Displacement Ventilation in Schools

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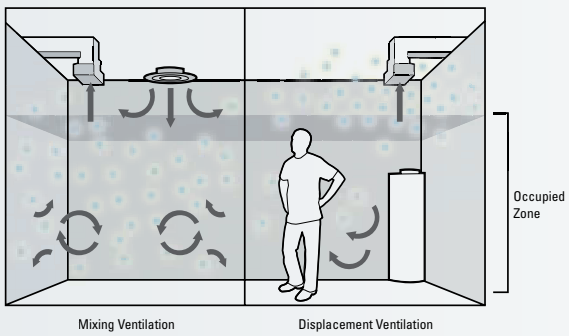
Introduction

Displacement Ventilation (DV) originated in industrial facilities in Europe as an effective way to remove contaminants from the occupied zone. It has since gained popularity in a variety of applications in both Europe and North America due to its superior air quality, thermal comfort, and energy efficiency.

Displacement differs from traditional overhead mixing systems in several fundamental ways:

Mixing Systems	Displacement Ventilation	Benefit of DV
55°F supply air	65-68°F supply air	**Improved thermal comfort and energy efficiency**
Mix the entire space	No mixing in the space	**Improved indoor air quality**
Diffusers drive air motion via high velocity supply air	Heat sources drive air motion via thermal plumes	**Improved thermal comfort and layout flexibility**
Uniform temperature	Stratified temperature	**Improved thermal comfort**
Conditions entire room	Only conditions the occupied zone (the first six feet of a space)	**Improved energy efficiency**
High supply velocity (minimum 150 fpm 1 ft from face)	Low supply velocity (40 fpm average at face)	**Improved thermal comfort**



Displacement provides high temperature, low velocity supply air, relying on the buoyancy forces of air to drive air motion.

The result is high ventilation effectiveness and improved thermal comfort delivered in an energy efficient manner.

Indoor Environmental Quality (IEQ)

Displacement ventilation systems produce environments with extremely high indoor environmental quality, producing the following IEQ benefits that are all critical design criteria in schools.

Superior Air Quality and Ventilation Effectiveness

In DV systems, the supply air must pass through the breathing zone before being exhausted, because it travels from a low level to ceiling mounted returns. As it does this, it carries contaminants away from the occupant, leading to a high ventilation effectiveness compared to mixing systems.

Displacement results in a high ventilation effectiveness (1.2 or higher) compared to mixing systems (1.0 or below).

High Thermal Comfort

DV delivers supply air at an average of 40 fpm and at a temperature no more than 10°F cooler than the room air. This high temperature, low velocity supply air results in less draft and a lower percentage of people dissatisfied per ASHRAE Standard 55-2010.

A Quiet Environment and Improved Acoustics

Displacement diffusers distribute supply air at a very low velocity into a room, resulting in whisper quiet operation.

Displacement systems typically achieve NC levels of 15 to 20.

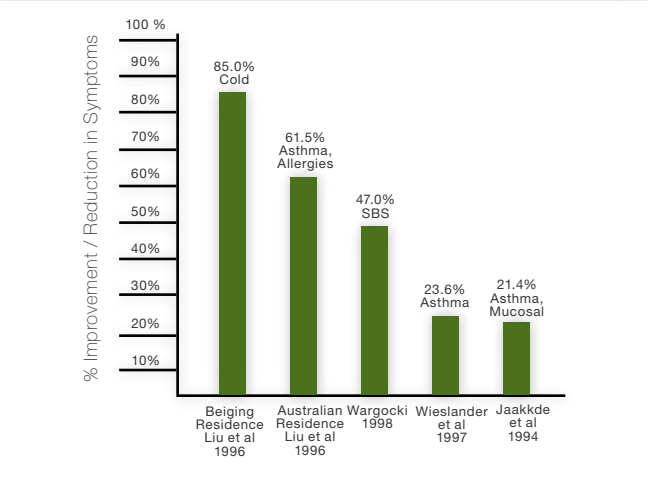
Benefits of Improved IEQ in Schools

Indoor Environmental Quality (IEQ) has been proven by several independent studies to have a major impact on the health, performance and attendance of students and teachers.

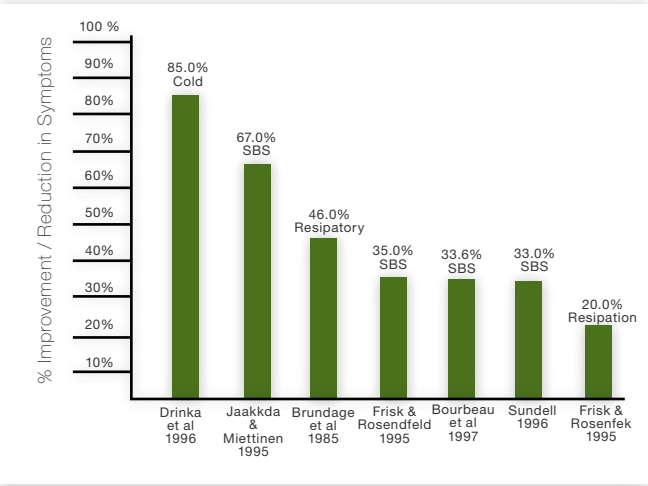
Student Health

CHPS Literature Review:

- Higher IAQ resulted in reduced asthma, colds, flus, and headaches



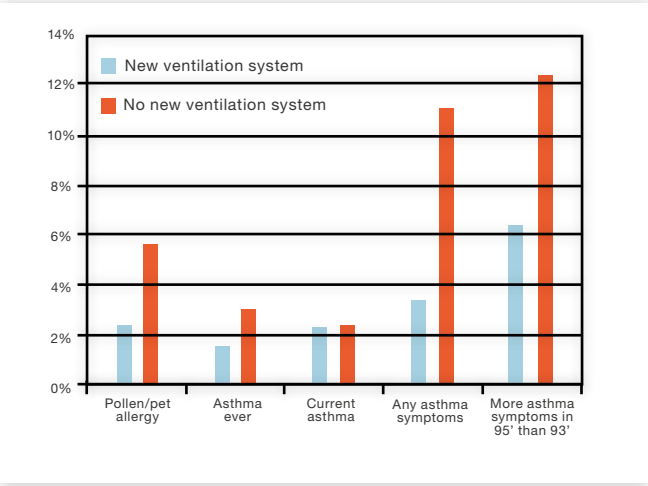
CHPS Literature Review



CHPS Literature Review

Smedje and Norback, 2000:

- Swedish study of 39 schools over a two year period
- 69% reduction in asthma for children attending schools with displacement systems

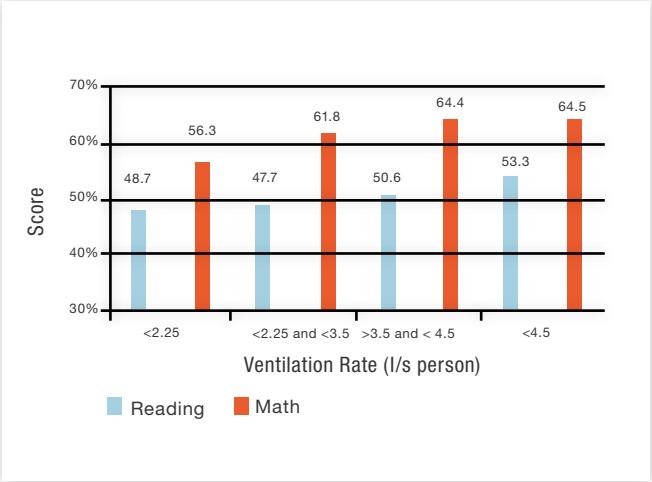


Smedje and Norback, 2000

Student Performance

Shaughnessy *et al.*, 2006:

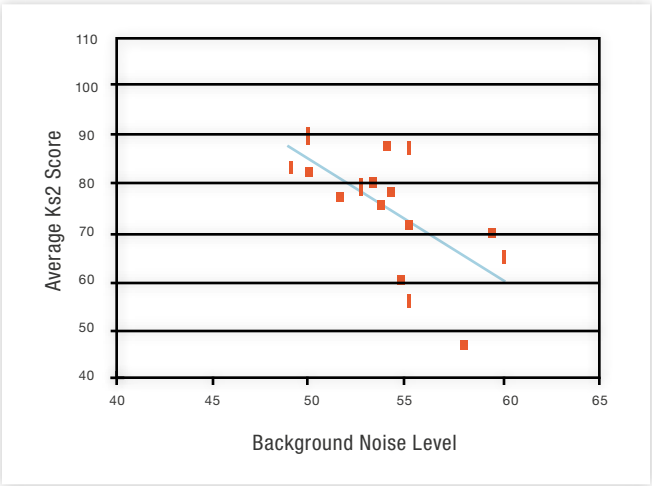
- Studied the effect of ventilation rate on student performance in standardized testing in 54 schools
- Found performance improvements in classrooms with higher ventilation rates



Shaughnessy *et al.*, 2006

Shield and Dockrell, 2003:

- Studied the relationship between classroom noise and student performance
- 21% test score improvement for students with less than 50 dBA background noise

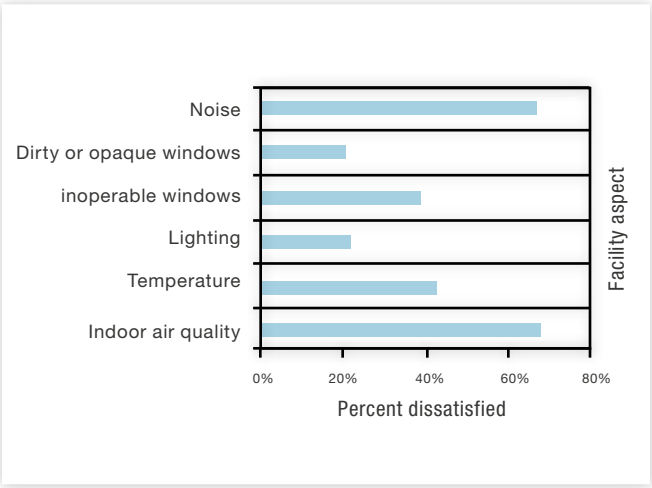


Shield and Dockrell, 2003

Teacher Retention

Buckley, Schneider, and Shang, 2004:

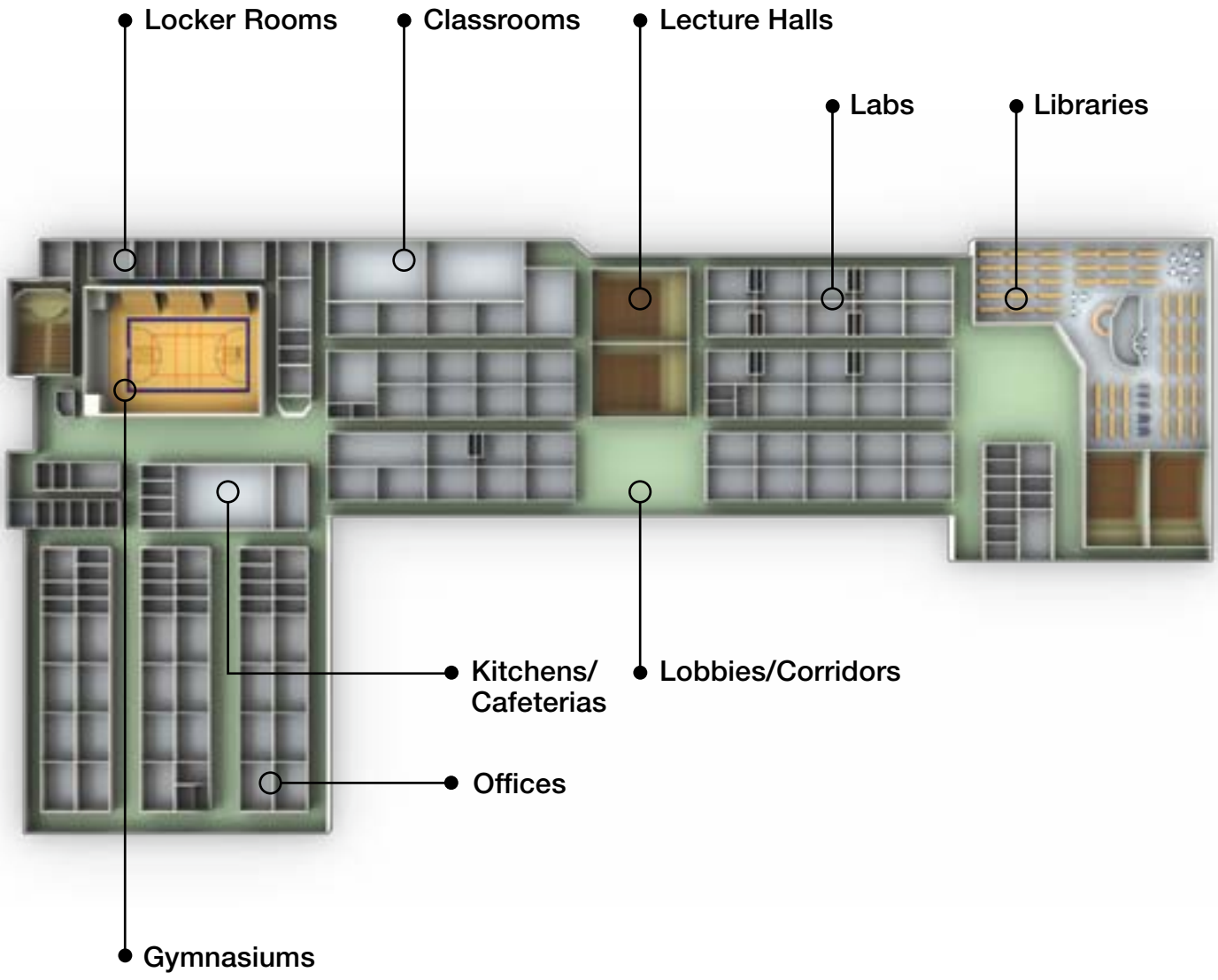
- Rated satisfaction of 835 teachers in 89 schools based on IEQ
- Improving satisfaction with IEQ resulted in a 5% increase in retention.



Buckley, Schneider, and Shang, 2004

Applying DV in Schools

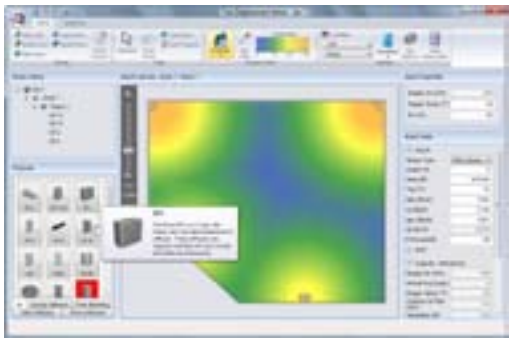
Displacement ventilation is a flexible method of air distribution that can be used throughout an educational facility to improve air quality and thermal comfort, while saving energy and reducing utility cost.



Displacement Ventilation in Classrooms

Classrooms form a large portion of most buildings by square footage and are where students and teachers spend most of their time. The indoor air quality, thermal comfort, and low noise levels of displacement ventilation make it ideal for this application.

These rooms are generally densely occupied for extended periods of time, making minimizing draft and maximizing usable space of primary concern.



Price DV Room Designer Software

Minimize Draft Zone

- Use Price Room Designer software to test diffuser layout for thermal comfort.

Integrate Diffusers

- DF1C corner mounted and DF1R recessed diffusers are excellent choices for maximizing usable space in a classroom.
- Custom diffusers can be integrated into furniture and millwork.

DF1C

Improved Ventilation Effectiveness

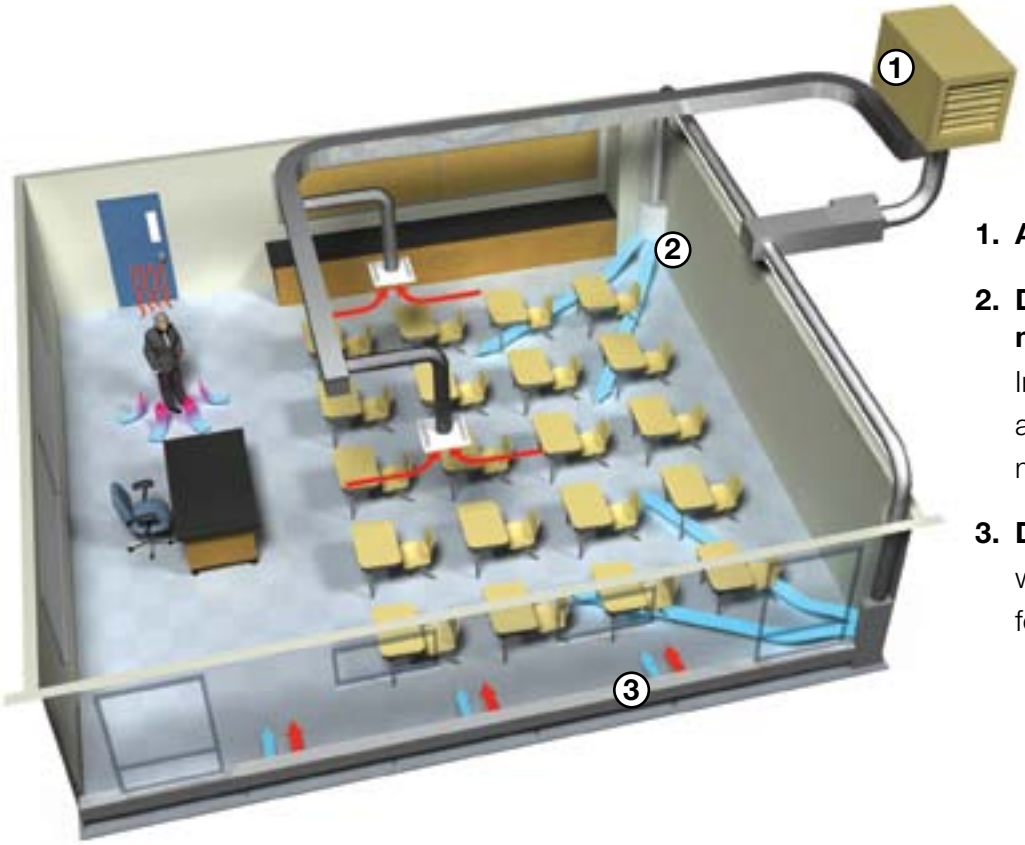
- The improved ventilation effectiveness of DV ensures that students receive clean fresh air sooner.
- Air changes can be reduced without compromising air quality to achieve energy savings.

DF1R

Acoustics

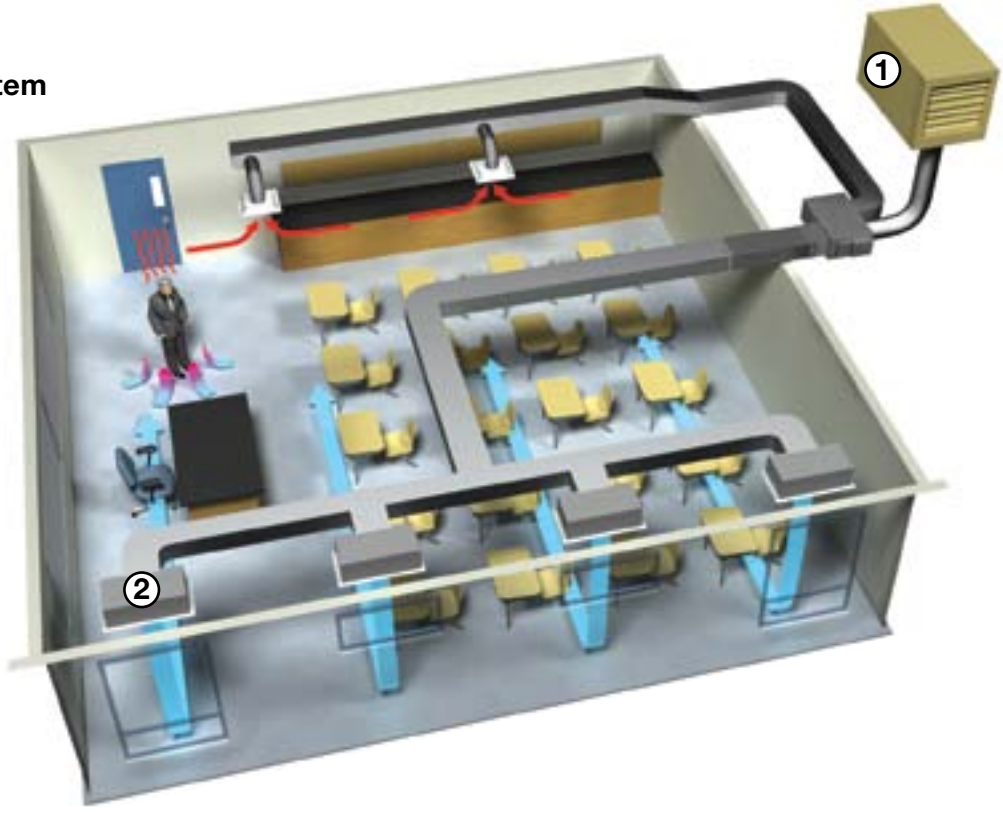
- Low noise levels are critical to a successful learning environment. DV can help schools achieve classroom noise levels under NC 20, resulting in improved concentration and performance.

Sample Classroom Applications



1. **Air Handling Unit**
2. **DR90 or DF1C corner mounted diffuser**
   Integrating diffusers with architectural elements maximizes usable space
3. **DLE-H linear enclosure**
   with integrated heat for perimeter heating requirements

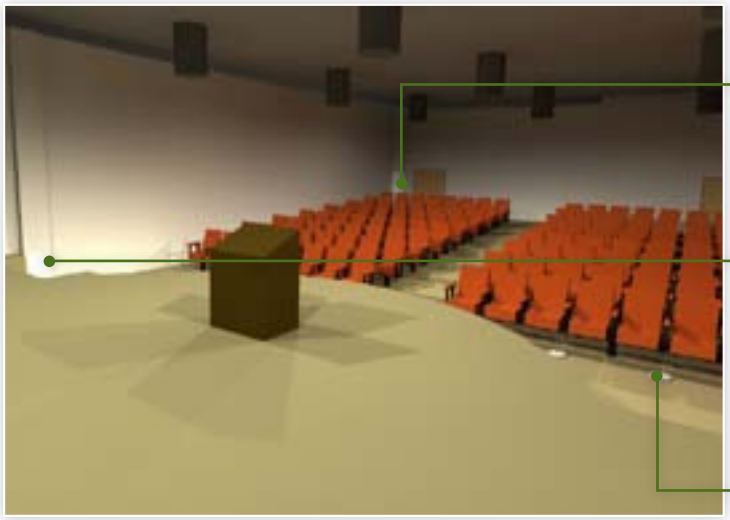
1. **Dedicated Outdoor Air System**
2. **DF1L lay-in displacement diffuser**
   Provides displacement cooling while maximizing usable space



DV in Auditoriums/Lecture Halls

The whisper quiet operation and superior air quality of displacement make it ideally suited for densely populated auditoriums.

In addition, since only the occupied space is cooled, energy is not wasted cooling the significant lighting loads and large amount of space near the ceiling.



DR90 or DF1C Corner Diffusers adjust air flow to accommodate various room loads

DF1W Wall Diffusers integrate seamlessly into the sidewall to save floor space

RFDD or ARFHD Underfloor Displacement Diffusers provide cool, fresh air to the occupants from the plenum beneath the floor

DV in Cafeterias and Kitchens

Displacement ventilation ensures that clean, fresh air is delivered to kitchen and cafeteria occupants, effectively removing contaminants and odors.

In the kitchen, the low velocity air does not disrupt the function of the exhaust hoods. The cooling load is also decreased, as heat generated by cooking equipment rises to the ceiling rather than being recirculated throughout the room.

Right: Stainless steel DR90 diffusers in a school kitchen

DV in Gymnasiums

Similar to theaters, gymnasiums typically have high ceilings. Conditioning these spaces with displacement cools only the occupied zone, resulting in significant energy savings.

Price offers industrial grade diffusers with heavy gauge faces capable of handling the abuse taken in a gymnasium. These spaces can also tolerate a higher face velocity due to the high activity levels of the occupants.

Diffusers in gymnasiums can produce higher face velocities, and typically have upgraded construction.

DV in Libraries

Libraries are often mixed-use spaces in schools, with areas for computer use, book storage, reading, and meetings. The ability to reconfigure the space quickly and economically is of great value.

An access floor and underfloor air distribution offers this flexibility, as diffusers can be relocated quickly, often without having to modify ductwork. Price offers several diffusers that combine the flexibility of UFAD with the superior air quality and thermal comfort of displacement, including RFDD and ARFHD round floor diffusers and DFG displacement floor grilles.

Above: Price Displacement Ventilation products installed in a library

CHPS and LEED for Schools

The Collaborative for High Performance Schools is a national K-12 green school rating system in the United States whose goal is to improve student performance and educational experience by applying high performance building criteria and the best possible building technology to schools.

Collarborative for High Performance Schools (CHPS)

CHPS recommends Displacement Ventilation as the preferred air distribution method and awards up to 4 CHPS points for its use.

Leadership in Energy and Environmental Design (LEED)

The United States Green Building Council's Leadership in Energy and Environmental Design (LEED) program has a rating system specifically designed for schools for which displacement ventilation can earn points.

Software Tools

Price offers the best software tools in the HVAC industry for selecting and evaluating displacement ventilation diffusers as they apply to schools.

Room Designer for Displacement Ventilation

Our revolutionary Room Designer for Displacement Ventilation allows a designer to select and lay out Price displacement diffusers based on draft risk comfort data.

The software calculates comfort using ASHRAE formulae based on local air temperature and local air velocity, responding in real-time to diffuser placement.

The software is specifically designed to accommodate school design criteria, including ventilation rates.

Visit **www.price-hvac.com/Software/Roomdesigner** to download Room Designer today!

All-In-One Selection Software

Price's All-In-One Selection software allows an engineer to perform air volume calculations, evaluate system performance and select products, including displacement ventilation diffusers, with speed and accuracy.

Visit **www.price-hvac.com/Software/AIO/** to download All-In-One today!

Price Sustainable Building Website

The Price Sustainable Building Website is the ultimate online resource for those looking to learn more about sustainable HVAC technologies like displacement ventilation.

The site features:

- Product Information
- Research Papers
- Case Studies
- Training Modules
- Smoke Test Videos
- Product Videos

Visit **www.price-hvac.com/sustainable** today!

Price Engineer's HVAC Handbook

The Most Comprehensive Guide to HVAC Fundamentals

The Price Engineer's Handbook is a compilation of the engineering knowledge related to the application of air distribution and noise control products and approaches gained at Price over the past 60 years.

The Handbook contains chapters on Displacement Ventilation and its applications, including liberal use of examples and graphics to help illustrate and explain concepts and systems.

Chapter 15: Displacement Ventilation

Chapter 16: Applications of Displacement Ventilation

Contact your local Price sales representative to reserve your copy.

Resources and Support

PRCN: Price Research Center North

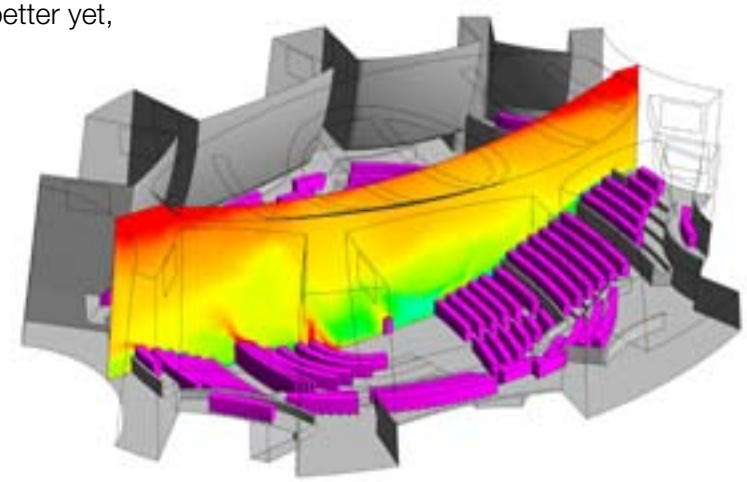
Price's state-of-the-art research laboratory, Price Research Center North, features the most advanced displacement flow visualization chambers, testing facilities, and mock-up rooms in North America.

Flow visualizations and mock-ups allow designers to simulate field conditions and evaluate system performance –giving them confidence that their space will perform as expected in the field.

Ask about our mock-up services on your next job, or better yet, visit PRCN yourself and tour the facilities.

Computational Fluid Dynamics Modeling

CFD provides a means to validate design before construction and gives confidence that the system will perform as intended in the field. Price has an experienced and proficient CFD team and we encourage designers to work with us to validate their designs.



Applications Support

Price is a service oriented company and has a dedicated Displacement Ventilation applications team devoted to answering your questions quickly, completely, and correctly. We are here to help! Our applications team regularly provides support on:

- Model Selection
- Layout Assistance
- Calculation Assistance
- On-site Training
- On-site Performance Validation

Price Training Programs and Webinars

The Price Training Programs (PTP) provides Consulting and Design Engineers with the training needed to specify and select air distribution equipment to best meet their design criteria. The displacement course covers everything you need to know about displacement products, including:

- Overview of DV
- Theory and Design Considerations
- Displacement Products
- PRCN and Engineering Support

Our webinars are another excellent way to learn about specific topics while gaining professional development hours.

Visit **www.price-hvac.com/ptp** to register today!

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The Price catalog is available online at www.price-hvac.com

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