

How Much Energy Can Balancing Save?

Monday, January 14 - 4:00 to 5:30 - Room B 315

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National Comfort Institute

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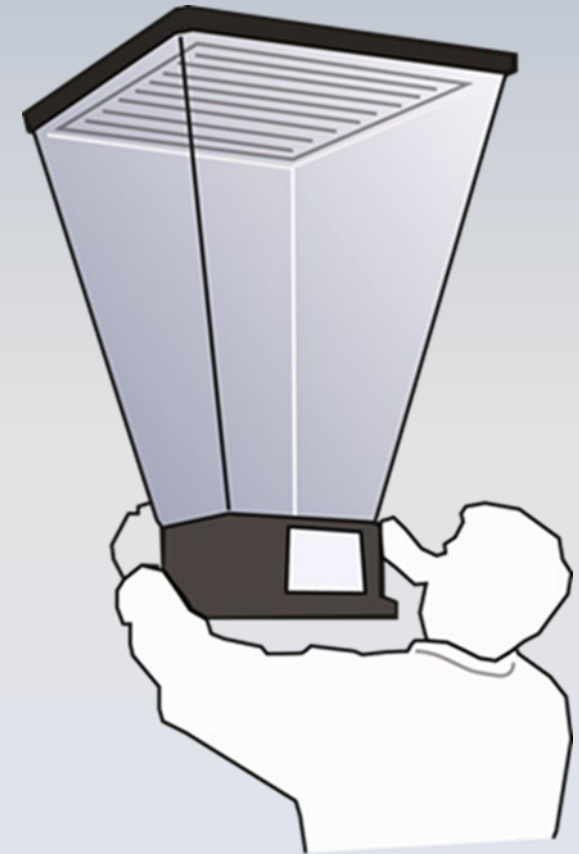


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Let's begin with a few questions...energy savings

How much energy does testing and balancing save?

- a. About 10%
- b. None
- c. 50% or higher
- d. It depends**



Source of energy savings

Where do the energy savings come from?

- a. Testing
- b. Balancing
- c. Additional Diagnostics
- d. **Addressing Issues Found**



Does a typical balancing report verify the system is operating efficiently?

A typical air balancing report:

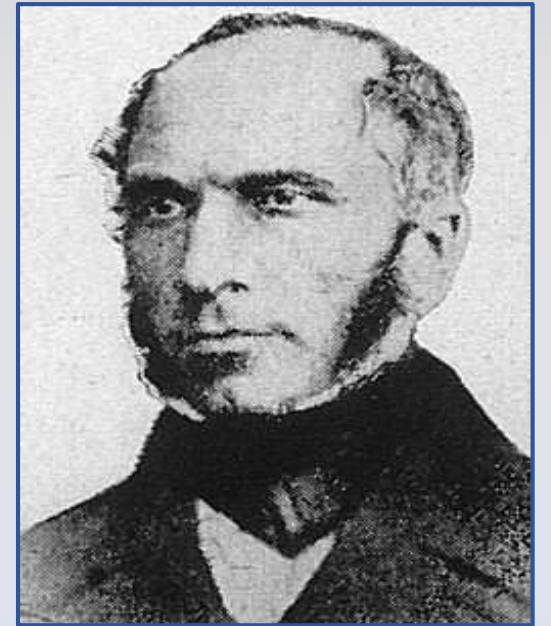
- a. Verifies the system is operating efficiently
- b. Assures equipment heating/cooling capacity is delivered into the occupied space
- c. **Verifies air and water flow rates match design**
- d. Assures all rooms are comfortable

Test and Balance and Efficiency History



Henri Pitot – Invented the Pitot tube in 1732 and laid the foundation for air and fluid measurement

Henry Darcey – Test methods and use of Pitot Tube was further developed in the mid 1850's



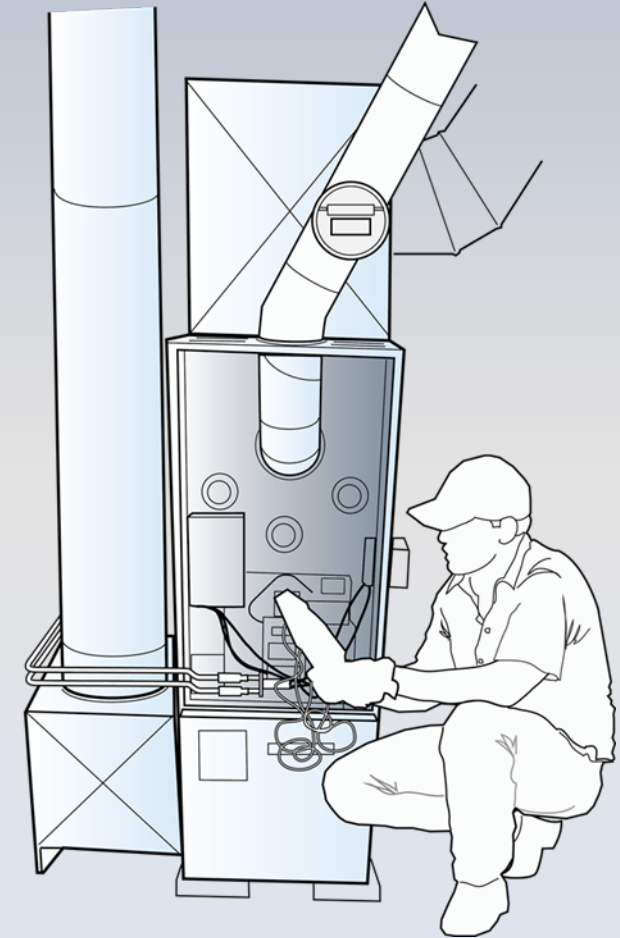
These, and many other pioneers, formed the groundwork of test and balance today

HVAC system test and balance

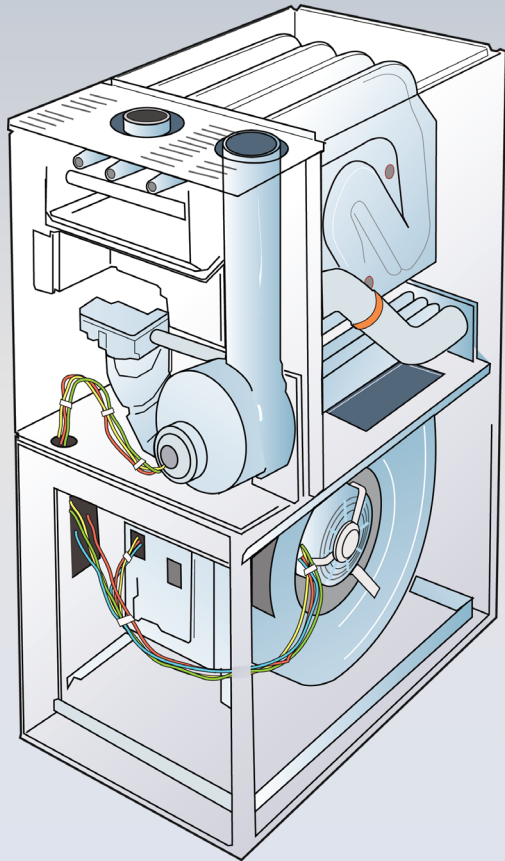
Architects and Engineers became aware design intent was not materializing once systems were installed.

In **1965** the first Test and Balance Agency is formed

Test and balance is **specified as the required method to verify field measured data** of an operating HVAC system.



HVAC and Efficiency

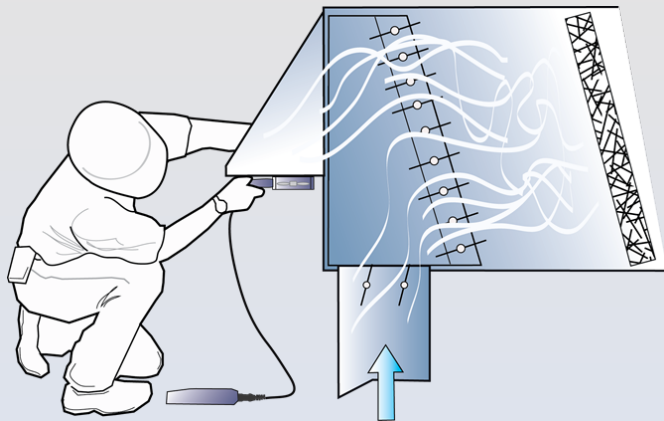


- **Government and utilities** jumped into the HVAC efficiency arena.
- Energy efficiency imposed on equipment manufacturers and utilities, who focused primarily on **equipment efficiency**.
- HVAC energy savings by utilities savings were **“deemed using bulk data.”**

Installed HVAC system efficiency testing

Balancing methods were developed and accepted to **measure and quantify energy efficiency of an installed HVAC system**

Consumers, contractors, government and utilities soon began to embrace field performance testing.



Balancing-based data began rolling in and a new source of energy savings was uncovered.

A wide gap between deemed energy savings and actual energy savings was documented.

50 Years of Testing and Balancing

Testing, Balancing, Beyond Balancing

- **Testing** alone doesn't save any energy, but by diagnosing the system based on test data many opportunities for savings can be uncovered
- **Balancing a system can save some energy** depending on the scenario
- **Including additional tests, diagnostics, and recommendations for repair** is where the real savings potential lies



Summary air balance report information

- Cover letter and certification statement
- **Exceptions** report
- Job and **equipment data** compared to specification, equipment specs, etc.
- **Field measurements** – Airflow, pressures, voltage, temperatures
- **Floor plan**, photos
- Instrument **calibration**, certification documentation
- *Missing from the upcoming report are: Non-air moving equipment, outside air, motor measurements, hydronics, auxiliary reports, etc.*

Project and System Data

Air Balance Report

Project and System Information
Sterling Consulting
29435 Route 57
Amherst, Ohio 44004
Matt Sterling 440-648-3494
matts@sterling.com
RTU-4 – Heating Mode
November 21, 2018
Technician – Isaac E



Air Moving Equipment Data

Air Balance Report

Air Moving Equipment	
Manufacturer	Weathershifter
Model Number	56DJX0240360
Serial Number	238DOFHH9385
Size	20 Ton/360k Btu Out Heat
Type	Packaged Unit
Location	N/E Rooftop Unit 9

Fan Motor Daa

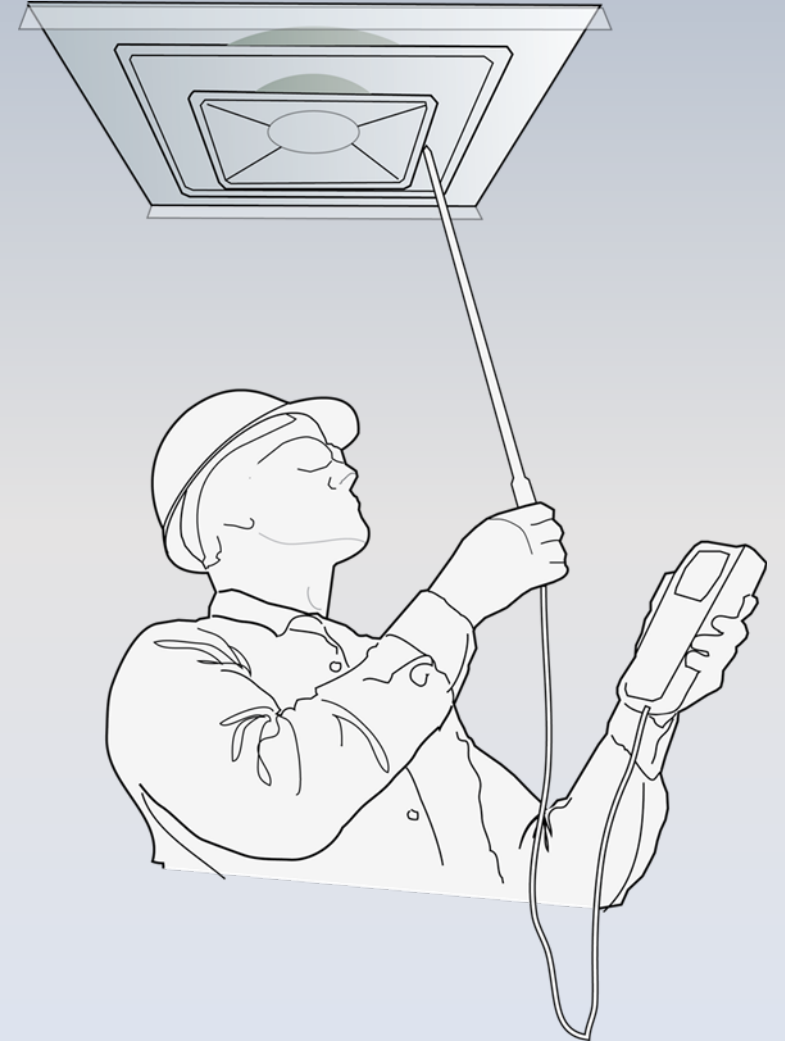
Air Balance Report

Fan Motor Data	
Manufacturer	Baldor
Model	EJMM3212T
Horsepower	5
Operating Volts	208/230 3 Phase
Rated RPM	3450
Motor Pulley Diameter	4.25"
Fan Pulley Diameter	8.75"

System Airflow

Air Balance Report

System Airflow	Required	Actual
Supply diffuser total	8000	5320
Return grille total	8000	6632
Economizer airflow	0	0



Grille and Diffuser Airflow

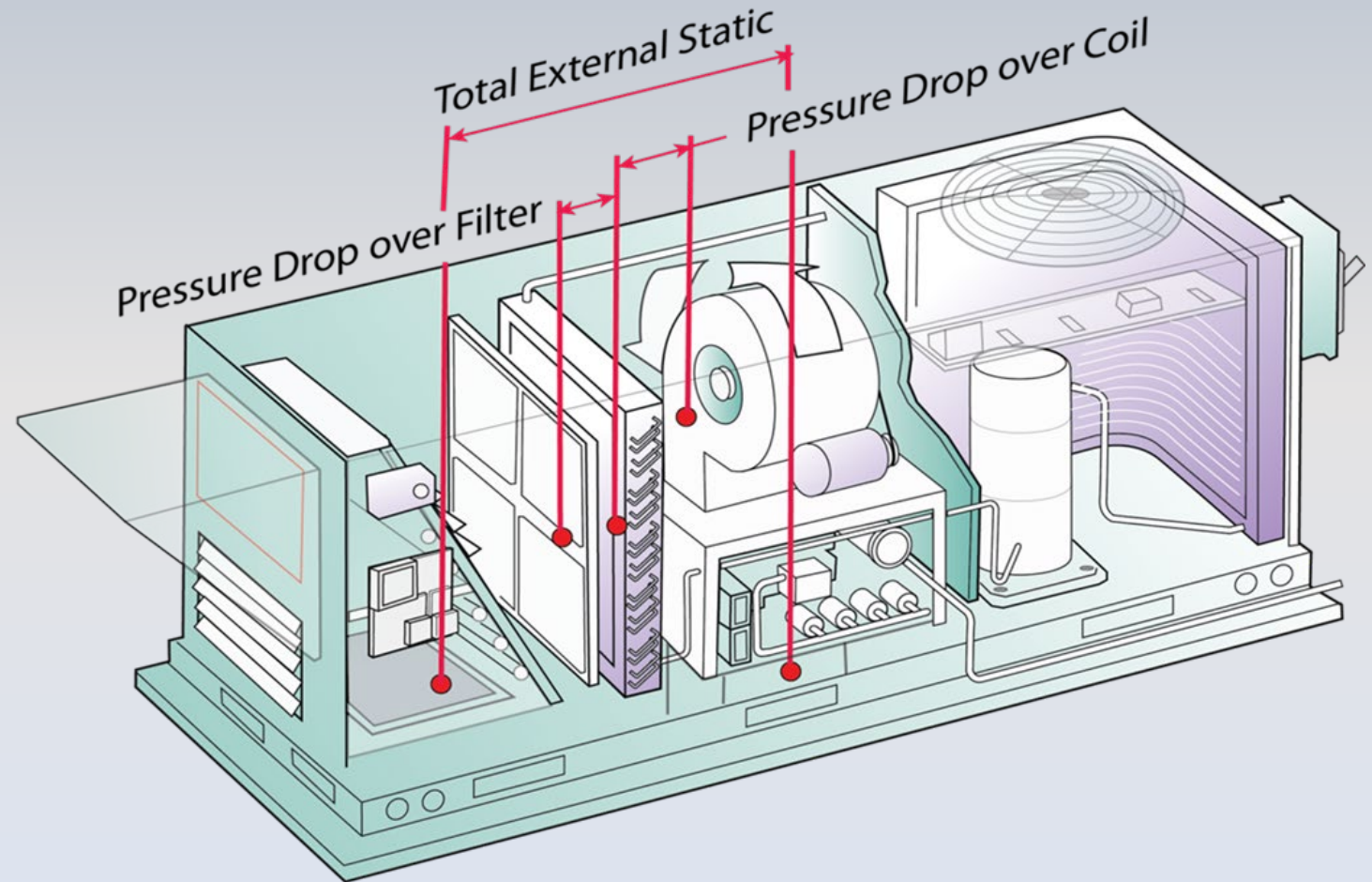
Air Balance Report – Proportionally Balanced

Room Name	Grille No.	Design cfm	Initial	Percent Required	Final cfm	Percent Required
Lobby West	1	2000	1640	82%	1340	67%
Lobby East	2	2000	840	42%	1375	69%
Administration	3	1500	1150	77%	970	65%
Accounting	4	1000	690	69%	730	73%
Conference	5	1500	1120	75%	905	60%
Total		8000	5440	68%	5320	66%
Equipment Plenum Inlet	R-1	8000	6872	86%	6632	83%

System Static Pressure

Air Balance Report

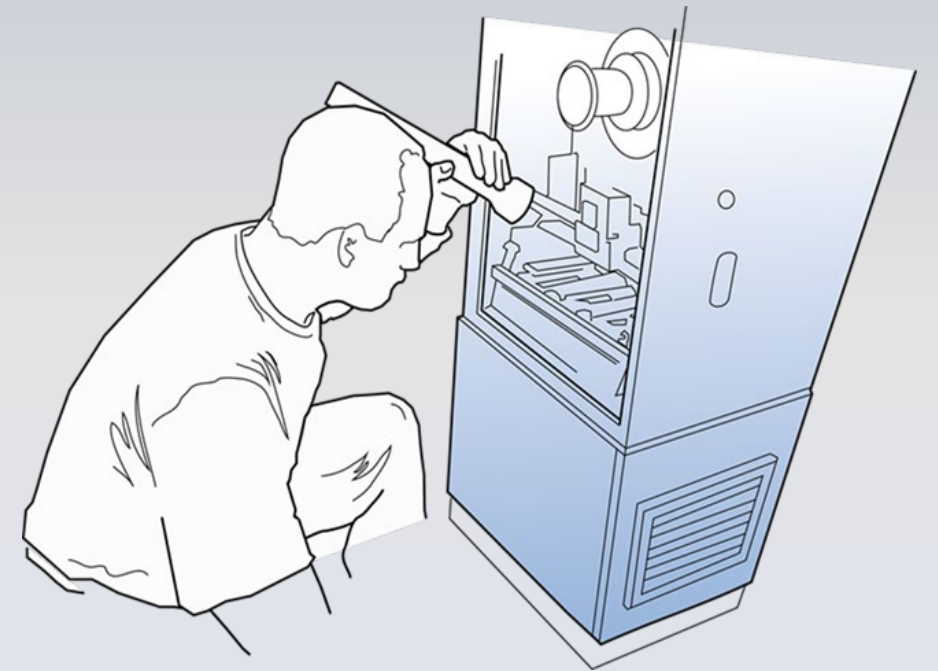
Static Pressure	Design	Actual
Total External	1.50"	2.16"



System temperatures (heating mode)

Air Balance Report

Equip DB temp	Design	Actual
Entering temp	65°	55°
Exiting temp	110°	100°
Equip temp change	45°	45°
Outdoor air temp	32°	18°



Air Balancing Report Conclusion

Air and water balancing has been **the proven method of field verification for more than 50 years.**

- It compares **design to actual field conditions**
- **Field Measurements** – Airflow, pressures, voltage, temperatures, fan speed
- **A verification** if what was designed and specified has or has not been delivered.



Beyond basic balancing

How hard would it be to add these measurements to your report?

- Fan airflow
- Average supply and return grille temperatures
- System static pressure profile
- System and Fan Watts

With this data and the data from a typical report **a few additional calculations** can provide **powerful diagnostic data** that can be used to identify more savings opportunities

Duct Performance

Now we'll contrast a typical air balance report to a system performance report

Air Balance Report

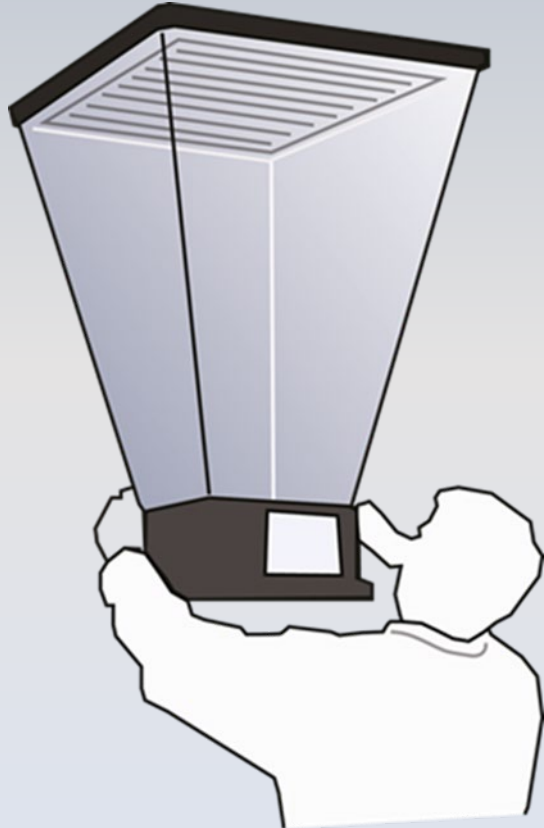


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System Airflow	Required	Balance Only
Supply diffuser total	8000	5320
Return grille total	8000	6632

Duct Performance

System Performance Report

System Airflow	Required	Balance Only	After Repairs
Fan airflow cfm	8000	6840	7455
- Supply diffuser total	8000	5320	7230
= Supply duct Leakage	0	1522	225
Fan airflow cfm	8000	6840	7455
-Return grille total	8000	6632	7285
= Return duct leakage	0	212	170

**New
Performance
Data Shown
In Blue**

Grille and diffuser airflow

Air Balance Report

Room Name	Grille No.	Design cfm	Balance Final	Percent Design	After Repairs	Percent Design
Lobby West	1	2000	1340	67%	1740	87%
Lobby East	2	2000	1375	69%	1785	89%
Administration	3	1500	970	65%	1410	94%
Accounting	4	1000	730	73%	925	93%
Conference	5	1500	905	60%	1340	89%
Total		8000	5320	66%	7230	90%
Equipment Plenum Inlet	R-1	8000	6632	83%	7285	91%

Grille and diffuser airflow and temperatures

System Performance Report

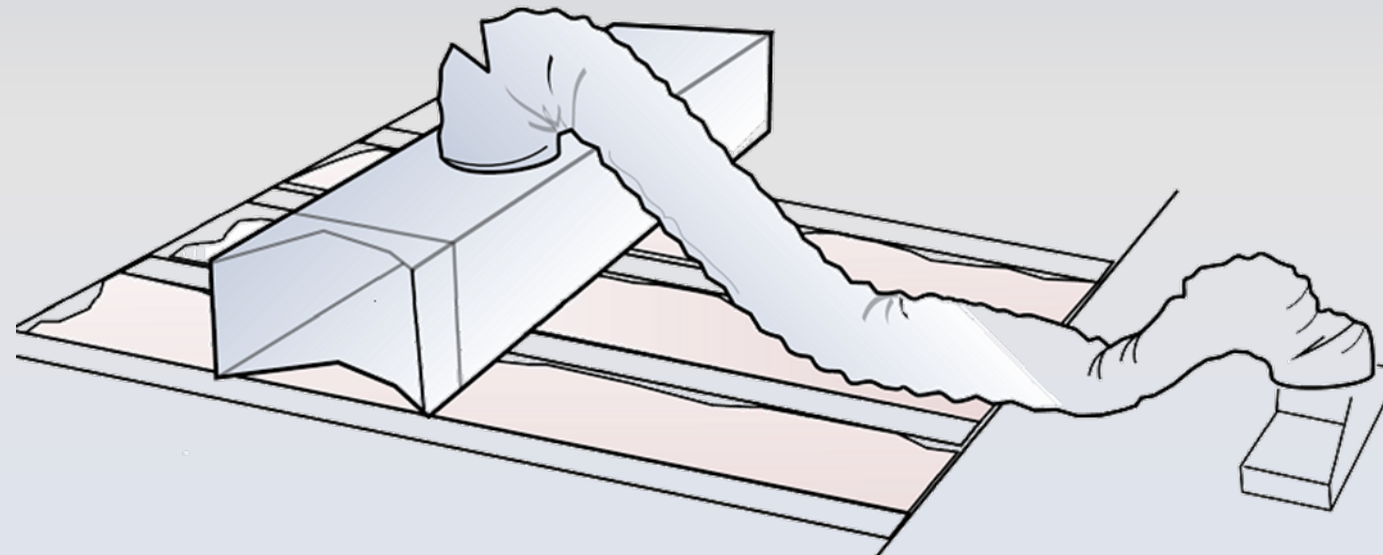
New Performance Data

Room Name	Grille No.	Design cfm	Balance Only	Percent Design	After Repairs	Percent Design	DB Temp
Lobby West	1	2000	1340	67%	1740	87%	108°
Lobby East	2	2000	1375	69%	1785	89%	111°
Administration	3	1500	970	65%	1410	94%	109°
Accounting	4	1000	730	73%	925	93%	110°
Conference	5	1500	905	60%	1340	89%	109°
Total		8000	5320	66%	7230	90%	109°
Equipment inlet	R-1	8000	6632	83%	7285	91%	69°

Static Pressure – Air Balance Report

New Performance Data

Static Pressure	Required	Balance Only	After Repairs
Total External Static	1.50"	2.16"	1.66"



System Static Pressure - System Performance Report

System Performance Report

Static Pressure	Required	Balance Only	After Repairs
Suction Pressure	.75"	.54"	.61"
Discharge Pressure	.75"	1.62"	1.01"
Total External Static	1.50"	2.16"	1.62"
Internal Coil Pressure	.30"	.38"	.32"
Internal Filter Pressure	.30"	.46"	.27"

New Performance Data



System temperatures (heating mode)

Air Balance Report



Equip DB temp	Required	Actual
Entering temp	65°	55°
Exiting temp	110°	100°
Equip temp change	45°	45°
Outdoor air temp	32°	18°

System temperature summary (heating mode)

System Performance Report

System Temps	Required	Balance Only	After Repairs
Equip exiting temp	110°	100°	114°
- Supply diffuser avg temp	110°	92°	109°
= Supply duct temp loss	0°	8°	5°
Return grille avg temp	65°	66°	69°
- Equip entering temp	65°	55°	63°
= Return duct temp loss	0°	11°	6°
Avg Grille Temp Difference	0	26°	40°

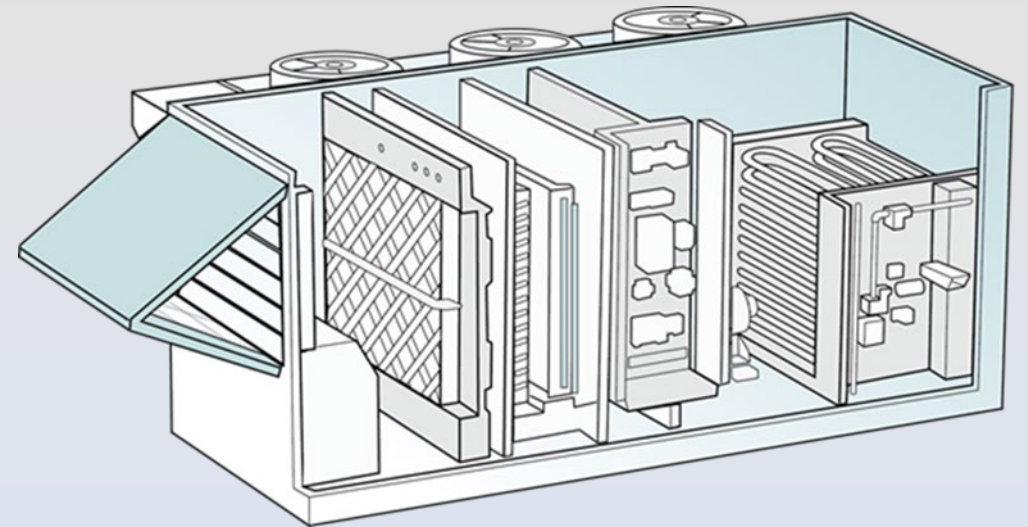
New Performance Data

Added energy saving measurements conclusion

A few extra **measurements** and a couple additional **calculation** turns air balancing testing into valuable energy savings diagnostics possible

- Fan airflow
- Average supply and return grille temperatures
- System static pressure profile
- System and fan watts

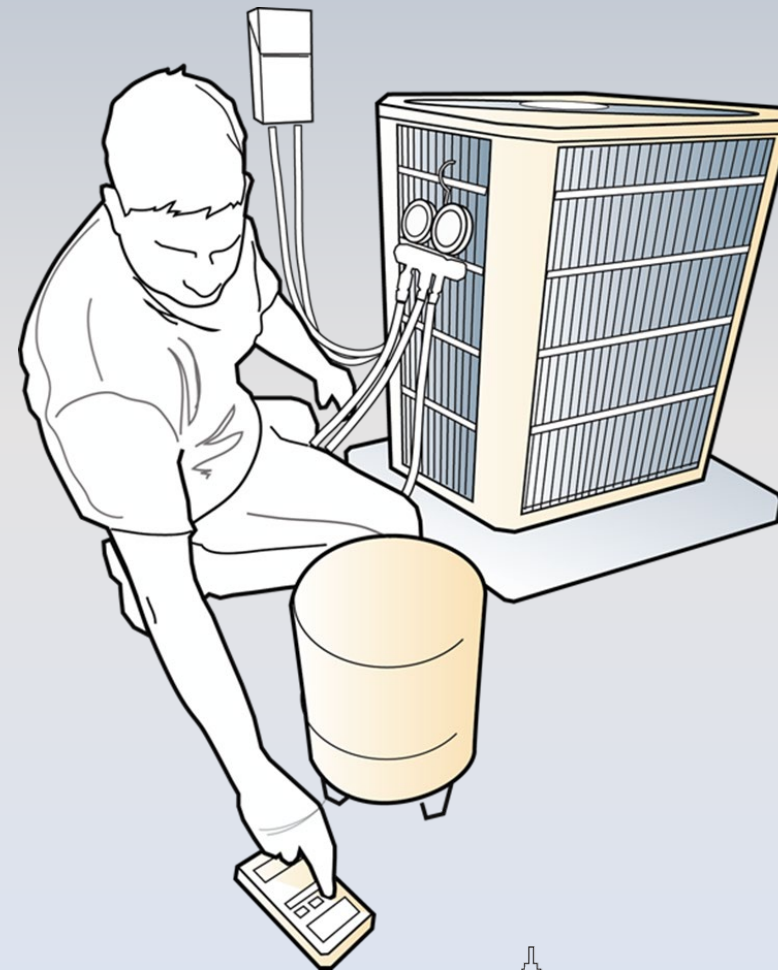
Once an HVAC professional is aware of defects revealed by testing, diagnostics is mostly common sense



Putting it All Together – Air Balance Reports and System Performance Reports

Using the data you've gathered you can make the following calculations

- Field measured system delivered BTUs
- Percent of delivered Btu into the occupied space
- Field measured system EER for cooling



BTU and EER equations

Heating

$$BTUh = 1.08 \times CFM \times \Delta T$$

Cooling

$$BTUh = 4.5 \times CFM \times \Delta h$$

$$EER = \frac{BTUh}{Watts}$$

Note: Full calculations with normalization for outside and equipment entering air conditions available in ASHRAE 221P – currently a draft in public review



System delivered Btu/hr. (heating or sensible Btu/hr.)

System Performance Report, Heating Mode

Measured System Value	Required	Balance Only	After Repairs
Supply Register Airflow	8,000	6632	7285
Average Grille and Register temp difference	42°	26°	40°
Heating Btu multiplier	1.08	1.08	1.08
Output / Delivered System Btu	360,000	186,200	314,700
÷ Equipment rated Btu	360,000	360,000	360,000
Percent of rated Btu delivered to cond space	100%	51%	87%

New Performance Data



System Watt Consumption and System EER (Cooling Systems Only - Btu/Watts)

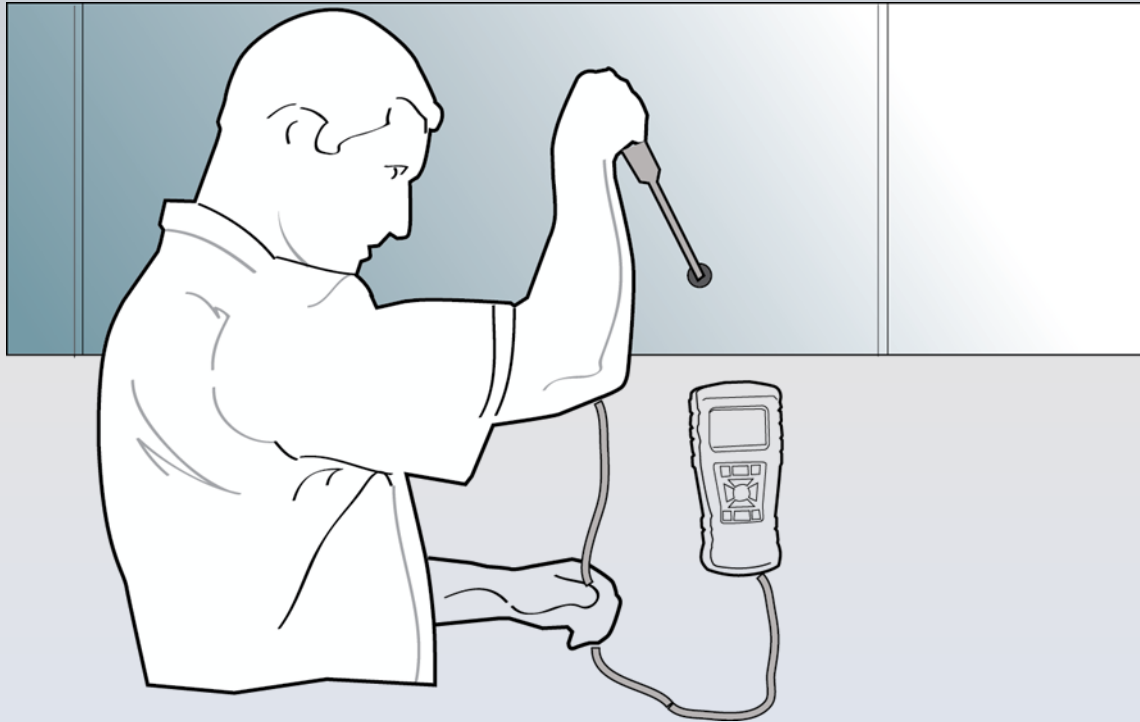
System Performance Report

Measured System Value	Required	Balance Only	After Repairs
Measured System Total Bth/hr	224,420	128,800	214,954
÷ Measured System Watts	17,260	16,437	16,922
= Installed System EER	13	7.8	12.7

New Performance Data



Estimating Energy Savings with BTUs and EER



Every system is different, and savings can range widely

Typical savings don't mean a whole lot

How can we use what we provide as balancers to accurately estimate savings?

Rough % Savings Estimation Approach

% of Rated Capacity Approach

$$\frac{BTU_{out} - BTU_{in}}{BTU_{in}} \times \%Lost$$

%Lost:

- Ducts outside or unconditioned: 100%
- Ducts partially conditioned: 50%
- Ducts fully conditioned: 0%

Multiply by annual energy expenditures for cost savings estimate

Estimating Savings with EER

$$kWh_{savings} = BTUh \times EFLH_c \times \left(\frac{1}{EER_{in}} - \frac{1}{EER_{out}} \right)$$

EFLHc = Equivalent Full Load Hours (Cooling)

Search for your state + “Technical Reference Manual”

So What Energy Does Balancing Actually Save?

- Start with real simple 50% to 80% improvement percent of savings. Then go deeper.
- We've provided many alternative views and a wide range of savings potential
- Based on experience and data, here are some average percent savings to expect based on the various approaches to Testing and Balancing



Typical Energy savings estimates for balancing related work

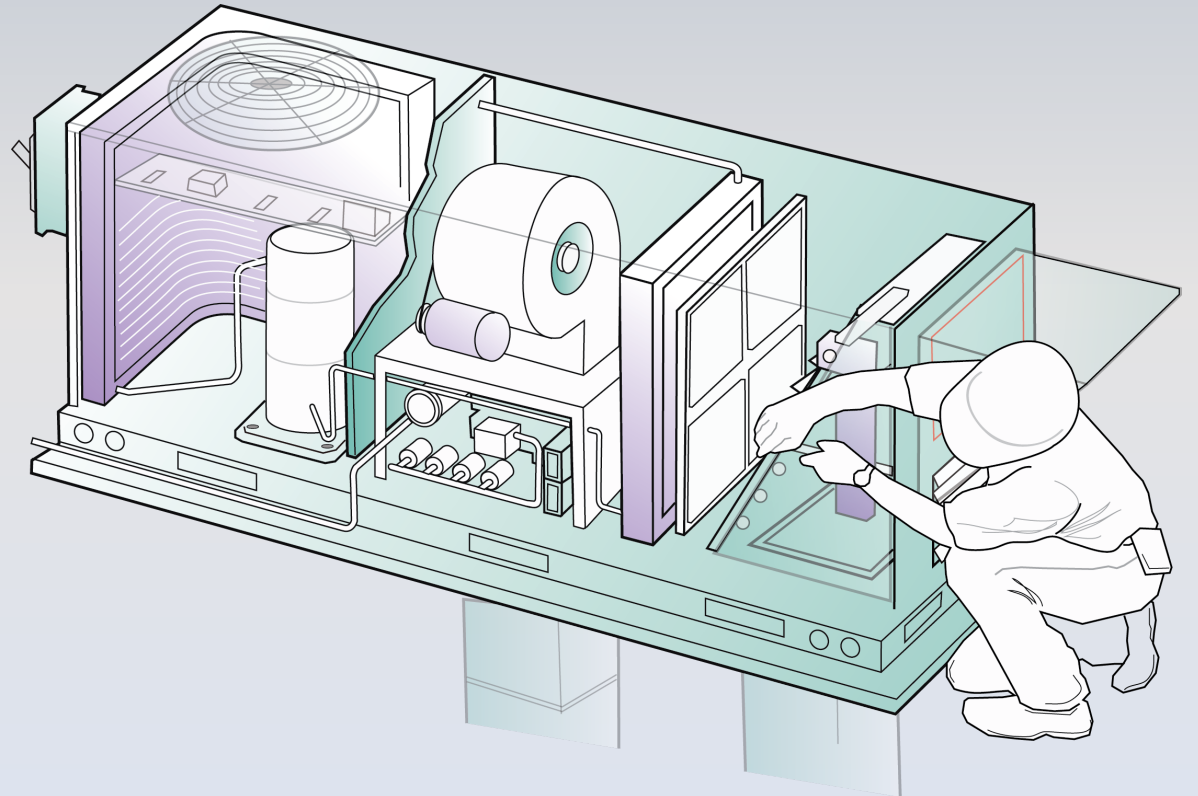
Balancing Work Type	Typical Percent of Savings
Testing and or diagnostics alone	0%
Balancing	5% to 10%
Minimal Repairs	8% to 13%
Typical Repairs	21% to 26%
Comprehensive Repairs	34% to 39%

Presentation Conclusion

Balancing principles can be easily adapted to diagnostics and finding solutions

This has the potential to yield significant energy savings

By implementing balancing principles and associated repairs any HVAC professional can improve the performance of a system



Thank You!

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