
KRUEGER
FORCED AIR HVAC SYSTEMS
It's more than just hot air...

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ABOUT ME
• Dan Int-Hout
• Chief Engineer
• 43 Years of Experience
• Voting Member ASHRAE Residential Building Committee
• ASHRAE / Distinguished Lecturer
• Published over 50 articles and technical papers
• Manages presentation of product data and provides advanced application engineering for our sales reps

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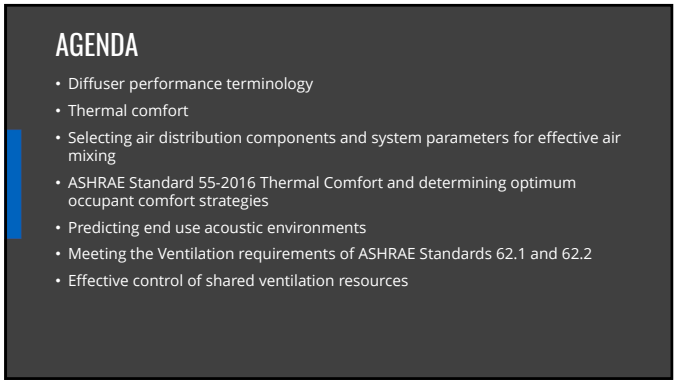
AGENDA
• Diffuser performance terminology
• Thermal comfort
• Selecting air distribution components and system parameters for effective air mixing
• ASHRAE Standard 55-2016 Thermal Comfort and determining optimum occupant comfort strategies
• Predicting end use acoustic environments
• Meeting the Ventilation requirements of ASHRAE Standards 62.1 and 62.2
• Effective control of shared ventilation resources

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RESIDENTIAL, MULTI-FAMILY (Low, Medium and High Rise), AND COMMERCIAL

- Air distribution follows basic rules, whether an office or a residence
- The air distribution system in most single family dwellings, even expensive ones, is seldom highly engineered
- With multi-family dwellings, there are opportunities to distribute ventilation or heating/cooling flow within or between residences.
- Ventilation codes are requiring variable quantities of ventilation air as occupants run kitchen hoods and driers
- This implies that a shared ventilation supply needs to be dynamically controlled to be effective, which starts to closely resemble a commercial VAV system

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TERMINOLOGY

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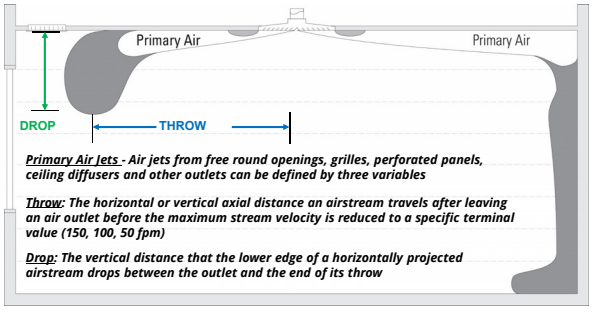
UNDERSTANDING THE TERMINOLOGY



Primary Air Jets *- Air jets from free round openings, grilles, perforated panels, ceiling diffusers and other outlets can be defined by three variables*

Throw*: The horizontal or vertical axial distance an airstream travels after leaving an air outlet before the maximum stream velocity is reduced to a specific terminal value (150, 100, 50 fpm)*

Drop*: The vertical distance that the lower edge of a horizontally projected airstream drops between the outlet and the end of its throw*

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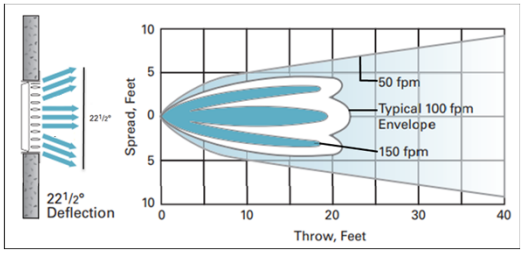
UNDERSTANDING THE TERMINOLOGY



***Spread** - The divergence of the airstream in a horizontal or vertical plane after it leaves the outlet*

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UNDERSTANDING THE TERMINOLOGY

Understanding primary air jet variables enables:

- Accurate prediction of room air flow
- Improvement of thermal comfort
- Proper selection of grilles, registers, and diffusers
- Making the best economic decision understanding the tradeoffs between cost and performance

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UNDERSTANDING THE TERMINOLOGY

The Basis of Catalog Performance Data

- Throw – The horizontal or vertical axial distance an airstream travels after leaving an air outlet, usually assumes a surface adjacent to the air outlet
- Pressure – Can be total pressure or static pressure
- Sound – Can be either NC or Octave Band data

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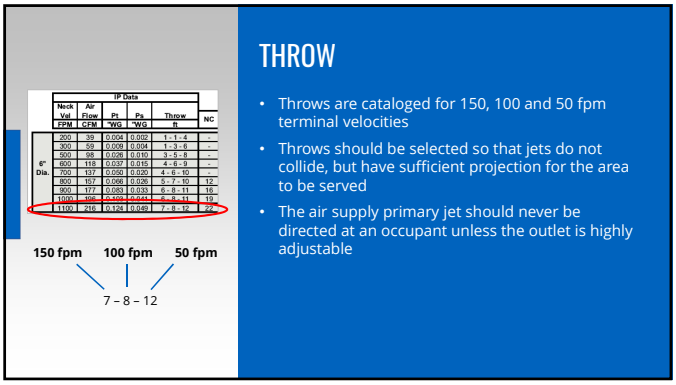

THROW

- Throws are cataloged for 150, 100 and 50 fpm terminal velocities
- Throws should be selected so that jets do not collide, but have sufficient projection for the area to be served
- The air supply primary jet should never be directed at an occupant unless the outlet is highly adjustable

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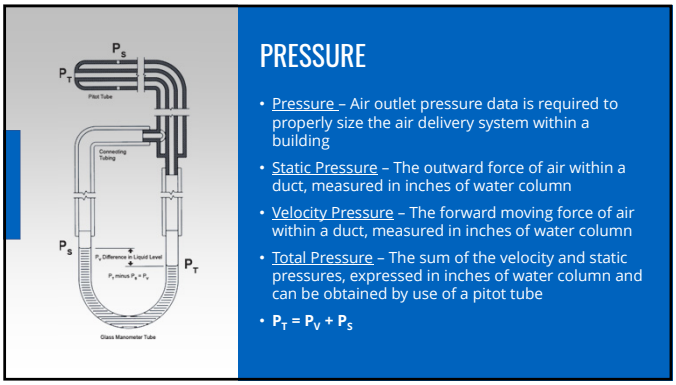

PRESSURE

- Pressure – Air outlet pressure data is required to properly size the air delivery system within a building
- Static Pressure – The outward force of air within a duct, measured in inches of water column
- Velocity Pressure – The forward moving force of air within a duct, measured in inches of water column
- Total Pressure – The sum of the velocity and static pressures, expressed in inches of water column and can be obtained by use of a pitot tube
- $P_T = P_V + P_S$

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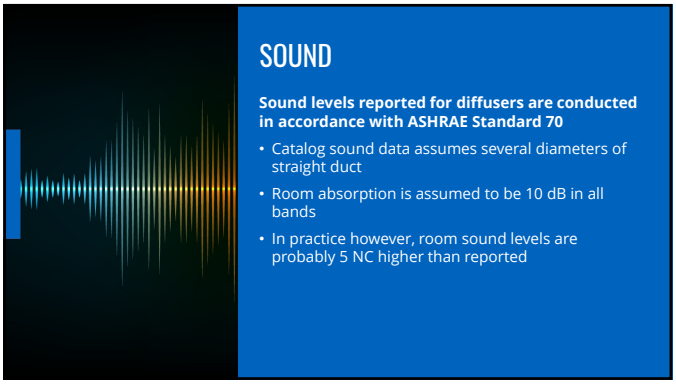

SOUND

Sound levels reported for diffusers are conducted in accordance with ASHRAE Standard 70

- Catalog sound data assumes several diameters of straight duct
- Room absorption is assumed to be 10 dB in all bands
- In practice however, room sound levels are probably 5 NC higher than reported

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POOR AIR DISTRIBUTION
T-STAT

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OPTIMAL AIR DISTRIBUTION
T-STAT

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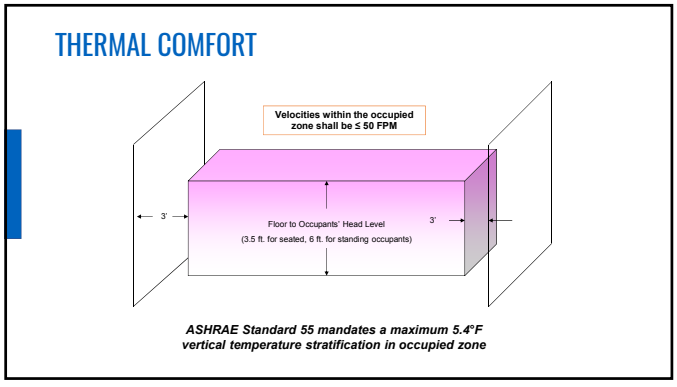
THERMAL COMFORT
Velocities within the occupied zone shall be ≤ 50 FPM
3'
Floor to Occupants' Head Level
(3.5 ft. for seated, 6 ft. for standing occupants)
3'
ASHRAE Standard 55 mandates a maximum 5.4°F vertical temperature stratification in occupied zone

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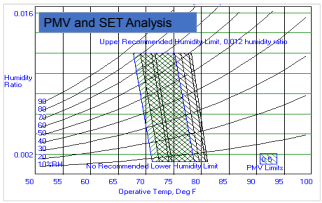
ADPI, LEED, AND THERMAL COMFORT



- 73°F (22.7°C) setpoint satisfies most Standard 55 input conditions
- Radiant effects are negligible (typically)

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Poll #2

Certificate Password:

HotAir19

Note: This password is case sensitive

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PROPER OVERHEAD HEATING DESIGN

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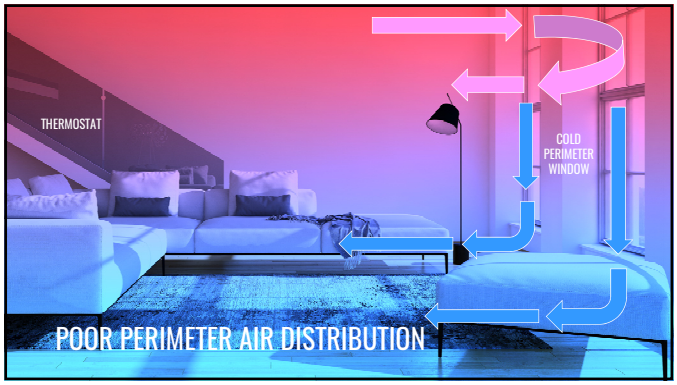
THERMOSTAT
COLD PERIMETER WINDOW
POOR PERIMETER AIR DISTRIBUTION

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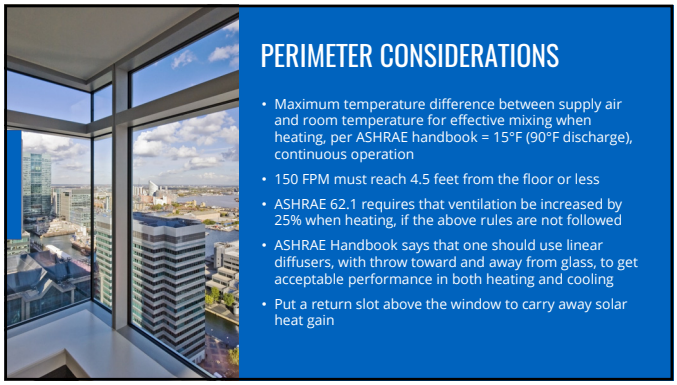
PERIMETER CONSIDERATIONS
• Maximum temperature difference between supply air and room temperature for effective mixing when heating, per ASHRAE handbook = 15°F (90°F discharge), continuous operation
• 150 FPM must reach 4.5 feet from the floor or less
• ASHRAE 62.1 requires that ventilation be increased by 25% when heating, if the above rules are not followed
• ASHRAE Handbook says that one should use linear diffusers, with throw toward and away from glass, to get acceptable performance in both heating and cooling
• Put a return slot above the window to carry away solar heat gain

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< 90°F SUPPLY AIR | T150 >8°
BEST IF SUPPLY IS 4' FROM THE WINDOW
COLD PERIMETER WINDOW
Overhead Heating
Revisiting a Lost Art
March 2007, ASHRAE Journal
WELL-MIXED PERIMETER AIR DISTRIBUTION

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NON-TYPICAL THROW ANALYSIS

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SPECIAL APPLICATIONS

High Bay Application - Ceilings Over 12' High

- Heating is a challenge due to buoyancy
  - Take advantage of vertical stratification where possible
  - Required Heating airflow rate may exceed cooling airflow rate
  - Keep heating supply air temperature to room temperature ΔT to a minimum
- If supplying air distribution from the ceiling, consider using round diffusers, drum louvers, or diffusers with some vertical projection
- One cannot use ADPI to predict heating performance
- Consider Displacement Ventilation

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DIFFUSER SELECTION & BUOYANCY

- ADPI isn't always the best way to analyze, select and place diffusers, especially with heating and high bay applications
- One can estimate throw as a function of ΔT and buoyancy
- Simple rule: Distance to 75 ft/min is affected by 1% / degree(F) ΔT

Example:

1. 20°ΔT Cooling, Vertical Down = +20% projection
2. 20°ΔT Heating, Vertical Down = -20% projection
3. 20°ΔT Heating, Along Ceiling = +20% projection

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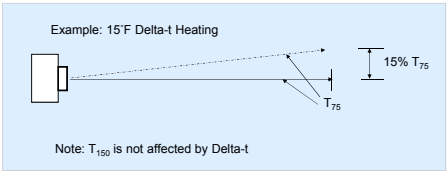
SIDE WALL REGISTER SELECTION AND BUOYANCY

Horizontal Free Jet:

- Vertical change @ 75 ft/min is affected by 1% of 75 fpm throw/F^0 ΔT



Horizontal Jet Buoyancy

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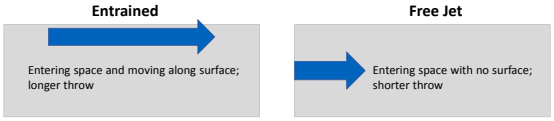
ENTRAINED VS. FREE JETS

- Most catalog throw data assumes jet is along a surface
- Exceptions include drum louvers, duct mounted grilles and vertical linear diffusers
- A free jet will be shorter than an entrained jet because it has more surface area to induce surrounding air, which shortens throw



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CONTINUOUS DUCT APPLICATIONS

- Use multiple drum louvers, duct mounted grilles, or continuous linear applications (longer than 10')
- Size duct as large as possible (duct inlet velocity < 1000 fpm)
- If inlet velocities are <1000 fpm, maintain constant duct size through entire length of run and balancing will be minimal

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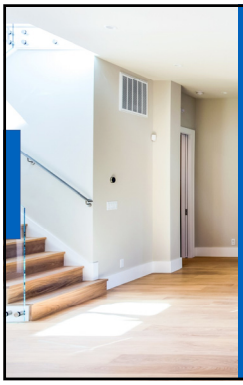

RETURNS

- Typically located in/near the ceiling
- Returns have an almost immeasurable effect on room air flows < 1.5 cfm/sf
- Suspended ceilings typically leak 1cfm/sf at 0.1" differential pressure
- Spaces with high airflow rates can benefit from low returns

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AIR FLOW CONTROL

- When air is ducted to multiple locations, the distribution may be tailored to the application with balancing dampers
- If the end use is variable, putting an actuated damper on one outlet will cause changes in all the other fixed damper flow rates
- Airflow control may be either **Pressure Dependent** or **Pressure Independent**
- A **Pressure Dependent** system simply opens or closes a damper in response to a control signal
- A **Pressure Independent** system has a flow sensor and control loop that responds to a control signal

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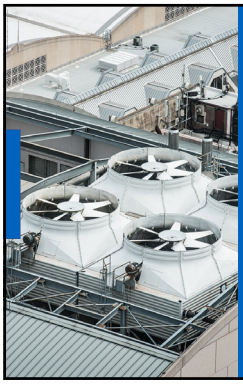

VENTILATION DELIVERY

- Ventilation is often supplied to the low pressure side of the HVAC system; where it is then mixed and distributed
- If ventilation air is delivered directly to the space, it may conflict with other room air distribution device air streams and the interaction should be evaluated
- If the local HVAC system has a variable speed fan and the ventilation supply utilizes a distributed system, the local control damper must be pressure independent.

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SUMMARY

- The science of air distribution is well understood in the commercial space, but in residential, it is often overlooked
- Forced air systems are best employed when the occupants are unaware of their existence – meaning no drafts or unwanted sounds
- To achieve this, all the components of a forced air system need to be understood

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CONTACT INFORMATION

Dan Int-Hout – Chief Engineer
dint-hout@krueger-hvac.com

www.krueger-hvac.com

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