Open Rack V3 Blind Mate Manifold Specification

Revision 1.0

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1. License

1.1 Acknowledgements

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2. OCP Tenets Compliance

2.1. Openness

This specification shares the key design interfaces and requirements to enable others outside of the group to use and adopt the valve designs for their application.

2.2. Efficiency

The sharing of this specification will allow others to leverage the components and save development time.

2.3. Impact

This specification and the development work performed by the suppliers in this group makes available to the community interoperable valves with the potential for multiple sources and leverage economies of scale.

2.4. Scale

The development of this specification with multiple suppliers that are interoperable will enable the solution to be deployable at scale.

2.5. Sustainability

This specification along with related specifications & guidelines for Orv3 Blind Mate will enable liquid cooling at scale will help reduce power consumption.

3. Revision Table

Date	Revision #	Author	Description
05APR24	1.0	Darryl Daniel (Meta) Tom Breda (Parker) Glenn Charest (Meta) Scott Stammer (Nvent)	Initial draft

4. Scope

This document defines technical specifications and interfaces for the blind mate manifold used in the Open Compute Project V3 Rack. This document, along with the *Open Rack V3 Base Specification* & the *Meta Open Rack Frame V3 Specification* shall comprise the product's technical specification to ensure the design and interfaces with the rack remain the standard across all platforms for all variants of Blind Mate Manifolds.

This specification is supplementary to the *Open Rack V3 Base Specification* (latest revision can be found on the OCP Open Rack/SpecsAndDesigns wiki page):
https://www.opencompute.org/wiki/Open_Rack/SpecsAndDesigns

5. Overview

This specification is the base specification that defines the fundamental requirements and interfaces for the ORv3 blind mate manifold that can be used to develop a manifold design. This specification is not a detailed specification of a particular design implementation. The rack interfaces that locate and position the manifolds in the rack frame are defined in the *Meta Open Rack Frame V3 Specification*. Liquid cooling capability within the Open Rack V3 ecosystem is needed to meet the increased cooling capacity requirements for future, higher power products, that will be developed within the broader Open Rack V3 ecosystem. The ORv3 blind mate manifolds, which are one component of the overall liquid cooling solution and are positioned in the rear of the rack, are used to distribute coolant from the remote pumping unit (RPU) or facility supply into the various IT Gear equipment within the rack. The ORv3 blind mate manifolds are designed to allow a lower impact on servicing as the service personnel do not have to manually connect/disconnect valves and hoses during IT gear installation which reduces service time and bring-up.

This specification is part of a family of specifications and guidelines that define the requirements for ORv3 Mate Liquid Cooling and include:

- *Open Rack V3 Base Specification*
- *Meta Open Rack Frame V3 Specification*
- *Open Rack V3 IT Gear Design Guide*
- *Open Rack V3 Blind Mate Quick Connector Specification (BMQC)*
- *Open Rack V3 Blind Mate Manifold Specification* (this document)

Note that collateral is included with this specification and includes the following:

- 2D Drawings of the blind mate manifold design reference with critical dimensions and tolerances

- 3D CAD (STEP) of the design reference (rack, blind mate manifolds, liquid cooling mounting kit.) Note that the design shared in the collateral is a simplified model with key interfaces and features and is not an actual complete manifold design.

6. Open Rack Compatibility

The Blind Mate Manifold is currently only compatible with OCP Rack V3 with an optional liquid cooling kit installed to provide the proper manifold interfaces. The liquid cooling kit consists of additional manifold interface brackets, structural brackets, and cross-braces which help stiffen the standard V3 rack to accommodate the additional forces and stresses induced from the pressurized liquid cooled IT gear. These components are not backwards compatible with previous iterations of the Open Rack Standard prior to V3, such as V2 or V1 racks.

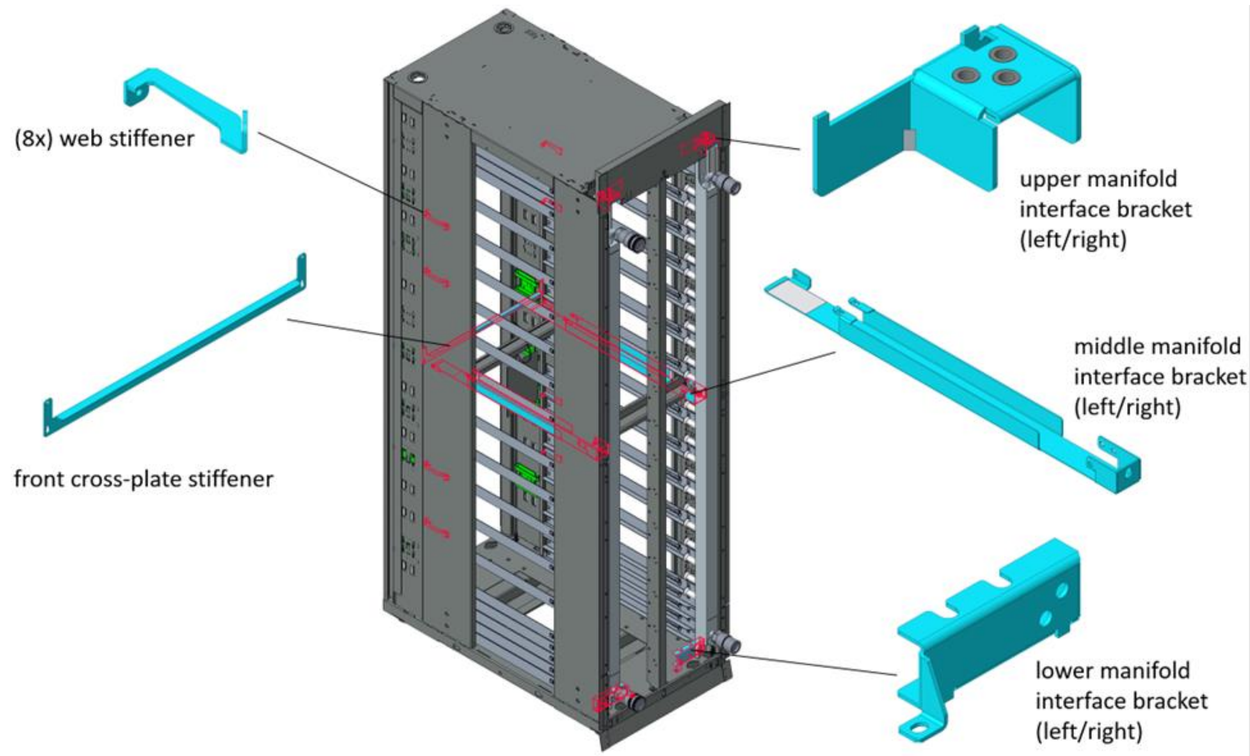

Fig.1 - Blind Mate Liquid Cooling Mounting Kit components

- **(8x) web stiffeners** – these mount into the front vertical members of the rack and provide additional stiffness to rack Datum A features which must counteract the forces from the blind mate IT gear injectors.

    - **(1x) front cross-plate stiffener** – mounts to the front of the rack and provides additional frame stiffness to counteract the additional liquid cooling forces; the cross-plate is mounted in the same OU slot as the standard frame cross-braces.
    - **left/right lower manifold interface brackets** – these serve as the lower mounting interface for the manifold Datum A surface (zone A1) and provide some additional structural support to help counteract the valve & fluid forces trying to push the manifold rearward,
    - **left/right middle manifold interface brackets** – these serve as the middle mounting interface for the manifold Datum A surface (zone A3) and provide additional structural support to help counteract the valve & fluid forces trying to push the manifold rearward; during installation into the rack, the bracket is registered off rack Datum A to minimize positional tolerance in the depth direction (Z-axis); the middle interface brackets are mounted to the standard ORv3 frame cross-braces (front & rear) and utilize the same OU slot within the rack; in the design reference, these braces are positioned in slot OU23, but could be +/- 1OU in either direction depending on end user needs. Other brace locations are possible; however, the developer will need to validate the design and will require design changes to some components, frame features, interfaces, and manifolds.
    - **left/right upper manifold interface brackets** – these serve as the upper mounting interface for the manifold Datum A surface (zone A2), provide some additional structural support to help counteract the valve & fluid forces trying to push the manifold rearward, and provide left/right constraint for the upper portion of the manifold via a guide pin in the bracket.
- Various fasteners to attach items listed above to the rack (see *Meta Open Rack Frame V3 Specification* for additional details)

7. Definitions

7.1 IT Gear

The IT Gear is the electronic equipment that mounts in the rack.

7.2 Rack

The rack is a cabinet, in this case Open Rack Version 3, that holds IT gear. It has casters that allow the rack to be moved. For more details, see the latest versions of *Open Rack V3 Base Specification* and *Meta Open Rack Frame V3 Specification* found on the OCP Contributions web page.

7.3 Blind Mate Quick Connector (BMQC)

The quick connectors discussed in this specification are blind mate liquid connectors that are dripless. They are the interface between the IT gear and the manifold to transmit liquid between them. In this implementation, a socket is located on the blind mate manifold and interfaces with a plug on the rear of the IT gear. For more detailed information, please refer to the *Open Rack V3 Blind Mate Quick Connector Specification (BMQC)*.

7.4 Leveling Feet

The leveling feet are used to adjust the leveling of the rack enclosure. The Meta implementation of ORv3 frame comes with four leveling feet.

7.5 OCP Large Quick Connector (LQC)

OCP developed Large Quick Connectors for fluid coupling between hardware. See latest revision of *OCP Large Quick Connector Specification* on the OCP contribution web page for more information.

8. System Orientation Reference

The following diagram indicates the system orientation reference. For the manifolds, when referencing “left” and “right” in this document and the included collateral, it refers to each manifold as viewed from the **REAR** of the rack as illustrated below.

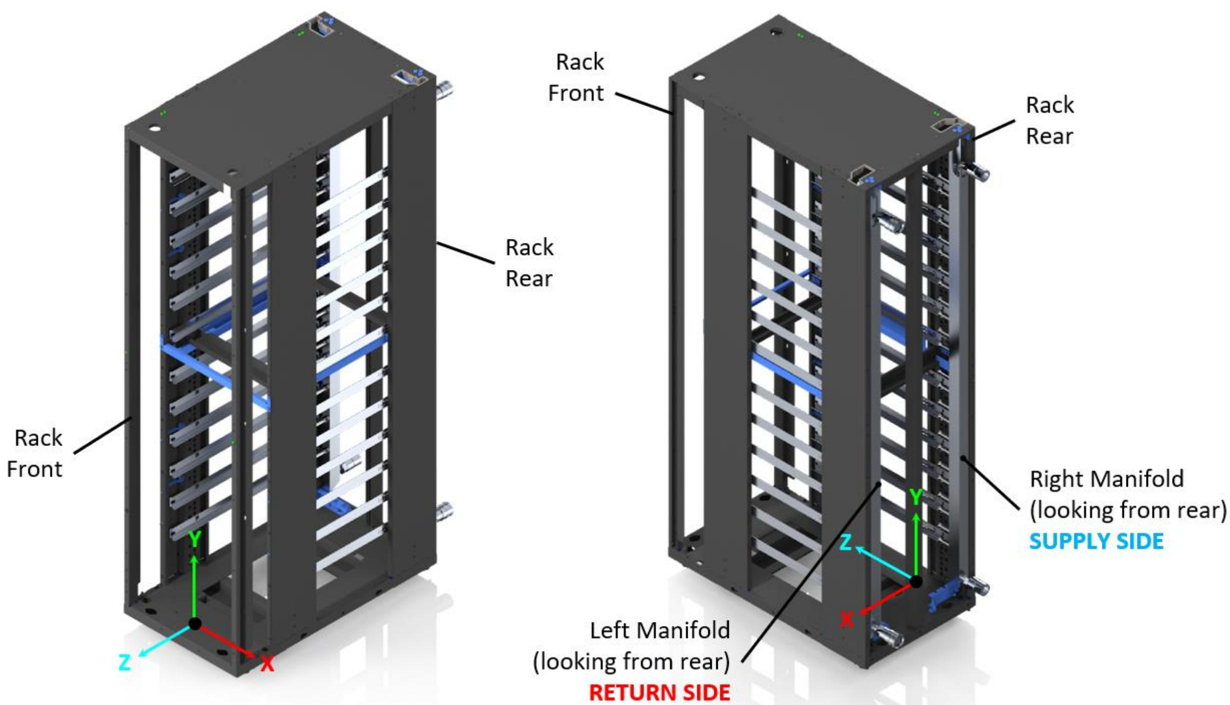

Fig. 2 - System Orientation: left/right manifold designation

9. Basic Manifold Requirements & Considerations

9.1 Requirements

9.1.1 Spatial & Interface Requirements

Manifold design must meet spatial and interface requirements outlined in this specification, including the valve interface surfaces, front-facing manifold surfaces, rack mounting interfaces, and maximum manifold width dimensions outlined in this specification.

9.1.2 Manifold Mounting Location

Manifolds should be rear mounted on the ORv3 frame and rear serviceable.

9.1.3 Plug height suggestion for unused ports

To prevent interference with IT gear within the rack, any plugged ports on the manifold should protrude a maximum per diagram below, from the manifold spot face.

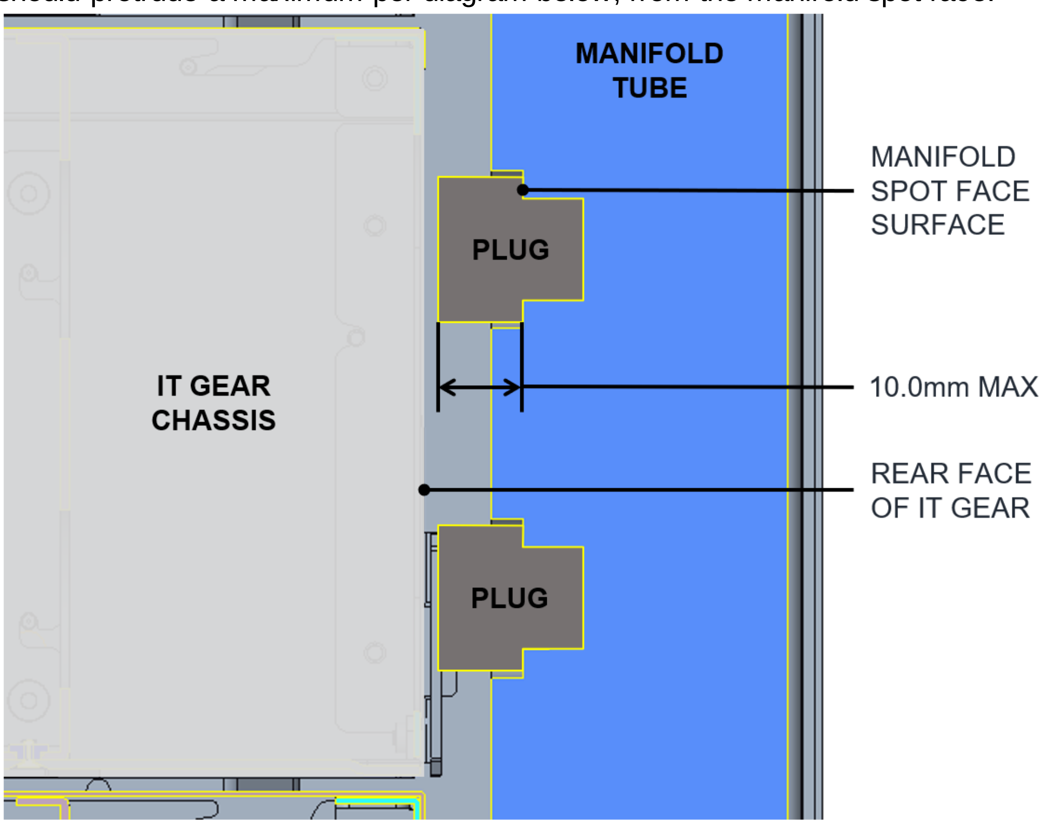

Fig. 3 - Maximum port plug protrusion

Additional detailed form/fit/function requirements outlined in sections below.

9.2 Design Considerations

9.2.1 General Considerations

Manifolds should fit within the overall footprint of the rack if possible. Deeper manifolds that extend beyond the rack footprint are not covered in this design reference, but this specification does not limit this.

Rear FRU (Field Replaceable Units) access should be maintained as much as possible, minimizing obstructions outside of the width of the manifolds.

9.2.2 Leveling Foot Access

The design reference allows clearance space for adjusting the rack leveling feet at the lower rear corners of rack. Specific tools and SOPs (Standard Operating Procedures) will vary by application. This clearance is not a hard requirement, but each developer will need to determine the appropriate tradeoffs between leveler access and design requirements.
In the design reference, the bottom face of the main manifold tube is defined as a volume keep-in to allow clearance for tool access to the rack leveling feet to allow for adjusting the height. The manifold bracket has reinforcement ribs on the front side, and a clearance area on the rear side to provide tool access such as a ratcheting socket wrench. Designs may vary in terms of the clearance needed.

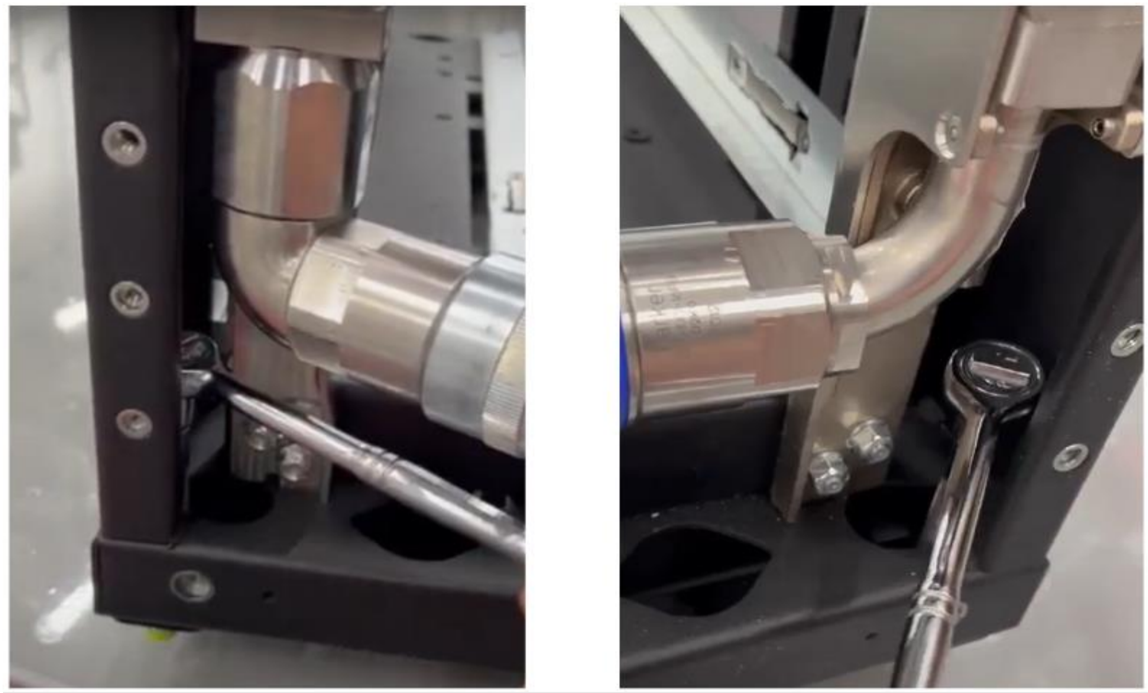

Fig. 4 - Tool access clearance for leveler foot adjustment

In the design reference provided, one example implementation of leveler foot tool access clearance is shared below:

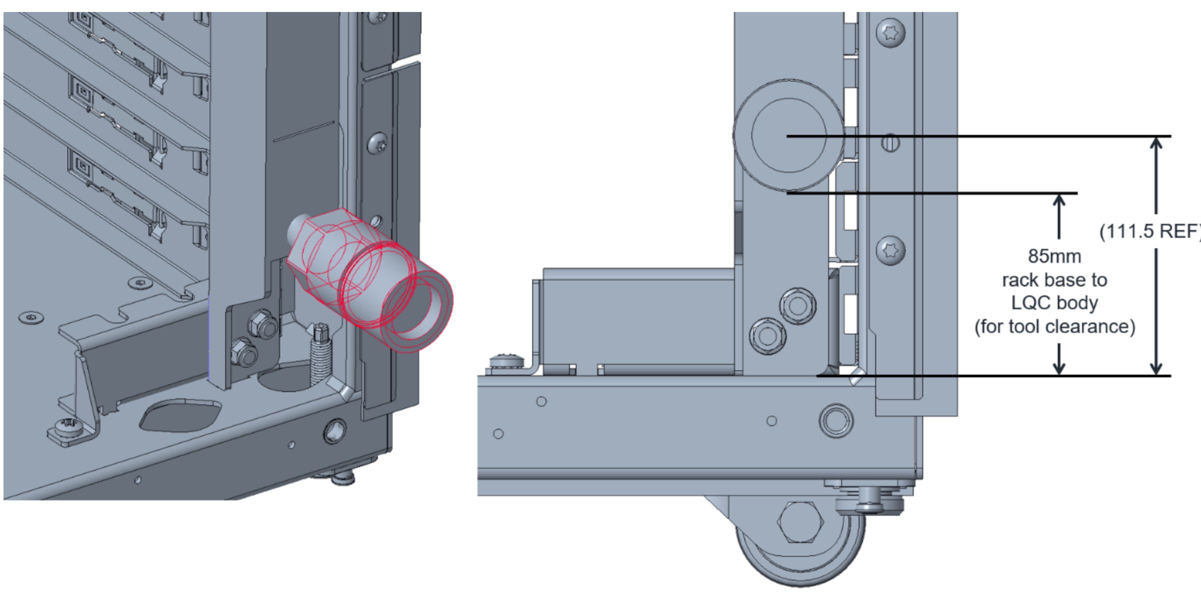

Fig. 5 - Design Reference clearance for leveler foot tool access

9.2.3 Air vent clearance (bottom hose exit only)

The solution may require an air purge vent for bottom fluid connections. The upper face of the manifold tube as defined in the design reference is influenced by the size of common air purge vents and adapters such as UQD connectors for connecting them to the manifold tube upper face. The space allocation includes clearance for removal of an air vent while the manifold is installed in the rack. The team developed the design reference around an assumed air vent assembly stack height of 140mm which provides enough clearance to disconnect a UQD04 valve (see figure below). Other designs may require different clearances depending on the specific air purge components used or whether an air purge vent is even necessary. One example implementation is shared below for reference only.

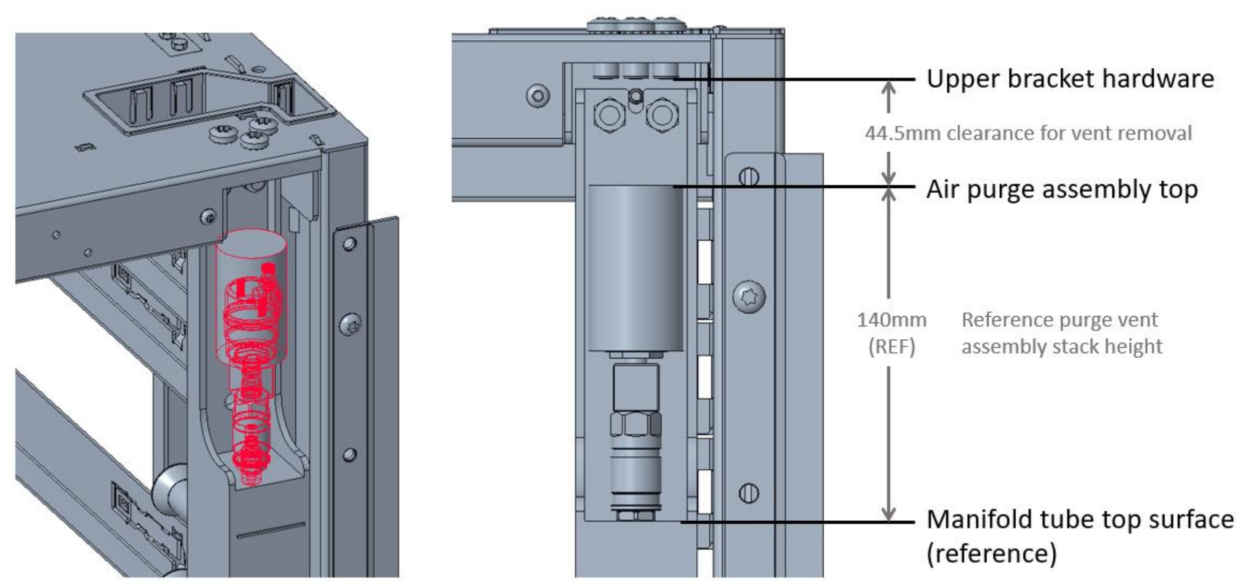

Fig. 6 - Air purge vent clearance to rack canopy

9.2.4 Various Connections Options

Manifolds can be customized to support top exit, bottom exit, or both, depending on end application (design reference supports top and bottom exit using OCP developed Large Quick Connectors, or LQC). These interfaces to external connections are not prescribed and left to the developer to determine.

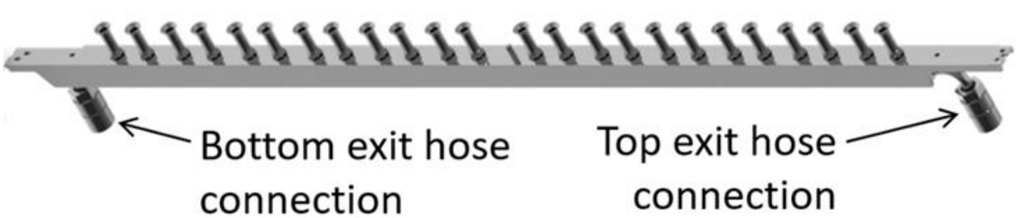

Fig. 7 - Top & bottom connections

Images and details around various connections and interfaces to external connections discussed below are provided for reference. The solution designer will need to develop what is appropriate for their end application.

The design can support optional straight, right angle, right-angle swivels, or 45° angled adapters. The design reference swivel adapters allow for flexible hose management during shipping and deployment.

Fig. 8 - Right angle, swivel & straight adapter options are possible.

The design can support multiple connection options (design reference includes OCP LQC adapters, but other adapters are possible such as barb fittings.

Fig. 9 - OCP LQC connector (left); 1" hose barb (right)

The design can support optional air purge vent assemblies. Vertical, right angle, and "tee" geometries may be possible. The design reference includes a right-angle option with OCP LQC connection to the manifold.

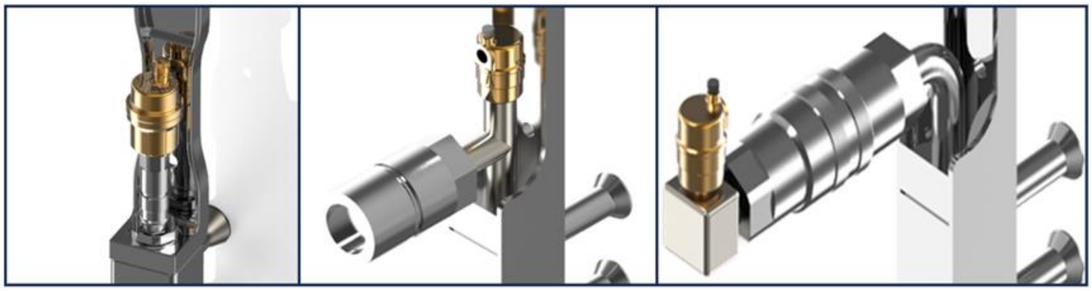

Fig. 10 - Air Purge Vent possibilities: Vertical (left); tee (middle); right angle LQC adapter (right)

9.2.5 Rear Security Door Considerations

If security doors are going to be used on the rack, verify that any manifold fittings and hoses do not interfere with the installation and use of the doors on the rear of the rack. Not all rack configurations will use a rear security door so this should be evaluated on a case-by-case basis. Hose routing exiting the security door also must be considered.

9.2.6 Rear Door Heat Exchanger Considerations

Some configurations of liquid cooled racks may use a rear door heat exchanger. It is important to verify that the fittings and hose routing from the manifolds do not interfere with the rear door heat exchanger.

9.2.7 Data Center Hot Aisle Intrusion

During planning and layout of the data center aisle, designers should evaluate the location and direction that the hoses exit the manifold. This specification allows for bottom or top hose entry to the Blind Mate Manifold, and each has its own hose routing considerations and constraints. Different methods of supplying coolant to the system will impact the hose routing, such as end-of-row CDU (Cooling Distribution Unit), overhead facility plumbing, or in-rack RPU.

9.2.8 IT Gear Considerations

See Section 14.3 in the Meta Open Rack Frame V3 Specification for details.

10. Mechanical Specifications

10.1 Manifold Dimensions and Tolerances

Refer to the 2D drawing collateral included with this specification for critical dimensions and tolerances. The dimensions shown in parentheses "**( )"** are for reference and may vary depending on the end user's needs.

10.2 Manifold Internal Cross-Section

Manifold cross-sections can vary if the design meets flow, stiffness, and form requirements (manifold and rack level). In this CLA group, the manifold designs from each supplier have differences in construction and cross-section. Flow simulations and structural FEA may be helpful to validate initial design criteria. Note that manifold weight may vary depending on the final design.

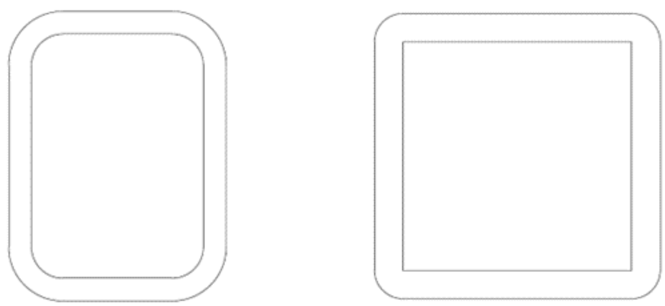

Fig. 11 - Varying tube cross-sections are possible

11. Mechanical Interfaces

11.1 Manifold Datums

The manifold design has several key datums. The datums are briefly explained with images below. The requirements for locations, location tolerances, and form tolerances of key features relative to these datums are called out in the 2D manifold reference design drawing. Some examples of the key features include spot faces for the valves, the ports for the valves, mounting features, and the tube outer profile. See the manifold reference design drawing included in the collateral with this specification for full interface definition. Refer to the *Meta Open Rack Frame V3 Specification* for details on frame datums and their relation to the manifold datums.

11.1.1 Manifold Datum A

Manifold Datum A is composed of 3 surfaces, Zones A1, A2 & A3, which serve as the primary mounting interface for the manifold to the liquid cooling mounting kit brackets in the rack. These 3 surfaces position the manifold in the front-to-rear direction within the rack.

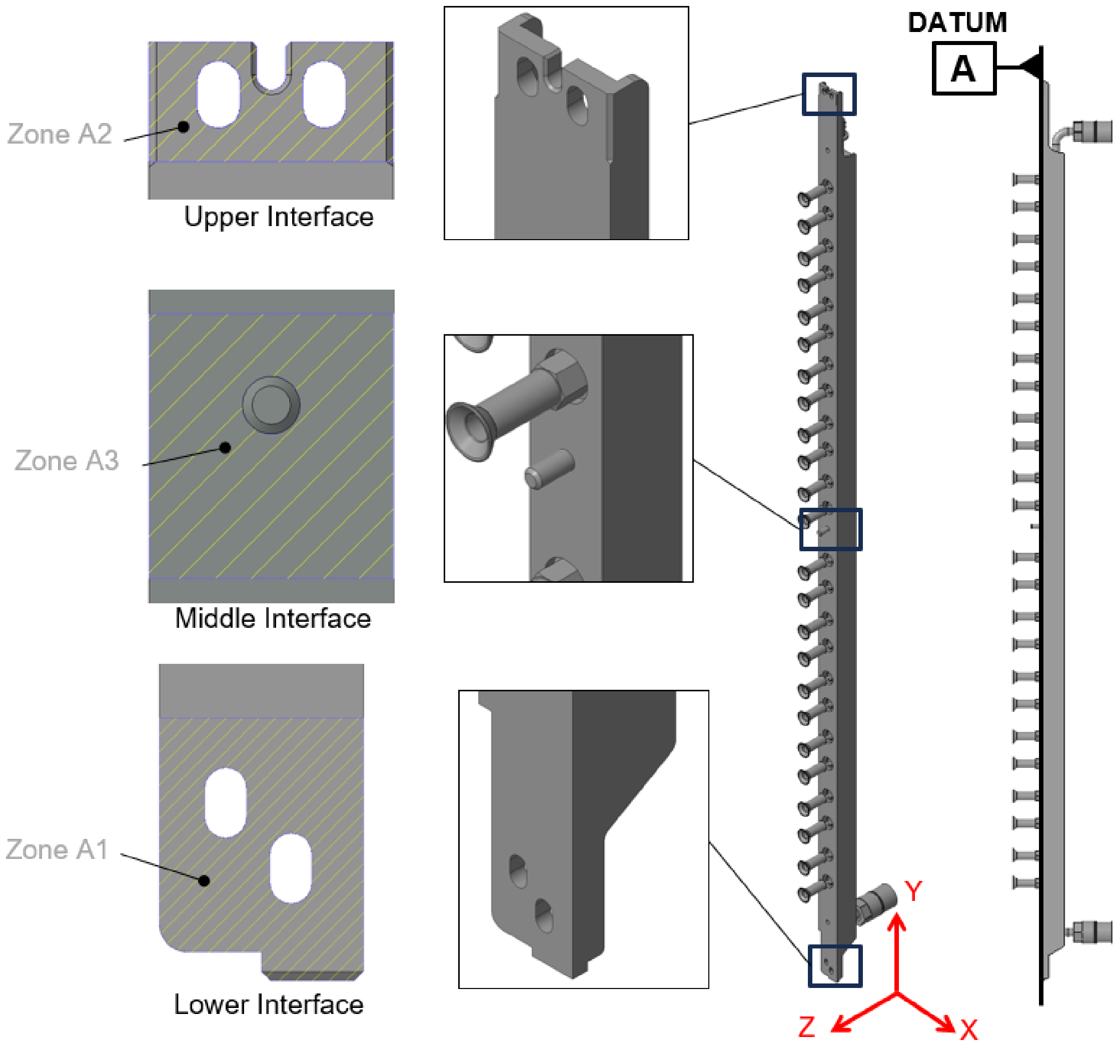

Fig. 12 – Manifold Datum A reference surfaces

11.1.2 Manifold Datum B

Manifold Datum B is defined as the centerline of the lower tab feature which provides left-to-right positioning for the bottom of the manifold within the rack.

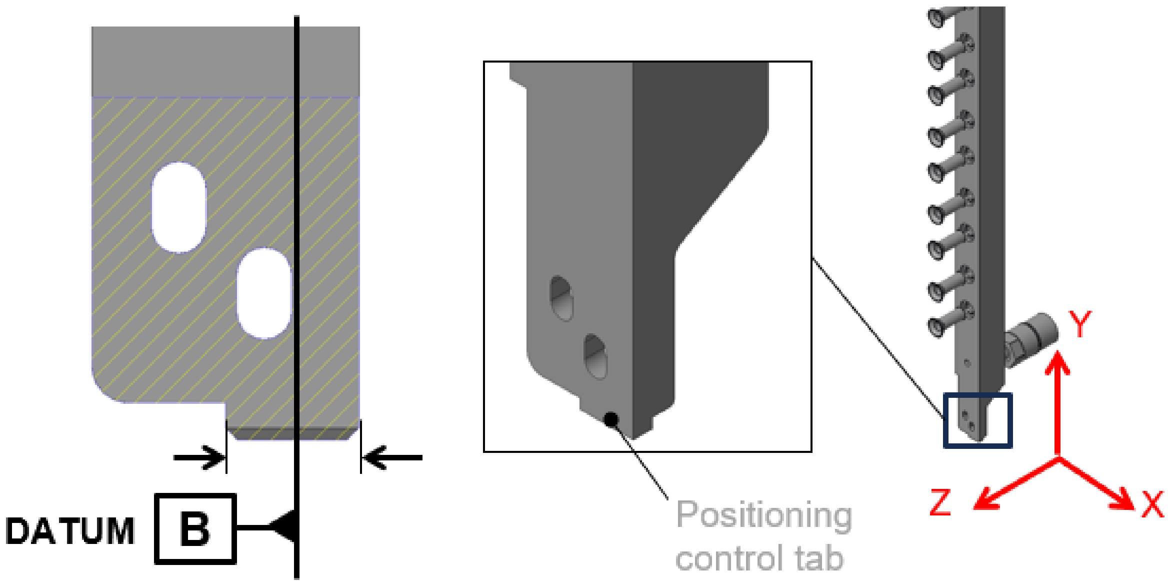

Fig. 13 – Manifold Datum B reference

11.1.3 Manifold Datum C

Manifold Datum C is defined as the centerline of the upper slot feature which provides left-to-right positioning for the top of the manifold within the rack.

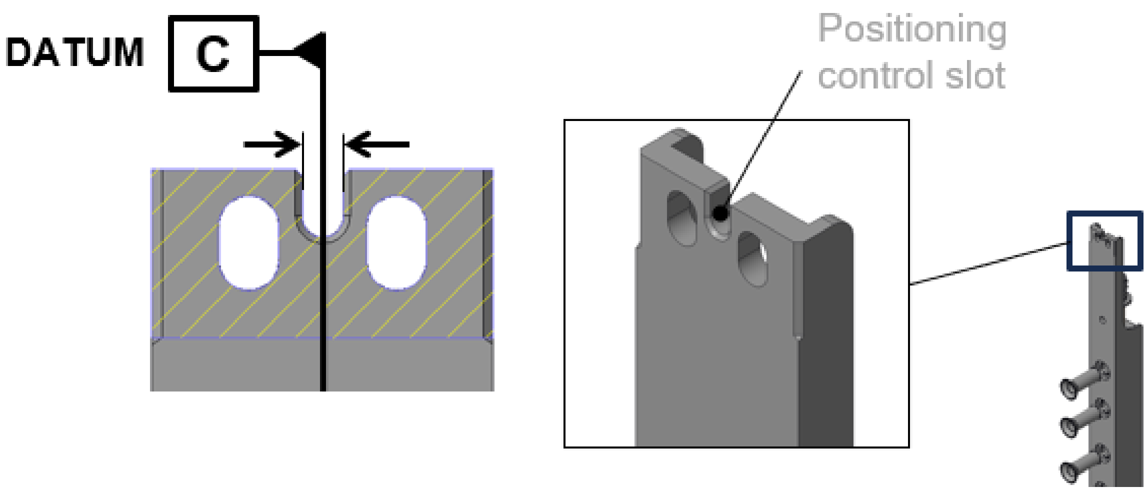

Fig. 14 – Manifold Datum C reference

11.1.2 Manifold Datum D

Manifold Datum D is defined as the lower face of the bottom manifold bracket. This surface rests on the base of the rack and provides vertical positioning for the manifold.

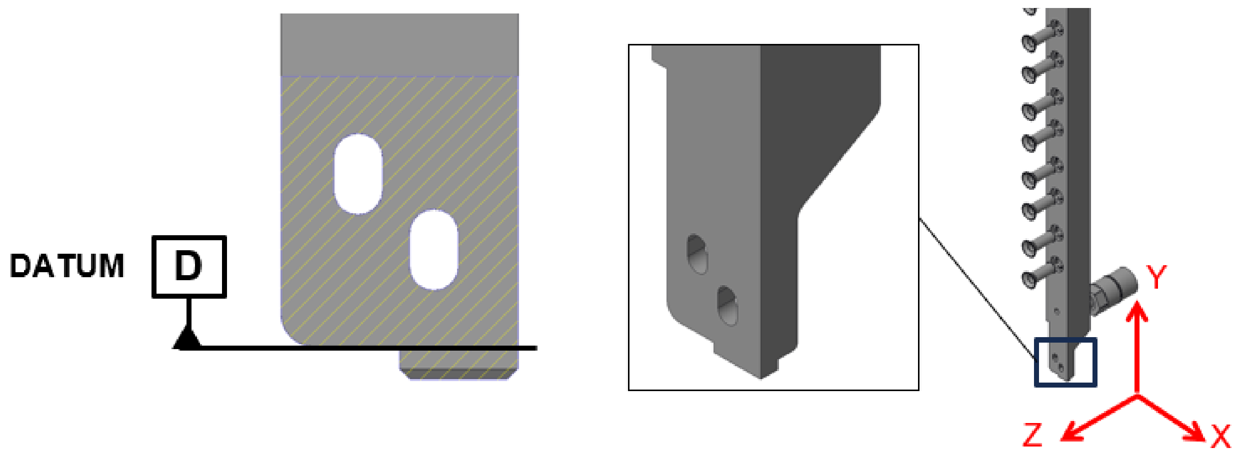

Fig. 15 – Manifold Datum D reference

11.2 Blind Mate Quick Connector Interfaces (Spot Face Definition)

11.2.1 Port & Thread requirements (per ISO-11926-1-1995)

Manifold requirements for the ORv3 Blind Mate Quick Connect valve interfaces are as follows:

- Port geometry: Female threads per ISO-11926-1-1995 for 3/4-16 UNF-2B
- Minimum 3 full threads

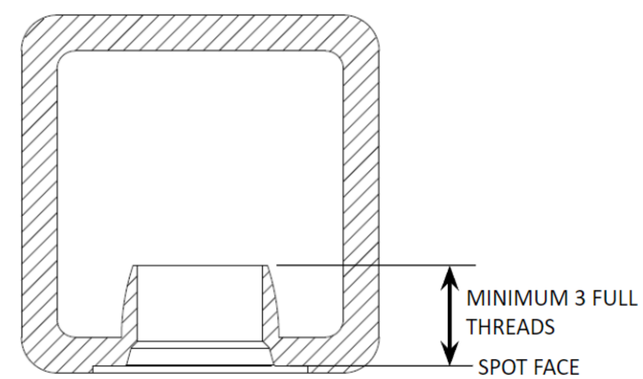

Fig. 16 - Minimum depth shall achieve 3 full threads

- Spot face (Quick Connect mounting interface surface) shall be positioned 6mm from the manifold Datum A surface.

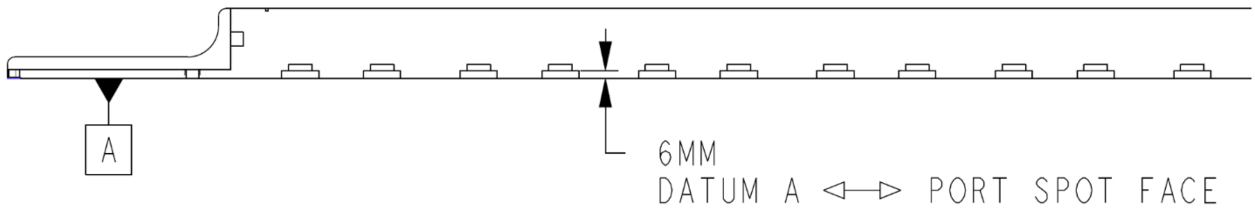

Fig. 17 - Minimum depth shall achieve 3 full threads

11.2.2 Locations of Ports

The quantity and vertical locations of the ports in the design reference geometry are not required. The CLA team's design reference used 24 valves, 12 on each side of the frame cross-brace. Developers are free to design other port locations and quantities as needed. The developer will need to evaluate manufacturability and process optimization for their design. In the reference layout, the cross-brace and middle interface bracket are located at slot OU23 but could be located +/- 1OU in either direction in the Meta frame version. Additional analysis would need to confirm manifold and rack stiffness in these alternate conditions.

Refer to included engineering 2D drawing and 3D CAD collateral for design reference port locations.

12. Mechanical Attachment, Manifold to Rack

Refer to the latest revision of *Meta Open Rack Frame V3 Specification* for more details on the attachment method, fasteners, and torque values. The blind mate liquid cooling kit is bolted onto a standard ORv3 frame and provides the mounting interfaces for the blind mate manifold.

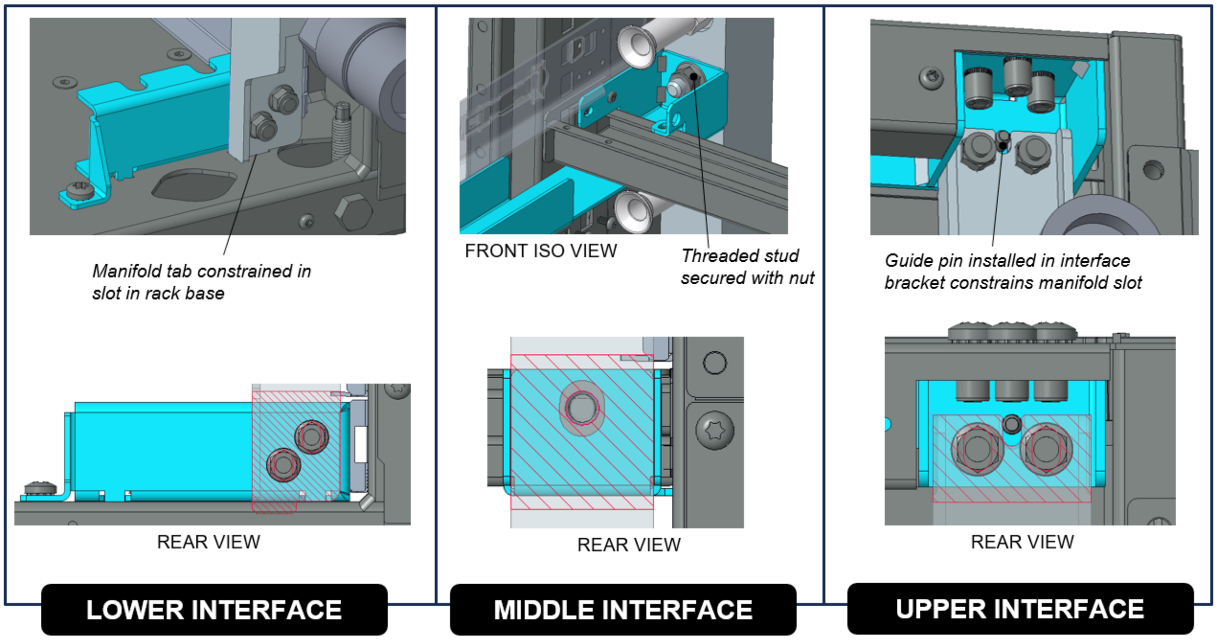

Fig. 18 – Rack mounting interfaces provided by liquid cooling mounting kit

13. Thermal Performance Requirements

To meet the thermal performance goals of the liquid cooling solution, the flow variation and pressure drop must be controlled by the branch components and manifold design.

13.1 Flow Performance Requirements

Based on computational analysis and assuming uniform flow impedance across all branches (including the QCs), flow distribution ≤ 5% between all branches is highly recommended across the intended flow range. In reality, the flow distribution also depends on the BMQC performance variation, branch pressure drops (for example flow through a chassis), and the inlet & outlet designs of the manifold. Therefore, it is important that computational analysis under ideal conditions yields a reasonably low flow distribution variation because in real testing with the reference design the actual measured variation was found to be higher (10% variation).

For consistency, it is recommended that the rack level fluid flow utilize the following flow direction: when looking from the rear of the rack, the rack fluid supply side is the right manifold, and the return side is the left manifold. The CLA group used this flow direction for all rack level flow testing, as well as 1” hoses & the LQC entrance. Both top and bottom LQC inlets were evaluated and branch to branch flow distribution performance was similar in both scenarios.

Note: Flow distribution is calculated as the difference in maximum and minimum flow rates divided by the average flow rate across all branches.

13.2 Pressure Drop Requirements

To promote uniform flow distribution and compensate for variation in QCs, branch components and manifold design, a minimum branch pressure drop should be specified based on computational analysis. It is recommended that this pressure drop be verified through experimental testing to determine the impact on flow distribution. In general, manifolds with a reasonably large flow section and longer distance between manifold inlet/outlet and the closest branch should yield a relatively low minimum branch pressure drop requirement (on the order of 1~2psi).

Figure 16 can be used to support calculations of rack pressure drop, the following PQ curve is provided which represents the flow impedance of a pair of manifolds only (other components such as blind mate valves, chassis PCL (Passive Coldplate Loop), rack-level hoses, large manual QCs, etc. are not accounted for).

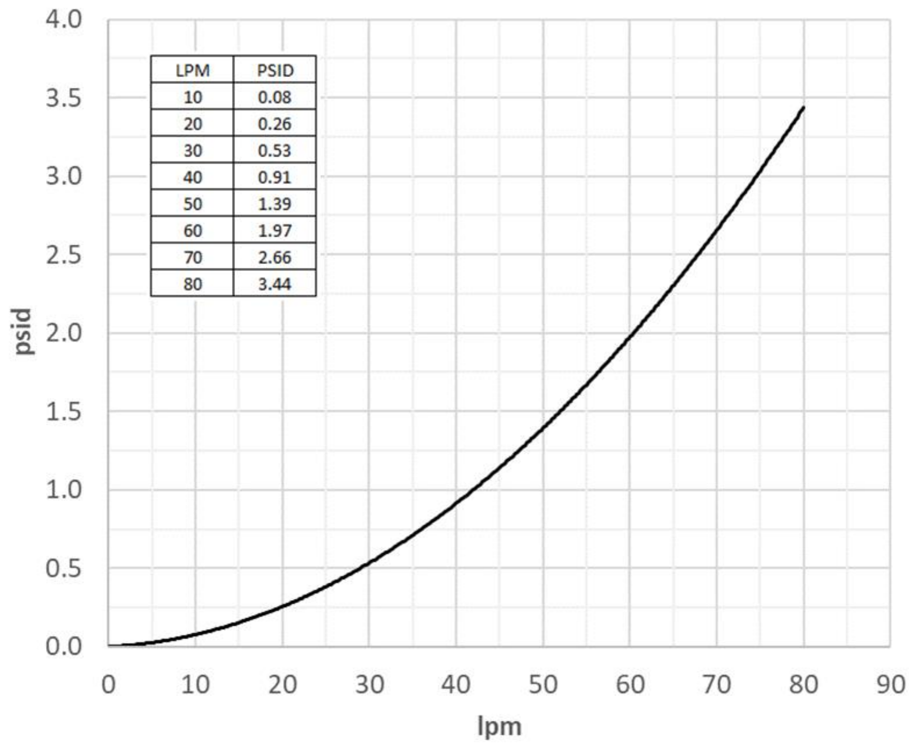

Fig. 19 – Pressure Drop Target - for a pair of manifolds (supply and return) as a function of volumetric flow rate at 25°C

14. Structural Requirements

To meet the minimum design goals of the overall liquid cooling solution, which considers BMQC working range, the rack frame, IT gear, and manifold have allowable budgets for deflections. The deflections are a result of fluid pressure, internal springs in the blind mate valves, and friction acting on the various components.

14.1 Allowable Manifold Deflection

The allowable manifold deflection at any point shall be no more than 1.0mm (in the depth direction) with respect to the ORv3 frame Datum A when mounted in the ORv3 rack frame with the liquid cooling mounting kit.

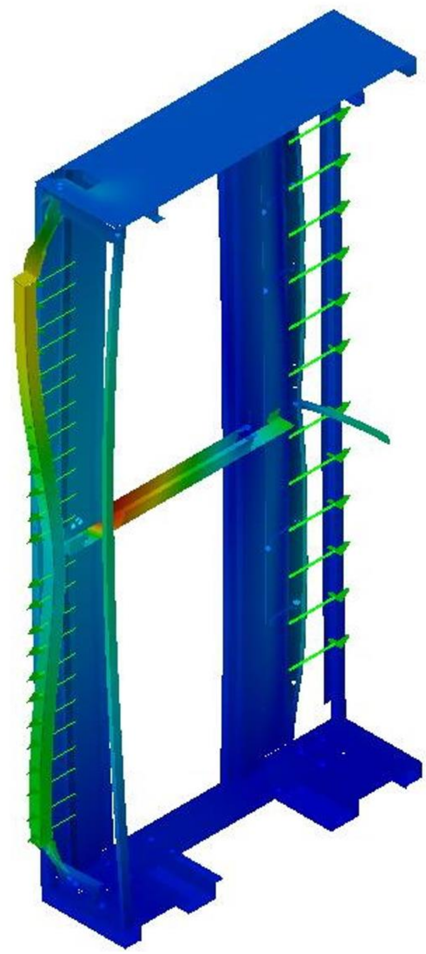

Fig. 20 – example FEA of manifold and exaggerated rack deflections (depth direction) due to hydraulic forces

Developers will also want to consider the effects of thermal expansion on manifolds at elevated temperatures when mounted in the rack. To ensure the blind mate valves are within their allowable working range and misalignment, it is important that the developer consider the effects of manifold CTE (Coefficient of Thermal Expansion), manifold deflection budget & tolerances, IT gear deflection budget & tolerances, rack deflection and tolerances, rack assembly tolerances, and external environmental inputs (shipping and handling, vibration, etc.). The tolerance requirements for the rack interfaces for the manifolds are defined in the latest revision of the *Meta Open Rack Frame V3 Specification* in the liquid cooling section. The *Open Rack V3 IT Gear Design Guide* defines the recommended tolerances and allowable deflections for the IT Gear chassis. The blind mate specification provides the allowable misalignment and working range requirements.

15. Hose Attachment & Routing

Hoses are not included in the scope of this base specification. For applications requiring hose barbs, refer to hose manufacturers for details as this will vary by hose design and supplier.

16. Maximum Working Pressure Rating

The manifold assembly shall have a maximum working pressure of 50 psig.

17. Fluid Information

17.1 Fluid Type

The fluid used for most tests by the team has been 25% propylene glycol-water mixture for testing. Note all durability and flow performance tests used Dowfrost LC25. Water was used for some pressure related tests to simplify testing. This design could be used with treated water, but the necessary analysis and testing would need to be conducted to confirm the components will work for specific end-user applications.

17.2 Fluid Temperature

The overall solution is developed based on a maximum working fluid temperature of 60°C.

18. Materials & Finish

Please note that end users should understand application functional requirements so that material which could impact function is not used. All components shall be ROHS compliant.

18.1 Non-Wetted Materials

Non-wetted materials are those materials which do not come into direct contact with the cooling liquid and may be used by suppliers for components and assemblies as long as they meet the functional requirements of the end-application.

18.2 Wetted Materials

Wetted materials are those which come into direct contact with the cooling liquid. The material compatibility has been established by the latest revision of the *Guidelines for Using Propylene Glycol-Based Heat Transfer Fluids in Single-Phase Cold Plate-Based Liquid Cooled Racks*. For this manifold specification, the following materials are to be used based on components:

- Manifold tube and end mounting brackets – SS 303, 304/304L, 316/316L
- Sealant or Lubricants – these are not specified in the design reference; use of sealants and lubricants is permitted and should be checked for compatibility with the coolant used.
- Hoses and hose materials are not defined in this specification as it is not within the manifold assembly's scope.
- The design can support air purge valves when needed. However, since the hardware definition of this option is left up to the developer, wetted materials for this option are not defined.

18.3 Material Coefficient of Thermal Expansion (CTE)

Due to the impact of thermal expansion on the manifold tube due to temperature rise in the coolant and air temperature over the operating range, the Coefficient of Thermal Expansion (CTE) is an important parameter for manifold design because it can impact the position of the BMQC valves and manifold affect tube dimensions.

The maximum recommended value for CTE is 17.3 x 10-6 °C -1 which is based on tube material of 304 stainless steel.

18.4 Finish

- All metal components are to be passivated, plated or electro-polished to avoid corrosion over time in the lifecycle of the product.
- Non-wetted fasteners should use zinc plated steel or alloy steel with passivated finish instead of stainless steel due to the potential for galling.
- Finish shall be RoHS compliant.

19. Safety and Environmental Compliance Requirements

19.1 General safety construction requirements

- Manifold and coolant 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.

19.2 Plastic parts flammability

- Minimum flammability requirements for manifold assembly components should be considered for each unique application but are not mandated in this specification.
- Tubing can be made of minimum HB75 class material if the thickness of the material is < 3mm, or minimum HB40 class material if the thickness of the material is ≥ 3mm.

19.3 Hydrostatic pressure

Manifold shall be designed to meet the following hydrostatic pressure and creep resistance tests.

Test items	Requirements	Reference	Criteria
Hydrostatic pressure (Normal operation)	The following test shall be performed at normal operation room temperature. ● Manifold shall be designed to meet three times the maximum working pressure specified by the manufacturer. ● ambient temperature: 45C ● fluid temperature: 60C ● fluid pressure: 3 x 50psig = 150 psig	UL62368-1	During and after tests, there shall be no rupture, no leaks and no loosening of any connection or part.
Hydrostatic pressure (Abnormal operation)	The following test shall be performed at abnormal operating condition when single fault condition is applied to Manifold. ● Manifold shall be designed to meet two times the maximum working pressure specified by the manufacture at the maximum temperature measured during application of abnormal condition (such as covering the ventilations of the final end product- rack) ● ambient temperature: 55C ● fluid temperature: 60C ● fluid pressure: 2 x 50psig = 100 psig	UL62368-1	During and after tests, there shall be no rupture, no leaks and no loosening of any connection or part.

Creep resistance	Non-metallic parts in Manifold shall show no sign of deterioration such as cracking and embrittlement during/ after the following tests. ● Two samples of Manifold shall be conditioned for 14 days at a temperature of 87°C ● Following the conditioning, the system shall comply with the above hydrostatic pressure tests	UL62368-1	Non- metallic parts shall show no sign of deterioration such as cracking and embrittlement

19.4 Tensile requirement

Tubing and associated fittings that may be used in Manifold design shall meet the following tensile strength tests.

Test items	**Requirements**	**Reference**	**Criteria**
Tensile strength	The following tensile tests shall be performed on ten specimens of tubing material in accordance with ISO 527 standard. ● Five specimens made shall be tested in the as received condition ● Another five specimens shall be tested after a conditioning test for 40 days at 38°C in a full draft air-circulating oven or in a water bath filled with the intended liquid and maintained at 38°C.	ISO 527 UL62368-1	The tensile strength after conditioning shall not be less than 60% of the tensile strength before the tests.

19.5 Mechanical strength

Test items	Requirements	Reference	Criteria
Force test	A force of 30N ± 3N is applied to any accessible part for a duration of 5 sec.	UL62368-1	After tests, there shall be no rupture, no leaks and no loosening of any connection or part.

19.6 Environmental Compliance Requirements

- RoHS Directive (2015/863/EU); aims to reduce the environmental impact of EEE by restricting the use of certain substances during manufacture.
- REACH Regulation (EC) No 1907/2006; the risk assessment for the restriction of PFAS, and registration with the European Chemicals Agency (ECHA), evaluation, authorization, and restriction of chemicals.
- WEEE Directive (2012/19/EU); aims to reduce the environmental impact of EEE by restricting the use of certain substances during manufacture.
- Substances of Concern In articles as such or in complex objects (Products): product shall not contain any substances regulated by EPA 40 CFR75

20. Environmental Requirements

- Operating Conditions: 5°C to 60°C, 10%RH to 93%RH* (max. fluid temperature 60°C)
- Non-Operating Conditions: -40°C to 70°C, 5%RH to 95%RH (no fluid)
  **Tested with Dowfrost LC25 (PG25), other fluids may affect the above values.*

21. References

[1] Open Compute Project (OCP) document/specification references:

A. Open Rack Specs & Design Wiki, https://www.opencompute.org/wiki/Open_Rack/SpecsAndDesigns
B. "*Open Rack V3 Base Specification*", 2024, OCP
C. "*Meta Open Rack Frame V3 Specification*", 2024, OCP
D. "*Open Rack V3 Blind Mate Quick Connector Specification (BMQC)*", 2024, OCP
E. "*Open Rack V3 IT Gear Design Guide*", 2024, OCP

F. “*Guidelines for Using Propylene Glycol-Based Heat Transfer Fluids in Single-Phase Cold Plate-Based Liquid Cooled Racks*”, 2022, OCP
G. “*OCP Large Quick Connector Specification*”, 2023, OCP

[2] “*Connections for general use and fluid power - Ports and stud ends with ISO 725 threads and O-ring sealing - Part 1: Ports with O-ring seal in truncated housing*", ISO-11926-1-1995

[3] “*Audio/Video, Information and Communication Technology Equipment - Part 1: Safety Requirements*”, UL 62368-1 IEC:2014

Appendix A - Requirements for IC Approval (to be completed by contributor(s) of this Spec)

List all the requirements in one summary table with links from the sections.

Requirements	**Details**	**Link to which Section in Spec**
Contribution License Agreement	OWF CLA 1.0	Link to Sec 1
Are All Contributors listed in Sec 1: License?	Yes	
Did All the Contributors sign the appropriate license for this spec? Final Spec Agreement/HW License?	Yes	
Which 3 of the 5 OCP Tenets are supported by this Spec?	Openness Efficiency Impact Scale Sustainability	Link to Sec 2
Is there a Supplier(s) that is building a product based on this Spec? (Supplier must be an OCP Solution Provider)	yes	nVent Parker
Will Supplier(s) have the product available for GENERAL AVAILABILITY within 120 days?	No – each manifold design will be unique	Please have each Supplier fill out Appendix B (N/A)