Training & Education
ECM APPLICATIONS AND BALANCING ISSUES FOR FAN COILS AND NEW TERMINAL UNIT EQUIPMENT AND SOUND AND NOISE IN OCCUPIED SPACES II
EPIC FAN TECHNOLOGY®

FAN COIL UNITS
Fan coils have traditionally been residential products – no design team defining the interior ambient.

Equipment designs are set at the absolute lowest first cost.

Any static pressure increase will cause the equipment to be de-rated.
FAN CURVES

EPIC ECM • Fan Performance Curves
- Airflow vs. External Static Pressure
FAN CURVES

Fan Performance Curves
- Airflow vs. External Static

PSC Motor

3-Speed ECM Motor

Individual Speeds are Adjustable

EPIC ECM Motor
CONTROL SEQUENCE

NEAR FULL LOAD

A F

TIME
CONTROL SEQUENCE

PART LOAD

AF

TIME
OPERATING SEQUENCE

NEAR NO LOAD

AF

TIME
MODULATING THE WATER AND AIR

- Takes Diversity Out of System at Water and Air Side
- Reduces Energy at Fan Motor
- Reduces Energy at Pump
- Makes Room More Comfortable
- Lowers Noise
- Reduces $\Delta T$ on Curtain Wall
- Payback on extra cost = 6 to 18 months
CONTROL SEQUENCES

Continuous Run Motor with Full Modulation Rather than Multiple Stages to Achieve Greater Operating Range

Holds Water and Air Together in Coil Longer for Higher Delta T to Chiller or Boiler
LOWER HUMIDITY

Better Comfort
Higher Set Point
LOWER HUMIDITY

Better Comfort
Higher Set Point
LOWER HUMIDITY

Better Comfort
Higher Set Point
LOWER HUMIDITY

Better Comfort
Higher Set Point
LOW OPERATING COST

- 4.72 EPIC Units Operating for the Cost of 1 Unit With PSC Motor
- Saving up to $127 per year at $0.10 per kWH
UNITS PROVIDE WIDEST FLEXIBILITY

- Superior Control Sequence For Full Modulation of Water and Airflow
- Better Control of Space Temperature and Humidity
- Lowest Sound Levels
- Lowest Energy Use with Greatest Space Comfort
MAKING TOMORROW’S IDEAS TODAY’S REALITIES
EPIC FAN TECHNOLOGY

FAN POWERED CHILLED WATER TERMINAL
PRODUCTS

FPCWT (DOAS) with Chilled Water Coil

FPCWT (DOAS) with Electric Heat
UNIT LAYOUT

- Two devices control airflow
- De-linked by induction port
- Difficult to balance
- Short circuiting primary air to return is not an option
- Pressure independent operation a must
GENERAL INFORMATION

▪ Official name from AHRI is Fan Powered Chilled Water Terminal Unit
▪ It is a Series Terminal Unit with a coil over the induction port
▪ Perfect for:
  • Office buildings
  • Lab spaces
  • Anywhere chilled beams or fan powered terminal units could be used with a dedicated outdoor air system
WHAT DOES IT DO?

- Modulates both the water and the air allowing the system to run in part load and takes diversity out of the system
- Provides sensible cooling at the Terminal Unit location in a DOAS system
- Replaces the air handlers in the building with the addition of an outdoor air unit
- Allows heat reclaim in the ceiling space
- Provides all the benefits of series unit
- Allows use of specialized diffusers
RATING PROBLEMS

- There is no standard for this unit
- Will be treated as a Fan Powered Terminal Unit
- Currently using ASHRAE 130 and probably ASHRAE 79 for the coils
- Plan for AHRI is to write a new Standard like 880
STANDARDS

- **Meets ASHRAE 62.1**
  - Meets Table 6.2 (ADPI from AHSRAE 113) that requires the T150 isovel to reach a plane 4.5’ above the floor during heating mode or requires an increased ventilation by 30%
  - Chilled Beams will not comply

- **Complies with ASHRAE 55**
  - Use of high tech and most common diffusers allows best air distribution effectiveness, $E_z$ values from ASHRAE 62.1
COIL INFORMATION

- Coil intended to be all sensible but might include occasional small latent capacity
  - Drip pan catches that
  - Filter is optional
- For regular latent capacity use a fan coil with OA option
  - This will require a filter
MAKING TOMORROW’S IDEAS TODAY’S REALITIES
IF A TREE FALLS IN THE FOREST AND NOBODY HEARS IT, DOES IT MAKE A NOISE?
SOUND AND NOISE

A high level overview of standards that affect sound levels on FAN COILS, FAN POWERED TERMINAL UNITS and FAN POWERED CHILLED WATER TERMINAL UNITS

- ASHRAE and AHRI have an agreement for Standard development
- ASHRAE does Method of Test
- AHRI does rating points
AHRI 885:
Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets

- Written by AHRI with data from ASHRAE Handbook and other standards and sources.
- Estimates resultant sound pressure levels
- Non-ducted units not currently included.
DIFFERENT PATHS TO OCCUPIED SPACE

885 then takes all the different sound paths and examines how each would affect the room **SOUND AND NOISE** levels. This is more about noise, but some about sound.

- **Sound Power** is the measure of energy being generated in the terminal unit – This is sound.
- **Sound Pressure** is the measure of pressure on a person’s eardrum. That part of sound pressure that detracts from the listener’s attention (like static on the radio) is noise. Noise is generally an irritant.

*The answer to the question is NO!*
Resultant NC does not describe sound quality

Radiated NC shown is hissy

Discharge NC shown is rumbly

No single number descriptor is going to describe sound quality
<table>
<thead>
<tr>
<th>COMMENTS ON STANDARDS</th>
<th>GOOD</th>
<th>BAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHRI 885</td>
<td>Will provide single number rating, NC, for comparison between manufacturers</td>
<td>Appendix E is often referenced as the resultant sound levels in the occupied space. It is not. It is the resultant sound level in the space described in appendix E, and that is probably not the same as the occupied space in the building in question. MAY REQUIRE NEW APPENDICES</td>
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</table>
SOUND AND NOISE

ANSI/ASHRAE 130: Methods of Testing Air Terminal Units

- Developed under ASHRAE TC 5.3
- ANSI/ASHRAE 130 instructs the manufacturer or laboratory how to run a performance test on all types of VAV Terminal Units
AHRI 880: Performance Rating of Air Terminals

- Developed under AHRI ACDD section
- Essentially same as ANSI/ASHRAE STANDARD 130, except there are mandatory rating points
AHRI Certification Points
Fan Powered Terminal Units

Performance Data • AHRI Certification and Performance Notes

<table>
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<tr>
<th>Unit Size</th>
<th>Inlet Size</th>
<th>Fan CFM</th>
<th>Fan Watts</th>
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<td>I/s</td>
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<td>100</td>
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<td>2 8</td>
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<td>3 10</td>
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<td>1800 849</td>
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<td>7 16</td>
<td>2800 1321</td>
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Fan Only* @ .25" w.g. (62 Pa) ΔPs

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<td>2 3 4 5 6 7</td>
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<tr>
<td>Primary CFM</td>
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<td>Min. Inlet ΔPs</td>
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<tr>
<td>Pa</td>
<td>72 61 58 55 56 59</td>
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<td>Radiated</td>
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Fan + 100% Primary @ 1.5" w.g. (375 Pa) ΔPs w/ .25" w.g. (62 Pa) Discharge ΔPs

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<td></td>
<td>80 76 70 62 60 61</td>
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</tbody>
</table>

Ratings are certified in accordance with AHRI Standards

AHRI CERTIFIED

VAU Terminals
AHRI Standard 880

www.ahridirectory.org
ASHRAE Standard 79 Has A Sound Test Now

For Radiated sound, the unit is mounted in a reverberant chamber and lagged ducts are attached to the inlet and outlet so that only the sound emitted from the unit is measured in the room. This is the radiated sound power from the unit casing.
ASHRAE Standard 79 Has A Sound Test Now

For Discharge sound power the unit is mounted outside the reverberant chamber and ducted into the room. This sound is piped through the ducts through the diffusers and into the occupied space.
## STANDARDS COMMENTS

<table>
<thead>
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<th>COMMENTS ON STANDARDS</th>
<th>GOOD</th>
<th>BAD</th>
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<tr>
<td>ANSI/ASHRAE 79</td>
<td>Has been rewritten and updated</td>
<td>Had been ignored for a long time</td>
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<tr>
<td></td>
<td>Now has a method of sound testing</td>
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<tr>
<td>ANSI/AHRI 440</td>
<td></td>
<td>Needs sound rating certification points</td>
</tr>
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- Getting sound ratings in 440 will be difficult
- There are 20+ voting members worldwide
Currently, there are no ASHRAE nor AHRI Standards for the Fan Powered Chilled Water Terminal Units
MAKING TOMORROW’S IDEAS TODAY’S REALITIES
TESTING, ADJUSTING AND BALANCING SERIES FAN POWERED VAV TERMINAL UNITS WITH ELECTRONICALLY COMMUTATED MOTORS
VOLUME CONTROLLER CARD

- Requires 24 VAC Power (Red LED constant)
- **Green** LED indicates airflow in 100’s of cfm. One full blink = 100 CFM and last one is scaled
- Place multimeter leads on the TP1 and TP2 terminals to measure Vdc (refer to ECM Fan Calibration table)

Volume controller card can be Automatic or Manual

- 0 - 10 Vdc mode allows BAS to adjust airflow
- Manual mode (Constant Volume) potentiometer sets airflow (CW increases and CCW decreases)
FLOW HOODS

- Used for proportional air balance of diffusers
- Calibrated on wind tunnel with a 24” x 24” straight down duct
- Flow Hood skirt size should closely match the diffuser size and a firm seal should be made around the diffuser
- Horizontal flows can generate errors
2. **Back-pressure compensation** using different supply register and diffuser styles
STANDARD HOOD:
Error% vs Flow for a selected group of diffusers
CFD ANALYSIS OF AIRFLOW PATTERNS INSIDE A HOOD

Provided by Dwyer
FLOW MEASUREMENTS

Calibration Condition

Oversized Skirt
FLOW MEASUREMENTS

2 x 2 Pattern Diffuser

Slot Diffuser
# EXPLANATION OF ASYMMETRY EFFECTS

## Vertical Inlet Duct Height - 0 Duct Diameter - No Damper

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<th>Diffuser Type</th>
<th>Forward Throw Asymmetry</th>
<th>Total Pressure Increase</th>
<th>NC Increase</th>
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<td>1.4 - 1.7</td>
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<td>Round</td>
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<td>1.4 - 1.6</td>
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<tr>
<td>Plaque</td>
<td>1.2 - 1.3</td>
<td>1.4 - 1.7</td>
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<tr>
<td>Perforated</td>
<td>1.3</td>
<td>1.4 - 1.6</td>
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<tr>
<td>Modular core</td>
<td>1.4</td>
<td>1.2 - 1.4</td>
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<tr>
<td>Louvered</td>
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<td>1.5 - 1.8</td>
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Reference: ASHRE RP-1335
✓ Verify Air Handler is operating at “Full Cool” conditions
✓ Obtain multi-meter with clamp for amp reading
✓ Verify the Red LED is illuminated and the Green LED blips are present at the volume control card
✓ Set the fan airflow at full cooling volume
✓ Count the blinks should be 1/100 cfm plus last one scaled.
Operating Sequence
EPIC Fan Powered Terminal Unit

Airflow

Maximum Heating
Fan Airflow
Dead Band
Damper Airflow
Maximum Cooling

Heating Set Point
Cooling Set Point

Room Temperature
The controls contractor should have entered 2 equations into the local controller

- One equation solves for the demanded airflow and outputs a voltage value. That voltage can be measured at the voltage terminals on the card.
- The second equation solves for airflow volume and outputs the cfm to the BAS to be read by the building engineer.
MOTOR CONTROLLER CARD
<table>
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<th>CFM</th>
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</table>
The Division 25 Subcontractor shall field program the design set points as indicated in the Contract Document schedules for:

1. Maximum cooling fan airflow
2. Minimum fan airflow
3. Maximum heating fan airflow
4. Maximum primary damper airflow
5. Minimum primary damper airflow

(NOTE.)

Airflow settings shall be reported from the BMCS in cubic feet per minute or liters per second as scheduled, not as a percentage of the set points.
TERMINAL UNIT BALANCING PROCEDURE

1. Drive the VAV damper closed.

2. Shut down the fan terminal unit and remove the construction filter from the induction port return air inlet.

3. Prior to powering the terminal unit, the fan volume control card shall be verified to be in the 0 – 10 vdc mode.

4. The primary air handling unit shall be operating and providing adequate air to test the Terminal Units.
5. The Terminal Unit shall be started and adjusted through the Division 25 BMCS to the maximum cooling fan airflow rate. Fan airflow shall be verified by measuring the fan volume control card DC voltage signal. DC voltage shall be compared to the terminal unit airflow chart provided by the terminal unit manufacturer to determine the fan airflow rate.

6. Count the green light blinks and verify count at 1 blink/100 cfm with the last one scaled.

7. The Air Balance Subcontractor shall not readjust the fan from this point on.
8. After the fan is set to the specified airflow. The induced air opening shall be covered with a temporary cover during this test except for a 3” diameter test opening with a string hanging down across the hole.

9. Adjust the primary air flow until the string is neutralized. At this point the fan and damper airflow is equal and all duct and connection irregularities have been calibrated out.

10. At this point the K or F factor shall be set in the local controller to reflect the fan airflow. Airflow shall be recorded and set.
11. Remove the inlet restriction from the induction port.

12. Reset the fan for minimum airflow using voltage readings from (TP1 and TP2) and referencing it to the E.C. motor fan calibration table. Record the number.

13. Reset the fan for the maximum heating airflow using voltage readings from (TP1 and TP2) and referencing it to the E.C. motor fan calibration table. Record the number.

14. Recheck and confirm the correction factor established in setting the maximum cooling airflow at primary air valve for minimum airflow.
DIFFUSER PROPORTIONAL BALANCING

- Always begin with the dampers open
- Each Diffuser is measured with a Flow hood
- Begin measuring from the furthest outlet back to the FPB
- Sum all airflows for the total measured airflow for the cooling zone.
- Compare scheduled and measured airflows
- Calculate corrected airflow
- Proportional Balance diffusers within 10%
FPTB (Tag # SIZE 5) JOB SITE TAG  
NAILOR IND.

FAN VOLTAGE 0.5-10VDC/AMPS

<table>
<thead>
<tr>
<th>MAX</th>
<th>MIN</th>
<th>HTR MAX</th>
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HEAT

<table>
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<tr>
<th>STAGE 1 AMPS</th>
<th>STAGE 2 AMPS</th>
<th>E.W.T/ L.W.T</th>
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Schedule A/F = 2000  
Total Meas. = 1694  
Factor=2000/1694 = 1.18

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<tr>
<th>DIFFUSER</th>
<th>Schedule A/F</th>
<th>PROP %</th>
<th>MEASURED A/F</th>
<th>CORRECTED A/F</th>
<th>% Difference</th>
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**Do Not Reset Fan**
15. Balancing hoods shall be used only to confirm a proportional air balance for diffusers attached to an individual fan powered terminal unit. Adjust manual balancing dampers on each diffuser as necessary to achieve a proportional balance of the diffusers with a maximum difference of ten (10%) percent between the diffuser design airflow and the adjusted reading on each diffuser. Lock damper handles in place after final readings are made.
16. Replace fan powered terminal unit inlet air filters with clean set supplied by the Division 25 Subcontractor.

17. Report all deficiencies to the Division 25 Subcontractor and to the Engineer.

18. Reset room sensor to the design set point.

19. The final balanced position of manual balancing dampers shall be permanently marked on the ductwork or insulation by the Air Balancing Subcontractor.
MAKING TOMORROW’S IDEAS TODAY’S REALITIES