Rules of Thumb

- Minimum 2.5 duct diameters on outlet
- Minimum 3 to 5 duct diameters on inlet
- Avoid inlet swirl
Recommendations

- Allow enough space in the building design to allow for appropriate fan connections to the system
Recommendations

- Use allowances in the design calculations when space or other factors dictate less than optimum arrangement of the fan outlet and inlet connections
Recommendations

- Include adequate allowance for the effect of all accessories and appurtenances on the performance of the system and the fan
Questions?

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Questions?

Mark Stevens

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Break and Sponsor Expo

- Visit all booths to enter drawing for gold and silver bars
- Booth representatives will sign off on tracking sheet
- Place completed sheet in box
- Drawing before Networking Lunch

- Gold/Silver Drawing Sponsored by Hammam Industries & Co.
INTRODUCING FAN ENERGY INDEX

Michael Ivanovich
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Learning Objectives

- Fan Energy Index (FEI) is a fan efficiency metric that can include motor and drive (belt-driven, direct-drive, and VFD)
- Fan Energy Index will replace Fan Efficiency Grade (FEG) eventually in ASHRAE 90.1 and ASHRAE 189.1
- Fan Energy Index can include design-point application data (airflow and pressure) to optimize fan size and type for maximum efficiency
Outline

• Fan efficiency metrics – a quick comparison
• Why Fan Energy Index
• Introducing Fan Energy Index
• Where to learn more
“Elements” of Fan Energy

Overall Fan Power (wire to air)

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

Fan Power (at the shaft)

Fan Power Out
Comparison of Fan Efficiency Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Reference Standard or Publication</th>
<th>Where Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan Efficiency Grade (FEG)</td>
<td>AMCA 205 and ISO 12759</td>
<td>ASHRAE 90.1, ASHRAE 189.1, International Energy Conservation Code, European Regulation, federal regulations in some Asian countries</td>
</tr>
<tr>
<td>Fan Motor Efficiency Grade (FMEG)</td>
<td>ISO 12759</td>
<td>European Regulation, product regulations in some Asian countries</td>
</tr>
</tbody>
</table>
## Comparison of Fan Efficiency Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Wire to Air</th>
<th>Fan Only</th>
<th>Total Pressure</th>
<th>Static Pressure</th>
<th>Covers Selection</th>
<th>Covers Part-Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan Efficiency Grade (FEG)</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
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<tr>
<td>Fan Motor Efficiency Grade (FMEG)</td>
<td>x</td>
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<td>x</td>
<td>x</td>
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<td></td>
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<tr>
<td>Fan Energy Index</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
Introducing Fan Energy Index

- Fan *Energy* Index (FEI) = \( \frac{\text{Baseline Power}}{\text{Fan Power}} \)

- Power = Fan Electrical Input Power (FEP)
- Baseline Power = Maximum FEP @ a given operating point
- Fan Power = Actual FEP @ a given operating point
Introducing Fan Energy Index

- FEI can be expressed in terms of overall wire-to-air efficiency of the driven fan system (top) and electrical power input to the driven fan (bottom)

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

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

Because goal for regulation or incentive is to reduce power
Introducing Fan Energy Index

- These overall values can either be measured using electrical input power or they can be calculated from the combination of individual components.

\[
\text{Overall Efficiency} = \text{Fan Efficiency} \times \text{Trans Efficiency} \times \text{Motor Efficiency} \times \text{Controller Efficiency}
\]

\[
\text{Overall Input Power} = \text{Fan Shaft Power} + \text{Trans Loss} + \text{Motor Loss} + \text{Controller Loss}
\]

Multiply efficiency losses for Overall Efficiency
Add efficiency losses for Overall Input Power
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 peak operating conditions
- Peak fan efficiency for a given model varies little across diameters
  - FEG used in ASHRAE 90.1 has this characteristic
Regulatory Dilemma

- Typical practice is to select smaller-diameter fans for lowest first cost
- Result is smaller, inefficient 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
Fan Energy Index Establishes “Selection Bubbles”

- Selection bubbles are regions of a fan curve that are compliant
- Designers must size and select fans that will run within the bubble
- Manufacturers software will only show compliant selections for given operating conditions
- Result is fewer fan models eliminated from market
- Some shifting from less-efficient types to more-efficient types
- Emphasis is on proper sizing and selection
Introducing Fan Energy Index

- FEI ≥ 1.0 is compliant
  - FEI varies along the fan curve
    - This is what makes selection matter
    - Higher efficiency fans have greater number of possible selections (applications)
    - Lower efficiency fans have fewer applications, but are not necessarily removed from market
  - FEI is independent of fan type
    - This promotes selecting more efficient fan types
Figure courtesy of Greenheck article In HPAC Engineering July 2016
## What does this mean to Fan Selections?

Electronic Fan Selection Software based on Total Pressure  
**Design Point 10,000 CFM at 3.0” Pt**  
[283,000 lpm at 85 pascal]

<table>
<thead>
<tr>
<th>Fan Size (in.) [mm]</th>
<th>Fan Speed (rpm)</th>
<th>Fan Power (bhp)</th>
<th>Actual Total Efficiency</th>
<th>Baseline Power (bhp)</th>
<th>FEI</th>
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<tbody>
<tr>
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<td>3238</td>
<td>11.8</td>
<td>40.1%</td>
<td>7.96</td>
<td>0.67</td>
</tr>
<tr>
<td>20 [510]</td>
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<td>7.96</td>
<td>0.83</td>
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<td>0.99</td>
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<td>24 [610]</td>
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<td>1.16</td>
</tr>
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<td>1.28</td>
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<tr>
<td>30 [770]</td>
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<td>5.73</td>
<td>82.5%</td>
<td>7.96</td>
<td>1.39</td>
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<tr>
<td>33 [840]</td>
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<tr>
<td>36 [920]</td>
<td>778</td>
<td>6.01</td>
<td>78.7%</td>
<td>7.96</td>
<td>1.32</td>
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</tbody>
</table>

Table courtesy of Greenheck article In *HPAC Engineering* July 2016
<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>
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<tr>
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<td>40.10%</td>
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<td></td>
<td>7.96</td>
<td>0.67</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>
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<td>0.83</td>
<td>24%</td>
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<tr>
<td>22 [560]</td>
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<td>8.02</td>
<td>68%</td>
<td>59.00%</td>
<td>47%</td>
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<td>106%</td>
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<tr>
<td>33 [840]</td>
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<td>83.40%</td>
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<td>109%</td>
</tr>
<tr>
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<td>78.70%</td>
<td>96%</td>
<td>7.96</td>
<td>1.32</td>
<td>97%</td>
</tr>
</tbody>
</table>

Look How That Same Table Plays Out
## Fan Energy Index - Applications

### 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 Regulation</td>
<td>FEI $\geq$ 1.0 at Design Point</td>
</tr>
<tr>
<td>ASHRAE 90.1</td>
<td>FEI $\geq$ 1.0 at Design Point</td>
</tr>
<tr>
<td>ASHRAE 189.1</td>
<td>FEI $\geq$ \textbf{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
U.S. Dept. of Energy Fan Energy Index (FEI) Summary

- DOE will limit fan power based on point of operation
- FEI will increase energy savings compared to eliminating fan models from the market
- FEI is a good comparison of relative energy consumption
- FEI can be used for green codes and utility rebates
Where to Learn More


Questions?

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SIZING AND SELECTING SAND LOUVERS

Saad Ali

General Manager, MENA Region
Ruskin Titus Gulf
Saad.ali@ruskintitus.com
Targets of Lecture

- Why IEQ
- Indoor Pollutants
- HVAC Systems
- Strategies to Improve IEQ
- Definition of Louvers
- Standard & Test Certifications
- Sizing of Sand Louvers
Targets of Lecture

- Air Quality Improvements Initiatives in GCC
- Sand Storms – visibility
- Current states
- HVAC Systems
- Definition of Louvers
- Standard & Test Certifications
- Sizing of Sand Louvers
Current state Worldwide

WHO reported that globally around 7 million people deaths - one in eight of total global deaths – were attributable to air pollution exposure in 2012 (WHO, 2014).

Middle East is located in an arid region, therefore we are geographically exposed to hot dry air from the desert and hot moist air from the Gulf. This is a major environmental concern.

In the Middle East and North Africa, about $13 billion in Gross Domestic Product (GDP) are lost every year due to dust storms.

Dust storms contribute to poor air quality. The World Health Organization estimates that seven million people die from poor air quality every year.
Particulate Matter (PM) are mainly from Natural origin.
 Ambient air pollution: Due to the geographical location of the Gulf region, it is higher in particulate matter (PM).
In the Middle East, natural dust (from the desert) has been found to be the main contributor of both PM2.5 (52%) (Karagulian et al., 2015).
Environmental Quality in Qatar: achievements

- Qatar has adopted the Sustainable or “green” building design to wisely use the resources to create high-quality, healthier and more energy-efficient homes and commercial buildings.

one of Qatar’s most environmentally-friendly office structures

The pioneering work of Qatar Founda (o n (QF) in the arena of sustainability

The coolest sustainable architecture in the Gulf Al Shamal Stadium – 2022 FIFA World Cup
<table>
<thead>
<tr>
<th>AD</th>
<th>DXB</th>
<th>SHJ</th>
<th>AJM</th>
<th>UQM</th>
<th>RAK</th>
<th>FUJ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>13</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>41</td>
</tr>
</tbody>
</table>
What are local regulations doing to drive product performance in the right direction for better IAQ?
Typical HVAC System
Strategies to Improve IAQ in HVAC air system

1. Prevention is better than Cure
   a) Temperature/ Humidity control
   b) Adequate Filtration systems
   c) Adequate fresh and/or supply air
What is a louvre?

• A louver or louvre is a window blind or shutter with horizontal slats that are angled to admit light and air, but to keep out rain, direct sunshine, and noise. The angle of the slats may be adjustable, usually in blinds and windows, or fixed.
Louvers

**Louvers:** Allow air to pass through it while keeping out unwanted elements such as sand, water, dirt, and debris.

**Louvers Types:**
- Sand trap louver
- Exhaust air louver
- Fresh air louver
- Acoustic louver
Sand Louver: Form and Function

• Pre-filtration Media for airborne sand
• Architectural (STATIC) ventilation device integrated in the building envelope
• Minimum Sand particle size 76um
• Self cleaning / No entrapment
Typical sand rejection

- Test Chamber Simulation
New AMCA Sand Louver Test Standard

- AMCA 511 Publication and Seal
Certificates

- ANSI/AMCA Standard 500-L defines sand particle size distribution
- AMCA Publication 511 defines four class levels of sand penetration effectiveness.

<table>
<thead>
<tr>
<th>Grade (μm)</th>
<th>Mass (%)</th>
</tr>
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<tbody>
<tr>
<td>&gt;699</td>
<td>0.5</td>
</tr>
<tr>
<td>423-699</td>
<td>3.0</td>
</tr>
<tr>
<td>353-422</td>
<td>12.0</td>
</tr>
<tr>
<td>251-352</td>
<td>30.0</td>
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<tr>
<td>211-250</td>
<td>20.0</td>
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<tr>
<td>152-210</td>
<td>27.0</td>
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<tr>
<td>104-151</td>
<td>6.0</td>
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<tr>
<td>76-103</td>
<td>1.0</td>
</tr>
<tr>
<td>&lt;76</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100% to 90%</td>
</tr>
<tr>
<td>B</td>
<td>89.9% to 80%</td>
</tr>
<tr>
<td>C</td>
<td>79.9% to 70%</td>
</tr>
<tr>
<td>D</td>
<td>Below 70%</td>
</tr>
</tbody>
</table>

Table 1. Requirements for standard test sand (Table 8 from ANSI/AMCA Standard 500-L).
New AMCA Sand Louver Test Standard

AMCA’s Standard Test Sand Particle Size Distribution (ISO 14688-1:2002)

Graphs showing sand removal effectiveness and pressure drop as functions of free area velocity.
Sizing of Sand Louvers

1) Determine the air flow and maximum air pressure drop

2) On the pressure drop chart, start at the selected pressure drop and draw a horizontal line across until it intersects the line. At the intersection point, draw a line straight down to the free area velocity line.

3) Calculate the free area required on the louver by taking the air flow amount and divide it by the determined free area velocity by using formula
\[ A = \frac{Q}{V} \]

Where, \( A \) = Free Area of Sand Louver in \( m^2 \)
\( Q \) = Air Volume in \( m^3/s \)
\( V \) = Free Area Velocity in \( m/s \)

E.g. \( Q = 1000 \text{ l/s} = 1 \text{ m}^3/\text{s} \)
\( \Delta P = 20 \text{ Pa} \)
Corresponds to pressure drop 20Pa free area velocity is 2.1 m/s
A = 1/2.1 = 0.47 m² (Select the free area equal or greater than calculated. Refer below chart) So Louver size = 2000 x 800

<table>
<thead>
<tr>
<th>Width in mm</th>
<th>200</th>
<th>400</th>
<th>600</th>
<th>800</th>
<th>1000</th>
<th>1200</th>
<th>1400</th>
<th>1600</th>
<th>1800</th>
<th>2000</th>
<th>2200</th>
<th>2400</th>
<th>2600</th>
<th>2800</th>
<th>3000</th>
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<tr>
<td>400</td>
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<td>0.031</td>
<td>0.051</td>
<td>0.071</td>
<td>0.091</td>
<td>0.111</td>
<td>0.131</td>
<td>0.151</td>
<td>0.171</td>
<td>0.191</td>
<td>0.211</td>
<td>0.231</td>
<td>0.251</td>
<td>0.271</td>
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<td>0.061</td>
<td>0.101</td>
<td>0.141</td>
<td>0.180</td>
<td>0.220</td>
<td>0.259</td>
<td>0.299</td>
<td>0.339</td>
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<td>0.418</td>
<td>0.457</td>
<td>0.497</td>
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<td>0.102</td>
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<td>0.262</td>
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<td>0.462</td>
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<td>0.655</td>
<td>0.755</td>
<td>0.855</td>
<td>0.955</td>
<td>1.055</td>
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Thank you for listening.
Questions?

Saad Ali

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CAR PARK VENTILATION DESIGN PER QCDD

Arun Thakur

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Recognized Standards

- QCDD GA_7.0-Revisions_2015
- Dubai Civil Defense
- ASHRAE
- BS-7346-7:2013
- NFPA-88,92
Objectives

The objective of the smoke clearance system design is to:

a) Assist firefighters by providing ventilation to allow speedier clearance of the smoke once the fire has been extinguished.

b) Help reduce the smoke density and temperature during the course of a fire.
Design Criteria

- Natural ventilation
- Natural & mechanical ventilation
- Mechanical ventilation
Natural Ventilation

a) Car parks with 40% of its total enclosure area in at least two of its opposing walls.

b) Maximum distance from the fixed opening to the farthest point in the area shall be limited to 45 meters.

c) The car park area should not be more than 2230 m\(^2\).

d) Such car parking cannot be more than three levels.
Natural & Mechanical Ventilation Combination

a) Fixed supply opening should be 2.5% of the floor area.
b) These openings should be the source of outside air.
c) Velocity of air through these openings should not exceed 5 m/s.
Design Criteria

- Fresh air requirement for mechanical ventilation

*Makeup flow rate preferably 85% of exhaust rate*
Design Criteria

- Exhaust air requirement for mechanical ventilation

Normal: 6 ACH minimum
Emergency: 10 ACH minimum
Design Criteria

- Redundancy for extract fan

Failure of any single fan will not result in more than 50% reduction of airflow.
Computational Fluid Dynamics-CFD

- ANSYS fluent
- FDS (fire dynamic simulator)

QCDD-recognized software.
CFD Acceptance Criteria

- Design fire size & location
- Inlet air temperature
- Safe height
- Temperature
- Visibility
- Duration
CFD Acceptance Criteria

- Design fire size (4 mw)
The design fire must be considered to be in the most onerous location, preferably the most remote location from the exhaust points.
Inlet air temperature or supply air temperature in consideration is \textit{46 degrees C}. This is generally an acceptable temperature for input.
CFD Acceptance Criteria

- Acceptance criteria for ventilation system employing jet fans @1.8m above floor level, within 20 minutes, attains the following:

  a) Temperature of the smoke layer should not exceed 20 minutes.

  b) Visibility should be minimum 10 m upstream of the fire.
CFD Acceptance Criteria

- Acceptance criteria for grid size

*Grid size must be maximum of 0.2 m X 0.2 m X 0.2 m near to heat load location & maximum of 0.4 m X 0.4 m X 0.4 m for other areas.*
CFD Acceptance Criteria

- Sensitivity study

*It means even with the loss of a jet fan nearest to the fire, the acceptance criteria are still met.*
The jet fan in the blue circle is kept in off mode for the sensitivity study.
Temperature profile @ 1.8m height

@ 5 minutes

@10 minutes
Temperature profile @ jet fan height

@ 5 minutes

@10 minutes
Visibility profile @ 1.8m height

@ 5 minutes

@10 minutes
Visibility profile @ jet fan height

@ 5 minutes

@10 minutes
Why CFD?

10 ACH

15 ACH

25 ACH
Questions?

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Speakers

- Roberto Arias, Director of Technology (Director Técnico), Zitrón S.A
- Mark Stevens, Executive Director, AMCA International
- Michael Ivanovich, Senior Director, Industry Relations AMCA International
- Saad Ali, Group General Manager – Middle East/North Africa, Ruskin Titus Gulf
- Arun Thakur, CFD Analyst, Maico Gulf
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