Moving

The Basics of Air
(Quietly & Efficiently)

An Introduction to the Principles of Moving Air Quietly & Efficiently


Basics of Air Model
Moving Air Quietly:

Operate the H/C appliance at its sweet spot
Keep Ms. Smith happy: Heat/cool her individual rooms properly

Why is this important:
Gov’t. & Utility programs come and go, Ms. Smith (our customer) still pays our rent.
Problems for Ms Smith:

- Immediate
  - Excessive air noise
  - Short filter life, before equipment shutdown
- Equipment
  - Failure, Compressor & power venter motors
- Utility Costs (in case of gas furnace)
  - Electric waste, pushing air through ducts
  - Gas waste, not scrubbing off heat

Problems caused by:

- Hi Efficiency HVAC appliances move more air, surprise-surprise!
- Manufacturers have shrunk appliance sizes
- Ceiling space restricted for trunk ducts, little partition wall space to run duct between levels
- Ignorance that bad fittings, more often than undersized duct, choke air flow.

Gary Milligan taking a motor current reading.

1 cubic foot weighs 1/10 lb. (almost)
How to measure the temperature rise of a furnace.

May 5 2014

How to measure the temperature rise of a furnace.

Temperature rise of the air = \( B - A \)

- \( A \) is the temperature of the return air to the furnace.
- \( B \) is the temperature of the supply air from the furnace.

R/A = 70°F

**Rated Temperature Rise (°F):**

- **160°F**
  - 90
  - 80
  - 70
  - 60
  - 50
  - 40
  - 30
  - 20
  - 10
  - 10°F

- **140°F**
  - 90
  - 80
  - 70
  - 60
  - 50
  - 40
  - 30
  - 20
  - 10
  - 10°F

- **105°F**
  - 90
  - 80
  - 70
  - 60
  - 50
  - 40
  - 30
  - 20
  - 10
  - 10°F

- **100°F**
  - 90
  - 80
  - 70
  - 60
  - 50
  - 40
  - 30
  - 20
  - 10
  - 10°F

1980 Gas 80%

Electric

1990 Gas 90%

Heat Pump (Air/Geo Source)

R/A = 70°F
CFM per 1000 BTU/hr (output)

1980 Gas 80%
Electric
1990 Gas 90%
Heat Pump (Air/Geo Source)

Standard Vs Hi Efficiency Nat.
Gas Furnace

Airco Furnace
Standard Efficiency 80%
In: 85K BTU/hr
Out: 68 K BTU/hr
Air Circulation Required
730 cfm @ 85°F
Recommended ESP .15” W.C.

Lennox
High Efficiency 95%
In: 70K BTU/hr
Out: 67.9K BTU/hr
Air Circulation Required
1257 cfm @ 50°F
Recommended ESP .30” W.C.

Note: Same cabinet sizes up to 130 BTU/hr.

CHANGE:
For same output, air flow increases by +72%
Result of Direct Changeout, Summary
(after matching BTU/hr output)

<table>
<thead>
<tr>
<th>Standard Efficiency</th>
<th>High Efficiency</th>
<th>Difference:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airco 80% (std)</td>
<td>Lennox 95%</td>
<td></td>
</tr>
<tr>
<td>Outpt 68 K B/h</td>
<td>Output 67.9K B/h</td>
<td></td>
</tr>
<tr>
<td>Air flow @ 85°F</td>
<td>Air flow @ 50°F</td>
<td>+72%</td>
</tr>
<tr>
<td>730 CFM</td>
<td>1257 CFM</td>
<td></td>
</tr>
<tr>
<td>ESP recommended</td>
<td>ESP result*</td>
<td>+213%</td>
</tr>
<tr>
<td>.15&quot; W.C.</td>
<td>.44&quot; W.C.</td>
<td></td>
</tr>
<tr>
<td>Fan Motor HP</td>
<td>Fan Motor HP</td>
<td>+412%</td>
</tr>
<tr>
<td>1/6 (.166)</td>
<td>.85</td>
<td></td>
</tr>
</tbody>
</table>

*Very low ESP was achieved on initial installation; No allowance for A/C or filters included.
DOUBLE INLET

Means air can come in both sides shaft end side and motor side.

FAN POWER

Thank you
Armando Cobo

100% ELECT. WATTS (IN)

60% SHAFT WATTS (OUT) OR HORSE POWER

33% AIR WATTS (OUT) OR HORSE POWER

USEFUL AIR POWER

26% OUTPUT

WASTED % OF AIR POWER
Velocity Comparisons

Friction Loss per 100 feet of straight duct.

Ps: Have you ever seen 100 straight feet of duct in any house???
Eli Howard SMACNA/ASHRAE chair tech committee
Standard Drop Elbow

- Sharp throat
- Bad deal!
- Sharp heal
- Doesn’t hurt much

Almost no air here

Clean undisturbed air here. Good

Reasonably Good Filter Location, presents near uniform air velocity over 100% of area of face of filter

Filter Element Here
88% lower than without T.V.s
3 Splitter Vanes installed immediately upstream of electronic filter

2 Great (free flowing) fittings installed back to back
Branch Issues:

Symptom:
- Ms. Smith has hot (in summer) rooms

Problem:
- Branch Ducts undersized
- Branch ducts too long
- Branch duct full of ‘fittings’
- No interior wall space
- Can’t use exterior walls

Note:
- Equipment by and large doesn’t care
Oval Fittings Study
(today’s duct of choice for 2x4 walls)

6”ø ovalled to 3 ¼ x 8
(straight duct)

6”ø to oval angle boot
(short way fitting)

6”ø to oval end boot
(long way fitting)

Oval Fitting People

- Mr. Gary Milligan HVAC Contractor/A Fitter
- Mr. Steve Savage TQ Sheet Metal/contractor
- Tony Nardi TQ Sheet Metal/wholesaler
- Lauris Krisch P.Eng. Sheet Metal Manufacturer
- Dr. Don W. McAdam P.Eng. Heat transfer/fluid dynamics
- David Hill, Vent. Manufacturer
- Sean Allan, CET, Sheet Metal Mfg draftsman
Riser Ducts

- 6\" ø
- 5\" ø
- 6\" oval 3\"x11\"
- 8\" oval 3\"x10\"
- 6\" oval 3\"x8\"

All ~ equivalent to 6\" ø round

~ Equivalent to 5\" ø round
1. Base Case - Round

<table>
<thead>
<tr>
<th>Fitting Size</th>
<th>Equivalent Length (ft)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5&quot; x 90° Round</td>
<td></td>
<td>31</td>
</tr>
<tr>
<td>6&quot; x 90° Round</td>
<td></td>
<td>34</td>
</tr>
</tbody>
</table>
### Equivalent Length (Le) Chart: Common Round 90° Fittings — Diameter Varies

<table>
<thead>
<tr>
<th>Elbow Fitting</th>
<th>D in</th>
<th>R in</th>
<th>590 Le</th>
<th>1000 Le</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Piece Elbow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Use</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>2.5</td>
<td>14</td>
<td>174</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>3</td>
<td>25</td>
<td>392</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>4.5</td>
<td>34</td>
<td>697</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>5</td>
<td>40</td>
<td>883</td>
</tr>
<tr>
<td>8 Piece Elbow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long Radius</td>
<td>5</td>
<td>10</td>
<td>2</td>
<td>68</td>
</tr>
<tr>
<td>Common use is</td>
<td>8</td>
<td>16</td>
<td>3</td>
<td>174</td>
</tr>
<tr>
<td>two, 4-piece</td>
<td>12</td>
<td>24</td>
<td>4</td>
<td>392</td>
</tr>
<tr>
<td>elbows</td>
<td>16</td>
<td>32</td>
<td>5</td>
<td>697</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>36</td>
<td>5</td>
<td>883</td>
</tr>
</tbody>
</table>

### Right Angle Boot

- **Fitting Size**: 3" x 10"
- **Equivalent Length (ft)**: 6" Round – 3"x10" Rect.: 41
2b. End Boot

<table>
<thead>
<tr>
<th>Fitting Size</th>
<th>Equivalent Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; Round – 3&quot;x10&quot; Rect.</td>
<td>Total 92</td>
</tr>
</tbody>
</table>
ASHRAE Fundamentals 2009

Example: 3” x 8” (nominal) flat oval all info in inches and sq. in. Apr. 3, ’10

<table>
<thead>
<tr>
<th>Shape (nominal size, in.)</th>
<th>Actual Size (inch)</th>
<th>Perimeter inch</th>
<th>Actual area in sq. in.</th>
<th>Diameter based on ‘actual’ area (in)</th>
<th>De (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round 6”</td>
<td>6”φ</td>
<td>18.84</td>
<td>Circled in green</td>
<td>6”</td>
<td>6.00</td>
</tr>
<tr>
<td>Flat oval 3 x 8</td>
<td>3 x 7.71</td>
<td>18.84</td>
<td>Circled in green</td>
<td>5.20</td>
<td>5.02</td>
</tr>
<tr>
<td>Flat oval 3 x 8</td>
<td>3.25 x 7.57</td>
<td>18.84</td>
<td>22.33</td>
<td>5.33</td>
<td>5.18</td>
</tr>
</tbody>
</table>

De = Diameter, equivalent (if equivalent friction round duct were substituted)
8. Oval End 90°
End Boot

Total Equivalent Length

- 5” Round – 6” Oval (3”x7-3/4”)
- 6” Round – 6” Oval (3”x7-3/4”)
- 6” Round – 8” Oval (3”x10-7/8”)

All duct shown is 3x10 with standard off the shelf fittings
### Oval Fittings Study

#### Fitting #  |  Fitting Size                      | Total Equivalent Length in Feet |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5” x 90° Round</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>6” x 90° Round</td>
<td>34</td>
</tr>
<tr>
<td>2</td>
<td>6” Round – 3”x10” Rectangle</td>
<td>41</td>
</tr>
<tr>
<td>3</td>
<td>6” Round – 3”x10” Rectangle</td>
<td>92</td>
</tr>
<tr>
<td>4</td>
<td>6” Round – 3”x10” Rectangle</td>
<td>46</td>
</tr>
<tr>
<td>5</td>
<td>5” Round – 6” Oval (3”x7-3/4”)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>6” Round – 6” Oval (3”x7-3/4”)</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>5” Round – 6” Oval (3”x7-3/4”)</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>6” Round – 6” Oval (3”x7-3/4”)</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>6” Round – 8” Oval (3”x10-7/8”)</td>
<td>55</td>
</tr>
<tr>
<td>7</td>
<td>6” Round – 6” Oval (3”x7-3/4”)</td>
<td>77</td>
</tr>
<tr>
<td>8</td>
<td>5” Round – 6” Oval (3”x7-3/4”)</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>6” Round – 6” Oval (3”x7-3/4”)</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>6” Round – 8” Oval (3”x10-7/8”)</td>
<td>60</td>
</tr>
<tr>
<td>9</td>
<td>6” Oval (3”x7-3/4”)</td>
<td>85</td>
</tr>
<tr>
<td>10</td>
<td>6” Oval (3”x7-3/4”)</td>
<td>123</td>
</tr>
</tbody>
</table>
### SA Branch Run Sizing .3 In. wc ESP

#### Maximum CFM per Branch Run

<table>
<thead>
<tr>
<th>Branch Duct Size</th>
<th>Max. No. of fittings per branch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 ftg</td>
</tr>
<tr>
<td>4&quot;Ø</td>
<td>35</td>
</tr>
<tr>
<td>5&quot;Ø</td>
<td>65</td>
</tr>
<tr>
<td>6&quot;Ø</td>
<td>100</td>
</tr>
<tr>
<td>7&quot;Ø</td>
<td>160</td>
</tr>
</tbody>
</table>

#### Fitting Size Table

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<thead>
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<th>Fitting Size</th>
<th>Total Equivalent Length in ft.</th>
<th># Fittings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5&quot; x 90° Round</td>
<td>31</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>6&quot; x 90° Round</td>
<td>34</td>
<td>0.9</td>
</tr>
<tr>
<td>2</td>
<td>6&quot; Round - 3&quot;x10&quot; Rectangle</td>
<td>41</td>
<td>1.1</td>
</tr>
<tr>
<td>3</td>
<td>6&quot; Round - 3&quot;x10&quot; Rectangle</td>
<td>92</td>
<td>2.6</td>
</tr>
<tr>
<td>4</td>
<td>6&quot; Round - 3&quot;x10&quot; Rectangle</td>
<td>46</td>
<td>1.3</td>
</tr>
<tr>
<td>5</td>
<td>5&quot; Round - 6&quot; Oval (3&quot;x7-3/4&quot;)</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>6&quot; Round - 6&quot; Oval (3&quot;x7-3/4&quot;)</td>
<td>20</td>
<td>0.6</td>
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<tr>
<td></td>
<td>5&quot; Round - 6&quot; Oval (3&quot;x7-3/4&quot;)</td>
<td>29</td>
<td>0.8</td>
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<tr>
<td></td>
<td>6&quot; Round - 6&quot; Oval (3&quot;x7-3/4&quot;)</td>
<td>110</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>6&quot; Round - 8&quot; Oval (3&quot;x10-7/8&quot;)</td>
<td>55</td>
<td>1.5</td>
</tr>
<tr>
<td>6</td>
<td>6&quot; Round - 6&quot; Oval (3&quot;x7-3/4&quot;)</td>
<td>77</td>
<td>2.2</td>
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<td>5&quot; Round - 6&quot; Oval (3&quot;x7-3/4&quot;)</td>
<td>24</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>6&quot; Round - 6&quot; Oval (3&quot;x7-3/4&quot;)</td>
<td>149</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>6&quot; Round - 8&quot; Oval (3&quot;x10-7/8&quot;)</td>
<td>60</td>
<td>1.7</td>
</tr>
<tr>
<td>8</td>
<td>6&quot; Oval (3&quot;x7-3/4&quot;)</td>
<td>85</td>
<td>2.4</td>
</tr>
<tr>
<td>9</td>
<td>6&quot; Oval (3&quot;x7-3/4&quot;)</td>
<td>123</td>
<td>3.5</td>
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