APPLICATION GUIDE

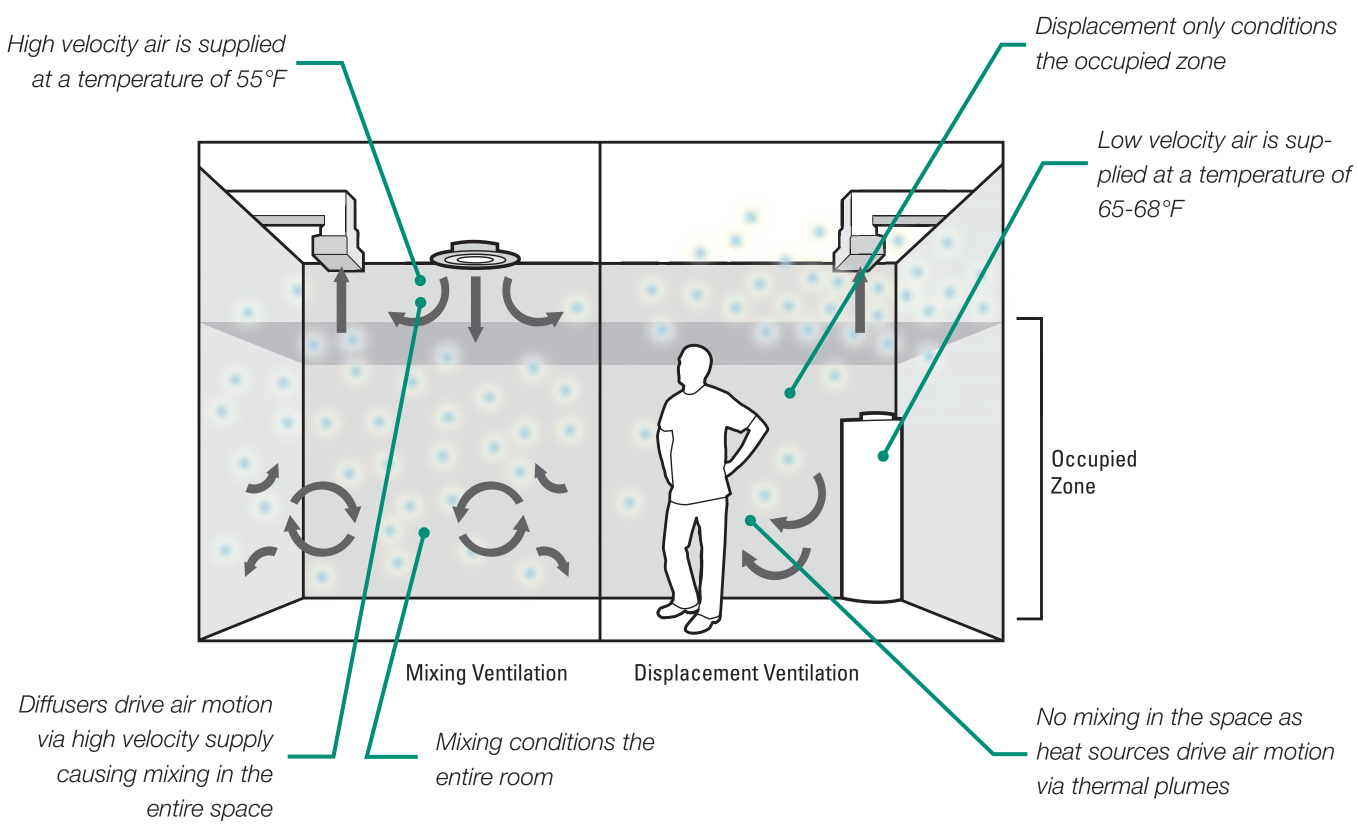
DISPLACEMENT

price | DISPLACEMENT

HOW DOES DISPLACEMENT WORK?

Displacement ventilation provides low velocity air at around 65°F that relies on buoyancy forces to drive the air motion. Supply air spreads across the floor until encountering thermal plumes from heat sources that naturally drive the clean, conditioned air up through the breathing zone. Heat and contaminants are carried up to high-level return or exhaust grilles instead of getting recycled through the space. The result is high ventilation effectiveness and improved thermal comfort delivered in an energy efficient manner.

Displacement Compared to Mixed Air Systems



COMMON APPLICATIONS - HIGH CEILINGS

Displacement ventilation creates a stratified environment that can greatly benefit high ceiling areas and reduce airflow requirements for the space. Diffusers can be uniquely integrated into the structure through the floor or walls to lend additional flexibility to the architectural design of the space.

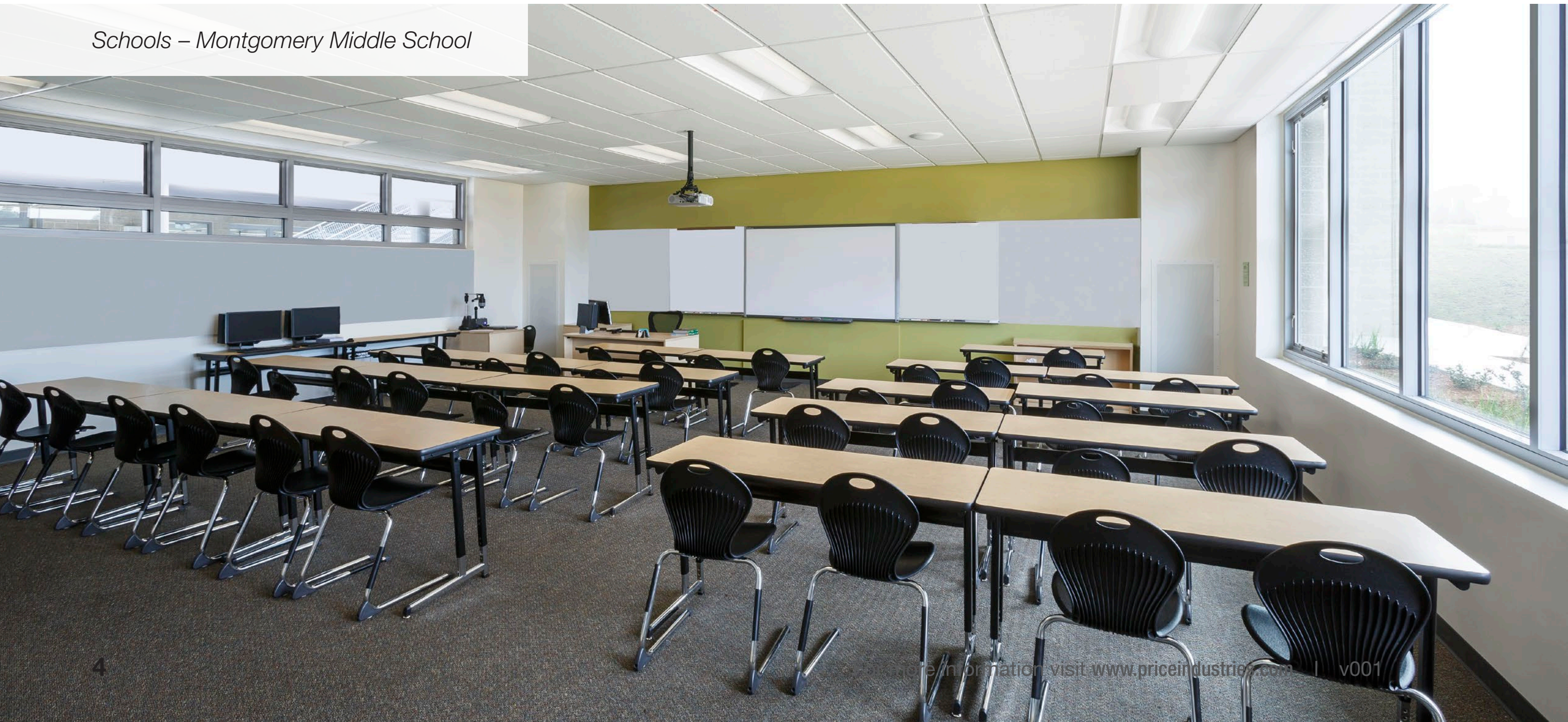
Auditoriums – Kauffman Center for Performing Arts

Airports – San Francisco International Airport T2

Casinos – Edgewater Casino

COMMON APPLICATIONS - HIGH OCCUPANCY

High occupancy applications such as schools or offices can implement displacement ventilation to provide a superior indoor environment improving the air quality, reduce noise levels generated by air delivery systems and offer additional flexibility using air that is driven by the heat sources and not by the high velocity mixing of the space. This system can be beneficial to occupant health and performance.



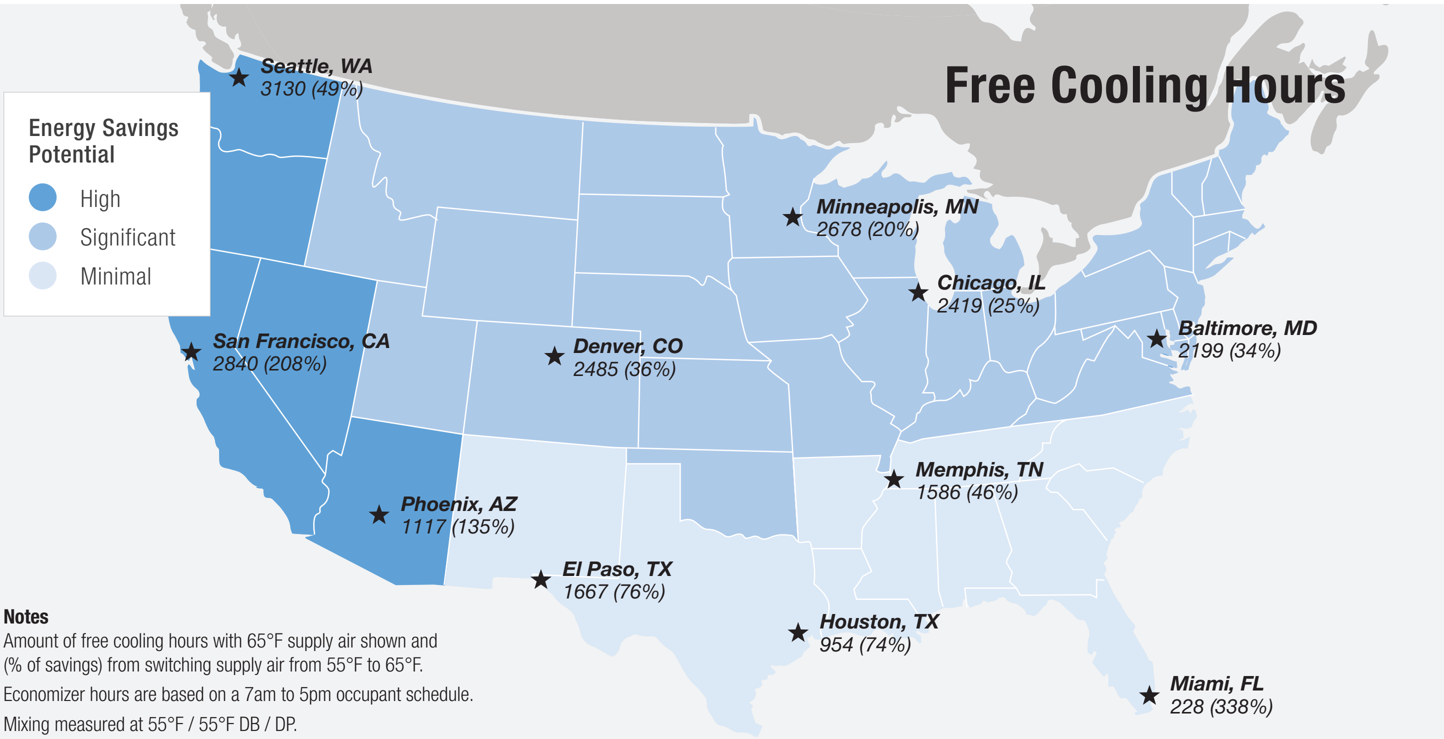
Schools – Montgomery Middle School

BENEFITS OF DISPLACEMENT VENTILATION

1. Energy Savings

Increased Free Cooling Hours

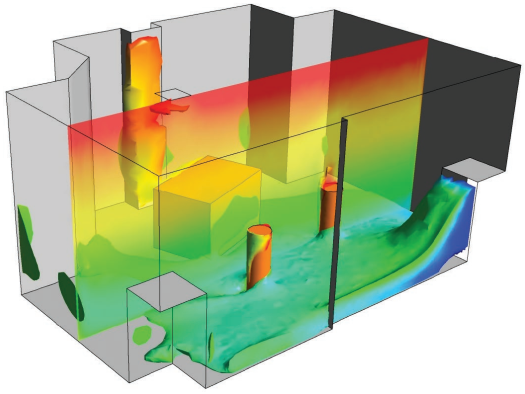
Warmer supply air allows for increased economizer usage and free cooling. In areas of the country where the outdoor humidity allows, displacement ventilation increases the number of economizer hours that can be used to save air conditioning energy. For example, in some regions, changing the supply air temperature from 55°F to 65°F can double the number of economizer hours.



Notes
Amount of free cooling hours with 65°F supply air shown and (% of savings) from switching supply air from 55°F to 65°F.
Economizer hours are based on a 7am to 5pm occupant schedule.
Mixing measured at 55°F / 55°F DB / DP.
Displacement measured at 65°F / 55°F DB / DP.

Stratification

Displacement ventilation creates a vertical temperature differential throughout the space. This means that even though the supply air is warmer than mixing systems, the return air temperature is higher than the occupied space set point. ASHRAE 55 2017 currently allows the temperature differential from the ankle height to the head region to be designed at 5.4°F for seated occupants and 7.2°F for standing occupants. Stratification should be maximized to optimize energy savings by reducing airflow requirements while also considering proper comfort. This benefit can be substantial with taller spaces.



Displacement Ventilation: Stratified temperature

Temperature in Fahrenheit

Reduced Outdoor Air Requirement

The result of supplying the fresh air at low level and letting buoyancy drive the air through the space creates an improvement in air quality from a fully mixed system. ASHRAE recognizes this improvement and allows for a reduction in outside air required to condition a space. Zone air distribution effectiveness (E_z) is used to quantify this improvement and is defined as a measure of how effectively the zone air distribution uses its supply air to maintain acceptable air quality in the breathing zone (ASHRAE 62.1 2013).

From ASHRAE 62.1 2013

Breathing Zone Outdoor Airflow

The outdoor airflow required in the breathing zone of the occupiable space: V_{bz}

Air Supply Method	E_z (ASHRAE 62.1)
Mixed - Heating	0.8 – 1.0
Mixed - Cooling	1.0
Displacement	1.2

Values summarized from ASHRAE 62.1 2013 table 6.2.2.2

Zone Outdoor Airflow

The zone outdoor airflow (V_{OZ}), i.e., the outdoor airflow rate that must be provided to the ventilation zone by the supply air distribution system, shall be determined in accordance with Equation 6.2.2.3: $V_{OZ} = V_{bz} / E_Z$

Sample Calculation

Mixing

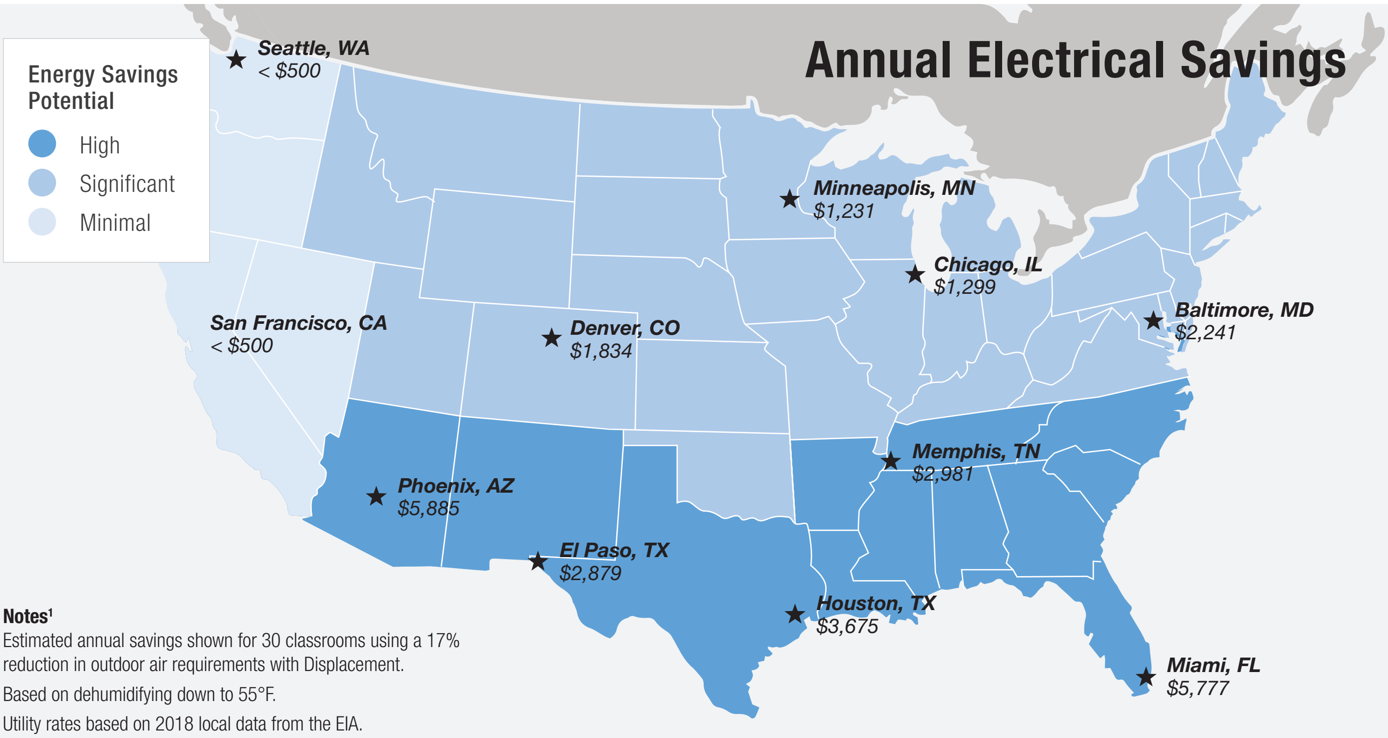
$$V_{OZ,M} = V_{bz} / E_{Z,M} = V_{bz} / 1.0 = V_{bz}$$

Displacement

$$V_{OZ,DV} = V_{bz} / E_{Z,DV} = V_{bz} / 1.2 = 0.83\ V_{bz}$$

= ***17% Reduction in outdoor air requirement***

Reducing the ventilation rate can translate to significant energy savings in hot and humid climates.



Notes[1]

Estimated annual savings shown for 30 classrooms using a 17% reduction in outdoor air requirements with Displacement.

Based on dehumidifying down to 55°F.

Utility rates based on 2018 local data from the EIA.

References listed on page 10.

2. Increased Indoor Environmental Quality

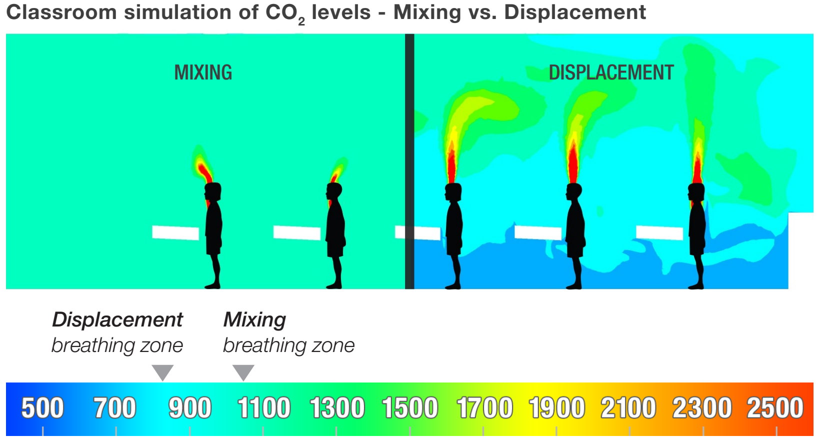
Superior Indoor Air Quality

The Environmental Protection Agency (EPA) suggests schools investigate using displacement ventilation: "Designers should investigate a method called vertical displacement ventilation or thermal displacement ventilation. This approach successfully uses natural convection forces to reduce fan energy and carefully lift air contaminants up and away from the breathing zone."[2]

Many studies claim large improvements in air quality with Displacement Ventilation.

- Classroom study with DV shows 17% – 27% lower peak CO_2 levels in the breathing zone than the control space with a mixed air system.[3]
- ASHRAE recognizes a minimum 20% improvement in air quality.[4]
- Spaces using Displacement resulted in 25% – 90% better air quality than spaces using overhead mixing air systems.[5]
- A two year study in 12 schools retrofitted with DV reported a reduction in reported asthmatic symptoms by 69%.[6]

Classroom simulation of CO_2 levels - Mixing vs. Displacement



CO_2 LEVELS IN PARTS PER MILLION

Several independent studies have analyzed the **impact of CO_2 and Indoor Air Quality on occupant performance and health.**

- A 400 ppm increase in CO_2 resulted in a 21% decrease in cognitive scores.[7]
- An increase in CO_2 levels correlated to an increase in health symptoms and a reduction in performance.[8]
- Higher CO_2 concentrations were associated with an increase of wheezing attacks in children.[9]

Indoor air quality studies reveal high CO_2 levels in U.S. classrooms throughout the country.

- One Texas study[10] that reviewed 120 randomly selected classrooms with unit ventilators and heat pumps found that:
  - 88% exceeded 1,000 ppm peak CO_2 concentrations
  - 22% and 54% had 3,000 ppm and 2,000 ppm peak CO_2 levels respectively.
- Similar trends were identified in a Washington and Idaho study.[11] This study also noted that:
  - A 1,000 ppm increase in space CO_2 corresponded to a 10% – 20% increase in student absence.

References listed on page 10.

High Thermal Comfort

Displacement Ventilation supplies air at a low face velocity (typically 40 fpm) into the occupied zone and at a temperature around 10°F cooler than the set point. The increase in supply air temperature combined with the low velocity airflow results in superior thermal comfort.

Improved Acoustics

The displacement system creates a quiet environment due to the low velocity air introduced into the space. Lower noise levels are advantageous for spaces such as classrooms, offices, auditoriums, libraries and other noise critical areas. One classroom study noted an 8 dBA reduction in sound level by using a displacement air flow in comparison to a classroom nearby that used a mixed air ceiling system.[3]

3. Reduced Maintenance

Application in Focus – Schools

EPA suggests central AHUs instead of unit ventilators to minimize health and maintenance issues [12]

“It is more difficult to assure proper maintenance of multiple units over time and they [unit ventilators] present additional opportunities for moisture problems through wall penetrations and from drain pan and discharge problems.”

The EPA states that “maintenance issues can lead to lower Average Daily Attendance (ADA)” which is used as a metric for acquiring federal funding in a number of states. Displacement Ventilation contains similar mechanical components to an overhead VAV mixed air system but simply delivers the air into the space in a more efficient manner.

In Space Maintenance	Displacement Ventilation	Unit Ventilator	VRF
No Filters	✓	✗	✗
No Drain Pans	✓	✗	✗
No Coils to Clean	✓	✗	✗
No Envelope Wall Openings	✓	✗	✓
No Refrigerant Line Monitoring	✓	✓	✗

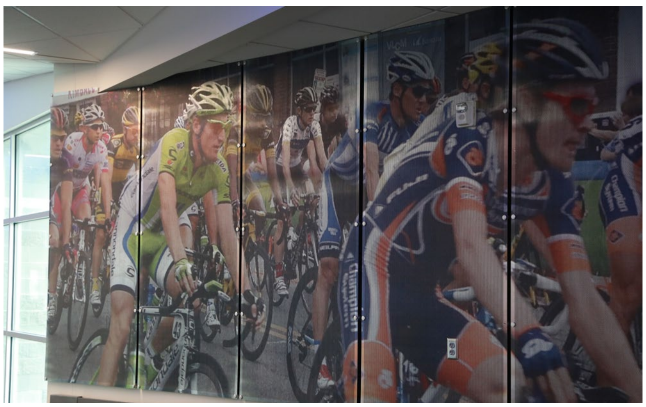
References listed on page 10.

4. Architectural Integration

+ Can be integrated into structure and furniture elements to free up ceiling space.
+ Available in various colors, sizes and custom finishes, seamlessly integrating into any space.
+ Special mounting options, inlet locations, and integrated utilities.
+ Heavy-duty construction available for high traffic areas such as gyms, schools, and industrial settings.

Schools

Displacement diffusers in this school are integrated behind the perforated wall design.

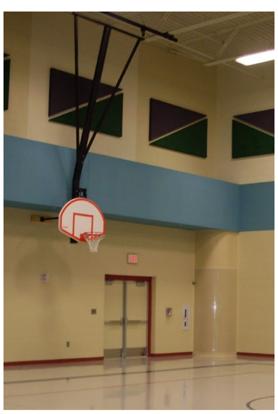


Libraries

Displacement diffusers can be equipped with a number of options including duct covers and bases to suit the architecture of the space.

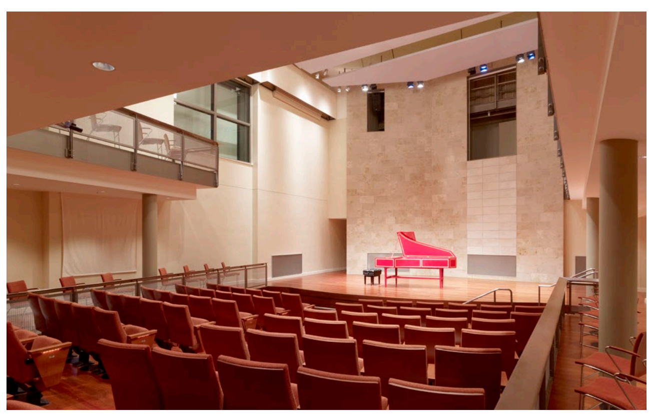
Gymnasiums

The rugged construction options for displacement diffuser make them well suited to the demanding K–12 gymnasium environment. Other advantages include straight forward aesthetic integration and an insensitivity to obstructions allowing for installation behind bleachers or other furniture.



Performance Hall / Auditorium

Diffusers can be hidden beneath seating to provide fresh air directly to the occupied zone. The low velocity and low pressure drop across displacement diffusers result in superior acoustical performance.



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