Training & Education
ECM APPLICATIONS AND BALANCING ISSUES FOR FAN COILS AND NEW TERMINAL UNIT EQUIPMENT

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Nailor Industries, Inc.

Date
FEATURES APPLICATIONS BENEFITS
Some States have already adopted the 2013 version – Oregon and Massachusetts maybe others

Some States will take up to 4 to 7 years to adopt 2013 version

California uses their own energy code, and it is same as 2013
90.1 GOAL

ASHRAE 90.1 New Construction Commercial Efficiency Requirements

Energy Use Index (1975 Use = 100)

Historical Whole Building Savings

Year

Future Target

Path B

90.1-2021 (BOD Goal)

90.1-2028?

90.1-2025 Est

90.1-2028?

90.1-2022 Est

90.1-2019 Est

90.1-2015 Goal

90.1-2013

90.1-2010

90.1-2007

90.1-2004

90.1-2001

90.1-1999

90.1-1989

90A-1980

90-75

150 Ton AC Chiller

10 Ton Rooftop

500 Ton WC Chiller

Path B
Energy is the largest cost.

Life cycle building costs.

Energy is largest cost.
Everybody wants to decrease energy, so why not turn the system off?

Are these the most important issues?
It has been reported that the #1 reason for not renewing a lease is **Occupant Dissatisfaction** with Thermal or Acoustical environment.

$2.00/Square foot for energy - $200 to $500/square foot for salaries.
ASHRAE 90.1, APPENDIX G, G3.1.2.2

Equipment Capacities, “The equipment capacities (i.e. system coil capacities) for the baseline building design shall be based on sizing runs for each orientation (per table G3.1, No. 5a) and shall be oversized by 15% for cooling and 25% for heating...”
2 TYPES OF ECM's

3-Speed

- Five fixed speeds
- Programmable speed selections
- Limited turn-down – 50% of max

EPIC Fan Control

- Full Modulation
- Noise Reduction – 15 to 20 NC
- Fan Energy Reduction – Up to 90%
PERFORMANCE DATA

Series Flow • PSC Motor Fan Curves
Airflow vs. Downstream Static Pressure

- Fan curves shown are applicable to 120, 208, 240 and 277 volt, single phase PSC motors.

### Electrical Motor Data

<table>
<thead>
<tr>
<th>Unit Size</th>
<th>Motor H. P.</th>
<th>PSC Motor FLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/10</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>1/10</td>
<td>3.3</td>
</tr>
<tr>
<td>3</td>
<td>1/4</td>
<td>5.8</td>
</tr>
<tr>
<td>4</td>
<td>1/2</td>
<td>6.2</td>
</tr>
<tr>
<td>5</td>
<td>1/2</td>
<td>10.1</td>
</tr>
<tr>
<td>6</td>
<td>3/4</td>
<td>13.4</td>
</tr>
<tr>
<td>7</td>
<td>2 &amp; 1/2</td>
<td>20.2</td>
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</table>

FLA = Full load amperage
• Slip is difference between shaft and magnetic field rotation speed

• Speed reduction is by loss of strength in magnetic field not change in rotational rate

• Efficiency drops dramatically in PSC motors as speed drops
EPIC FAN CURVE

- Programmed maximum and minimum airflows beneath fan curve.
- Efficiency improved at top end and fairly constant across entire operating range
- Extra airflow at top and bottom of curve
- FLA occurs at top right, not top left
WATTS PER CFM

- To calculate savings, look at Watts per CFM
- Horsepower is meaningless
- You need to know
  - Rated FLA
  - Rated MOP and MCA
  - Application HP
  - Application AMPS
- Savings are huge – applies to Terminal Units, Fan Coil Units and Fan Powered Chilled Water Terminal Units
PERFORMANCE DATA

Series Flow · ECM Motor Option Fan Curves
EPIC Fan Technology® - Airflow vs. Downstream Static Pressure
PERFORMANCE DATA

Series Flow • ECM Motor Option Fan Curves
EPIC Fan Technology® - Airflow vs. Downstream Static Pressure
WATT CONSUMPTION
SO WHAT DO YOU GET?

EPIC™/ECM MOTOR TECHNOLOGY

- Significant energy saving
  (67% average compared to PSC motors)
- Unique factory pre-set air volume capability (+/-5%)
- Pressure independent fan operation
- LED for visual indication of air volume
- Field adjustable fan air volume controller
- Remote fan air volume adjustment capability from BAS
- Larger turn down ratios mean more flexibility for tenant changes
- Fan status relay
- Fan interlock relay
MAKING TOMORROW’S IDEAS
TODAY’S REALITIES
EPIC FAN TECHNOLOGY®

FAN POWERED TERMINAL UNITS
SERIES TERMINAL UNITS

Diagram showing airflow paths in a series terminal unit:
- Primary Air
- Recirculated Plenum Air
- Fan
- Discharge Air
- Heater
ASHRAE 90.1, APPENDIX G, G3.1.2.2

Equipment Capacities, “The equipment capacities (i.e. system coil capacities) for the baseline building design shall be based on sizing runs for each orientation (per table G3.1, No. 5a) and shall be oversized by 15% for cooling and 25% for heating...”
SERIES TERMINAL UNITS

Operating Sequence
EPIC Fan Powered Terminal Unit

Airflow

Maximum Heating
Fan Airflow
Dead Band

Maximum Cooling
Damper Airflow

Heating Set Point
Cooling Set Point

Room Temperature
SERIES TERMINAL UNITS

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
SERIES TERMINAL UNITS – POOR PLAN

Operating Sequence
Low Temperature Application - No Temperature Rise

Airflow

51° F

45°-48° F

Still 51°-55° F
Overcools in Dead Band

Dead Band

Room Demand
SERIES TERMINAL UNITS

Operating Sequence
Low Temperature Application - With Temperature Rise

Airflow

Room Demand

51°F
45°F-48°F

Dead Band

Raises Discharge Air Temperature to Protect Space From Overcooling. 60° Design
ACCURACY OF CONTROL

\[ y = -0.0611x^5 + 1.6449x^4 - 17.009x^3 + 83.525x^2 + 16.974x + 196.55 \]
\[ R^2 = 0.9999 \]

\[ y = 1.1471E^{-15}x^5 - 6.4746E^{-12}x^4 + 1.3977E^{-08}x^3 - 1.4315E^{-05}x^2 + 1.1675E^{-02}x - 1.3973E+00 \]
\[ R^2 = 9.9987E-01 \]
TERMINAL UNIT BENEFITS

- **Lower Fan Energy**
  - Fan efficiency improves cubically as airflow decreases

- **Less Plenum Heat**
  - Fan airflow decreases as primary airflow decreases
  - Some plenum heat is necessary at minimum flow to insure against over-cooling

- **Built-in Fan Status on BMS**

- **Built-in Fan Safety Switch for Electric Heat**

- **More Efficient Motor at All Airflows**
THE FIRST LAYOUT OF FAN POWERED TERMINAL UNIT – SIDE POCKET FANS
ORIGINAL COMPONENTS
ONE OF FIRST 3 INSTALLATIONS
REVERSE ANGLE – VOLUME CONTROL
COMBINED BDD, FAN AND HEATER
Figure 27. Parallel Flow Terminal Configuration
Fig. 2 Initial Parallel Fan Powered VAV Sequence
SERIES UNIT – ABOUT 1979
Figure 26. Series Flow Terminal Configuration
ORIGINAL SERIES CONTROL SEQUENCE

ROOM SET POINT

FAN AIR

PLENUM AIR

PRIMARY AIR

AIRFLOW

HEAT ON

ROOM TEMPERATURE
The RP 1292 research project and subsequent research projects on Series and Parallel VAV Terminal Units has to date generated 28 ASHRAE Technical Papers. The latest three are being presented at the summer 2019 meeting.

Of these papers 9 have won ASHRAE awards. Two of these also won the Crosby-Field award.

This does not count a couple of Journal articles, at least one other publication in an ASHRAE Technical publication and the ASHRAE Design Guide for Air Terminal Units. There are a few more to go.

Also, papers on the subsequent research, RP 1741, on fan coil units will begin shortly. There will be several of those as well.
### CONTRASTING PARALLEL AND SERIES

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<th>ISSUE</th>
<th>PARALLEL</th>
<th>SERIES</th>
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<tr>
<td>LOW TEMPERATURE AIR</td>
<td>POOR CONTROL</td>
<td>AVAILABLE OPTION</td>
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<tr>
<td>DEDICATED OUTDOOR AIR SUPPLY</td>
<td>POOR CONTROL</td>
<td>AVAILABLE OPTION</td>
</tr>
<tr>
<td>FIRST COST</td>
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</tr>
<tr>
<td>OPERATING COSTS</td>
<td>INCREASED</td>
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<tr>
<td>90.1 REQUIREMENT TO COUNT MOTOR HORSEPOWER</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>INCREASED AIR HANDLER HP</td>
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<tr>
<td>NOISE LEVELS</td>
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<td>62.1 ALLOWS CREDIT FOR RECIRCULATED AIR REDUCING OUTDOOR AIR REQUIREMENTS</td>
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<td>POTENTIAL SAVINGS WITH ECM MOTORS</td>
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