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

Overall Fan Power (wire to air)

Fan Power (at the shaft)

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

![Graph showing Fan Efficiency Grade with varying impeller diameters and corresponding peak total efficiencies.](image-url)
Single Point Metric

![Graph showing efficiency gain and typical selection](image)
Leaves Efficiency Gains on the Table

Efficiency, $\eta$

Air Flow, $Q$

25 - 40%
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>
<td>6.0 [4.5]</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.
Regulatory Dilemma

- 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>
<th>Fan Power (bhp) [kW]</th>
<th>Actual Total Efficiency (%)</th>
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<th>FEG</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></td>
<td></td>
<td></td>
<td>7.96</td>
<td>0.67</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>36 [920]</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

![Graph showing the FEI Range for Constant Speed Fan](image-url)
FEI Range for Centrifugal with Speed Control

EFFICIENT FAN

[Diagram showing performance characteristics of high efficiency fans with peak efficiency points marked.]

INEFFICIENT FAN

[Diagram showing performance characteristics of low efficiency fans with peak efficiency points marked.]
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](http://www.amca.org)
- AMCA White Papers: [www.amca.org/whitepapers](http://www.amca.org/whitepapers)
- AMCA Standards Bookstore: [www.amca.org/store](http://www.amca.org/store)
Thank You Very Much… and… Questions?