

VAPOR CHAMBER

TECHNICAL SPECIFICATIONS

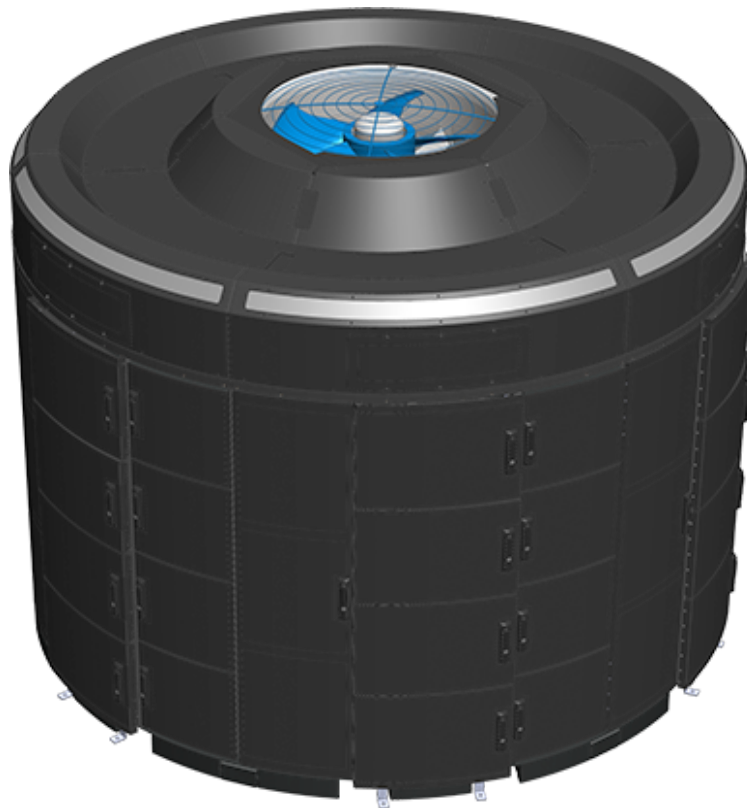


Version 3

OVERVIEW

The demands of modern applications, workloads and users continue to increase and organizations are looking for innovative and practical ways to increase density and significantly lower their CAPEX and OPEX investments when deploying compute and data storage resources. This is true for many scenarios, from remote to on-premise, and including new edge computing deployments. Edge computing deployments in particular present new challenges for data center design and use, as they are often in remote locations (such as at the base of a cell tower) where space is at a premium for one or multiple tenants and you're often repurposing a structure or space that wasn't designed to be a data center.

The Vapor Chamber is designed to meet these needs. It is a patented cylindrical rack and enclosure system, rated to house 150 kW of IT equipment for stable, long-term operation. That's upwards of 15,000 CPU cores, all in a 2.88 m (9.45-foot) diameter Chamber designed to provide optimal airflow for IT equipment and secure multi tenant operation. The Vapor Chamber includes Vapor IO software for autonomic operation, remote lights-out monitoring and programmatic API-driven control. This combination of innovative hardware and software makes the Vapor Chamber the foundation of the dense, distributed and remotely-operable data center infrastructure needed to power the edge.

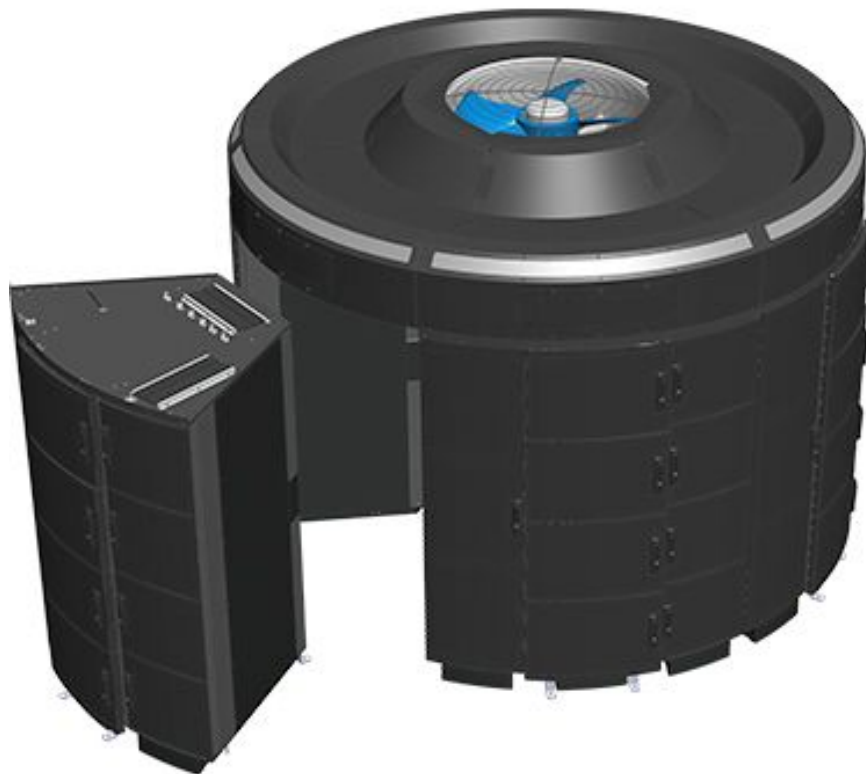


The Vapor Chamber

Engineered for the edge, the Vapor Chamber allows an unprecedented level of compute and data storage resource to be deployed and operated in a cost and space-efficient way in a variety of locations, beyond the capabilities of traditional IT equipment racks that rely on raised floors and cold and hot aisles. The flexibility and efficiency of the Vapor Chamber's micro data center design allows any organisation to support the growing need for distributed high-performance data center resource deployed at the edge of the network, in support of low-latency applications such as 5G telephony, autonomous driving, AR/VR and other emerging use cases.

The Vapor Chamber solves the key challenges of operating a modern data center. Traditional rectangular rack designs suffer from many problems, including low density (6-12 kW per rack), air recirculation problems (particularly at the bottom of the rack), air pressure mismatches and uneven cooling, impacting the long-term reliability of the IT equipment. The unique system design of the Vapor Chamber addresses all of these issues, enabling hyperscale-like densities through superior air recirculation and evenly-distributed cooling at the edge. The benefits of the Vapor Chamber apply for one or multiple Chambers within the same room. Even in a typical rectilinear equipment room, the Vapor Chamber achieves higher densities than other systems.

The Vapor Chamber was designed from the ground up for multi tenancy. Many edge deployments will need to support multiple tenants on the same infrastructure for a range of use cases from traditional data center colocation to emerging 5G networks, which will require shared infrastructure to be economically viable. To support multi tenancy the Vapor Chamber provides physical separation between tenants, with up to 24 tenants per Chamber. Each tenant is provided access to only their IT equipment, fiber and power. The innovative and secure Vapor Wedge Security Zones system with electronic and physical access control is part of the Vapor Chamber, isolating tenants from each other to ensure uninterrupted operation.



The Vapor Chamber with one Wedge Rack being inserted

KEY FEATURES:

- Six Wedge Racks per Chamber each supporting 36 RU of standard 19" rack equipment
 - Open19 (with 19" adapters) and OCP supported
- Rated to house 150 kW of equipment per Chamber for high-density deployment
- Four security zones per Wedge Rack for secure multi tenancy (optional)
 - Up to 24 separate, physically-secured tenants per Chamber
 - Chamber can be configured for single or multi tenant use on a per-rack basis
- Vapor IO software for autonomic operation and remote monitoring
 - Running on [Vapor Edge Controller \(VEC\)](#) devices integrated into the Chamber
 - The VEC system runs in an N+5 configuration between all six Wedge Racks
- Ninety-two sensors per Chamber for remote monitoring, self-regulation and automated operation
- Equal air flow for all IT equipment within the Chamber, top, middle and bottom
 - Vastly superior to traditional rack and enclosure systems
 - Supports uneven load distribution between Wedge Racks for ease of deployment and future proofing
 - Increased IT equipment lifetime via superior cooling everywhere in the rack
- Lower energy costs than a traditional rack and enclosure system at the same density
- Greater efficiency and compute capacity for your data center

MOREOVER THE VAPOR CHAMBER:

- Requires no special flooring; the Vapor Chamber can be placed directly on a concrete slab
 - The Chamber can also be deployed on a raised floor system if present
- Is just 2.88 m (9.45') in diameter, requiring only a 6.1 m x 6.1 m (20' x 20') space for full operational clearances
- Requires no special air handling, air walls or fan walls; standard room flood is sufficient
 - Supports mixed-air and ducted-return to facility cooling system
- Supports the full temperature operating range of IT equipment; unlike a traditional rack and enclosure system
 - Maintains less than 2°C temperature differential from top to bottom of rack
- Supports ad-hoc maintenance and the easy addition or removal of IT equipment
- Can be deployed in one day, from start to finish

Patent Protected: <https://www.vapor.io/ip/patents/>

ENVIRONMENTS FOR THE VAPOR CHAMBER

The Vapor Chamber can be deployed in a number of different environments. These include standard data center environments but also non-standard office or retail space, or remote outdoor enclosures such as equipment sheds at the base of cell towers, without the need for special cooling systems. This is made possible by the Vapor Chamber's unique airflow design which uses a built-in [Central Exhaust Cell \(CEC\)](#) as a heat-evacuation chimney, rather than relying on a traditional hot and cold aisle approach to the data center. This unique configuration of the Vapor Chamber makes it more efficient than other alternatives, and also easier to deploy; although it does not remove the need for climate control, the Chamber can operate with a higher input air temperature than traditional rack and enclosure systems, lowering the cost and difficulty of climate control for the HVAC.

The increased density, capacity, efficiency and edge-readiness of the Vapor Chamber makes it ideal for matching the increasing demand for modern applications. These demanding applications include large-scale IoT, autonomous vehicles and 5G mobile services which all benefit from data center locality and the low-latency performance it can bring. In this way the Vapor Chamber makes high-performance edge computing and other emerging scenarios and use cases practical, forming the foundation of the next-generation internet.

OUTDOOR DEPLOYMENT AND THE VAPOR EDGE MODULE (VEM)

For outdoor deployments, such as in locations that have no suitable shed or structure, the Vapor Edge Module (VEM) can be used. The VEM is a self-contained Micro Modular Data Center (MMDC) which includes a Vapor Chamber as well as all of the additional critical systems required by modern data center infrastructure, such as:

- Power distribution
- Integrated UPS
- Cooling (self-contained)
- Physical security
- Fire suppression
- Racking systems for IT equipment

Designed for outdoor deployment, the VEM is weather-hardened and can be installed in a single day, placed directly on a concrete slab or on structural piers. The first version of the VEM can accommodate up to 24 separate tenants (future versions will support up to 30), and is rated to support 150 Kw of IT equipment. In addition, the VEM is factory-assembled and factory-tested; it is delivered to the deployment site as a single unit. Cooling is self-contained and provided by the VEM; no external air, additional HVAC equipment or water supply is required. These characteristics make the VEM a deploy-anywhere high-performance data center solution.



The Vapor Edge Module (VEM)

PHYSICAL SECURITY

Because edge data centers do not usually have on-site security personnel, the Vapor Chamber and of the VEM have security features that facilitate unsupervised tenant access.

Key physical security features of the Vapor Chamber include:

- IT equipment secured behind metal physically and electronically lockable doors
 - Doors and locks have sensors that monitor access
- [Vapor Wedge Security Zones](#) provide physical security for multi-tenant environments, supporting up to 24 tenants depending on the configuration.
 - Each zone protects against any one tenant disrupting the equipment, power or network connectivity of another tenant's security zone.

Key physical security features for the VEM include:

- Exterior access controls to prevent unauthorized access to the VEM and IT equipment via the VEM service vestibule

- Video cameras mounted on the exterior and interior of the VEM, transmitting all activity to a Network Operations Center (NOC)
- Isolated zone access controls via rotation of the Vapor Chamber on a motorized turntable
 - When personnel are authenticated and authorized, the Chamber automatically rotates into the correct position to provide access to only the Wedge Rack or security zone associated with that specific individual

FIRE SUPPRESSION

VEM units are shipped with Early Detection VESDA systems and fire suppression as an option. Standalone Vapor Chambers deployed inside a data center, office space, or other enclosure depend on the in-building fire suppression system.

SECURE CARRIER INTERCONNECTION

The Vapor Chamber and the IT equipment contained within it can be securely connected to a telecommunications carrier network or other network connectivity peering partner through standard fiber-based network connectivity. This will often occur physically via a Meet Me Room (MMR). Multiple Vapor Chambers or other rack and enclosure systems within the same building will also typically be interconnected via the MMR for local communication between equipment and tenants. The VEM unit includes a dedicated MMR facility.

ENVIRONMENTAL / OPERATING REQUIREMENTS

Wedge Rack Input for Density of 22.5kW (135kW Total Chamber Load)	(6x) 3 Phase 208V/120V with neutral 50/60 Hz with 80A breakers OR (6x) 3 Phase 400V/230V with neutral 50/60 Hz with 40A breakers										
Central Fan Input	(1x) 3 Phase 380-480V 50/60 Hz with a 10A breaker										
Upper Chamber Service Power	(1x) 1 Phase 120-230v 50/60Hz with a 20A breaker										
Storage Temperature	-40C (-40F) to +80C (176F) *										
Operational Temperature Rating	-10C (14F) to +40C (104F) *										
Humidity	Operating: 20-80% non-condensing * Non-operating: 5%-95% non-condensing *										
Spacing	Clearance of 1.21m (4') on all sides minimum										
Noise Level	<table border="0"> <tr> <td>Motor RPM</td> <td>dba @ 3ft</td> </tr> <tr> <td>100%:</td> <td>90</td> </tr> <tr> <td>75%:</td> <td>83</td> </tr> <tr> <td>50%:</td> <td>72</td> </tr> <tr> <td>25%:</td> <td>65</td> </tr> </table> <p>Note: Noise levels shown above will decrease when Vapor Chamber is installed in the ductwork and/or HVAC system</p>	Motor RPM	dba @ 3ft	100%:	90	75%:	83	50%:	72	25%:	65
Motor RPM	dba @ 3ft										
100%:	90										
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* Actual operational constraints will be subject to the specifications of lesser-performing IT equipment in the rack. The Vapor Chamber cannot make IT equipment perform outside of its defined temperature or humidity operating ranges.

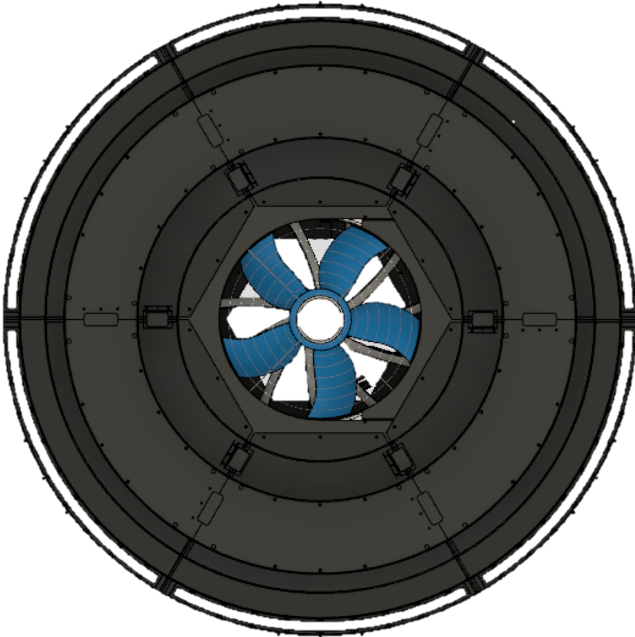
VAPOR CHAMBER EQUIPMENT LOAD

IT Equipment Airflow Requirement (CFM/kW)	Total Chamber Capacity (kW)
100	210
120	175
140	150
155	135
160	131

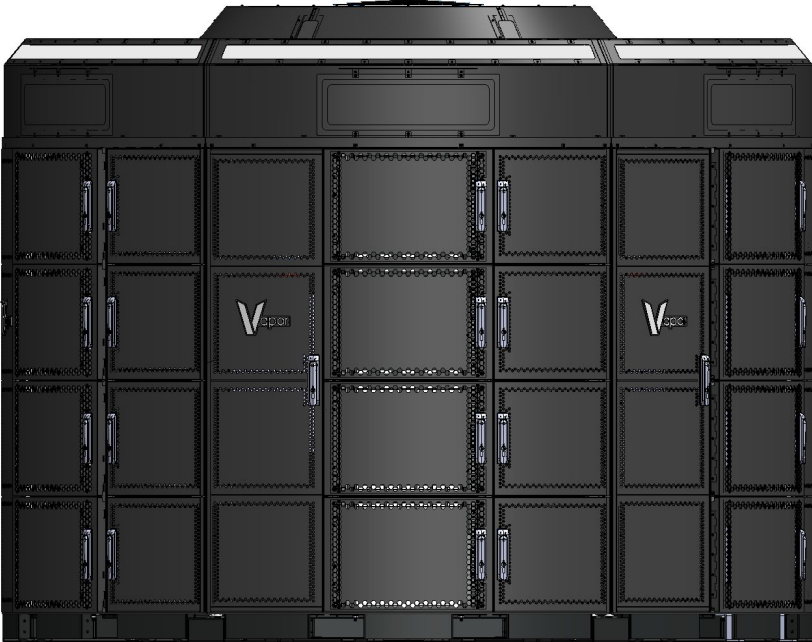
Note: Building cooling system must support the resulting temperature delta between inlet and outlet air to maintain IT equipment temperature and thus safe operation over time. Figures assume the same airflow requirement for all Wedge Racks; that between racks there is no large difference in the airflow required due to the quantity or type of IT equipment installed. Total Chamber capacity of 150 kW is the most frequently-used and is determined by the airflow requirement of the IT equipment installed.

DIMENSIONS

VAPOR CHAMBER

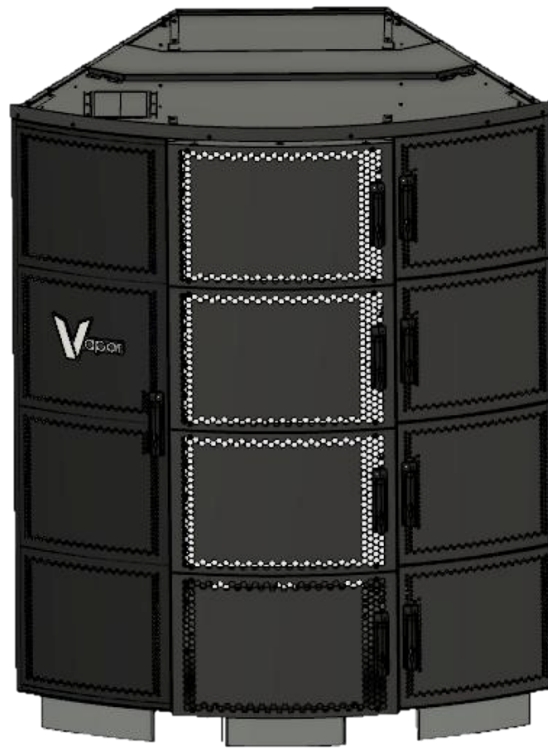


Diameter: 2.88m (9.45')



Overall Height: 2.29m (7.5')

WEDGE RACK



A Vapor Chamber has six Wedge Racks.

WEDGE RACK DIMENSIONS

Front Width: 1.44 m (4.7')	Height: 1.77 m (5.8')
Rear Width: 0.56 m (1.8')	Depth: 0.99 m (3.2')
Depth with Door Open: 1.54 m (5.1')	

Note: Front and rear Wedge Rack widths are different as the rear of the rack tapers. Door extends 0.55 m (1.8') past front of Chamber when open.

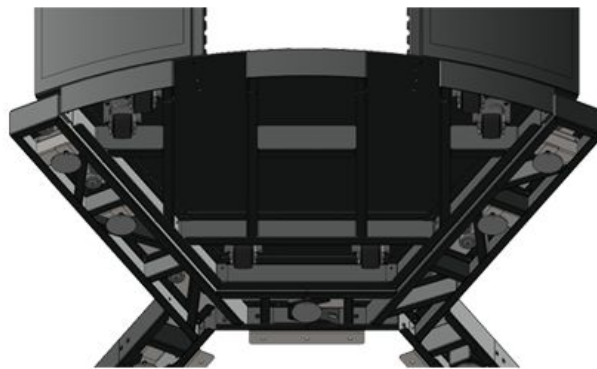
CHAMBER STRUCTURE

The Vapor Chamber has three distinct sections:

- **Lower Chamber:** Consists of six Wedge Racks and a Leveling Base. Serves as the foundation of the Vapor Chamber and provides support for the other sections that integrate to form the Chamber. The Leveling Base maintains the contact between the Vapor Chamber and the floor.
- **Upper Chamber:** Houses the central exhaust fan and provides space for cable management. It also incorporates sensors and the LED light ring. An Upper Chamber is not used inside a VEM.
- **CEC:** The central exhaust cell around which the Chamber is arranged. Acts as a hot air exhaust chimney and ensures consistent airflow throughout the chamber.

LOWER CHAMBER

The Lower Chamber is made up of six Wedge Racks, each of which connects to the integrated Leveling Base.



Top left: Overhead view of the Leveling Base

Top right: Angled view of the Leveling Base

Bottom: Underside view of Wedge Rack on top of Leveling Base

Each Wedge Rack is a self-contained unit that can be easily removed or installed independently of other Wedge Racks located within the same Vapor Chamber. It is possible to operate the Chamber with empty or partially-filled Wedge Racks,

which may occur temporarily during Chamber or Wedge Rack maintenance. During normal operation however all Wedge Racks will be present.

INTEGRATION

Once the Leveling Base has been assembled and adjusted, Wedge Racks can be rolled into place fully-populated or empty. The patented Leveling Base helps guide the Wedge Racks into place and then lifts them up off their casters slightly by using ball transfer units. This innovative design ensures that the Wedge Rack's weight is transferred to the Leveling Base, thereby evenly distributing it across the floor and preventing heavy point loads. A latching system on the Wedge Rack then secures it in place.

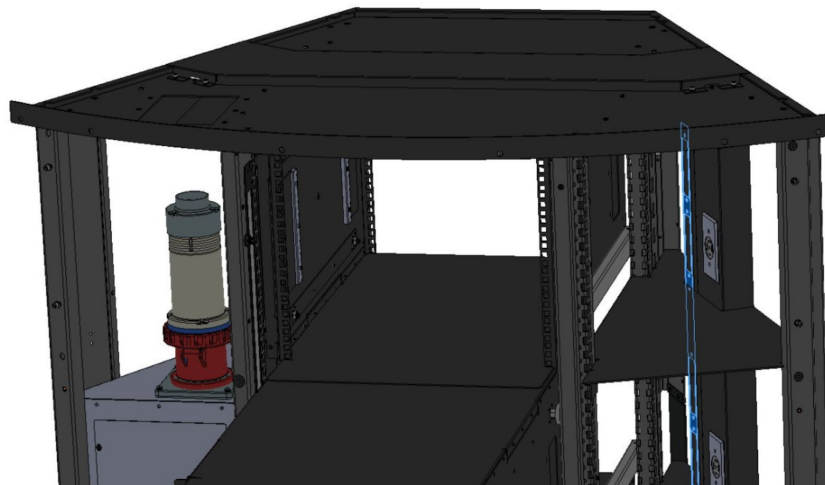
The Vapor Chamber can be deployed in a wide range of environments, even those not designed for IT equipment. For example, the Vapor Chamber can operate on uneven floors with its unique Leveling Base. The Chamber and its Leveling Base will also distribute the weight of any installed IT equipment, which minimizes the point loads on the floor from densely-filled racks in order to accommodate a wide range of surfaces, IT equipment and support structures.

The Wedge Rack design makes it easy to service equipment from the front or the back of the rack. Each Wedge Rack has quick-disconnects for power and network, making it easy to remove each rack for maintenance and service independent of other racks in the Vapor Chamber. To access the rear of IT equipment in a rack, a technician may easily roll the rack out of the Leveling Base. If service is required for equipment in a single [Modular Equipment Pod](#), the individual Pod can be easily removed while leaving the Wedge Rack in place. Equipment can be removed and added while the Chamber fan is running. Individual Pods can be loaded with IT equipment and run through burn-in testing before being integrated to a Chamber.

CUSTOMER ZONES

A Customer Zone is the combination of space within a Wedge Rack for a Modular Equipment Pod and access to the fiber and power for that Pod, all of which are physically protected so that access is only provided to the appropriate customer. Customers may order each Wedge Rack optionally divided into up to four Customer Zones. This allows for fine-grained multi tenant scenarios with up to four separate customers per Wedge Rack, and up to 24 separate customers in a single fully-loaded Vapor Chamber with all Wedge Racks and Modular Equipment Pods installed. With this degree of flexibility a single Vapor Chamber can serve many distinct users at once, with different needs and use cases; or a Chamber can be dedicated to one tenant.

Secure multi tenancy in the Vapor Chamber is provided by Vapor Wedge Security Zones, detailed in the section [Multi Tenancy with Vapor Wedge Security Zones](#).



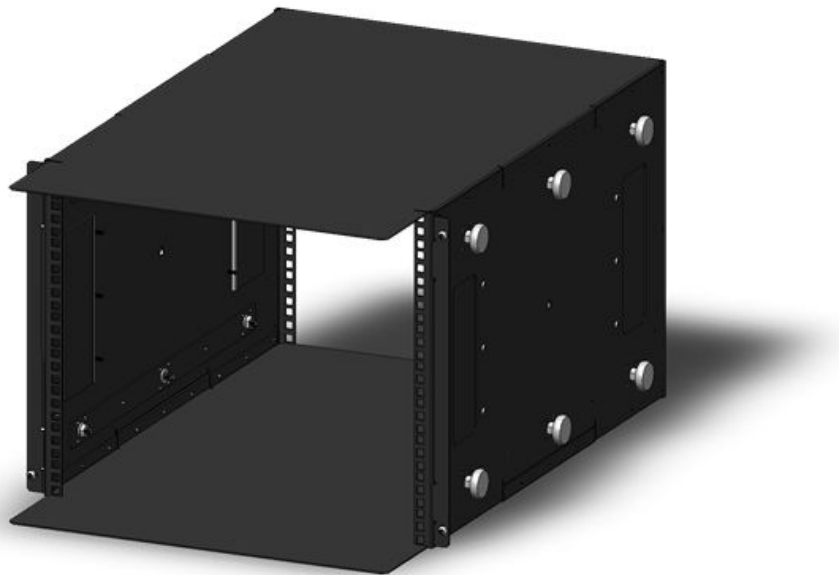
Wedge Rack with doors removed to show Customer Zones

MODULAR EQUIPMENT PODS

A Modular Equipment Pod is a removable mini-rack into which customer IT equipment is installed, before the Pod itself is then integrated into a Wedge Rack. Each Modular Equipment Pod is capable of supporting up to 9 RU of standard 19" IT equipment. A Wedge Rack can hold up to four such Pods when ordered for multi-tenant operation. Note that a 1 RU Power Distribution Unit (PDU) must be included in each Pod. A wheel and rail system in the Wedge Rack guides each Pod into and out of the rack, ensuring that it is easy to insert and remove Pods even when they are full of IT equipment. Six wheels on each side of the Pod slide onto corresponding rails in the Wedge Rack. A service technician can quickly and easily access the rear of IT equipment within the Chamber by sliding the Pod out using this rail system.

For additional flexibility in deployment, technicians can integrate Modular Equipment Pods on- or off-site and even stress test equipment in the Pod before integrating it into the Vapor Chamber. This allows a Vapor Chamber tenant or operator to perform standard burn-in and benchmark tests in order to identify issues with their IT equipment before integrating into the Vapor Chamber. This will often save valuable time, speeding up maintenance tasks and increasing the chances of achieving a trouble-free deployment.

Each Modular Equipment Pod provides side-mounted fiber and power ports which align to the adjacent Customer Power and Fiber Zones of the Wedge Rack, described in the section [Multi Tenancy with Vapor Wedge Security Zones](#). This design makes each Pod independent of others, eliminating interdependence and protecting against interaction between tenants within the Chamber.



Modular Equipment Pod

WEDGE RACK SPECIFICATIONS

Supported Equipment	Standard 48.3 cm (19") Rack Compatible Open19 Compatible OCP Compatible
Height	36 RU (Rack Units 48.3 cm x 4.45 cm (19" x 1.75"))
Depth	Total Equipment Depth: 94 cm (37") 48.3 cm (19") Front Rail to Back Rail Distance: 64.8 cm (25.5")
Mobility	Six heavy-duty casters per Wedge Rack; a single person can easily roll a full Wedge Rack into or out of the Chamber Wedge Racks include slots for pallet jack forks
Empty Weight	~181kg (400 lbs.)
Customer Security Zones (Optional)	Four Customer Zones per Wedge Rack 9 RU Each (1 RU must be dedicated to a PDU) Tenant-secure fiber and power cabling per Zone Standard 48.3 cm (19") Rack Compatible Open19 Compatible
Rack Level Monitoring/Control	One VEC per Wedge Rack

LEVELING BASE SPECIFICATIONS

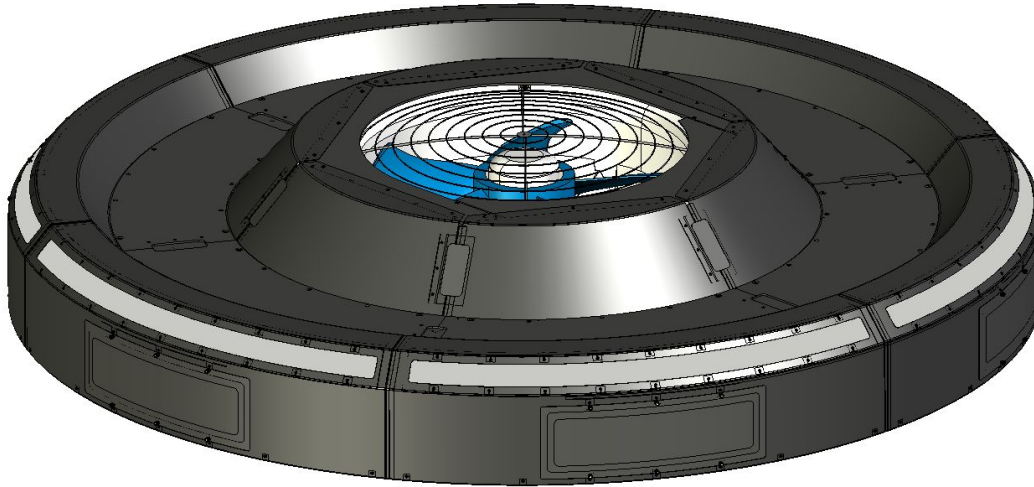
Features	Leveling, rack alignment and weight distribution base
Floor Level Requirement	Floor will require maximum 0.64cm (¼") level across 3.05 m (10'). Leveling feet adjust to 2.5 cm (1") difference but will require the use of a pallet jack to install Wedge Racks.

LOWER CHAMBER SPECIFICATIONS

Chamber Emergency Power off (EPO)	One switch per Vapor Chamber
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UPPER CHAMBER

The Upper Chamber houses the central exhaust fan and serves as an area for cable management. In a typical indoor deployment, a hot-air chimney connects from the top of the Upper Chamber to a return air plenum in the datacenter sub-ceiling. The chimney fully contains the hot exhaust from the Vapor Chamber and ensures it does not re-circulate to the equipment. Incoming power cables travel along the chimney and into the top of each Wedge Rack to power IT equipment within the Chamber. The Upper Chamber contains sensors for monitoring exhaust air temperature and airflow. Software running on the [VEC](#) uses data from these sensors and others throughout the Chamber to dynamically control the speed of the 91.4 cm (36") central fan, ensuring optimal airflow for IT equipment and safe operation.



Upper Chamber

KEY FEATURES

- 91.4 cm (36") direct drive 21,000 Cubic Feet per Minute (CFM) variable speed fan
 - Easily quick-swappable with a team of two
- Real-time airflow measurement
- Exhaust air temperature measurement
- Cable quick connect management
- Six maintenance access panels, one per Wedge Rack
- Six programmable LED light bars, one per Wedge Rack

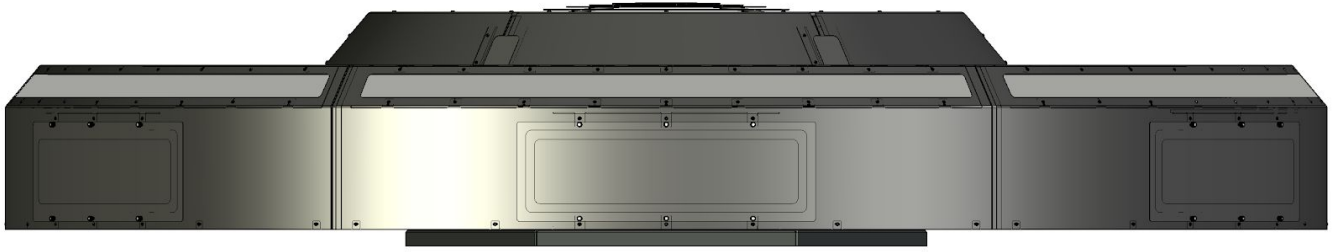
LED LIGHT RING

The Vapor Chamber integrates an LED light ring around the top of the Upper Chamber, comprised of six individual bars, one above each Wedge Rack. These bright and color-rich LED light bars can be programmatically configured to display millions of color combinations in a blinking or solid fashion. The LED light ring is a visual indicator that turns on in response to a range of user-programmed events, as orchestrated through the VEC, described in the section [Vapor Edge Controller \(VEC\) and Software](#).

Some common examples of uses for the LED light ring are:

- To indicate the status of a Vapor Chamber tenant's IT equipment
 - Visually guides a technician to a rack of interest for IT equipment servicing and maintenance
- To indicate Vapor Chamber owner or facilities team status
- Branding for the owner or tenants of the Vapor Chamber

- To indicate the current Vapor Chamber fan speed or load
- To indicate the space available in each Wedge Rack for IT equipment



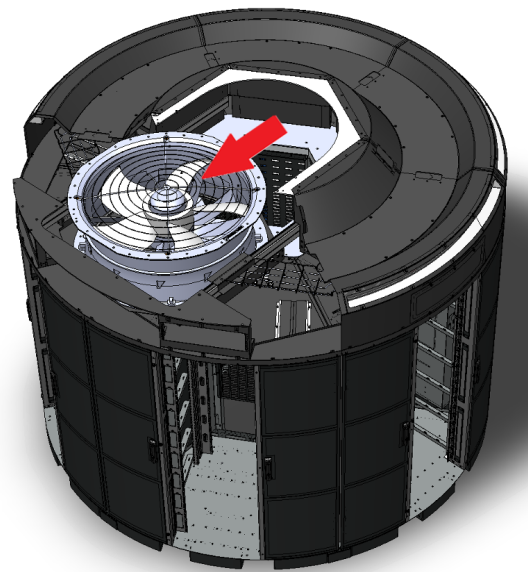
LED light ring (visible as light grey bars in the upper third of this image)

FAN AND FAN REMOVAL

The quick-swappable 21,000 CFM fan located in the upper Chamber can be easily swapped out by a team of two. A sliding rail design makes it easy to disconnect the fan and slide it into position for removal. The fan can then be lifted upwards and out of the Chamber for maintenance or replacement. Each person involved in lifting the fan should be capable of lifting a 75 lb load overhead to ensure the safety of people and equipment, and the fan must be lifted by its housing rather than by any physical contact with the fan blades, as the fan blade edges are serrated to reduce fan noise and optimise airflow.



Fan separated from Upper Chamber



Rail system for easy removal of fan from Upper Chamber

CENTRAL EXHAUST CELL (CEC)

In a traditional data center design, one underappreciated challenge is maintaining neutral static (aka, “zero static”) pressure between the cold and hot aisles. This ensures that air flows through the IT equipment at precisely the defined rate as required by the equipment design. When a pressure mismatch develops, such as positive pressure in the hot aisle, the IT equipment’s fans or the building cooling system must work harder to ensure enough air is available to move through the IT equipment and cool it. This creates huge inefficiencies and over time can even result in equipment failure as the building’s cooling system is unable to counteract the pressure difference without the addition of expensive upgrades.

With this in mind, Vapor’s patented CEC is a unique replacement for the traditional data center hot aisle design. It is the central support structure of the Vapor Chamber and also serves as the hot air chimney within the Chamber. A variably-perforated wall separates the CEC from the rear portion of the IT equipment in each Wedge Rack. The carefully-engineered perforations of the CEC allow optimal airflow while maintaining neutral static pressure, which is key to achieving a sufficient supply of air and consistent heat evacuation from the Vapor Chamber.



CEC Positioned on Lower Chamber Leveling Base

DESIGN

The design of the CEC allows the Vapor Chamber to operate safely with higher densities of IT equipment compared to a traditional rack and enclosure system, even with a higher inlet air temperature. Combined with the rest of the Vapor Chamber design, the CEC eliminates the need for the traditional hot and cold aisle approach to data center airflow.

The fan within the Upper Chamber draws large volumes of air through the Vapor Chamber from the outside, and removes stagnant hot air from the IT equipment within each Wedge Rack. This hot air is then expelled from the Vapor Chamber into an attached chimney, ducting or other channel that removes this hot exhaust from the Chamber. The high efficiency of this system and the volume of air it is able to move allows the Chamber to support high densities of IT equipment within a small footprint (i.e., 135 kW within a 2.88 m (9.45') diameter), even with smaller clearances around the Chamber and higher inlet air temperatures than a traditional system.

INTEGRATION

The CEC attaches to the Lower Chamber Leveling Base. The Leveling Base distributes the weight of the CEC throughout the area of the Leveling Base, helping to avoid point loads on the floor. The Upper Chamber attaches to the top of the CEC,

providing the optimal level of cooling performance and structural support for the Vapor Chamber. When Wedge Racks are integrated into the Leveling Base, the rear of their IT equipment is positioned against the CEC for optimal airflow.

SENSORS

The Vapor Chamber incorporates over 92 sensors to monitor and tune its airflow to maximum efficiency. The sensors connect to the [VECs](#) in each [Wedge Rack](#) which run sophisticated software for local monitoring, Chamber control and optimization. All of the sensor data is available to external services via an HTTP API, allowing remote management and monitoring as well as aggregation of data across multiple Chambers and multiple sites.

TEMPERATURE SENSORS

Temperature sensors are installed between the Upper Chamber and Lower Chamber, and along the entire height of each Wedge Rack to provide a real-time view of the thermal characteristics and status of the Chamber. The sensors in the Upper Chamber monitor the exhaust air from the CEC. An ambient room temperature sensor located on the outside of the Chamber and the temperature sensors along the height of each rack provide detailed data about the temperature of inlet air entering the Chamber from the room. Temperature information from sensors integrated into the motherboards of servers that provide data via supported monitoring protocols, such as IPMI, can also be used by the VEC.

AIRFLOW SENSORS

A sensor in the Upper Chamber monitors the speed of exhaust air movement from the CEC. In addition, differential pressure sensors throughout the Lower Chamber provide a way to compare the air pressure at the front of each Wedge Rack to that between the rear of the Wedge Rack and the CEC wall. These pressure readings allow software on the VEC to adjust the fan speed to maintain optimal airflow by equalizing to neutral pressure.

OTHER SENSORS

Other sensors are present throughout the Vapor Chamber to measure air humidity and other conditions. These sensors provide visibility into detrimental operating conditions which may develop and, if left unchecked, could result in damage to IT equipment within the Chamber or other undesirable consequences. Any combination of sensor readings can be used by the VEC software to trigger user-programmable actions autonomically.

VAPOR EDGE CONTROLLER (VEC)

Within each of the six [Wedge Racks](#) of a Vapor Chamber is a VEC. These VECs control the operation of the Chamber by running software which provides detailed telemetry data from the sensors throughout the Chamber. An HTTP-based API is used to access this data. All VECs within the Chamber run Kubernetes and function as a six-node cluster. These vital software components operating in the VEC are containerized and use Kubernetes for container orchestration, management, and fault-tolerance.

Each VEC is a device positioned in the left side of its Wedge Rack, inside the [Secure Facility Zone](#) in a Chamber configured for multi tenancy. This limits physical access to the VEC to the Chamber owner or facilities team, as each VEC is responsible for all of the tenants within a Wedge Rack.

VEC SOFTWARE

The VEC runs many crucial software components for Chamber operation. The key components are:

- VEC Server
 - The VEC Server software system autonomically operates the Chamber while also collecting Chamber telemetry. The VEC server provides a remotely-operable RESTful API that allows an operator or external application to communicate with Chamber and its devices such as the fan, LED light bar, and sensors. With

an extensible plugin architecture, the server can be adapted to communicate with new types of equipment and support new protocols after deployment.

- The VEC Server software is open source, with an SDK available for users to create their own plugins.
- Auto Fan
 - A custom Vapor service that operates within the Chamber and dynamically adjusts the Chamber fan speed based on many factors including temperature, airflow, and pressure data from the sensors throughout the Chamber.
- I2C Plugin
 - A plugin for the VEC Server that communicates with sensors and devices that use the I²C protocol throughout the Chamber such as Chamber LEDs, temperature sensors, and pressure sensors.
- RS485 Plugin
 - A plugin for the VEC Server that communicates with sensors and devices that use the RS-485 protocol throughout the Chamber such as the Chamber fan, airflow sensors, and humidity sensors.

Currently supported plugins also include IPMI. Additional plugins will be available including Redfish, Intel AMT, Modbus over IP and SNMP v3 to expand the capabilities of the Chamber through VEC software.

MULTI TENANCY WITH VAPOR WEDGE SECURITY ZONES

To support secure multi tenancy, each [Wedge Rack](#) within a Vapor Chamber can be securely segmented for use by up to four tenants. Up to 24 separate tenants can be present in the Vapor Chamber, each with their own separate and secure fiber and power cabling as well as secure access to their own IT equipment in one or more Modular Equipment Pods.

KEY FEATURES

- Supports secure multi tenancy with up to four tenants per Wedge Rack
 - Up to 24 secure tenants per Vapor Chamber
- Unique physical design provides tenant security but allows facility staff access
- Access control to IT equipment per tenant, with both physical and electronic locks
 - Each tenant can access only their own secured IT equipment, fiber and power
- Recording and auditable log of each IT equipment access event regardless of the lock type used

DOORS

Wedge Racks are divided into three columns, each with different access doors. When facing the rack, to the left is a single door for access by the facilities team, whereas the central and right doors allow for secure customer access. The doors in the Customer Equipment column (center) align with their counterparts in the Customer Fiber and Power column to its right, limiting tenant access to only their equipment and only their fiber and power. Optionally, if the Chamber or Wedge Rack will be used by a single tenant only, the central column door can be replaced with a non-segmented single-lock version to allow for quicker equipment access.



Doors present on each Wedge Rack

ACCESS CONTROL AND MONITORING

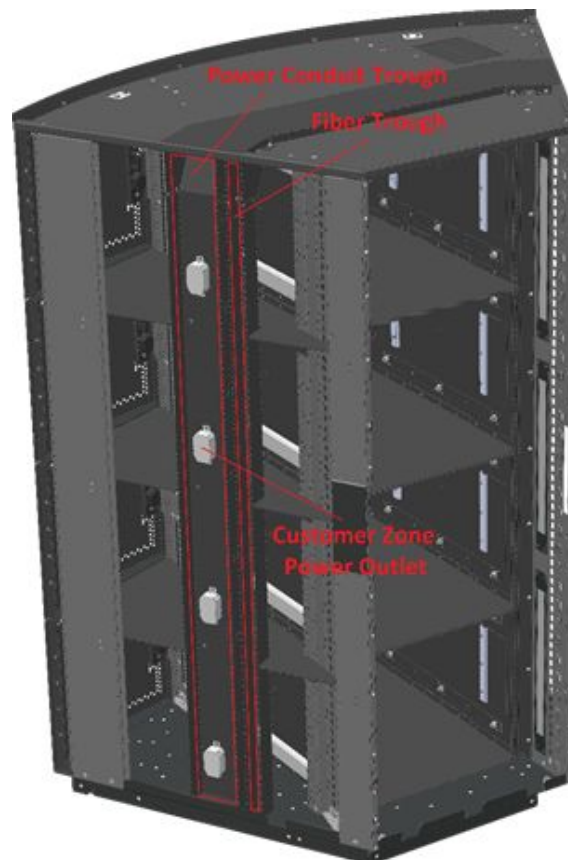
Each door on the Wedge Rack is individually lockable using physical or electronic lock mechanisms. This ensures that only the correct tenant is able to access the IT equipment behind that door, as well as their own segmented fiber and power. Access attempts to any of these secured areas can be logged by the VEC and can then be audited by the facility team to investigate an incident or provide an auditable record of secure Chamber operation to a tenant.

CUSTOMER FIBER AND POWER ZONES

Isolated Customer Fiber and Power Zones provide strong security and protection against one tenant interrupting the operation of another's equipment, or their fiber and power. The Wedge Rack implements dedicated fiber and power cabling conduit to each tenant. Due to the physical design of the Wedge Rack, each tenant is only able to access fiber and power that corresponds to their IT equipment. This allows the Vapor Chamber to support secure multi tenancy even in the presence of potentially hostile tenants.

In addition, dedicated power outlets are provided for each Customer Zone. Fiber and power cabling feeds through from the Modular Equipment Pod for each tenant in the central column of the Wedge Rack. This cabling is connected to fiber and power in the adjacent Customer Power and Fiber zone. As well as securing tenant equipment, this design also simplifies deployment.

Each Customer Zone receives, through the [Secure Facility Zone](#), a separate 20 A three-phase breaker, with ANSI C12 class revenue-grade power metering. Tenants are also supplied with 12 strands of single-mode fiber (OS2) and 12 strands of multi-mode fiber (OM4). No copper-based network connectivity such as Gigabit Ethernet is provided to Customer Zones.



Note: Side panel removed to show details

Rear view of the Wedge Rack showing Customer Power and Fiber Zones

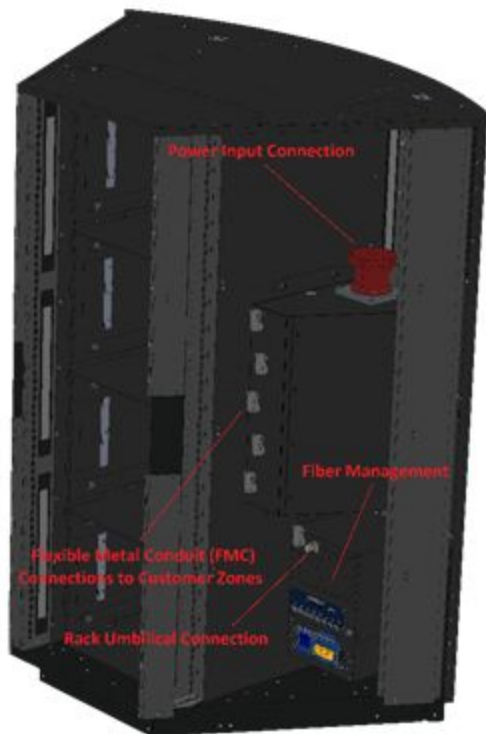
SECURE FACILITY ZONE

The central and right columns of each Wedge Rack are dedicated to Customer Equipment Zones and Customer Fiber and Power Zones respectively. The left column however is dedicated to the facilities team and forms the Secure Facility Zone.

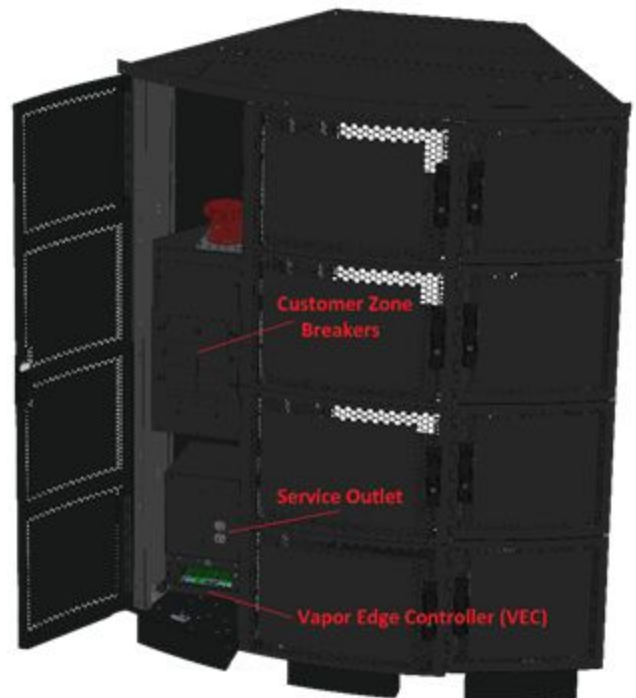
The Secure Facility Zone supplies each Customer Zone with the following:

- Three-phase power input
- Individual breakers
- ANSI C12 class revenue-grade power metering
- Remote power cut-off capability
- Fiber network cabling breakouts

In addition, the Secure Facility Zone of each Rack contains the VEC which manages the operation of that Wedge Rack. There is no tenant access provided to the Secure Facility Zone. Each Wedge Rack is physically designed to limit access to the Secure Facility Zone to only those who are authorized to access it, preventing damage by potentially hostile tenants.



Rear and side view of Secure Facility Zone



Front view of Secure Facility Zone

AUXILIARY EQUIPMENT SPACE

Four of the six Wedge Racks of the Vapor Chamber have additional equipment space in the Upper Chamber above each rack. This auxiliary space can accommodate up to 3 RU of 48.3 cm (19”) shallow depth rack equipment, and does not provide rear mounting capability. It is well-suited for additional monitoring equipment, status display hardware or other lighter-weight equipment that would otherwise take up space within the main Modular Equipment Pods. Equipment which is shared by the tenants of a Wedge Rack or that is used by the facilities team may also be situated in these additional spaces.

INTERNATIONAL POWER OPTIONS

The Vapor Chamber may be ordered in several power configurations to allow for deployment in many countries. For each country, the correct power connector types and colors are used. The internal power conversion and distribution equipment within the Vapor Chamber is rated to handle the variations in electricity supply from national standards across the world, and so only the power connectors and color indicators are changed between regional variants of the Chamber.

Please contact sales@vapor.io to discuss your specific needs.

SALES, PRICING AND OTHER INFORMATION

Please contact sales@vapor.io for any of the following:

- Inquiries
- Spare parts
- Software licensing
- Training
- Chamber repair
- Service and maintenance

Auto Fan

A plugin that operates as part of the VEC Server. Auto Fan controls the fan speed of the Vapor Chamber based on telemetry from many of the sensors throughout the Chamber, such as airflow and internal and external pressure, to provide the optimal airflow for IT equipment throughout each Wedge Rack.

Central Exhaust Cell (CEC)

A patent-pending variably-perforated structure which allows the fan in the Upper Chamber to evenly draw the required amount of air through all of the IT equipment installed within the Vapor Chamber, providing consistent cooling to all of the equipment in the Wedge Racks regardless of their location in the rack.

Customer Equipment Zone

A physically-protected zone within a Wedge Rack which is configured for multi tenancy. The Customer Equipment Zone contains the Modular Equipment Pod of a particular tenant and feeds for their fiber and power. Each Customer Equipment Zone is protected by the design of the Wedge Rack from physical damage by other tenants.

Customer Fiber and Power Zone

A physically-protected zone within a Wedge Rack that is configured for multi tenancy. The Customer Fiber and Power Zone is the area of the Wedge Rack through which the fiber and power for a particular tenant is delivered to their Customer Equipment Zone. Each Customer Fiber and Power Zone is protected by the design of the Wedge Rack from physical damage by other tenants.

Emergency Power Off (EPO)

A switch which immediately removes power from the Vapor Chamber and all IT equipment within it. Used in the case of emergencies such as unsafe operating conditions.

LED Light Ring

Six LED light bars which circle the perimeter of the Upper Chamber and visually indicate Chamber status, including tenant equipment status and any other event or status indicator as programmed in the VEC. Typically used to guide on-site technicians to resolve an issue quickly.

Leveling Base

The unique physical base of the Vapor Chamber which allows the Chamber to be deployed on a wide variety of even and uneven flooring. The design of the Leveling Base avoids the creation of point loads, evenly distributing the weight of the connected Wedge Racks and their IT equipment across the entire base.

Lower Chamber

The part of the Vapor Chamber comprising the Leveling Base and Wedge Racks. The Lower Chamber forms the physical foundation for the Chamber on to which the CEC and Upper Chamber are integrated.

Meet Me Room (MMR)

A room or space dedicated for the interconnection of multiple networks or data center operators. The MMR is typically contained within the same building as multiple micro data centers or in a nearby structure.

Micro Data Center

A physically-compact data center which provides high-density compute, storage and network resource within a small footprint. This combination of power and size makes micro data centers optimal for edge deployment. The ideal micro data center combines up to 150 kW of IT equipment within a physical diameter of less than 10 feet.

Micro Modular Data Center (MMDC)

A micro data center which is deployed in a self-contained unit, containing both the micro data center and all of the equipment needed for it to operate such as fire suppression and UPS infrastructure.

Modular Equipment Pod

9 RU mini-rack that contains IT equipment and slides into the Wedge Racks. For multi-tenant environments, Pods can be allocated on a tenant-by-tenant basis. For a single tenant Wedge Rack, all Pods are used by that tenant. Modular Equipment Pods make it easy to install IT equipment on- or off-site and stress test the configuration before integration with the Chamber. This design also allows Pods to be added and removed as needed during Chamber operation.

Secure Facility Zone

A physically-protected zone within a Wedge Rack. The Secure Facility Zone is designed to be accessed only by the facility team or Vapor Chamber owner. It contains infrastructure that impacts all tenants within a Wedge Rack such as fiber, power, the VEC and Emergency Power Off (EPO).

Upper Chamber

The upper part of the Vapor Chamber which houses the fan, LED light ring and airflow sensors. The top of the Upper Chamber connects to the building HVAC ductwork to provide a path for hot exhaust air to be removed.

Vapor Chamber

A micro data center designed and manufactured by Vapor IO, which supports 150 kW of IT equipment in a 9.5 foot diameter circular enclosure. The Vapor Chamber's innovative patent-pending air circulation and rack system ensures balanced cooling even when racks have different equipment densities. Designed to be deployed inside a variety of purpose-built or general-purpose structures, the Vapor Chamber delivers unmatched density at almost any edge location.

Vapor Edge Controller (VEC)

A device integrated into each Wedge Rack within the Vapor Chamber that is responsible for telemetry and remote monitoring and operation of the Chamber. All VECs within a Vapor Chamber operate together in a redundant and failover-capable configuration.

Vapor Edge Module (VEM)

A self-contained Micro Modular Data Centre (MMDC) integrating a Vapor Chamber and all of the supporting infrastructure required to operate it, including cooling, fire suppression and backup power supplies. Delivered as a single unit suitable for outdoor deployment, the VEM can be placed directly onto a cement foundation or structural piers and configured for production operation within a day.

Vapor Wedge Security Zones

A unique system implemented in Wedge Racks configured for multi tenancy that protects the IT equipment of each tenant as well as the fiber and power provided to that tenant from harm by other tenants.

VEC Server

The software operated by the VEC within each Wedge Rack. The VEC Server provides a RESTful HTTP-based API and a range of plugins for remote monitoring and operation of edge facilities that utilize Vapor Chamber or Vapor Edge Module.

Wedge Rack

A modular component of the Vapor Chamber. The Wedge Rack is where IT equipment is mounted. There are six Wedge Racks per Vapor Chamber, all of which connect to the Leveling Base of the Vapor Chamber to lock into place for operation. Each Wedge Rack can be optionally divided into up to four physically-isolated Customer Equipment Zones to support multi-tenancy and colocation business models.

Vapor, Vapor IO, Vapor Chamber, Vapor Edge Module (VEM), Vapor Edge Controller (VEC), Wedge Rack, Vapor Wedge Security Zones and the stylized-V Vapor logo are trademarks or registered trademarks of Vapor IO, Inc.

The Vapor Chamber is covered by one or more US patents: <https://www.vapor.io/ip/patents/>

Updated: May 17, 2018

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