Fan Efficiency Metrics

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Presentation Outline

• Introduction to AMCA
• Why Obsolete the Current Metric (FEG)?
• Introduction of the Fan Energy Index
• Questions
Introduction to AMCA

• **Air Movement and Control Association Int.**
• Not-for-profit manufacturers association established in 1917
• More than 370 member companies worldwide
• Mission is to promote the health, growth and integrity of the air movement and control industry
Content Development

- Test Standards
  - ANSI Accredited
  - ISO Member
- Application Guides
- White Papers
- Videos
- Magazine
- Social Media
AMCA Educational Programs

- Meetings
- Conferences
- Engineering Seminars
- Workshops
Worldwide Network of Test Labs

- Chicago headquarters
- Regional independent labs
  - Dubai
  - Malaysia
  - France
  - Korea
- Accredited manufacture’s labs
  - > 50 worldwide
The AMCA Certified Ratings Program

- Helps ensure honest and accuracy in product rating
- 3,690 product lines certified
  - 5.4 percent over the last year.
- 270 participating companies
  - 12 percent gain since last
Why Obsolete the Current Metric (FEG)?
"Elements" of Fan Power

- Electrical Power In
- Motor Loss (10%)
- Drive Loss (3% - 10%)
- Bearing Loss (3%)
- Aerodynamic Loss (10% to 20%)

Overall Fan Power (wire to air)

Fan Power (at the shaft)
Fan Efficiency Grade
Single Point Metric

Air Flow, $Q$

Efficiency, $\eta$

3 – 5% Efficiency Gain

Typical Selection
Leaves Efficiency Gains on the Table

![Graph showing efficiency gains with air flow. The efficiency increases up to a certain point and then decreases, with an efficiency range of 25-40% indicated.]
# Fan Efficiency Varies with Size for a Duty Point

<table>
<thead>
<tr>
<th>Fan Size [in.] (mm)</th>
<th>Fan Speed (rpm)</th>
<th>Fan Power (bhp) [kW]</th>
<th>Actual Total Efficiency (%)</th>
<th>FEG</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 (460)</td>
<td>3,238</td>
<td>11.8 [8.8]</td>
<td>40.1</td>
<td>85</td>
</tr>
<tr>
<td>20 (510)</td>
<td>2,561</td>
<td>9.6 [7.2]</td>
<td>49.5</td>
<td>85</td>
</tr>
<tr>
<td>22 (560)</td>
<td>1,983</td>
<td>8.0 [6.0]</td>
<td>59.0</td>
<td>85</td>
</tr>
<tr>
<td>24 (610)</td>
<td>1,579</td>
<td>6.8 [5.0]</td>
<td>69.1</td>
<td>85</td>
</tr>
<tr>
<td>27 (685)</td>
<td>1,289</td>
<td>6.2 [4.6]</td>
<td>75.8</td>
<td>85</td>
</tr>
<tr>
<td>30 (770)</td>
<td>1,033</td>
<td>5.7 [4.3]</td>
<td>82.5</td>
<td>85</td>
</tr>
<tr>
<td>36 (920)</td>
<td>778</td>
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<td>85</td>
</tr>
</tbody>
</table>
Finally, we also needed to address:

- The regulation of electrical input power
- The use of fan static pressure for non-ducted fans
- The elimination of categories to allow product substitution
- DOE could not regulate fan application, but they COULD regulate how fan data is presented to the public
Regulatory Dilemma

• Typical regulations are based on increasing “peak efficiency” by eliminating products that do meet a baseline “peak efficiency”
• Fan efficiency is highly sensitive to actual operating conditions
• Peak fan efficiency for a given model varies little across diameters
  ▪ FEG used in ASHRAE 90.1 has this characteristic
  ▪ Peak fan efficiency for a given model varies slightly with fan speed.
Typical practice is to select smaller-diameter fans for lowest first cost. Result is smaller, less-efficient fans that meet peak-efficiency requirements. 90.1 had provision for selecting fans within 10 percentage points of peak total efficiency. Greatly complicates application and enforcement.
Introduction of the Fan Energy Index
Fan Energy Index Establishes “Selection Bubbles”

- Selection bubbles are regions of a fan curve that are compliant.
- Designers must size and select fans so that the nominal design point falls within the bubble.
- Manufacturers software will only show compliant selections for given operating conditions.
- The direct result is that few fan are models eliminated from market.
- Some shifting from less-efficient types to more-efficient types.
- Emphasis is on proper sizing and selection.
Fan Efficiency Index (FEI)

FEI = \frac{Selected \ Fan \ Efficiency}{Baseline \ Fan \ Efficiency}

FEI = \frac{Baseline \ Fan \ Electrical \ Input \ Power}{Selected \ Fan \ Electrical \ Input \ Power}
Baseline Fan Shaft Input Power

\[ H_{i,\text{ref}} = \frac{(Q_i + Q_0)(P + P_0 \times \frac{\rho}{\rho_{\text{std}}})}{1000 \times \eta_0} \]

- \( Q_i \) - selected fan airflow
- \( P_i \) - selected fan total pressure (ducted), or tatic pressure (nonducted)
- \( P \) - air density
- \( \rho_{\text{std}} \) - standard air density
- \( Q_0 \) - 0.118 m\(^3\)/s (SI), or 250 cfm (IP)
- \( P_0 \) - 100 Pa (SI), or 0.40 in.wg (IP)
- \( \eta_0 \) - 66% for ducted applications and 60% for nonducted applications
Baseline Electrical Input Power

\[ H_{i,\text{ref}} = \frac{(Q_i + Q_0)(P + P_0 \times \frac{\rho}{\rho_{\text{std}}})}{1000 \times \eta_o} \]

\[ W_{i,\text{ref}} = H_{i,\text{ref}} + \text{AMCA 203 Belt Loss} + \text{IE3 Motor loss} \]

\[ W_{i,\text{ref}} = \text{Baseline Electrical Input Power} \]
### Comparing FEI against FEG

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<tr>
<th>Fan Size [in.] (mm)</th>
<th>Fan Speed (rpm)</th>
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<th>Actual Total Efficiency (%)</th>
<th>Baseline Power</th>
<th>FEG</th>
<th>FEI</th>
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<td>1.32</td>
</tr>
</tbody>
</table>
# More Comparisons

<table>
<thead>
<tr>
<th>Fan Size (in.) [mm]</th>
<th>Fan Speed (rpm)</th>
<th>Speed Reduction from Smallest Diameter</th>
<th>Fan Power (bhp)</th>
<th>Power Reduction from Smallest Diameter</th>
<th>Actual Total Efficiency</th>
<th>Efficiency improvement Over Smallest Diameter</th>
<th>Baseline Power (bhp)</th>
<th>FEI</th>
<th>FEI Improvement over Smallest Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 [460]</td>
<td>3238</td>
<td>11.8</td>
<td>40.10%</td>
<td>7.96</td>
<td>0.67</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 [510]</td>
<td>2561</td>
<td>79%</td>
<td>9.56</td>
<td>81%</td>
<td>49.50%</td>
<td>23%</td>
<td>7.96</td>
<td>0.83</td>
<td>24%</td>
</tr>
<tr>
<td>22 [560]</td>
<td>1983</td>
<td>61%</td>
<td>8.02</td>
<td>68%</td>
<td>59.00%</td>
<td>47%</td>
<td>7.96</td>
<td>0.99</td>
<td>48%</td>
</tr>
<tr>
<td>24 [610]</td>
<td>1579</td>
<td>49%</td>
<td>6.84</td>
<td>58%</td>
<td>69.10%</td>
<td>72%</td>
<td>7.96</td>
<td>1.16</td>
<td>73%</td>
</tr>
<tr>
<td>27 [685]</td>
<td>1289</td>
<td>40%</td>
<td>6.24</td>
<td>53%</td>
<td>75.80%</td>
<td>89%</td>
<td>7.96</td>
<td>1.28</td>
<td>91%</td>
</tr>
<tr>
<td>30 [770]</td>
<td>1033</td>
<td>32%</td>
<td>5.73</td>
<td>49%</td>
<td>82.50%</td>
<td>106%</td>
<td>7.96</td>
<td>1.39</td>
<td>107%</td>
</tr>
<tr>
<td>33 [840]</td>
<td>887</td>
<td>27%</td>
<td>5.67</td>
<td>48%</td>
<td>83.40%</td>
<td>108%</td>
<td>7.96</td>
<td>1.4</td>
<td>109%</td>
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<td>24%</td>
<td>6.01</td>
<td>51%</td>
<td>78.70%</td>
<td>96%</td>
<td>7.96</td>
<td>1.32</td>
<td>97%</td>
</tr>
</tbody>
</table>
How Will FEI Be Used?

<table>
<thead>
<tr>
<th>Body</th>
<th>FEI Requirement (forecast – not certain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Federal or California Regulation</td>
<td>FEI ≥ 1.0 at Design Point</td>
</tr>
<tr>
<td>ASHRAE 90.1</td>
<td>FEI ≥ 1.0 at Design Point</td>
</tr>
<tr>
<td>ASHRAE 189.1</td>
<td>FEI ≥ 1.10 at Design Point</td>
</tr>
<tr>
<td>Rebates</td>
<td>FEI = Savings over Baseline</td>
</tr>
</tbody>
</table>

FEI = 1.10 means 10% energy savings over baseline
FEI Range for Constant Speed Fan
FEI Range for Centrifugal with Speed Control

![Diagram of FEI Range for Centrifugal with Speed Control](image.png)

**Efficient Fan**

- High Efficiency Fan
- Peak Efficiency

**Inefficient Fan**

- Low Efficiency Fan
- Maximum speed in which FEI ≥ 1.0 at best efficiency point
Status

• AMCA Standard 208 in ballot phase per ANSI process
• AMCA 208 will be integrated into ISO 12759
• Default losses for drive components based on AMCA 207 (draft ISO 12750)
• FEI would be calculated using rating data taken during AMCA 210 or ISO 5801 tests
• U.S. DOE regulation stalled, but would be based on FEI
• California started regulation picking up where DOE left off
• ASHRAE 90.1 replacing FEG with FEI
• U.S. efficiency rebates will be based on FEI
Resources

• AMCA International: www.amca.org
• AMCA White Papers: www.amca.org/whitepapers
• AMCA Standards Bookstore: www.amca.org/store
Thank You Very Much… and…Questions?