# Testing, Adjusting and Balancing (TAB) Fundamentals for Engineers, Commissioning and Energy Management Providers


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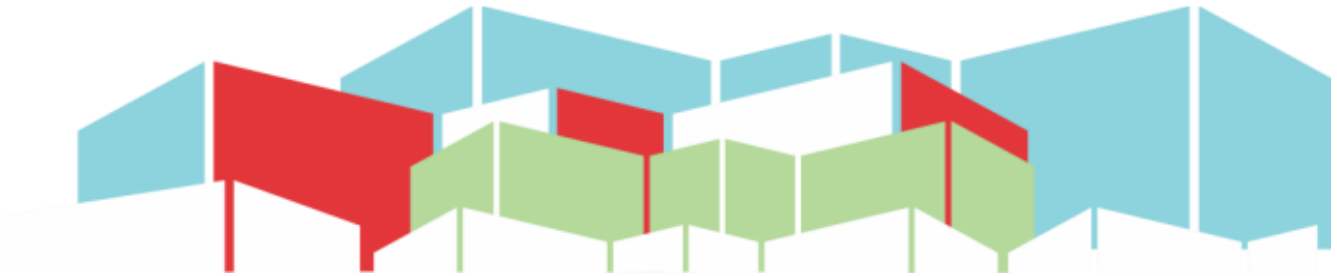
TABITT


Associated Air Balance Council

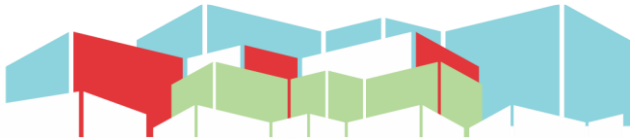
*The World's Leading Association of Independent Test & Balance Agencies*



# TAB Fundamentals for Engineers/ Commissioning Providers

## Learning Objectives

- ✓ **Agenda** – TABA Review of Construction Documents to Include the Equipment Submittal Performance Data – Provides Basis for TAB Plan.
- ✓ **Application** – TAB Instrumentation Specific to the Type of System for Accurate Data Collection and Record Measurement.
- ✓ **Analysis** – TAB Record Measurement vs Equipment Performance Submittal Data Evaluate Differences for Improved Efficiency.



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# TAB Fundamentals for Engineers/ Commissioning Providers

**Learning Objectives**

- ✓ **Understand** – Configuration of Variable Air Handler/ Hydronic Systems Necessary to Establish Repeatable Record Measurements.
- ✓ **Create** – Project Team Environment TAB Integration Schedule, Process for the Navigation of Operational Challenges.
- ✓ **Evaluate** – Compliance with Plans and Specifications, Identify Corrective Action where Data Collection Deviates from Submittal, Fan Curves, Qualify Pump Performance and System Flow.

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# What is Testing, Adjusting and Balancing?

The **Associated Air Balance Council (AABC)** defines **Testing, Adjusting and Balancing (TAB)** as:

"A systematic process of measuring, adjusting and documenting the performance of HVAC air and hydronic systems so that they operate in accordance with the design intent and contract documents."

**AABC** defines **Total System Balance** as:

"Testing and balancing the HVAC systems and related control systems to perform at the design intent and operate at an optimal level, using methodical approach with verifiable test result."

# What is Testing, Adjusting and Balancing?

The AABC TAB procedures ensure that HVAC system components operate in accordance with the design intent and contract documents.

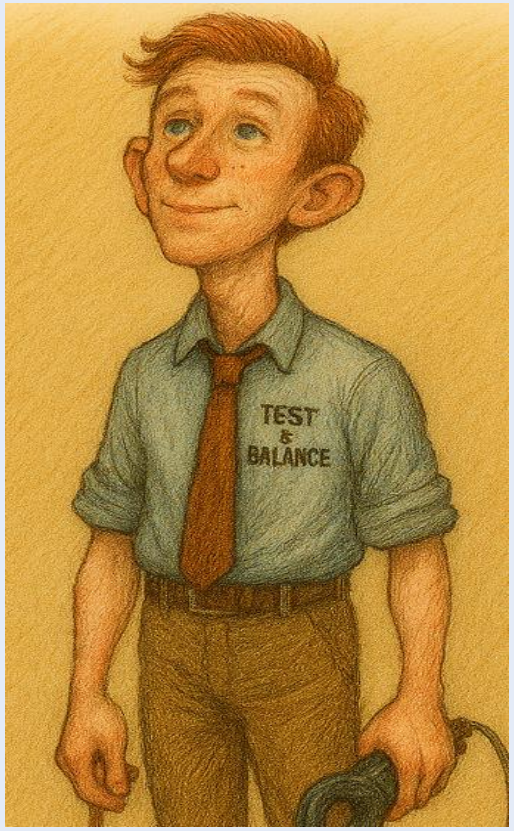
- Testing: The use of calibrated instruments to measure airflow, water flow, pressure, temperatures and related system parameters to determine actual system performance.
- Adjusting: The systematic regulation of air and hydronic distribution devices (dampers, valves, rotational speeds) to bring measured values into compliance with design requirements.
- Balancing: The proportional distribution of air and water flows through system mains, branches and terminal devices so that each component receives the required quantity within the allowable tolerances.

# TAB *Agenda*, Plan, Observation Report = Quality Assurance

- TAB Agenda documents the performance criteria recorded from the Equipment Schedules with cross-check of the Equipment Performance Submittal Data.
  - *May identify minor discrepancies between the equipment schedules and submittals.*
  - *May identify chilled/ hot water coil capacities which do not adhere to the design schedules.*
  - *Air/ water system analysis of connected design load vs diversity (variable volume systems).*

TAB Specification 23 05 93

- Part 3 Execution
- Para 3.1 Examination



# TAB Agenda, *Plan*, Observation Report = Quality Assurance

- TAB Plan is developed through examination of Contract Document Owner Project Requirements. Once the TBE becomes familiarized with the design intent, the TBE may identify conditions which preclude proper TAB of systems.
  - *Provides strategies with step-by-step procedure for the balancing of the systems.*
  - *Verifies selection types, quantities and locations of TAB devices.*
  - *Review supply/ return air ductwork and hydronic piping routing/ dimensions.*

TAB Specification 23 05 93

- Part 3 Execution
- Para 3.1 Examination



# TAB Agenda, Plan, *Observation Report* = Quality Assurance

- TAB Observation Report confirms the operational readiness of the HVAC system and may identify installation conditions which preclude proper TAB and/or service of equipment and systems.
  - *Site observations focus upon the device placement and/or omission of any specialty devices.*
  - *TAB System Readiness Checklist (AABC National Standards TSB Ch. 6):*
    - *Start-up is performed, rotation is correct, operation is without vibration*
    - *Automatic Temperature Control systems operational*
    - *Filter installation inspected for bypass*

TAB Specification 23 05 93

- Part 3 Execution
- Para 3.1 Examination



# TAB Instrumentation Selection/ Application

- ✓ **Accuracy** – Correct instrument range selection and accuracy ensures the Airflow, Water Flow, Pressure and Temperature measurements are precise. Inaccurate instrumentation can lead to Improper Balancing, System Inefficiency and Failure to Meet Design Intent.
- ✓ **Compliance** – TAB instrumentation must meet the AABC, NEBB or ASHRAE Standards. Instruments must be Calibrated having NIST-Traceability and with the Accuracy Class necessary to comply with these Standards.
- ✓ **Calibration** – TAB calibrated instrumentation provides Consistent Results. Poor accuracy class selection or uncalibrated tools can introduce Systematic Errors compromising the entire TAB effort and report contents.







# TAB Instrumentation Selection/ Application

- ✓ **Suitability** – Air systems instrumentation include Pitot Tube, Flow Hood, Anemometer, Tachometer, Ammeter, Temperature Probes; Water system instrumentation include Flow Meters, Ultrasonic Meter or Pressure Meter/ Gauges and Thermometer.

- ✓ **Range and Resolution** – TAB instrumentation must be provided with the Correct Measurement Range for anticipated Flows and Pressures. Insufficient Resolution can mask Small but Critical Deviations in System Performance.



# TAB Instrumentation Selection/ Application





































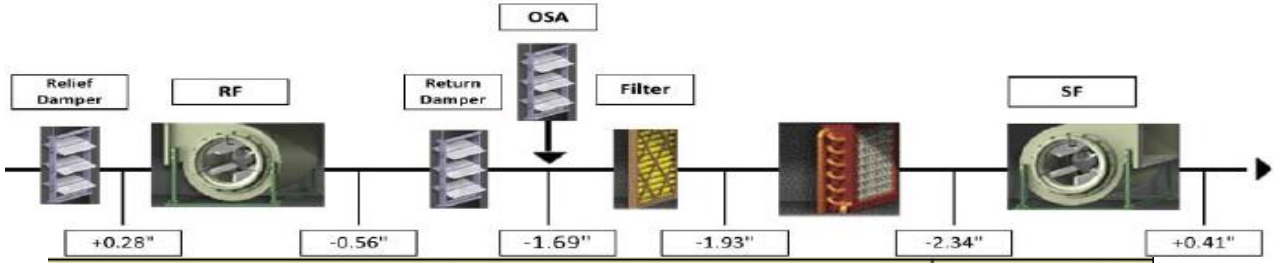



# TAB Measurement vs Equipment Performance Submittal Data

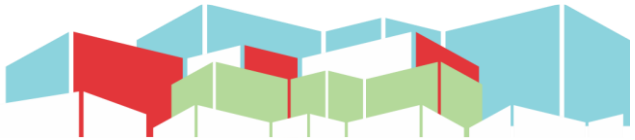
## TAB Report Review (EOR) TAB Verification (Cx)

- AHU Constant Speed Single Zone
  - Observe Total Fan CFM @ Fan RPM
    - Fan Dsg 14000 vs Act 14798 = 1.06%
    - RPM Dsg 2069 vs Act 1777 = 86%
    - HWC Dsg 0.13"wc
    - CHWC Dsg 0.48"wc
    - Dsg 0.61"wc vs Act 0.41"wc = 82%
    - TSP Dsg 5.36"wc vs Act 2.75"wc
  - Total S/A CFM Outlets = 13762 CFM
    - Dsg CFM 14000 vs Act 13762 = 98%
    - Losses = Friction, Dynamic and Leakage
- CHWP/ HWP Constant Speed
  - Same Review/ Verification using Coil dP

| Measurement | Method | Specified | Actual |
|---|---|---|---|
| Total Fan CFM | *Traverse* | 14000 | 14798 |
| Total S/A CFM | *Outlets* | 14000 | 13762 |
| Total R/A CFM | *Inlets* | 10000 | 10480 |
| O/A CFM | | 4000 | 4318 |
| Fan RPM | | 2069 | 1777 |
| TSP - ESP X | | 2.50" | 2.18" |




| Description | APD (in.H20) |
|---|---|
| OSA - Louver & Damper (Outside Air) | 0.24 |
| MIN OSA - Louver & Damper (Outside Air) | 0.20 |
| Filter 1, Pre / Final (Average Pressure Drop) | 1.59 |
| Hot Water Coil 1 | 0.13 |
| Chilled Water Coil 1 | 0.48 |
| Plenum Fan 1 (Supply) 14,000 ACFM @ 5.36 in.H20 | 0.00 |
| SA Opening (Supply Air) | 0.22 |
| Plenum Fan 1 (Supply) - Supply Air - SA Opening ESP: | 2.50 |
| Total Static Pressure: | 5.36 |



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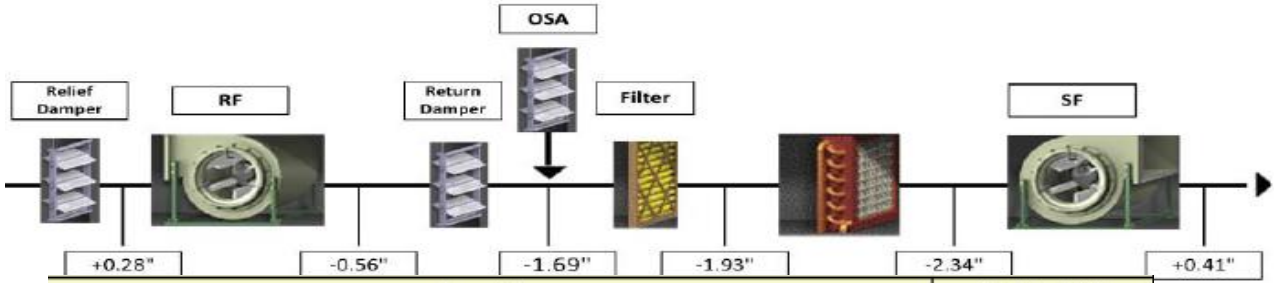
# Configuring Air Handler Unit/ Hydronic Systems w/Diversity

**TAB Report Review (EOR) TAB Verification (Cx)**

- AHU Variable Speed Single Zone
  - Total Fan CFM vs Fan RPM (Fan Law 1 - 16870)
    - Fan Dsg 14000 vs Act 14798 = 1.06%
    - RPM Dsg 2069 vs Act 1777 = 86%
    - ESP Dsg 2.5"wc vs Act 1.68"wc
  - Total S/A CFM Outlets = 13762 CFM (Prev)
    - Dsg CFM 16800 vs Act 13762 (TUs 100%)
    - Adjust TUs Max Cool = BAS DSP = 1.0"wc
    - Identify the TU Furthest Off Design CFM
    - BAS Override (4) TUs 700 CFM (ea) Closed
    - BAS DSP Sensed Value Increases to 1.5"wc
    - Observe Lowest TU @ ›90% Design CFM
    - BAS Duct Static Pressure Setpoint of 1.5"wc
- CHWP/ HWP Variable Speed
  - Same Process Establishing Hydronic Loop dP StPt

| Measurement | Method | Specified | Actual |
|---|---|---|---|
| Total Fan CFM | *Traverse* | 14000 | 14798 |
| Total S/A CFM | *Outlets* | 16800 | 15562 |
| Total R/A CFM | *Inlets* | 10000 | 10480 |
| O/A CFM | | 4000 | 4318 |
| Fan RPM | | 2069 | 1777 |
| TSP - ESP X | | 2.50" | 2.18" |




| Description | APD (in.H20) |
|---|---|
| OSA - Louver & Damper (Outside Air) | 0.24 |
| MIN OSA - Louver & Damper (Outside Air) | 0.20 |
| Filter 1, Pre / Final (Average Pressure Drop) | 1.59 |
| Hot Water Coil 1 | 0.13 |
| Chilled Water Coil 1 | 0.48 |
| Plenum Fan 1 (Supply) 14,000 ACFM @ 5.36 in.H20 | 0.00 |
| SA Opening (Supply Air) | 0.22 |
| Plenum Fan 1 (Supply) - Supply Air - SA Opening ESP: | 2.50 |
| Total Static Pressure: | 5.36 |

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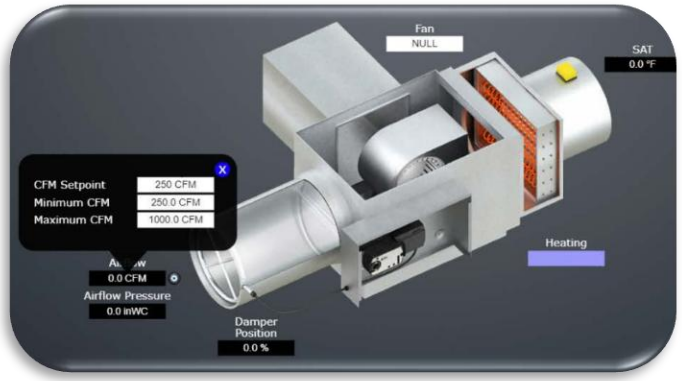
# Configuring Variable Air Volume System w/Diversity

| Measurement | Method | Specified | Actual |
|---|---|---|---|
| Total Fan CFM | *Traverse* | 14000 | 14798 |
| Total S/A CFM | *Outlets* | 14000 | 13762 |
| Total R/A CFM | *Inlets* | 10000 | 10480 |

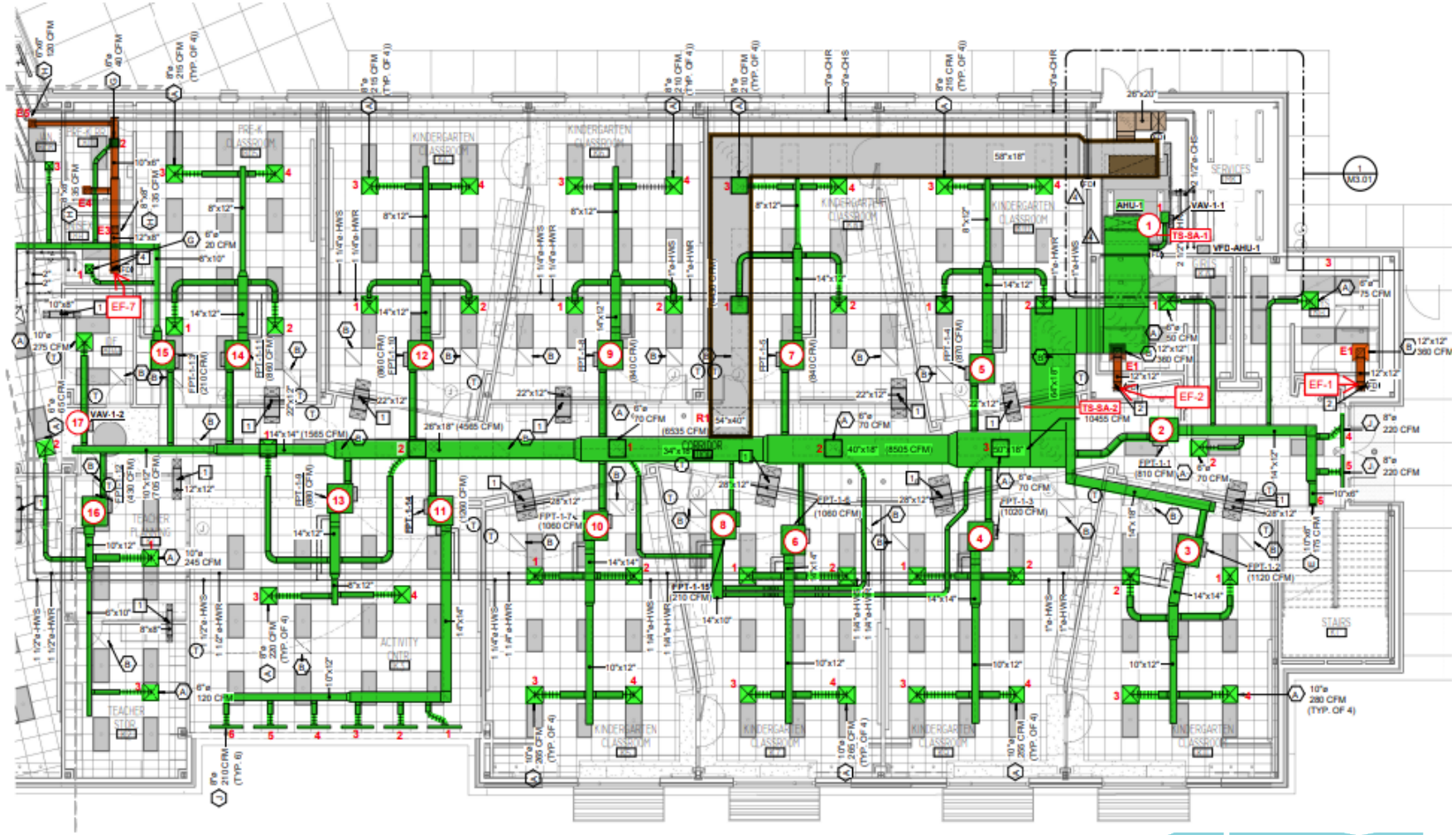
Force Cooling Max – Measure and Record Air Distribution CFM
Identify DSP and Lowest TU CFM

| Measurement | Method | Specified | Actual |
|---|---|---|---|
| Total Fan CFM | *Traverse* | 14000 | 14798 |
| Total S/A CFM | *Outlets* | 16800 | 15562 |
| Total R/A CFM | *Inlets* | 10000 | 10480 |

Force (4) TUs Closed – Observe the Lowest TU CFM >90% (min); Record New DSP and Release all Overrides

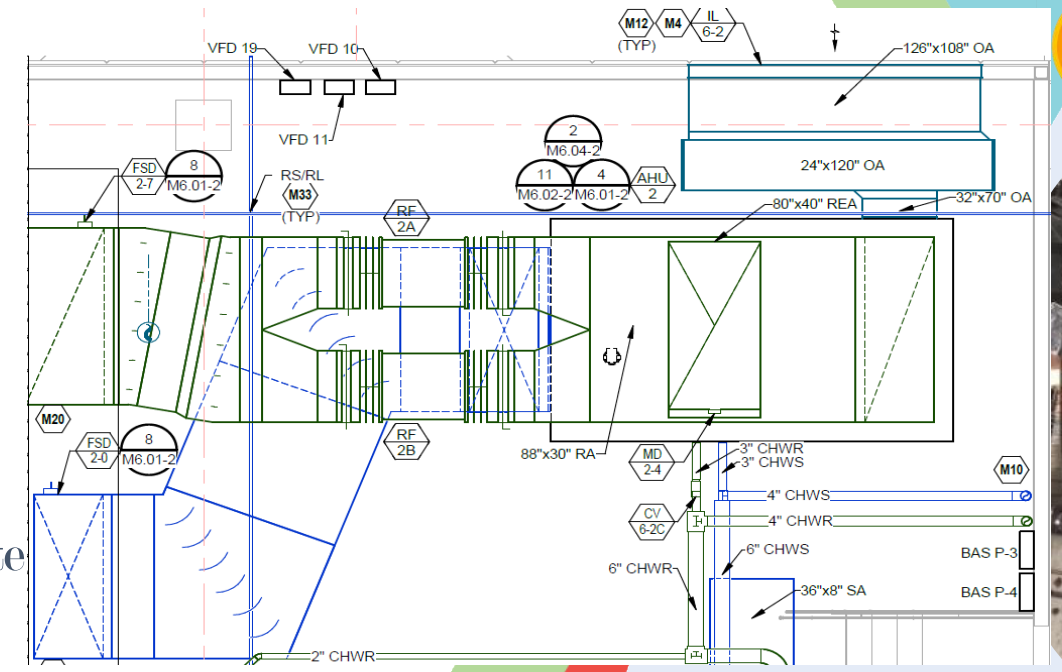



BAS verification of DSP with 100% TUs in Control; Set Max Cool of a TU Verify CFM Output; Summate for Total



# Potential TAB Pitfalls Data Collection/ Record Measurement

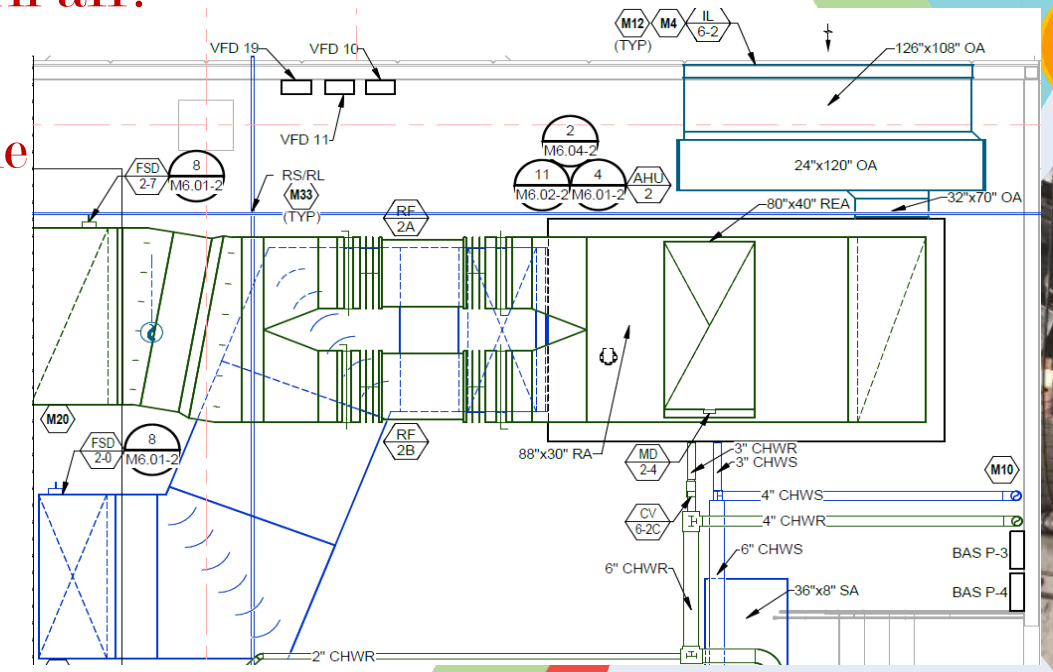
- Mechanical Equipment Rooms often provide challenges where TAB technicians may not be able to collect data in compliance with the established AABC standards and procedures.
  - Equipment Room perimeter is limited resulting in space constraints
  - Access may be available, however is insufficient to allow proper use of the instrumentation
  - Straight ductwork is necessary uniform duct traverse location; alternate method is required.






# Potential TAB Pitfalls Data Collection/ Record Measurement

- How is the TAB agent to collect the total supply, return & outside airflow?
  - Supply/ Return Air Duct Traverse locations?
  - Coil Face Velocity reading? Maybe, but what about the return air?
  - Isolating the return/ relief air fans from the air handler unit's supply fan creates a configuration which allows for the proper collection in record measurement data.






# Project Team Environment/ TAB Integration

## ❖ Steps in Creating a Project Team Environment:

- ✓ TAB agency may proactively coordinate with the Prime Contractor
  - Check-in with the Project Superintendent at their onsite office/ trailer as an introduction.
  - TBE may request that the Prime Contractor's MEP representative to walk the project site.
  - MEP representative assists in coordination with the GC Scheduler modifying the schedule.
  - TABA follow up providing time allowances (by systems/ areas) to work into the schedule.
- ✓ CxP and TABA may attend the Owner-Architect-Contractor (OAC) Meetings
  - Communicate the details of the TAB Plan outlining system specifics.
  - Communicate the Contractor Responsibilities (System Readiness).
  - Communicate Site Observations impeding the TAB process.
- ✓ TABA regularly attend Commissioning Meetings
  - Provide the System Readiness Checklist to the Cx Team (Mechanical Representative).
  - Provide Site Observation Reports to CxP identifying resolution Cx Team.

# TAB Report Compliance with Plans and Specs

## 1. Executive Summary

- ✓ Confirms the overall report content is compliant with the design intent.
- ✓ Outlines any specific system configuration required by the TAB process.
- ✓ Lists any unresolved discrepancies or deficiencies.

## 2. Air and Water Balance Data

- ✓ Compare recorded CFM/GPM values against design specifications.
- ✓ Check tolerances (AABC/project specific) airflow and hydronic systems.

## 3. Equipment Details

- ✓ Confirm manufacturer make and model match the equipment submittals.
- ✓ Ensure locations and areas served align with the mechanical drawings.

## 4. Static Pressure Profiles

- ✓ Review fan static pressures verse design performance data submittals.
- ✓ Check for proper placement of test ports and accuracy of readings.

# TAB Report Compliance with Plans and Specs

## 5. Fan and Pump Curves

- ✓ Validate operating points (RPM/ BHP) correlate with Fan/Pump Laws.
- ✓ Ensure the Curves are included and match expected performance.

## 6. Controls Verification

- ✓ Check that the control setpoints align with the design intent.
- ✓ Verify each control device is installed in the correct position for its application.
- ✓ Verify pressure and temperature control sensed values are calibrated.
- ✓ Confirm sequence of operations were tested and documented.

## 7. Special Testing

- ✓ If specified, sound, vibration, pressurization, or air quality testing.
- ✓ Verify results meet the specifications or the project requirements.

# TAB Report Compliance with Plans and Specs

## 8. Instrumentation and Calibration

- ✓ Ensure calibration certificates are included and current.
- ✓ Confirm instruments used are appropriate for the measurements taken.

## 9. Documentation Completeness

- ✓ All systems and components on the equipment schedules are included.
- ✓ Duct traverse locations are identified upon the mechanical plan.
- ✓ Air handler dP station locations are identified upon the mechanical plan.
- ✓ TAB report data fields are complete, in cases where performance data is not provided upon the mechanical schedule, equipment submittal data may be a reliable source of information.

## 10. Discrepancy and Deficiency Lists

- ✓ Outlines each system discrepancy observed, itemizing open issues.
- ✓ Provides specific details and may provide recommended corrective measures.

# TAB Fundamentals for Engineers and CxA Summary

Test and Balance Reports should be evaluated for:

Completeness –

- Does the Executive Summary provide a complete narrative of system performance?
- Are the equipment and components present, traceable and internally consistent?
- Are all equipment sheets complete with design and record measurement data?
- Reference – AABC National Standards for Total Systems Balance (Chapter 1)

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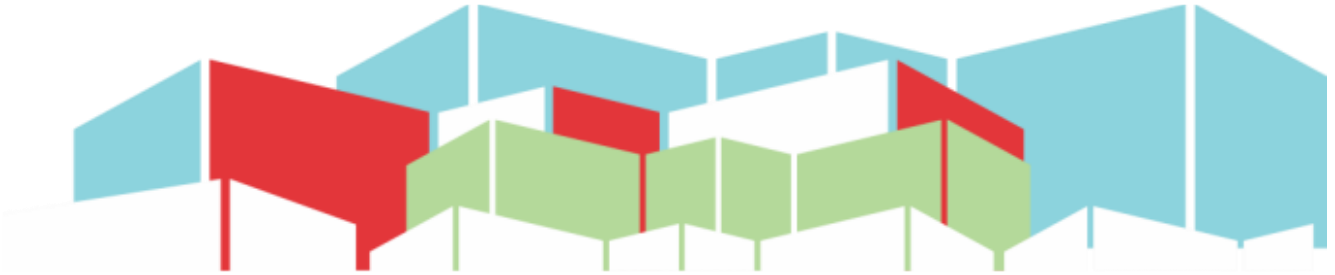

# TAB Fundamentals for Engineers and CxA Summary

Test and Balance Reports should be evaluated for:

Accuracy –

- Do the test results meet the design requirements within specified tolerances?
- Do the test results correlate with the fan and pump laws?
- Do the internal component dP align with equipment submittal performance data?

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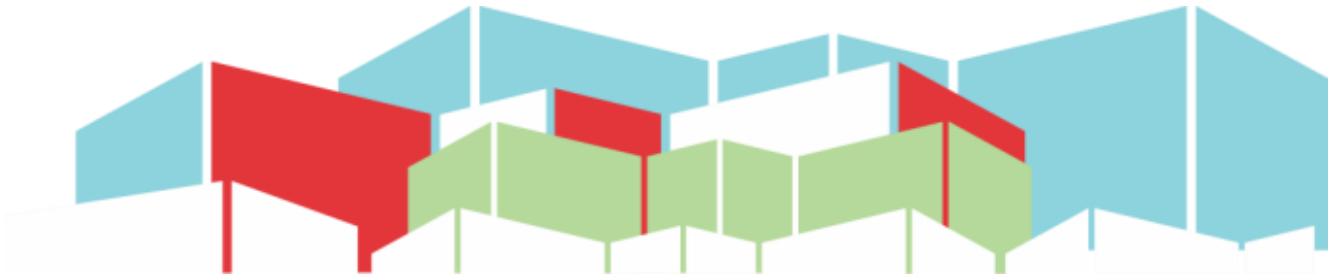

# TAB Fundamentals for Engineers and CxA Summary

Test and Balance Reports should be evaluated for:

Verification –

- Are the systems configuration outlined adequately to duplicate record measurement?
- Does the system dP setpoint result in accurate and repeatable record measurement?
- Do the terminal unit Max/ Min/ Htg parameters align with the equipment schedules submittals and are calibration k-Factors recorded in TAB report?

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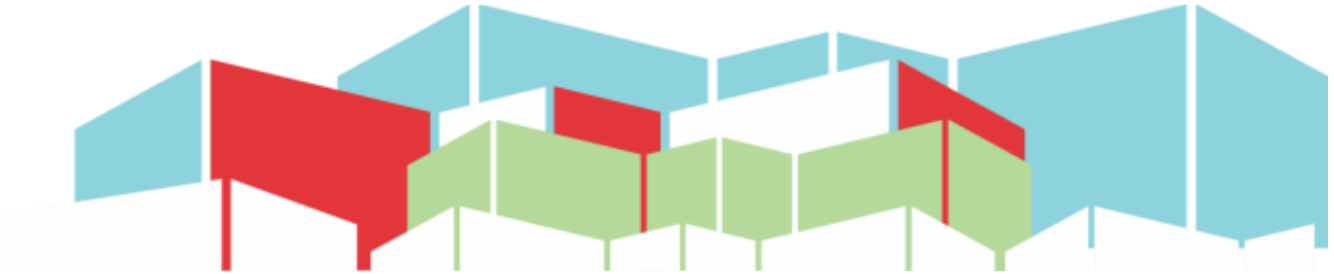




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