

Server Direct-to-Chip Cold Plate Surface Flatness and Roughness Specs - Official Technical Overview & Hardware Datasheet

EXECUTIVE SUMMARY

This document defines the authoritative surface metrology specification for direct-to-chip (DTC) cold plate assemblies deployed in high-density server platforms. As thermal design power (TDP) envelopes for next-generation CPUs, GPUs, and AI accelerators exceed 1000W per socket, the interfacial quality between the cold plate base and the processor integrated heat spreader (IHS) becomes the single most critical determinant of junction-to-coolant thermal resistance. This datasheet establishes the mandatory flatness and roughness tolerances, measurement methodologies, and verification protocols for all OEM-qualified cold plate hardware.

The specifications herein are derived from empirical thermal characterization across production server platforms and are intended for thermal engineers, mechanical designers, and datacenter integration teams responsible for liquid-cooled infrastructure qualification.



ARCHITECTURE & CHASSIS DESIGN

Cold plate assemblies covered by this specification are constructed from copper C1100 or aluminum 6063-T5 base plates with nickel plating optional for corrosion resistance in mixed-metal loops. The mechanical interface between the cold plate and the processor package is mediated by a thin layer of thermal interface material (TIM), whose performance is directly governed by the surface topography of the cold plate base.

Key design parameters include base plate thickness (typically 3.0 mm to 5.0 mm), microchannel fin geometry, inlet/outlet port configuration (G1/4 or quick-disconnect), and mounting hole pattern compatible with Intel Socket E, AMD SP5/SP6, and OAM 2.0 form factors. The surface finish specification applies to the entire primary contact region, defined as the rectangular area

circumscribing the processor IHS footprint plus a 2.0 mm peripheral margin.

HARDWARE FEATURES

Mandatory surface quality attributes include:

Flatness (Planarity): The maximum deviation from a reference plane across the contact region shall not exceed 25 micrometers (um) for standard server CPUs and 15 um for high-wattage AI accelerators. This is a critical-to-quality (CTQ) parameter directly affecting TIM bond line thickness (BLT).

Surface Roughness: The arithmetic average roughness (Ra) shall be maintained between 0.2 um and 0.8 um. Surfaces smoother than 0.2 um risk insufficient TIM anchoring and pump-out; surfaces rougher than 0.8 um introduce excessive contact resistance.

Waviness (Wt): The maximum waviness height shall not exceed 5 um over any 10 mm sampling length to prevent localized TIM starvation.

Surface Defects: No scratches, pits, or inclusions exceeding 50 um in depth or 200 um in length are permitted within the contact region.

COMPLIANCE & STANDARDS

All cold plate surface specifications conform to the following industry standards:

- ASME B46.1 Surface Texture (Surface Roughness, Waviness, and Lay)
- ISO 4287 Geometrical Product Specifications (GPS) - Surface Texture
- ASTM D374M Standard Test Methods for Thickness of Solid Electrical Insulation (TIM BLT verification)
- IEC 62368-1 Safety requirements for liquid-cooling systems in IT equipment
- OCP Cold Plate Base Specification (Open Compute Project) Rev 2.1

Measurement shall be performed using a coordinate measuring machine (CMM) with a minimum resolution of 1 um, or a non-contact optical profilometer with sub-micron vertical resolution. Contact profilometry is permitted only for roughness verification.

TECHNICAL SPECIFICATIONS

Parameter	Specification
Base Plate Material	Copper C1100 (standard) / Aluminum 6063-T5 (lightweight option)

Plating	Electroless Nickel (Ni-P), 5-10 μm thickness, optional
Contact Region Flatness (CPU)	≤ 25 μm total deviation from reference plane
Contact Region Flatness (AI/GPU)	≤ 15 μm total deviation from reference plane
Surface Roughness (Ra)	0.2 μm to 0.8 μm
Surface Waviness (Wt)	≤ 5 μm over 10 mm sampling length
Maximum Surface Defect Depth	50 μm
Maximum Surface Defect Length	200 μm
Measurement Method (Flatness)	CMM or optical profilometer, 1 μm resolution
Measurement Method (Roughness)	Contact or optical profilometer, per ISO 4287
TIM Bond Line Thickness (nominal)	25 μm to 75 μm (dependent on TIM viscosity and mounting pressure)
Mounting Pressure	30-70 PSI (application-specific)
Port Type	G1/4 BSPP or quick-disconnect (QD) coupling
Operating Coolant Temperature	20C to 65C (non-condensing)
Maximum Operating Pressure	5 bar (72.5 PSI)
Leak Rate	< 0.5 mL/min at 5 bar

Compliance Standards	ASME B46.1, ISO 4287, OCP Cold Plate Spec Rev 2.1
Certification	Certificate of Conformance (CoC) per lot
Form Factor Compatibility	Intel Socket E, AMD SP5/SP6, OAM 2.0

The following table enumerates the complete surface metrology specification envelope for server DTC cold plate assemblies.

ORDERING OPTIONS

Standard part numbers encode base material, plating, port type, and surface grade. Customers requiring tighter flatness (e.g., 10 um for extreme-density AI sleds) must specify the precision grade option. Custom microchannel geometries and non-standard mounting patterns are available under NRE. All cold plates are shipped with a Certificate of Conformance (CoC) documenting measured flatness and roughness values for each production lot.

