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## PART 1 - INTRODUCTION

### 1.1 Purpose

- A. This guide specification covers the requirements for testing, adjusting, and balancing (TAB) of heating, ventilating, and air-conditioning (HVAC) air and water distribution systems. The Construction Contractor and its subcontractors shall make the following preliminary mechanical system tests and obtain approval and acceptance of Yale, CxA, AOR, and EOR.
- B. Acceptance testing during construction and achieving an acceptable final air and water balance are critical elements of project completion. Therefore, the balancing and the associated report must be accomplished and submitted before substantial completion. Similarly, timely reviews by Yale, AOR, EOR, CxA, will ensure that the final balance is acceptable prior to occupancy.


## PART 2 - TESTING, ADJUSTING, AND BALANCING OF HVAC

### 2.1 General Design Requirements

- A. The Testing, Adjusting, and Balancing specification shall be developed by the Engineer of Record (EOR) and based on the most current version of the Unified Facilities Guide Specifications (UFGS) 23 05 93 Testing, Adjusting, and Balancing for HVAC.
- B. Require the Contractor to provide test certifications showing the test has been made and is approved by local authorities and the Yale Project Manager.
- C. Balancing shall be performed by a company that is AABC or NEBB certified. The TAB contractor shall be hired under a separate contract from the mechanical contractor.
- D. Specifications shall indicate the TAB contractor shall demonstrate and reproduce measurements shown in TAB report. If the recheck proves to be different from the final report by more than the tolerances allowed, the balancing report shall be rejected.
  - 1. If the retest elicits a measured flow deviation of 10% or more from that recorded in the certified report in 10% or more of the retested selections, the report shall be rejected.
  - 2. If the report is rejected, all systems shall be readjusted and tested, new data recorded, new certified reports submitted, and new inspection tests made, all at no cost to the owner.

### 2.2 Required Submittals


- A. Pre-construction Submittals
  - 1. Records of Existing Conditions for renovation and alteration projects
  - 2. Independent TAB Agency and Personnel Qualifications

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- 3. TAB Design Review Report
- B. Shop Drawings
  - 1. TAB Schematic Drawings and Report Forms
- C. TAB Procedures
  - 1. Proposed procedures for TAB, submitted with the TAB Schematic Drawings and Report Forms.
  - 2. Testing Equipment Calibration
  - 3. Systems Readiness Check (Pre-TAB)
  - 4. TAB Execution
  - 5. TAB Verification
- D. Test Reports
  - 1. TAB Design Review Report
  - 2. Completed Pre-Final DALT Report
  - 3. Certified Final DALT Report
  - 4. Certified Final TAB Report for Season 1
  - 5. Certified Final TAB Report for Season 2

### PART 3 - EXECUTION

- A. Outline specifications are provided in Appendix A for Designer reference.
  - 1. This document conveys the importance of this specification section and the minimum level of direction necessary for the constructor(s) to successfully execute the associated scope of work.
- B. Contract specifications development shall be the sole responsibility of the Designer of Record.

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## Appendix – A

### *Guide Specifications for Testing, Adjusting, and Balancing*

*Designer Note: This document is an outline version specification only to be used as a minimum guide and is Not for Construction. The Designer shall provide construction specifications for the project as required in coordination with Yale.*

## PART 2 - INTRODUCTION

### 2.1 PURPOSE


- A. This guide specification covers the requirements for testing, adjusting, and balancing (TAB) of heating, ventilating, and air-conditioning (HVAC) air and water distribution systems.

### 2.2 REFERENCES

- A. The most current version of the following standards, guidelines, and manuals issued by the identified organizations and published for use as of the contract document issuance date.
  1. Air Movement and Control Association International, Inc. (AMCA)
    - a. AMCA 203-90 - Field Performance Measurements of Fan Systems
  2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
    - a. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality
  3. Associated Air Balance Council (AABC)
    - a. AABC National Standards for Total System Balance
  4. National Environmental Balancing Bureau (NEBB)
    - a. NEBB Procedural Standards for Measurements and Assessment of Sound and Vibration
    - b. NEBB Procedural Standards for Testing, Adjusting and Balancing Environmental Systems
  5. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
    - a. SMACNA 1780 HVAC Systems - Testing, Adjusting and Balancing
    - b. SMACNA 1858 HVAC Sound and Vibration Manual
  6. SMACNA 016 HVAC Air Duct Leakage Test Manual

### 2.3 DEFINITIONS

- A. AABC: Associated Air Balance Council
- B. DALT: Duct air leakage test
- C. DALT'd: Duct air leakage tested
- D. HVAC: Heating, ventilating, and air conditioning
- E. NEBB: National Environmental Balancing Bureau
- F. Out-of-tolerance data: Pertains only to field acceptance testing of Final DALT or TAB report. When applied to DALT work, this phase means "a leakage rate measured during DALT field acceptance testing which exceeds the leakage rate allowed by SMACNA Leak Test Manual for

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an indicated duct construction and sealant class." When applied to TAB work this phase means "a measurement taken during TAB field acceptance testing which does not fall within the range of plus 5 to minus 5 percent of the original measurement reported on the TAB Report for a specific parameter."

- G. Season 1, Season 2: Depending upon when the project HVAC is completed and ready for TAB, Season 1 is defined, thereby defining Season 2. Season 1 could be the season of maximum heating load, or the season of maximum cooling load.
- H. TAB: Testing, adjusting, and balancing (of HVAC systems)
- I. TAB'd: HVAC Testing/Adjusting/Balancing procedures performed
- J. TAB Agency: TAB Firm


#### 2.4 SIMILAR TERMS

1. In some instances, terminology differs between the Contract and the TAB Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results.
2. The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding AABC, NEBB, or TABB requirements where differences exist.


SIMILAR TERMS			
Contract Term	AABC Term	NEBB Term	TABB Term
TAB Standard	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems	Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems	International Standards for Environmental Systems Balance
TAB Specialist	TAB Engineer	TAB Supervisor	TAB Supervisor
Systems Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures	Field Readiness Check & Prelim. Field Procedures

#### 2.5 WORK DESCRIPTION

- A. The work includes duct air leakage testing (DALT) and testing, adjusting, and balancing (TAB) of new and existing heating, ventilating, and cooling (HVAC) air and water distribution systems including equipment and performance data, ducts, and piping which are located within,

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- on, under, between, and adjacent to buildings, including records of existing conditions.
- B. Perform TAB in accordance with the requirements of the TAB procedural standard recommended by the TAB trade association that approved the TAB Firm's qualifications. Comply with requirements of AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 (TABB) as supplemented and modified by this specification section. All recommendations and suggested practices contained in the TAB procedural standards are considered mandatory.
  - C. Conduct DALT and TAB of the indicated existing systems and equipment and submit the specified DALT and TAB reports for approval. Conduct DALT testing in compliance with the requirements specified in SMACNA “HVAC AIR DUCT LEAKAGE TEST MANUAL”, except as supplemented and modified by this section. Conduct DALT and TAB work in accordance with the requirements of this section.
  - D. Air Distribution Systems
    1. Test, adjust, and balance systems (TAB) in compliance with this section. Obtain Owner's written approval before applying insulation to exterior of air distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.
  - E. Water Distribution Systems
    1. TAB systems in compliance with this section. Obtain Owner's written approval before applying insulation to water distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. At Contractor's option and with Owner's written approval, the piping systems may be insulated before systems are TAB'd.
    2. Terminate piping insulation immediately adjacent to each flow control valve, automatic control valve, or device. Seal the ends of pipe insulation and the space between ends of pipe insulation and piping, with waterproof vapor barrier coating.
    3. After completion of work under this section, insulate the flow control valves and devices as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.
  - F. Tab Schematic Drawings
    1. Show the following information on TAB Schematic Drawings:
      - a. A unique number or mark for each piece of equipment or terminal.
      - b. Air quantities at air terminals.
      - c. Air quantities and temperatures in air handling unit schedules.
      - d. Water quantities and temperatures in thermal energy transfer equipment schedules.
      - e. Water quantities and heads in pump schedules.
      - f. Water flow measurement fittings and balancing fittings.
      - g. Ductwork Construction and Leakage Testing Table that defines the DALT test requirements, including each applicable HVAC duct system ID or mark, duct pressure class, duct seal class, and duct leakage test pressure.


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## 2.6 SUBMITTALS

- A. Preconstruction Submittals
  - 1. Records of Existing Conditions
  - 2. Independent TAB Agency and Personnel Qualifications
  - 3. TAB Design Review Report
- B. Shop Drawings
  - 1. TAB Schematic Drawings and Report Forms
- C. TAB Related HVAC Submittals
  - 1. A list of the TAB Related HVAC Submittals, no later than seven (7) days after the approval of the TAB Agency and Personnel Qualifications.
- D. TAB Procedures
  - 1. Proposed procedures for TAB, submitted with the TAB Schematic Drawings and Report Forms.
  - 2. Testing Equipment Calibration
  - 3. Systems Readiness Check (Pre-TAB)
  - 4. TAB Execution
  - 5. TAB Verification
- E. Test Reports
  - 1. TAB Design Review Report
  - 2. Completed Pre-Final DALT Report
  - 3. Certified Final DALT Report
  - 4. Prerequisite HVAC Work Checkout List for Proportional Balancing
  - 5. Prerequisite HVAC Work Checkout List for Season 1
  - 6. Certified Final TAB Report for Season 1
  - 7. Prerequisite HVAC Work Checkout List for Season 2
  - 8. Certified Final TAB Report for Season 2
- F. Certificates
  - 1. Independent TAB Agency and Personnel Qualifications
  - 2. TAB Pre-Field Engineering Report
  - 3. Instrument Calibration Certificates
  - 4. Completed Pre-Final DALT Work Checklist
  - 5. Advance Notice of Pre-Final DALT Field Work
  - 6. Advance Notice of TAB Field Work for Proportional Balancing
  - 7. Advance Notice of TAB Field Work for Season 1
  - 8. Advance Notice of TAB Field Work for Season 2


## 2.7 QUALITY ASSURANCE

- A. Independent AABC or NEBB or TABB tab agency:
  - 1. To secure approval for the proposed agency, submit information certifying that the TAB agency is a first-tier subcontractor who is not affiliated with any other company participating in work on this contract, including design, furnishing equipment, or construction. Further,


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submit the following, for the agency, to Owner for approval:


- a. Independent AABC or NEBB or TABB TAB agency:
    - 1) TAB agency: AABC registration number and expiration date of current certification; or NEBB certification number and expiration date of current certification; or TABB certification number and expiration date of current certification.
    - 2) TAB team supervisor: Name and copy of AABC or NEBB or TABB TAB supervisor certificate and expiration date of current certification.
    - 3) TAB team field leader: Name and documented evidence that the team field leader has satisfactorily performed full-time supervision of TAB work in the field for not less than 3 years immediately preceding this contract's bid opening date.
    - 4) TAB team field technicians: Names and documented evidence that each field technician has satisfactorily assisted a TAB team field leader in performance of TAB work in the field for not less than one year immediately preceding this contract's bid opening date.
    - 5) Current certificates: Registrations and certifications are current, and valid for the duration of this contract. Renew Certifications which expire prior to completion of the TAB work, in a timely manner so that there is no lapse in registration or certification. TAB agency or TAB team personnel without a current registration or current certification are not to perform TAB work on this contract.
  - b. TAB Team Members: TAB team approved to accomplish work on this contract are full-time employees of the TAB agency. No other personnel are allowed to do TAB work on this contract.
  - c. Replacement of TAB team members: Replacement of members may occur if each new member complies with the applicable personnel qualifications, and each is approved by the Owner.
- B. Qualifications
1. TAB Firm
    - a. The TAB Firm must be either a member of AABC or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including TAB of environmental systems, the performance of clean rooms and clean air devices, building systems commissioning, and the measuring of sound and vibration in environmental systems.
    - b. Certification must be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor must immediately notify the Owner and submit another TAB Firm for approval. Any firm that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections to be performed by the TAB Firm will be considered invalid if the TAB Firm loses its certification prior to Contract completion and must be performed by an approved successor.

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- c. These TAB services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The TAB Firm must be a prime subcontractor of the Contractor and be financially and corporately independent of the mechanical subcontractor, reporting directly to and paid by the Contractor.
- 2. TAB Related HVAC Submittals
  - a. The TAB Specialist must prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. Ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.
- C. Responsibilities
  - 1. The Contractor is responsible for ensuring compliance with the requirements of this section. The following delineation of specific work responsibilities is specified to facilitate TAB execution of the various work efforts by personnel from separate organizations. This breakdown of specific duties is specified to facilitate adherence to the schedule listed in the paragraph “TAB SUBMITTAL AND WORK SCHEDULE”.
  - 2. Contractor
    - a. TAB personnel: Ensure that the DALT work, and the TAB work is accomplished by a group meeting the requirements specified in the paragraph “TAB PERSONNEL QUALIFICATION REQUIREMENTS”.
    - b. Pre-DALT/TAB meeting: Attend the meeting with the TAB Supervisor and ensure that a representative is present for the sheet metal contractor, mechanical contractor, electrical contractor, and automatic temperature controls contractor.
    - c. HVAC documentation: Furnish one complete set of the following HVAC-related documentation to the TAB agency:
      - 1) Contract drawings and specifications
      - 2) Approved submittal data for equipment
      - 3) Construction work schedule
      - 4) Up-to-date revisions and change orders for the previously listed items
    - d. Submittal and work schedules: Ensure that the schedule for submittals and work required by this section and specified in the paragraph “TAB SUBMITTAL AND WORK SCHEDULE” is met.
    - e. Coordination of supporting personnel:
      - 1) Provide the technical personnel, such as factory representatives or HVAC controls installer required by the TAB field team to support the DALT and the TAB field measurement work.
      - 2) Provide equipment mechanics to operate HVAC equipment and ductwork mechanics to provide the field designated test ports to enable TAB field team to accomplish the DALT and the TAB field measurement work. Ensure these support personnel are present at the times required by the TAB team and cause no delay in the DALT and the TAB field work.
      - 3) Conversely, ensure that the HVAC controls installer has required support from the

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- TAB team field leader to complete the controls check out.
- f. Deficiencies: Ensure that the TAB Agency submits all Design/ Construction deficiency notifications directly to the Owner within 3 days after the deficiency is encountered. Further, ensure that all such notification submittals are complete with explanation, including documentation, detailing deficiencies.
  - g. Prerequisite HVAC work: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as prerequisite work items, the deficiencies pointed out by the TAB team supervisor in the design review report.
  - h. Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's pre-field engineering report. Do not allow the TAB team to commence TAB field work until all the following are completed.
    - 1) HVAC system installations are fully complete.
    - 2) HVAC prerequisite checkout work lists specified in the paragraph “PRE-FIELD TAB ENGINEERING REPORT” are completed, submitted, and approved. Ensure that the TAB Agency gets a copy of the approved prerequisite HVAC work checklist.
    - 3) DALT field checks for all systems are completed.
    - 4) HVAC system filters are clean for both Season 1 and Season 2 TAB field work.
  - i. Advance notice: Furnish to the Owner with advance written notice for the commencement of the DALT field work and for the commencement of the TAB field work.
  - j. Insulation work: For required DALT work, ensure that insulation is not installed on ducts to be DALT'd until DALT work on the subject ducts is complete. Later, ensure that openings in duct and machinery insulation coverings for TAB test ports are marked, closed, and sealed.
3. TAB Agency
    - a. Provide the services of a TAB team which complies with the requirements of the paragraph “INDEPENDENT TAB AGENCY PERSONNEL QUALIFICATIONS”. The work to be performed by the TAB agency is limited to testing, adjusting, and balancing of HVAC air and water systems to satisfy the requirements of this specification section.
  4. TAB Team Supervisor
    - a. Overall management: Supervise and manage the overall TAB teamwork effort, including preliminary and technical DALT and TAB procedures and TAB team field work.
    - b. Pre-DALT/TAB meeting: Attend meeting with Contractor.
    - c. Design review report: Review project specifications and accompanying drawings to verify that the air systems and water systems are designed in such a way that the TAB engineer can accomplish the work in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters,

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- balancing valves, and manual volume dampers.
- d. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency, such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the pre-field engineering report, the during the DALT or TAB field work.
  - e. Pre-field engineering report: Utilizing the following HVAC-related documentation; contract drawings and specifications, approved submittal data for equipment, up-to-date revisions and change orders; prepare this report.
  - f. Prerequisite HVAC work checklist: Ensure the Contractor gets a copy of this checklist at the same time as the pre-field engineering report is submitted.
  - g. Technical assistance for DALT work.
    - 1) Technical assistance: Provide immediate technical assistance to TAB field team.
    - 2) DALT field visit: Near the end of the DALT field work effort, visit the contract site to inspect the HVAC installation and the progress of the DALT field work. Conduct a site visit to the extent necessary to verify correct procedures are being implemented and to confirm the accuracy of the Pre-final DALT Report data which has been reported. Also, perform sufficient evaluation to allow the TAB supervisor to issue certification of the final report.
  - h. Final DALT report: Certify the DALT report. This certification includes the following work:
    - 1) Review: Review the Pre-final DALT report data. From these field reports, prepare the Certified Final DALT report.
    - 2) TAB Verification: Verify adherence, by the TAB field team, to the procedures specified in this section.
  - i. Technical Assistance for TAB Work: Provide immediate technical assistance to the TAB field team for the TAB work.
    - 1) TAB field visit: At the midpoint of the Season 1 and Season 2 TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work.
    - 2) TAB field visit: Near the end of the TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Review the TAB final report data and certify the TAB final report.
  - j. Certified TAB report: Certify the TAB report. This certification includes the following work:
    - 1) Review: Review the TAB field data report. From this field report, prepare the certified TAB report.
    - 2) Verification: Verify adherence, by the TAB field team, to the TAB plan prescribed by the pre-field engineering report and verify adherence to the procedures specified in this section.

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- k. Design/Construction deficiencies: Within 3 working days after the TAB Agency has encountered any design or construction deficiencies, the TAB Supervisor must submit written notification directly to the Owner, with a separate copy to the Contractor, of all such deficiencies. Provide in this submittal a complete explanation, including supporting documentation, detailing deficiencies. Where deficiencies are encountered that are believed to adversely impact successful completion of TAB, the TAB Agency must issue notice and request direction in the notification submittal.
- 1. TAB Field Check: The TAB team supervisor must attend and supervise Season 1 and Season 2 TAB field check.

D. Project/Site Conditions

- 1. If "existing conditions" does not apply, delete this paragraph.
- 2. DALT and TAB Services to Obtain Existing Conditions
  - a. Conduct DALT and TAB of the indicated existing systems and equipment and submit the specified DALT and TAB reports for approval. Conduct this DALT and TAB work in accordance with the requirements of this section.


E. Sequencing And Scheduling

- 1. Projects with Phased Construction
  - a. This specification section is structured as though the HVAC construction, and thereby the TAB work, will be completed in a single phase. When the construction is completed in phases, the DALT work and TAB work must be planned, completed, and accepted for each construction phase.
  - b. Phasing of Work
    - 1) This specification section is structured as though the HVAC construction, and thereby the TAB work, is going to be completed in a single phase.
    - 2) All elements of the TAB work are addressed on this premise. When a contract is to be completed in construction phases, including the TAB work, and the DALT work, the TAB work and DALT work must be planned for, completed, and approved by the Owner with each phase. An example of this case would be one contract that requires the rehabilitation of the HVAC in each of several separated buildings. At the completion of the final phase, compile all approved reports and submit as one document.
- 2. DALT and TAB Submittal and Work Schedule
  - a. Submit this schedule, and TAB Schematic Drawings, adapted for this particular contract, to the Owner for review and approval. Include with the submittal the planned calendar dates for each submittal or work item. Resubmit an updated versions to conform to the construction schedule. Compliance with the following schedule is the Contractor's responsibility.
    - (1) Independent TAB Agency and Personnel Qualifications: Within 45 calendar days after date of contract award, submit TAB agency and personnel qualifications.
    - (2) Design Review Report: Within 60 calendar days after the date of the TAB

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agency personnel qualifications approval, submit design review report.

- i) TAB Design Review Report: Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.
- (3) Pre-DALT/TAB Meeting: Within 90 calendar days after the date of the design review report.
- (4) Submit Pre-final DALT Report: Within one working day after completion of DALT field work, submit Pre-final DALT Report. Separate Pre-final DALT reports may be submitted to allow phased testing from system to system.
- (5) Submit Final DALT Report: Within 15 calendar days after completion of successful DALT Work Field Check.
- (6) Pre-Field TAB Engineering Report: Within 90 calendar days after approval of the TAB agency Personnel Qualifications, submit the Pre-Field TAB Engineering Report.
- (7) Prerequisite HVAC Work Check Out List for Season 1 TAB Field Work: At a minimum of 115 calendar days prior to scheduled testing, submit Season 1 prerequisite HVAC work check out list certified as complete, and submit advance notice of commencement of Season 1 TAB field work.
- (8) Season 1 TAB Field Work: At a minimum of 90 calendar days prior to construction completion, accomplish Season 1 TAB field work.
- (9) Submit Season 1 TAB Report: Within 15 calendar days after completion of Season 1 TAB field work, submit Season 1 TAB report.
- (10) Season 1 TAB Field Check: 30 calendar days after Season 1 TAB report is accepted by the Owner, conduct Season 1 field check.
- (11) Complete Season 1 TAB Work: Prior to construction completion, complete all TAB work, except Season 2 TAB work.
- (12) Prerequisite HVAC Work Check Out List for Season 2 TAB Field Work: Within 150 calendar days after date of the commencement of the Season 1 TAB field work, submit the Season 2 prerequisite HVAC work check out list certified as complete.
- (13) Season 2 TAB Field Work: Within 180 calendar days after date of commencement of the Season 1 TAB field work and when the ambient temperature is within Season 2 limits, accomplish Season 2 TAB field work.
- (14) Submit Season 2 TAB Report: Within 15 calendar days after completion of Season 2 TAB field work, submit Season 2 TAB report.
- (15) Season 2 TAB Field Check: 30 calendar days after the Season 1 TAB report is approved by the Owner, conduct Season 2 field check.
- (16) Complete Season 2 TAB Work: Within 15 calendar days after the completion

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of Season 2 TAB field data check, complete all TAB work.

3. TAB Pre-Field Engineering Report
  - a. Submit report containing the following information:
    - 1) Step-by-step TAB procedure:
      - A) Strategy: Describe the method of approach to the TAB field work from start to finish. Include in this description a complete methodology for accomplishing each seasonal TAB field work session.
      - B) Air System Diagrams: Use the contract drawings and duct fabrication drawings if available to provide air system diagrams in the report showing the location of all terminal outlet supply, return, exhaust and transfer registers, grilles and diffusers. Use a key numbering system on the diagrams which identifies each outlet contained in the outlet airflow report sheets. Show intended locations of all traverses and static pressure readings.
      - C) Procedural steps: Delineate the intended procedural steps to be taken by the TAB field team to accomplish the required TAB work of each air distribution system and each water distribution system. Include intended procedural steps for TAB work for subsystems and system components.
    - 2) Pre-field data: Submit AABC or NEBB or SMACNA 1780 data report forms with the following pre-field information filled in:
      - A) Design data obtained from system drawings, specifications, and approved submittals.
      - B) Notations detailing additional data to be obtained from the contract site by the TAB field team.
      - C) Designate the actual data to be measured in the TAB field work.
      - D) Provide a list of the types of instruments, and the measuring range of each, which are anticipated to be used for measuring in the TAB field work. By means of a keying scheme, specify on each TAB data report form submitted, which instruments will be used for measuring each item of TAB data. If the selection of which instrument to use, is to be made in the field, specify from which instruments the choice will be made. Place the instrument key number in the blank space where the measured data would be entered.
    - 3) Prerequisite HVAC work checkout list: Provide a list of inspections and work items which are to be completed by the Contractor. This list must be acted upon and completed by the Contractor and then submitted and approved by the Owner prior to the TAB team coming to the contract site.
      - A) At a minimum, a list of the applicable inspections and work items listed in the "NEBB PROCEDURAL STANDARDS", Section III, "Preliminary TAB Procedures" under paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" must be provided for each separate system to be TAB'd.

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F. Subcontractor Special Requirements

1. Perform all work in this section in accordance with the paragraph “SUBCONTRACTOR SPECIAL REQUIREMENTS” in Section 01 30 00 ADMINISTRATIVE REQUIREMENTS, stating that all contract requirements of this section must be accomplished directly by a first-tier subcontractor. No work may be performed by a second-tier subcontractor.

G. Instrument Calibration Certificates


1. It is the responsibility of the TAB firm to provide instrumentation that meets the minimum requirements of the standard under which the TAB Firm's qualifications are approved for use on a project. Instrumentation must be in proper operating condition and must be applied in accordance with the instrumentation's manufacturer recommendations.
2. All instrumentation must bear a valid NIST traceable calibration certificate during field work and during Owner acceptance testing. All instrumentation must be calibrated within no later than one year of the date of TAB work or Owner acceptance testing field work.

H. Tab Standard

1. Perform TAB in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., AABC MN-1, NEBB PROCEDURAL STANDARDS, or SMACNA 1780 unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard are considered mandatory. Use the provisions of the TAB Standard, including checklists, report forms, etc., as nearly as practical, to satisfy the Contract requirements. Use the TAB Standard for all aspects of TAB, including qualifications for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, adhere to the manufacturer's recommendations.
2. All quality assurance provisions of the TAB Standard such as performance guarantees are part of this contract. For systems or system components not covered in the TAB Standard, TAB procedures must be developed by the TAB Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements are considered mandatory, including the latest requirements of ASHRAE 62.1.


I. Qualifications

1. TAB Firm
  - a. The TAB Firm must be either a member of AABC or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including TAB of environmental systems, the performance of clean rooms and clean air devices, building systems commissioning, and the measuring of sound and vibration in environmental systems.
  - b. Certification must be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor must


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immediately notify the Owner and submit another TAB Firm for approval. Any firm that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections to be performed by the TAB Firm will be considered invalid if the TAB Firm loses its certification prior to Contract completion and must be performed by an approved successor.


- c. These TAB services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The TAB Firm must be a prime subcontractor of the Contractor and be financially and corporately independent of the mechanical subcontractor, reporting directly to and paid by the Contractor.
- 2. TAB Related HVAC Submittals
  - a. The TAB Specialist must prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. Accompany the submittals identified on this list with a letter of approval signed and dated by the TAB Specialist when submitted to the Owner. Ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.
- J. Responsibilities
  - 1. The Contractor is responsible for ensuring compliance with the requirements of this section. The following delineation of specific work responsibilities is specified to facilitate TAB execution of the various work efforts by personnel from separate organizations. This breakdown of specific duties is specified to facilitate adherence to the schedule listed in the paragraph “TAB SUBMITTAL AND WORK SCHEDULE”.
  - 2. Contractor
    - a. TAB personnel: Ensure that the DALT work, and the TAB work is accomplished by a group meeting the requirements specified in the paragraph “TAB PERSONNEL QUALIFICATION REQUIREMENTS”.
    - b. Pre-DALT/TAB meeting: Attend the meeting with the TAB Supervisor and ensure that a representative is present for the sheet metal contractor, mechanical contractor, electrical contractor, and automatic temperature controls contractor.
    - c. HVAC documentation: Furnish one complete set of the following HVAC-related documentation to the TAB agency:
      - 1) Contract drawings and specifications
      - 2) Approved submittal data for equipment
      - 3) Construction work schedule
      - 4) Up-to-date revisions and change orders for the previously listed items
    - d. Submittal and work schedules: Ensure that the schedule for submittals and work required by this section and specified in the paragraph TAB SUBMITTAL AND WORK SCHEDULE is met.
    - e. Coordination of supporting personnel:
      - 1) Provide the technical personnel, such as factory representatives or HVAC controls

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- installer required by the TAB field team to support the DALT and the TAB field measurement work.
- 2) Provide equipment mechanics to operate HVAC equipment and ductwork mechanics to provide the field designated test ports to enable TAB field team to accomplish the DALT and the TAB field measurement work. Ensure these support personnel are present at the times required by the TAB team and cause no delay in the DALT and the TAB field work.
  - 3) Conversely, ensure that the HVAC controls installer has required support from the TAB team field leader to complete the controls check out.
- f. Deficiencies: Ensure that the TAB Agency supervisor submits all Design/Construction deficiency notifications directly to the Owner within 3 days after the deficiency is encountered. Further, ensure that all such notification submittals are complete with explanation, including documentation, detailing deficiencies.
  - g. Prerequisite HVAC work: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as prerequisite work items, the deficiencies pointed out by the TAB team supervisor in the design review report.
  - h. Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's pre-field engineering report. Do not allow the TAB team to commence TAB field work until all the following are completed.
    - 1) HVAC system installations are fully complete.
    - 2) HVAC prerequisite checkout work lists specified in the paragraph "PRE-FIELD TAB ENGINEERING REPORT" are completed, submitted, and approved. Ensure that the TAB Agency gets a copy of the approved prerequisite HVAC work checklist.
    - 3) DALT field checks for all systems are completed.
    - 4) HVAC system filters are clean for both Season 1 and Season 2 TAB field work.
  - i. Advance notice: Furnish to the Owner with advance written notice for the commencement of the DALT field work and for the commencement of the TAB field work.
  - j. Insulation work: For required DALT work, ensure that insulation is not installed on ducts to be DALT'd until DALT work on the subject ducts is complete. Later, ensure that openings in duct and machinery insulation coverings for TAB test ports are marked, closed, and sealed.
3. TAB Agency
    - a. Provide the services of a TAB team which complies with the requirements of the paragraph "INDEPENDENT TAB AGENCY PERSONNEL QUALIFICATIONS"
    - b. The work to be performed by the TAB agency is limited to testing, adjusting, and balancing of HVAC air and water systems to satisfy the requirements of this specification section.

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4. TAB Team Supervisor
  - a. Overall management: Supervise and manage the overall TAB teamwork effort, including preliminary and technical DALT and TAB procedures and TAB team field work.
  - b. Pre-DALT/TAB meeting: Attend meeting with Contractor.
  - c. Design review report: Review project specifications and accompanying drawings to verify that the air systems and water systems are designed in such a way that the TAB engineer can accomplish the work in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.
5. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency, such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the pre-field engineering report, the during the DALT or TAB field work.
  - a. Pre-field DALT preliminary notification: Monitor the completion of the duct installation of each system and provide the necessary written notification to the Owner.
  - b. Pre-field engineering report: Utilizing the following HVAC-related documentation; contract drawings and specifications, approved submittal data for equipment, up-to-date revisions and change orders; prepare this report.
  - c. Prerequisite HVAC work checklist: Ensure the Contractor gets a copy of this checklist at the same time as the pre-field engineering report is submitted.
  - d. Technical assistance for DALT work.
    - 1) Technical assistance: Provide immediate technical assistance to TAB field team.
    - 2) DALT field visit: Near the end of the DALT field work effort, visit the contract site to inspect the HVAC installation and the progress of the DALT field work. Conduct a site visit to the extent necessary to verify correct procedures are being implemented and to confirm the accuracy of the Pre-final DALT Report data which has been reported. Also, perform sufficient evaluation to allow the TAB supervisor to issue certification of the final report.
  - e. Final DALT report: Certify the DALT report. This certification includes the following work:
    - 1) Review: Review the Pre-final DALT report data. From these field reports, prepare the Certified Final DALT report.
    - 2) TAB Verification: Verify adherence, by the TAB field team, to the procedures specified in this section.
  - f. Technical Assistance for TAB Work: Provide immediate technical assistance to the TAB field team for the TAB work.
    - 1) TAB field visit: At the midpoint of the Season 1 and Season 2 TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB

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- field work.
- 2) TAB field visit: Near the end of the TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work.
  - 3) Review the TAB final report data and certify the TAB final report.
- g. Certified TAB report: Certify the TAB report. This certification includes the following work:
- 1) Review: Review the TAB field data report. From this field report, prepare the certified TAB report.
  - 2) Verification: Verify adherence, by the TAB field team, to the TAB plan prescribed by the pre-field engineering report and verify adherence to the procedures specified in this section.
- h. Design/Construction deficiencies: Within 3 working days after the TAB Agency has encountered any design or construction deficiencies, the TAB Supervisor must submit written notification directly to the Owner, with a separate copy to the Contractor, of all such deficiencies. Provide in this submittal a complete explanation, including supporting documentation, detailing deficiencies. Where deficiencies are encountered that are believed to adversely impact successful completion of TAB, the TAB Agency must issue notice and request direction in the notification submittal.
- i. TAB Field Check: The TAB team supervisor must attend and supervise Season 1 and Season 2 TAB field check.
- K. Test Reports
1. Data from DALT Field Work
    - a. Report the data for the Pre-final DALT Report and Certified Final DALT Report in compliance the following requirements:
      - 1) Report format: Submit report data on Air Duct Leakage Test Summary Report Forms in accordance with SMACNA “HVAC Air Duct Leakage Test Manual”. In addition, submit in the report, a marked duct shop drawing which identifies each section of duct tested with assigned node numbers for each section. Include node numbers in the completed report forms to identify each duct section. The TAB supervisor must review and certify the report.
      - 2) The TAB supervisor must include a copy of all calculations prepared in determining the duct surface area of each duct test section. In addition, provide the ductwork air leak testing (DALT) reports with a copy(s) of the calibration curve for each of the DALT test orifices used for testing.
      - 3) Instruments: List the types of instruments used to measure the data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date. Instruments must have been calibrated within one year of the date of use in the field. Instrument calibration must be traceable to the measuring standards of the National Institute of Standards and Technology.
      - 4) Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

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## 2. Certified TAB Reports


### a. Submit: TAB Report for Season 1 and TAB Report for Season 2 in the following manner:

- 1) Report format: Submit the completed pre-field data forms approved in the pre-field TAB Engineering Report completed by TAB field team, reviewed and certified by the TAB supervisor. Bind the report with a waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data must be typewritten. Handwritten report forms or report data are not acceptable.
- 2) Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded. Include in the TAB report continuous time versus temperature recording data of wet and dry bulb temperatures for the rooms, or zones, as designated.
  - A) Measure and compile data on a continuous basis for the period in which TAB work affecting those rooms is being done.
  - B) Measure and record data only after the HVAC systems installations are complete, the systems fully balanced and the HVAC systems controls operating in fully automatic mode.
  - C) Data may be compiled using direct digital controls trend logging where available. Otherwise, temporarily install calibrated time versus temperature/humidity recorders for this purpose. The HVAC systems and controls must be fully operational a minimum of 24 hours in advance of commencing data compilation. Include the specified data in the Season 1 TAB Report and Season 2 TAB Report.
- 3) System Diagrams: Provide updated diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations. Use a key numbering system on the diagram which identifies each outlet contained in the outlet airflow report sheets.
- 4) Static Pressure Profiles: Report static pressure profiles for air duct systems. Report static pressure data for all supply, return, relief, exhaust and outside air ducts for the systems listed. Include the following in the static pressure report data, in addition to AABC/NEBB/TABB required data:
  - A) Report supply fan, return fan, relief fan, and exhaust fan inlet and discharge static pressures.
  - B) Report static pressure drop across chilled water coils, DX coils, hot water coils, steam coils, electric resistance heating coils and heat reclaim devices installed in unit cabinetry or the system ductwork.
  - C) Report static pressure drop across outside air, return air, and supply air automatic control dampers, both proportional and two-position, installed in unit cabinetry.
  - D) eliminators, air flow straighteners, air flow measuring stations or other pressure drop producing specialty items installed in unit cabinetry, or in the system

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ductwork. Examples of these specialty items are smoke detectors, white sound generators, RF shielding, wave guides, security bars, blast valves, small pipes passing through ductwork, and duct mounted humidifiers. Do not report static pressure drop across duct fittings provided for the sole purpose of conveying air, such as elbows, transitions, offsets, plenums, manual dampers, and branch takes-offs.

- E) Report static pressure drop across outside air and relief/exhaust air louvers.
- F) Report static pressure readings of supply air, return air, exhaust/relief air, and outside air in duct at the point where these ducts connect to each air moving unit and at the following locations:
  - (1) Main Duct: Take readings at four locations along the full length of the main duct, 25 percent, 50 percent, 75 percent, and 100 percent of the total duct length.
  - (2) Floor Branch Mains: Take readings at floor branch mains served by a main duct vertical riser.
  - (3) Branch Main Ducts: Take readings at branch main ducts.
  - (4) VAV Terminals: Take readings at inlet static pressure at VAV terminal box primary air branch ducts.
  - (5) VAV Terminals, Fan Powered: Take readings at fan discharge and inlet static pressures for series and parallel fan powered VAV terminal boxes.
- G) Duct Traverses: Report duct traverses for main and branch main supply, return, exhaust, relief and outside air ducts. This includes all ducts, including those which lack 7 1/2 duct diameters upstream and 2 1/2 duct diameters downstream of straight duct unobstructed by duct fittings/offsets/elbows. The TAB Agency must evaluate and report findings on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pilot traverse plane.
- H) Instruments: List the types of instruments used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.
- I) Instrumentation, used for taking wet bulb temperature readings must provide accuracy of plus or minus 5 percent at the measured face velocities. Submit instrument manufacturer's literature to document instrument accuracy performance is in compliance with that specified.
- J) Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.
- K) Performance Curves: The TAB Supervisor must include, in the TAB Reports, factory pump curves and fan curves for pumps and fans TAB'd on the job.
- L) Calibration Curves: The TAB Supervisor must include, in the TAB Reports, a factory calibration curve for installed flow control balancing valves, flow venturis and flow orifices TAB'd on the job.

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2.8 WARRANTY

- A. Furnish workmanship and performance warranty for the TAB system work performed for a period not less than 1 years from the date of Owner acceptance of the work; issued directly to the Owner. Include provisions that if within the warranty period the system shows evidence of major performance deterioration, or is significantly out of tolerance, resulting from defective TAB or DALT workmanship, the corrective repair or replacement of the defective materials and correction of the defective workmanship is the responsibility of the TAB firm. Perform corrective action that becomes necessary because of defective materials and workmanship while system TAB and DALT is under warranty 7 days after notification, unless additional time is approved by the Owner. Failure to perform repairs within the specified period of time constitutes grounds for having the corrective action and repairs performed by others and the cost billed to the TAB firm. The Contractor must also provide a 1-year contractor installation warranty.

PART 3 - PRODUCTS

- 3.1 Not used.


PART 4 - EXECUTION

4.1 PRE-DALT/TAB MEETING

- A. Meet with the Owner's technical representative and the designing engineer of the HVAC systems to develop a mutual understanding relative to the details of the DALT work and TAB work requirements. Ensure that the TAB supervisor is present at this meeting. Requirements to be discussed include required submittals, work schedule, and field quality control.


4.2 DALT PROCEDURES

- A. Instruments, consumables, and personnel
  - 1. Provide instruments, consumables and personnel required to accomplish the DALT field work. Follow the same basic procedure specified below for TAB Field Work, including maintenance and calibration of instruments, accuracy of measurements, preliminary procedures, field work, workmanship and treatment of deficiencies. Calibrate and maintain instruments in accordance with manufacturer's written procedures.
- B. Advance Notice of Pre-Final DALT Field Work
  - 1. On completion of the installation of each duct system indicated to be DALT'd, notify the Owner in writing prior to the Owner's technical representative duct selection field visit.
- C. Ductwork To Be DALT'd
  - 1. From each duct system indicated as subject to DALT, the Owner's technical representative will randomly select sections of each completed duct system for testing by the Contractor's TAB Firm. The sections selected will not exceed 20 percent of the total measured linear footage of duct systems indicated as subject to DALT. Sections of duct systems subject to

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DALT will include 20 percent of main ducts, branch main ducts, branch ducts and plenums for supply, return, exhaust, and plenum ductwork.

2. It is acceptable for an entire duct system to be DALT'd instead of disassembling that system in order to DALT only the 20 percent portion specified above.
- D. DALT Testing
1. Perform DALT on the HVAC duct sections of each system as selected by the Use the duct class, seal class, leakage class and the leak test pressure data indicated on the drawings, to comply with the procedures specified in SMACNA “HVAC AIR DUCT LEAKAGE TEST MANUAL”.
  2. DALT ductwork of construction class of 3-inch water gauge static pressure and below if indicated to be DALT'd. Complete DALT work on the Owner's technical representative selected ductwork within 48 hours after the ductwork was selected for DALT. Separately conduct DALT work for large duct systems to enable the DALT work to be completed in 48 hours.
- E. Completed Pre-Final DALT Report
1. After completion of the DALT work, prepare a Pre-final DALT Report meeting the additional requirements specified in Appendix B “REPORTS - DALT and TAB”. Data required by those data report forms shall be furnished by the TAB team. Prepare the report neatly and legibly; the Pre-final DALT report shall provide the basis for the Final DALT Report.
  2. TAB supervisor shall review, approve and sign the Pre-Final DALT Report and submit this report within one day of completion of DALT field work. Verbally notify the Owner's technical representative that the field check of the Pre-Final DALT Report data can commence. After completion of the DALT work, prepare a Pre-final DALT Report using the reporting forms specified. TAB team to furnish data required by those data report forms. Prepare the report neatly and legibly; the Pre-final DALT report is the basis for the Final DALT Report. TAB supervisor must review and certify the Pre-final DALT Report and submit this report within one day of completion of DALT field work. Verbally notify the Owner that the field check of the Pre-final DALT Report data can commence.
- F. Quality Assurance - Owner's technical representative DALT Field Acceptance Testing
1. In the presence of the Owner's technical representative and TAB team field leader, verify for accuracy Pre-final DALT Report data selected by the Owner's technical representative. For each duct system, this acceptance testing shall be conducted on a maximum of 50 percent of the duct sections DALT'd.
  2. Further, if any data on the Pre-final DALT report form for a given duct section is out-of-tolerance, then field acceptance testing shall be conducted on data for one additional duct section, preferably in the same duct system, in the presence of the Owner's technical representative.
- G. Additional Field Acceptance Testing
1. If any of the duct sections checked for a given system are determined to have a leakage rate measured that exceeds the leakage rate allowed by SMACNA Leak Test Manual for an

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indicated duct construction class and sealant class, terminate data checking for that section. The associated Pre-final DALT Report data for the given duct system will be disapproved. Make the necessary corrections and prepare a revised Pre-final DALT Report. Reschedule a field check of the revised report data with the Owner's technical representative.

H. Certified Final DALT Report

1. On successful completion of all field checks of the Pre-final DALT Report data for all systems, the TAB Supervisor is to assemble, review, certify and submit the Final DALT Report to the Owner for approval. On successful completion of all field checks of the Pre-Final DALT Report data for all systems, the TAB Supervisor shall assemble, review, approve, sign and submit the Final DALT Report in compliance with Appendix B “REPORTS - DALT and TAB” to the Owner for approval.

I. Prerequisite for TAB Field Work

1. Do not commence TAB field work prior to the completion and approval, for all systems, of the Final DALT Report.

4.3 TAB PROCEDURES

A. TAB Field Work


1. Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents.
2. That is, comply with the requirements of SMACNA 1780 and SMACNA 1858, except as supplemented and modified by this section.
3. Provide instruments and consumables required to accomplish the TAB work. Calibrate and maintain instruments in accordance with manufacturer's written procedures.
4. Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. Conduct TAB work, including measurement accuracy, and sound measurement work in conformance with the SMACNA 1780 (HVAC Systems - Testing, Adjusting and Balancing) and SMACNA 1858 (HVAC Sound and Vibration Manual) procedures, except as supplemented and modified by this section.
5. The only water flow and air flow reporting which can be deferred until the Season 2 is that data which would be affected in terms of accuracy due to outside ambient conditions.

B. Preliminary Procedures

1. Use the approved pre-field engineering report as instructions and procedures for accomplishing TAB field work. TAB engineer is to locate, in the field, test ports required for testing. It is the responsibility of the sheet metal contractor to provide and install test ports as required by the TAB engineer.


C. TAB Air Distribution Systems

1. Units With Coils
  - a. Report heating and cooling performance capacity tests for hot water, chilled water, DX and steam coils for the purpose of verifying that the coils meet the indicated design

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capacity. Submit the following data and calculations with the coil test reports:

- 1) For air handlers with capacities greater than 26,370 Watts, 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity.
  - A) Do not determine entering and leaving wet and dry bulb temperatures by single point measurement, but by the average of multiple readings.
  - B) Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity.
- 2) For units with capacities of 26,370 Watts, 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:
  - A) Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.
2. Air Handling Units
  - a. Air handling unit systems including fans (air handling unit fans, exhaust fans and winter ventilation fans), coils, ducts, plenums, mixing boxes, terminal units, variable air volume boxes, and air distribution devices for supply air, return air, outside air, mixed air relief air, and makeup air.
3. Rooftop Air Conditioning
  - a. Rooftop air conditioning systems including fans, coils, ducts, plenums, and air distribution devices for supply air, return air, and outside air.
  - b. For refrigeration compressors/condensers/condensing units/evaporators, report data as required by NEBB, AABC, and TABB standard procedures, including refrigeration operational data.
4. Heating and Ventilating Units
  - a. Heating and ventilating unit systems including fans, coils, ducts, plenums, roof vents, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.
5. Makeup Air Units
  - a. Makeup air unit systems including fans, coils, ducts, plenums, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.
6. Return Air Fans
  - a. Return air fan system including fan ducts, plenums, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.
7. Fan Coils
  - a. Fan coil unit systems including fans, coils, ducts, plenums, and air distribution devices for supply air, return air, and outside air.
8. Exhaust Fans
  - a. Exhaust fan systems including fans, ducts, plenums, grilles, and hoods for exhaust.


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#### D. TAB Water Distribution Systems


1. Chilled Water
  - a. Chilled water systems including chillers, condensers, cooling towers, pumps, coils, system balance valves and flow measuring devices.
  - b. For water chillers, report data as required by AABC, NEBB and TABB standard procedures, including refrigeration operational data.
2. Heating Hot Water
  - a. Heating hot water systems including boilers, hot water converters (e.g., heat exchangers), pumps, coils, system balancing valves and flow measuring devices.
3. Dual Temperature Water
  - a. Dual temperature water systems including boilers, converters, chillers, condensers, cooling towers, pumps, coils, and system balancing valves, and flow measuring devices.

#### E. Sound Measurement Work

1. Areas To Be Sound Measured
  - a. In the following spaces, measure and record the sound power level for each octave band listed in ASHRAE HVAC Applications Handbook, Noise Criteria:
    - 1) All HVAC mechanical rooms, including machinery spaces and other spaces containing HVAC power drivers and power-driven equipment.
    - 2) All spaces sharing a common barrier with each mechanical room, including rooms overhead, rooms on the other side of side walls, and rooms beneath the mechanical room floor.
2. Procedure
  - a. Measure sound levels in each room, when unoccupied except for the TAB team, with all HVAC systems that would cause sound readings in the room operating in their noisiest mode. Record the sound level in each octave band. Attempt to mitigate the sound level and bring the level to within the specified ASHRAE HVAC Applications Handbook, noise criteria goals, if such mitigation is within the TAB team's control.
  - b. State in the report the ASHRAE HVAC Applications Handbook, noise criteria goals. If sound level cannot be brought into compliance, provide written notice of the deficiency to the Contractor for resolution or correction.
3. Timing
  - a. Measure sound levels at times prescribed by AABC or NEBB or TABB.
4. Meters
  - a. Measure sound levels with a sound meter complying with ASA S1.4, Type 1 or 2, and an octave band filter set complying with ASA S1.11 PART 1. Use measurement methods for overall sound levels and for octave band sound levels as prescribed by NEBB.
5. Calibration
  - a. Calibrate sound levels as prescribed by AABC or NEBB or TABB, except that calibrators emitting a sound pressure level tone of 94 dB at 1000 hertz (Hz) are also acceptable.
6. Background Noise Correction


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- a. Determine background noise component of room sound (noise) levels for each (of eight) octave bands as prescribed by AABC or NEBB or TABB.
- F. TAB Work on Performance Tests Without Seasonal Limitations
  - 1. Performance Tests
    - a. In addition to the TAB proportionate balancing work on the air distribution systems and the water distribution systems, accomplish TAB work on the HVAC systems which directly transfer thermal energy. TAB the operational performance of the heating systems and cooling systems.
  - 2. Ambient Temperatures
    - a. On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.
  - 3. Sound Measurements
    - a. Comply with the paragraph “SOUND MEASUREMENT WORK”, specifically, the requirement that a room must be operating in its noisiest mode at the time of sound measurements in the room. The maximum noise level measurements could depend on seasonally related heat or cooling transfer equipment.
  - 4. Coils
    - a. Report heating and cooling performance capacity tests for hot water, chilled water, DX, and steam coils for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:
      - 1) For Central station air handlers with capacities greater than 26,370 Watts 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests.
      - 2) Entering and leaving wet and dry bulb temperatures are not determined by single point measurement, but the average of multiple readings.
    - b. Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity.
    - c. For units with capacities of 26,370 Watts 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:
      - 1) Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.
- G. TAB Work on Performance Tests with Seasonal Limitations
  - 1. Performance Tests
    - a. Accomplish proportional balancing TAB work on the air distribution systems and water distribution systems, in other words, accomplish adjusting and balancing of the air flows and water flows, any time during the duration of this contract, subject to the limitations

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specified elsewhere in this section. However, accomplish, within the following seasonal limitations, TAB work on HVAC systems which directly transfer thermal energy. Accomplish proportionate balancing TAB work on the air distribution systems and water distribution systems, in other words, accomplish adjusting and balancing of the air flows and water flows, any time during the duration of this contract, subject to the limitations specified elsewhere in this section. However, accomplish, within the following seasonal limitations, TAB work on HVAC systems which directly transfer thermal energy.

2. Season Of Maximum Load
  - a. Visit the contract site for at least two TAB work sessions for Season 1 and Season 2 field measures. Visit the contract site during the season of maximum heating load and visit the contract site during the season of maximum cooling load, the goal being to TAB the operational performance of the heating systems and cooling systems under their respective maximum outdoor environment-caused loading. During the seasonal limitations, TAB the operational performance of the heating systems and cooling systems.
3. Ambient Temperatures
  - a. On each tab report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.
4. Sound Measurements
  - a. Comply with the paragraph “SOUND MEASUREMENT WORK”, specifically, the requirement that a room must be operating in its noisiest mode at the time of sound measurements in the room. The maximum noise level measurements could depend on seasonally related heat or cooling transfer equipment.
5. Coils
  - a. Report heating and cooling performance capacity tests for hot water, chilled water, DX, and steam coils for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:
    - 1) For Central station air handlers with capacities greater than 26,370 Watts 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests.
    - 2) Entering and leaving wet and dry bulb temperatures are not determined by single point measurement, but the average of multiple readings.
  - b. Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity.
  - c. For units with capacities of 26,370 Watts 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:
    - 1) Determine the apparent coil capacity by calculations using single point measurement

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of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

H. Workmanship

1. Conduct TAB work on the HVAC systems until measured flow rates are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. This TAB work includes adjustment of balancing valves, balancing dampers, and sheaves. Further, this TAB work includes changing out fan sheaves and pump impellers if required to obtain air and water flow rates specified or indicated. If, with these adjustments and equipment changes, the specified or indicated design flow rates cannot be attained, contact the Owner for direction.

I. Deficiencies


1. Strive to meet the intent of this section to maximize the performance of the equipment as designed and installed. However, if deficiencies in equipment design or installation prevent TAB work from being accomplished within the range of design values specified in the paragraph “WORKMANSHIP”, provide written notice as soon as possible to the Contractor and the Owner describing the deficiency and recommended correction.
2. Responsibility for correction of installation deficiencies is the Contractor's. If a deficiency is in equipment design, call the TAB team supervisor for technical assistance. Responsibility for reporting design deficiencies to Contractor is the TAB team supervisors.

J. TAB Reports

1. Additional requirements for TAB Reports are specified in Appendix B REPORTS - DALT and TAB.
2. After completion of the TAB field work, prepare the TAB field data for TAB supervisor's review and certification, using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms is to be furnished by the TAB team. Except as approved otherwise in writing by the Owner, the TAB work and thereby the TAB report is considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph “WORKMANSHIP”.
3. Prepare the report neatly and legibly; the pre-final TAB report is the final TAB report minus the TAB supervisor's review and certification. Obtain, at the contract site, the TAB supervisor's review and certification of the TAB report.
4. Verbally notify the Owners Technical Representative that the field check of the TAB report data can commence; give this verbal notice 48 hours in advance of field check commencement. Do not schedule field check of the TAB report until the specified workmanship requirements have been met or written approval of the deviations from the requirements have been received from the Owner.

K. Quality Assurance - COTR TAB Field Acceptance Testing

1. TAB Field Acceptance Testing
  - a. During the field acceptance testing, verify, in the presence of the Owners Technical Representative, random selections of data (water, air quantities, air motion, sound level readings) recorded in the TAB Report. Points and areas for field acceptance testing are to

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be selected by the Owners Technical Representative. Measurement and test procedures are the same as approved for TAB work for the TAB Report.


- b. Field acceptance testing includes verification of TAB Report data recorded for the following equipment groups:
    - 1) Group 1: All chillers, boilers, return fans, computer room units, and air handling units (rooftop and central stations).
    - 2) Group 2: 25 percent of the VAV terminal boxes and associated diffusers and registers.
    - 3) Group 3: 25 percent of the supply diffusers, registers, grilles associated with constant volume air handling units.
    - 4) Group 4: 25 percent of the return grilles, return registers, exhaust grilles and exhaust registers.
    - 5) Group 5: 25 percent of the supply fans, exhaust fans, and pumps.
  - c. Further, if any data on the TAB Report for Groups 2 through 5 is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, additional group data verification is required in the presence of the Owners Technical Representative. Verify TAB Report data for one additional piece of equipment in that group. Continue this additional group data verification until out-of-tolerance data ceases to be found.
2. Additional Owners Technical Representative TAB Field Acceptance Testing
    - a. If any of the acceptance testing measurements for a given equipment group is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, terminate data verification for all affected data for that group. The affected data for the given group will be disapproved.
    - b. Make the necessary corrections and prepare a revised TAB Report. Reschedule acceptance testing of the revised report data with the Owners Technical Representative.
    - c. Further, if any data on the TAB Report for a given field acceptance test group is out-of-tolerance, then field test data for one additional field test group as specified herein. Continue this increase field test work until out-of-tolerance data ceases to be found. This additional field testing is up and above the original 25 percent of the of reported data entries to be field tested.
  3. Prerequisite for Approval
    - a. Compliance with the field acceptance testing requirements of this section is a prerequisite for the final Owner approval of the TAB Report submitted.

#### 4.4 MARKING OF SETTINGS

- A. Upon the final TAB work approval, permanently mark the settings of HVAC adjustment devices including valves, gauges, splitters, and dampers so that adjustment can be restored if disturbed at any time. Provide permanent markings clearly indicating the settings on the adjustment devices which result in the data reported on the submitted TAB report.

#### 4.5 MARKING OF TEST PORTS

- A. The TAB team is to permanently and legibly mark and identify the location points of the duct

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test ports. If the ducts have exterior insulation, make these markings on the exterior side of the duct insulation. Show the location of test ports on the as-built mechanical drawings with dimensions given where the test port is covered by exterior insulation.


#### 4.6 APPENDICES

- A. Appendix A: WORK DESCRIPTIONS OF PARTICIPANTS
- B. Appendix B: REPORTS - DALT and TAB
- C. Appendix C: DALT AND TAB SUBMITTAL AND WORK SCHEDULE
- D. Appendix D: REQUIREMENTS FOR DUCT AIR LEAK TESTING


#### 4.7 APPENDIX A

##### A. WORK DESCRIPTIONS OF PARTICIPANTS

1. The Contractor is responsible for ensuring compliance with all requirements of this specification section. However, the following delineation of specific work items is provided to facilitate and co-ordinate execution of the various work efforts by personnel from separate organizations.
2. Contractor
  - a. HVAC documentation: Provide pertinent contract documentation to the TAB Firm, to include the following: the contract drawings and specifications; copies of the approved submittal data for all HVAC equipment, air distribution devices, and air/water measuring/balancing devices; the construction work schedule; and other applicable documents requested by the TAB Firm. Provide the TAB Firm copies of contract revisions and modifications as they occur.
  - b. Schedules: Ensure the requirements specified under the paragraph "DALT and TAB Schedule" are met.
  - c. Pre-DALT and TAB meeting: Arrange and conduct the Pre-DALT and TAB meeting. Ensure that a representative is present for the sheet metal contractor, the mechanical contractor, the electrical contractor, and the automatic temperature controls contractor.
  - d. Coordinate Support: Provide and coordinate support personnel required by the TAB Firm in order to accomplish the DALT and TAB field work. Support personnel may include factory representatives, HVAC controls installers, HVAC equipment mechanics, sheet metal workers, pipe fitters, and insulators. Ensure support personnel are present at the work site at the times required.
  - e. Correct Deficiencies: Ensure the notifications of Construction Deficiencies are provided as specified herein. Refer to the paragraph CONSTRUCTION DEFICIENCIES. Correct each deficiency as soon as practical with the Owner and submit revised schedules and other required documentation.
  - f. Pre-TAB Work Checklists: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as

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- designed. Include as pre-TAB work checklist items, the deficiencies pointed out by the TAB team supervisor in the design review report.
- g. Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's DALT and TAB Work Procedures Summary. Do not allow the TAB team to commence TAB field work until all the following are completed.
  - h. Give Notice of Testing: Submit advance notice of proportional balancing, Season 1, and Season 2 TAB field work accompanied by completed prerequisite HVAC Work List
  - i. Insulation work: Ensure that no insulation is shall not be installed on ducts to be DALT'd until DALT work on the subject ducts is complete.
  - j. Ensure the duct and piping systems are properly insulated and vapor sealed upon the successful completion and acceptance of the DALT and TAB work.
3. TAB Team Supervisor
- a. Overall management: Supervise and manage the overall TAB teamwork effort, including preliminary and technical DALT and TAB procedures and TAB team field work.
  - b. Schedule: Ensure the requirements specified under the paragraph "DALT and TAB Schedule" are met.
  - c. Submittals: Provide the submittals specified herein.
  - d. Pre-DALT/TAB meeting: Attend meeting with Contractor. Ensure TAB personnel that will be involved in the TAB work under this contract attend the meeting.
  - e. Design Review Report: Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.
  - f. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency, such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the DALT and TAB Procedures Summary, the during the DALT or TAB field work.
  - g. Ensure the Contractor is properly notified and aware of all support personnel needed to perform the TAB work. Maintain communication with the Contractor regarding support personnel throughout the duration of the TAB field work, including the TAB field acceptance testing checking.
  - h. Ensure all inspections and verifications for the Pre-Final DALT and Pre-TAB Checklists are completely and successfully conducted before DALT and TAB field work is performed.
  - i. Advance Notice: Monitor the completion of the duct system installations and provide the Advance Notice for Pre-Final DALT field work as specified herein.
  - j. Technical Assistance: Provide technical assistance to the DALT and TAB field work.

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- k. Deficiencies Notification: Ensure the notifications of Construction Deficiencies are provided as specified herein. Comply with requirements of the paragraph CONSTRUCTION DEFICIENCIES. Resolve each deficiency as soon as practical and submit revised schedules and other required documentation.
- l. Procedures: Develop the required TAB procedures for systems or system components not covered in the TAB Standard.
- 4. TAB Team Field Leader
  - a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, EXECUTION.
  - b. Full time: Be present at the contract site when DALT field work or TAB field work is being performed by the TAB team; ensure day-to-day TAB teamwork accomplishments are in compliance with this section.
  - c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC work list, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

#### 4.8 APPENDIX B

##### A. REPORTS - DALT and TAB


- 1. All submitted documentation must be typed, neat, and organized. All reports must have a waterproof front and back cover, a title page, a certification page, sequentially numbered pages throughout, and a table of contents. Tables, lists, and diagrams must be titled. Generate and submit for approval the following documentation:

##### B. DALT and TAB Work Execution Schedule

- 1. Submit a detailed schedule indicating the anticipated calendar date for each submittal and each portion of work required under this section. For each work entry, indicate the support personnel (such as controls provider, HVAC mechanic, etc.) that are needed to accomplish the work. Arrange schedule entries chronologically.

##### C. DALT and TAB Procedures Summary

- 1. Submit a detailed narrative describing all aspects of the DALT and TAB field work to be performed. Clearly distinguish between DALT information and TAB information. Include the following:
  - a. A list of the intended procedural steps for the DALT and TAB field work from start to finish. Indicate how each type of data measurement will be obtained. Include what Contractor support personnel are required for each step, and the tasks they need to perform.
  - b. A list of the project's submittals that are needed by the TAB Firm in order to meet this Contract's requirements.
  - c. The schematic drawings to be used in the required reports, which may include building floor plans, mechanical room plans, duct system plans, and equipment elevations. Indicate intended TAB measurement locations, including where test ports need to be provided by the Contractor.

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- d. The data presentation forms to be used in the report, with the preliminary information and initial design values filled in.
- e. A list of DALT and TAB instruments to be used, edited for this project, to include the instrument name and description, manufacturer, model number, scale range, published accuracy, most recent calibration date, and what the instrument will be used for on this project.
- f. A thorough checklist of the work items and inspections that need to be accomplished before DALT field work can be performed. The Contractor must complete, submit, and receive approval of the Completed Pre-Final DALT Work Checklist before DALT field work can be accomplished.
- g. A thorough checklist of the work items and inspections that need to be accomplished before the Season 1 TAB field work can be performed. The Contractor must complete, submit, and receive approval of the Completed Season 1 Pre-TAB Work Checklist before the Season 1 TAB field work can be accomplished.
- h. A thorough checklist of the work items and inspections that need to be accomplished before the Season 2 TAB field work can be performed. The Contractor must complete, submit, and receive approval of the Completed Season 2 Pre-TAB Work Checklist before the Season 2 TAB field work can be accomplished.
- i. The checklists specified above shall be individually developed and tailored specifically for the work under this contract. Refer to NEBB PROCEDURAL STANDARDS, Section III, "Preliminary TAB Procedures" under the paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" for examples of items to include in the checklists.

**D. Design Review Report**

- 1. Submit report containing the following information:
  - a. Review the contract specifications and drawings to verify that the TAB work can be successfully accomplished in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.
  - b. Submit a typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the DALT work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. If no deficiencies are evident, state so in the report.

**E. Completed Pre-Final DALT Work Checklist**

- 1. Report the data for the Pre-Final DALT Report meeting the following requirements:
  - a. Submit a copy of the approved DALT and TAB Procedures Summary: Provide notations describing how actual field procedures differed from the procedures listed.
  - b. Report format: Submit a comprehensive report for the DALT field work data using data presentation forms equivalent to the "Air Duct Leakage Test Summary Report Forms"


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located in the SMACNA “HVAC AIR DUCT LEAKAGE TEST MANUAL”. In addition, submit in the report, a marked duct shop drawing which identifies each section of duct tested with assigned node numbers for each section. Node numbers shall be included in the completed report forms to identify each duct section.

- c. Calculations: Include a copy of all calculations prepared in determining the duct surface area of each duct test section. Include in the DALT reports copy(s) of the calibration curve for each of the DALT test orifices used for testing.
- d. Instruments: List the types of instruments used to measure the data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date. Instruments are to be calibrated within one year of the date of use in the field; instrument calibration is to be traceable to the measuring standards of the National Institute of Standards and Technology.
- e. TAB Supervisor Approval: Include on the submitted report the typed name of the TAB supervisor and the dated signature of the TAB supervisor.


F. Final DALT Report

- 1. On successful completion of all COTR field checks of the Pre-final DALT Report data for all systems, the TABS Supervisor shall assemble, review, sign and submit the Final DALT Report to the Owner for approval.
- 2. TAB Reports: Submit TAB Report for Proportional Balancing, Season 1, and Season 2 in the following manner:
  - a. Procedure Summary: Submit a copy of the approved DALT and TAB Procedures Summary. When applicable, provide notations describing how actual field procedures differed from the procedures listed.
  - b. Report format: Submit the completed data forms approved in the pre-field TAB Engineering Report completed by TAB field team, reviewed, approved and signed by the TAB supervisor. Bind the report with a waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data shall be typewritten. Handwritten report forms or report data are not acceptable.
  - c. Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded. Include in the TAB report continuous time versus temperature recording data of wet and dry bulb temperatures for the rooms, or zones, as designated in the following list:
    - 1) Data shall be measured and compiled on a continuous basis for the period in which TAB work affecting those rooms is being done.
    - 2) Data shall be measured/recorded only after the HVAC systems installations are complete, the systems fully balanced and the HVAC systems controls operating in fully automatic mode. Provide a detailed explanation wherever a final measurement did not achieve the required value.
    - 3) Data may be compiled using direct digital controls trend logging where available.

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Otherwise, the Contractor shall temporarily install calibrated time versus temperature/humidity recorders for this purpose. The HVAC systems and controls shall have been fully operational a minimum of 24 hours in advance of commencing data compilation. The specified data shall be included in the Season I TAB Report and Season 1 and Season 2 TAB Report.

- d. Air System Diagrams: Provided updated diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations.
- e. Air Static Pressure Profiles: Report static pressure profiles for air duct systems including AHU-1, RTAC-1, MUA-1. Report static pressure data for all supply, return, relief, exhaust and outside air ducts for the systems listed. The static pressure report data shall include, in addition to AABC or NEBB or TABB required data, the following:
  - 1) Report supply fan, return fan, relief fan, and exhaust fan inlet and discharge static pressures.
  - 2) Report static pressure drop across chilled water coils, DX coils, hot water coils, steam coils, electric resistance heating coils and heat reclaim devices installed in unit cabinetry or the system ductwork.
  - 3) Report static pressure drop across outside air, return air, and supply air automatic control dampers, both proportional and two-position, installed in unit cabinetry.
  - 4) Report static pressure drop across air filters, acoustic silencers, moisture eliminators, air flow straighteners, air flow measuring stations or other pressure drop producing specialty items installed in unit cabinetry, or in the system ductwork. Examples of these specialty items are smoke detectors, white sound generators, RF shielding, wave guides, security bars, blast valves, small pipes passing through ductwork, and duct mounted humidifiers.
  - 5) Report static pressure drop across outside air and relief/exhaust air louvers.
  - 6) Report static pressure readings of supply air, return air, exhaust/relief air, and outside air in duct at the point where these ducts connect to each air moving unit.
  - 7) Do not report static pressure drop across duct fittings provided for the sole purpose of conveying air, such as elbows, transitions, offsets, plenums, manual dampers, and branch takes-offs.
- f. Duct Transverses: Report duct traverses for main and branch main supply, return, exhaust, relief and outside air ducts. This shall include all ducts, including those which lack 7 1/2 duct diameters upstream and 2 1/2 duct diameters downstream of straight duct unobstructed by duct fittings/offsets/elbows. The TAB Agency shall evaluate and report findings on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pitot traverse plane as defined by AMCA 203, "Field Measurements", Section 8, paragraph 8.3, "Location of Traverse Plane".
- g. Instruments: List the types of instruments used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.


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- 1) Instrumentation, used for taking wet bulb temperature readings shall provide accuracy of plus or minus 5 percent at the measured face velocities. Submit instrument manufacturer's literature to document instrument accuracy performance is in compliance with that specified.
- h. Performance Curves: The TAB Supervisor shall include, in the TAB Reports, factory pump curves and fan curves for pumps and fans TAB'd on the job.
- i. Calibration Curves: The TAB Supervisor shall include, in the TAB Reports, a factory calibration curve for installed flow control balancing valves, flow venturis and flow orifices TAB'd on the job.
- j. Data From TAB Field Work: After completion of the TAB field work, prepare the TAB field data for TAB supervisor's review and approval signature, using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms shall be furnished by the TAB team. Except as approved otherwise in writing by the Owner, the TAB work and thereby the TAB report shall be considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph WORKMANSHIP.


#### 4.9 APPENDIX C

##### A. DALT AND TAB SUBMITTAL AND WORK SCHEDULE

1. Perform the following items of work in the order listed adhering to the dates schedule specified below. Include the major items listed in this schedule in the project network analysis schedule required by Section 01 32 17.00 20 COST-LOADED NETWORK ANALYSIS SCHEDULES (NAS).
2. Submit TAB Agency and TAB Personnel Qualifications: Within 42 calendar days after date of contract award.
3. Submit the DALT and TAB Work Execution Schedule: within 14 days after receipt of the TAB agency and TAB personnel qualifications approval. Revise and re-submit this schedule 28 days prior to commencement of DALT work and 28 days prior to the commencement of TAB Season 1 work and TAB Season 2 work.
4. Submit the DALT and TAB Work Procedures Summary: within 14 days after receipt of the initial approved DALT and TAB Work Execution Schedule.
5. Meet with the COTR at the Pre-DALT/TAB Meeting: Within 28 calendar days after receipt of the approved initial DALT/TAB Execution Schedule.
6. Submit Design Review Report: Within 56 calendar days after the receipt of the approved initial DALT and TAB Work Execution Schedule.
7. Conduct measurements and submit the Record of Existing Facility Conditions: within 28 days after receipt of approved DALT and TAB Work Procedures Summary.
8. Advance Notice of Pre-Final DALT Field Work: After the completed installation of the HVAC duct system to be DALT'd, submit to the Owner an Advance Notice of Pre-Final DALT Field Work accompanied by the completed Pre-Final DALT Work Checklist for the subject duct system.

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9. Ductwork Selected for DALT: Within 14 calendar days after receiving an acceptable completed Pre-Final DALT Work Checklist, the Owner's technical representative (COTR) will select the project ductwork sections to be DALT'd.
10. DALT Field Work: Within 48 hours of COTR's selection, complete DALT field work on selected project ductwork.
11. Submit Pre-Final DALT Report: Within two working days after completion of DALT field work, submit Pre-final DALT Report. Separate Pre-final DALT reports may be submitted to allow phased testing from system to system.
12. Quality Assurance - COTR DALT Field Checks: Upon approval of the Pre-final DALT Report, the COTR's DALT field check work shall be scheduled with the Owner.
13. Submit Final DALT Report: Within 14 calendar days after completion of successful DALT Work Field Check, submit Season 1 TAB report.
14. Advance Notice of Season 1 TAB Field Work: At a minimum of 14 calendar days prior to Season 1 TAB Field Work, submit advance notice of TAB field work accompanied by completed Season 1 Pre-TAB Work Checklist.
15. Season 1 TAB Field Work: At a minimum of 84 calendar days prior to CONSTRUCTION COMPLETION, and when the ambient temperature is within Season 1 limits, accomplish Season 1 TAB field work.
16. Submit Season 1 TAB Report: Within 14 calendar days after completion of Season 1 TAB field work, submit initial Season 1 TAB report.
17. Season 1 Quality Assurance - COTR TAB Field Check: 30 calendar days after initial Season 1 TAB report is approved by the Owner, conduct Season 1 field check.
18. Complete Season 1 TAB Work: Prior to CONSTRUCTION COMPLETION, complete all TAB work, except Season 2 TAB work, and submit final.
19. Receive the approved TAB report: Within 21 calendar days, receive the report from Owner approved TAB report.
20. Advance Notice of Season 2 TAB Field Work: At a minimum of 126 calendar days after CONSTRUCTION COMPLETION, submit advance notice of Season 2 TAB field work accompanied by completed Season 2 Pre-TAB Work Checklist.
21. Season 2 TAB Field Work: Within 14 calendar days after date of advance notice of Season 2 TAB field work and when the ambient temperature is within Season 2 limits, accomplish Season 2 TAB field work.
22. Submit Season 2 TAB Report: Within 14 calendar days after completion of Season 2 TAB field work, submit Season 2 TAB report.
23. Season 2 Quality Assurance - COTR TAB Field Checks: 28 calendar days after the Season 2 TAB report is approved by the Owner, conduct Season 2 field check.
24. Complete Season 2 TAB Work: Within 14 calendar days after the completion of Season 2 TAB field data check, complete all TAB work.
25. Receive the approved TAB report: Within calendar 21 days, receive the report from Owner.

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4.10 APPENDIX D

A. REQUIREMENTS FOR DUCT AIR LEAK TESTING

1. Specify the Duct Test Pressure in inches W.C. the same the Duct Static Pressure in inches W.C.
  - a. Specify the duct leak class as follows:
    - 1) For duct static pressure of less than 2 inches W.C., specify Class 12 for round duct and Class 24 for rectangular duct.
    - 2) For duct static pressure of 2 inches to 3 inches W.C., specify Class 6 for round duct and Class 12 for rectangular duct.
    - 3) For duct static pressure of higher than 3 inches W.C., specify Class 3 for round duct and Class 6 for rectangular duct.
- B. For duct static pressure of less than 2 inches W.C., specify Class 12 for round duct and Class 24 for rectangular duct.

		SYSTEMS			
		Package Rooftop w/VAV Unit No. [1]	Package Rooftop w/VAV Unit No. [2]	Package Rooftop w/CV Unit No. [1]	Package Rooftop w/CV Unit No. [2]
Duct System Static Pressure, in millimeters W.C.	for Supply	[100]	[100]	[50]	[50]
	for Return	[50]	[50]	[25]	[25]
	for Exhaust	[ ]	[ ]	[ ]	[ ]
	for Outside Air	[50]	[50]	[25]	[25]
System Oval/Round Duct and Rectangular Duct SMACNA Seal Class	for Supply	A	A	A	A
	for Return	A	A	A	A
	for Exhaust	A	A	A	A
	for Outside Air	A	A	A	A
System Oval/Round Duct SMACNA Leak Class	for Supply	[3]	[3]	[6]	[6]
	for Return	[6]	[6]	[12]	[12]
	for Exhaust	[ ]	[ ]	[ ]	[ ]
	for Outside Air	[6]	[6]	[12]	[12]
System Rectangular	for Supply	[6]	[6]	[12]	[12]



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Duct SMACNA Leak Class					
	for Return	[12]	[12]	[24]	[24]
	for Exhaust	[ ]	[ ]	[ ]	[ ]
	for Outside Air	[12]	[12]	[24]	[24]

SYSTEMS					
		Package Rooftop w/VAV Unit No. [1]	Package Rooftop w/VAV Unit No. [2]	Package Rooftop w/CV Unit No. [1]	Package Rooftop w/CV Unit No. [2]
Duct Test Pressure, in millimeters W.C.	for Supply	[100]	[100]	[50]	[50]
	for Return	[50]	[50]	[25]	[25]
	for Exhaust	[ ]	[ ]	[ ]	[ ]
	for Outside Air	[50]	[50]	[25]	[25]
Duct System Static Pressure, in millimeters W.C.	for Supply	[50]	[50]	[13]	N/A
	for Return	[25]	[25]	[13]	N/A
	for Exhaust	[13]	[13]	N/A	[25]
	for Outside Air	[25]	[25]	N/A	N/A
System Oval/Round Duct and Rectangular Duct SMACNA Seal Class	for Supply	A	A	A	A
	for Return	A	A	A	A
	for Exhaust	A	A	A	A
	for Outside Air	A	A	A	A
System Oval/Round Duct SMACNA Leak Class	for Supply	[6]	[6]	12	N/A
	for Return	[12]	[12]	12	N/A

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	for Exhaust	[12]	[12]	N/A	[12]
	for Outside Air	[12]	[12]	N/A	N/A

		SYSTEMS			
		Package Rooftop w/VAV Unit No. [1]	Package Rooftop w/VAV Unit No. [2]	Package Rooftop w/CV Unit No. [1]	Package Rooftop w/CV Unit No. [2]
System Rectangular Duct SMACNA Leak Class	for Supply	[12]	[12]	[24]	N/A
	for Return	[24]	[24]	24	N/A
	for Exhaust	[24]	[24]	N/A	[24]
	for Outside Air	[24]	[24]	N/A	N/A
Duct Test Pressure, in millimeters W.C.	for Supply	[50]	[25]	[13]	N/A
	for Return	[25]	[25]	[13]	N/A
	for Exhaust	[13]	[13]	N/A	[25]
	for Outside Air	[25]	[25]	N/A	N/A

		SYSTEMS			
		Package Rooftop w/VAV Unit No. [1]	Package Rooftop w/VAV Unit No. [2]	Package Rooftop w/CV Unit No. [1]	Package Rooftop w/CV Unit No. [2]
Duct System Static Pressure, in inches W.C.	for Supply	[4]	[4]	[2]	[2]
	for Return	[2]	[2]	[1]	[1]
	for Exhaust	[ ]	[ ]	[ ]	[ ]
	for Outside Air	[2]	[2]	[1]	[1]
System Oval/Round Duct and Rectangular Duct SMACNA	for Supply	A	A	A	A
	for Return	A	A	A	A
	for Exhaust	A	A	A	A



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Seal Class	for Outside Air	A	A	A	A
System Oval/Round Duct SMACNA Leak Class	for Supply	[3]	[3]	[6]	[6]
	for Return	[6]	[6]	[12]	[12]
	for Exhaust	[ ]	[ ]	[ ]	[ ]
	for Outside Air	[6]	[6]	[12]	[12]
System Rectangular Duct SMACNA Leak Class	for Supply	[6]	[6]	[12]	[12]
	for Return	[12]	[12]	[24]	[24]
	for Exhaust	[ ]	[ ]	[ ]	[ ]
	for Outside Air	[12]	[12]	[24]	[24]

		SYSTEMS			
		Package Rooftop w/VAV Unit No.	Package Rooftop w/VAV Unit No.	Package Rooftop w/CV Unit No.	Package Rooftop w/CV Unit No.
		[1]	[2]	[1]	[2]
Duct Test Pressure, in inches W.C.	for Supply	[4]	[2]	[4]	[2]
	for Return	[2]	[2]	[1]	[1]
	for Exhaust	[ ]	[ ]	[ ]	[ ]
	for Outside Air	[2]	[2]	[1]	[1]
Duct System Static Pressure, in inches W.C.	for Supply	[2]	[2]	[0.5]	N/A
	for Return	[1]	[1]	[0.5]	N/A
	for Exhaust	[0.5]	[0.5]	N/A	[1]
	for Outside Air	[1]	[1]	N/A	N/A
System Oval/Round	for Supply	A	A	A	A



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Duct and Rectangular Duct SMACNA Seal Class	for Return	A	A	A	A
	for Exhaust	A	A	A	A
	for Outside Air	A	A	A	A
System Oval/Round Duct SMACNA Leak Class	for Supply	[6]	[6]	12	N/A
	for Return	[12]	[12]	12	N/A
	for Exhaust	[12]	[12]	N/A	[12]
	for Outside Air	[12]	[12]	N/A	N/A

SYSTEMS					
		Package Rooftop w/VAV Unit No.	Package Rooftop w/VAV Unit No.	Package Rooftop w/CV Unit No.	Package Rooftop w/CV Unit No.
		[1]	[2]	[1]	[2]
System Rectangular Duct SMACNA Leak Class	for Supply	[12]	[12]	[24]	N/A
	for Return	[24]	[24]	24	N/A
	for Exhaust	[24]	[24]	N/A	[24]
	for Outside Air	[24]	[24]	N/A	N/A
Duct Test Pressure, in inches W.C.	for Supply	[2]	[2]	[0.5]	N/A
	for Return	[1]	[1]	[0.5]	N/A
	for Exhaust	[0.5]	[0.5]	N/A	[1]
	for Outside Air	[1]	[1]	N/A	N/A