Displacement Ventilation for Schools

ADVANCING THE SCIENCE OF AIR DISTRIBUTION

light powered | k-12 education | woodgrains | dual-function | energy solutions

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Titus
Redefine your comfort zone.™

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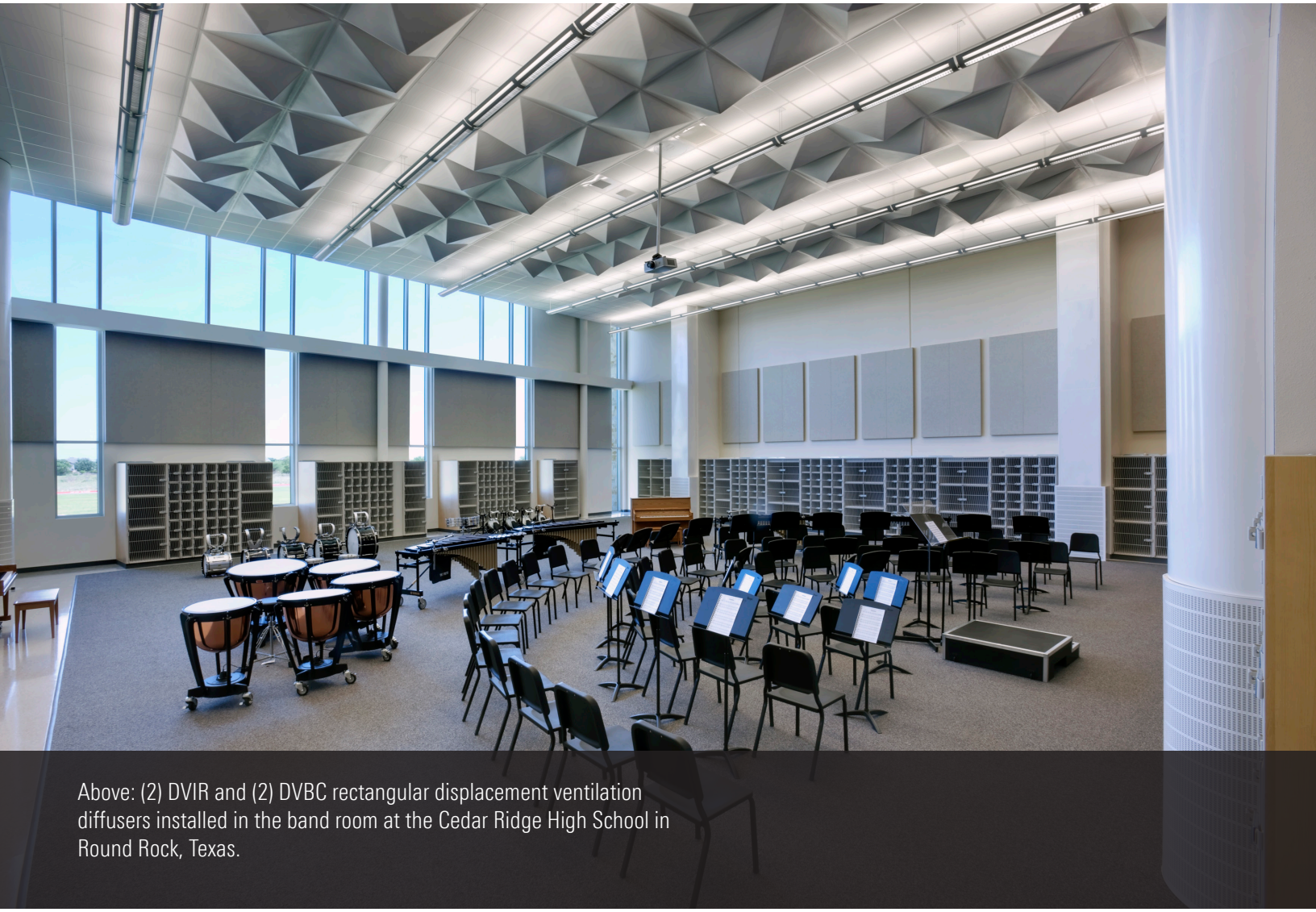

Above: (2) DVIR and (2) DVBC rectangular displacement ventilation diffusers installed in the band room at the Cedar Ridge High School in Round Rock, Texas.

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Overview – Displacement Ventilation Systems

EDUCATIONAL FACILITIES HAVE A NEW SOURCE FOR FRESH AIR

Displacement Ventilation systems use low velocity cold air to displace warm room air. They are defined by ASHRAE as fully stratified systems. Supply air is introduced low in the occupied space and travels along the floor until it reaches a heat source, such as a person or computer. Natural convection flows cause the supply air to rise around the heat source.

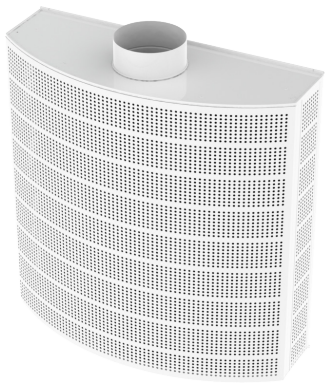
The Displacement Ventilation system is similar to an UnderFloor Air Distribution (UFAD) system in that is uses warmer supply air and lower pressures then a conventional overhead system. As a result, displacement ventilation systems have many of the same benefits of UFAD systems, such as longer economizer periods, potential energy savings from the warmer supply air and lower horsepower fans, and quiet operation. Although many parts of North America need to cool the supply air below 65°F for humidity reasons, all areas should benefit from the increased economizer time.

An additional benefit to Displacement Ventilation systems is that ASHRAE Standard 62.1-2007 Ventilation for Acceptable Indoor Air Quality gives Displacement Ventilation Systems a Ventilation Effectiveness Factor of 1.2. Ventilation Effectiveness is a measure of how effectively the zone air distribution uses its supply air to maintain acceptable air quality in the breathing zone. A Ventilation Effectiveness Factor of 1.2 means that a lower volume of fresh air can be used to meet ASHRAE 62.1 requirements. This makes displacement ventilation systems an effective way to achieve the LEED Increased Ventilation credit.

One of the challenges to displacement ventilation is that the diffusers are placed in the occupied zone, typically along the wall. Because displacement diffusers supply air directly into the room, placement of the diffusers is critical to achieving a comfortable space. The ASHRAE Guideline recommends that the air velocity in the occupied zone not exceed 50 fpm. For a displacement diffuser, the zone where the velocity exceeds 50 fpm is called the adjacent zone or near zone. Occupants need to be placed outside of the adjacent zone for comfort. A typical displacement diffuser can maintain comfort in a space that is approximately 5-6 times the length of the adjacent zone.

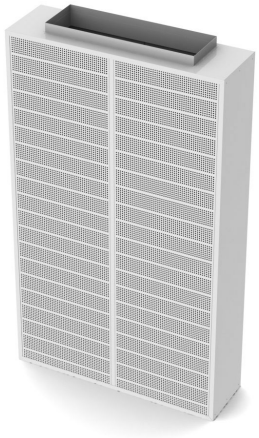
Titus has a full line of displacement ventilation diffusers to accommodate any application. One unique feature of Titus displacement diffusers is the variable air pattern controllers located behind the perforated face. The pattern controllers can be adjusted to change the size and direction of the supply airflow pattern and adjacent zone area. Engineers may not always know the final room layout or furniture location during the design phase. Titus displacement diffusers provide the perfect solution by offering adjustability without the need to move or change the location of the diffuser. This ability to shape and customize the airflow pattern and adjacent zone to match requirements in the occupied space ensures the highest level of thermal comfort for building occupants.

rectangular displacement diffusers



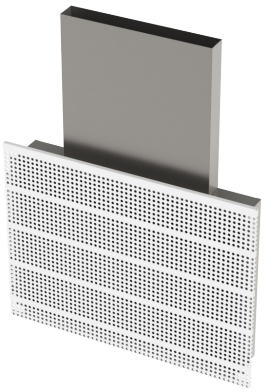
DVBC

The DVBC is a rectangular displacement diffuser with a curved face for wall mount applications. The air pattern controllers are easily adjustable to change the airflow spread pattern.



DVRI

The DVRI is a rectangular displacement diffuser that can be positioned against the wall in a flush or surface mount orientation. It has a one-way air distribution pattern and supplies a large volume of air air at low velocities into the occupied zone.

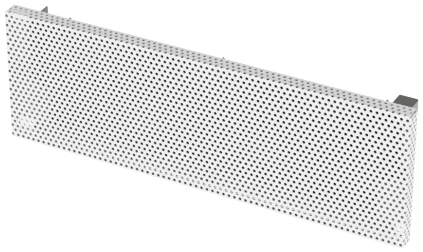


DVIR

The DVIR is a rectangular displacement diffuser with a one-way discharge pattern designed for flush mount applications. Constructed of galvanized steel and aluminum, the DVIR is designed for in-wall applications.

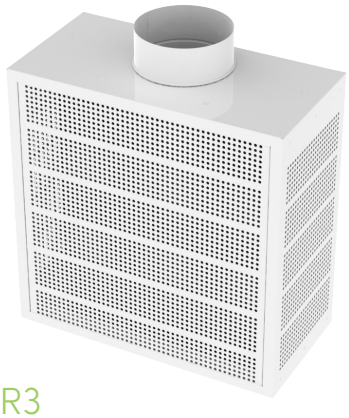
All Titus Displacement Ventilation products can contribute toward achieving LEED EA Credit 1: Optimize Energy Performance; IEQc2: Increased Ventilation; and IEQc7.1: Thermal Comfort - Design.

Woodgrain finish options are available for select displacement ventilation products.



DVR1

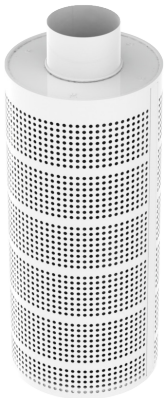
The DVR1 is a rectangular displacement diffuser with a one-way discharge pattern designed for stair riser applications.



DVR3

The DVR3 is a rectangular displacement diffuser with a three-way discharge pattern designed for flush mount applications.

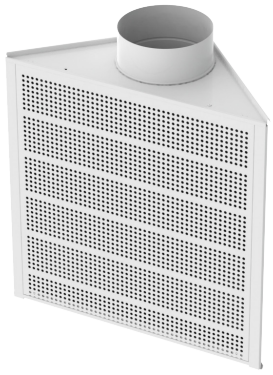
circular displacement diffuser



DVCP

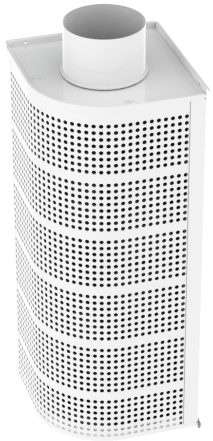
The DVCP is a round freestanding circular displacement diffuser designed for floor mounted applications. It provides a 360° air distribution discharge pattern. The DVCP is designed to supply a large volume of air at low velocity into the occupied space and works well in lobbies, airports and restaurants.

corner mount displacement diffusers



DVC1

The DVC1 is a flat face corner mount displacement diffuser that is designed for corner mounted applications. The unit has a two-way air distribution pattern and easily adapts to different floor layouts.



DVVC

The DVVC is a corner mount displacement diffuser designed for corner mounted applications. The unit has a two-way air distribution pattern and easily adapts to different floor layouts.

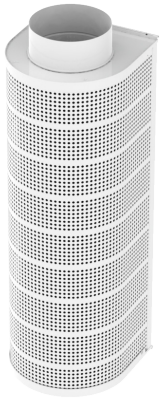
semi-circular displacement diffusers

DV180

The DV180 is a semi-circular displacement diffuser with a 180 degree air discharge pattern. It is great for wall or surface mount applications and can be easily integrated into semi-circular building columns.

All Titus Displacement Ventilation products can contribute toward achieving LEED EA Credit 1: Optimize Energy Performance; IEQc2: Increased Ventilation; and IEQc7.1: Thermal Comfort - Design.

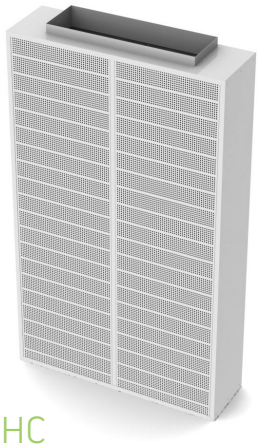
Woodgrain finish options are available for select displacement ventilation products.



DVHC

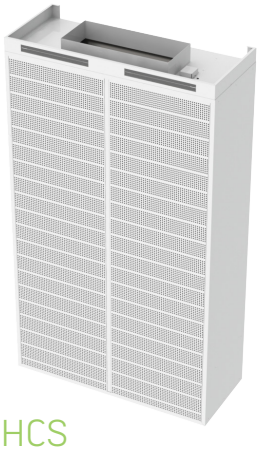
The DVHC is a semi-circular displacement diffuser with a 180 degree air discharge pattern.

heating & cooling displacement diffusers



DVRI-HC

The DVRI-HC "Plexicon" is a dual function diffuser that combines displacement ventilation cooling and mixed air heating from one unit. The unique dual plenum design utilizes a single supply duct connection with a motorized damper for ease of design and installation.



DVRI-HCS

The DVRI-HCS "Solar Plexicon" is a solar-powered, energy-harvesting, dual function diffuser that combines displacement ventilation cooling and mixed air heating from one unit. It requires no external power connections and utilizes solar panels to store energy to power the unit.

The Importance of Fresh Air in Schools

NEW STUDIES SHOW IMPROVED LEARNING ABILITIES WITH THE PROPER HVAC SYSTEM

CLEAN AIR - AN EXTREMELY VALUABLE COMMODITY

Early childhood education is a very important and vital piece for our society. It helps to establish the basic foundation in which our children will grow and develop into productive members of the world we live in. Kids today spend the majority of their days in schools and yet many of our nation's school buildings are in poor conditions, with several systems in need of repair or replacement. Most state and local budgets have grown increasingly limited especially in today's economy, so funding for new school construction and renovation are carefully and often times scrutinized. It is important to ensure that investments are going toward efforts that can best foster healthier buildings and safer learning environments.

Administrators, designers and architects are aware that the improved quality of school buildings can have a major impact on a student's health and learning capabilites. It's no fluke that when classrooms are clean, healthy and have an abundance of daylight, that students tend to be more productive, less prone to illness and are more focused on their studies.

A major and sometimes hidden component that plays an important role in school buildings is the design of the HVAC system. A properly or poorly designed system will have a major impact on the air quality and ventilation available in the school. Building systems and materials used also contribute to the overall learning environment as well. They can either have a positive impact on the air quality in a building where the heating, ventilation and cooling systems filter out pollutants in ambient air, or they can have a detrimental effect on the air quality by allowing increased particulate matter, volatile organic compounds (VOCs) and other toxic materials to exist. Moisture intrusion leads to mold problems and other toxins can then become an issue. VOCs present a variety of health concerns including respiratory issues, visual disorders, memory impairment and much more. Building professionals are becoming more aware of how many materials inside the buildings are actually unhealthy for us.

Toxins in buildings are not just limited to VOCs, but exist in other areas too. There are several other toxins present inside the schools and they can have major impacts on air quality. We have just begun to be fully comprehend the effects they have on our learning environment. Some are toxins such as formaldehyde, which is present in many building products like furniture and casework. Other toxins that have been found are Phthalates and Bisphenol A (BPA). These toxins exist in several plastics used in the construction process. All of these chemicals not only create health problems in terms of breathing and respiration, but can also generate other health issues for us due to proximity or skin exposure. Additional information about specific air quality issues in schools is publically provided by the U.S. EPA.

TODAY, RESEARCH HAS SHOWN US?

Research within this field has increased over the years as HVAC system technology has evolved. Knowledge of Sick Building Syndrome (SBS) and the effect that it can have on people has spread more widely. This highly technical field consists mainly of medical researchers. A study

was done several years ago that investigated the effects of various air pollutants on children's health in schools. In its findings, however, it stated that there was not enough evidence available to directly link air pollutants to the impact on learning. Those same researchers and others at Lawrence Berkeley National Laboratories (LBNL) also developed an online library called the Indoor Air Quality Scientific Findings Resource Bank. It provides thorough information on the many aspects of this field.

The lack of adequate ventilation in classrooms is clearly an area that requires additional research. Because most classrooms today are in need of renovations or repair, they do not have active ventilation installed and rely primarily on windows and doors for the source of air. In one field study on real measured ventilation rates in schools, some classrooms were reported to have mechanical ventilation rates as low as 3.4 cubic feet per minute (Turk et al., 1989). This result is less than a third of the required rate (15 cfm) provided by ASHRAE in Standard 62 for classrooms. According to the LBNL Resource Bank, "Three studies of ventilation and respiratory illness (one performed in military barracks, one in a nursing home and one in a jail) found an increase in respiratory illness with very low ventilation rates compared to substantially higher ventilation rates (2.5 versus 20 cfm per person, 8 versus 26 cfm per person, 4 versus 8 cfm per person). In these studies, the percentage increase in respiratory illness in buildings or spaces with the lower, compared to higher, ventilation rates ranged from approximately 50% to 370%. Similar results might be expected in other high density buildings such as school classrooms, though no data are available." The Resource Bank also concluded similar details about the effect that ventilation rates can have on SBS. Existing research has shown sufficient evidence existed to determine that ventilation rates below 50 cfm per person can greatly impact the health and productivity of occupants.

The past few years have seen incredible advancements in research regarding ventilation rates, CO_2 levels and student success in schools. In one study researchers found that task speed increased dramatically in students (10 –12 years old) when outdoor air supply rates were increased from 6.4 to 18 cfm/person, which produced a CO_2 level change from 1300 to 900 ppm (Wyon & Wargocki, 2007). CO_2 levels and ventilation have also been shown to have a connection to average daily attendance (ADA). In a study conducted in 2004, Shendell et al studied 409 typical classrooms and 25 portable classrooms in Washington and Idaho, comparing indoor CO_2 levels to student attendance records. In classrooms where CO_2 was measured to be regularly surpassing 1000 ppm, they saw a 0.5% – 0.9% average decrease in ADA. Incidentally, in portable classrooms, annual ADA was 2% lower than in traditional classrooms.

Significant research has also been done on existing ventilation systems. Researchers are curious to know their connections to student health and learning as well. One study showed a decrease in respiratory illness, asthma in particular, in schools in Sweden that had new ventilation systems installed (compared to schools with older ventilation systems or none) (Smedje & Norbäck, 2000). However, these results are inconclusive. Additional tests performed by other researchers have similar results.

Another factor that sometimes goes unnoticed is that student health can be adversely affected by poor outdoor air quality in and around school buildings (Frumkin et al, 2007). There are several sources of outdoor air pollution that can affect children and adults as well. The U.S. EPA has recently published a comprehensive guideline on school siting that addresses these issues.

WHAT RESEARCH ON AIR POLLUTANTS STILL NEEDS TO BE DONE?

Public health research has clearly demonstrated that there is a strong connection between air pollutants and respiratory health. Research has primarily centered around understanding the impacts of design decisions and building materials rather than other important factors. The most informative research in air quality considers HVAC design and materials specifications as the independent constants and examines the effects that these decisions have on (1) direct air pollutant measurements, (2) health impacts of students or (3) productivity impacts of students.

Additionally, the following concerns related to proper ventilation need further consideration:

- How do various HVAC system designs and maintenance procedures impact our air quality?
- How does materials selection, such as those that include VOCs, affect student health and the learning environment?

Introducing the Titus Solar Plexicon

THE MOST ENERGY EFFICIENT, SOLAR-POWERED SOLUTION FOR AIR DISTRIBUTION

Displacement ventilation is growing in popularity as engineers and design professionals seek to use air distribution systems that are ultra efficient and occupant friendly. The benefits of displacement ventilation include energy savings, and the highest level of indoor air quality (IAQ) of any HVAC system in the market. An additional factor, the cost of the system, is also driving the decision process toward displacement. One reason cost has become so important is the fact that more and more designs with displacement ventilation are also calling for a supplementary heating system as well. Since heating from a traditional displacement system is not possible, providing a second HVAC system to heat the occupied space presents challenges on the cost, design, and installation sides.

To provide a solution, Titus developed the DVIR-HCS Solar Plexicon dual function diffuser. The Solar Plexicon addresses the heating problem by incorporating two air distribution delivery methods - stratified and mixed ventilation, into one diffuser assembly with a single supply duct connection. The Solar Plexicon uses displacement principles to cool and mixed airflow principles to heat the occupied space. The design features two separate internal plenums that provide separate air passage ways for cooling and heating. The front plenum is ducted to a DVRI face to provide displacement cooling. The rear plenum in the unit is ducted to a CT diffuser located at the bottom of the diffuser to provide heating from the floor level. Pattern controllers were added to the CT to provide additional spread in heating mode. The result is a unique dual function diffuser that provides an optimum level of cooling and heating per ASHRAE without the need for a secondary heating system.

To power the auto-changeover action when changing to the cooling or heating mode, the solar Plexicon utilizes the same wireless, energy-harvesting platform that is found in the EOS solar diffuser. The energy-harvesting process that drives the auto-changeover function is achieved by using solar light energy to power the unit. Two miniature motor/actuator assemblies are mounted internally and connected to dampers. Each assembly is powered by solar panels mounted on the unit that gather sun and ambient room light and stores the energy on a capacitor. An internal circuit board houses the energy storing capacitor, temperature sensing device, and specially programmed algorithmic logic to regulate actuation changeover time and sequence. The unit "wakes up" every 10 minutes to check the room and supply air temperature and logs both. When an air temperature is recorded out of the pre-set dead band, the smart logic instructs the diffuser to change the blade position for either heating or cooling. If the temperature that is recorded calls for heating, the logic instructs the actuator to direct the airflow to the CT diffuser for mixed airflow heating. If the temperature that is recorded calls for cooling, the logic instructs the actuator to direct the airflow to the DVRI face for low velocity displacement cooling.

The Solar Plexicon is designed to operate with all types of HVAC systems in the market (Single Duct, Dual Duct, Fan-Powered, DX, etc.). To

Displacement Diffuser Adjustment

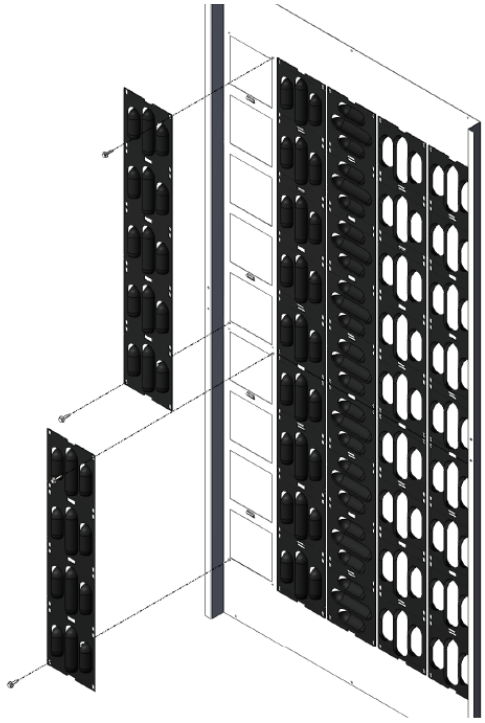


Illustration 1. Adjusting the pattern

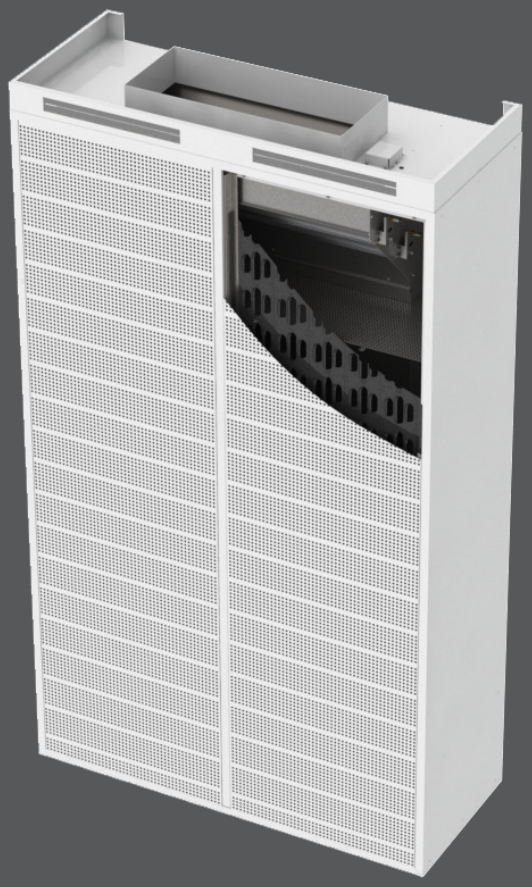
accomplish this, the unit was created with a narrow temperature band for the cooling and heating changeover actuation. The default values for the band are 78 degree F. for heating and 71 degree F. for cooling. In addition, the changeover set-points are adjustable. Each default set-point can be adjusted in one 2-degree increment up or down. This provides maximum flexibility by allowing the installing contractor to customize the band to fit any type of HVAC system they may be using. At the narrowest point, the band can be adjusted to 73 degrees F. for cooling and 76 degrees F. for heating. The band can also be expanded to 11 degrees or shifted up or down in 7 degree increments depending on system requirements.

The benefits of the Plexicon unit can be seen throughout the building process. Design engineers don't have to worry about designing and integrating a secondary system for the heating requirements. This saves valuable time and energy during the planning and design phase. Contractors can save time and money since they don't have to install a secondary air delivery system that includes additional ductwork, diffusers and controls. The building owner doesn't have to pay for the second system which saves money on the overall project. Finally, the building occupants can enjoy the highest level of thermal comfort and indoor air quality delivered by low velocity displacement cooling, or mixed airflow heating from the floor level. With the solar Plexicon, Titus continues to provide "Clever, Creative, Comfort" in a new and innovative way.

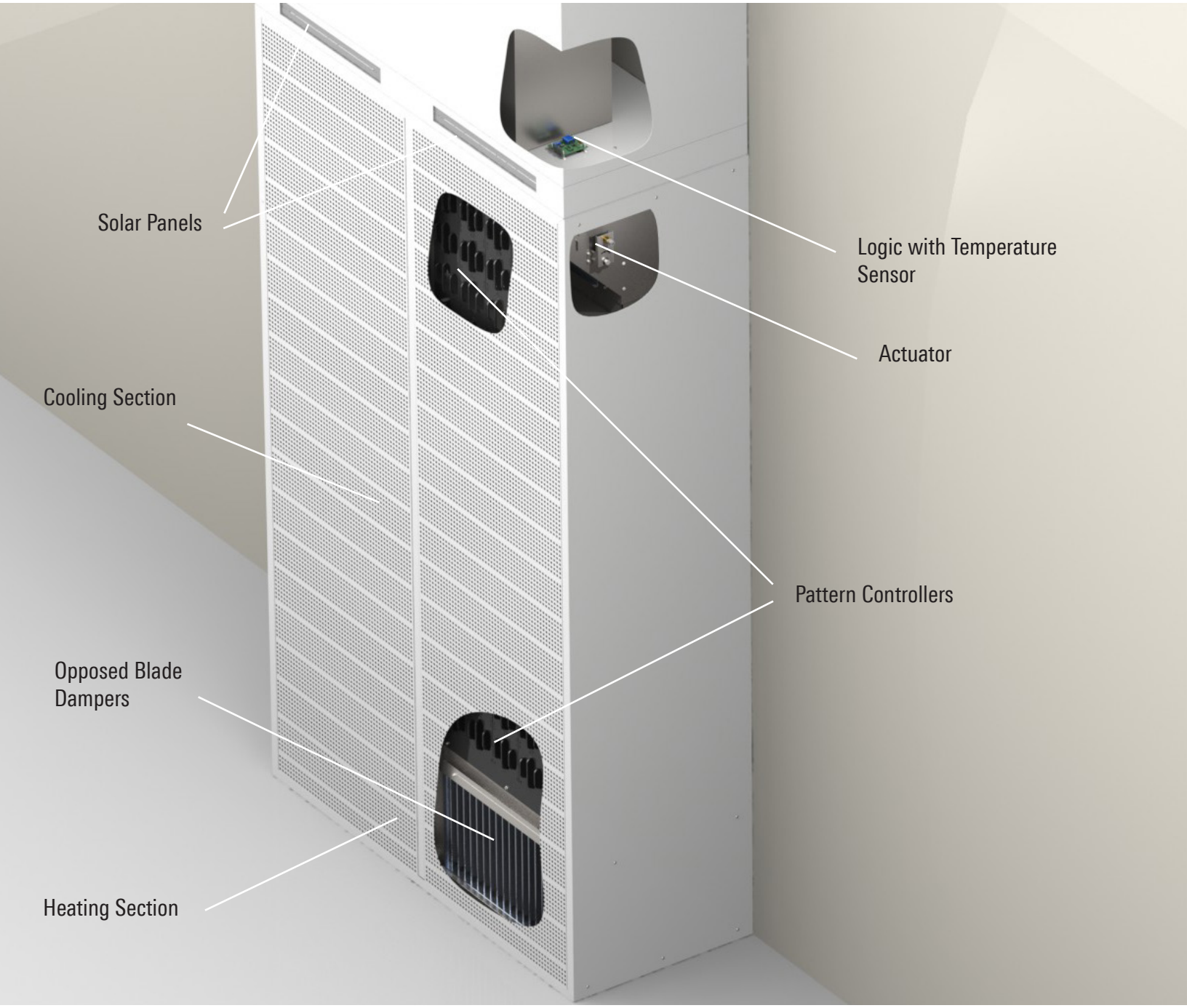
All Titus Displacement diffusers feature integral variable air pattern controllers located in the unit behind the perforated face (see illustration 1). These pattern controllers can be removed and repositioned to change the adjacent zone pattern from the diffuser face. To adjust the pattern: (see illustration 2).

- Remove diffuser face
- Remove louvers
- Reposition louvers
- Replace face

This unique feature provides a high level of flexibility for the end user. They can react to changes in the space by adjusting the adjacent zone rather than disconnecting and moving the diffuser. Illustration 3 shows a conference room with displacement diffusers and the standard adjacent zone from the factory. Illustration 4 shows how these adjacent zones can be changed to accomodate the needs in the space.

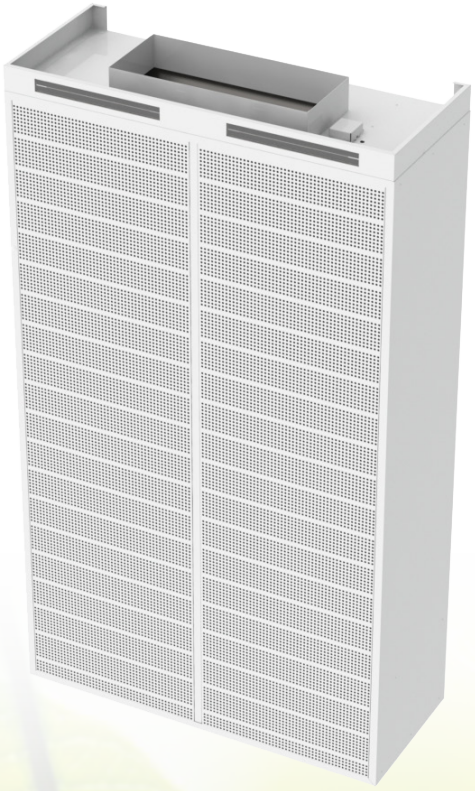


Cutaway view of the DVIR-HCS Solar Plexicon showing the adjustable pattern controllers and blade actuators



The innovative design of the Solar Plexicon created an energy-efficient HVAC unit that will revolutionize the industry. Cooling and heating that comes from a device that requires no external power source will save building owners hundreds of thousands of dollars over the life cycle of their new or renovated building.

LEED CREDITS available via DISPLACEMENT VENTILATION SYSTEMS



ENERGY AND ATMOSPHERE

Credit 1: Optimize Energy Performance

INDOOR ENVIRONMENTAL QUALITY

Credit 2: Increased Ventilation
Credit 7.1: Thermal Comfort - Design

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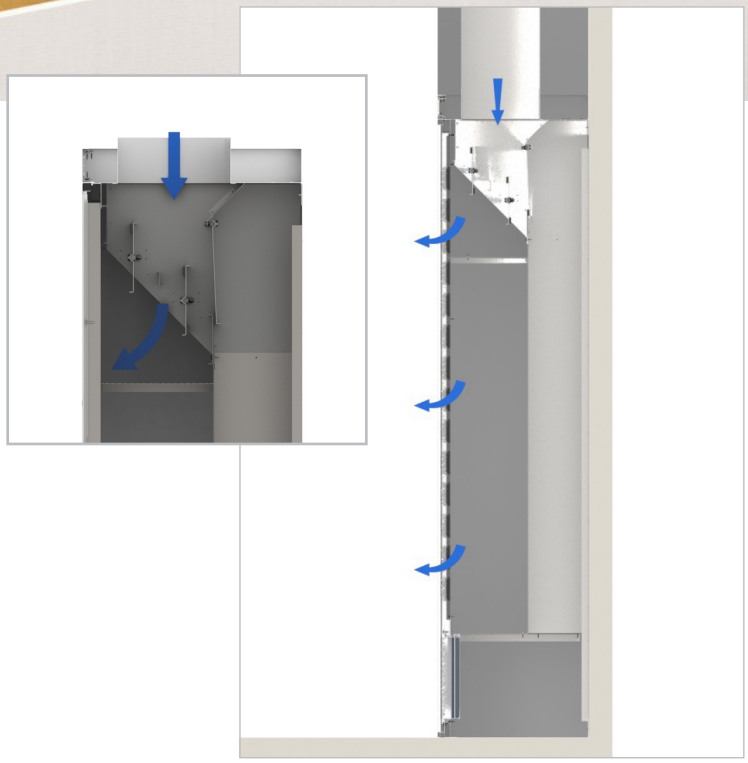
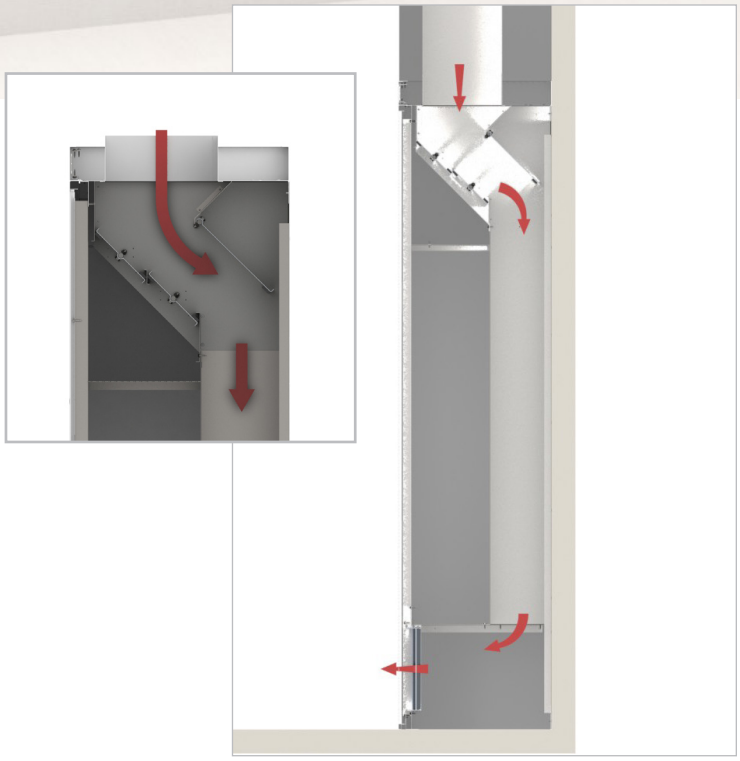
How Cooling works in the Solar Plexicon

In cooling mode, cool air is directed to travel straight down and come out of the top portion of the face of the diffuser via the adjustable air pattern controllers. Cool fresh air then enters the occupied zone and provides comfort.



How Heating works in the Solar Plexicon

In heating mode, warm air is directed to travel down pass the adjustable air pattern controllers toward the bottom portion of the face of the diffuser and leave via the opposed blade dampers. Warm air then enters the occupied zone to provide comfort.



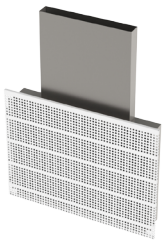
Cedar Ridge High School

Client: Round Rock ISD
Architects: KAH Architects / Perkins + Will
Location: Round Rock, TX
LEED Certification: LEED Certified

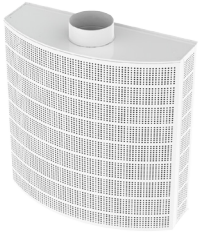
ABOUT THE PROJECT

Round Rock ISD envisioned a sleek, modern new campus that would foster growth and development for its students. They wanted a high school capable of unlocking the hidden abilities of their students and one that would aid their teachers in preparing their students for the next chapter of their lives. Cedar Ridge High School is the result.

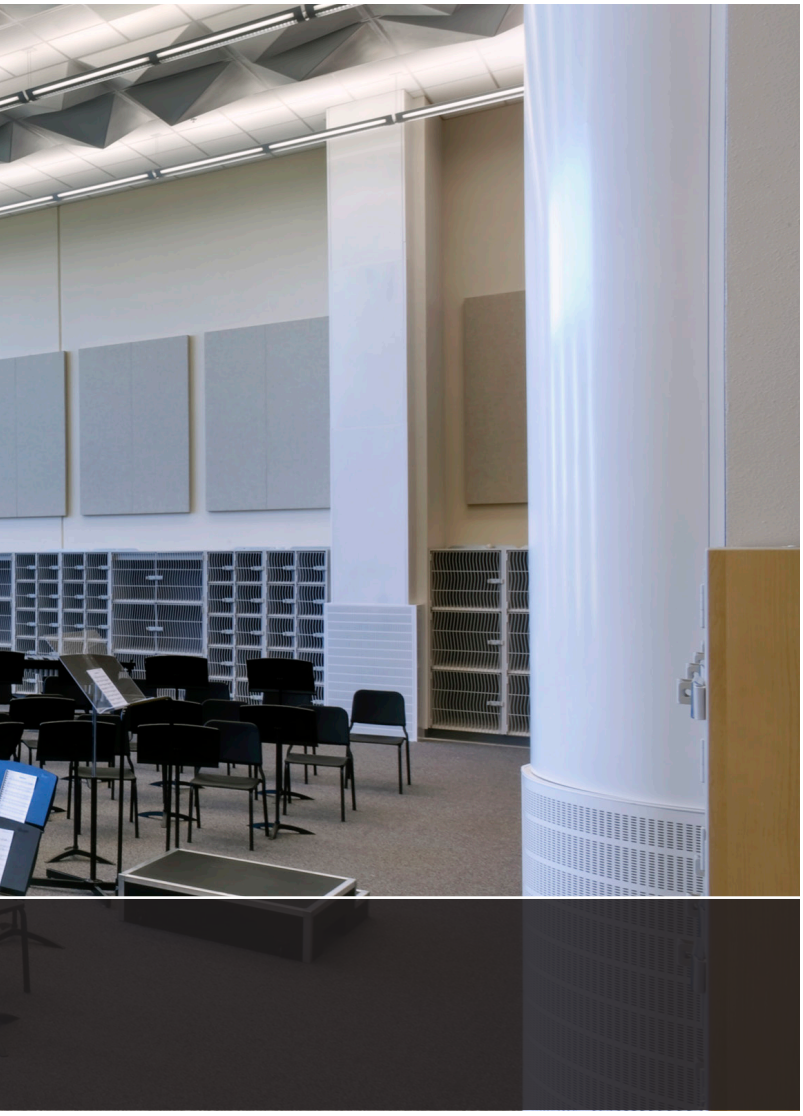
Cedar Ridge High School is a unique two-story, 375,000 square-foot high school divided into four distinct academies: Academy of International Business and Economics, Academy of Professional Studies, Academy of Science, Technology, Engineering, and Mathemathics, and the Academy of Visual and Performing Arts. Each academy houses its own media center, administration suites and planning areas for teachers. The common areas for all students are the cafeteria, the athletic facility and the outdoor courtyard which is considered the heart of campus and is home to several multi-purpose events.

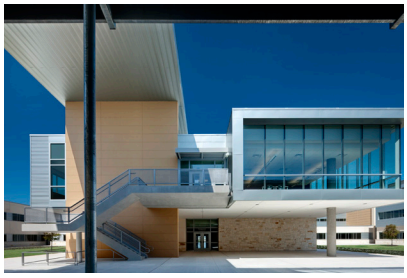


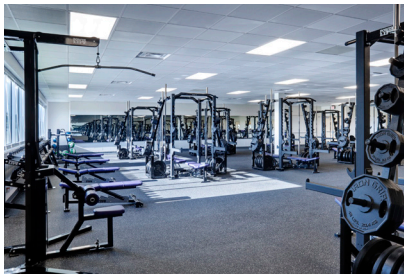
DVIR

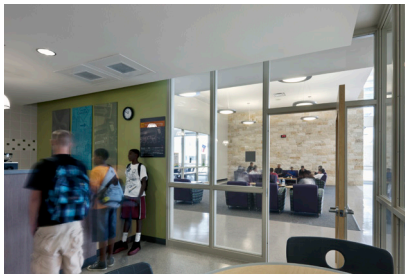


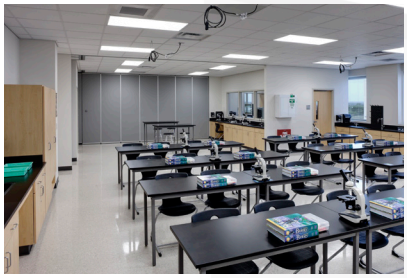
DVBC











The design team and Round Rock ISD wanted this school to be an environmentally friendly facility. This LEED Certified school has several sustainable elements featured. It uses local limestone materials on the exterior of the buildings and offers an abundance of natural light. All the windows allow natural light to penetrate deep into the occupied spaces.

THE TITUS SOLUTION

The HVAC system featured in the high school also contributed toward it achieving LEED Certification. Titus has an abundance of products installed that provide energy savings to the school. Several areas in the new high school utilize displacement ventilation, which is a unique alternative for air distribution.

The DVIR and DVBC are rectangular displacement diffusers. The DVIR is a unidirectional discharge diffuser designed for flush mount applications. The DVBC has a curved face and discharges air via a three-way pattern. Both units provide air distribution by supplying large volumes of air at low velocities into the occupied zone. Easily adjustable air pattern controllers inside the units can create different airflow patterns in the space to optimize occupant comfort.

THE END RESULT

There have been numerous studies on the importance of proper ventilation in our schools. Cedar Ridge High School has a state-of-the-art HVAC system that provides superior performance for its students and faculty. The new high school is also a beautiful campus that has created the best learning environment for the students of Round Rock, Texas. The teachers, staff and administration now have a technologically advanced partner that will assist them in molding the future leaders for the next generation.

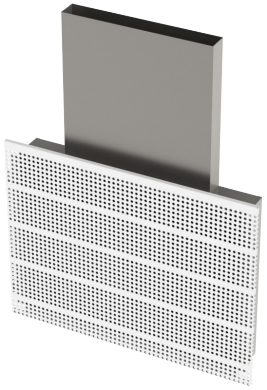
Willard Elementary School

Client: Concord Public Schools
Architect: OMR Architects
Location: Concord, Massachusetts
LEED Certification: None

ABOUT THE PROJECT

The new Willard Elementary School, which opened its doors for the first time this year, is a state-of-the-art building designed by the Office of Michael Rosenfeld, Inc (OMR) Architects. This award winning, full-service architectural firm listened to and incorporated many design elements from the clients to create a new education facility for young minds to grow and prosper.

The students, faculty and staff wanted their new building to be something that their previous one wasn't - to be an energy efficient and safe structure that everyone would be proud of. OMR created a green learning environment for all students, grades K-5 to learn from. The students have created and produced podcasts and brochures that highlight additional sustainable features. Touch screens monitor the elementary school's energy consumption. The library, located in the heart of the school, benefits from an abundance of natural light. The natural light is able to penetrate deep into the building by light shelves that are



DVIR

located in the classroom.

THE TITUS SOLUTION

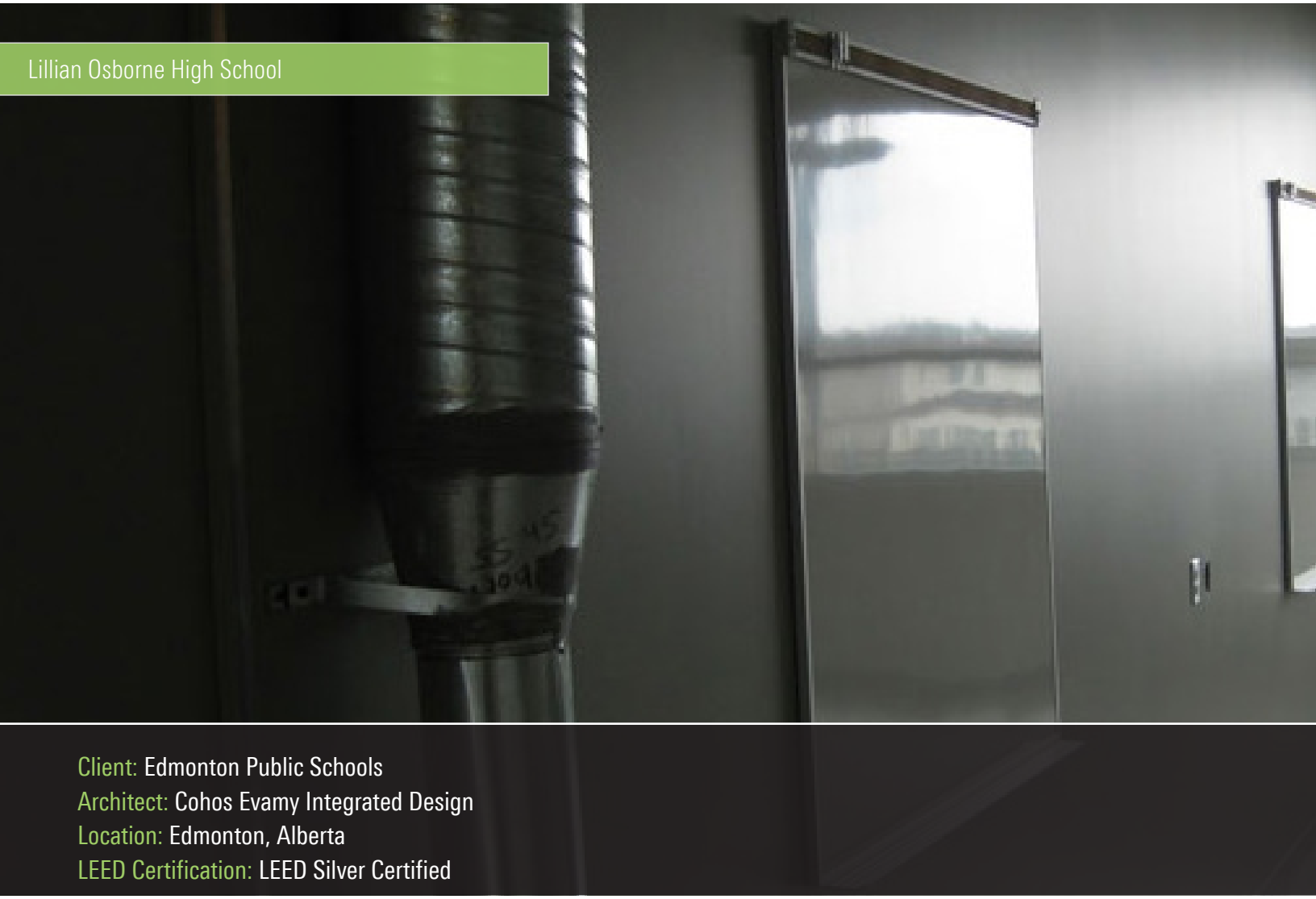
When designing and building an energy efficient facility, the HVAC systems are extremely important and cannot be overlooked. OMR not only relied on utilizing diffusers and grilles, but wanted to create a unique HVAC system that would have all other elementary facilites green with envy. Displacement Ventilation, a unique method of air distribution, was selected and Titus had the perfect product - the DVIR.

The DVIR is a rectangular displacement diffuser with a unidirectional discharge designed for flush mount applications. It provides air distribution by supplying a large volume of air at a low velocity to the occupied zone. Adjustable air nozzles inside the unit can create different airflow patterns in the space to optimize occupant comfort.

The DVIR displacement unit wasn't the only Titus product used in the elementary school. Williard Elementary also has several other high performance grilles and diffusers to provide a total air distribution solution. The OMNI diffuser can be seen in various locations as well as the FlowBar. The OMNI is an architecturally pleasing unit that delivers a uniform 360 degree horizontal air pattern. The FlowBar architectural linear diffuser system maximizes engineering performance without sacrificing aesthetic considerations of the designer. FlowBar's outstanding performance allows higher air flows than conventional linear diffusers and produces lower noise levels.

THE END RESULT

Willard Elementary School is a remarkable achievement in Green Building design and cooperation. The Concord, Massachusetts community received a unique school that has energy efficient technology both inside and out while creating the perfect learning environment for their children to grow and develop.



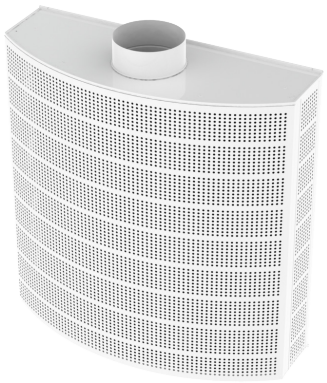
Lillian Osborne High School

Client: Edmonton Public Schools
Architect: Cohos Evamy Integrated Design
Location: Edmonton, Alberta
LEED Certification: LEED Silver Certified

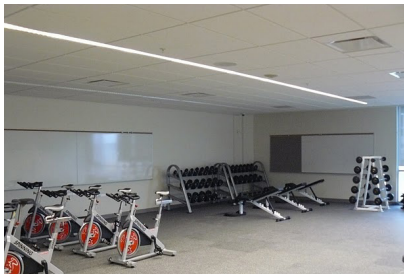
ABOUT THE PROJECT

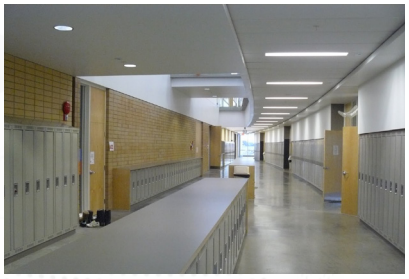
Lillian Osborne High School is the first school in Edmonton to achieve LEED certification. Designed to achieve the LEED Silver Certification by Cohos Evamy Integrated Design, the school opened its doors for the 2009-2010 school year and is a testiment to Edmonton Public School's commitment to provide superior learning environments for its district's students.

The architects designed the school to incorporate Green Building design concepts in the construction and operation of the building with specific regards to the Indoor Environmental Quality - (IEQ). The school utilizes effective ventilation systems that assist in ensuring thermal comfort for the students and faculty. The design of the mechanical and lighting systems will allow increased controllability of these systems for the users as well. Carpets, paints and adhesives were selected based on their ability to emit low volatile organic compounds (VOCs). The architects also placed an emphasis on bringing in more natural light into the occupied



DVBC





spaces. The Lillian Osborne High School will only use environmentally approved or "green" cleaning products and chemicals.

THE TITUS SOLUTION

With their focus on IEQ and wanting a unique ventilation solution for the classroom environment, Titus had the perfect product. The DVBC is a rectangular displacement diffuser with a curved face for wall mount applications. It is designed to supply a large volume of air at low velocities into the occupied zone. This model can contribute toward achieving LEED EA Credit 1: Optimize Energy Performance; IEQc2: Increased Ventilation; and IEQc7.1: Thermal Comfort - Design. Displacement Ventilation is a great alternative to conventional overhead ceiling supply systems. Displacement Ventilation provides design flexibility, energy savings, and the highest level of Indoor Air Quality (IAQ).

THE END RESULT

Designing and building sustainable buildings that are recognized by LEED are not limited to the United States. It is an international goal that can definately have a positive impact on the world. By building the Lillian Osborne High School, the Edmonton Public School District has created a unique learning environment for their students to grow, develop and learn about the world in which we live.

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