In-Floor Cooling Solutions

Airflow Management Solutions for Raised Floor Data Centers

Tate® AIRFLOW

Virtual Aisle Containment

In-floor Cooling Airflow Panels and Controls

Virtual containment uses a set of solutions to deliver the right amount of air when it's needed directly to the equipment. This is accomplished using directional airflow panels, control devices and doors at the end of the aisle to nearly eliminate bypass air, providing containment without the need for a roof.

Directional Airflow Panels

DirectAire®
68% Open area directional airflow panel.

DirectAire Al
60% Open area aluminum directional airflow panel.

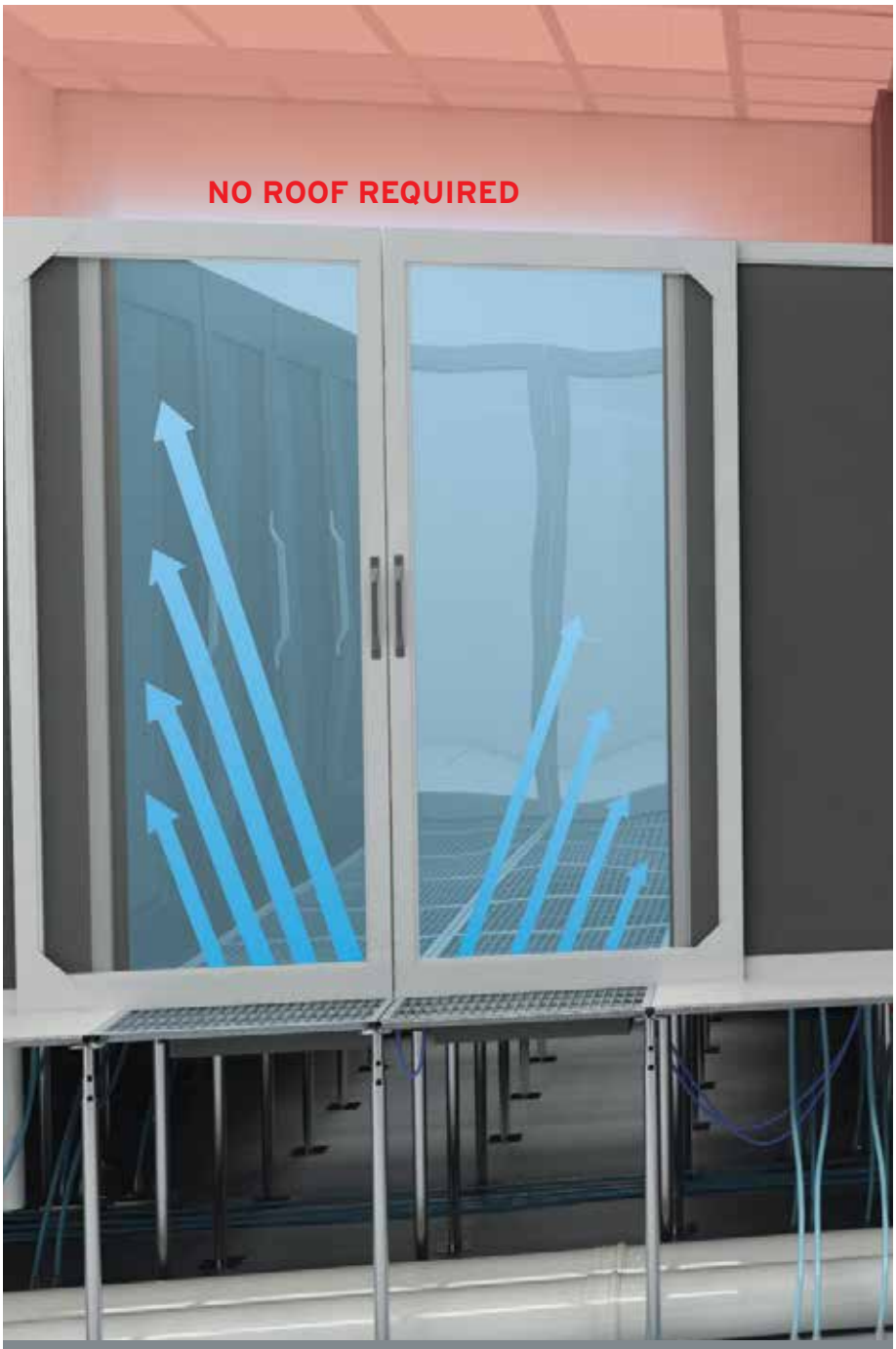
DirectPerf
Available in 25% and 32% open area and provides directional airflow to the rack.

Airflow Controls

SmartAire MZ Damper
Automatic damper to regulate the airflow through a panel to maintain a desired inlet air temperature as a whole or via segmented zones.

Opposed Blade Damper
Offers manual airflow adjustment between 0-100%.

PowerAire Fan Assist
Temperature controlled variable speed fan that provides airflow to areas with low or no static pressure.



Benefits of Virtual Containment

- First cost savings over other containment strategies
- Comparable cooling capacity to physical containment
- No fire suppression, lighting or service distribution concerns associated with adding a roof.

Physical Aisle Containment

In-floor Cooling Airflow Panels and Controls

Benefits of Physical Containment

- Significantly reduces bypass airflow
- Customizable products and sizes for any retrofit application
- Can achieve 100% capture index at the server

Containing the airflow of an entire aisle has been shown to improve capacity and energy efficiency by reducing bypass airflow. Many legacy airflow panels supply air in a vertical plume requiring the use of physical containment systems to reduce bypass airflow and improve capacity and efficiency.

Vertical Airflow Panels

GrateAire
High volume airflow panels with high rolling loads for contained aisles

Perforated Panel
Standard airflow panels for contained aisles

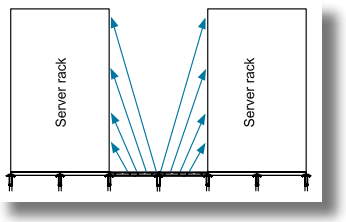
Airflow Controls

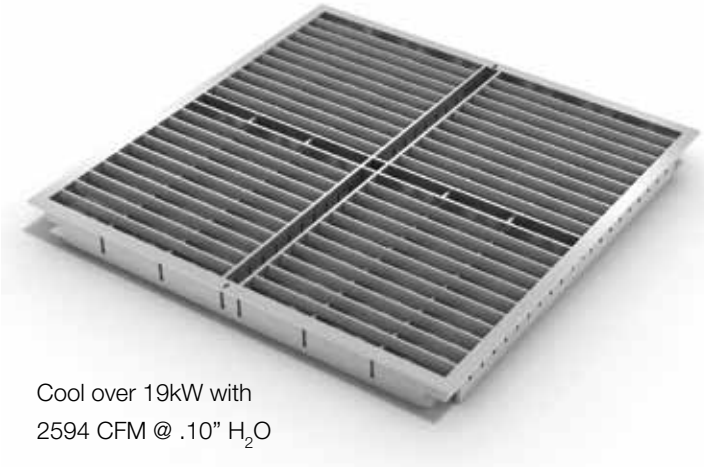
SmartAire MZ Damper
Automatic damper with modes to regulate and maintain a specific static pressure, as well as, a Technician mode for activated cooling while conducting service work in contained hot aisles.

Opposed Blade Damper
Offers manual adjustment between 0-100%

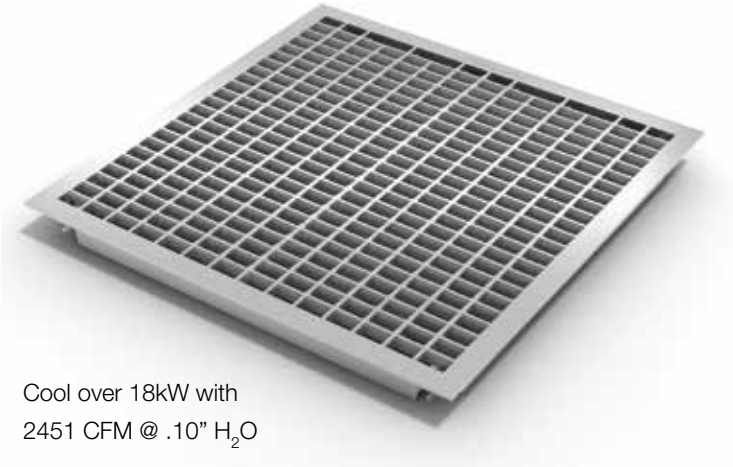
Airflow Panels: Directional Flow

For Maximum Air Capture





Cool over 19kW with
2594 CFM @ .10" H_2O



Cool over 18kW with
2451 CFM @ .10" H_2O

DirectAire® & DirectAire X2 Panels

DirectAire uses patent pending technology to angle the air toward the equipment achieving a 93% capture index. DirectAire is designed to evenly distribute airflow across the full height of a standard 42U rack. DirectAire X2 is designed to divide the airflow evenly in two directions to provide even distribution to racks on both sides of a cold aisle.

Panel Features

- Reduce capital expenditures on cooling infrastructure by up to 40%
- Saves up to 40% in annual fan energy without the use of containment
- 93% Capture Index
- 68% open area provides 2,594 CFM @ .1" H_2O
- Cools over 19kW per rack @ .1" H_2O
- DirectAire X2 cools up to 10kW per rack @ .1" H_2O
- 2,500 lbs design load
- 2,000 lbs 10 pass rolling load capacity
- Available in 24" and 60cm panel sizes

DirectAire® Al Panels

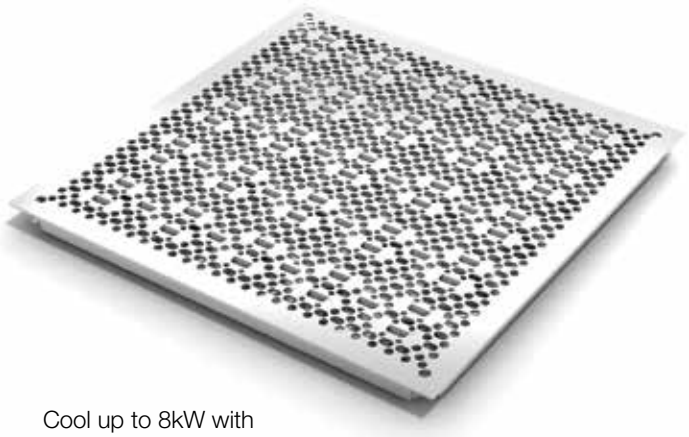
The DirectAire Al is an all aluminum airflow panel that provides the same directional airflow benefits of the steel DirectAire. This allows the panel to provide similar cooling capacities with a panel that is 40% lighter.

Panel Features

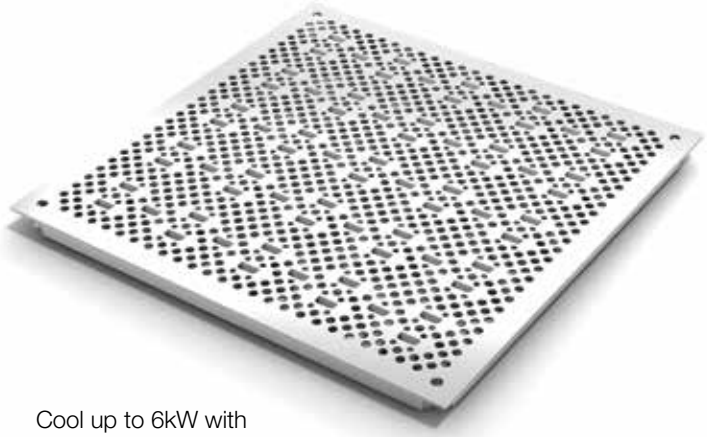
- Die-cast aluminum construction
- 40% lighter than a steel DirectAire®
- 93% Capture Index
- 60% open area provides 2,451 CFM @ .1" H_2O
- Cools over 18kW per rack @ .1" H_2O
- 1,500 lbs design load
- 1,250 lbs 10 pass rolling load capacity
- Surface adjustable and automatic damper options
- Available in 24" and 60cm panel sizes

Airflow Panels: Directional Flow

For Maximum Air Capture



Cool up to 8kW with
1121 CFM @ .10" H_2O



Cool up to 6kW with
765 CFM @ .10" H_2O

DirectPerf 32% Panels

In uncontained spaces DirectPerf 32% provides nearly the same cooling capacity as a standard 56% open area grate using about half the airflow.

Panel Features

- Same kW cooling capacity as GrateAire®
- 32% open area delivers 1,121CFM @ .1" H_2O when installed without a damper
- Directional air flow achieves a 88% capture index
- Cools up to 8kW per rack
- Can save over 40% in annual fan energy without the use of containment
- Easily integrates into an existing 24" and 60cm raised floor systems

DirectPerf 25% Panels

Directional Perf 25% directs the airflow toward the server rack to significantly improve energy efficiency and reduce bypass air.

Panel Features

- 25% open area delivers 765CFM @ .1" H_2O when installed without a damper
- Directional air flow achieves a 93% capture index.
- Cools up to 6kW per rack
- Can save over 40% in annual fan energy without the use of containment
- Easily integrates into an existing 24" and 60cm raised floor systems

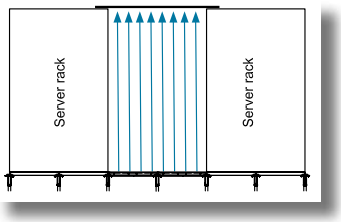
*Load Performance Chart**

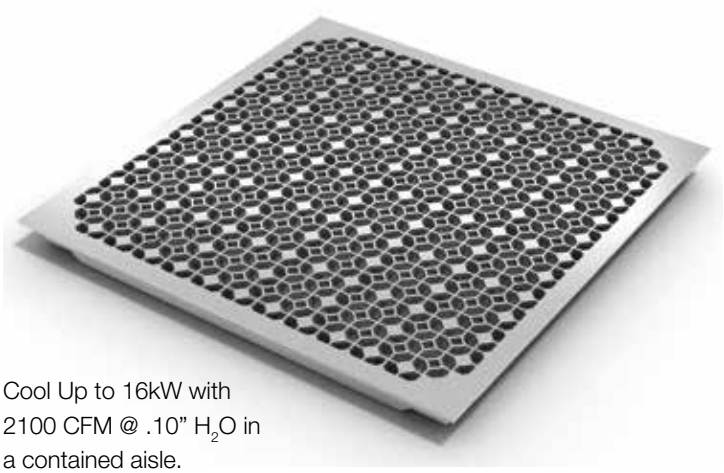
Airflow Panel	Understructure	System Weight (lbs/sqft)	Static Loads (lbs)			Rolling Loads (lbs)		Impact Loads (lbs)	Capture Index	Open Area
			Design Load	Safety Factor	Ultimate Load	10 Passes	10,000 Passes			
DirectAire	Bolted Stringer	13.0 (63kg/m^2)	2500 (11.1kN)	Min. > 2	>5000 (22.2kN)	2000 (8.9kN)	2000 (8.9kN)	200 (91kg)	93%	68%
DirectAire X2	Bolted Stringer	13.0 (63kg/m^2)	2500 (11.1kN)	Min. > 2	>5000 (22.2kN)	2000 (8.9kN)	2000 (8.9kN)	200 (91kg)	93%	68%
DirectAire Al	Bolted Stringer	7.4 (36kg/m2)	1500 (6.7kN)	Min. > 2	>3000 (13.3kN)	1250 (5.6kN)	1000 (4.4kN)	150 (68kg)	93%	60%
DirectPerf 32	Bolted Stringer	6.25 (30kg/m^2)	1250 (5.6kN)	Min. > 2	>2500 (11.1kN)	-	-	150 (68kg)	88%	32%
DirectPerf 25	Bolted Stringer	6.85 (33kg/m^2)	1250 (5.6kN)	Min. > 2	>2500 (11.1kN)	-	-	150 (68kg)	93%	25%

** System Design Load is based on permanent set ≤ 0.010" and is verified by loading panels in accordance with the CISCA concentrated load method but with panels installed on actual understructure instead of steel blocks. (Testing on blocks does not represent performance of an actual installation.) Ultimate, Rolling, and Impact Load tests are performed using CISCA Test Procedures. Safet Factor is Ultimate Load divided by Design Load.*

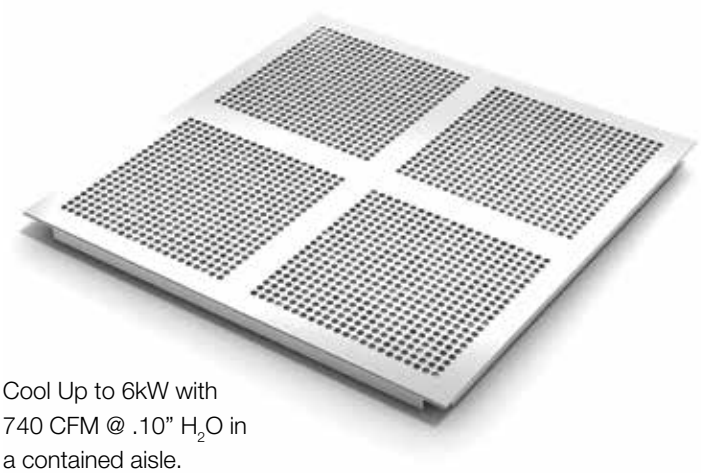
Airflow Panels: Vertical Flow

Physical Aisle Level Containment Airflow Panels





Cool Up to 16kW with
2100 CFM @ .10" H_2O in
a contained aisle.



Cool Up to 6kW with
740 CFM @ .10" H_2O in
a contained aisle.

GrateAire® Panels

Tate's aluminum GrateAire offers high volume airflow for physically contained aisles with high heat densities. With 56% open area the lightweight aluminum panel is ideal for areas that need high airflow and load capacity.

Panel Features

- GrateAire die-cast aluminum panels are compatible with any 24" or 60cm bolted stringer systems
- Cools up to 16kw per rack in a contained aisle
- 56% open area
- High rolling load capacity (1000 lbs/800 lbs)
- Available with top surface adjustable damper
- Available with an unpainted textured surface or epoxy powder coatings
- Interchangeable with Tate's full line of laminated raised floor panels in a stringer system

Perforated Panels

Tate's perforated steel panels are available with a range of load performance characteristics. The most economical approach to supplying air in a contained cold aisle perforated panels are the traditional choice.

Panel Features

- Compatible with any 24" or 60cm stringer systems.
- 25% open area
- Strong design loads with safety factors of 2
- Available with top surface adjustable damper
- Steel perforated panels are available with High Pressure Laminate, vinyl and rubber floor coverings
- Interchangeable with laminated ConCore, All Steel and Woodcore panels in a stringer system
- Aluminum perforated panels are available for use with a bolted stringer aluminum system

Load Performance Chart

Airflow Panel	Understructure	System Weight (lbs/sqft)	Static Loads (lbs)			Rolling Loads (lbs)		Impact Load (lbs)	Capture Index*	%Open Area
			Design Load	Safety Factor	Ultimate Load	10 Passes	10,000 Passes			
GrateAire	Bolted Stringer	6.25 (30kg/m²)	1000 (4.4kN)	Min. > 2	>2000 (8.9kN)	1000 (4.4kN)	800 (3.6kN)	100 45kg)	50%	56%
Perf 800	Bolted Stringer	7.0 (34kg/m²)	800 (3.6kN)	Min. > 2	>1600 (7.1kN)	-	-	150 (68kg)	50%	25%
Perf 1000	Bolted Stringer	7.5 (37kg/m²)	1000 (4.4kN)	Min. > 2	>2000 (8.9kN)	-	-	150 (68kg)	50%	25%
Perf 1250	Bolted Stringer	8.25 (40kg/m²)	1250 (5.6kN)	Min. > 2	>2500 (11.1kN)	-	-	150 (68kg)	50%	25%

** System load tests are conducted following CISCA's Recommended Test Procedures with the exception of Design Load. Design Load is a CISCA Concentrated Load Test performed on actual understructure using yield point and safety factors in place of deflection. Capture Indexes are based on uncontained aisles.*

Effectively Cool Variable Loads

Automated Controls are Critical to Manage Airflow using Virtual Aisle Containment

Data centers rack loads frequently change on a minute-by-minute basis due to inconsistent processing demands and equipment upgrades. This load variability has been driven by the improved efficiency of IT hardware over time, increasing the difference between idle power consumption, and 100% utilization. This fact, coupled with the growing use of cloud computing, makes manual tuning of the airflow at the panel level impossible.

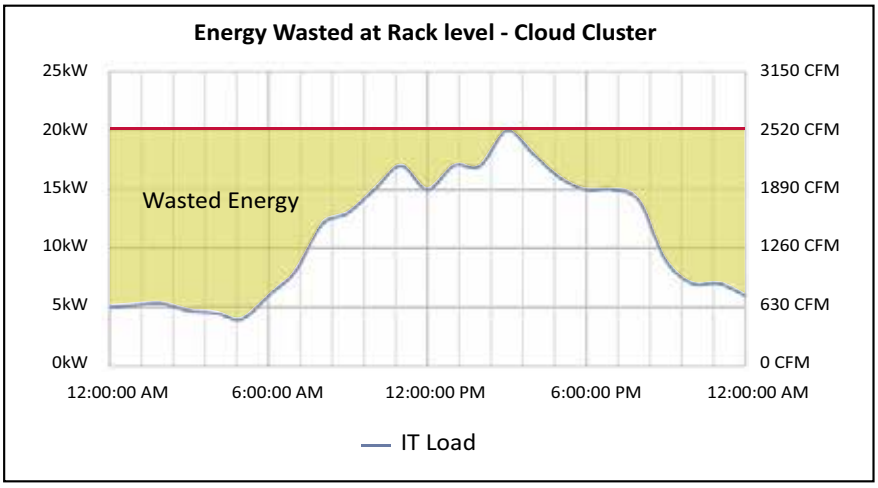
The solution has been to provide sufficient air to accommodate the peak energy demands of the rack, resulting in wasted bypass air and over-cooling during all less than peak conditions.

Improve Cooling Effectiveness

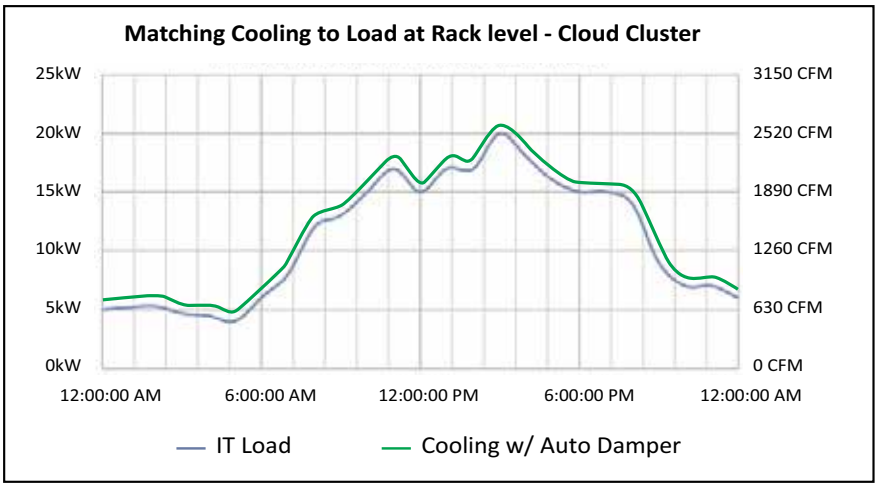
Tate has adapted variable-air-volume (VAV) technologies similar to those found in commercial office applications to control airflow delivery to the IT racks by automatically adjusting the amount of air that is delivered through each panel.

These solutions measure the air temperature at the face of the rack and adjusts the flow to ensure that the server inlet air temperature is never above the user defined set point. When deployed using best practices, these systems are able to virtually eliminate bypass air, and account for any local temperature fluctuations.

This chart shows the energy wasted when variable IT load exists at the rack level. The wasted energy in yellow results from designing for peak load.



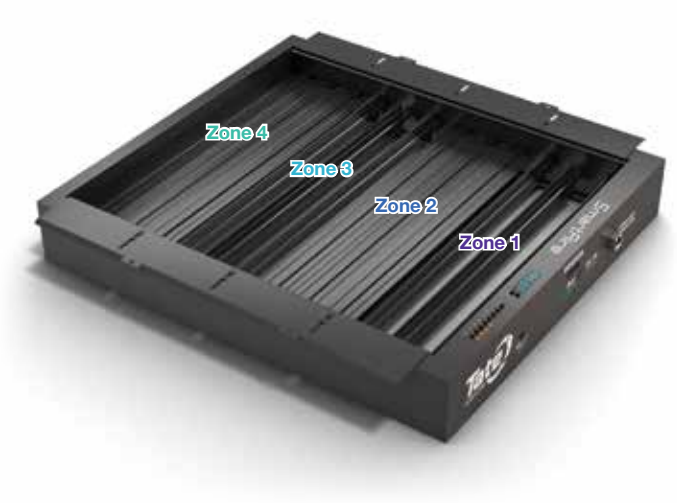
By matching cooling to the IT load at the rack level the wasted energy that results from designing to peak load can be eliminated. By delivering only the right amount of air required to cool the rack a savings of over 40% in fan energy can be realized.

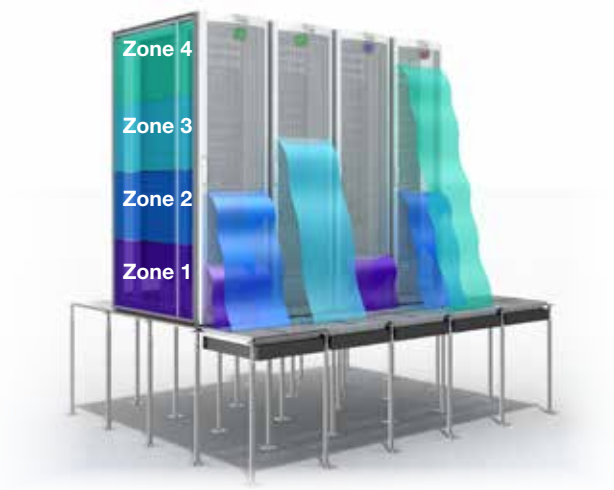


SmartAire® MZ dampers are installed under DirectAire panels shown to the left Four temperature sensors are mounted to the face of the rack to monitor each zone individually. A LED status indicator allows for at-a-glance monitoring of the rack temperature. If the temperature is above or below the preset range, the LED will glow red or blue respectively to indicate the variance.

SmartAire® MZ

Automatic Airflow Controls





The new SmartAire MZ automatic variable-air-volume damper offers the most granular airflow control available for a data center. The unit monitors and adjusts cooling independently to 4 separate zones to allow for variable loads and partially deployed areas within a rack. During equipment changes, the unit automatically re-balances the airflow in the facility without manual control adjustments.

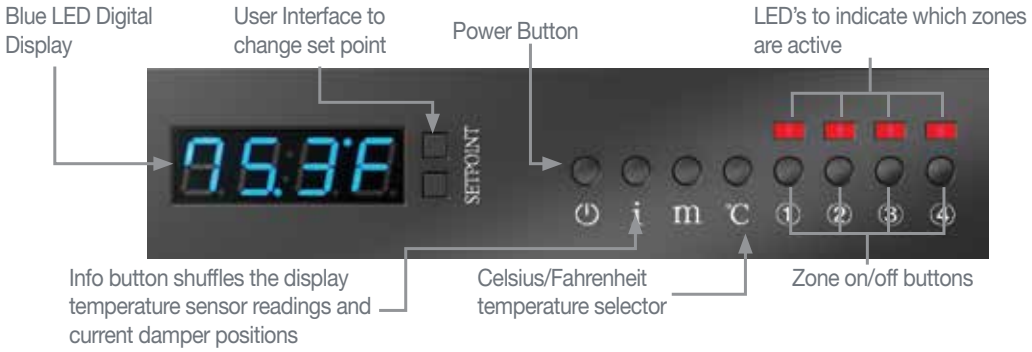
The SmartAire MZ features a rack face-mounted LED temperature status indicator. The LED provides an at-a-glance indication of temperature by glowing blue, green, or red based upon the preset range.

A SmartAire MZ Basic option is also available as a manual variable-air-volume damper with a single temperature probe and rack-mounted LED temperature status indicator.

Key Performance Characteristics

- Automatically re-balances airflow during equipment refresh or tenant changes
- 0-22kW supported IT load with DirectAire panel
- Fail safe operation: opens 100% during failure
- Supports POE, Power Over Ethernet
- Four zone damper positions are variable from 0-100%
- Rack-Mounted LED Temperature Status Indicator
- Multiple control options available
  - Quad - 4 rack mounted temperature sensor each controlling an individual zone
  - Dual - zones 1&2 and 3&4 are controlled together
  - Single - entire unit acts a single zone
  - P - pressure differential sensor
  - T - technician activated unit

Easy to Use Interface for Set Point and Zone Control



Improved Containment Design

Eliminate Server Leakage in Contained Cold Aisles

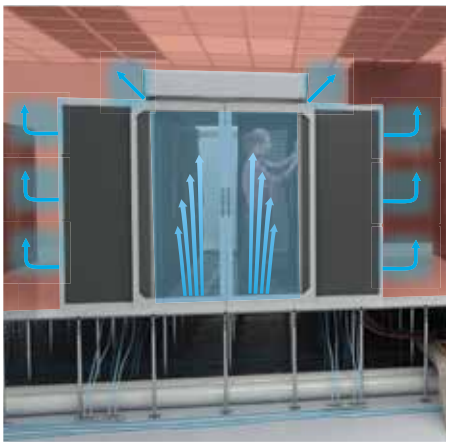
SmartAire MZ's Pressure Sensing mode is designed for situations where the contained aisle or rack experiences a variable load profile.

When servers enter idle mode they draw less air from the contained system, causing static pressure to increase. As static pressure builds in the aisle, the air will also be forced through servers even if the fans are idle or off. This wasted energy can be solved with the use of SmartAire MZ.

When installed under airflow panels, SmartAire MZ can vary the airflow into a contained system to satisfy a desired static pressure, reducing bypass air. SmartAire MZ monitors the static pressure differential from the contained cold aisle to the hot aisle in order to maintain a balance when rack loads vary. This balance reduces bypass airflow through servers, racks and other containment structures.

Static Pressure (Pa)	DirectAire CFM (L/s)	CFM @ 100% (L/s)	CFM @ 0% (L/s)
0.02 (5Pa)	1151 (543)	1018 (480)	126 (59)
0.04 (10Pa)	1626 (767)	1426 (673)	181 (85)
0.08 (20Pa)	2318 (1093)	1998 (943)	260 (123)
0.10 (25Pa)	2594 (1224)	2226 (1051)	292 (138)

Cold Aisle Containment Air Leakage



Without SmartAire® MZ Dampers in the cold aisle to maintain a neutral static pressure, conditioned air will leak through idle servers and other gaps in the containment structure.

Increase Productivity

On Demand Cooling to Allow for Longer Occupancy in Contained Hot Aisles

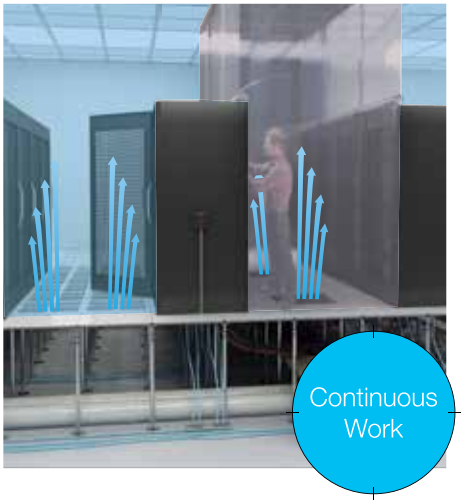
The Hot Aisle in a containment system can often exceed acceptable working conditions, meaning that the amount of time which a technician can work on the equipment is reduced, limiting productivity. OSHA exposure limits for working environments indicate a certain ratio of rest and work when working in high temperatures.

SmartAire MZ's Technician Mode gives the technician the ability to enter the hot aisle by controlling the temperature of the aisle. The technicians achieve this by activating the unit which modulates the amount of cool plenum air which enters the hot aisle.

Before the technician enters the hot aisle, the units are activated by a user supplied trigger. Once activated, the units automatically modulate to allow cool air to reach the hot aisle. Once the established temperature is reached, the tech can comfortably and easily work in the contained aisle without the need for breaks.

Static Pressure (Pa)	DirectAire CFM (L/s)	CFM @ 100% (L/s)	CFM @ 0% (L/s)
0.02 (5Pa)	1151 (543)	945 (446)	51 (24)
0.04 (10Pa)	1626 (767)	1313 (620)	73 (34)
0.08 (20Pa)	2318 (1093)	1824 (861)	106 (50)
0.10 (25Pa)	2594 (1224)	2226 (1051)	292 (138)

Work Continuously in the Hot Aisle



SmartAire® MZ provides on-demand cooling; lowering temperatures in a contained hot aisle allowing the technician to safely work on equipment in the aisle for an extended period of time.

PowerAire® Quad

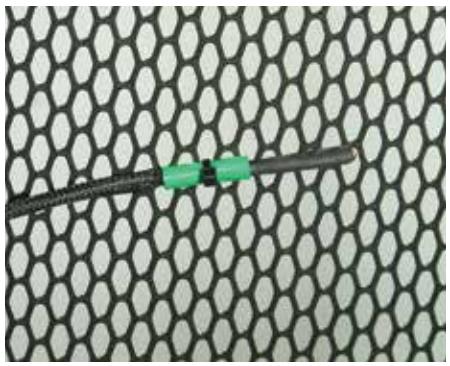
Fan Assisted Airflow Controls

PowerAire® Quad

The PowerAire Quad fan is equipped with 4 fans connected in parallel to provide built in redundancy. This unit is only 4" deep making it ideal for retrofit situations with finished floor heights as low as 7.5". This unit can cool up to 18kW of supported IT load per PowerAire Quad/DirectAire @ 0.1" H_2O.

Key Performance Characteristics

- Zero maintenance
- Installation can be carried out by IT staff
- Multiple control options available
- EC fan technology is variable from 0-100%
- Available in 100-120V or 200-240V power options
- Viewable Peak Temp for walkthrough check of racks
- Available Auto Transfer Switch offers A/B power feed
- 24" and 60cm raised floor compatible



Temperature probes are mounted to the face of the rack

Temperature display and set-point interface.

PowerAire fans should only be installed under DirectAire panels to keep the air directed toward the equipment.

Manual Airflow Controls

Manual Zone Control for Diverse and Partially Loaded Racks

Manual Zone Control for Diverse and Partially Loaded Racks

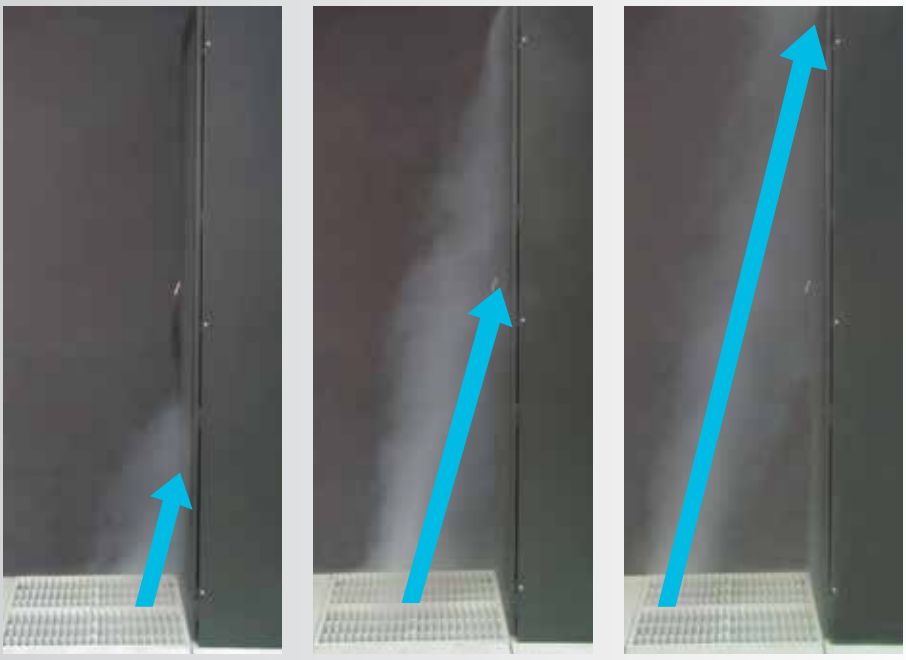
Multi-zone Opposed Blade Damper

Tate's multi-zone opposed blade damper enables the airflow delivery to be balanced based on the specific load in a 14U section of the rack. The damper can be individually adjusted for three zones within the rack (top, middle and bottom) without removing the airflow panel. The Multi-zone ensures fast and accurate balancing to a fixed IT load and is the recommended manual damper for virtual containment

Key Features

- Reduces cooling energy usage.
- For use with full or partial loaded racks.
- Provides the most granular airflow control available
- Easily adjustable from above without panel removal
- Panel-mounted dampers available for DirectAire AI and DirectPerf 32%

The adjacent smoke tests showing the Multi-zone Opposed Blade Damper operating in combination with the DirectAire Panel to target airflow delivery to each of the three zones in the rack.



Bottom 14U Zone | Middle 14U Zone | Top 14U Zone

Manual Airflow Controls

Manual Zone Control for Diverse and Partially Loaded Racks

Dual-zone Opposed Blade Damper for use with DirectAire X2 Panels

Dual-zone Opposed Blade Damper

The dual-zone damper allows the user to control the airflow through each half of a panel independently so that racks on opposite sides of the aisle can receive the right amount of cooling for the load in the rack.

Key Performance Characteristics

- Provides more airflow at 100% open than slide dampers
- Easily adjustable from above without grate removal
- Drop in design allows for easy retrofits, with DirectAire X2 in a Tate bolted stringer systems

Opposed Blade Damper for use with DirectAire®, DirectAire AI, DirectPerf 32%, and GrateAire® Panels

Opposed Blade Damper (OBD)

Tate's opposed blade damper allows the user infinite airflow adjustability with very little airflow resistance. Easily adjustable through the top surface of the panel for balancing airflow to IT equipment with fixed requirements.

Key Performance Characteristics

- Provides more airflow at 100% open than slide dampers
- Easily adjustable from above without panel removal
- Drop in design allows for easy retrofits under Tate airflow panels

Slide Damper for use with DirectPerf 25% and standard perf panels only

Slide Damper

Tate's slide damper can be factory attached to standard perforated panels for manual airflow adjustments.

Key Performance Characteristics

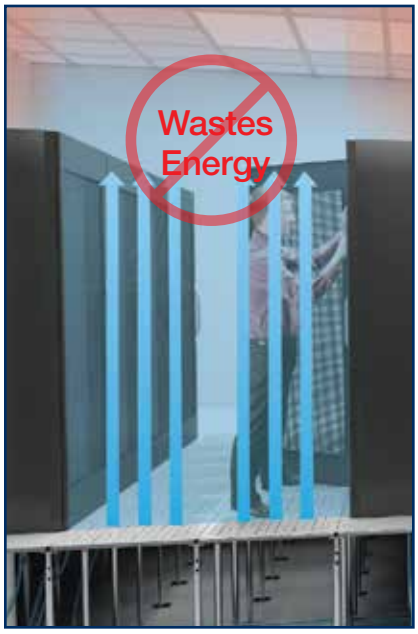
- Factory assembled to airflow panel
- Reduces cooling energy usage
- Easily adjustable from above without panel removal

The Value of Aisle Level Containment

Eliminating By-pass Air Using Virtual and Physical Strategies

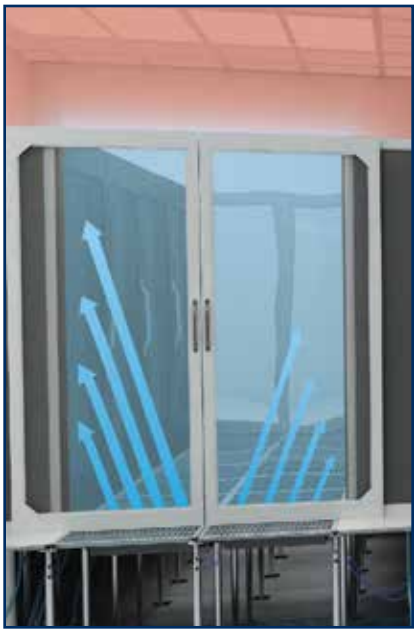
Many existing data centers use vertical plume airflow panels that waste over 50% of the air they supply. Selecting the proper containment strategy to reduce by-pass air is a critical evaluation.

Containment strategies increase cooling capacity and efficiency by ensuring the supply air is funnelled through the equipment. There are many advantages to virtual containment however some existing facilities may find it more feasible to build a physical containment system. For information on Tate's ContainAire® line of physical aisle containment products visit our website at www.tateinc.com.



Typical hot aisle/cold aisle layouts have a significant amount of mixing reducing capacity and efficiency.

Physical containment can be applied using legacy products to ensure maximum airflow to the racks.



Virtual containment eliminates the need for a roof and the code requirements that accompany them.

Bypass Air Cost Chart for Panels Without Physical Containment

The chart below shows the by-pass airflow reduction and energy savings potential of using a directional airflow panel in comparison to a vertical plume airflow panel in a typical hot aisle/cold aisle data center layout.

Airflow Panel w/o Damper	CFM (L/s)	Capture Index (%)	CFM @ Rack Face	Cooling Capacity (kW/Rack)	Uncontained CFM Bypass Air	Annual Cost of Bypass Air / Panel
DirectAire	2007 (947)	93	1867 (881)	14.8	140 (66)	$63
DirectAire AI	1913 (906)	93	1779 (840)	14.1	125 (59)	$56
Directional Perf 32	890 (420)	88	783 (354)	6.2	107 (28)	$49
Directional Perf 25	602 (284)	93	560 (264)	4.4	42 (20)	$21
GrateAire	1608 (759)	50	804 (379)	6.4	804 (379)	$357
Standard Perf	584 (275)	50	292 (138)	2.3	292 (138)	$133

Cooling capacity per rack is based on: CFM x Capture Index % / 126 (CFM needed to cool 1kW @ 25° ΔT) at .06" H_2O
Cost of 1kW/hr energy: $0.08, kW to move 1 CFM: 0.00064

Airflow Performance Information

CFM & kW Capacity Chart

Airflow Panel	0.02" H_20 (5 Pa)		0.04" H_20 (10 Pa)		0.06" H_20 (15 Pa)		0.08" H_20 (20 Pa)		0.10" H_20 (25 Pa)	
	CFM (L/s)	(kW/Rack)	CFM (L/s)	(kW/Rack)	CFM (L/s)	(kW/Rack)	CFM (L/s)	(kW/Rack)	CFM (L/s)	(kW/Rack)
DirectAire										
w/o Damper	1151 (543)	8.5	1626 (767)	12.0	2007 (947)	14.8	2318 (1093)	17.1	2594 (1224)	19.1
w/ OBD	986 (465)	7.3	1427 (673)	10.5	1789 (844)	13.2	2056 (970)	15.2	2331 (1100)	17.2
w/ SmartAire MZ	939 (443)	6.9	1312 (619)	9.7	1595 (753)	11.8	1833 (865)	13.5	2041 (963)	15.1
w/ PA Quad	2012 (950)	14.9	2061 (973)	15.2	2111 (996)	15.6	2158 (1018)	15.9	2199 (1038)	16.2
DirectAire AI										
w/o Damper	1123 (528)	8.3	1572 (753)	11.6	1913 (906)	14.1	2200 (1062)	16.3	2451 (1167)	18.1
w/ OBD	857 (404)	6.3	1293 (610)	9.5	1546 (730)	11.4	1745 (824)	12.9	1951 (921)	14.4
w/ SmartAire MZ	869 (410)	6.4	1208 (570)	8.9	1465 (691)	10.9	1679 (792)	12.4	1867 (881)	13.8
w/ PA Quad	2018 (952)	14.9	2110 (996)	15.6	2140 (1010)	15.8	2130 (1005)	15.7	2158 (1019)	15.9
DirectPerf 32%										
w/o Damper	531 (251)	3.7	744 (351)	5.2	890 (420)	6.2	1010 (477)	7.1	1121 (529)	7.8
w/ OBD	480 (227)	3.4	693 (327)	4.8	822 (388)	5.7	963 (454)	6.7	1063 (502)	7.4
DirectPerf 25%										
w/o Damper	357 (168)	2.6	496 (234)	3.7	602 (284)	4.4	689 (325)	5.1	765 (361)	5.6
w/ Slide damper	260 (123)	1.9	367 (173)	2.7	447 (211)	3.3	515 (243)	3.8	574 (271)	4.2
GrateAire										
w/o Damper	916 (432)	3.6	1320 (623)	5.2	1608 (759)	6.4	1860 (878)	7.4	2096 (989)	8.3
w/ OBD	810 (382)	3.2	1121 (529)	4.5	1386 (654)	5.5	1595 (753)	6.3	1785 (842)	7.1
w/ Slide damper	504 (238)	2.0	712 (336)	2.8	876 (413)	3.5	1008 (476)	4.0	1128 (532)	4.5
Standard Perf										
w/o Damper	332 (152)	1.3	476 (224)	1.9	584 (275)	2.3	666 (314)	2.6	746 (352)	3.0
w/ Slide damper	237 (112)	0.9	328 (155)	1.3	402 (190)	1.6	461 (218)	1.8	515 (243)	2.0

Cooling capacity per rack is based on: CFM x Capture Index % / 126 (CFM needed to cool 1kW @ 25° ΔT)
Test Conducted with fans operating at 100% power and dampers 100% open.

Tate has been an industry leading global provider of innovative next generation products for data center applications for over 50 years. Our world-class manufacturing plants have the flexibility to create modular solutions quickly with up-front cost optimization and Tate's in-house engineering team has the experience and industry knowledge to design the best solutions from concept to completion.

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