

2025

SMACNA ANNUAL CONVENTION

Maui, Hawaii

OCTOBER 26-29



Test and Balance Friend or Foe

Presented By: Doug Ratley

The contents of this message is a representation of real life situations and could be a result of your design or installation.
It might even be your facility.

Certifications

- TABB Certified Test and Balance Technician
- TABB Certified Test and Balance Supervisor
- TABB Certified Life Safety Technician (Levels 1 and 2)
- TABB Certified Life Safety Supervisor (Levels 1 and 2)
- TABB Certified HVAC Fire Life Safety Contractor (Level 1)
- TABB Certified Commissioning Agent
- TABB Certified Air Quality Technician
- TABB Certified Air Quality Supervisor
- TABB Certified Total Building Energy Audit Technician
- TABB Certified Fume Hood Performance Testing Technician
- UE Certified Level 1 Sound & Vibration Testing
- Level One Certified Infrared Thermographer
- Advanced Certification for Bio-Safety Cabinets (Eagleson Institute)
- NSF International Biohazard Cabinet Field Certified Accreditation Program
- NAFA (National Air Filtration Association) Certified Technician

Survey - Who is Present?

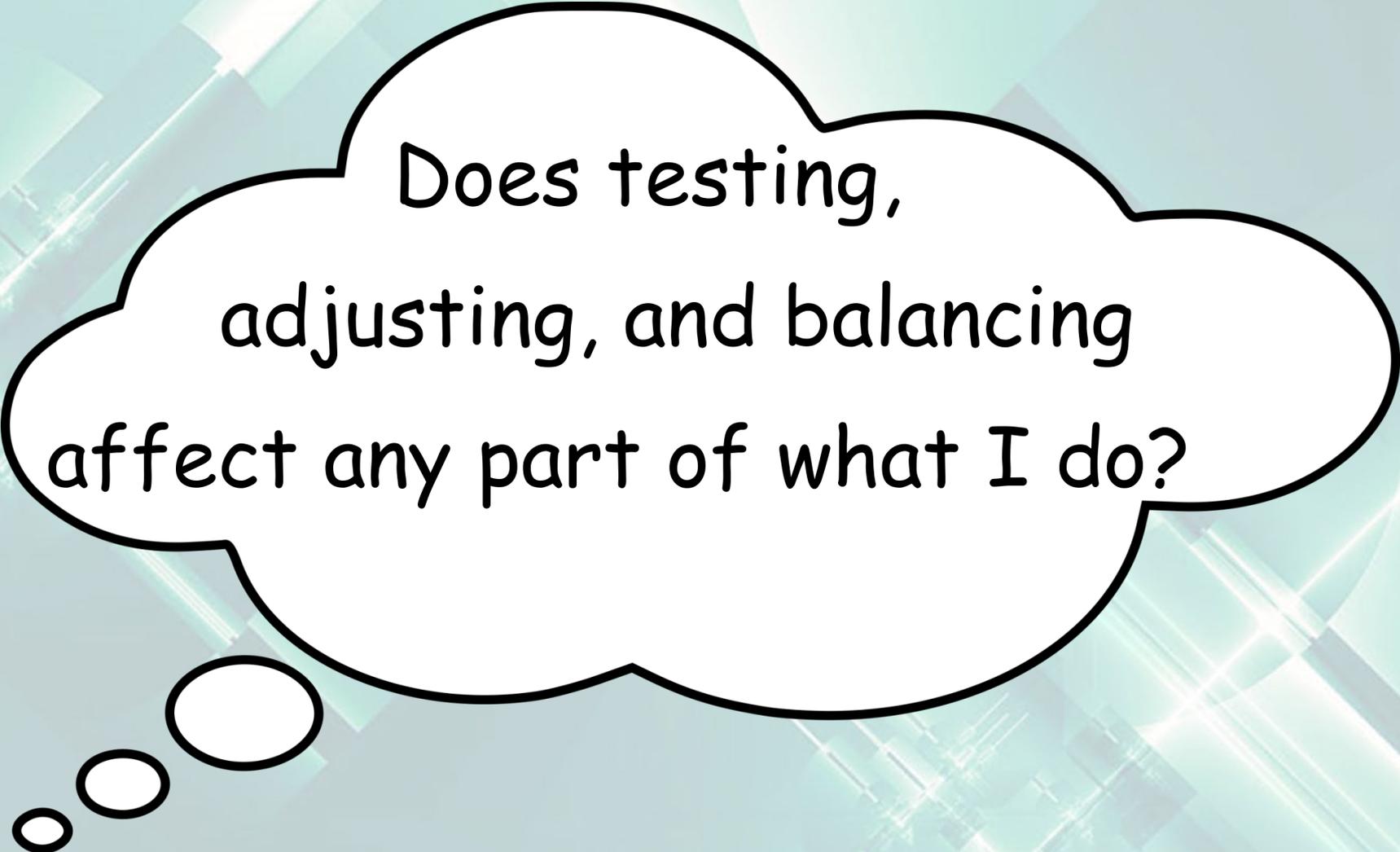
- Architect
- Engineer
- Mechanical Contractor
- Sheet Metal Contractor
- Test & Balance Contractor
- Others

Presentation Goals

1. What *is* testing, adjusting, and balancing (TAB)?
2. What are the benefits of TAB?
3. How is TAB performed?
4. What other functions can TAB perform?
5. Test and Balance - Friend or Foe?



Question



Does testing,
adjusting, and balancing
affect any part of what I do?

What is your favorite type of music?



HVAC Equipment And Musical Instruments



Question - Music or Noise?

What happens when one or more of the instruments are not tuned properly?

Noise

What happens when instruments do not play together, maybe the wrong key or a different tempo?

Noise

HVAC Instruments

Air Handling Units (AHUs), Roof-top Units (RTUs), Dedicated Outdoor Air Units (DOAUs), Make-up Air Units (MUAs), Heat Recovery Units (HRUs)



Air Handling Unit (AHU): Typically Serve Entire Floors Or Multiple Floors Of A Building



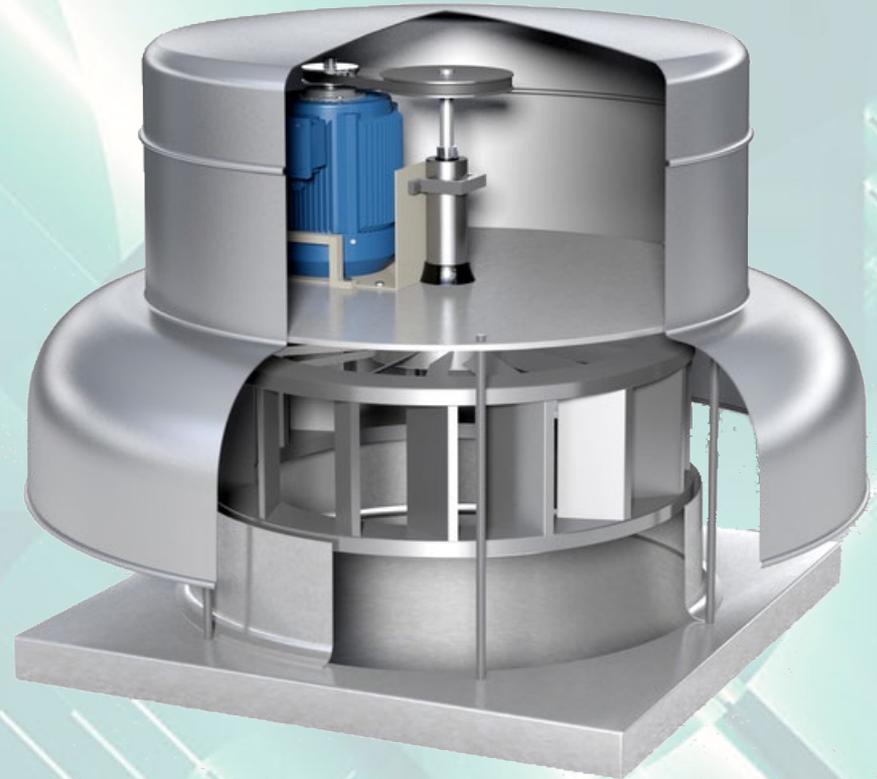
Roof-Top Unit (RTU): Used To Move Air Into And Around The Space

HVAC Instruments

Exhaust Fans (EFs), Exhaust Recovery Units (ERUs)



Exhaust Fans: Used To Remove Air From The Building Or Space



Exhaust Fan Cutaway

HVAC Instruments

Variable Terminal Units (VAVs), Constant Volume Terminal Units (CAVs), Fan Terminal Units (FTUs), Venturi Valves (VVs)



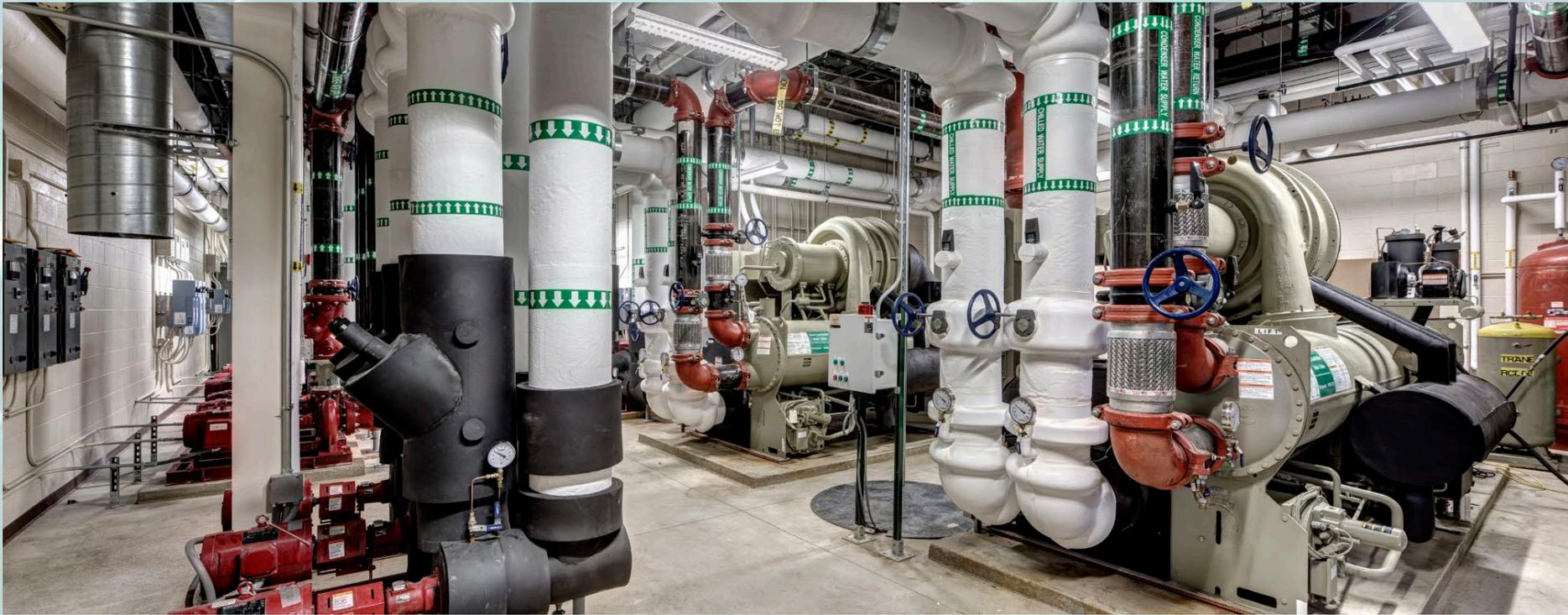
Variable Terminal Unit: Typically Above Ceiling; Used To Control Airflow & Temperature Of Space



Venturi Valve: Typically Above Ceiling; Used For Precise Measurement And Control Of Airflow

HVAC Instruments

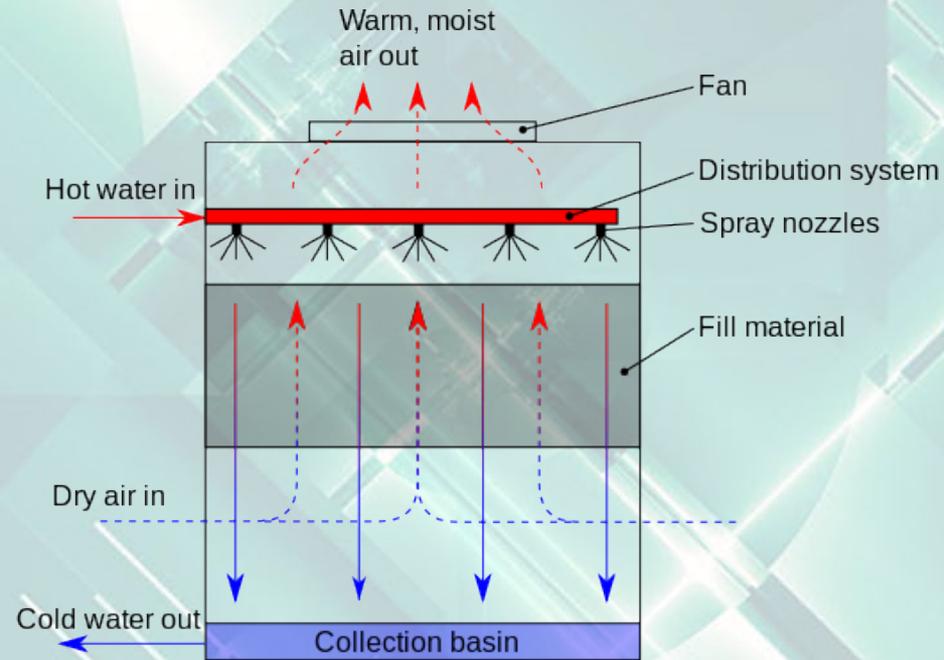
Pumps & Chillers



Supply The Chilled Water To The Other Equipment For Cooling The Entire Building Or Complex

HVAC Instruments

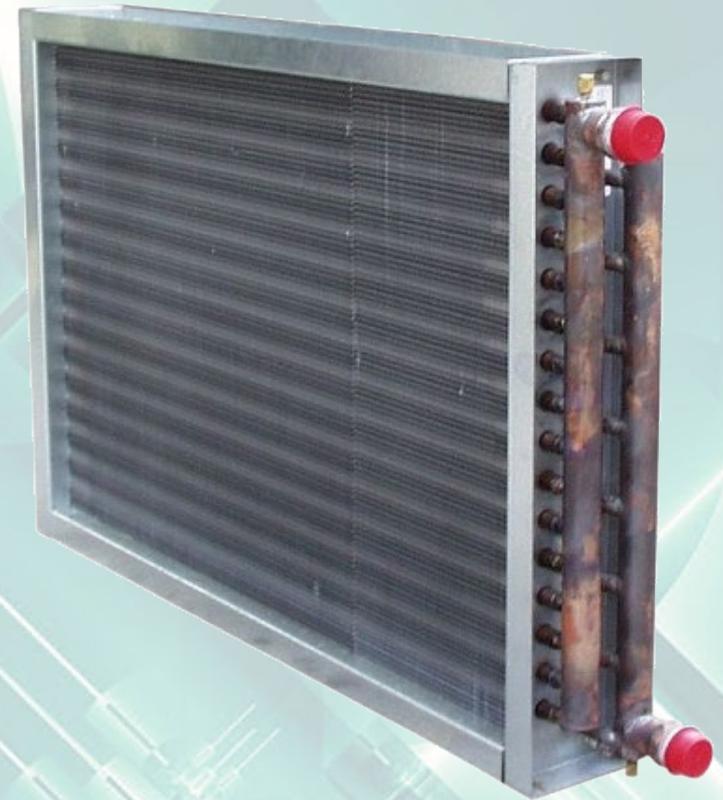
Cooling Towers



Used To Eject Heat From Chilled Water System To Atmosphere

HVAC Instruments

Pumps, Boilers, and Heating Water Coils



The Boiler Provides Heating Water or Steam to Other Equipment Such as Coils to Produce Heat for the Interior and/or Exterior of a Building or Entire Campus

What is Testing, Adjusting, and Balancing (TAB)?

Definition per the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

“Testing, adjusting, and balancing is the process of checking and adjusting all environmental systems in a building to produce the design objectives.”

What is Testing, Adjusting, and Balancing (TAB)?

- Environmental systems include the building heating, ventilating, and air conditioning (HVAC); all are used to intelligently move air and water throughout the building.
- TAB personnel accurately measure airflow, water flow, pressure, temperature, humidity, and more.
- Using these measurements, TAB personnel adjust HVAC system performance to improve efficiency and comfort.

TAB Certification Bureaus



TESTING, ADJUSTING AND BALANCING BUREAU
THE PROFESSIONAL'S CHOICESM



National Environmental Balancing Bureau

SMACNA



AABC

Associated Air Balancing Council

What TAB is not.

- Mechanical Systems Commissioning
- Project Quality Control



Question

- Who are the critical players for TAB?
- What is the role of each with respect to TAB?

Owner

- Communicate the requirements to the design team so they can develop a well-defined scope for the project.
- Hold the project team accountable.

Owner

"THE LOWEST BIDDER"

John Ruskin 1819 - 1900
Author/Economist

It's unwise to pay too much, but it's worse to pay too little. When you pay too much, you lose a little money, that is all. When you pay too little, you sometimes lose everything, because the thing you bought was incapable of doing the job it was bought to do. The common law of business balance prohibits paying a little and getting a lot - it can't be done. If you deal with the lowest bidder, it is well to add something for the risk you run, and, if you do that, you will have enough to pay for something better. Building Owners should use prudence when obtaining bids and making the final selection. They should ensure that all contractors are bidding the same quality and are legitimate business concerns. Good plans and specifications ensure this.



PARADE MAGAZINE • JANUARY 10, 1988 • PAGE 13

Architect

- Provide ample space for the installation of the mechanical equipment and service.
- Separate noise/vibration generating spaces from sensitive spaces.
- Design sealed room envelopes for critical room pressure relationships.

Mechanical Engineer

- Develop written project specifications.
- Create comprehensive drawings with a control strategy and well-defined sequence of operation.
- *There is no substitute for a well written specification and set of drawings.*

TAB Specifications

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING

The Construction Manager shall obtain the services of an independent firm to perform the HVAC system testing and balancing. The testing and balancing firm shall be a certified member of the Associated Air Balancing Council (AABC) and all work shall be done in accordance with AABC standards. The Heating Contractor shall assist Balancing Contractor and shall schedule this contractor's work, notifying the Owner when this has been done.

The plans and specifications shall be reviewed during the Bidding period for location of balancing devices, and if required, for proper balancing, recommend to the engineer additional devices and location of said balancing devices. This review and recommendation must take place at least one (1) weeks before bids are due. If the balancing contractor does not perform review before bidding, no consideration shall be given for additional compensation for additional balancing devices.

The TAB Firm shall visit the project site during construction and prior to Testing and Balancing to observe construction and to verify that balancing devices are being installed in proper locations, that ductwork and piping is being installed in a manner that provides proper flow, and that equipment is being installed properly.

The purpose of the site visit is to make sure that the mechanical systems, ductwork, piping and all related balancing devices are being installed properly. All systems must be observed and reported prior to finish ceiling installation.

After each site visit, the TAB Firm shall prepare a field observation report which shall indicate percentages of work installed and any discrepancies in the installation of the systems relating to Testing and Balancing. Each report shall indicate: percentage of construction completed, which mechanical systems are being installed, which balancing devices are being installed and location of devices, that ductwork and piping fittings are proper and proper flow, etc., and in accordance with Project Design Document. Report shall be sent to the engineer for distribution.

The Heating Contractor shall assist the test and balance firm as follows:

1. Provide the test and balance firm with one copy of the HVAC plans, specifications, addendum and approved equipment submittals.
2. Install all balancing devices in a manner that will leave them accessible and readily adjustable.
3. Field leak testing of Air Handling Units.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section. The Testing, Adjusting, and Balancing Contractor shall be a prime contractor to the Project Construction Manager.
- B. Related Sections

1. General requirements for testing agencies are specified in the Division 01 Section Quality Control Services.
2. Other Division 23 Sections specify balancing devices and their installation, and materials and installations of mechanical systems.
3. Division 23 Section "Duct Accessories".

1.2 SUMMARY

- A. The Section specifies the requirements and procedures total mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.
- B. Test, adjust, and balance the following mechanical systems:
 1. Air handling unit and related supply, return, exhaust, outdoor air duct systems in their entirety.
 2. Exhaust fans and related duct systems in their entirety.
 3. Any other Mechanical item indicated on the plans and schedules not identified herein that has ductwork or piping connected to it.
 4. Field leak testing of HEPA filter housings.
- C. This Section does not include:
 1. Testing pressure vessels for compliance with safety codes;
 2. Specifications for materials for patching mechanical systems;
 3. Specifications for materials and installation of adjusting and balancing devices. If devices must be added to achieve proper adjusting and balancing, refer to the respective system sections for materials and installation requirements.
 4. Requirements and procedures for piping and ductwork systems leakage tests.

1.3 DEFINITIONS

- A. Systems testing, adjusting, and balancing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes:
 1. The balance of air and water distribution;
 2. Adjustment of total system to provide design quantities;
 3. Electrical measurement;
 4. Verification of performance of all equipment and automatic controls;
 5. Sound and vibration measurement.
 6. The balance of steam and condensate distribution.
 7. Building temperature control system.
- B. Test: To determine quantitative performance of equipment.
- C. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, throttling).

Construction Project Manager or General Contractor

- Provide sufficient time for the TAB work to be performed
 - Before the equipment / furniture is installed
- Seal the room envelopes properly for critical room pressure relationships
- Scheduling of tasks
 - i.e. - carpet is being installed or floors waxed

Mechanical Contractor

- Install the equipment so that it is accessible.
- Ensure all equipment is started and fully operational.
- Make sure heating/chilled water system are free of air.

Sheet Metal Contractor

- Install the equipment so that it is accessible.
- Open and lock all manual dampers fully open.
- Verify motorized dampers have a full range of motion.

Plumbing Contractor

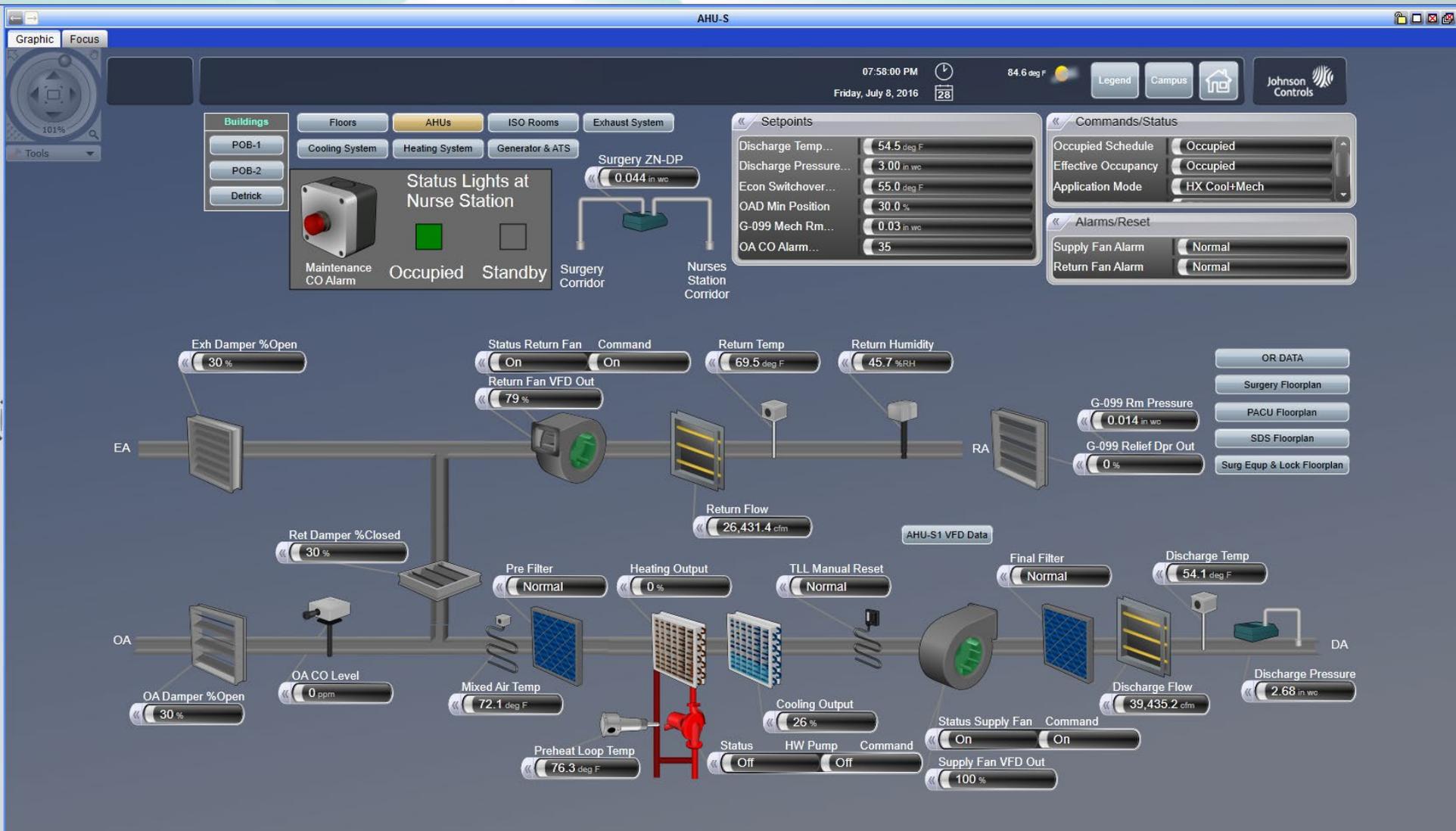
- Install the equipment so that it is accessible.
- Verify domestic hot water system is operational.

Electrical Contractor

- Verify equipment is rotating correctly.
 - Some types of fans will discharge air the correct way when it is rotating backwards, but only about $\frac{1}{2}$ the volume expected.

Controls Contractor

- Verify hardware and software is fully installed and operational.
- Provide TAB with access to controls and make changes to the system as needed.



Example: Air Handling Unit Viewed Through The Building Automation System (BAS)

Who are the critical players for TAB and what is the role of each?

- **Owner**

- Communicate the requirements to the design team so they can develop a well-defined scope for the project.
- Hold the project team accountable.

- **Architect**

- Provide ample space for the installation of the mechanical equipment and service.
- Separate noise/vibration generating spaces from sensitive spaces.
- Design sealed room envelopes for critical room pressure relationships.

- **Engineer**

- Develop written project specifications.
- Create comprehensive drawings with a control strategy and well-defined sequence of operation.
- There is no substitute for a well written specification and set of drawings.

- **Project Manager/General Contractor**

- Provide sufficient time for the TAB work to be performed before the equipment / furniture is installed (not when the floors are finished or carpet is installed)
- Seal the room envelopes properly for critical room pressure relationships
- Scheduling of tasks

- **Mechanical Contractor**

- Install the equipment so that it is accessible.
- Ensure all equipment is started and fully operational.

- **Sheet Metal Contractor**

- Install the equipment so that it is accessible.
- Open and lock all manual dampers fully open.

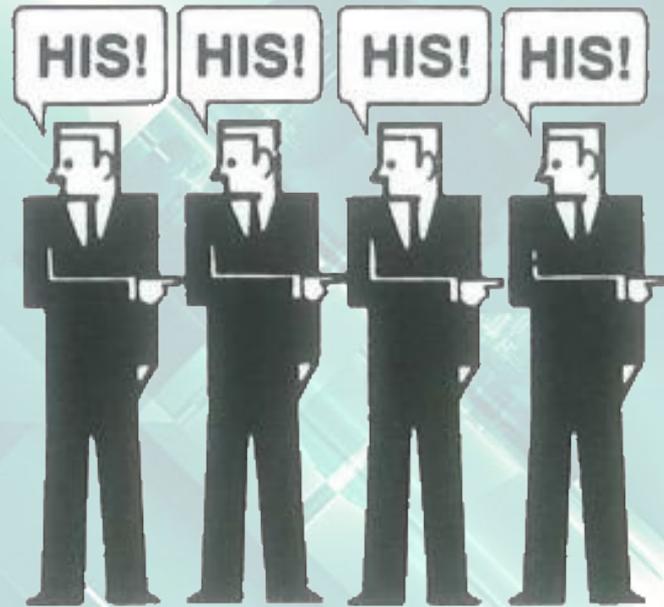
- **Electrical Contractor**

- Verify equipment is rotating correctly.

- **Control Contractor**

- Verify hardware and software is fully installed and operational.
- Set TAB up to access controls and make changes to the system as needed.

WHO'S FAULT?



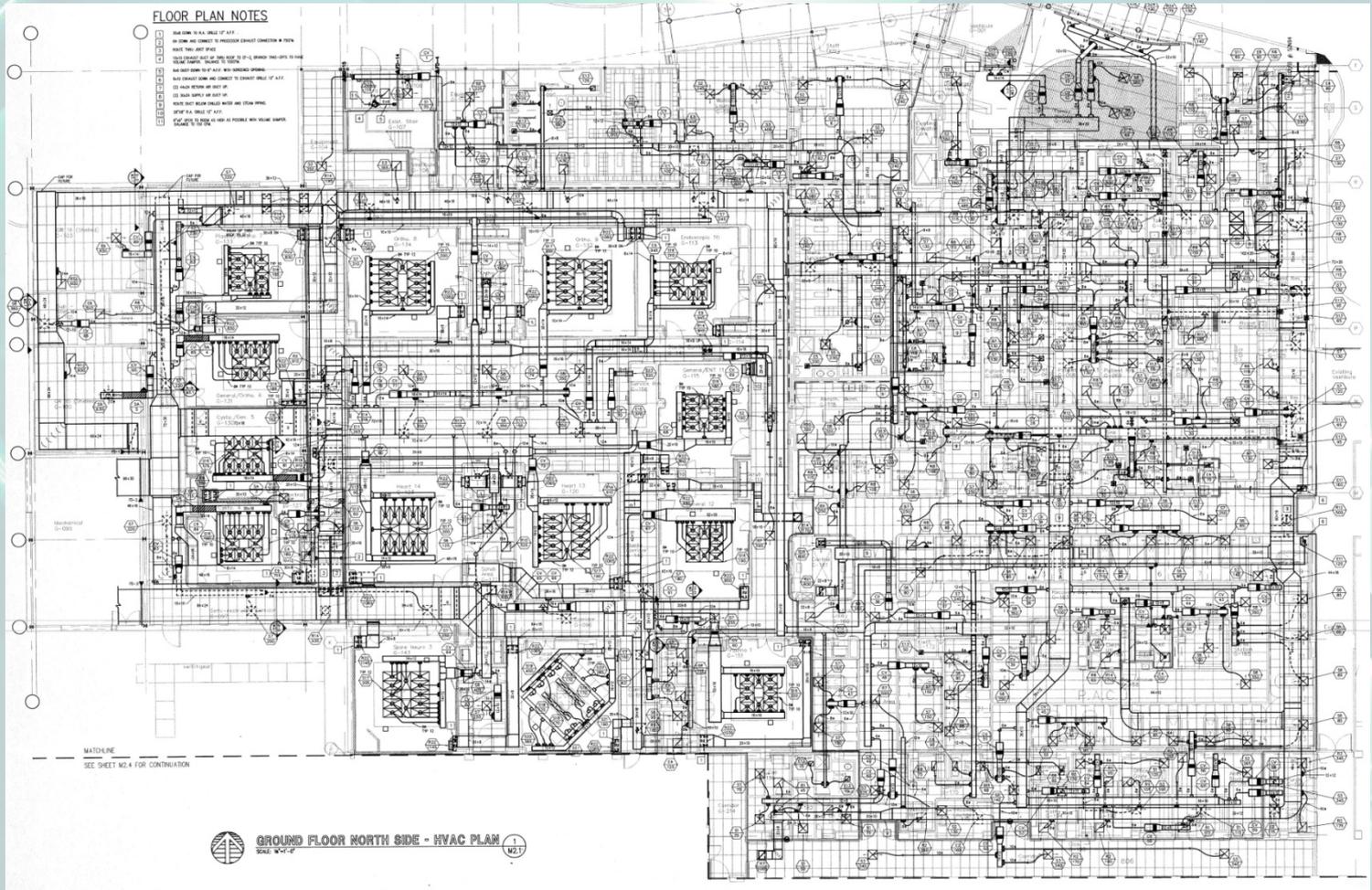
What is the TAB process?

- Is the project reusing existing equipment *or* will it be new?
- For a project that is a renovation or that may reuse existing equipment a survey of the existing systems should be performed early in the design phase of the project.
- Surveys provide the project engineer with accurate information of how the equipment is currently performing compared to the requirements of the new design.
- As equipment ages, intentional and unintentional changes occur which affect system performance:
 - The system may be found to be operating above or below the original design parameters.
 - Renovations or remodels can create changes this is especially true for partial renovations.
 - Controls may not be operating correctly.
 - Lack of funds for proper maintenance.

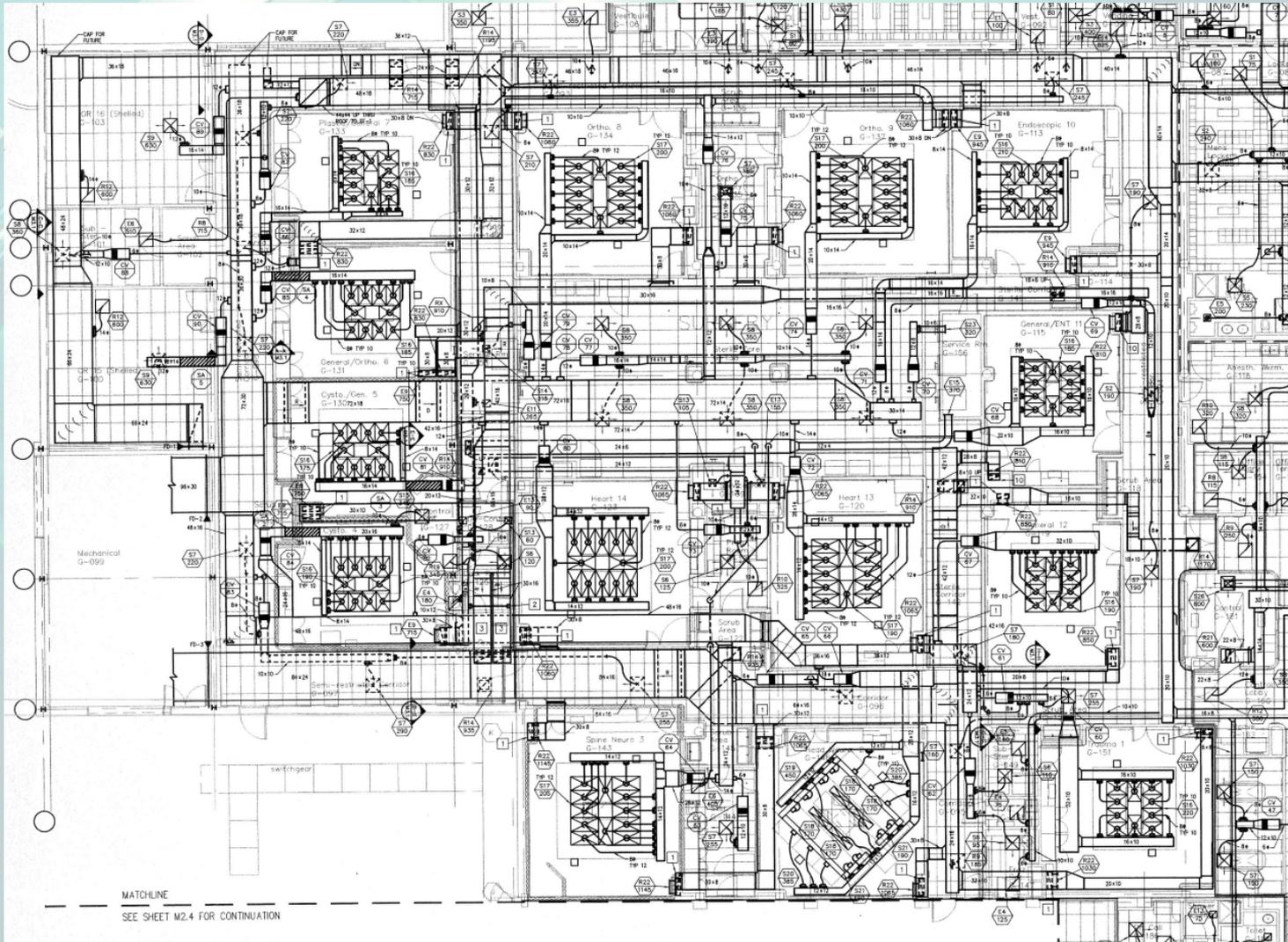
What is the TAB process?

Project Setup and Evaluation

1. Review project design drawings and specifications.

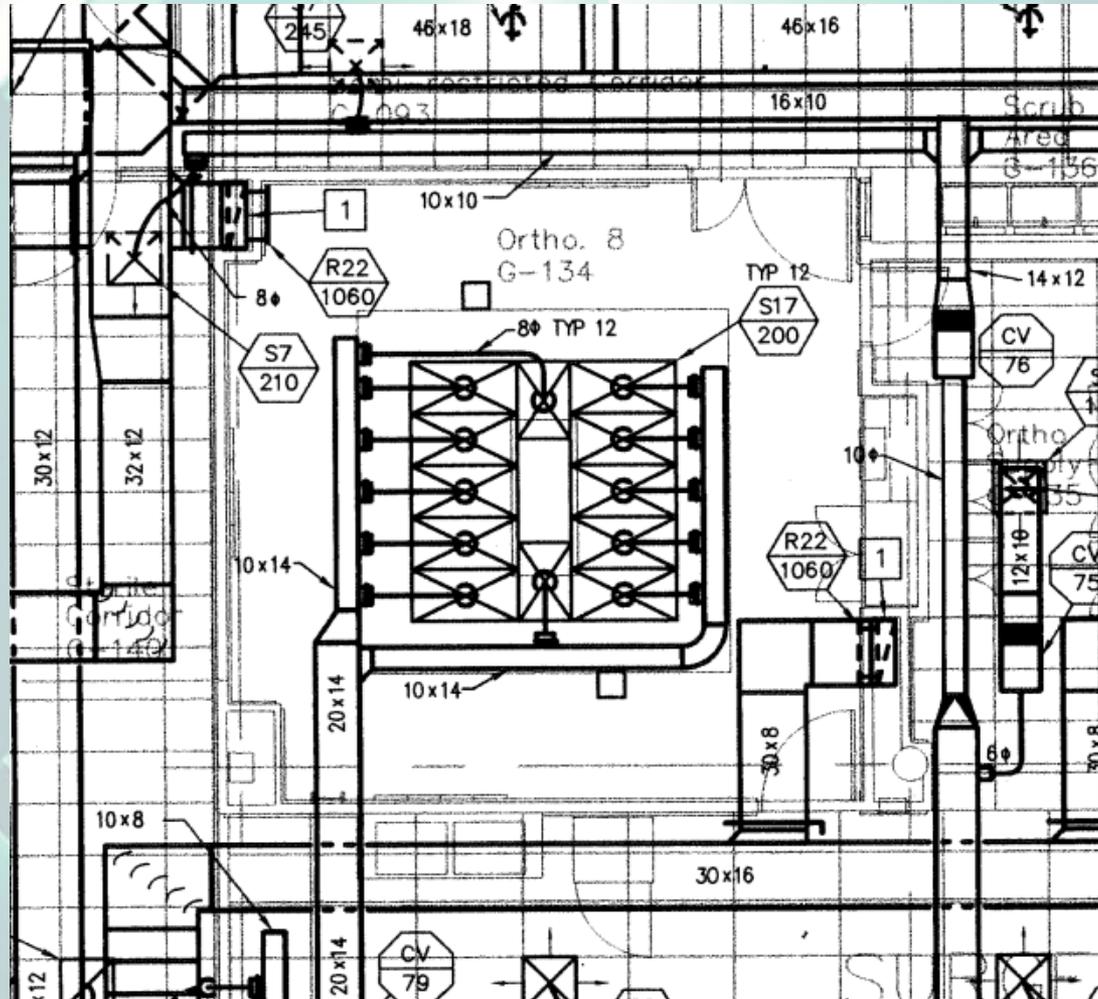


Documentation Used To Setup TAB Procedures



Example: Project Drawings for Surgery Area

Documentation Used To Setup TAB Procedures

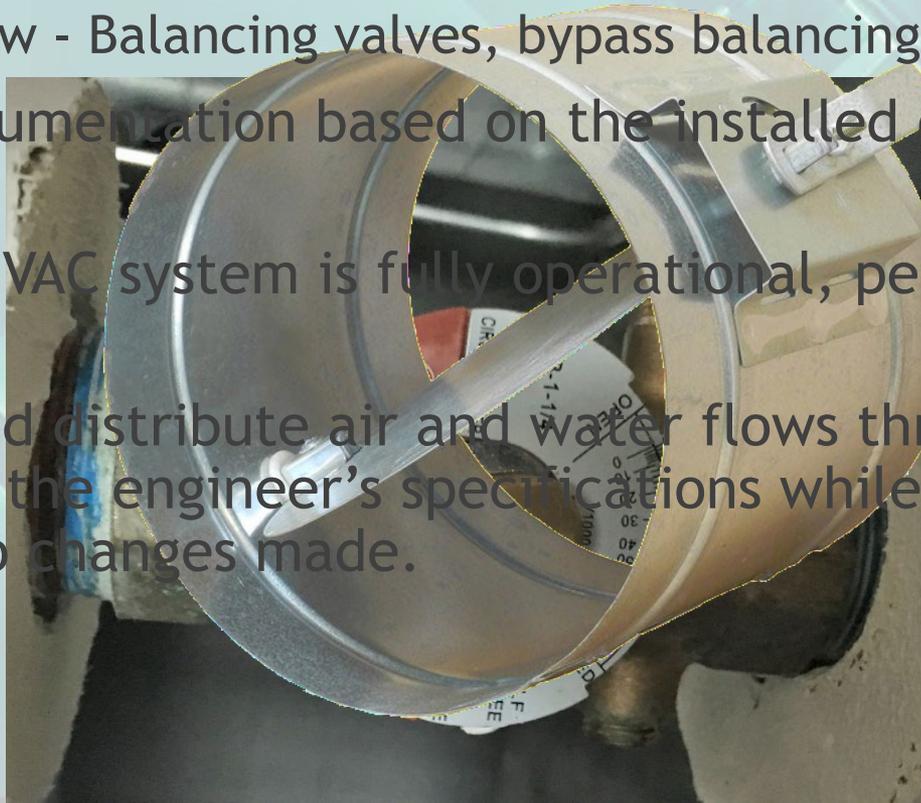


Example: Project Drawings for Surgery Suite

What is the TAB process?

Project Setup and Evaluation

1. Review project design drawings and specifications.
2. Determine if any TAB related system components have been overlooked, such as the lack of or incorrect location for:
 - a) Airflow - Manual volume dampers; branch or otherwise.
 - b) Waterflow - Balancing valves, bypass balancing valves
3. Create documentation based on the installed or modified systems.
4. After the HVAC system is fully operational, perform an on-site evaluation.
5. Measure and distribute air and water flows throughout the building to the engineer's specifications while evaluating system response to changes made.



Tools Used To Measure HVAC Systems



Flow Hood: Used To Measure Airflow



Data Meter: Used To Measure Airflow, Pressures, And Temperatures

Tab Report

HYDRONIC TEST

PROJECT DESCRIPTION
CAMPUS / BUILDING / FLOOR
SYSTEM / LOCATION
TESTED BY

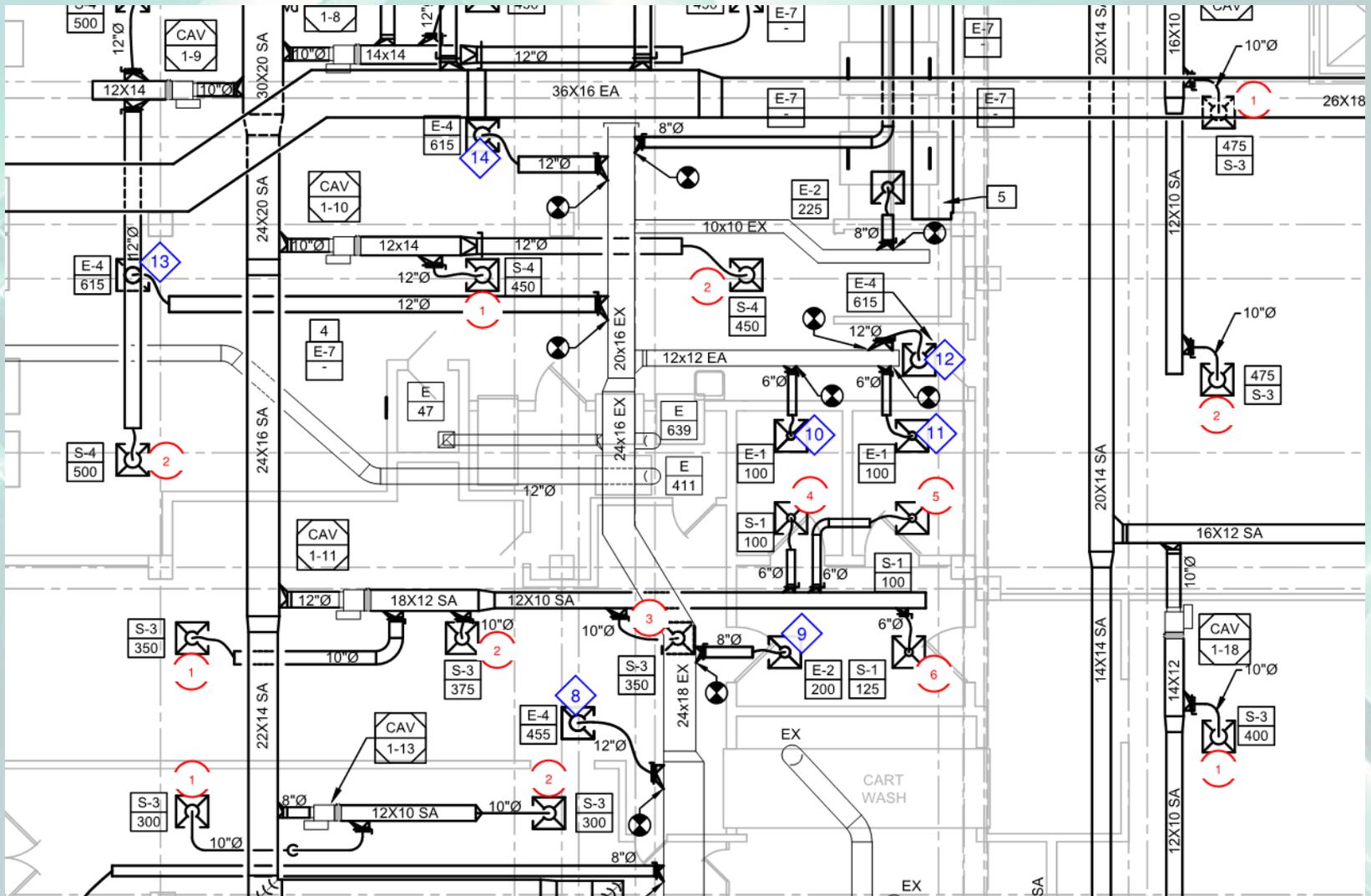
Soiled Holding AHU Installation
HVAC-2A / Roof
Michael Olack

DATE 02/08/16
JOB # 15000

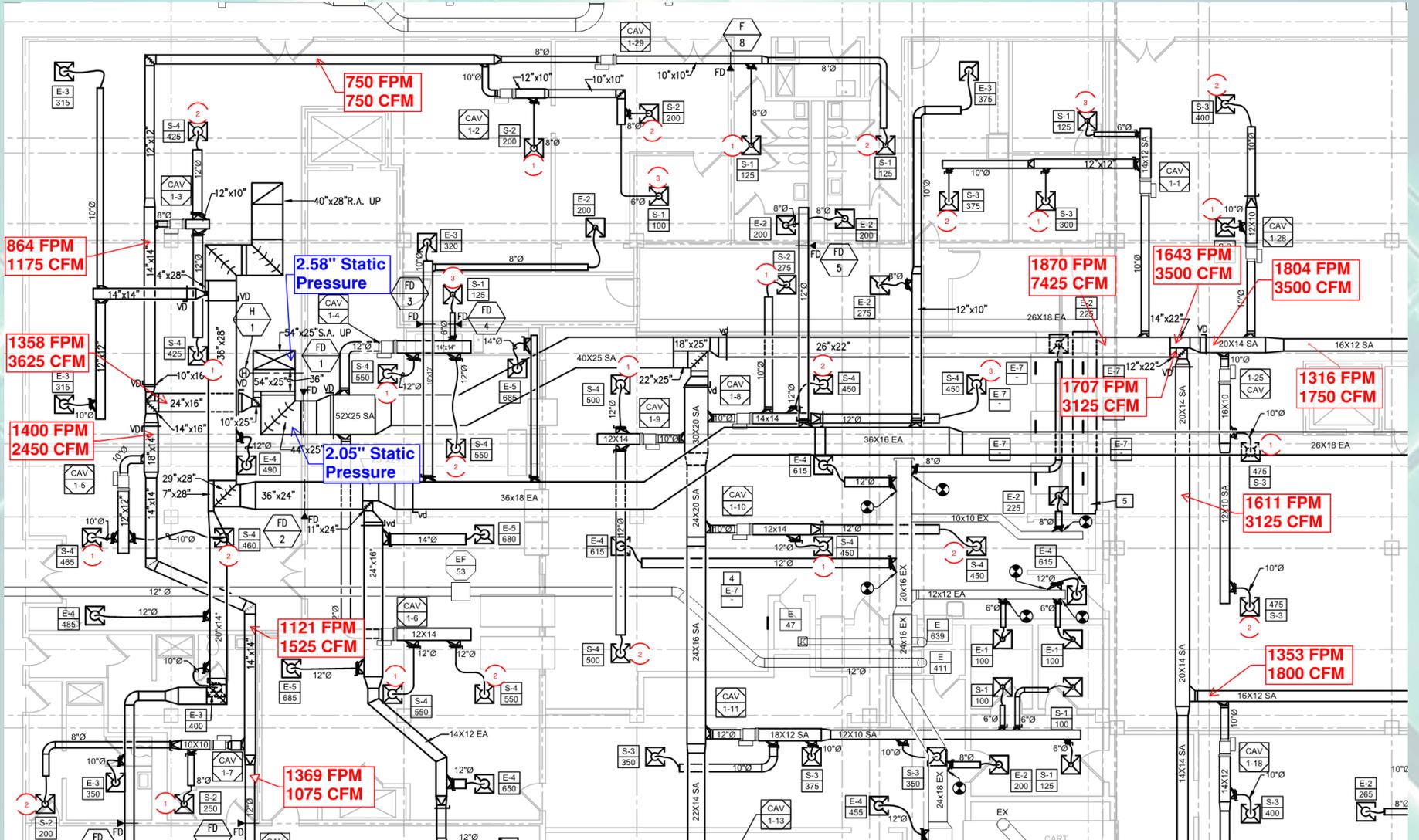
MARK	NEXUS MODEL	DESIGN GPM	PRELIMINARY			FINAL			NOTES
			ΔP (in)	Setting*	GPM	ΔP	Setting*	GPM	
CAV1-1	1B	1.6	73	0	2.13	42	20	1.61	
CAV1-2	1A	0.9	91	0	1.19	55	20	0.92	
CAV1-3	1B	1.5	60	0	1.93	38	20	1.54	
CAV1-4	1B	2.2	101	0	2.50	78	30	2.20	
CAV1-5	1B	1.7	67	0	2.04	47	20	1.71	
CAV1-6	1B	2.0	87	0	2.32	65	30	2.01	
CAV1-7	1A	0.8	64	0	1.00	42	15	0.81	
CAV1-8	1B	1.6	57	0	1.88	42	20	1.61	
CAV1-9	1B	1.8	74	0	2.14	53	25	1.81	
CAV1-10	1B	1.6	77	0	2.19	42	20	1.61	

NOTES

Tab Report



Tab Report



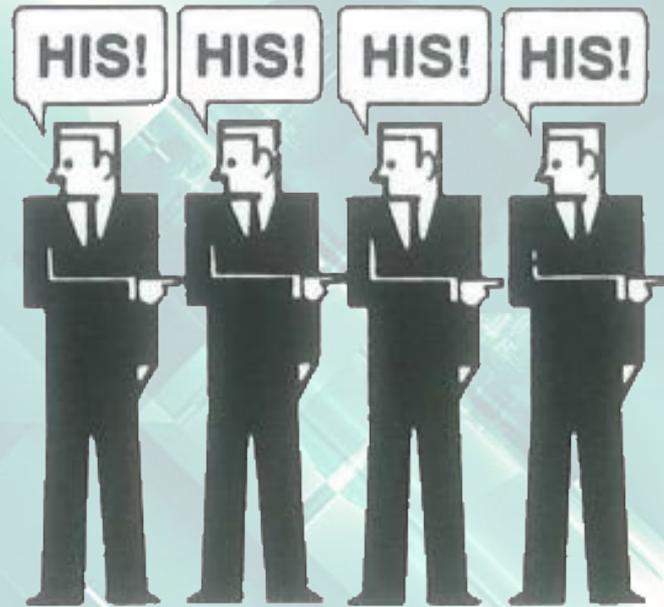
Testing, Adjusting, and Balancing Limitations

- It is common for TAB contractors to have a deficiency list detailing items that have prevented them from completing the test and balance of systems.
- Some of the deficient items may have been created by one or more of the installing contractors.
- The TAB firm is usually a subcontractor with no authority to push anyone to make any corrections whatsoever.
- Projects typically have a specific window of time for completion.
- Using measurement data, root problems can be identified and solutions developed.

What Will Restrict the Test and Balance Process?

- Equipment and/or components not installed.
- Controls not programmed or thoroughly checked.
- HVAC equipment not operating properly.
- Fans / pumps operating backwards.
- Air in the hydronic systems.
- Floors having carpet installed or wax applied.
- Fire Alarm System Testing - Usually shuts down the HVAC System

WHO'S FAULT?



Benefits Of TAB

- The building & HVAC systems work together more efficiently.
- Will lower utility costs
- Increase occupant safety and comfort
- Reduce wear on equipment and increase operational life.

How Does TAB Affect Health Care Facilities?

1. Center For Medicare And Medicaid Services (CMS)
2. Missouri State Code of Regulations
3. National Fire Protection Agency (NFPA)
4. Facility Guidelines Institute (FGI)
5. American National Standards Institute (ANSI)
6. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
7. American Society for Healthcare Standards (ASHE)
8. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO)
9. Det Norske Veritas Germanischer Lloyd (DNV GL)

How Does TAB Affect Health Care Facilities?

1. Center for Medicare and Medicaid Services (CMS), Missouri State Code of Regulations, and National Fire Protection Agency (NFPA), and Missouri State Code of Regulations are setting the standards.
2. The Joint Commission and Det Norske Veritas - Germanischer Lloyd (DNV-GL), are enforcing them through surveys of the Hospitals and Ambulatory Facilities.
3. Health care facilities are also dealing with daily operational guidelines from organizations such as: The Association of the Advancement of Medical Instrumentation (AAMI), the Association of periOperative Registered Nurses (AORN).

Crosswalk of Sterile Processing Department HVAC Guidelines April 9, 2015

AAMI ST79 A4:2013	ASHRAE	AORN**	Proposal
Decontamination area	Soiled or Decontamination Room	Decontamination area	Decontamination room
Negative (3.3.6.4)	Negative	Negative	Negative
10 (3.3.6.4)	6	6	10
30-60%	NR	NR	NR
60-65 F, 16-18 C (3.3.6.5)	72-78 F, 22-26 C	72-78 F, 22-26 C	60-73
Preparation and Packaging	Clean workroom	Preparation and Packaging/clean workroom	Clean workroom
Positive	Positive	Positive	Positive
10	4	4	10
30-60% (3.3.6.6)	max 60%	max 60%	≤ 60%
68-73 F, 20-23 C (3.3.6.5)	72-78 F, 22-26 C	72-78 F, 22-26 C	68-73

Endoscopy History

Endoscopy			
Edition	Air Pressure Requirement	Outdoor Air Changes	Total Air Changes
AIA 1996-1997	Neutral	2	6
AIA/FGI 2001	Negative	2	6
AIA/FGI 2006	Neutral	2	6
FGI 2010	Positive	2	15
FGI 2014	No Requirement	2	6

History

- Designed by architects and engineers
 - No worries - everything is ok

History

- Air Changes per Hour
- Pressure Relationships
- Temperature
- Humidity
- Fire/Smoke Dampers were not tested
- Fire Doors were not inspected

Critical Rooms

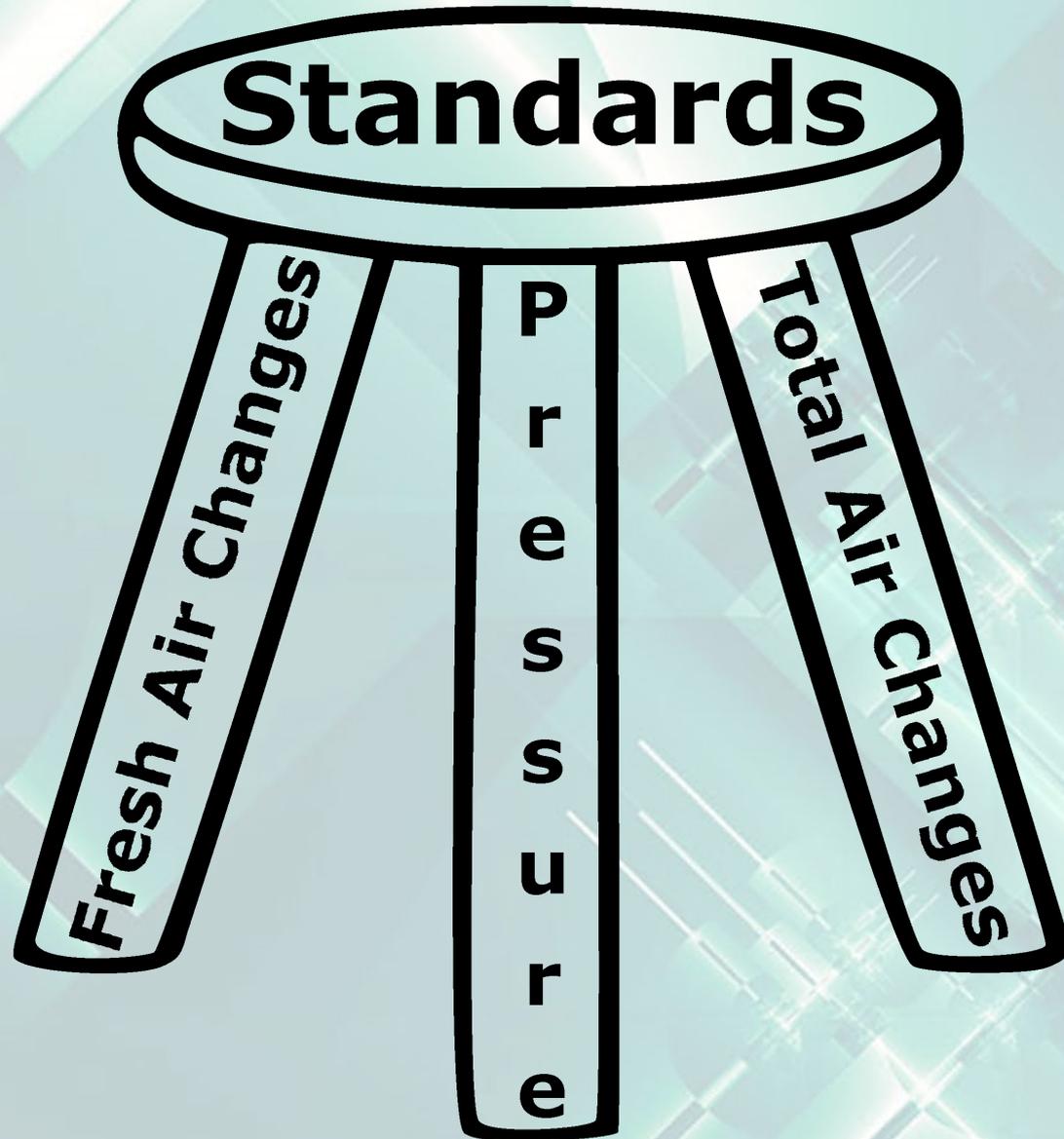
What are some of the types of critical rooms that are on the CMS radar?

Certification for Total Air Changes, Fresh Air Changes, and Pressure Relationships

The following list consists of rooms or areas that are typically tested in the main Hospital, Surgery Center or Ambulatory facility.

- Surgery and Critical Care
 - Operating Suites
 - C – Section
 - Cysto
 - Cath Labs
 - Bi Plane
 - Interventional Radiology
 - Intensive Care (ICU, PVICU, CVICU)
 - Central Medical and Surgical Supply
 - Decontamination Room, Clean Work Room, Clean Storage
- Isolation
 - Airborne Infectious Isolation (Negative Pressure)
 - Protective Environment Room (Positive Pressure)
 - Bone Marrow Unit
 - Burn Unit
- Diagnostic and Treatment
 - Bronchoscopy
 - Endoscopy
 - Colonoscopy
 - Scope Cleaning
 - Decontamination Room, Clean Sterile, Clean Storage
 - Laboratory
 - Cytology
 - Histology
 - Microbiology
 - Pathology
 - Pharmacy
 - Nuclear Medicine
 - Autopsy/Morgue
 - Medicine Rooms
 - Ultrasound Rooms
 - Soiled and Clean Linen Rooms
 - Soiled Utility Rooms
- Emergency Room
 - Decontamination Room
 - Trauma Room
 - Airborne Infectious Isolation Zone

What are the requirements for critical rooms?

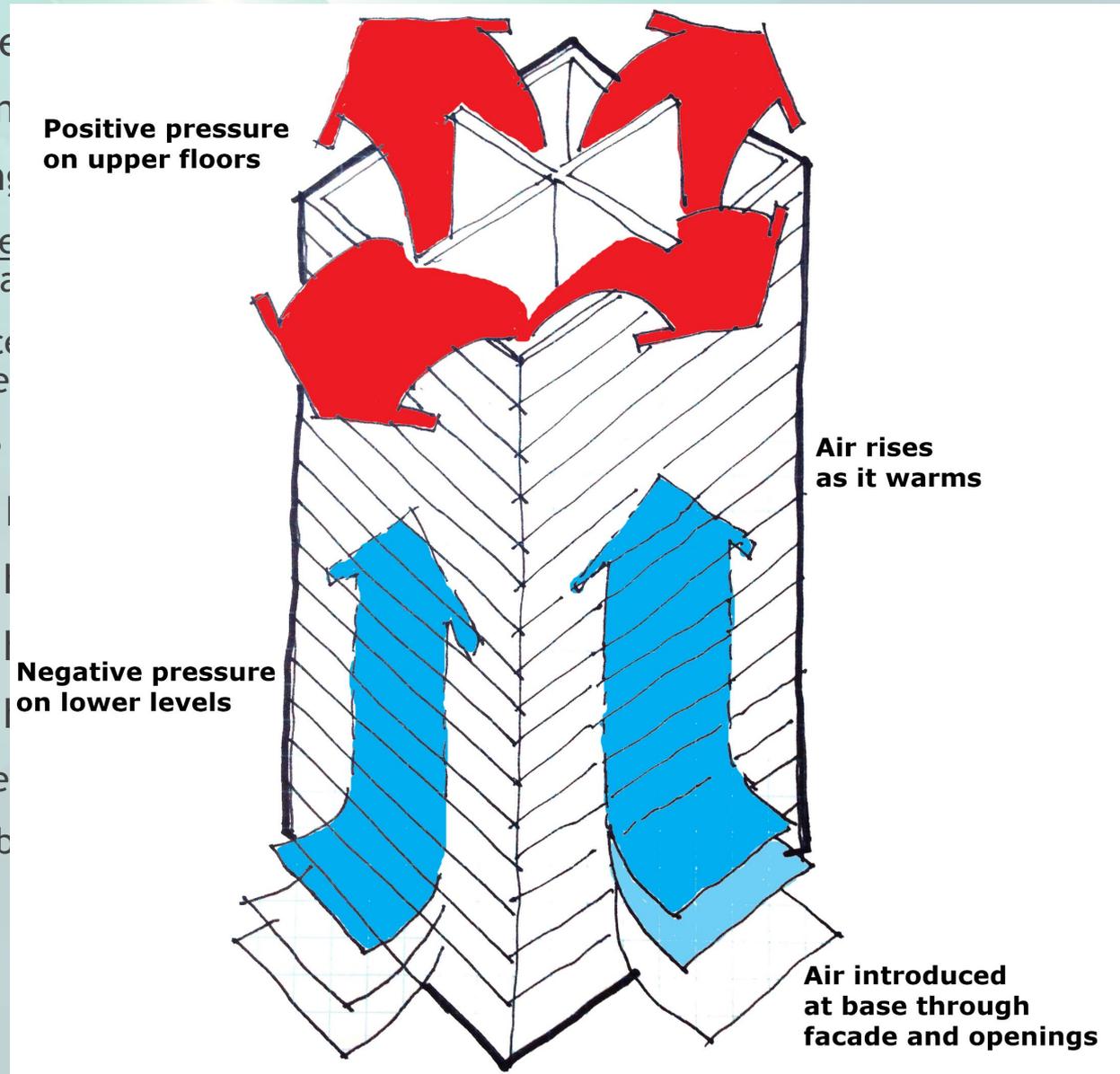


What are the requirements for critical rooms?

- Factors that affect air changes.
 - Is the space served by constant or variable supply/exhaust/return air volumes?
 - Is the space served by a constant or variable fresh supply air volume?
 - Air change requirements are only a minimum requirement.

What are the requirements for critical rooms?

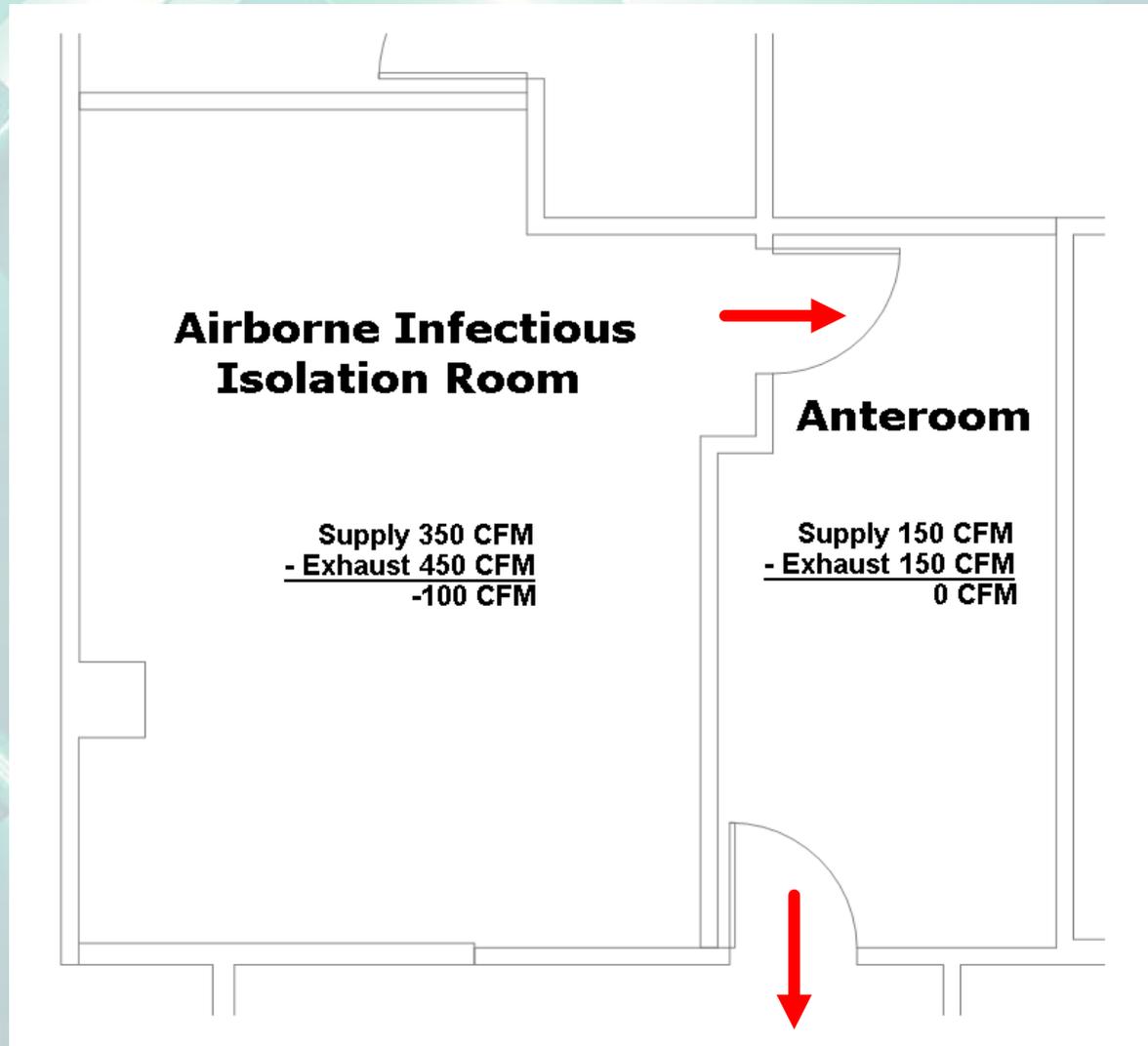
- How porous is the space
- Is the room served by con
- Are the controls operating
 - How constant is the refe supply/exhaust/return a
 - Is the space or reference influenced by 100+ othe
- Is the space or reference
- Does the associated AHU
- Does the associated unit
- Does the associated unit
- Does the associated unit
 - Example #1: A helicopte
 - Example #2: When the b building?



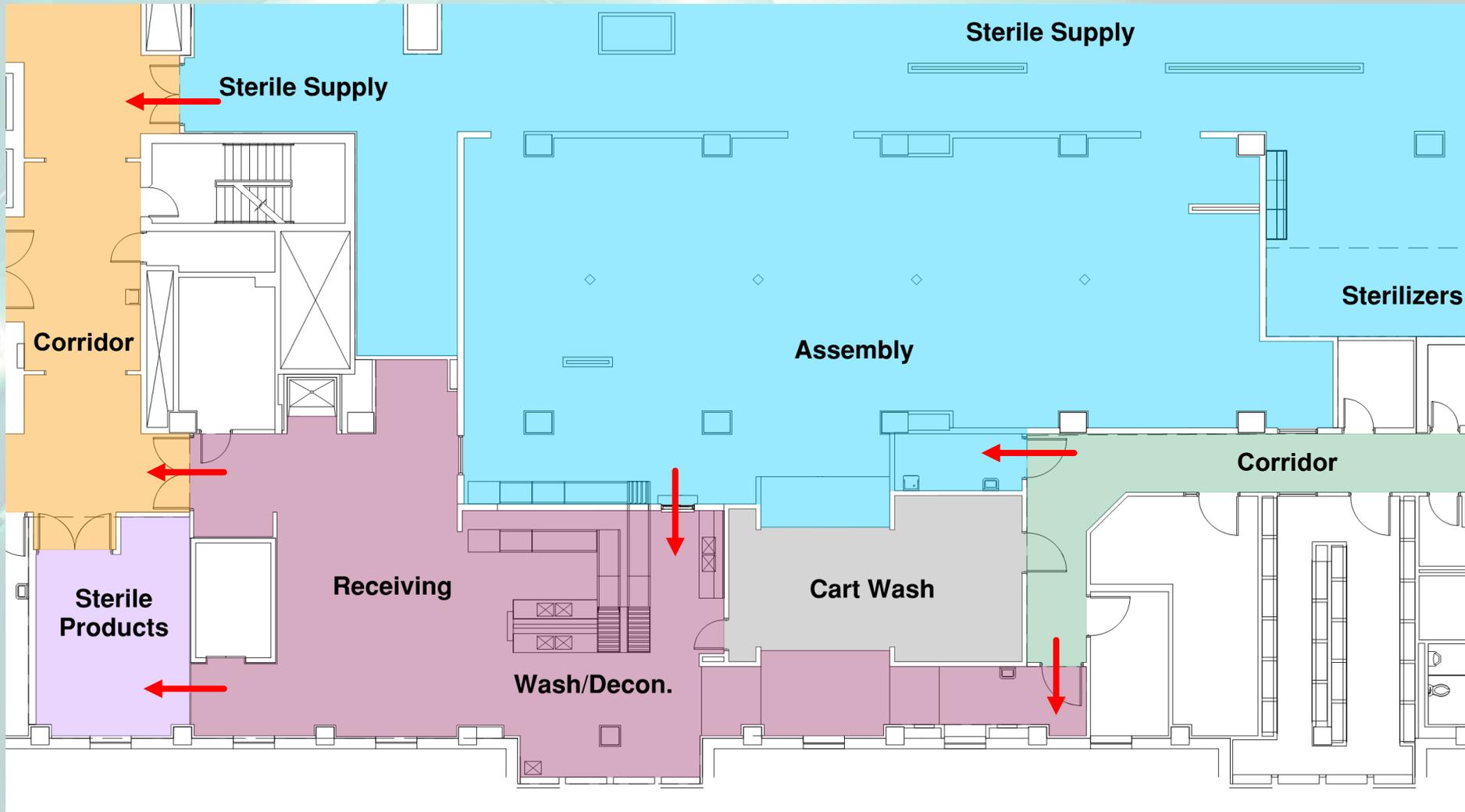
What are the requirements for critical rooms?

- Room Pressures
 - Using CFM offset strategy to obtain room pressure differential
 - Supply airflow 1,800 CFM
 - Return airflow 1,600 CFM
 - What is the room pressure?
 - It depends...
 - **Airflow offset does not guarantee a desired room pressure differential.**

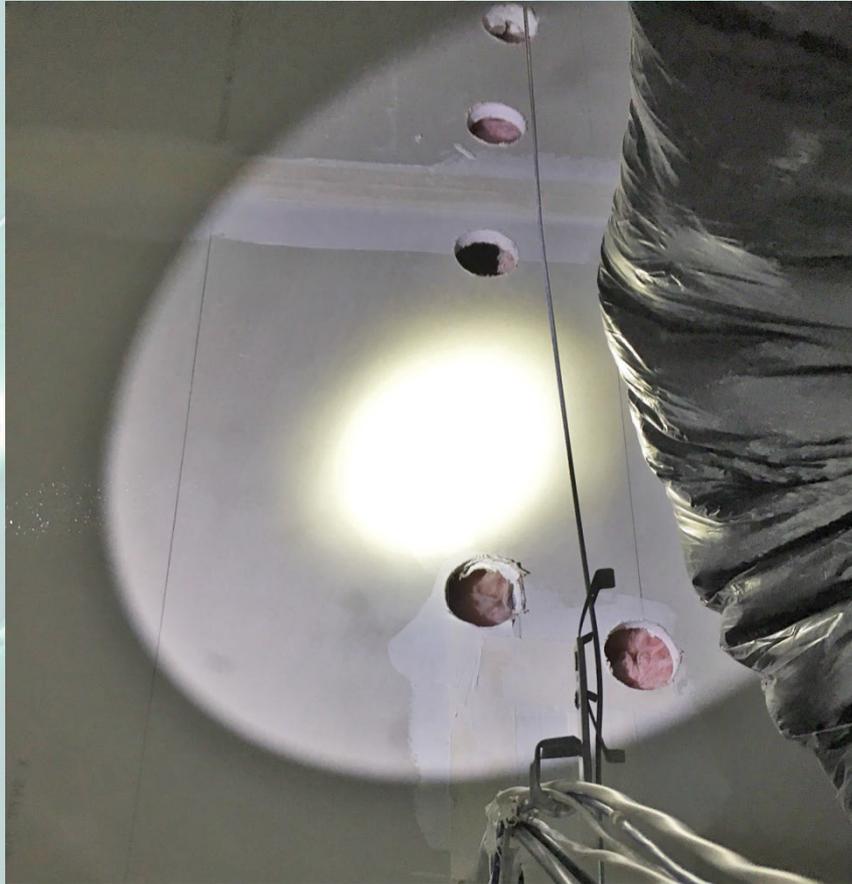
Simple Differential Pressures



Complex Differential Pressures



Space Not Maintaining Pressure Or Air Changes?



Holes In Wall Above Ceiling In Pressure Sensitive Space



Holes In Wall Above A Biosafety Cabinet In Pressure Sensitive Space

Space Not Maintaining Pressure Or Air Changes?



Security Gate To Pressure Sensitive Space

Space Not Maintaining Pressure Or Air Changes?



Dirty Exhaust Air
Measurement Device

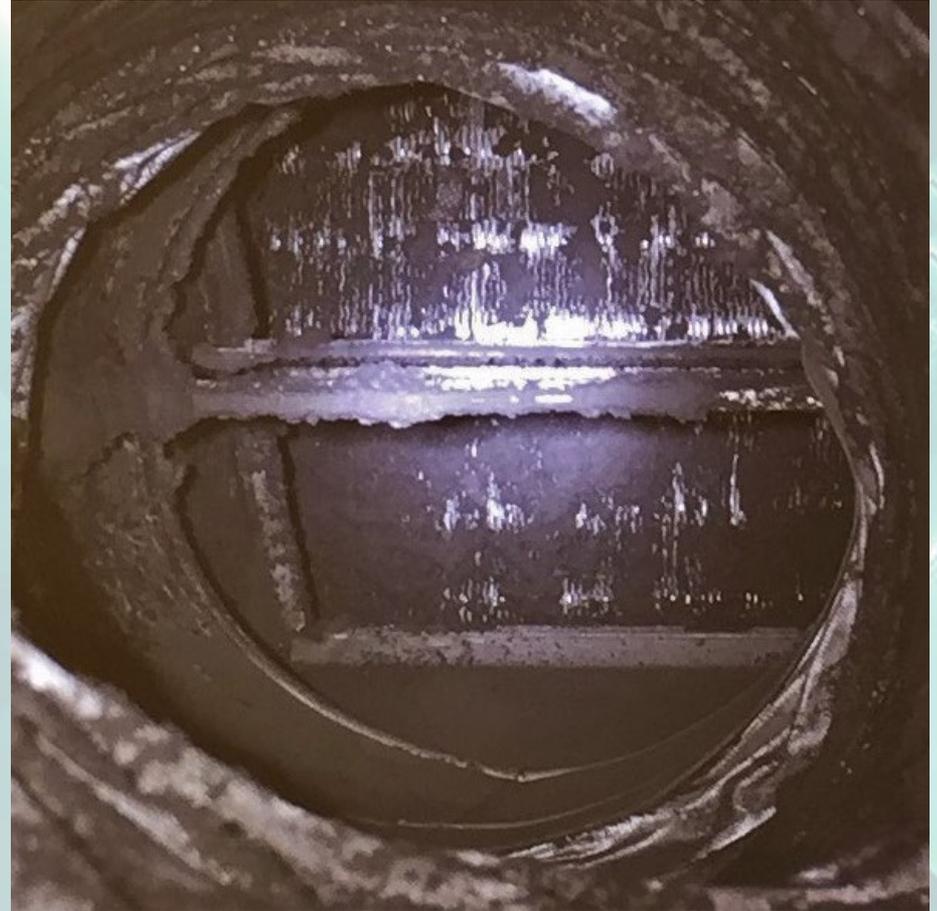


Cleaned Exhaust Air
Measurement Device

Space Not Maintaining Pressure Or Air Changes?

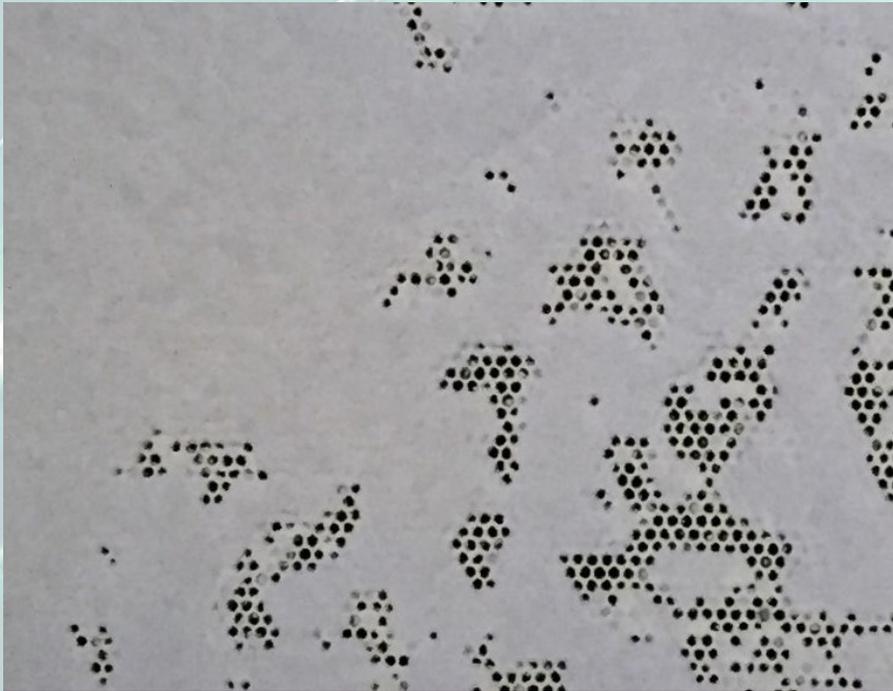


Dirt Forced Out Of AHU Chilled Water Coil

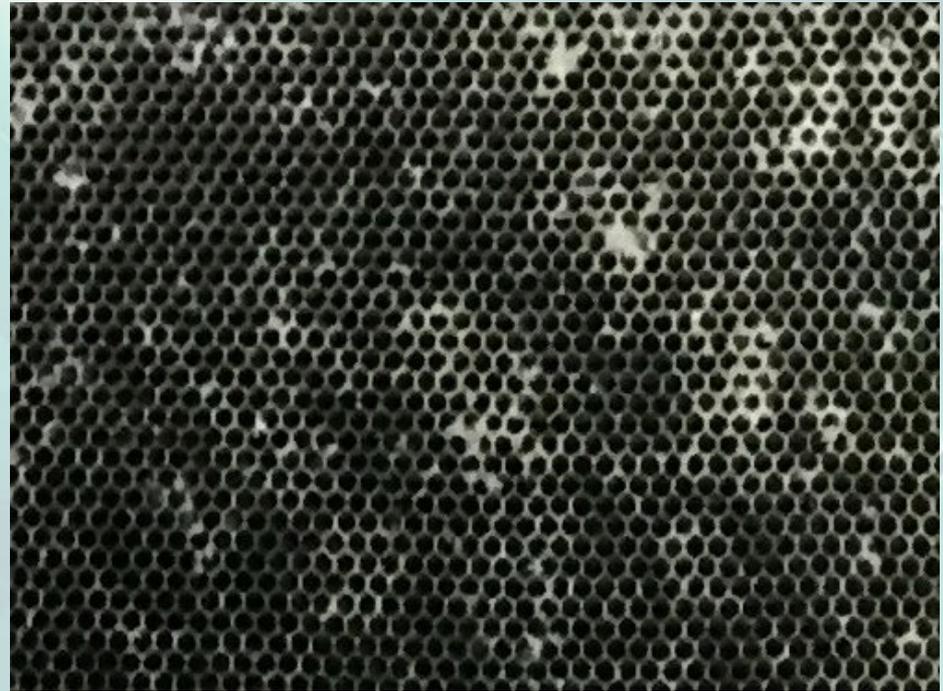


Years Of Dirt Built Up On VAV Reheat Coil Blocking Airflow

Space Not Maintaining Pressure Or Air Changes?



Waveguide In Duct Blocked By Dust



Waveguide In Duct After Cleaning

Space Not Maintaining Pressure Or Air Changes?



Improperly Connected Flex Is Separating From Tap



Improperly Installed Tap Has Separated

Space Not Maintaining Pressure Or Air Changes?



Damper Actuator: Actuator mount is loose so the actuator is spinning instead of the damper.

Not Controlling Temperature or Humidity?



Condensate Forming On Diffuser & Insulation



Condensate Forming On Duct With Internal Liner

Not Controlling Temperature or Humidity?



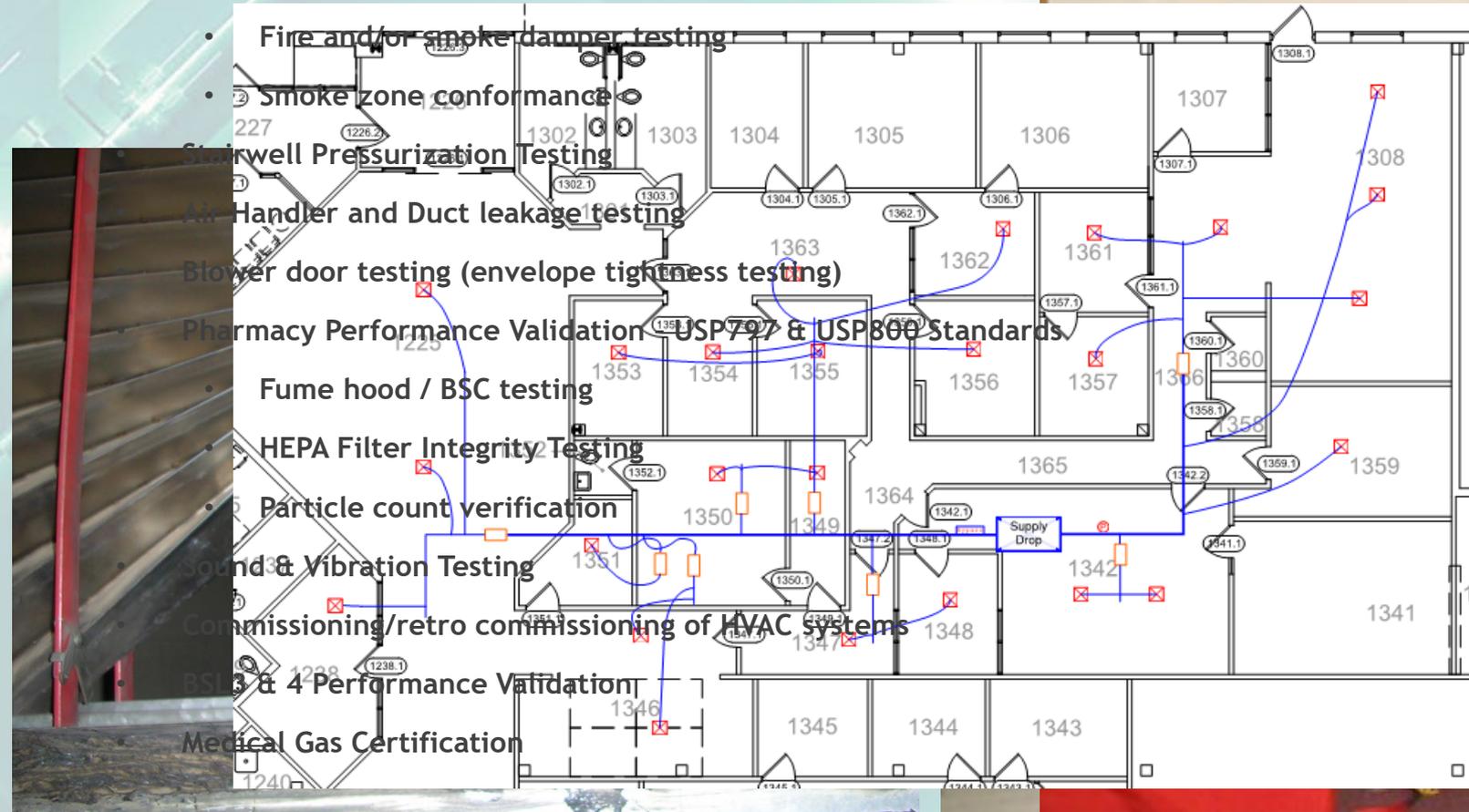
Drain Pan Growth Prevention Pad Surrounded
By Growth



Growth On Air Handling Unit
Liner

What are some other ways TAB can help in buildings?

- Existing HVAC equipment performance assessment & investigation
- Create as-built one line drawings & schematics
- Life safety system verification



Goals

1. What is testing, adjusting, and balancing (TAB)?
2. What are the benefits of TAB?
3. How is TAB performed?
4. What other functions can TAB perform?
5. Test and Balance - Friend or Foe?



Questions



Does testing,
adjusting, and balancing
affect our patient care?

Questions?