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Reservoir and Pumping Unit Specification

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1. Scope

This document defines technical specifications and high-level requirements for a reservoir and pumping unit (RPU) designed for in-rack or rack-level closed-loop liquid cooling solutions as part of air-assisted liquid cooling in air-cooled data centers. Proposed designs should comply with requirements of Open Rack v2, Open Rack v3 and Olympus rack architectures. Standard 19” racks (EIA310) should also be natively supported, unless technical or design requirements/details conflict with support of aforementioned primary architectures.

Note the following areas and topics will not be covered in or are not within the purview of this document:

- Rack manifolds
- Quick connect fittings
- Cold plates

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3. Acknowledgements

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4. Terminology

LC	Liquid cooling or liquid cooled
AALC	Air-assisted liquid cooling; this term may be used interchangeably with “hybrid cooling” in this document
LTA HX	Liquid-to-air heat exchanger; used to exhaust heat from the coolant loop to air driven through it
RPU	Reservoir and pumping unit
Door HX	Door heat exchanger; rack-mount LTA HX
QC	Quick connect fitting; used to connect or separate adjacent or mating parts of an LC or AALC solution

5. Overview

Projected trends in component power and density are beginning to push the limits of traditional air cooling. Closed-loop liquid cooling with effective liquid-to-air heat exchange (in short, air-assisted liquid cooling or AALC) is a potential approach to extending the capability of existing air-cooled facilities and permit smoother transition to facility water systems for data center operators.

Before requirements of the RPU are detailed, the concept of AALC should be clearly understood. The goal is cost- and resource-efficient, and performance-optimized generation of above-ambient temperature coolant for liquid cooling needs. The block diagram below outlines the AALC solution, individual components (cold plates inside IT gear and QC fittings are not shown) and should provide a high-level understanding of how the combined system functions.

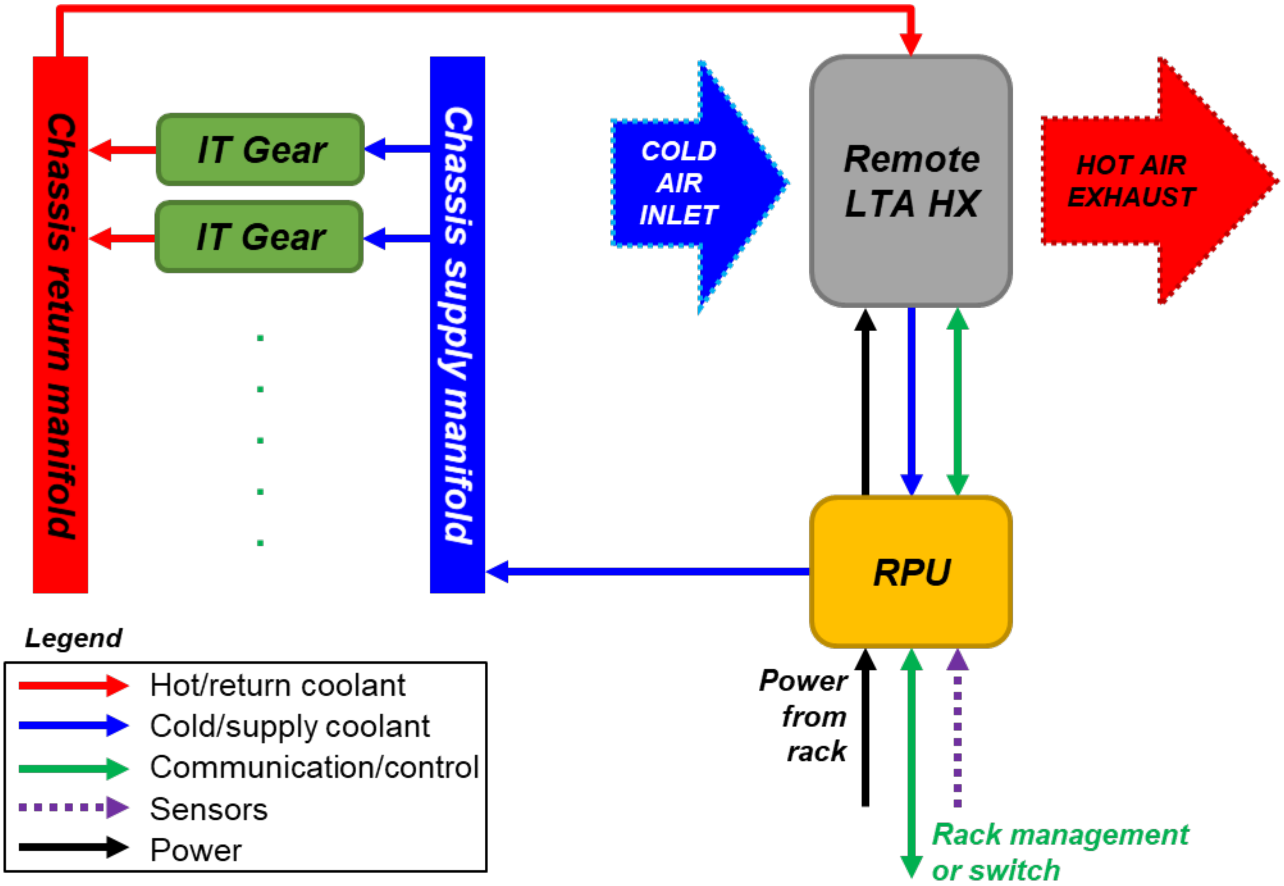


Figure 1: Block diagram of air-assisted liquid cooling outlining the concept and components

As seen in Fig. 1, the RPU forms the "hub" of an AALC solution. It is responsible for delivering power to and, control and monitoring of the LTA HX section. The latter may constitute (but is not limited to) reading sensors from and sending feedback control signals to fans. As a result, the LTA HX assembly can be flexible, optimized for performance, efficiency and cost, and eliminate unnecessary overhead (power supply units, primary control electronics, human and communication interfaces, etc. generally employed in stand-alone units). The RPU is also responsible for communication with hierarchically higher-level components such as rack management device (RMD) or top of the rack (ToR) switches for pushing AALC status, alarms and sensor information. Precise definition of RPU requirements will be covered in following sections.

A few AALC solutions are outlined in figures below, but the final implementation is up to the end-user (and their vendors). The defining characteristic of each type is how the LTA HX part is implemented. A concept not visualized, but similar to Fig. 2, involves installing the LTA HX in a rack-mount chassis as opposed to a Door HX that needs to be mounted to the rack frame and extends beyond the rack volumetric.

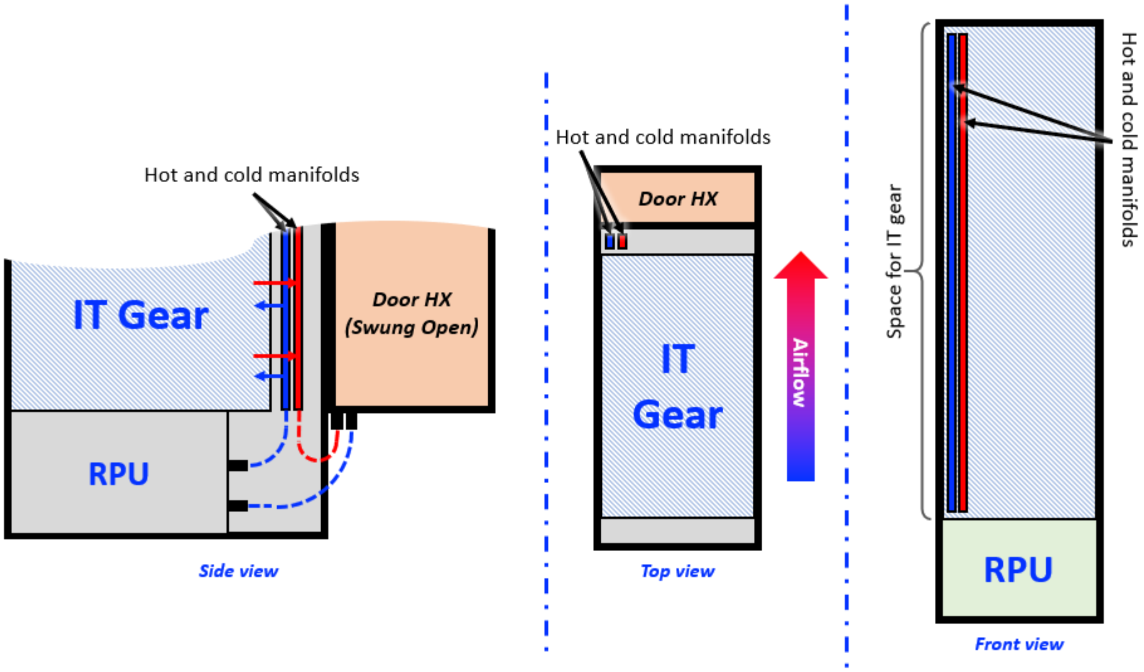


Figure 2: Door HX mounted to rack and coupled with RPU and manifolds to form AALC solution (sample embodiment)

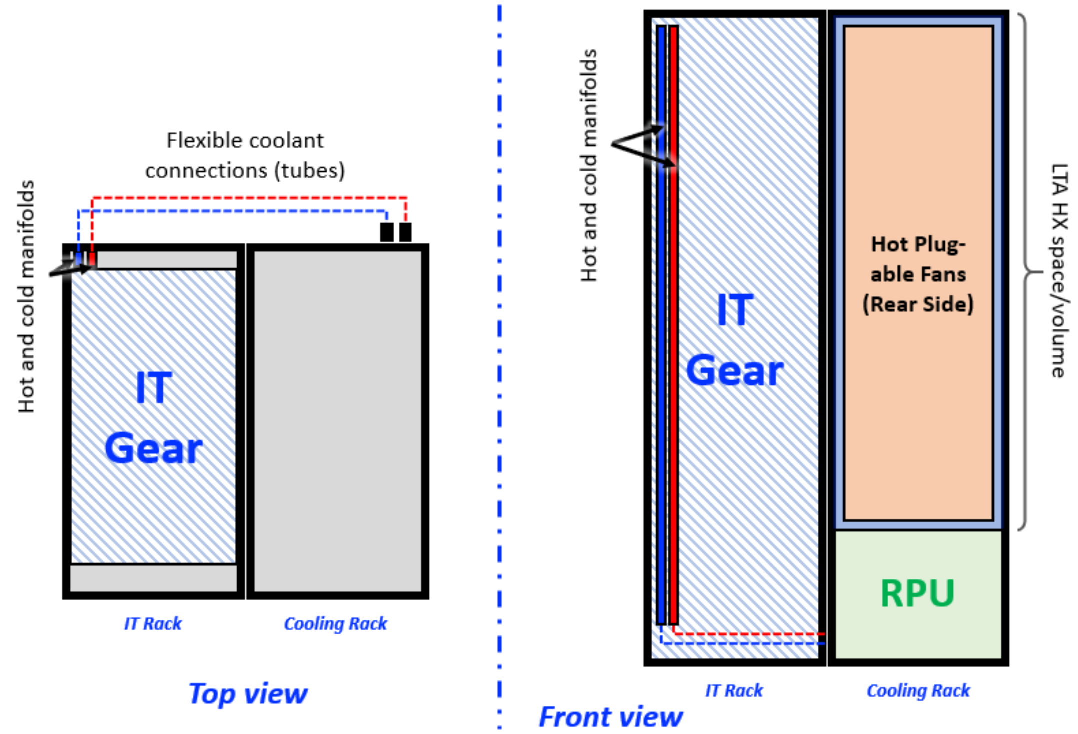


Figure 3: RPU and LTA HX installed in an adjacent cooling rack (side car) and coupled with LC components in IT rack to form AALC solution (sample embodiment)

6. RPU Requirements

The overlying design goals of the RPU, and air-assisted liquid cooling (as a whole), are:

- Standardization, to promote flexibility in liquid-to-air heat exchange portion and interchangeability of designs from multiple suppliers
- Serviceability
- Quality and reliability
- Cost and performance optimized

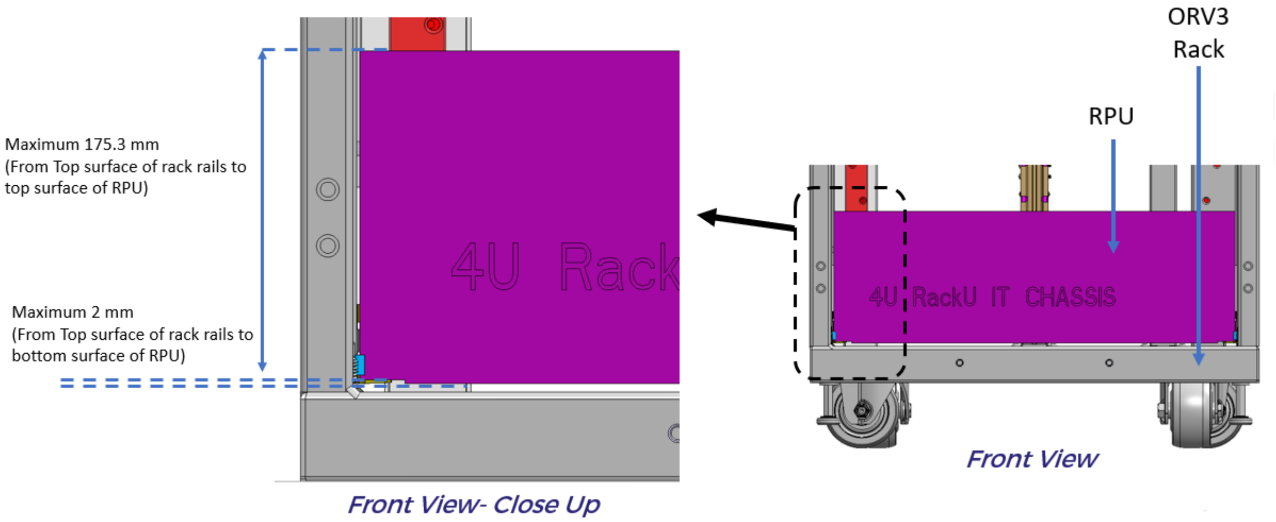
The RPU design should be the control, monitoring and power delivery hub of the AALC solution. Following sections outline requirements for this component.

6.1 Physical

- *Form factor*: Chassis should be designed for potential use in both EIA310 and Open Racks. As the former is more constrained dimensionally, the RPU should comply with the dimensional form factor of a 4RU (19”) IT chassis for its height and width. Depth of the chassis is constrained by the Open Rack’s smaller depth. Below are the maximum requirements and suggested overall RPU dimensions.
    - *Height Requirements*: Designed to fit within 4RU rack space. Maximum dimensions below must account for RPU and adapter shelf tolerance stack-up.

      175.3 mm, measured from top surface of rack rails to top surface of RPU. (This requirement allows for a minimum 0.8 mm gap between RPU unit and IT gear directly above)

      2 mm, measured from the top surface of rack rails to bottom surface of RPU.



Front View- Close Up

Front View

Figure 4 RPU Height Requirements

- *Chassis Width Requirement*: 17.23” (445.25 mm) maximum width after tolerance stack up is accounted for. This allows 2 mm of clearance on each side during a worst-case scenario, with EIA-10 450 mm +/- 0.75 mm tolerance.
- *Front Panel Requirements:* Maximum overall width will be 19.20” (487.68 mm +/- 0.20 mm) and the front panel must have mountings holes/slots spaced to meet EIA-10 mounting requirements.

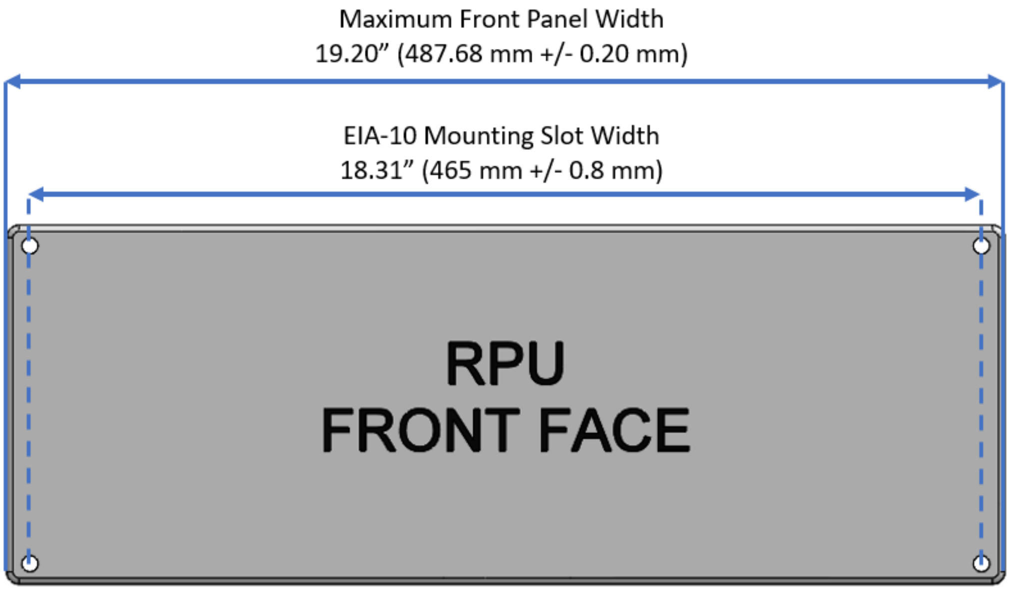


Figure 5 RPU Front Panel Requirements

- *__RPU Chassis Length Recommendation:__ Recommend maximum RPU length of 820 mm, measured from front panel to rear panel*

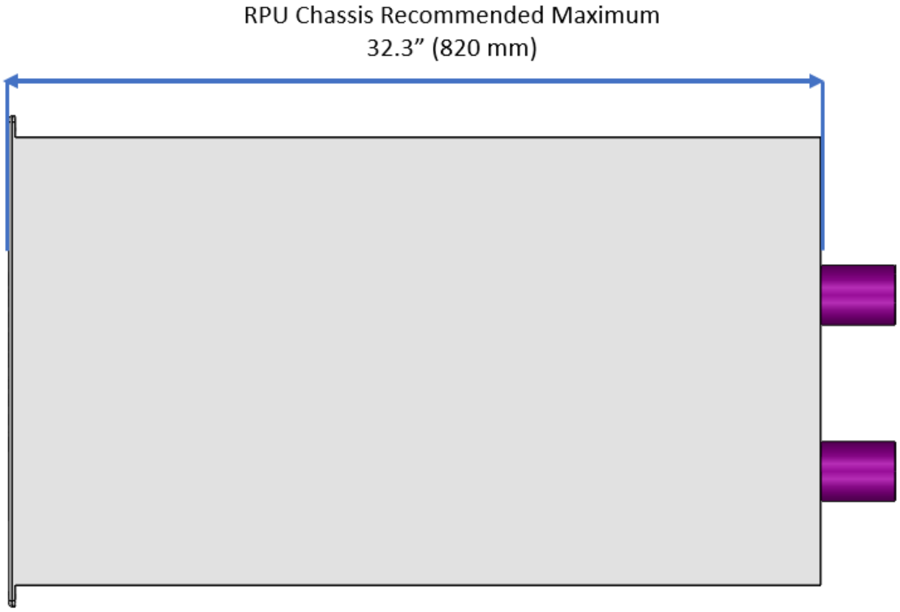


Figure 6 RPU Chassis Length Recommendation

- *__RPU Fit Requirements (ORV3)__*: Constrained by ORV3 depth and bus bar positioning. Using ORV3 as reference.

787.8 mm maximum from ORV3 equipment catch edge to RPU rear panel

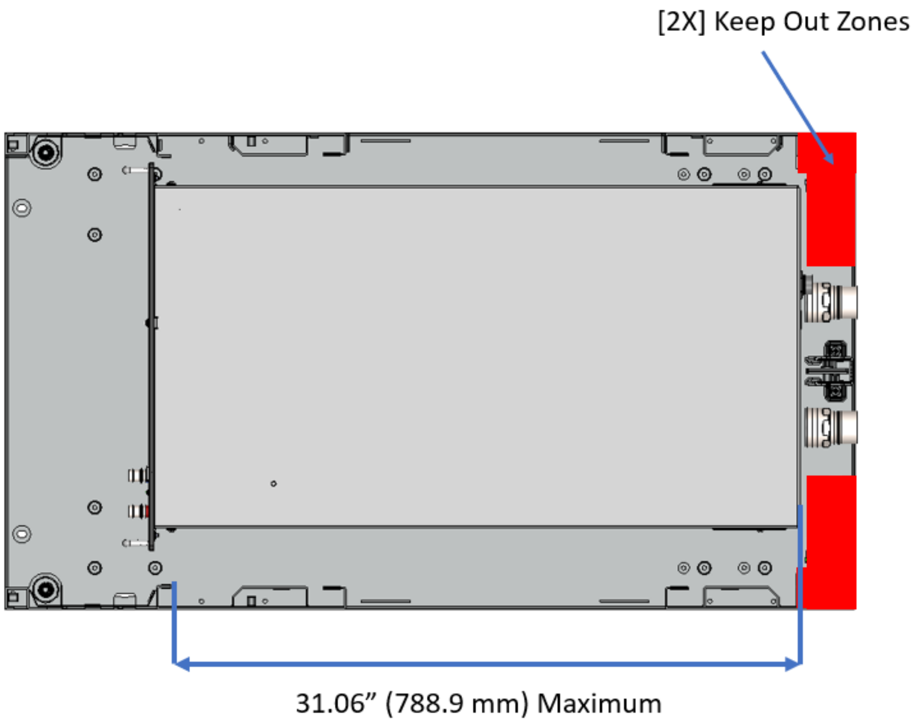


Figure 7: RPU Fit Requirements in ORV3

The RPU should provide adequate space for coolant, electrical, communication and other auxiliary connections within the rack volumetric. For use in an Open Rack, RPU internals may be repackaged in a 4OU enclosure or the 4RU chassis may be mounted to an adapter frame (preferred approach).

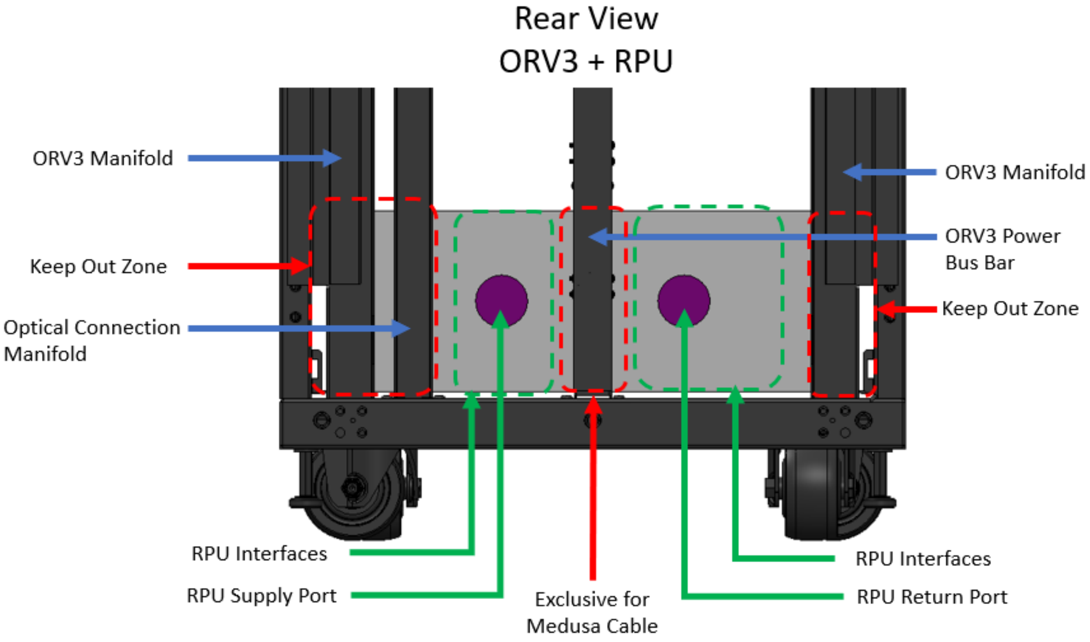


Figure 8 Keep-out references for RPU in ORV3

- *<u>RPU Fit Requirements (Olympus)</u>*:

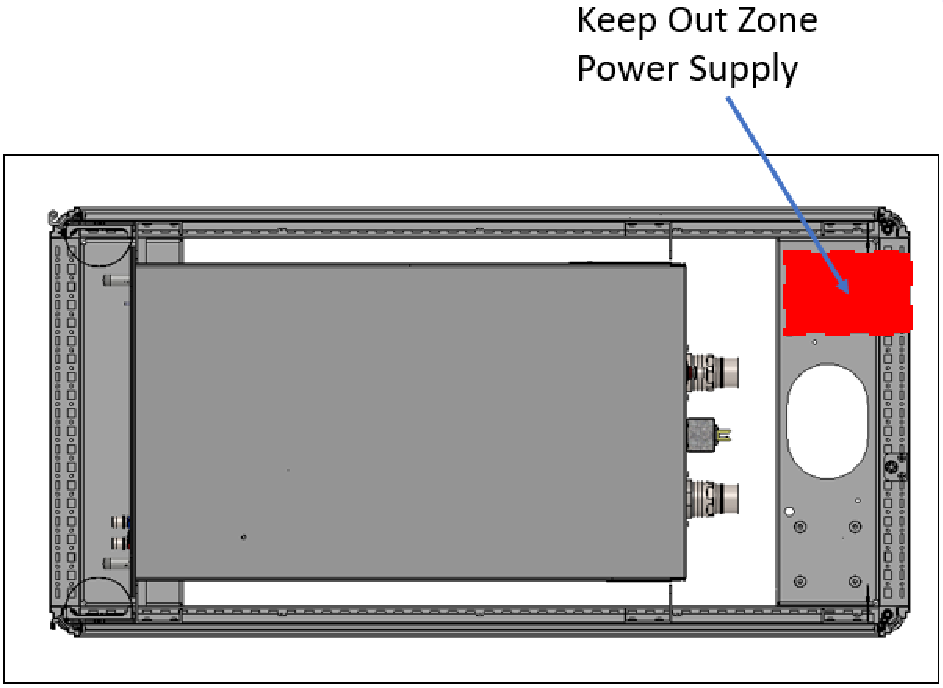


Figure 9 Keep-out references for RPU in Olympus Rack

- *<u>Load rating</u>*: As the baseline solution with be designed for 19” racks, this chassis will interface with the rack structure (EIA310) using a rail kit. The weight of the chassis primed with coolant (including rail kit) should not be greater than 75kg, with a preferred value of 60kg. For an Open Rack configuration, the 19” RPU can be installed using an adapter shelf, a 21” RPU chassis that mounts directly into the Open Rack will be explored.

6.2 Interfaces

- *<u>Coolant</u>*: The RPU will interface with the supply coolant manifold and LTA HX part. These connections will be located at the rear face of the RPU (looking from the cold aisle side of the rack) and 20mm manual, dry-break QCs (Female/Socket on RPU) are recommended for this interface to minimize impact of coolant-side pressure drop. Intrusion of these large tubing and connections are permitted in the hot aisle, but must be limited to the depth of door heat exchanger assembly (when using the latter as LTA HX part). A secondary coolant connection will be located at the front face of the RPU (looking from the cold aisle side of the rack) for the purpose of replenishing coolant in the reservoir or retrieving small samples for evaluation of coolant health (chemistry). This connection will employ a manual, dry-break QC and a smaller size (3mm or 5mm) is recommended. Coolant connection type, size and location should stay the same across AC and DC RPU variants.

- *Electrical*: Chassis should be designed to accommodate both AC and DC power input without violating the other interface keep out zones. Power input interfaces should be located at the rear face of the RPU.
    - ORV2: RPU should interface with the power busbars (at the rear of the rack). and be capable of receiving 12V DC power (anticipated supply range of 11 to 13 VDC).
    - ORV3: RPU should interface with the power busbars (at the rear of the rack). and be capable of receiving 48V DC power (anticipated supply range of 46 to 52VDC). Cabling and DC connectors to enable the aforementioned are TBD.
    - EIA: When designed for AC power input, 230VAC (50/60Hz) supply options via standard C14 plug-in connector is recommended. AC to 48V power shelf is required for input power into RPU. Additional recommendations include support for A/B power supply redundancy at the rack (AC only).

  As previously stated, the RPU will serve as the hub for an AALC solution. It is optional for the RPU to power the LTA HX part (Door HX or side car). However, the overall power budget of the rack will need to be considered to determine if the feed into the RPU can support this. If this feature is available, the power supply interface should be located at the rear face of the RPU. The DC power cable should include adequate slack to accommodate hinging of the Door HX or interfacing with the side car heat exchanger.

  Maximum power consumption from RPU at the higher end of flow specification (50 LPM) should not exceed 2% of total rack power consumption. Total liquid cooling solution, including liquid to air heat exchanger and fans to not exceed 5% of power consumption.
- *Communication*: The RPU should be designed with the ability to interface with rack-level management systems (top-of-the-rack switch or in-rack management device) for control and monitoring purposes. RS485 or RJ45 (ethernet) ports should be supported along with the following protocols – Modbus RTU/IP, SNMP v2/v3 (optional) or HTTP (optional). A single port should be located at both the front and rear face of the RPU for ease of cable management based on the end-user's rack assembly.
- Front Accessible Interfaces (Locations of each interface defined by end-user)
    - Minimum 2X LED Lights for status (software configurable color and functionality)
    - 2X Serviceable Pump Tray Status LED Lights (software configurable color and functionality), hot swappable pump tray only
    - 1X RJ45 Communication to rack management device or switches (receptacle)
    - RJ45 (s) Leak sensor alert GPIO's to IT racks and switch (4 preferred as shown in Figure 10, but it could vary based on end user's requirement)
    - Fill, Drain, Vent ports (3 mm orifice, dry-break Quick connect, socket/female)
    - Grounding Stud (For AC variant), size and length references: M5 stud, 15 mm long
    - 2X pull handles for RPU handling and installation
- Rear Accessible Interfaces (Locations of each interface defined by end-user)

  - Supply and Return coolant port (20 mm orifice, dry-break Quick connect, plug, male)
  - Heat exchanger power and communication port
  - 3x external leak detection port
  - Power connector (Medusa connector for ORv rack, C14 for AC variant)
- *Leak Detection:* Figure 6 below illustrates the leak detection and communication between the IT Rack and the Cooling Rack (RPU/HEX Rack). This architecture supports up to 4 chassis in an IT rack. It is therefore primarily suitable for applications such as AI/ML implementations that employ multiple high power ASIC's in a single chassis. Leak sensors are implemented to detect leaks from the cooling system in each chassis. A GPIO is asserted to alert the RPU when a leak is detected in the chassis. A GPIO is asserted by the RPU if a leak is detected in the RPU or HEX. Both the RPU and heat exchanger have internal and external leak sensors. Loss of cooling is communicated to system management via GPIO and also via Modbus messaging.

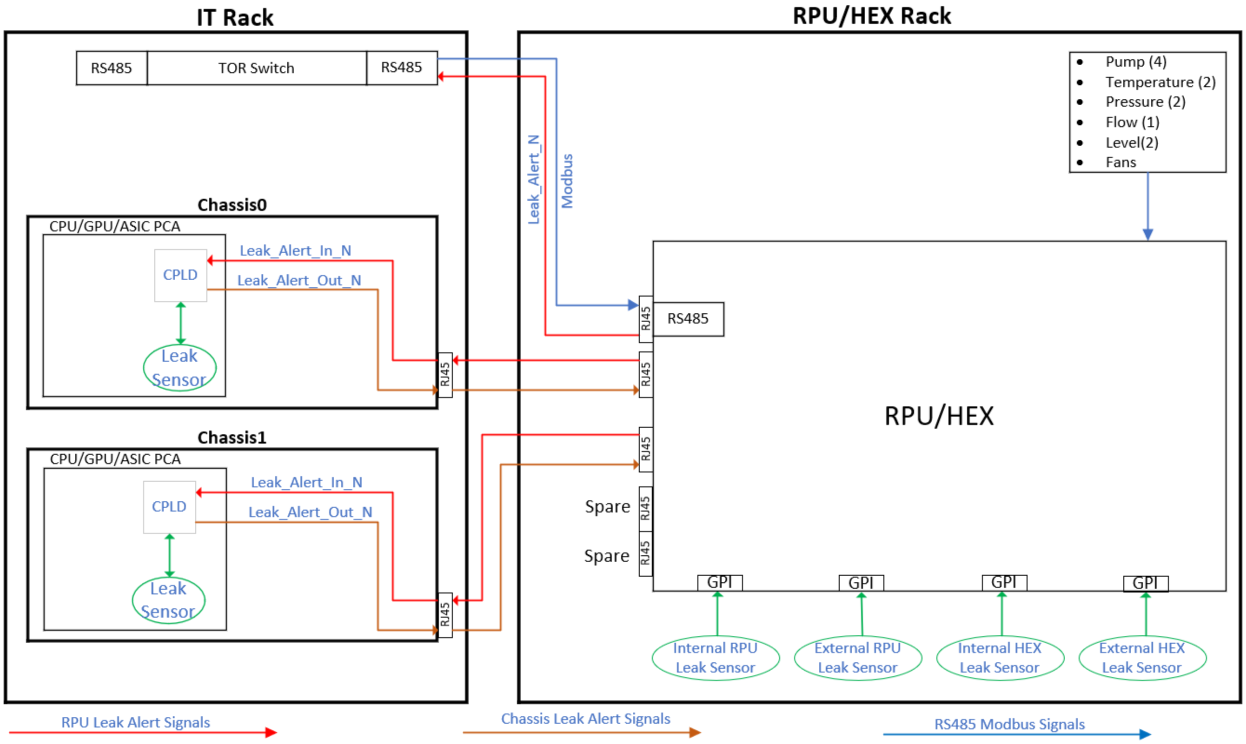


Figure 10 Leak Detection and Communication Block Diagram (High Power Chassis)

- *Leak Detection (Scalable):* Figure 7 below illustrates a more scalable architecture that supports more than 4 chassis in an IT rack. This architecture requires a Rack Management Device (RMD) to aggregate and facilitate communication of leak detection between the chassis, RPU and rack system management.

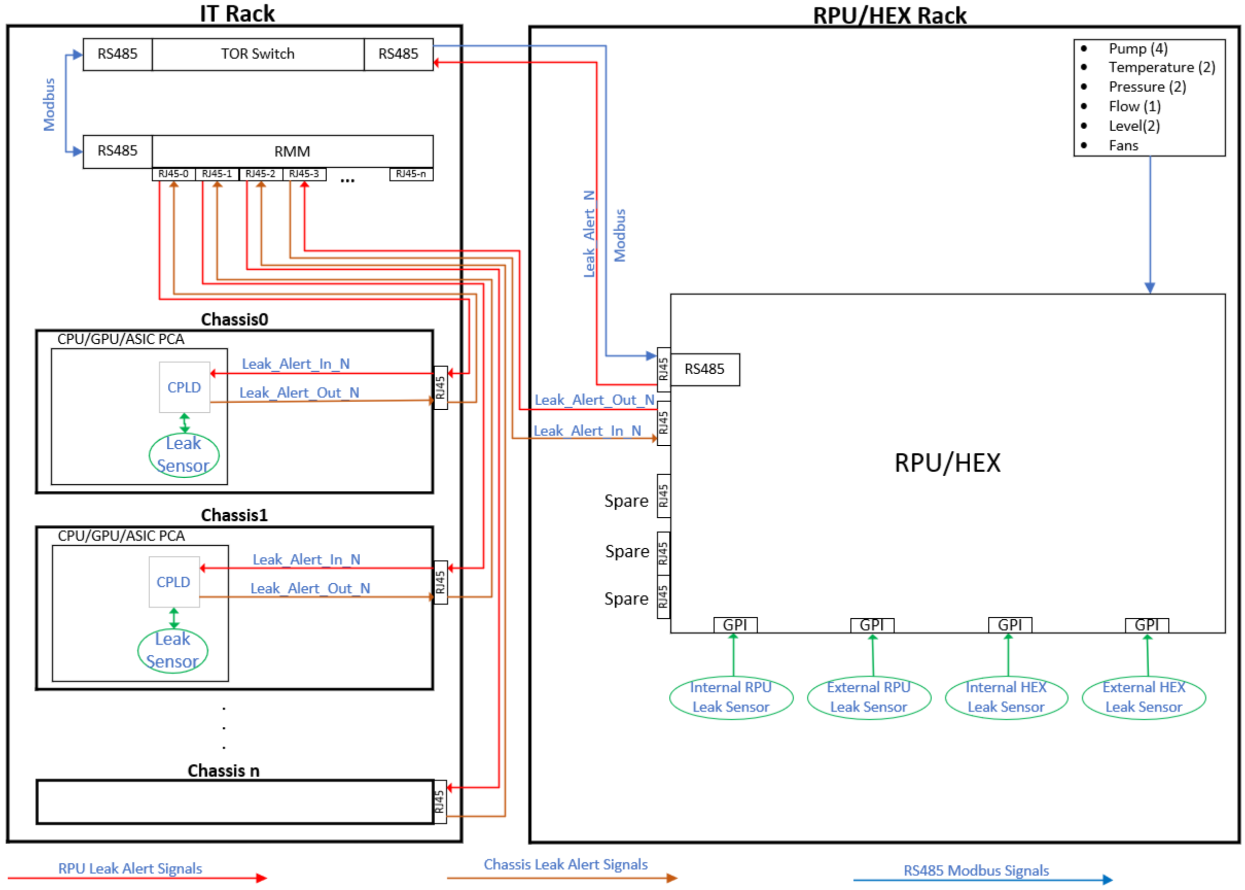


Figure 11 Leak Detection and Communication Block Diagram (Low Power Chassis)

- *Other*: The RPU will monitor and control operation of the LTA HX part. In addition, leak detection solutions may be deployed at the rack. These interfaces should be located at the rear face of the RPU. Additional handles on both sides of RPU need to be placed with front pull handles to ensure safe handling and installation of RPU.

6.3 Performance

The primary objective of the RPU is drive coolant through the closed loop of an AALC solution. Following are performance targets:

- Coolant flow rate range of 20~50LPM. Tradeoffs of extending this range to 70LPM should be evaluated. These targets should be based on 25% propylene glycol as the coolant.
- N+1 pump redundancy is a must
- Total power consumption of an AALC solution should be ≤ 5% of its rated cooling capacity (including LTA HX part). This value assumes normal/typical operation;

not including failure or alarm conditions. The RPU, by itself, should account for ≤ 40% of the target.

6.4 Monitoring and Control

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

As an AALC solution can impact facility-level resources such as airflow, power, etc.; monitoring and control are critical to ensuring efficient, long-term operation. Following are parameters that should be monitored:

- Air-side: Inlet and outlet temperatures, pressure drop (across LTA HX part), airflow consumption, fan speeds
- Coolant-side: Inlet and outlet temperatures and pressures, flow rate, pump speeds
- Overall: Cooling capacity, power consumption

Monitoring health of the solution is equally critical and following alarms should be implemented to trigger necessary service events:

- Failures:
    - Fan & pump: Failure usually observed (but not limited to) when operating speed drops below a pre-determined threshold. In-built redundancy should compensate for this loss and sustain operation.
    - Sensor/communication: Failure may manifest as loss of readings or signals. As long as power to systems are maintained, operation must be sustained (efficiency requirements may be relaxed in this case). In case of sensors, auxiliary readings may be pulled-in to maintain control. For example, if both coolant supply and return temperatures are measured at the RPU, one could substitute for the other.
    - Power delivery monitoring: Failure may manifest as loss of 48VDC power between RPU and LTA HX. RPU may sustain operation (while tracking coolant supply temperature) to determine if this is a short-term concern/bug before triggering alarm(s).
- Coolant health:
    - Periodic sampling and lab analysis are required to determine the coolant health. This includes pH, corrosion additive depletion, biological growth inhibitor depletion, etc.
    - Some leading indicators can be measured in-line but are currently impractical to add to the RPU. Testing equipment is available to measure pH, conductivity and ionic containments. This is outside the scope of this specification.
    - The period of this should be based on the recommendations of the individual coolant vendors.

    - Please reference ASHRAE TC 9.9 Whitepaper entitled "Water-Cooled Servers – Common Designs, Components and Processes" for more details.
- Other: Reservoir level low, coolant health, leak detection (internal and/or remote)

Control is critical to ensuring performance targets are met across operational ranges. Following are parameters (air- and coolant-side) that should drive the same:

- Temperature (including compensation for altitude)
- Cooling capacity: Employment of each solution will be dependent on supported IT gear (kW of cooling and coolant flow rate requirements) and location of facility (altitude). A configuration file may be employed to establish such high-level operational requirements and boundary conditions.

In the event control goes offline, RPU should continue to maintain capability of cooling (like chassis fans in IT gear) and sustain operation.

6.5 Operational

The RPU should be designed with ease of serviceability and long-term, reliable operation in-mind. Detailed requirements are as follows:

- Serviceable or replaceable from the cold aisle and designed for tool-less operation
- Visual signals, such as LEDs, should be used to indicate events for online replaceable parts and system operation
- RPU should be designed for reliable, long-term operation. Pumps should target an L5 of ≥ 10 years at a coolant ingress temperature of 45°C.
- Electrical fuse(s) should be sized to enable a minimum margin of 50%
- RPU to be used with an external pumping unit to fill the entire liquid cooling system if needed (excluding Server-level cooling) from the front of the RPU

7. Sensor Requirements

7.1 Sensor List

The RPU is the brain for air-assisted liquid cooling. Sensors are critical to ensure the effective control scheme as well as field safe techniques such as alarms during failures. The RPU should be able to collect the sensor information from both remote liquid to air side (remote LTA HX) and internal RPU side. The sensor requirements are listed below:

Table 1 Required Sensor List for RPU (Inside RPU)

Sensor Name	Location/Function	Range	Sensor Accuracy
T_coolant_supply	Supply coolant temperature to IT gear	0°C to 100°C	±1°C

T_coolant_return	Return coolant temperature from LTA HX	0°C to 100°C	±1°C
Coolant Volumetric Flow Rate	Volumetric flow rate for coolant to LTA HX	10 L/min to 100 L/min	±1 L/min
Pump1 speed	Pump speed (RPM) in RPU	0 – Max RPM	±10%
Pump2 speed	Pump speed (RPM) in RPU	0 – Max RPM	±10%
… (PumpN speed)			
Internal Leak sensor	Leak detection	0 – No leak detected 1 – Leak detected	N/A
P_coolant_supply	Supply coolant pressure to IT gear	0 – 145 PSI	±1.5 PSI
P_coolant_return	Return coolant pressure from LTA HX	0 – 145 PSI	±1.5 PSI
Level sensor (Low)	Reservoir low level sensor	1 – Normal 0 – Low	N/A
Level sensor (High)	Reservoir low level sensor	1 – Normal 0 – Full	N/A
Pump Temperature	Pump temperature for electrical or motor	0°C to 100°C	±1°C
RPU Power Consumption	Total power consumption consumed by RPU	W	±2%

Table 2 Required Remote Sensor List (Outside RPU)

Sensor Name	Location/Function	Range	Sensor Accuracy
T_HX_Inlet	Inlet liquid temp into HX	0°C to 100°C	±1°C
T_air_in_1	Inlet air temperature for LTA HX airside	0°C to 100°C	±1°C
T_air_out_1	Outlet temperature for LTA HX airside	0°C to 100°C	±1°C
T_air_rackon_1	Rack air on temperature	0°C to 100°C	±1°C
T_air_in_2	Inlet air temperature for LTA HX airside	0°C to 100°C	±1°C
T_air_out_2	Outlet temperature for LTA HX airside	0°C to 100°C	±1°C
T_air_rackon_2	Rack air on temperature	0°C to 100°C	±1°C
T_air_in_3	Inlet air temperature for LTA HX airside	0°C to 100°C	±1°C

T_air_out_3	Outlet temperature for LTA HX airside	0°C to 100°C	±1°C
T_air_rackon_3	Rack air on temperature	0°C to 100°C	±1°C
dP_LTA HX (optional)	Pressure drop across LTA HX	TBD	±2%
Airflow (calculated)	Air-side airflow through LTA HX	5 to 6500 CFM	±2%
Fan1 PWM	Fan duty cycle	0-100%	±0.5%
Fan2 PWM	Fan duty cycle	0-100%	±0.5%
… (FanN_PWM)			
Fan1_speed	Fan speed (RPM)	0 – Max RPM	±10%
Fan2_speed	Fan speed (RPM)	0 – Max RPM	±10%
…(FanN_speed)			
Fan Power	Total fan power	W	±2%
External Leak sensor	Leak detection	0 – No leak detected 1 – Leak detected	N/A

7.2 Control Scheme

Control algorithm should be implemented in the RPU to ensure desirable operating condition. The RPU will control based on two setpoints: Coolant pressure differential (supply and return) and Coolant Supply temperature.

- *Coolant Differential Pressure*: The data center will set the desired coolant differential pressure (via redfish, and/or in a cfg file upgraded via firmware upgrade) based on the IT gear installed in the rack. The differential pressure will be used to ensure the desired flow rate is achieved, regardless of how many chassis are installed in the rack. The control system will vary the pump speed to achieve the desired differential pressure.
- *Coolant Supply Temperature*: The data center will set the desired coolant supply temperature (via redfish, and/or in a cfg file upgraded via firmware upgrade) based on the IT gear installed in the rack. The control system will vary the fan speed to achieve the desired coolant supply temperature.

7.3 Alarms and Field Safety

- *Alarms and Warnings*: All sensors shall be configured with both warnings and alarms. All sensors shall hi and low warnings and alarms (i.e. Temperature < 5C or Greater than 50C), and fault alarms. Only those warnings and alarms that are configured will be reported. Warnings are non-latching and represent the current state of the system. Alarms are latching and must be cleared by an acknowledgement from the DCIM. System management should be alerted for all the failure modes outlined in table below. Examples of failure mode is showed in below table.

Table 3 Example Failure Modes and Anticipated RPU Responses

Item	RPU Response
Pump Failure (with remaining redundancy)	• Increase Heat Exchanger fans speed • Turn on Fault LED
Heat Exchanger Fan Failure (with remaining redundancy)	• Increase pump speed • Turn on Fault LED
Low Pressure Detected	• Turn on Fault LED
High Pressure Detected	• Turn on Fault LED
High Temperature Detected	• Increase pump speed to max • Increase fans speed to max • Turn on Fault LED
Flow Rate Sensor Triggered	• Increase pump speed to max • Fan speed still controlled by coolant temperature • Turn on Fault LED

- *Catastrophic Failures and Field Safety*: Catastrophic failures are characterized as those which require the system to shut down due to risk of further damage to equipment of safety of equipment and service personnel.

Table 4 Example Catastrophic Failures and Field Safety Requirements

Item	RPU Response	IT Rack Response
RPU Leak (Int. or Ext. Sensor)	• Turn off pumps • Turn off fans • Turn on Leak Detected LED • Assert Pump Stop Signal to IT rack • Assert Cooling Loss Siren (CLS) to system management	• System Implementation Dependent ○ Emergency power down ○ Controlled power down ○ Throttle CPU/GPU/ASIC ○ No response ▪ Depend on CPU/GPU/ASIC internal thermal management
IT Rack Leak (Int. or Ext Sensor)	• Turn off pumps • Turn off fans • Assert Cooling Loss Siren (CLS) to system management	• Assert IT Leak Detection Signal to RPU • System Implementation Dependent ○ Emergency power down ○ Controlled power down ○ Throttle CPU/GPU/ASIC ○ No response

		▪ Depend on CPU/GPU/ASIC internal thermal management
Fluid Level Sensor Triggered	• Assert Pump Stop Signal to IT • Turn off pumps • Turn off fans • Turn on Fault LED	• System Implementation Dependent ○ Emergency power down ○ Controlled power down ○ Throttle CPU/GPU/ASIC ○ No response ○ Depend on CPU/GPU/ASIC internal thermal management

8. Environmental Conditions

Following table outlines air-side conditions for both operational and non-operational conditions.

Table 5 operational and non-operational conditions

Specification	Condition	Requirements
Temperature	Operating (Inlet)	• 41°F to 95°F (5°C to 35°C) • Maximum rate of change: 18°F/hour (10°C/hour) • Allowable derating guideline of 1.6°F/1000ft (0.9°C/304m) above 3000ft
	Non-operating (Storage)	• -40°F to 158°F (-40°C to 70°C) • Rate of change less than 36°F/hour (20°C/hour)
	Non-operating (Transportation or short-term storage)	• -67°F to 185°F (-55°C to 85°C) • Rate of change less than 36°F/hour (20°C/hour)
Humidity	Operating	• 10% to 90% relative humidity (RH); non-condensing • Maximum rate of change of 20% (RH) per hour
	Non-operating	• 5% to 95% relative humidity (RH); non-condensing • 100.4°F (38°C) maximum wet bulb temperature
Altitude	Operating	• 10,000ft (3050m) maximum • Rate of change less than 1500 ft./min (457m/min)
	Non-operating	• 30,000ft (9144m) maximum • Rate of change less than 1500 ft./min (457m/min)

Gaseous contamination: Severity level G1 per ANSI/ISA 71.04-1985

9. Serviceability and Operational Impact

9.1 Touch Points

When installed in the rack and operational, surfaces of the RPU that are accessible should always be maintained at or below 65°C. This is to ensure safety of personnel during service operations.

9.2 Pump

Minimum number of cycles for pump removal/installation: This is dependent on a number of factors including (but not limited to) expected failure rates. As a starting point, a minimum of 20 cycles must be supported or designed-in (a single cycle includes uninstallation and reinstallation of a part). As influencing parameters are better understood or evaluated, this value can be defined based on expected cycles through the life of the product (from assembly to de-commissioning) with a safety factor.

9.3 Filtration

The RPU system peripherals such as Cold Plates, valves and other components that are sensitive to small particulates will dictate the specific filtration requirements. Because these components introduce smaller flow paths relative to the RPU, it is important to ensure all equipment is thoroughly flushed before deployments.

At a minimum, a 100-micron filter is to be used to reduce the risk of clogging up delicate path ways in the system. Depending on the Cold Plate and valves used in the system, a smaller filter size may be needed.

The filter can be located inside or outside the RPU. If the lifetime of the filter is expected to be under 5 years under continuous operation, the filter will need to be easily accessible for servicing and replacement without stopping flow to the system.

Considerations for an additional filter at RPU fill port to be made to reduce the number of contaminants introduced to the system during coolant maintenance and top-ups. External fill kits can also include in-line filter.

9.4 Loading Force

Loading force is dependent on total system weight and rails used for mounting to rack. For ORV3 systems, RPU system weight should not exceed 80 kg to be able to use ORV3 rails and maintain acceptable loading force into the rack.

9.5 LED Standard

Start with GREEN and AMBER, but this might vary based on end-user.

9.6 Service events

The RPU's hot-swappable pump design should allow for field replacement of the pump as well as any fans required to provide cooling to the pumps.

As the RPU is rack mounted, and will not have accessibility from the top or sides, any other failure with components within the RPU will require the entire system is replaced. This will require service personnel to power down the rack, and entire the hot aisle to disconnect the large dry-break QDs.

10. Compliance and Safety

10.1 ESD compliance

The RPU shall be certified to EN 55032 and EN 55035 for noise EMC immunity and emission.

10.2 Flame Rating

Plastic parts (except tubing) used in Liquid Cooling system shall be made of min. 94V-1 material. Tubing can be made of min. HB75 class material if the thinnest thickness of the material is < 3 mm, or min. HB40 class material if the thinnest thickness of the material is ⩾ 3 mm.

10.3 Safety

The RPU shall be certified to UL/IEC 62368-1.

10.4 Air Venting Size

Max venting size should be less or equal than 5mm.

10.5 Environmental

The RPU shall comply with the Directive on Restriction of the use of certain hazardous substances in electrical and electronic equipment, 2011/65/EU.

10.6 Noise

Noise exposure shall meet the requirements of the local regulatory agency. See below for EMEA and USA reference values.

- EMEA: Daily noise exposure level (8h) of 80dB(A) and peak sound pressure of 112Pa respectively
- USA: Designed to meet requirements of 29 CFR 1910.95 (OSHA). Occupational exposure limit (OEL) specifies an 8-hour TWA sound level of 85dBA.

10.7 Vibration & shock

The system shall meet shock and vibration requirements according to the following IEC specifications: IEC78-2-(*) & IEC721-3-(*) Standard & Levels; the testing requirements are listed in Table 9.21. Training Supercomputer prototype server shall exhibit fully compliance to the specification without any electrical discontinuities during the vibration and shock tests. No physical damage or limitation of functional capabilities (as defined in this specification) shall occur to the Training Supercomputer prototype server during the non-operational vibration and shock tests.

Table 6 Vibration and Shock Requirements

	Operating	**Non-Operating**
Vibration	0.5g acceleration, 1.5mm amplitude, 5 to 500 Hz, 10 sweeps at 1 octave / minute per each of the three axes (one sweep is 5 to 500 to 5 Hz)	1g acceleration, 3mm amplitude, 5 to 500 Hz, 10 sweeps at 1 octave / minute per each of the three axes (one sweep is 5 to 500 to 5 Hz)
Shock	6g, half-sine 11mS, 5 shocks per each of the three axes	12g, half-sine 11mS, 10 shocks per each of the three axes

11. Production Test Requirements

The RPU should be tested to ensure proper leak free operation out of the box.

11.1 Leak Testing

Gas leak testing shall occur during the manufacturing process to ensure that there are no leaks.

11.2 Functional Testing and Calibration

Functional testing shall ensure that all sensors are operating as expected. Any sensor that needs calibration shall be configured at the factory.

11.3 Burn-in Testing

Burn-in testing shall be performed on the RPU in-order to catch pre-mature failures of the entire assembly. The methodology for this test is dependent on the individual components used, operating conditions and other factors.

11.4 Test-to-failure:

As part of long-term reliability testing, HALT and/or Test-to-failure is expected to be performed on a sample size of 3 units to determine the upper and lower functional thresholds of the RPU. This would entail the following.

- Thermal Cold Step (TCS): 25C; ROC: 10C/min (-); 10 min stress/power cycle test during dwell; Determine operating limit
- Thermal Hot Step (THS): 25C; ROC: 10C/min (+); 10 min stress/power cycle test during dwell; Determine operating limit
- Thermal Shock: (TCS operating limit + 5C) – (THS operating limit – 5C); ROC: 50C/min; 5 cycles (thermal, power); 5 min dwell or as applicable to higher thermal mass components reaching steady state
- Mechanical Vibration: 5 Grms; 5 Grms increments, 10 min dwell with stress; Determine operating limit and destruction limit (at >30 Grms, reduce to 5 Grms at every step)
- Combined Thermal-Mechanical Stress: Combined thermal shock and vibration test with thermal cycling at fixed vibration state for 5 combined cycles

Sample units under test would need to be monitored for functional performance as part of this activity and driven towards initiating permanent failure to capture the design robustness of the RPU.

12. Long Term Reliability

Long term reliability of the RPU can be categorized into Mechanical, Electrical, Thermal, Communications, and Chemical implications of product quality and reliability, and as such would be accounted to ensure the following tests are executed as prior to volume production ensuring the samples are pre-conditioned as well as functionally verified before and after the tests listed below. Note that the tests listed below encompass stress testing various functional aspects of the RPU based on a mutually agreed upon sample size and applicable application needs.

Table 7 Long Term Reliability Test Requirements

Stress Test	**Test Criteria**	**Standards (As Applicable)**	**Sample Size**
Power Cycling	Temperature @ Max rated ambient, 250 cycles. Power up= Time to boot + time to acquire IP + time to record min. of one log. Pass criteria: the power up time should be less than certain threshold (usually couple of minutes, pending on end-user's requirement)	N/A	3
Hydrostatic Pressure	5x operating (35psi) = 175psi for 120s dwell. Pass criteria: no leaks, ruptures, loosening	UL 62368	3
Communications Check	Monitoring performance, data	N/A	-
Coolant Check	Dwell @ max coolant temp for 10 hrs. Compare coolant sample to baseline lab analysis	N/A	3
Leak Check	Fill unit with N2/H2 to 35psi, dwell time 24hrs. Attach gauge to fill/drain port. Pass criteria: final pressure within 10% of 35psi.	N/A	3

Shock and Vibration	Section 8.7 (from above) Pass criteria: passes hydrostatic test, normal power and pump operation	IEC78-2, IEC721-3	1
Altitude (Operating)	6000ft Pass criteria: no overheat, pass hydrostatic pressure test	N/A	1
Altitude (Non-Operating)	10000ft Pass criteria: pass hydrostatic pressure test	N/A	1
Packaging	No damage/performance impact pre/post-test	ISTA-2A (Vibe, Drop)	3
Thermal Cycling (Operating)	Temperature: 15C to 45C; RH: 10%-90% ROC: 10C/15min; 5%/min Cycles: 50 (at max thermal ramp rate available). Pass criteria: No leaks, passes hydrostatic pressure test, functional test requirements	N/A	3
Thermal Cycling (Non-Operating)	Temperature: -20C to 70C; RH: 10%-90% ROC: 10C/min; 5%/min Cycles: 50 (at max thermal ramp rate available). Pass criteria: No leaks, passes hydrostatic pressure test, functional test requirements	N/A	3
Humidity (Operating)	RH: 10%-90% ROC: 5%/min Cycles: 50 (at max thermal ramp rate available). Pass criteria: No leaks, passes hydrostatic pressure test, functional test requirements	N/A	3
Humidity (Non-Operating)	RH: 10%-90% ROC: 5%/min	N/A	3

	Cycles: 50 (at max thermal ramp rate available). Pass criteria: No leaks, passes hydrostatic pressure test, functional test requirements		
4-Corner Testing	15C-45C, 10-90%; 25 cycles across all corners; 30min dwell; Max pump	N/A	3
Dust Chamber	Passes functional test	IEC 60529 (IP5X/IP6X)	1
Durability	25 mate/un-mate cycles; No damage/perf impact		3
Salt fog	No damage/performance impact	ASTM B117	3
Coolant soak	Operation for 90 days with coolant at 65°C; Coolant sampling 200ml – 0, 30, 60 & 90 days; in clear glass bottles for visual check prior to sending to coolant vendor for chemical analysis	N/A	3