

Test & Balance Seminar for CxAs, Engineers, & TAB Professionals

**Tuesday, April 16, 2019
8:30 a.m. – 4:30 p.m.**



Understanding the Proper Approach to Maintain Consistent Outside Airflow in Variable Volume Systems

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Engineered Air Balance Co., Inc.

This session will cover:

Impact of reduced fresh air, Maintain the required outside and different types and configurations of systems. Constant vs. variable volume. System setup for testing. Data recording and reporting.



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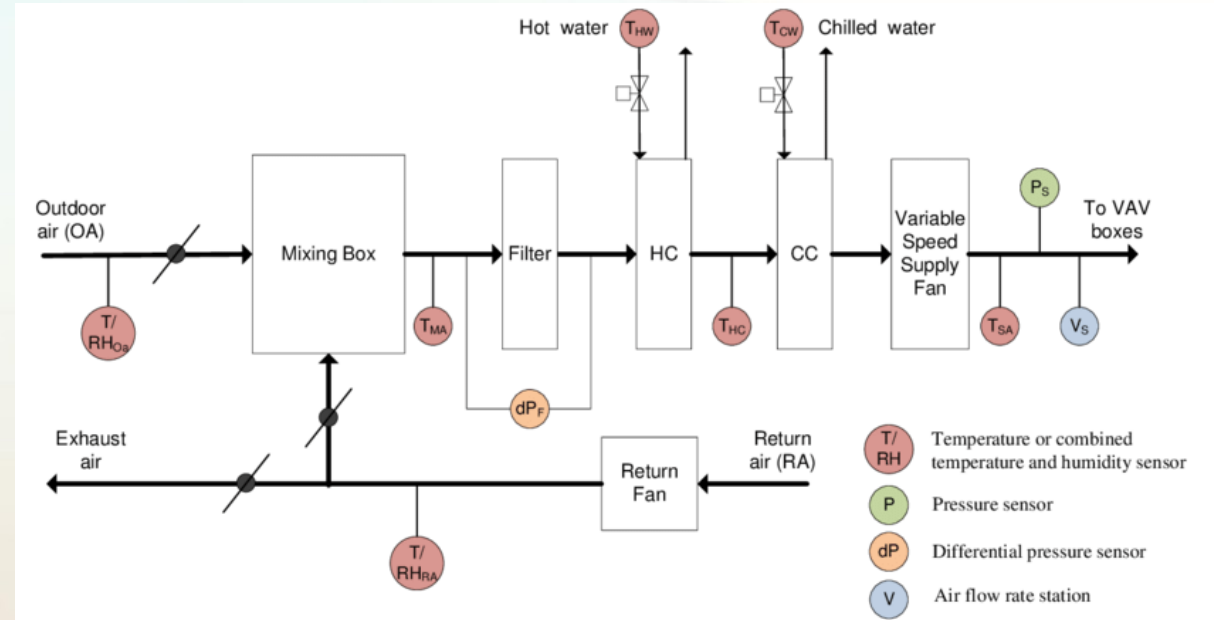
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Course Description

- Initial Review for Compliance
- Equipment Performance and Outside Air Verification
- What testing is performed
- Process of verifying consistent airflow quantities
- Why is such testing performed
- How is it accurately accomplished

Learning Objectives

- To understand the impact of reduced outside capacities
- Be able to explain why and how outside air capacity testing is set up and performed
- Understand what data should be recorded and reported for outside air verification
- Identify the important aspects of identifying variances in construction documents and how the variations impact system and building performance.

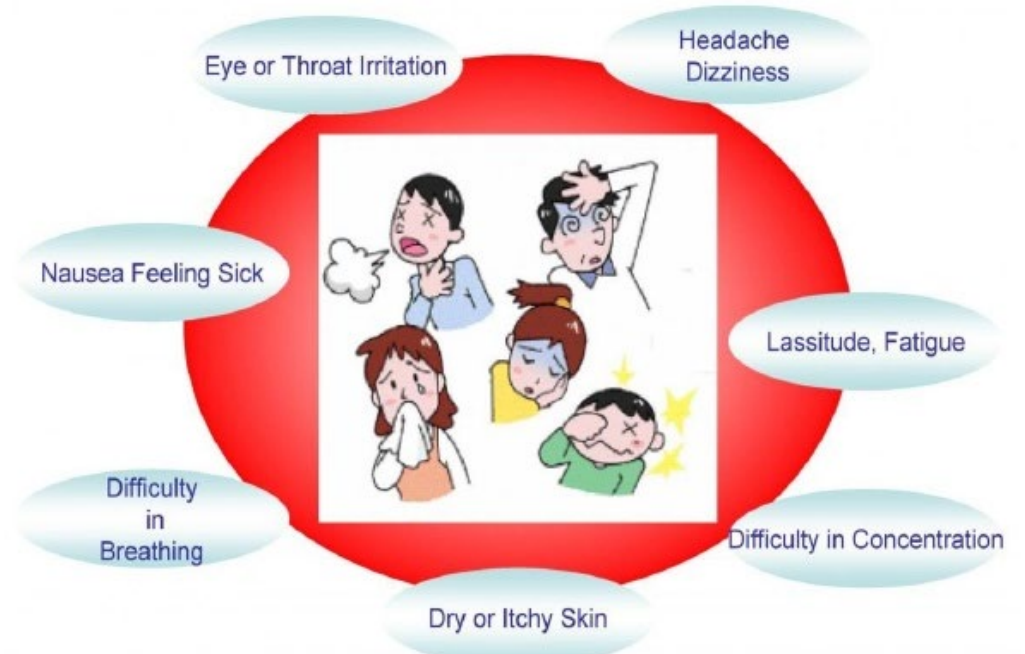


Reduced/Eliminated Outside Air

- Building Impact:
 - Operate In a Negative
 - Poor Air Quality
 - Mold/Mildew
 - Odors
 - Humidity Issues

- Inducing Untreated Outside Air:

Symptoms of Sick Building Syndrome



Initial Document Review – What is evaluated?

- Equipment Configurations:
 - VAV
 - Constant Volume
 - Return Air Fans
 - Level of Diversity
 - Minimum Airflow
- If VAV:
 - Terminal Box:
 - Total Maximum Flow
 - Total Minimum Flow
 - Outside Air Values
 - Flow Stations
 - Min/Min
 - Min/Max
 - Max
 - Return Air
 - Ventilation Capabilities
 - Damper Tracking

Initial Review – Mech Scheduled Values

Basis of Design - VAV

Max Supply Airflow	25,000 CFM
Max Return Airflow	25,000 CFM
Minimum Outside Air	5,000 CFM
Terminal Box Max Total CFM (Diversity) 0%	24,500 CFM
Terminal Box Min Total CFM	6,125 CFM (25%)
General Exhaust Total	6,000 CFM

- Initial Review Concerns:

Initial Review – Mech Scheduled Values

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- Initial Review Concerns:
 - Oversized Return Air Fan

Initial Review – Mech Scheduled Values

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- Initial Review Concerns:
 - Oversized Return Air Fan
 - Minimum Flow of Terminal Boxes may be too low to maintain OA Value

Initial Review – Mech Scheduled Values

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 - Excess Exhaust

Initial Review – Mech Scheduled Values

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- Initial Review Concerns:
 - Oversized Return Air Fan
 - Minimum Flow of Terminal Boxes may be too low to maintain OA Value
 - Excess Exhaust
 - Negative Building

Initial Review – Mech Scheduled Values

Basis of Design – CAV

Max Supply Airflow	35,000 CFM
Minimum Outside Air	10,000 CFM
General Exhaust Total	2,500 CFM

- Initial Review Concerns:
 - Excess Outside Air

Initial Review – Mech Scheduled Values

Basis of Design – CAV

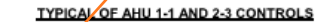
Max Supply Airflow	35,000 CFM
Minimum Outside Air	10,000 CFM
General Exhaust Total	2,500 CFM

- Initial Review Concerns:
 - Excess Outside Air
 - Over-Pressurized Structure

Review Equipment Configuration and Control Components

- Unit Configuration
 - With or Without Return Air Fan
 - Economizer Capabilities
 - Airflow Stations
 - Damper Configuration – Return/Relief/Outside Air
 - Individual Damper Actuators
 - Individual Control Signals

- Unit Configuration
 - Without an integrated return air fan

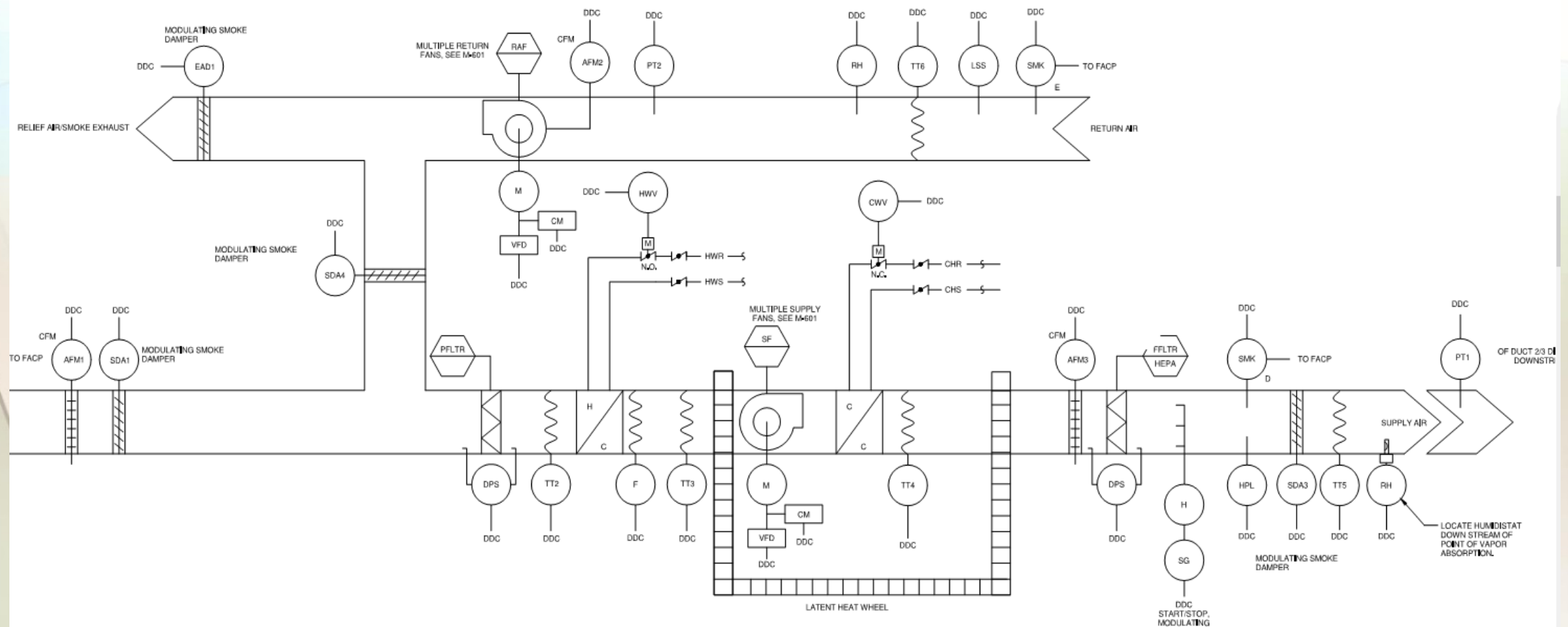


Review Equipment Configuration and Control Components

- Unit Configuration
 - Without a Return Air Fan

Reference	Point Name	AI	AO
AFDP	Air Filter Differential Pressure (Typical of Each - Pre and Final Filters)	X	
BSP	Building Static Pressure	X	
CCV	Cooling Coil Valve		X
CCVF	Cooling Coil Valve Feedback	X	
CFMINT	Airflow Station Integration (For Monitoring Purposes Only)		
CHWENGVLVINT	CHW Energy Valve BACnet Integration		
CO2	Space CO2	X	
DSSP	Downstream Static Pressure (Typical of Each)	X	
FRZ	Freeze Stat Safety (Typical of Each)		
MAT	Mixed Air Temp (Typical of Each)	X	
OACFM	Outside Air CFM	X	
OAD	Outside Air Damper		X
OADF	Outside Air Damper Feedback	X	
PHT	Preheat Temp (Typical of Each)	X	
PHV	Preheating Valve		X
PHVF	Preheating Valve Feedback	X	
RAD	Return Air Damper		X
RADF	Return Air Damper Feedback	X	
RAF	Relief Air Fan Start/Stop		
RAFF	Relief Air Fan VFD Fault		
RAFS	Relief Air Fan VFD Speed Command		X
RAFST	Relief Air Fan Status		

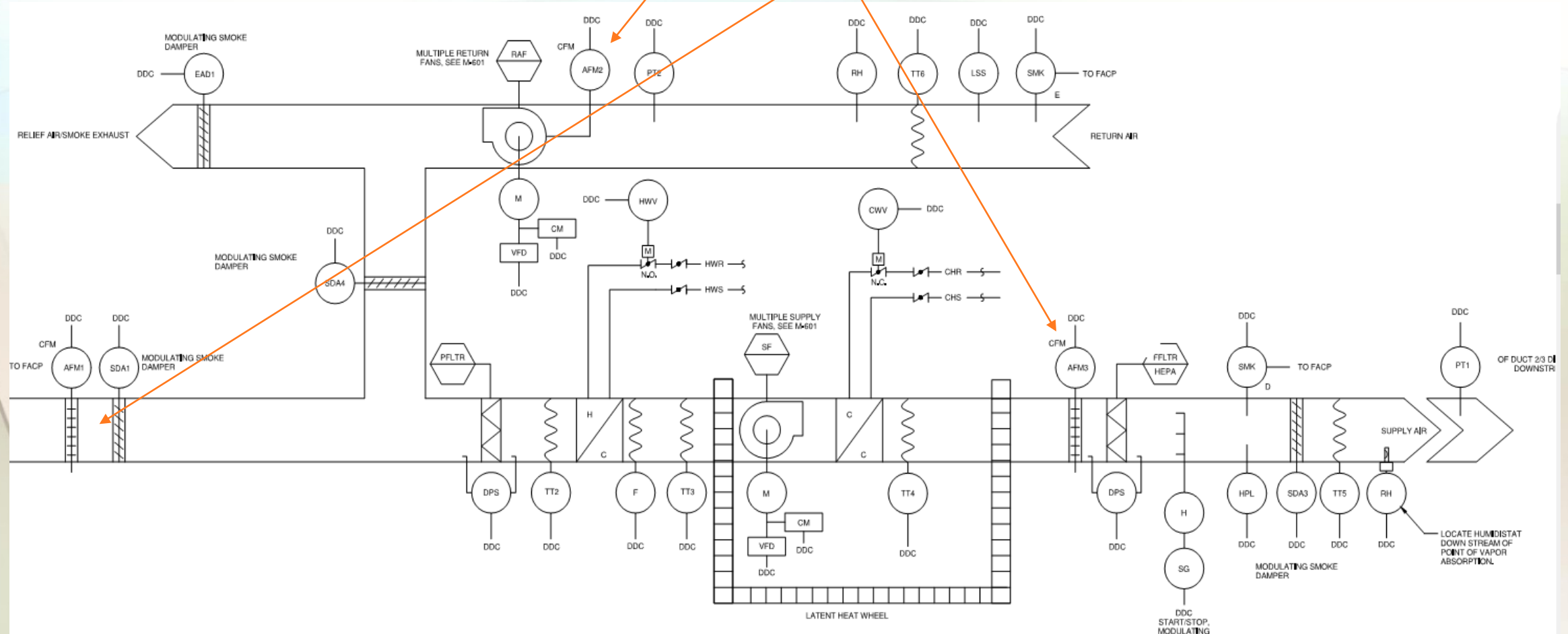
- AHU with return fan configuration



Review Equipment Configuration and Control Components

- AHU with return fan configuration

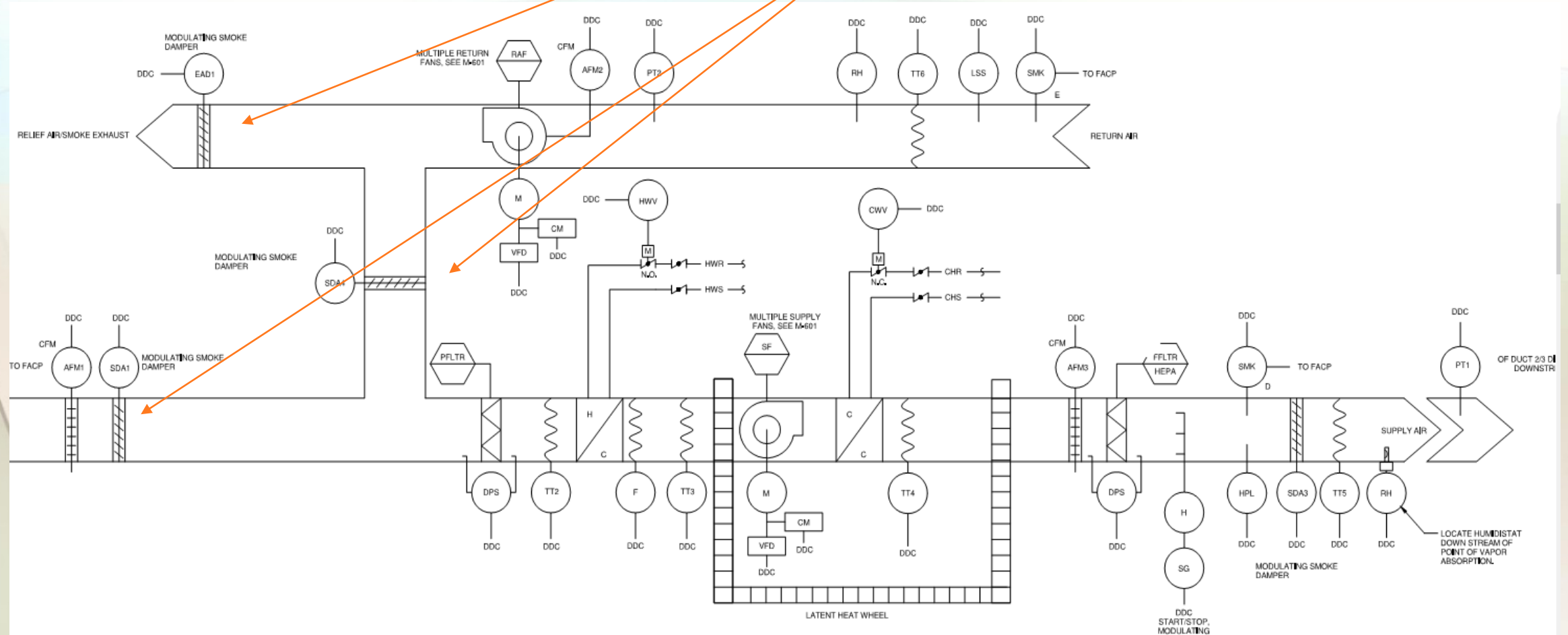
Flow Stations



Review Equipment Configuration and Control Components

- AHU with return fan configuration

Independent Damper Control



Unit Configuration Discussion Points

- Additional Variable Volume Review Points:
 - Mixed Air Static Pressure Monitor
 - Can be used to maintain required outside airflow – less accurate than flow stations & Fan Tracking
 - Location of Manual Dampers in RA & OA
 - If insufficient return air static pressure to induce minimum outside air
 - Used for setting of volumes during maximum airflow verification
 - Unit may not have ventilation capabilities
 - OA duct sizing relative to CFM requirements
 - OA Preheating Coils/Filtration Requirements

Unit Configuration Discussion Points cont.

- Additional Variable Volume Review Points:
 - Ductwork configuration of OA plenum
 - Minimum & Maximum damper sections
 - Flow Station locations to monitor all volumes or only minimum airflow
 - Minimum OA Damper section 2-Position
 - Maximum OA Damper section modulating
 - OA duct sizing relative to CFM requirements
 - Flow Station Capabilities if applicable

Unit Configuration Discussion Points cont.

- Additional ASHRAE Review Points:
 - From ASHRAE 62.1 – 2013
 - 5.3 Ventilation System Controls. Mechanical systems shall include controls in accordance with the following subsections.
 - 5.3.1 All systems shall be provided with manual or automatic controls maintain no less than the outdoor air intake flow (V_{Ot}) required by Section 6 under all of the conditions are dynamic reset conditions.
 - 5.3.2 systems with fans supplying bearable primary air (V_{ps}) including singles on VAV and multiples on recirculating VAV systems, shall be provided with one or more of the following:
 - a. Outdoor air intake, return air dampers, or a combination of the two that modulate(s) to maintain no less than the outdoor air intake flow(V_{Ot})
 - b. Outdoor air injection fans and modulates maintain no less than the outdoor air intake flow (V_{Ot})
 - c. Other means of ensuring compliance with Section 5.3.1

Unit Configuration Discussion Points cont.

- Additional ASHRAE Review Points cont.:
 - From ASHRAE 62.1 – 2013
 - 8. Operations and Maintenance
 - 8.4.1.8 Outdoor Air Flow Verification.
 - The total quantity of outdoor air to air ambulance, except for units under 2000 CFM (1000L/s) a supplier, shall be measured in minimum outdoor air mode once every five years. If measured outdoor airflow rates are less than the minimum rate ($\pm 10\%$ balancing tolerance) documented in the O&M manual, they shall be adjusted or modified to bring them to the minimum designed rate or evaluated to determine if the measured rates are in compliance with the standard.

Field Testing Procedures

- Verification of Outside Airflow from Maximum to Minimum Air handling unit operation:
 - All VAV Terminal TAB activities complete
 - Perform Pitot Tube traverse in the best possible location(s)

Traverse Recommendations

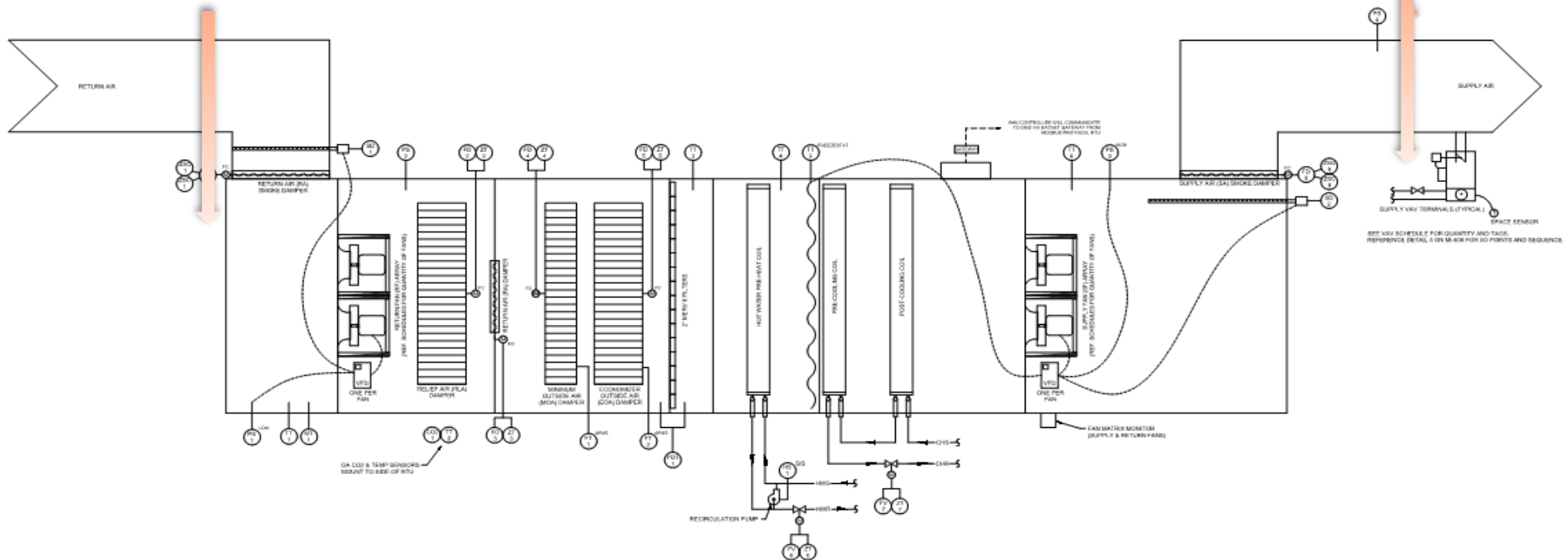
- Duct size shall not change in a traversed section.
- Face the Pitot tube into the airstream and parallel to the ductwork at each measurement point and measure the velocity pressure.
- Convert velocity pressure to FPM (m/s) velocity before averaging if the traverse is performed at other than standard conditions.
- Take traverse measurements at actual conditions and actual cubic feet per minute [ACFM (l/s)]. Correct ACFM (l/s) to standard CFM [SCFM (l/s)] when specified by using the density correction.
- A traverse plane is suitable for flow measurements if more than 75% of the velocity pressure measurements are greater than 1/10 (10%) of the maximum velocity measurement and are not negative.
- The traverse average velocity should be above 1000 FPM to reduce the error of the digital manometer

Field Testing Procedures

- Verification of Outside Airflow from Maximum to Minimum Air handling unit operation:
 - All VAV Terminal TAB activities complete
 - Perform Pitot Tube traverse in the best possible location(s)
 - Verify accuracy of all flow stations
 - Evaluate the data for accuracy
 - All Pitot tube traverses should be
 - You made the attempt when the question(s) are asked

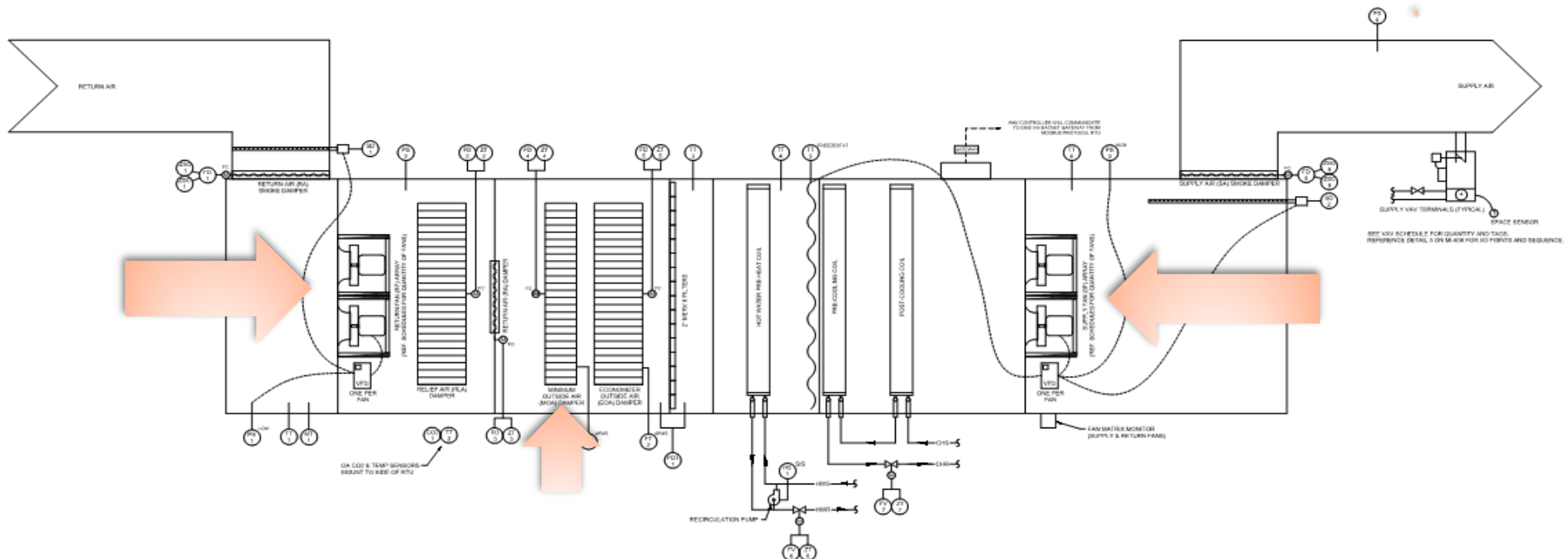
Field Testing Procedures

- Verification of Outside Airflow from Maximum to Minimum Air handling unit operation – Volumetric Tracking
 - All VAV Terminal TAB activities complete – System set to Maximum
 - Perform Pitot Tube traverse in the best possible location(s)



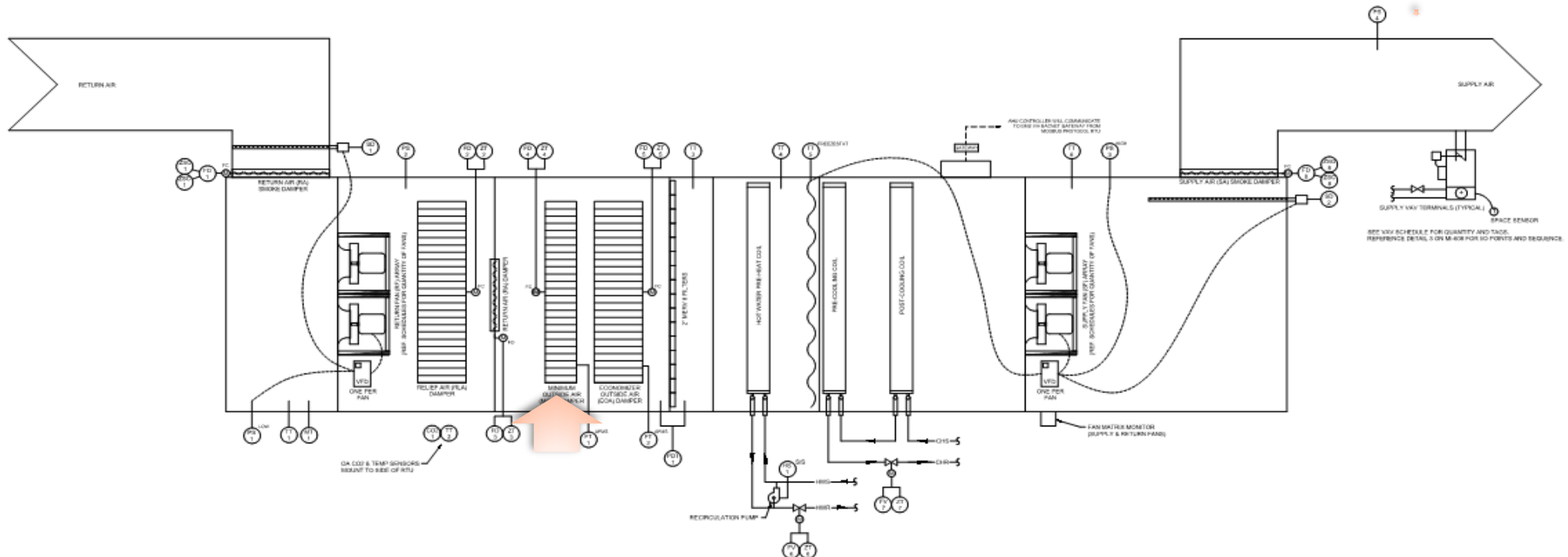
Field Testing Procedures

- Verification of Outside Airflow from Maximum to Minimum Air handling unit operation – Volumetric Tracking
 - After Pitot tube traverse complete
 - Verify Accuracy of all flow stations



Field Testing Procedures

- Verification of Outside Airflow from Maximum to Minimum Air handling unit operation – Volumetric Tracking
 - Calculate outside volume from SA/RA traverses
 - Verify accuracy of OA flow stations if applicable
 - Record & Document all unit operating data



Field Testing Procedures

- Set **50% of terminal boxes to MINIMUM airflow** – monitor the following:
 - Supply Air static pressure & Airflow – continues to match box totals

Field Testing Procedures

- Set 50% of terminal boxes to MINIMUM airflow – monitor the following:
 - Supply Air static pressure & Airflow – continues to match box totals
 - Return Air Volume has reduced to maintain MIN OA

Field Testing Procedures

- Set 50% of terminal boxes to MINIMUM airflow – monitor the following:
 - Supply Air static pressure & Airflow – continues to match box totals
 - Return Air Volume has reduced to maintain MIN OA
 - Calculated (or Flow Station) Outside Air Volume remains +/-10%

Field Testing Procedures

- Set 50% of terminal boxes to MINIMUM airflow – monitor the following:
 - Supply Air static pressure & Airflow – continues to match box totals
 - Return Air Volume has reduced to maintain MIN OA
 - Calculated (or Flow Station) Outside Air Volume remains +/-10%
 - Relative Fan Speeds

Field Testing Procedures

- Set 50% of terminal boxes to MINIMUM airflow – monitor the following:
 - Supply Air static pressure & Airflow – continues to match box totals
 - Return Air Volume has reduced to maintain MIN OA
 - Calculated (or Flow Station) Outside Air Volume remains +/-10%
 - Relative Fan Speeds
 - Fan Operating Conditions

Field Testing Procedures

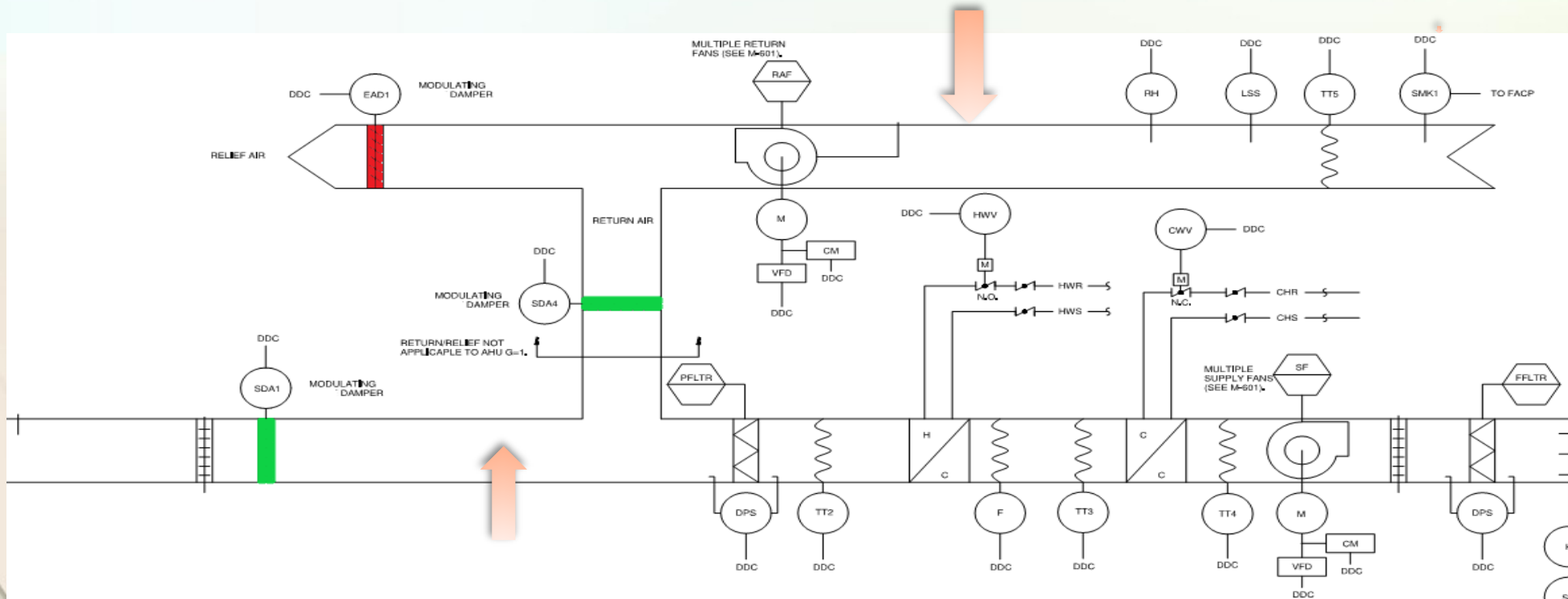
- Set **100% of terminal boxes to MINIMUM airflow** – and continue to monitor all of the following:
 - Supply Air static pressure & Airflow – continues to match box totals
 - Return Air Volume has reduced to maintain MIN OA
 - Calculated (or Flow Station) Outside Air Volume remains +/-10%
 - Relative Fan Speeds
 - Fan Operating Conditions

Field Testing Procedures

- With 100% of terminal boxes set to MINIMUM airflow:
 - Has Return Air fan reduced to minimum VFD speeds
 - Is Outside Air BELOW design CFM
 - Return Air dampers modulate closed?
 - Relief Air dampers remain closed?
 - Is there any noticeable supply/return fan surging or pulsations?
 - Is the supply air static pressure set point reset during this process?
 - Is the accuracy of ALL fan airflow stations maintained?
 - Remain within range?

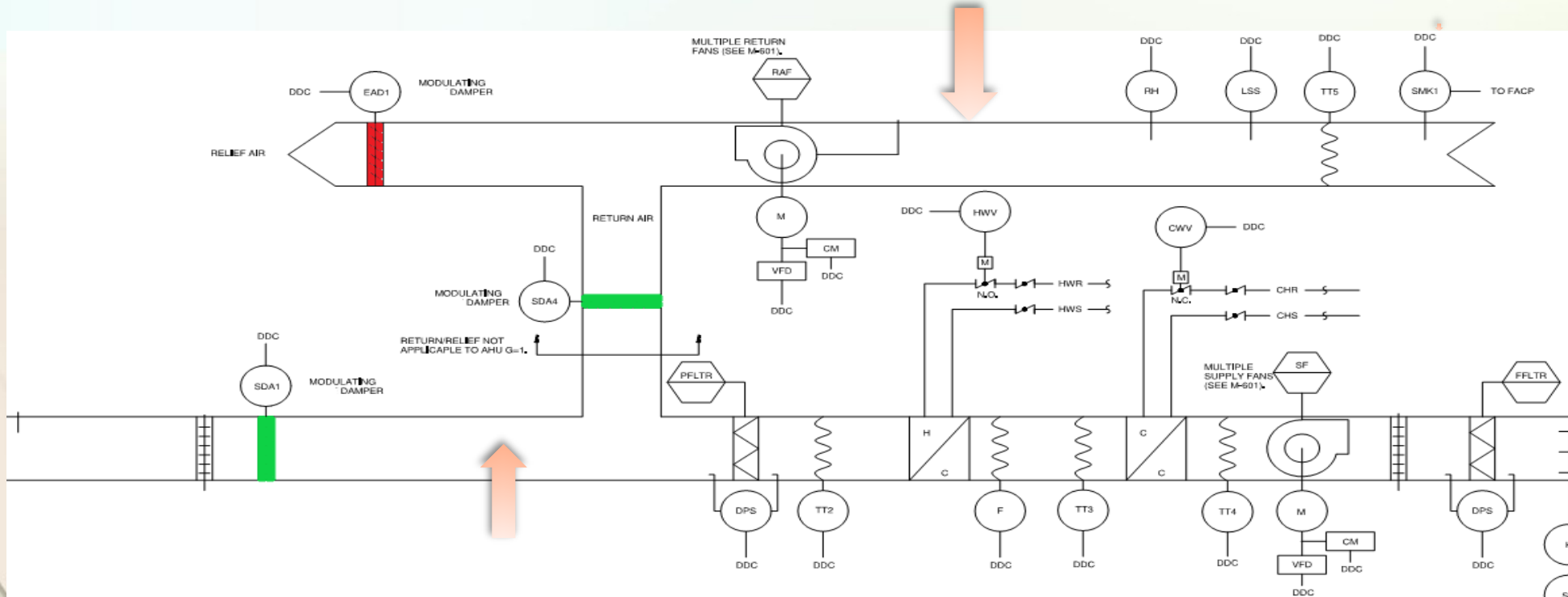
Field Testing Procedures

- Verification of Outside Airflow from Maximum to Minimum Air handling unit operation – **Plenum Pressurization Tracking**
 - All VAV Terminal TAB activities complete – System set to Maximum
 - Perform Pitot Tube traverse in the best possible location(s)



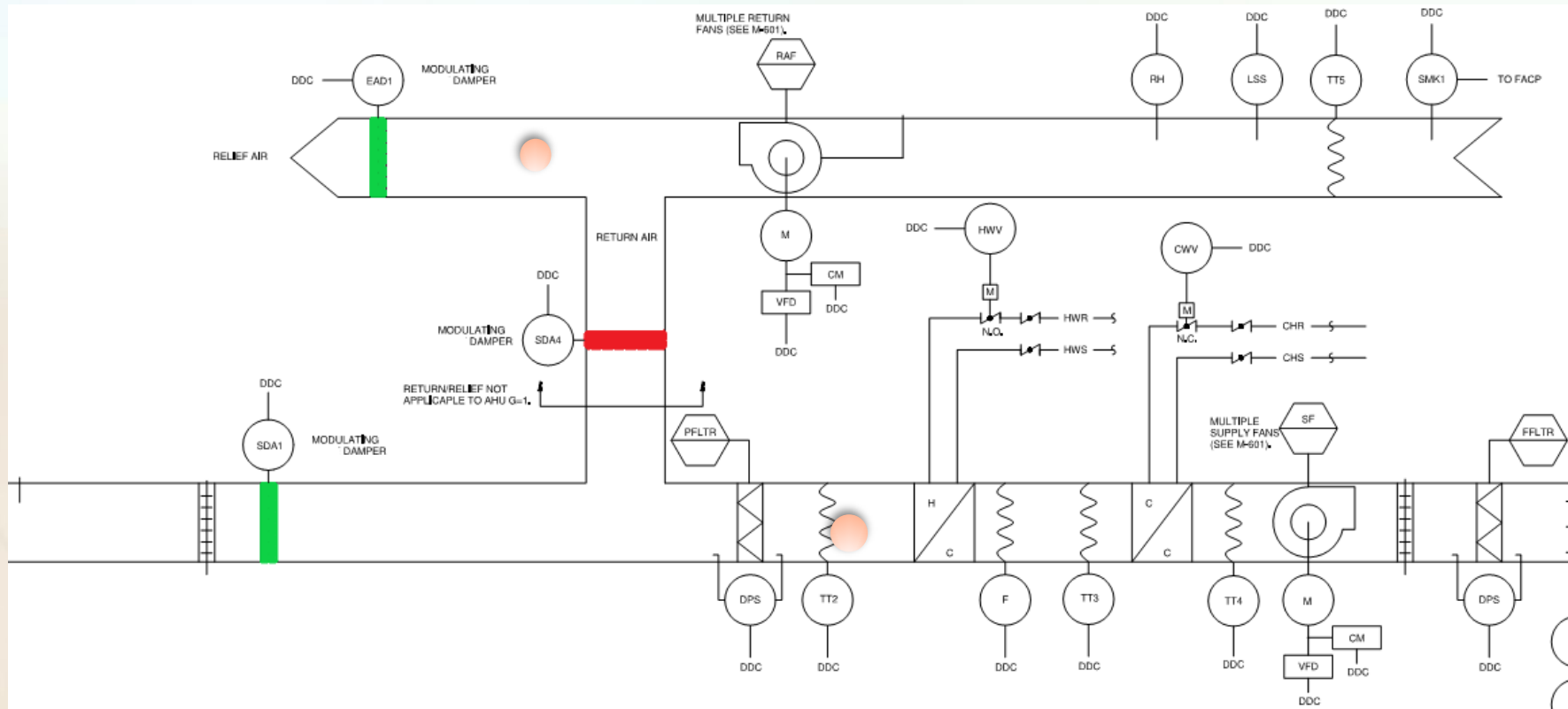
Field Testing Procedures

- Verification of Outside Airflow from Maximum to Minimum Air handling unit operation – Plenum Pressurization Tracking
 - **NO** flow stations for airflow verification
 - Manipulate system to full economizer – 100% OA



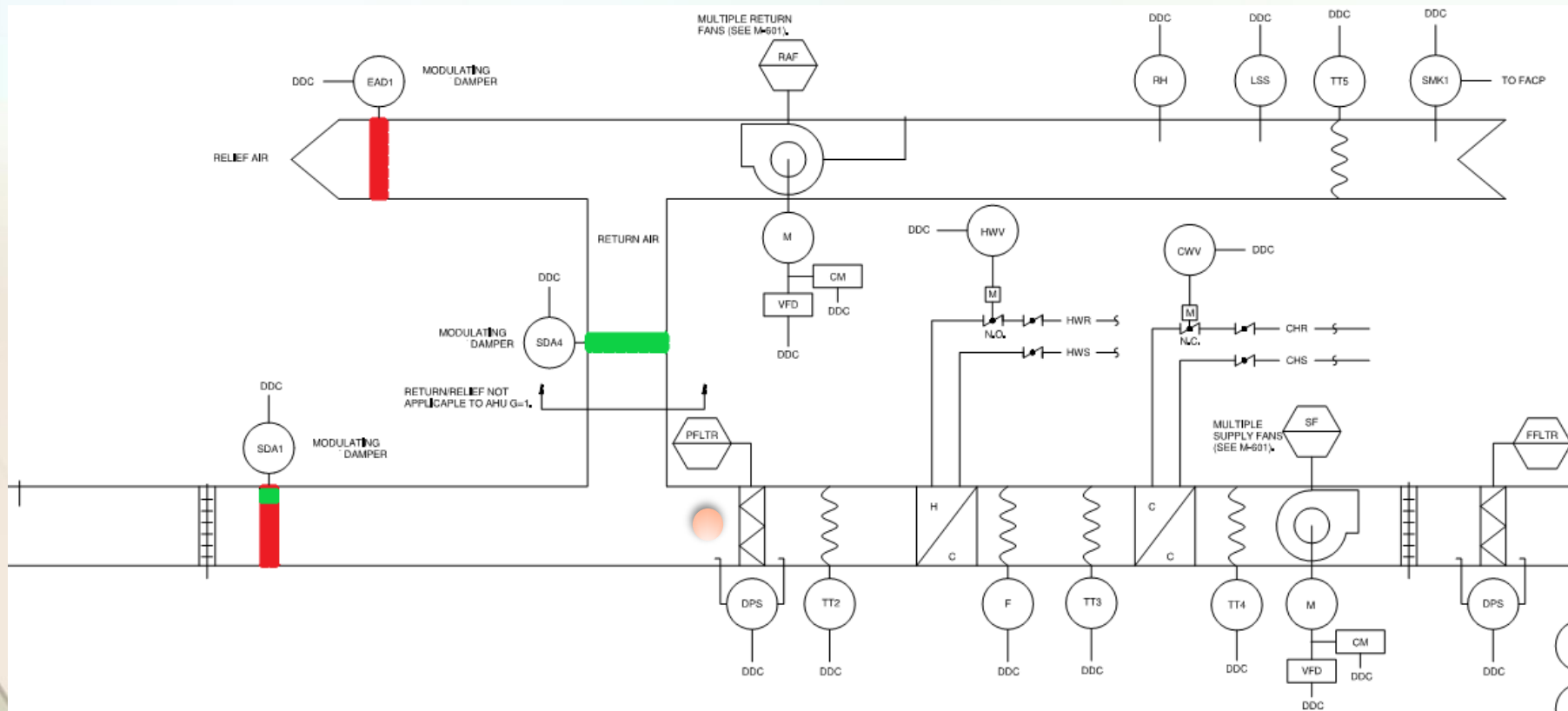
Field Testing Procedures

- Verification of Outside Airflow from Maximum to Minimum Air handling unit operation – Plenum Pressurization Tracking
 - Re-verify actual airflow under this configuration
 - Relief/Return Air/OA controlled by static pressure points



Field Testing Procedures

- Verification of Outside Airflow from Maximum to Minimum Air handling unit operation – Plenum Pressurization Tracking
 - Set system to MINIMUM OA
 - Reset Return Air/OA to control similar static pressure point



Field Testing Procedures

- Set 50% of terminal boxes to minimum airflow – monitor the following:
 - Supply Air static pressure & Airflow – continues to match box totals
 - Mixed Air Static Pressure +/- 10% of economizer & MIN OA settings
 - Calculate Outside Air Volume based on static pressure results
 - Monitor Fan Speeds and damper positioning
 - Adjust damper lead/lag positioning to obtain expected results

Field Testing Procedures

- Verification of Building Pressure from MAXIMUM to MINIMUM
Supply Airflow Testing
 - This activity must be performed concurrently with the OA flow verification during ALL unit configurations
 - Use of a Separate field instrument
 - Permanently installed building pressure device
 - Evaluate steady operation/location of device and reference location
 - Confirm if this should be a controlling point of only a monitor point

Summary Field Testing Procedures

- The best option is to have flow stations part of the initial design.
- IF THEY ARE NOT - Suggest to the design team to include them for the following reasons:
 - OA tracking more accurate
 - Relative low cost considering the life of the building
 - The SA/RA/OA flows can be logged & documented
 - If there are air quality issues in the future due to system manipulation
 - During building flush procedures, if applicable

Questions / Conclusion

- Design Review
 - Extremely Important to the suggest of the HVAC operation
- The location of the flow stations
 - Fan inlets
 - Duct Mounted
 - Operating Ranges
- The unit configurations and how that may affect the final data
 - With or Without a Return Fan
- Testing Procedures
 - Extremely Important to perform tracing procedures from MAX to MIN with DOCUMENTATION

Thank You

