerns and other factors beyond their control that might cause system failure to the attention of the Engineer and the Owner.

APPENDIX TAB1

A. These data collection points are for various HVAC systems and units. Some systems may not apply to this project.
B. Data shall include, at a minimum, the following points for each HVAC system/unit.
C. Air Moving Equipment:
    1) Designation
    2) Location
    3) Manufacturer
    4) Model
    5) Airflow, specified and actual
    6) Return airflow, specified and actual
    7) Outside airflow, specified and actual
    8) Total static pressure (total external), specified and actual
    9) Inlet pressure
    10) Discharge pressure
    11) Fan RPM
D. Return Exhaust Fan Data:
    1) Designation
    2) Location
    3) Manufacturer
    4) Model
    5) Total static pressure (total external), specified and actual
    6) Inlet pressure
    7) Discharge pressure
    8) Fan RPM, initial and final
E. Electric Motor:
    1) Manufacturer
    2) HP
    3) Frame
    4) Phase, voltage, amperage; nameplate and actual
    5) RPM
    6) Service factor
    7) Starter size, rating, heater elements
F. V-Belt Drive:
    1) Identification
    2) Driven sheave, diameter
    3) Belt, size and quantity
    4) Motor sheave, diameter
    5) Center to center distance, maximum, minimum, and actual
    6) Final components
G. Duct Traverse:
    1) System zone/branch
    2) Duct size

3) Area
4) Design velocity
5) Design airflow
6) Test velocity
7) Test airflow
8) Duct static pressure
9) Air temperature
10) Air correction factor

H. Air Monitoring Station Data:
1) Identification/location
2) System
3) Size
4) Area
5) Design velocity
6) Design airflow
7) Test velocity
8) Test airflow

I. Air Distribution Test Sheet:
1) Air terminal number
2) Room number/location
3) Terminal type
4) Terminal size
5) Area factor
6) Design velocity
7) Design airflow
8) Test velocity, initial and final
9) Test airflow, final
10) Percent of design airflow, initial and final
11) Air terminal throw
12) Air terminal inlet/outlet velocity

J. Terminal Unit Data:
1) Designation
2) Location
3) Manufacturer
4) Type, constant, variable, single, dual duct
5) Model
6) Size
7) Minimum static pressure
8) Minimum design airflow
9) Minimum actual airflow
10) Maximum design airflow
11) Maximum actual airflow
12) Inlet static pressure

K. Induct Unit Data:
1) Designation
2) Location
3) Manufacturer
4) Model

5) Size
6) Design airflow
7) Design nozzle pressure drop
8) Nozzle pressure drop, initial and final
9) Final airflow

L. Pump Data:
1) Designation
2) Location
3) Manufacturer
4) Size/Model
5) Impeller diameter
6) Service
7) Design flow rate, pressure drop
8) Actual flow rate, pressure drop
9) Discharge pressure
10) Suction pressure
11) Total operating head pressure
12) Shut-off, discharge and suction pressures
13) Shut-off, total head pressure

M. Heat Exchanger:
1) Designation
2) Location
3) Service
4) Manufacturer
5) Model and type
6) Steam pressure, design and actual
7) Primary water entering temperature, design and actual
8) Primary water leaving temperature, design and actual
9) Primary water flow, design and actual
10) Primary water pressure drop, design and actual
11) Secondary water entering temperature, design and actual
12) Secondary water leaving temperature, design and actual
13) Secondary water flow, design and actual
14) Secondary water pressure drop, design and actual

N. Cooling Coil Data:
1) Designation
2) Location
3) Service
4) Manufacturer
5) Size, face area, and fins/inch
6) Airflow, design and actual
7) Entering air DB temperature, design and actual
8) Entering air WB temperature, design and actual
9) Leaving air DB temperature, design and actual
10) Leaving air WB temperature, design and actual
11) Water flow, design and actual
12) Water pressure drop, design and actual
13) Entering water temperature, design and actual

14) Leaving water temperature, design and actual
15) All pressure drop, design and actual

O. Heating Coil Data:
1) Designation
2) Location
3) Service
4) Manufacturer
5) Size, face area, and fins/inch
6) Airflow, design and actual
7) Water flow, design and actual
8) Water pressure drop, design and actual
9) Entering water temperature, design and actual
10) Leaving water temperature, design and actual
11) Entering air temperature, design and actual
12) Leaving air temperature, design and actual
13) Air pressure drop, design and actual

P. Hydronic Flow Measuring Station:
1) Designation
2) Location
3) Manufacturer
4) Size
5) Model
6) Design flow rate
7) Design pressure drop
8) Actual/final pressure drop
9) Actual/final flow rate
10) Station calibrated setting

Q. Sound Level Report:
1) Location
2) Octave bands--equipment off
3) Octave bands--equipment on

R. Vibration Test:
1) Location of points
a) Fan bearing, drive end
b) Fan bearing, opposite end
c) Motor bearing, center (if applicable)
d) Motor bearing, drive end
e) Motor bearing, opposite end
f) Casing (bottom or top)
g) Casing (side)
h) Duct after flexible connection (discharge)
i) Duct after flexible connection (suction)
2) Test readings:
a) Horizontal, velocity and displacement
b) Vertical, velocity and displacement
c) Axial, velocity and displacement
3) Normally acceptable readings, velocity and acceleration
4) Unusual conditions at time of test

5) Vibration source (if non-complying)

S. Duct Leak Test:
   1) Description of ductwork under test
   2) Duct design operating pressure
   3) Duct design test static pressure
   4) Duct capacity, airflow
   5) Maximum allowable leakage equals duct capacity times leak factor
   6) Test apparatus
      a) Blower size
      b) Orifice, tube size
      c) Orifice size
      d) Date of calibration
   7) Test static pressure
   8) Test orifice differential pressure
   9) Measured leakage

T. Report is to include a listing of any abnormal or notable conditions not contained in the above.