Air Movement for Energy-Efficient Comfort in Conditioned Spaces
ASHRAE Standard 55-2010: Thermal Comfort
“Specify the combination of indoor thermal environmental factors and personal factors that will produce thermal environmental conditions acceptable to a majority of the occupants…”

Said another way:  
Quantify comfort for most
Thermal Comfort: What Affects It?

Thermal Comfort

- Air Temperature (°F)
- Humidity (% RH)
- Radiant Temperature (°F)
- Metabolic Rate (met)
- Clothing Insulation (clo)
- Air Speed/Velocity (fpm)

Environmental Factors

Personal Factors
Definitions

Predicted Percentage of Dissatisfied (PPD)
Predicted Mean Vote (PMV)
Operative Temperature

Comfort Zone
PMV: -0.5 to +0.5
PPD < 10%
MAJOR FUEL CONSUMPTION (BTU) BY END USE FOR ALL BUILDINGS, 2003

- Space Heating: 36%
- Cooling: 8%
- Ventilation: 7%
- Water Heating: 8%
- Lighting: 20%
- Cooking: 3%
- Refrigeration: 6%
- Office Equipment: 1%
- Computers: 2%
- Other: 9%

EIA CB ECS 2003
Air Movement for Summer Cooling
Designing for Thermal Comfort: Cooling

Typical Cooling Values

- Air temperature (75 °F)
- Humidity (50% RH)
- Metabolic rate (1 met)
- Radiant temperature (75 °F)
- Clothing insulation (0.5 to 1.0 clo)
- Air speed (40 fpm or less)

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<thead>
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<th>Typical</th>
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<tr>
<td>PPD</td>
<td>8%</td>
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<tr>
<td>PMV</td>
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Air Speed and Thermostat Offset

Cooling Effect From Elevated Air Speed

Assumptions:
- 85°F Air Dry Bulb & Mean Radiant Temp
- 20 fpm Air Speed (Base Conditions)
- 60% Relative Humidity
- 1.3 Met Metabolic Rate
- 0.5 Clo Clothing Level

Sources:
- Thermal Comfort Tool - UC Berkeley

100 - 250 fpm best cooling per Watt

ASHRAE Thermal Comfort Tool
Designing for Thermal Comfort: Cooling

Alternate Cooling Values

- **Air temperature** (80 °F)
- Humidity (50% RH)
- Metabolic rate (1.1 met)
- Radiant temperature (80 °F)
- Clothing insulation (0.5 to 1.0 clo)
- **Air speed** (120 fpm)

### Alternate

<table>
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Savings from Temperature Offset

According to the U.S. EPA and D.O.E. Energy Savings Calculator*, each degree of this thermostat offset saves 3% to 6% of cooling energy.

*U.S. EPA and D.O.E. Energy Savings Calculator
Shifting the Concept of Thermal Comfort

- $18.6 billion on residential AC in the US
- 63% rise in the cost of electricity since 2003
- The energy consumed by residential AC in the US doubled between 1993 and 2003
Shifting the Concept of Thermal Comfort

If every home in the US raised its thermostat setpoint 6F, we would eliminate 78 billion pounds of carbon.

- Park 7.4 million vehicles for a year.
- Carbon sequestered by 29 million acres of US forests in one year.
- Switch 925 million incandescent lamps to CFL bulbs.
- 9 coal-fired power plants for a year.
Air Movement for Winter Energy Efficiency
Stratification in Heating Mode

• Hot air rises
• Difficult to get uniformity
• Stratification of 0.5 – 1.0°F/ft.
• Higher average space temperature, heat loss, equipment runtime
Fan Jet Requirement
Forward Operation (No Reverse)
No Drafts

Cooling Effect From Elevated Air Speed

![Graph showing the cooling effect from elevated air speed.](image)
Destratification: Kentucky Guard Hangar

Fan Off

- 5' AFF
- 15' AFF
- 35' AFF

Dates:
11/2/2009 0:00
11/3/2009 0:00
11/4/2009 0:00
11/5/2009 0:00
11/6/2009 0:00
11/7/2009 0:00
11/8/2009 0:00
11/9/2009 0:00
11/10/2009 0:00
Destratification: Kentucky Guard Hangar

Fan On

5' AFF
15' AFF
35' AFF
Destratification: Kentucky Guard Hangar

Gas savings: $272,247 ft\(^3\) = 272.2 MCF per year

Cost savings: $2,714 per year

– Fan electricity: $37

Net savings: $2,677
Air Movement and Green Building Standards

LEED BD+C

- EA Prereq 2 Minimum Energy Performance
- EA Credit 2 Optimize Energy Performance
- EA Credit 4 Demand Response
- EA Credit 6 Enhanced Refrigerant Management
Questions?

877-BIG-FANS
Aircraft Hangars and Terminals
Government and Military
Public Spaces
Schools: K-12 and Universities
Worship Facilities
Outdoor Covered Areas
Locust Trace High School
Oakland Unified School District
Big Ass Solutions Testing Facility