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Compute Project

ACS Door Heat Exchanger Requirements for Open Rack

Revision 1.0

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1. SCOPE

This document defines the technical requirements and potential applications for a rack-mount door heat exchanger to be used with Open Rack. This document is specifically scoped for a rear-side, rack mounted heat exchanger solution; however, physical dimensions of the heat exchanger should be compatible for both rear and front mounting.

2. LICENSE

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3. ACKNOWLEDGEMENTS

The ACS Door Heat Exchanger Requirements for Open Rack was created through collaboration with many participating companies facilitated by the ACS Door Heat Exchanger sub-project under the Rack and Power group.

The ACS Door Heat Exchanger sub-project would like to kindly acknowledge the following for their contributions to this document:

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4. REVISION TABLE

Revision	Date	Comments
0.9	August 10, 2020	Draft for IC review
0.95	January 21, 2020	Adjustment to requirements document; modification of license section
1.0	June 15, 2021	Addition of appendix A; adjustments to accommodate two-phase coolants

5. TERMINOLOGY

The following is a list of terms or acronyms used frequently in this document.

- Door HX, rack-mount door heat exchanger assembly
- CDU, coolant distribution unit. A component used to drive a closed loop of coolant that absorbs heat from IT cabinets or equipment and rejects it to the facility cooling (water) system. This component can be sized to mount within an IT cabinet or installed on the data center floor to support multiple IT cabinets.
- RPU, reservoir and pumping unit. A component like the CDU, but without a heat exchanger to reject heat to the facility cooling system. It is designed to drive a closed-loop of coolant within or across IT cabinets and, when combined with a liquid-to-air heat rejection device like a Door HX, exhaust heat to facility air. Therefore, a cooling system employing an RPU can function in a facility designed for 100% air-cooling.
- TCS, Technology Cooling System, is the cooling system from the CDU to IT cabinets or equipment. This term is defined by ASHRAE to describe a type of liquid cooling implementation [1].
- FWS, Facilities Water Systems, is the facility cooling system. This term is defined by ASHRAE to describe a type of liquid cooling implementation [1].

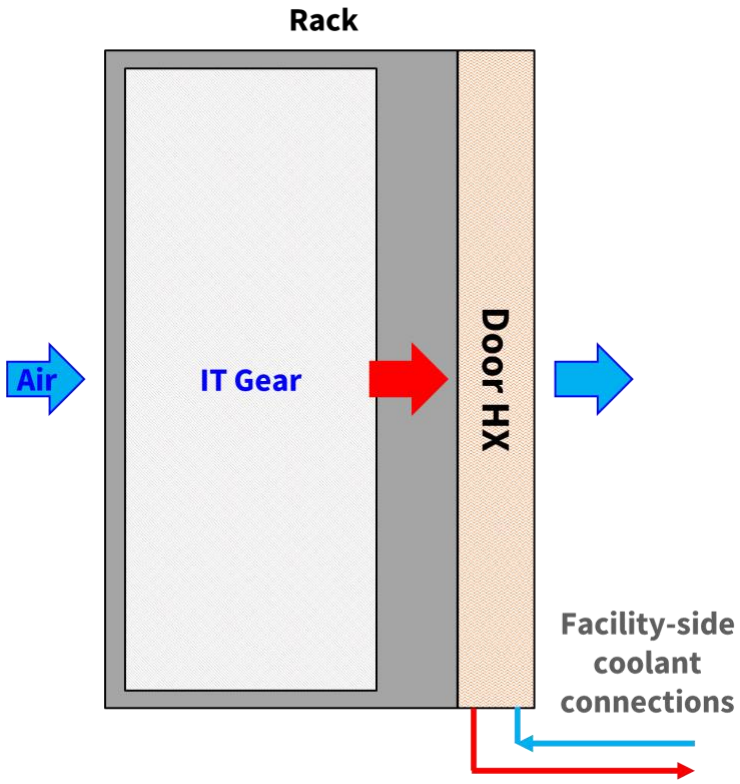


Figure 1: Simplified depiction of a traditional rear door heat exchanger

6. POTENTIAL APPLICATIONS

6.1 Traditional real door heat exchanger (air-to-coolant)

The most widespread application of a door heat exchanger is where the solution replaces the rear door of a rack and relies on the facility-provided coolant to make the rack thermally neutral to the room. Figure 1 provides a simplified representation of a rack outfitted with a rear door heat exchanger. In general, IT hardware within the rack is air-cooled and the door heat exchanger uses

facility coolant to absorb heat from exhaust air to return air to the facility at or near inlet air temperature to the rack. This rear door heat exchanger can either be a passive or active solution. The latter has fans integrated that help drive airflow to achieve the required amount of cooling and minimize/counteract back pressure on IT chassis fans. Depending on requirements, a passive solution may or may not have integrated sensors for monitoring.

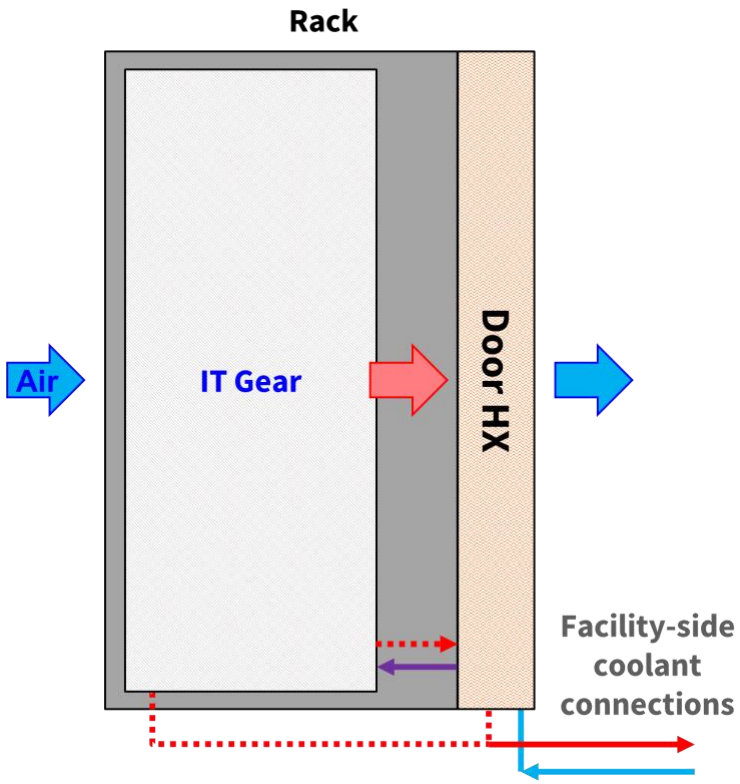


Figure 2: Simplified depiction of a rear door heat exchanger and facility coolant used to enable liquid cooling of IT gear

6.2 Liquid-cooled hybrid solution (air-to-coolant and coolant-to-coolant)

This solution is an extension of the traditional approach with the added feature of liquid-cooling IT hardware components in the rack. Availability of facility coolant at the rack is leveraged to liquid-cool high-power components in IT chassis. Rack-level liquid cooling infrastructure such as cold plates and manifolds are required. A CDU may also be employed for better control of coolant to the cold plates in each IT chassis. The rear door heat exchanger continues to serve a traditional function of capturing heat from exhaust air in order to return air to the room at or near the inlet air temperature to the rack. This approach may help enable higher IT component and rack powers. The rear door heat exchanger can be either a passive or active design. Careful selection of the Door HX and its internal circuitry must be considered so that the Door HX can achieve the cooling performance required at a flow rate that matches liquid cooling requirements of the IT chassis.

If a two-phase coolant is employed, appropriate design modifications would have to be considered.

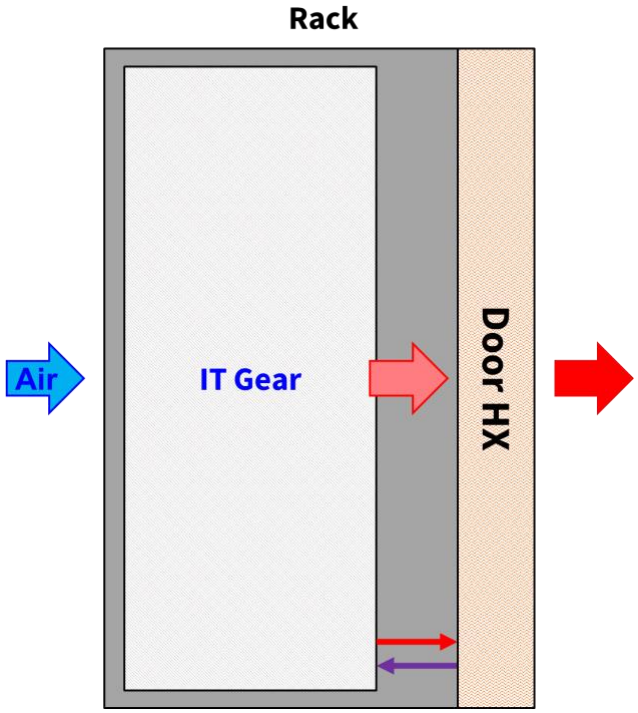


Figure 3: Simplified depiction of hybrid solution which use facility air to cool an internal coolant loop

6.3 Air-assisted solution (coolant-to-air)

This solution can be envisioned as the opposite of the one described in section 2.2. Heat exchanged in an internal (closed) coolant loop is exhausted to facility air using a door heat exchanger. Figure 3 provides a simplified depiction of how this system functions. Rack-level liquid cooling infrastructure such as cold plates, manifolds and CDU (coolant distribution unit; term used in a general sense here) are used to cool high-power IT components such as CPUs, GPUs, etc. The CDU drives the internal fluid loop and the door heat exchanger exhausts heat by using exiting air from the IT gear. Therefore, such a rack is 100% air-cooled and cold plates installed on components will receive above-ambient temperature coolant for heat transfer. This solution can provide the benefits of liquid cooling in an air-cooled facility. The Door HX can be either a passive or active type and is selected based on the capability of IT (server) fans and required cooling capacity (kW).

Designs must consider tube routing to the CDU. The door hinges should be placed on the side of the frame that allows the Door HX to open and close without stressing the tubes.

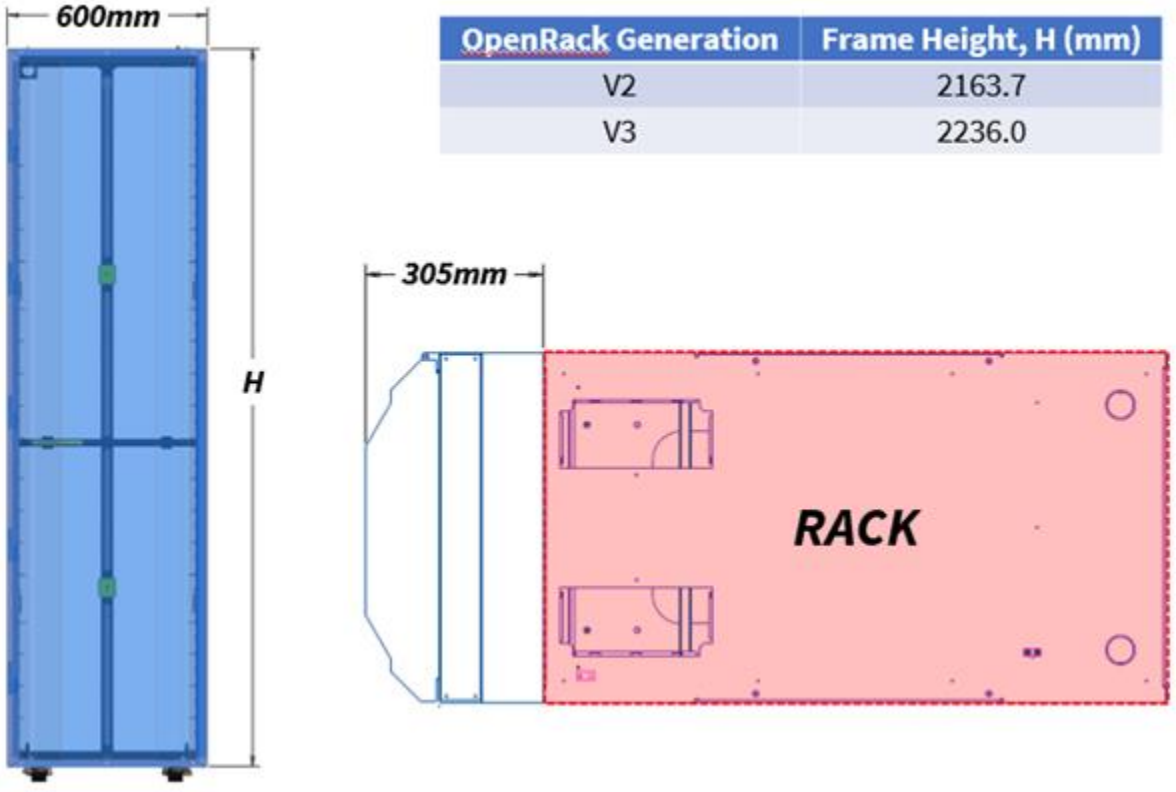
7. PHYSICAL REQUIREMENTS

7.1 Physical dimension of Door Heat Exchanger (Door HX)

Face area dimensions of the Door HX should be compatible with Open Rack architectures. Installation of the door to a rack should not impact deployable rack-to-rack pitch or require the addition of auxiliary components. Guidance for Door HX designs, whether active or passive, are as follows:

- The overall width of Door HX should be within the Open Rack's primary structure/frame, including structural elements or the external frame housing the heat exchanger core and an adapter frame for mounting against the rack.
- The overall height of Door HX should be within Open Rack's primary structure/frame, not including components touching the facility floor such as castors and levelling feet. The only components permitted to extend beyond said definition are coolant connections and physical interfaces specific to active doors such as power delivery and communication. The adapter frame may have adjustable feet for height alignment and load bearing. In general, leveling feet (or features) should be compliant with rack-specific requirements.
- Maximum preferred depth is 1ft (305mm), including the adapter frame for mounting against the rack. The detail dimension of rack and depth of Door HX is shown in Fig. 4 [2]. This requirement may be violated as long as the aisle spacing and/or ability to open the door by at least 90° (as outlined in Fig. 5) are met. Note that this should be agreed upon between the end-user and solution provider.

See Appendix A for Door HX mechanical requirements specific to Open Rack V3 with in-rack blind-mate manifolds and RPU (reservoir and pumping unit).



OpenRack Generation	Frame Height, H (mm)
V2	2163.7
V3	2236.0

Figure 4: Rear and top view of Open Rack showing maximum dimensions of mounted Door HX assembly

7.2 Layout Impact to Data Center

The Door HX shall be removable and mounted to Open Rack with a hinged solution for quick access to the rear side of the rack for easy servicing and maintenance, such as fans, power-bus bar, manifolds, etc. The operation of the Door HX should not impact any pre-existing data center layout or design aspects. This includes:

- When mounted to a rack and primed with coolant, the combined weight should be ≤1400kg (3086lbs) for Open Rack v2 and ≤1600kg (3520lbs) for Open Rack v3. Correspondingly, dry weight of the Door HX assembly and fluid volume should be provided for engineers to determine if this could meet data center floor loading limitations based on coolant employed. The maximum weight of Door HX with fluid volume shall be less than 150kg. The preferred weight of Door HX with fluid volume should be ≤ 100kg.
- Depending on layout and design of the data center, width of the aisle between rack faces can vary. The door heat exchanger defined here will require a minimum 3.94ft (1200mm) spacing in the aisle to permit opening of the hinged door heat exchanger at least 90° without interfering with adjacent racks as well as those across the aisle. The diagram describing this detail is in Fig. 5.

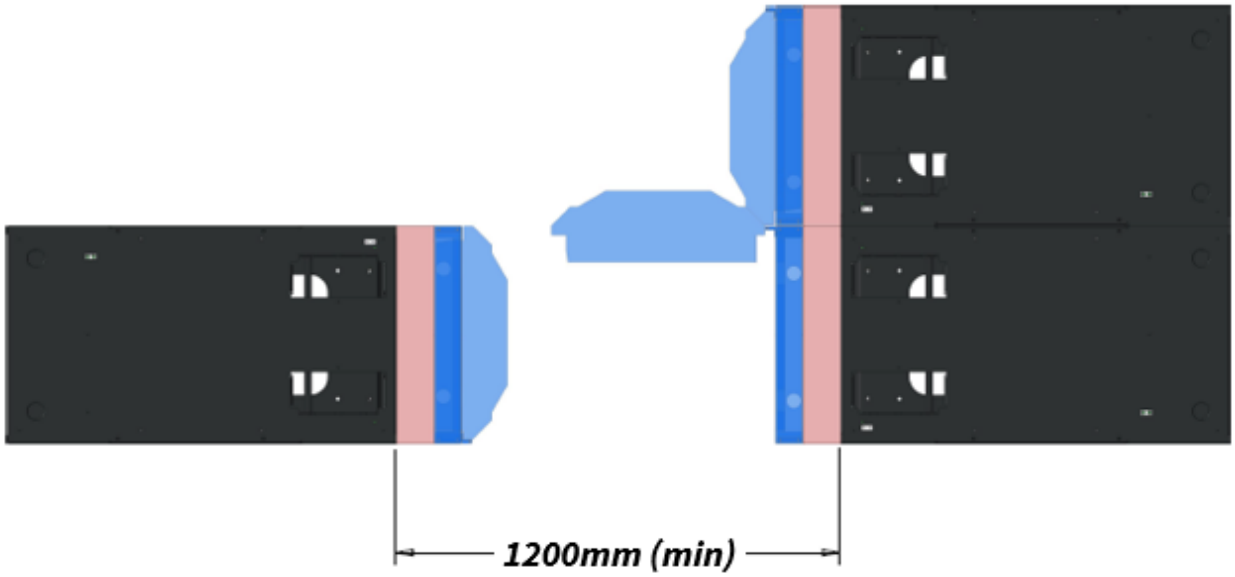


Figure 5: Required minimum aisle width to accommodate opening of Door HX by 90°

7.3 Physical Interfaces connections

As previously outlined, a Door HX may be either a passive or active variant. Depending on the type, following connections might be required

- *Connections to facility coolant*: Connections should be permitted from both top and/or bottom sides and should accommodate different interface types for flexibility on-site. Rigid pipe terminations at the door heat exchanger assembly are recommended to be 1" ID BSP type, with potential to accommodate/grow up to 1.5" ID. There should not be more than two connections to facility coolant; one connection for cold-coolant supply and another for hot-coolant return.
- *Service connections*: To facilitate draining and bleeding of a Door HX, service ports at both the top and bottom sides should be included.
- *Electrical connections*: The active Door HX should include active fans mounted on the accessible side of heat exchanger assembly. To provide power to the assembly, 110 or 230VAC (50/60Hz) supply options via standard C14 or C20 plug-in connector are recommended. Additional recommendations include door heat exchanger assembly being powered by the IT rack it is mounted against as well as support for A/B power supply redundancy (AC only). DC power may be supplied directly from the Open Rack busbar to

the Door HX solution. In this case, it's important to ensure that PSU and BBU shelves, and bus-bar design account for additional load.

- *Communication*: RS485 or RJ45 (Ethernet) ports should be supported along with the following protocols - Modbus RTU/IP, SNMP v2/3, HTTP (webserver) or IPv4/6. Similar to electrical connections, from a communication standpoint, it is recommended the Door HX assembly be a part of the rack it supports.

8. OPERATING (DC ENVIRONMENTAL) CONDITIONS

This section outlines supply conditions and operational targets of cooling resources provided by the facility for both IT gear within the rack as well as the Door HX. The final thermal solution of the system should be optimized and energy-efficient under both data center environmental and server operational conditions with the lowest capital and operating costs.

8.1 Air-side conditions

OCP Ready guidelines stipulate that compliant gear should meet Class A1 allowable environmental specifications as outlined by ASHRAE [3].

8.2 Water-side conditions

Following details outline the data center water-side supply or operating conditions.

- Coolant supply (inlet) temperature is a function of the data center or facility's capability. As general guidance, it's recommended to not drop below 16°C to avoid excessive condensation in the door heat exchanger solution. This is within range of W1 class by ASHRAE's definition [4]. Note, this does not stipulate that coolant temperature be maintained between 16~17°C, but rather defines a minimum requirement.
- Coolant-side temperature difference across Door HX: This value should be maximized to boost efficiency of facility-level cooling infrastructure, unless explicitly specified/defined by the data center (for example, ≥ 8°C). In practice, this parameter would depend on desired air-side performance and cooling capacity, it is usually specified by the customer, and involves a tradeoff between Door HX and chiller performance.
- Supported coolant types: May include water, glycol/water mixture and single or two-phase dielectric (highlighted for reference only). Coolant is usually specified by the customer.
- Operating pressure is a function of the data center or facility's capability. As general guidance, a floor-level coolant distribution unit may have a range of 140 – 450kPa [5]. Direct use of facility water may expose the equipment to higher operating pressures, especially in multi-story facilities. The door heat exchanger assembly must be designed to operate under said conditions.
- If water is used as the coolant for the door heat exchanger assembly, it is recommended to follow ASHRAE's guidelines for water quality [4]. Note there are specific recommendations based on whether the door heat exchanger assembly is connected to the FWS (Facilities Water System) or TCS (Technology Cooling System) loops.
    - Facility level coolant: Chapter 5, Table 5.3 Water Quality Specifications for Facility Water System (FWS) Loop
    - Equipment-level coolant: Chapter 6, Table 6.2 Water Quality Specifications - TCS Cooling Loop

In addition, the following guidance may also be leveraged - VDI 2035 Part 2, Table 1

- Filtration requirements depend on the type of implementation. In the traditional application of a Door HX, IT gear in the rack is air-cooled, and filtration at the facility-level should be adequate. For a hybrid solution, coolant is used by Door HX and IT gear (cold plates, manifolds and in-rack CDU). Due to smaller flow dimensions in this case, specific filtration requirements may need to be addressed, as outlined by ASHRAE [1].

9. PERFORMANCE / METROLOGY

Before performance and operational requirements can be highlighted, parameters of importance should be defined (as outlined in the following table). These apply to both active and passive types of the Door HX.

Table 1 – Parameters of importance and associated units

Parameter	**Units**
Rated cooling capacity	kW
Power consumption (at rated capacity)	W
Coolant inlet temperature	°C
Coolant outlet temperature	°C
Coolant flow rate	m^3/h or l/min
Coolant system pressure difference	kPa; curve based on flow rate should be provided
Air inlet temperature (approaching door)	°C
Air outlet temperature (leaving door)	°C
Air flow rate (through door; at 0Pa pressure difference between rack interior and room ambient)	m^3/h or ft^3/min
Air-side pressure drop across door assembly (for passive type)	Pa; curve based on flow rate should be provided

Requirements are highlighted as follows:

- For the active variant, N+1 rotor/fan redundancy is a must. In the event of a failure, increasing speed of functioning fans is permitted. To prevent recirculation or leakage through a failed unit, fans may be equipped with baffles (or equivalent component).

- Face area of the heat exchanger within the supporting frame should be maximized for performance and minimal backpressure. Finned footprint of Door HX core should be outlined for simulation/analysis.
- Curves (or table) of cooling capacity based on given coolant and air flow rates, inlet temperatures to the door, coolant of choice and operation at sea-level. Curves (or tables) corresponding to fan failure operation should also be included; specifically, impact to airflow requirements to achieve the rated cooling capacity.
    - Test conditions should be based on IEC 62610-4 [6] for verification and reporting of performance parameters such as cooling capacity, etc.
    - For the purpose of defining a rated cooling capacity, the following boundary conditions may be assumed

Table 2 – Reference conditions for verification of cooling capacity

Parameter	**Value**
Coolant inlet temperature	16°C
Air inlet temperature (approaching door)	45°C
Air outlet temperature (leaving door)	30°C
Altitude	0ft (sea-level)
Coolant type	Water (purified)

- For the passive type, low air-side pressure drop is highly recommended to minimize or eliminate the need for server fans to operate at higher speeds, thereby increasing cooling power. Impedance curve (pressure drop versus volumetric flow rate) based on sea-level operation should be provided.
    - For the passive type, it's recommended to maintain a pressure drop ≤ 15Pa at rated airflow
    - For the active variant, total power consumption should be ≤ 2% of rated cooling capacity (not including operation under fan failure)
- Low coolant-side pressure drop is highly recommended for efficient operation of the facility. Impedance curves for different coolant operations should be provided.
    - Pressure drop across the entire door heat exchanger assembly (including piping, valves, sensorics, etc.) should be ≤ 100kPa at rated coolant flow rate
    - Nominal operating coolant pressure should be ≤ 600kPa. This value is adequate to cover a row-level CDU (coolant distribution unit); however, a facility-level CDU might provide a higher pressure. In such cases, the vendor and end-user should work together to address this.
    - Maximum allowable coolant pressure should be ≤ 1000kPa (short-term operation; safety measure may be triggered beyond this value).

10. MONITORING & CONTROL

To ensure effective and efficient operation of the door heat exchanger, sensors and control represent valuable implementations or additions to the solution. Clear definition of sensor parameters (such as thresholds and alarms) enable the operator to ensure the device continues to function as intended in the long-term. Since passive and active variants function and may be operated differently, definitions/requirements are listed separately.

Table 3 – Sensors, controls and alarms for a passive Door HX

SENSORS – REQUIRED	
Type	**Detail/Comment**
Air temperature, In	More than one sensor preferred
Air temperature, Out	More than one sensor preferred
SENSORS - OPTIONAL	
Type	**Detail/Comment**
Air differential pressure	
Water temperature, In	
Water temperature, Out	
Water flow rate	
Water pressure	
Air humidity	
CONTROLS – OPTIONAL LOOP TYPE	
Parameter	**Detail/Comment**
Air temperature, Out	
Air temperature, Differential	
Water temperature, Out	
Water temperature, Differential	

CONTROLS – MANUAL	
Parameter	**Detail/Comment**
Water valve position	Manually adjusted at deployment; Pressure Independent balancing and Control Valves (PICV) are recommended, especially for multi-door installations.
ALARMS	
Name/Type	**Detail/Comment**
General	A single, binary definition that indicates there is an alarm condition
Power status	Binary (ON/OFF)
Air temperature, In	
Air temperature, Out	
Door open	Optional
Leak detection	Optional
Air differential pressure	Optional
Water temperature, In	Optional
Water temperature, Out	Optional
Water flow rate	Optional
Water pressure	Optional
Water valve position	Optional
Smoke	Optional

As an active rear door heat exchanger has more components and functionality compared to its passive counterpart, the following definitions/requirements apply in addition to those defined for the passive solution.

Table 4 – Additional sensors, controls and alarms for an active Door HX

SENSORS – REQUIRED	
Type	**Detail/Comment**
Fan speed	
Number of fans installed	To check deployed configuration
Input power	AC or DC input power
CONTROLS – OPTIONAL LOOP TYPE	
Parameter	**Detail/Comment**
Air temperature, In	
Air differential pressure	
CONTROLS – MANUAL	
Parameter	**Detail/Comment**
Fan speed	Manually adjusted at deployment or in-operation
ALARMS	
Name/Type	**Detail/Comment**
Fan speed	

Monitoring and reporting should employ the Redfish® standard (Redfish Scalable Platforms Management API) [7]. For more information, refer to: https://www.opencompute.org/wiki/Hardware_Management/SpecsAndDesigns

The table below outlines parameters that may be defined in the header section of the Redfish Door HX JSON file.

Table 5 – Parameters in header section of JSON file

Parameter	**Detail/Comment**
Name	
Manufacturer	Static
Model number	Static
Serial number	Static
Manufacture date	Static
Door HX type	Static; active or passive
Hardware revision	
Firmware revision	
Physical location	Optional
Asset tag	Optional

Redfish profile and reference documentation are currently WIP.

11. SERVICEABILITY

In general, the Door HX solution should be designed with ease of maintenance or serviceability in-mind. This includes (but may not be limited to) the following:

- Due to weight of the charged solution, features such as a spring-loaded, height adjustable swivel castor or equivalent may be employed for ease and safety of serviceability operations that require opening of the Door HX. Any implemented features must meet physical requirements outlined in Section 7.
- Ease of replacing Door HX - draining, un-mounting, installation and priming/charging
- Ease of access to physical interfaces (coolant connections, power supply and communication cables)
- Collection of expelled coolant (in case of leaks) and condensation in a drip tray with a feature to enable draining in-operation (or intermediate/external collection in facilities that do not have a raised floor or run-off area)
    - As a general guidance, coolant supply to the door heat exchanger may be raised to ≥ 16°C to avoid excessive condensation in the door heat exchanger (or specific value depending on the air-side operating conditions of the facility)
- Ease of replacing fan modules (on active variant of Door HX)
- Ease of replacing sensors or other accessible parts
- A serviceable air vent located at the highest point of the Door HX to allow for proper on-site charging of the system. An automatic air vent is recommended to allow air bubbles to escape the system

over time and to reduce pressure increases due to thermal expansion of the air and coolant during operation without liquid spilling. Additional considerations need to be taken when the Door HX inlet and outlets are located at the top of the unit.

- When connected to facility liquid, the fluidic connections must stay clear of regular human traffic paths but needs to be easily accessible for servicing. For a hybrid solution, fluidic connections between the Door HX, rack manifolds and CDU must follow the guidelines below.
    - The routing of the flexible rubber hoses must not violate the minimum bend radius specification of the hose (For both open and closed Door HX positions)
    - During servicing, when the Door HX is in an open position, the hoses should be routed in such a way to avoid any trip hazards and to allow accessibility to rear features of the CDU
    - Routing should avoid hoses in positions that cause unwanted stress to the fluidic connections or peripheral equipment such as the CDU or IT gear

12. RELIABILITY & QUALITY

This section will focus on aspects such as pressure or leak testing, sealing of airflow within the rack and other areas that can influence operational quality of a Door HX solution.

12.1 Pressure/leak testing

Ensuring the door heat exchanger solution has undergone adequate checks to prevent leaks in-operation is critical to deploying with confidence. Checks at both manufacturer and end-user locations are generally recommended. However, it's up to both parties to agree upon a course of action. Following sections outline recommended procedures for pressure testing and leak prevention.

- *Checks at manufacturer (required)*

  A common leak detection test is the pressure decay method. The complete door heat exchanger assembly should be pressurized with gas to a factor times the maximum allowable pressure (defined as ≤ 1000kPa in the section on Performance & Metrology). In general, the factor required for pressure testing is based on which standard is employed. IEC 62638-1 [8] stipulates setting twice (2) the abnormal or single-fault condition and ASME B31.n series, specifically B31.3 for process piping [9], states setting 1.5x design pressure (both can be based on maximum allowable pressure as outlined earlier in this section). As to which standard should be followed, that's a decision to be made between manufacturer and end-user.

  The leak value can be calculated as follows: $Q = (P_1 - P_2)V/t$

  Where,

  Q is the leak rate in mbar.l/s

  P_1 is pressure at the start of the test in mbar

  P_2 is pressure at the end of the test in mbar

  V is internal volume of the test sample in l (liters)

t is duration of the test in s (seconds)

Since both P_1, V and are known, test duration (t) is the variable that is adjusted to achieve a desired leak rate (Q) and depends on the sensitivity of the test equipment (primarily, the pressure transducer). Industry standards define 'water tight' as a leak rate of 10^{-2} mbar.l/s when helium is employed as the test medium.

Table 6 – Helium leak rate for different seal qualities [10]

Leak definition (seal quality)	**Helium leak rate (mbar.l/s)**
Water-tight	10^{-2}
Vapor-tight	10^{-3}
Bacterial-tight	10^{-4}
Fuel-tight	10^{-5}
Virus-tight	10^{-6}
Gas-tight	10^{-7}
Insulator seal-tight	10^{-10}

Gases other Helium may be employed for testing, such as air or Nitrogen. However, the leak rate definitions in Table 1 should be adjusted using multiplication factors based on whether the leak rate qualifies as either laminar viscous or molecular flow.

Table 7 – Converting leakage rate of helium to other gases

Medium to convert to	Multiply factor (multiply helium leakage rate by)	
	Laminar flow	Molecular flow
Argon	0.88	0.316
Air	1.08	0.374

Nitrogen	1.12	0.374
Water vapor	2.09	0.469
Hydrogen	2.23	1.410

Prior to shipment, the product should be charged with Nitrogen at the nominal operating pressure limit. At the integrator or end-user's site, if pressure is deemed present at-release (auditory signal), the product could be considered to have passed transportation.

- *Checks at integrator or end-user (recommended)*

  Prior to deployment, the product (post-integration) should undergo a final pressure check (like the criteria in Table 7, but with compressed air) prior to charging. To accommodate this, the Door HX assembly may be outfitted with a separate valve.

- *Leak detection in operation (recommended)*
  - Regular inspection of the system to check for droplets/leaks
  - Optional electronic leak detection at cabinet or floor level

12.2 Sealing of in-rack airflow

Sealing on the adapter frame and/or Door HX should be adequate to minimize leakage of server exhaust or entrainment of facility air. It's important to note that sealing within the rack is equally critical and should be considered as well.

For an IT rack employing a Door HX, the quality of airflow sealing at both sub-rack (or chassis) and cabinet (or rack) levels can be determined in accordance with IEC 62610-6 [11]. This standard helps define metrics for airflow recirculation and bypass, as well as measurement methods and should serve as guidance for rack integrators. In general, both recirculation and bypass ratios should be kept to a minimum to ensure cooling efficiency. Following are a few points to take note of:

- Installation of a rear-mounted door heat exchanger should not impact sub-rack or chassis inlet temperatures. When employing a passive door heat exchanger, added impedance should be understood to not severely impact recirculation. This could be addressed with adequate in-rack sealing.
- A rear-mounted door heat exchanger solution should interface with adequate sealing to the rack frame to avoid unnecessary, rack-level airflow bypass. When employing an active door heat exchanger, fan control logic should be appropriately tuned to ensure airflow is

efficiently used or prioritized through the IT chassis. Once again, adequate in-rack sealing is critical here.

13. ENVIRONMENTAL & REGULATIONS

13.1 Storage, Transportation & Contamination

The following environmental tests are recommended for execution per MIL-STD-810G [12], IEC 60068-2 [13]. The systems pre- and post-test should be verified for any functional impact.

Table 8 – Non-operational environmental conditions

Parameters	**System**
Gaseous Contamination	Severity Level G1 per ANSI/ISA 71.04-1985 [14]
Storage Relative Humidity	10% – 90%
Storage Temperature (Long Term)	-40°C – +70°C
Transportation Temperature (Short Term)	-55°C – +85°C

System should meet the following set of tests as applicable to reliability, and compliance needs

- Hydrostatic Pressure Test
  - Normal, Abnormal operation, and Creep resistance based hydrostatic pressure tests per IEC/UL62638-1 are to be executed.
  - The system is expected to meet the criteria of being able to sustain three times, and two times the maximum working pressure per design specifications while testing for normal, abnormal operational conditions respectively.
  - Creep resistance tests involve pre-conditioning of the units followed by hydrostatic pressure tests as listed above with the general requirement of no visible signs of rupture, cracking, embrittlement, and loose parts, or assemblies.
- Tensile Strength Test
  - Tensile strength of the system is recommended to be tested per ISO 527 [15], IEC/UL62638-1. Tensile strength of the pre-conditioned unit should not be < 60% of tensile strength before the test.
  - System should not see any visible signs of cracks, rupture, as well as functional impact.
- Mechanical Strength Test
  - Force test on critical assemblies, part of the system is recommended to be executed per IEC/UL62638-1.
  - System should not see any visible signs of cracks, rupture, as well as functional impact.

13.2 Vibration & Shock

Table 9 - Vibration and shock requirements

		Non-Operational
Rack	**Product Sine Sweep**	0.25G, 1-200-1 Hz, 1 Octave/min, 1 Cycle
Product Vibration Test	**Mechanical Handling-I**	1. Rotational Flat Edge Drop 2. Rotational Corner Drop 3. Side/inclined Impact 4. 22 deg Tilt 5. Flat/Vertical Drop 6. ASTM D880-92 [16], D6179-07 Level-II [17]
	Truck Transportation Test	ASTM D4169-16, D4728-17 (1-200 Hz, 180 min)
	Mechanical Handling-II	1. Rotational Flat Edge Drop 2. Rotational Corner Drop 3. Side/inclined Impact 4. ASTM D880-92, D6179-07 Level-II

13.3 Regulations / Compliance

- Comply with IEC/UL 60950-1 [18], 62638-1 3rd edition [8]
- General safety construction requirements
  - All products shall not contain any hazardous, flammable, or toxic substances classified by law or local regulation, and MSDS (Material Safety Data Sheet) must be provided. No liquid spillage is allowed during normal and abnormal operating conditions.
  - Galvanic corrosion should be mitigated, and essential coating/protection requirements should be enforced to curtain high temperature, relative humidity conditions.
- Plastic parts flammability
  - Plastic parts shall be made of min. V-1 material.
  - Tubing can be made of min. HB75 class material if the thickness of the material is < 3 mm, or min. HB40 class material if the thickness of the material is ≥ 3 mm.
- Leakage fail-safe
  - The system shall provide safeguards (such as a barrier or drip pan or supplementary containment vessel) against any spillage of internal liquid to effectively limit the spread of the spillage.
  - The leak from tubing connectors and similar joints in the liquid system shall not bridge an insulation in the final product.
  - If the liquid is corrosive, the leak shall not touch any connection of a protective ground conductor.

13.4 Labels and Markings

Labels and marking indicating the compliance of the system and/or sub-assemblies should be affixed for clear visibility.

14. APPENDIX A

This section of the document covers Door HX mechanical or physical requirements specific to Open Rack V3 with in-rack blind-mate manifolds and RPU (reservoir and pumping unit).

14.1 Mounting of adapter frame to Open Rack V3

A Door HX can be mounted to the rear of the Open Rack v3 via an adapter frame that interfaces with the rack on one side and the hinges off the Door HX on the other side. This adapter has certain mechanical requirements to allow proper mounting, serviceability, and access to data center features.

- The adapter frame is to be mounted to the Open Rack via M8 screws into nutserts placed on the rear of the rack at positions shown below.

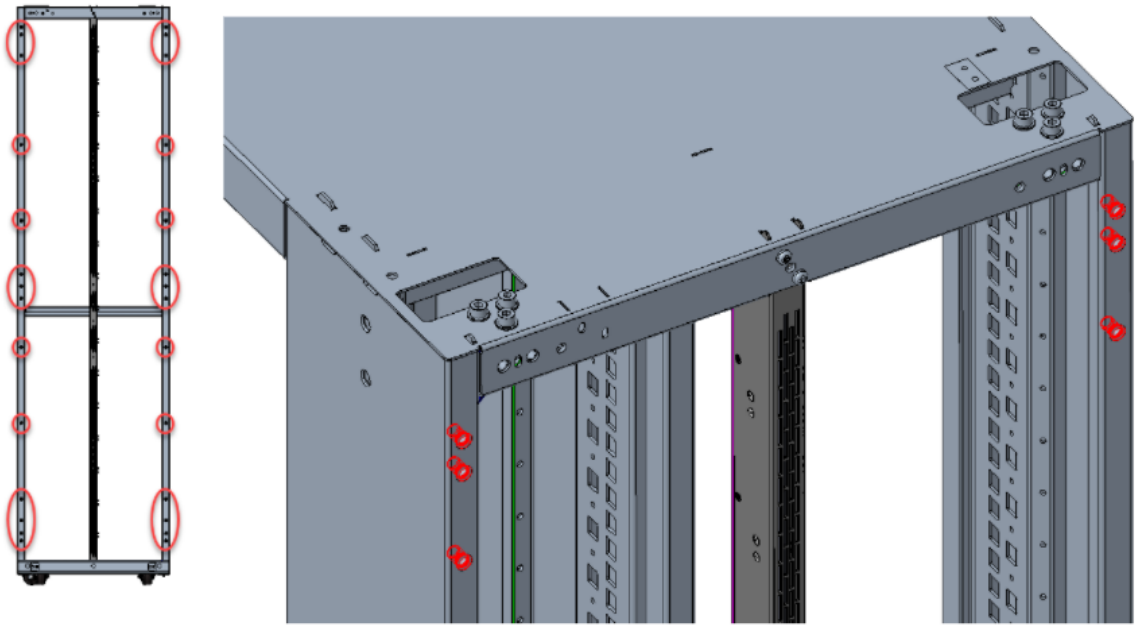


Figure 6: Rear and isometric views showing M8 threaded insert locations on rear of Open Rack for mounting Door HX assembly

- Opening of the door by at least 90° will be needed to remove hot and cold manifolds from the rear of Open Rack in hybrid and air-assisted solutions outlined above. The door will need to be designed in such a way as to not interfere with an adjacent rack when fully opened.

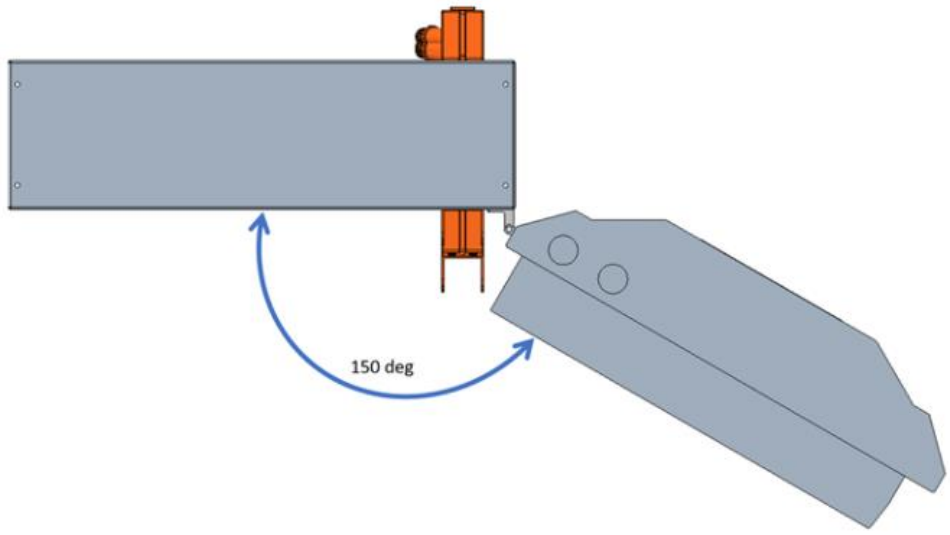


Figure 7: Top view of adapter frame and door heat exchanger in open position to allow removal of manifold (orange)

- Removal of manifolds from Open Rack will need to be possible without the removal of the adapter frame or Door HX to be serviced in the data center. The manifolds are installed into the rack via sheet metal brackets on top and bottom and mounted using M8 screws that thread into nutserts on the rack. The bottom manifold bracket must be in toed into slot on the bottom of the rack and then the whole manifold rotated along that pivot. Then the top bracket is flush with the rear surface of the rack.
    - *Note: the design and mounting of blind mate manifolds is still in progress and is subject to change. This appendix will be updated as new information becomes available.*

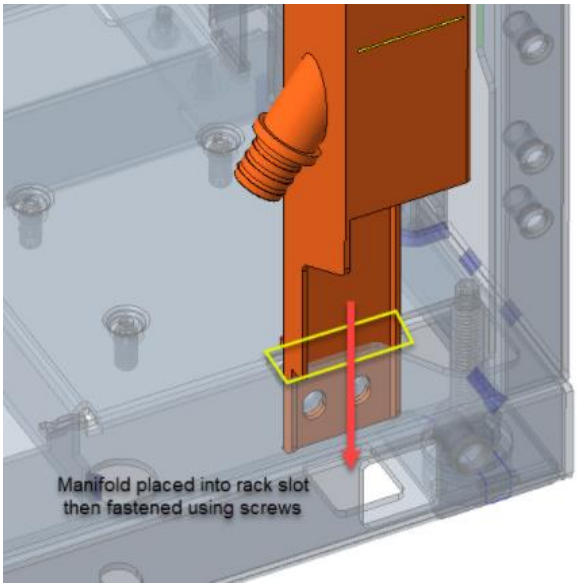


Figure 8: Isometric view of manifold inserted down into slot in Open Rack then fastened to bracket

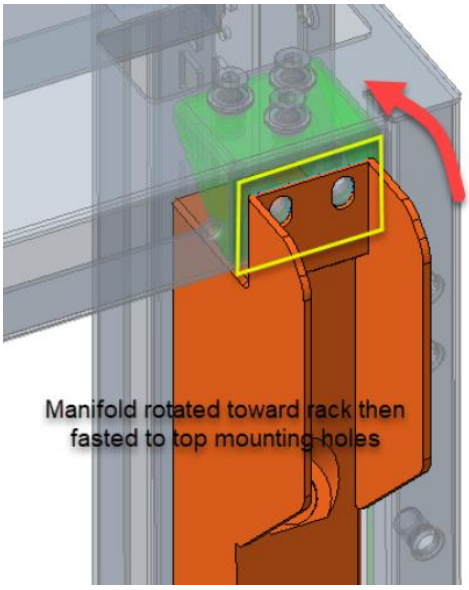


Figure 9: Isometric view of manifold rotated toward rack after bottom bracket inserted, then mounted to rear surface

14.2 Layout impact to data center

The operation of the Door HX should not impact any pre-existing data center layout or design aspects. This includes:

- Leveling feet should be mounted to bottom of adapter frame to provide load bearing and reduce shearing forces on mounting hardware attaching the adapter frame to the rear of Open Rack. Additionally, casters may be needed on the Door HX to prevent a large moment on the hinges between the door and adapter frame.

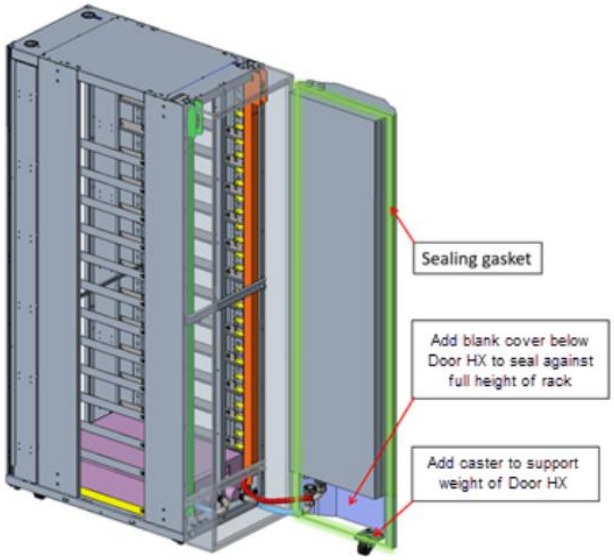


Figure 10: Isometric view of Door HX opened with provisions for airflow sealing and weight distribution

- Other considerations for layout:
    - Large hose connections (quick disconnect valves) from manifold and Door HX to RPU should swivel to allow rotation of Door HX without twisting of hoses (hose is fixed to manifold barb).
    - Location of inlet and outlet ports on Door HX will dictate length of hose used, ability to retract or collect within the adapter frame when Door is closed, and angle at which Door can be opened.
    - Orientation of Door HX hinge on the adapter frame will have an impact of the length of hose used, ease of quick connections to swivel as Door is opened and closed, and routing to the hot/cold manifolds and RPU supply/return.
    - Closed Door HX assembly should keep from air flow leakage around the outer perimeter and lower section of door. A gasket or similar material can be used to seal around the door to the adapter frame and between the adapter frame and rear surface of rack. In addition, a blanking panel should be added to cover any open areas that may allow air bypass.
    - The Open Rack and Door HX combined assembly should be able to traverse the data center environment using its caster wheels and be able to climb and descend ramps in the data center by having a minimum 15-degree approach and exit angle. This is measured from the tangent of the caster wheel to the outermost surface of the assembly.
    - Keep-outs: the adapter frame shall have keep-outs allowing the installation and removal of the manifolds, access to mounting hardware for the bus bar on Open Rack, and access to mounting hardware for the bottom bracket of manifolds.

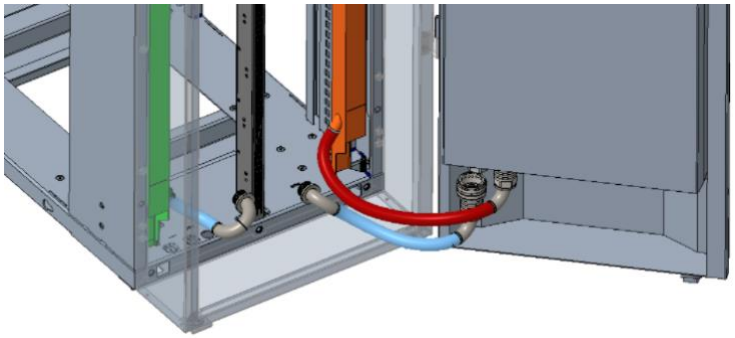


Figure 11: Isometric view of hose lengths connecting manifold and RPU to Door HX

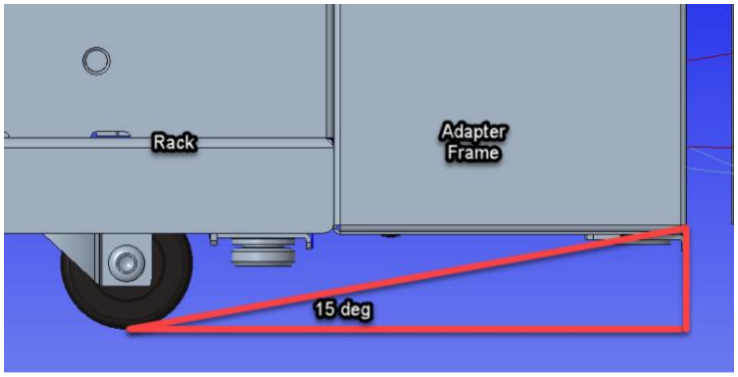


Figure 12: Side view of minimum approach and exit angles needed to traverse data center

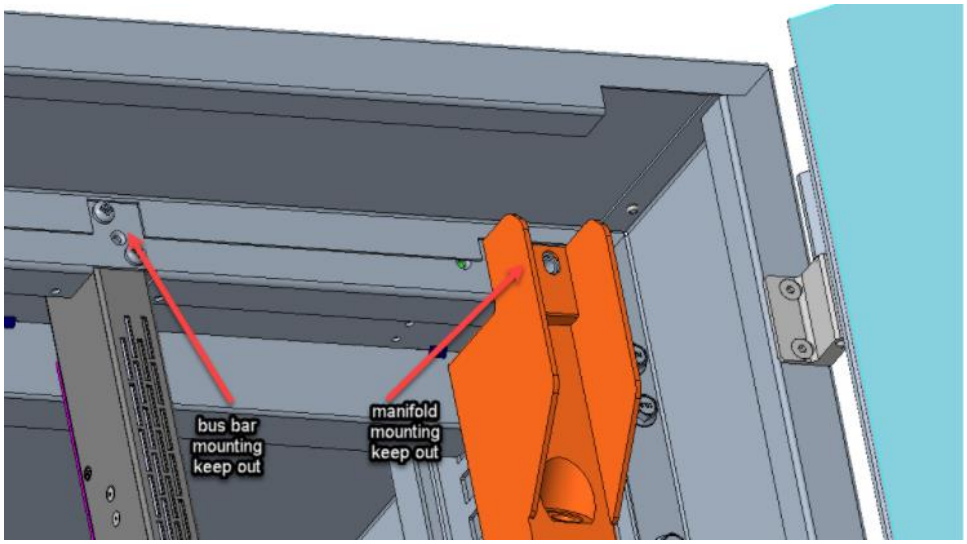


Figure 13: Isometric view of keep outs required for manifold and bus bar mounting hardware

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16. ABOUT OPEN COMPUTE PROJECT

The Open Compute Project Foundation is a 501(c)(6) organization which was founded in 2011 by Facebook, Intel, and Rackspace. Our mission is to apply the benefits of open source to hardware and rapidly increase the pace of innovation in, near and around the data center and beyond. The Open Compute Project (OCP) is a collaborative community focused on redesigning hardware technology to efficiently support the growing demands on compute infrastructure. For more information about OCP, please visit us at http://www.opencompute.org