Displacement Ventilation Introduction

Overview
Airflow in ventilated spaces generally can be classified by two different types; mixing (or dilution) ventilation and displacement ventilation. Mixing ventilation systems (**Figure 1**) generally supply air in a manner such that the entire room volume is fully mixed. The cool supply air exits the outlet at a high velocity, inducing room air to provide mixing and temperature equalization. Since the entire room is fully mixed, temperature variations throughout the space are small while the contaminant concentration is uniform throughout the zone.

Displacement Ventilation systems (**Figure 2**) introduce air into the space at low velocities which causes minimal induction and mixing. Displacement outlets may be located almost anywhere within the room, but have been traditionally located at or near floor level. The system utilizes buoyancy forces, generated by heat sources such as people, lighting, computers, electrical equipment, etc. in a room to remove contaminants and heat from the occupied zone. By so doing, the air quality in the occupied zone is generally superior to that achieved with mixing ventilation.

Concept
Displacement ventilation presents an opportunity to improve both the thermal comfort and indoor air quality (IAQ) of the occupied space. Displacement ventilation takes advantage of the difference in air temperature and density between an upper contaminated zone and a lower clean zone. Cool air is supplied at low velocity into the lower zone. Convection from heat sources creates vertical air motion into the upper zone where high level return outlets extract the air as illustrated in **Figure 3**. In most cases, these convection heat sources are also the contamination sources, i.e. people or equipment, thereby carrying the contaminants up to the upper zone, away from the occupants.

Since the conditioned air is supplied directly into the occupied space, supply air temperatures must be higher than mixing systems (usually above 63 degrees F) to avoid creating uncomfortable drafts. By introducing air at elevated supply air temperatures and low outlet velocity a high level of thermal comfort can be achieved with displacement ventilation.

Figure 1: Mixing (Dilution) Ventilation

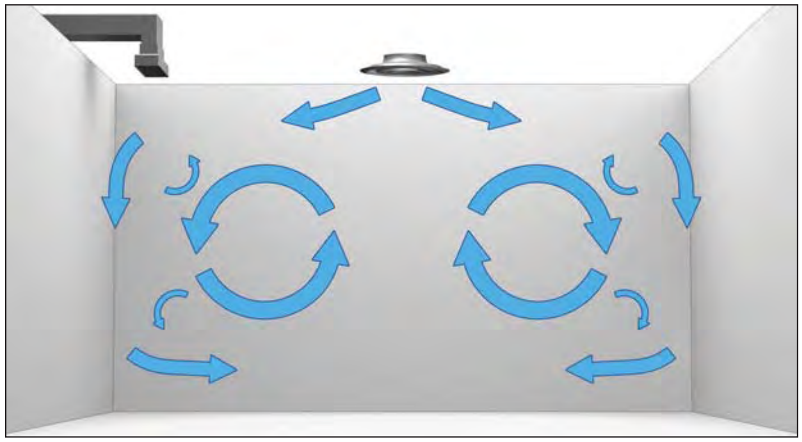


Figure 2: Displacement Ventilation

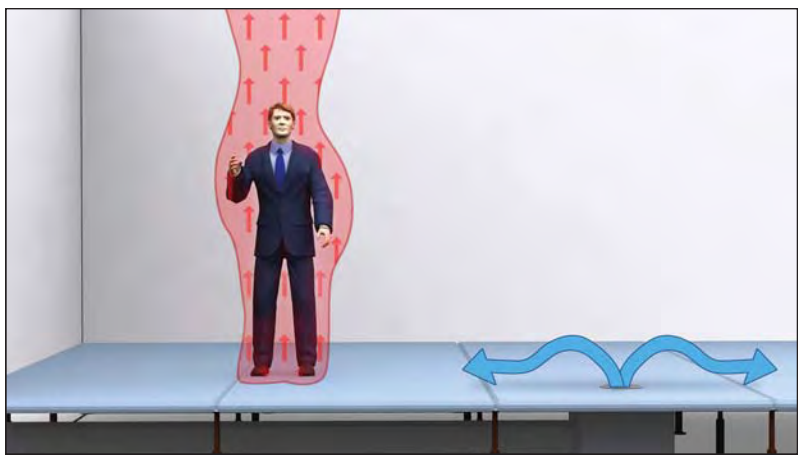
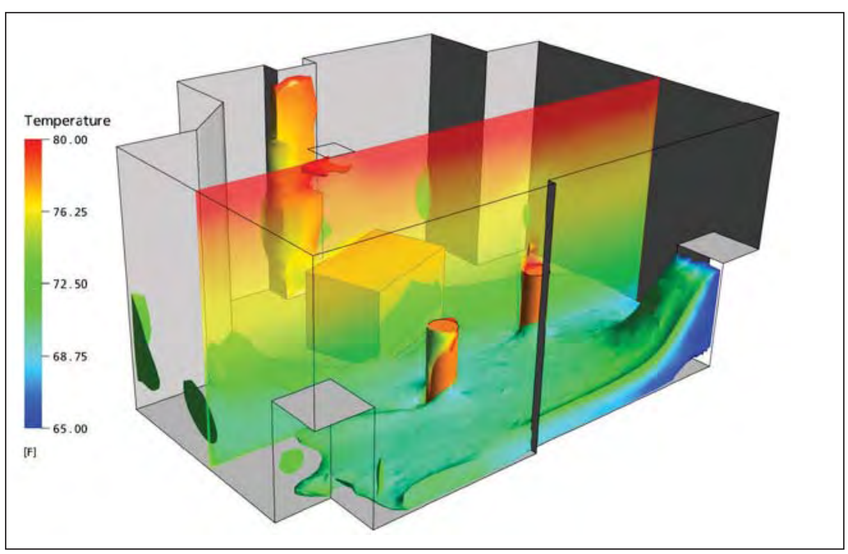


Figure 3: Displacement Flow Characteristics



All Metric dimensions ( ) are soft conversion.
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Displacement Ventilation Introduction

Benefits

1. Flexibility – as loads change within the space, a displacement system will be able to compensate. For example, if the space was designed to have a fairly even load distribution and now has the loads concentrated to one side, the system is able to compensate as the buoyant forces drive supply system and will draw the air towards the loads.
2. IAQ – Because fresh supply air is pooling at the floor level, personal thermal plumes draw fresh air up the body. All of the warm and polluted air is extracted at the high return. When properly designed, there should always be a greater amount of fresh air in the breathing zone when compared to a conventional dilution system.
3. Both the LEED® and Green Globes green building rating systems have credits that are applicable to displacement ventilation systems. See the Green Tips for further information.
4. Energy Savings –
   - The lower pressure drop associated with displacement ventilation outlets, may allow a reduction in fan energy with the selection of smaller fan components.
   - Economizer operating hours can be increased to take advantage of free cooling because supply air temperatures are higher than with overhead air distribution systems.
   - Chiller efficiency may be increased when the system is not dehumidifying, as there is a lower supply air temperature and higher return air temperature.

Typical Applications

- Displacement ventilation is an effective method of obtaining good air quality and thermal comfort in the occupied space. Spaces where displacement ventilation has been successfully used are:
  - Schools
  - Classrooms
  - Hospitals
  - Dining Rooms
  - Conference Rooms
  - Industrial Spaces
  - Theaters
  - Casinos
  - Restaurants
  - Meeting Rooms
  - Supermarkets
- Displacement ventilation is usually a good choice in the following cases:
  - Where the contaminants are warmer and/or lighter than the room air.
  - Where the supply air is cooler than the room air.
  - Where the room heights are 9 feet or more.
  - Where low noise levels are desired.
- Overhead Air Distribution may be a better choice than displacement ventilation in the following cases:
  - Where ceiling heights are below 8 feet.
  - Where disturbances to room airflow are strong.
  - Where contaminants are colder and/or denser than the ambient air.
  - Where cooling loads are high and radiant cooling is not an option.

Figure 4: Classroom Application

Figure 5: High Ceiling Application

Terminology

Adjacent Zone

The adjacent zone is defined as the distance from the diffuser face to a point where the velocity of the airstream is reduced below 40 FPM measured 1” above the floor.

Buoyancy

The vertical force exerted on a volume of air that has a density lower than the ambient air.

Breathing Zone

The estimated height at which occupants will inhale the surrounding air.

CFD

Computational Fluid Dynamics.The analysis of a space utilizing computers to simulate fluid motion. An example of output from a CFD analysis is shown in **Figure 8**.

Displacement Ventilation

Room ventilation created by room air displacement, by introducing air at low level in a space at a lower air temperature than the room air.

Draft

Unwanted local cooling of a body caused by movement of air.

Draft Temperature

The effective temperature based on the temperature and velocity of the supply air causing discomfort.

Green Globes®

A sustainable building rating system from the Green Building Initiative (GBI).

IAQ

Indoor Air Quality.

LEED®

Leadership in Energy and Environmental Design. A sustainable building rating program from the US Green Building Council.

Length, Adjacent Zone

The Length of the adjacent zone is the length from the diffuser face to a specified velocity, typically 40 FPM, refer to **Figure 6**.

Mixed Ventilation

Air diffusion where the mixing of supply and room air is intended.

Occupied Zone

An imaginary box in the room defined as 6 feet above the floor and not less than 24 inches from the walls.

Percent Dissatisfied (PD)

ASHRAE defines the percent dissatisfied as the percentage of people predicted to be dissatisfied with their environment due to draft.

Predicted Mean Vote (PMV)

The Predicted Mean Vote, PMV, is an index that predicts the mean value of the votes of a large group of persons in relation to a scale defined by ASHRAE [ASHRAE Standard 55 2004]

Predicted Percentage of Dissatisfied (PPD)

ASHRAE defines the predicted percentage of dissatisfied as “an index that establishes a quantitative prediction of the percentage of thermally dissatisfied people determined from PMV.” In real terms it is a measure of the thermal comfort performance in a space.

Thermal Plume

The air current rising from a hot body.

Stratification

When the temperature of the space varies with height.

Upper Zone

The space above the occupied zone.

Ventilation Effectiveness

The ratio of contaminants in the exhaust to the contaminates at the breathing level. An indication of how well a space is extracting contaminates, and an indication of IAQ.

Width, Adjacent Zone

The width of the adjacent zone is the width from the diffuser face to a specified velocity, typically 40 FPM, refer to **Figure 7**.

Figure 6

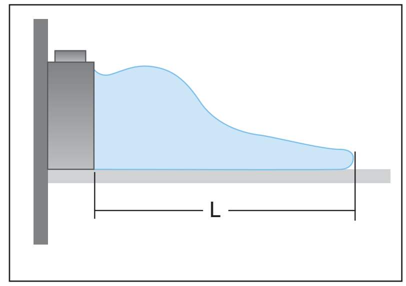


Figure 7

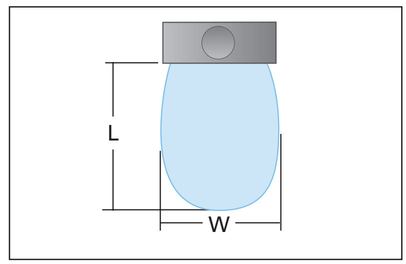
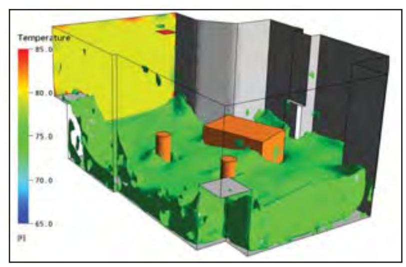


Figure 8



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