# High-Performance Two-Phase Cooling Under Different Cold Plate Orientations

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## Introduction

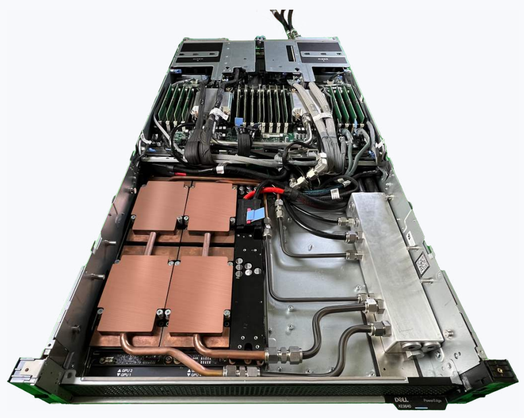
- **Thermal design power of processors is surging driven by AI workloads**
  - Current: ~1000W; Future: approaching 2000W
- **Two-phase direct-to-chip cooling offers great advantages**
  - Superior heat transfer (via nucleate boiling)
  - Isothermal processor case surface
  - Dielectric safety vs. water in case of leaks
  - Cost-effective and retrofittable to existing data centers
- **Higher chip- and rack-level power densities necessitate innovative thermal packaging and management designs:**
  - Traditional cold plates have standard horizontal upward orientation
  - New server designs (e.g., vertical blades, upside-down racks, double-sided cooling) require cold plates with horizontal downward or vertical orientations

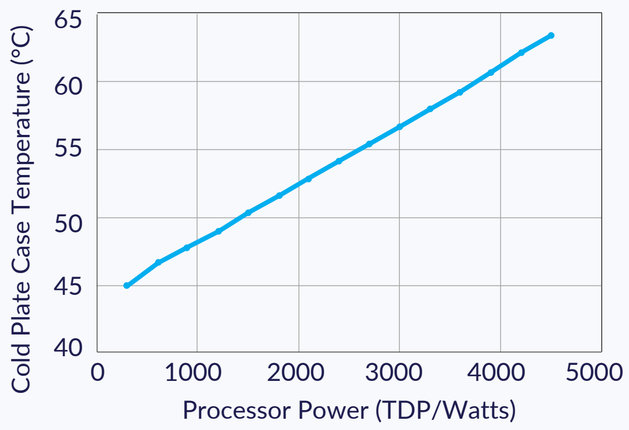

Liquid Cooled Kyber Rack with Vertical Servers Set for Deployment 2027 (NVIDIA at GTC March 2025)

## Example Two-Phase Products

**CDU:**

- Closed-loop system with dielectric fluid (eco-friendly R1233zd(E) or high-performance R515B)
- The largest cooling capacity two-phase in-row CDU: MR250
- Able to cool 250kW of H100 servers with 40°C facility water

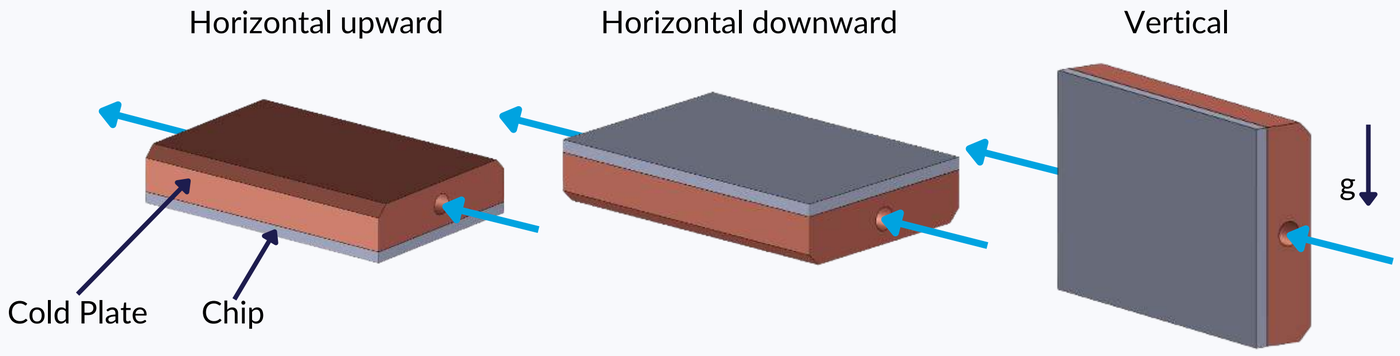





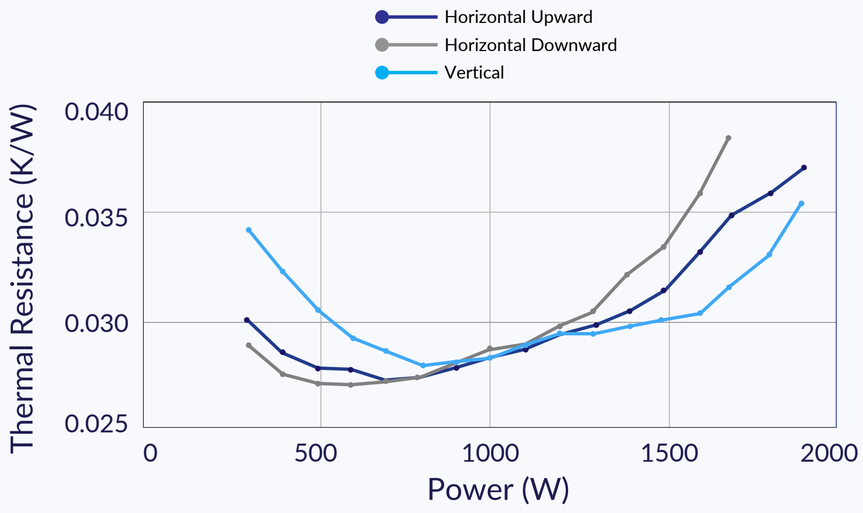

**Cold Plate:**

- Standard skived copper cold plate with flow boiling design
- Tested using R515B on a GPU TTV with saturation temperature at 40°C
- 4,500W was removed efficiently before wall power limitations were reached

## Orientation Effects on Performance




- Three orientations tested for a cold plate tested without any orientation-specific modifications
- Performance Differences attributed to vapor bubble behavior and buoyancy-driven flow patterns
- All orientations maintained high thermal performance; no dry-out observed
- Orientation-specific design should yield even better performance




## Summary: Orientation-Resilient Design

- Two-phase cooling delivers superior performance, enabling 250kW racks and 4500W TDP processors
- Future high-power racks and processors will require vertically mounted servers/processors or downward cooling
- Accelsius' two-phase flow boiling cold plates demonstrated reliable high performance in all orientations under consideration
- Our technology supports flexibility in server architecture (e.g., blades, edge racks, double-sided cooling), and enables thermal management of high-power processors in compact, high-density layouts

## References

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[6] Q. Wang, et al. "Universal Direct-to-Chip Cold Plates for Single- and Two-Phase Cooling," OCP Global Summit 2024.
[7] Q. Wang, et al. "A Practical Metric for Cold Plate Thermal Performance in Two-Phase Direct-to-Chip Cooling", Semi-Therm, 2025.
[8] Q. Wang, et al. "Performance Comparison of R1233zd(E) and R515B for Two-Phase Direct-to-Chip Cooling", IEEE ITherm, 2025.