Fan Efficiency Metrics

Mark Stevens, Executive Director
Michael Ivanovich, Senior Director, Industry Relations
Air Movement and Control Association International, Inc.
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

2017 AMCA Spring Meetings
February 27 & 28, 2017
Scottsdale, AZ

Find Your Way Out West.
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
Why Obsolete the Current Metric (FEG)?
Fan Efficiency Grade

Graph showing the relationship between Impeller Diameter (in) and Peak Total Efficiency, pTE (%). The graph includes lines for different Fan Efficiency Grades (FEG 85, FEG 80, FEG 75, FEG 71, FEG 67, FEG 63, FEG 60, FEG 56, FEG 53, FEG 50).
Single Point Metric

Efficiency, $\eta$

Air Flow, $Q$

3 – 5% Efficiency Gain

Typical Selection
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>
<td>78.7</td>
<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
Introduction of the Fan Energy Index
Fan Efficiency Index (FEI)

\[
FEI = \frac{\text{Selected Fan Efficiency}}{\text{Baseline Fan Efficiency}}
\]

\[
FEI = \frac{\text{Baseline Fan Electrical Input Power}}{\text{Selected Fan Electrical Input Power}}
\]
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 m³/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

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

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

\[ W_{i,\text{ref}} = \text{Baseline Electrical Input Power} \]
Baseline Efficiency with Constant $\eta_o$
Baseline Efficiency with Varying $\eta_o$
## Comparing FEI against FEG

<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>Baseline Power</th>
<th>FEG</th>
<th>FEI</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 (460)</td>
<td>3,238</td>
<td>11.8 [8.8]</td>
<td>40.1</td>
<td>7.96</td>
<td>85</td>
<td>0.67</td>
</tr>
<tr>
<td>20 (510)</td>
<td>2,561</td>
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<td>49.5</td>
<td>7.96</td>
<td>85</td>
<td>0.83</td>
</tr>
<tr>
<td>22 (560)</td>
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<td>59.0</td>
<td>7.96</td>
<td>85</td>
<td>0.99</td>
</tr>
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<td>7.96</td>
<td>85</td>
<td>1.16</td>
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<td>1,289</td>
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<td>75.8</td>
<td>7.96</td>
<td>85</td>
<td>1.28</td>
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<tr>
<td>30 (770)</td>
<td>1,033</td>
<td>5.7 [4.3]</td>
<td>82.5</td>
<td>7.96</td>
<td>85</td>
<td>1.39</td>
</tr>
<tr>
<td>36 (920)</td>
<td>778</td>
<td>6.0 [4.5]</td>
<td>78.7</td>
<td>7.96</td>
<td>85</td>
<td>1.32</td>
</tr>
<tr>
<td>Fan Size (in.) [mm]</td>
<td>Fan Speed (rpm)</td>
<td>Speed Reduction from Smallest Diameter</td>
<td>Fan Power (bhp)</td>
<td>Power Reduction from Smallest Diameter</td>
<td>Actual Total Efficiency</td>
<td>Efficiency improvement Over Smallest Diameter</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------</td>
<td>---------------------------------------</td>
<td>-----------------</td>
<td>----------------------------------------</td>
<td>------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>18 [460]</td>
<td>3238</td>
<td>11.8</td>
<td>40.10%</td>
<td></td>
<td>7.96</td>
<td>0.67</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>
</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>
</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>
</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>
</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>
</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>
</tr>
<tr>
<td>36 [920]</td>
<td>778</td>
<td>24%</td>
<td>6.01</td>
<td>51%</td>
<td>78.70%</td>
<td>96%</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

EFFICIENT FAN

INEFFICIENT FAN

Maximum speed in which FEI ≥ 1.0 at best efficiency point
FEI Range for Adjustable Pitch Axial
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 stated 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 Standards Bookstore: www.amca.org/store
Thank You Very Much... and... Questions?