Noise Control in HVAC

Active  Passive  or  None

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Why does noise matter

- Contract
- Affects people
Contract

Noise levels in terms of criteria

Probably vague in terms of locations etc
Affects people

- Well being and comfort
- Productivity
- Social interaction
- Absences
Noise

Background noise
Activity noise

Disturbance

Discomfort
### Noise Sources in Building Services

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<th>Description</th>
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<td>Grilles and diffusers</td>
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<td>Roof-top units</td>
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<td>Fan coil units</td>
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<td>Chillers, compressors and condensers</td>
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<td>Pumps</td>
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<td>Cooling towers</td>
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<td>Lifts</td>
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<td>Escalators</td>
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Fan Noise Propagation
Minimisation of fan noise

- Fan Selection
- Low airflow resistance
  - Use Speed control not dampers
  - Design for low resistance duct
Low airflow resistance

Design for

Streamlined inlet flow duct flow

Flow settling distances
Control of Noise Transmission in Ducts

Attenuation of Travelling Noise
Duct Attenuation

Size and Shape

Unlined  Lined
All duct systems have frequency dependent attenuation.
Lined Ducts used widely in the USA.

Gives noise attenuation and thermal insulation, but raises concerns for health. Not now recommended for sensitive locations except with special precautions. Older systems taken out, for example in schools and health care.

UK uses more localised silencers than USA. UK ~100%. USA ~50%
Lined Duct

Rectangular duct attenuation depends on Perimeter/area, \((P_d/A_d)\), and Lining Thickness

Attenuation is not as well known for circular ducts
Johns Manville Superduct RC Air Duct Board

Operating Temperature Limit: 250°F (121°C)
Figure 6.1  Attenuation of lined duct; 25 mm lining  [From CIBSE B5]
# Significance of $P_d/A_d$

<table>
<thead>
<tr>
<th>Duct Dimensions</th>
<th>$P_d/A_d$</th>
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<tbody>
<tr>
<td>3m x 3m</td>
<td>1.3</td>
</tr>
<tr>
<td>1m x 1m</td>
<td>4</td>
</tr>
<tr>
<td>1.2m x 0.3m</td>
<td>8</td>
</tr>
<tr>
<td>0.3m x 0.3m</td>
<td>13</td>
</tr>
<tr>
<td>0.15m x 0.15m</td>
<td>27</td>
</tr>
</tbody>
</table>
**Figure 6.1** Attenuation of lined duct; 25 mm lining
Localised Attenuation

Parallel baffle (passive) silencer
Parallel Baffle Silencer
Duct Silencers - parallel baffle

Considerations

- Length, width, height….. weight
- Baffle thickness, Air gap
- Air velocity
- Pressure loss - varies as (velocity)^2
- Location wrt fan, bends etc
Silencer attenuation 200mm/200mm
Variation with length

Octave band frequency Hz

Attenuation dB

2400mm
2100mm
1800mm
1500mm
1200mm
900mm
Limitations of Passive Silencers

• Poor low frequency attenuation

• LF attenuation improved by narrow air gaps and longer length

• This leads to higher pressure loss
Energy loss in silencers

Power (W) used against pressure loss

\[
\text{Air flow (m}^3/\text{s}) \times \text{pressure loss (Pa)} = \text{fan-motor efficiency}
\]

10m\(^3\)/s into 100Pa > 1KW
Energy use by fans in the UK
(Lockwood - FETA Magazine December 2005)

Fans in the range 1.1kW to 400kW consume
33.5TWh per year of electricity

Potential saving of
22.5% (7.5TWh)

by improved fan and system efficiency.
<table>
<thead>
<tr>
<th>Sector</th>
<th>Use   TWh</th>
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</thead>
<tbody>
<tr>
<td>Industry</td>
<td>113.926</td>
</tr>
<tr>
<td>Transport</td>
<td>8.528</td>
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<tr>
<td>Domestic</td>
<td>115.761</td>
</tr>
<tr>
<td>Public Admin</td>
<td>20.966</td>
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<tr>
<td>Commercial</td>
<td>74.328</td>
</tr>
<tr>
<td>Agriculture</td>
<td>4.025</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>337.444 TWh</strong></td>
</tr>
</tbody>
</table>
Signal mic

Controller

Loudspeaker

Control mic

Active silencer

Noise
Active silencers

- Good low frequency attenuation
- Normally combine active/passive for full range attenuation
- Lower pressure loss
- Smaller size and weight than passive for similar LF performance
- Higher initial cost?
Active Silencer attenuation
Silencer Requirements:
1. 1.5 m length;
2. <50 Pa pressure loss;
3. >25 dB attenuation at 125 Hz
4. Non-porous media

Not possible by passive silencer
Silencer Dimensions:
1500 L x 1400 W x 1600 H
View from reverb room into end of silencer from discharge side

1600 mm

1400 mm
Passive silencing √
Active silencing √

Is no silencing possible?
Is no silencing possible?

- Very quiet fan operating optimally
- Good duct design
- Modify our noise level requirements
  - less demanding criteria

[One of the necessary lifestyle changes in the future?]
Fan is quietest at maximum efficiency

[ASHRAE 2003]
Fan outlet configuration - 1

Slope 1 in 7

A > 1.5B

From SMACNA Guide - HVAC Sound and Vibration Manual 2005
Fan outlet configuration - 2

Full radius turning

Minimum 150mm radius

Good  Fair  Bad  Bad

From SMACNA Guide
Reducing air flow generated noise

From SMACNA Guide
FIGURE 3-14 RECOMMENDATIONS FOR MINIMIZING AIRFLOW GENERATED NOISE IN DUCT BRANCH TAKEOFFS
FIGURE 3-15 RECOMMENDATIONS FOR MINIMIZING AIRFLOW GENERATED NOISE IN DUCT TEES

From SMACNA Guide
Figure 3-16 Recommendations for minimizing airflow generated noise in duct elbows

From SMACNA Guide
Most duct elements have attenuation which increases with frequency, although attenuation may drop at higher frequencies.

Lined bends simple and effective

Residual low frequency attenuation requirements obtained by active silencers
Do we over-silence?

How much are criteria conditioned by culture and expectations?