# Overcoming the Spreading Limit: Total Thermal Resistance Reduction

MoltenDynamics
Precision Cooling. Unmatched Performance.

Thermal designers today face a choice between increasing power density and managing system complexity. When traditional air or water-glycol solutions hit the "Efficiency Wall," standard cooling becomes a bottleneck for architectural freedom.

## THE PROBLEM: The Resistance Bottleneck

- **Heat Flux Density:** Modern chips exceed the capacity of standard cold plate and water loop architectures.
- **The Spreading Limit:** Non-uniform heat distribution across CPU/GPU/HBM packages creates temperature gradients that limit performance.
- **Diminishing Returns:** Increasing fan or pumping power no longer yields proportional reductions in theta/jc.

## THE SOLUTION: Pumped Liquid Metal Loops

Our drop-in, closed-loop gallium-based solutions act as a "Thermal Lever," unlocking three core architectural advantages

- **100x Thermal Conductivity (k):** Compared to water-glycol, our fluid collapses the thermal boundary layer, allowing heat to soak into the fluid deeper and faster.
- **MHD Pumping (No Moving Parts):** Lorentz force pumps eliminate mechanical wear, vibration, and noise in an ultra-compact form factor.
- **Familiar Handling:** Liquid at room temperature with water-like viscosity, these alloys integrate seamlessly into existing infrastructure.

## IMPLEMENTATIONS: Flexible Integration

- **Liquid-Assisted Air Cooling (LAAC):** Replaces standard vapor chambers with a liquid metal loop to bypass the spreader bottleneck no facility water required.
- **Direct-to-Chip (D2C):** Full cold-plate integration for 1,000W+ sockets, delivering up to 4.5x higher sustained thermal density than traditional water blocks.

## THE PROOF: Data-Driven Performance

- **Heat Transfer Coefficient:** Our solutions sit on a significantly higher performance curve than high-end water cooling.
- **Pump Efficiency:** Our MHD pumps give us architectural freedom: silent, no moving parts, vs. conventional mechanical pumps.
- **Real-World Benchmarks:** Simulations and experimental data show liquid metal spreading ability that exceeds the current physical limits of copper/vapor.

# TECHNICAL DATASHEET: MOLTEN DYNAMICS CORE FLUID

## 1. Fluid Physics & Material Properties

| Property | Symbol | Value | Engineering Context |
|---|---|---|---|
| Density | ρ | 6,440 kg/m³ | 6.5x water; increased inertia and momentum. |
| Thermal Conductivity | k | 39.0 W/(m·K) | 65x water-glycol; bypasses boundary layer resistance. |
| Specific Heat | $c_p$ | 296 J/(kg·K) | Lower than water; heat is moved by flow, not bulk mass. |
| Melting Point | $T_m$ | −12 °C | Operates safely in sub-zero environments without additives. |
| Boiling Point | $T_b$ | ~2,000 – 2,200 °C | Effectively infinite headroom; will not boil in compute apps. |
| Viscosity (Kinematic) | v | 0.4 cSt | PG25-like; low pumping pressure requirements. |
| Prandtl Number | Pr | ~0.02 | Indicates thermal diffusion outpaces momentum. |
| Electrical Resistivity | ρ_e | 30 x $10^{-8}$ Ω·m | Critical for MHD pump efficiency. |
| Expansion | ΔV/V | 0.5% – 1% | Minimal risk compared to water's 9%. |

## 2. Thermal Engineering Constants

Liquid metal is a low-Prandtl-number fluid (Pr << 1). Traditional water-cooling correlations do not apply.

Thermal Boundary Layer: High thermal conductivity drives and facilitates rapid diffusion into the bulk fluid, bypassing traditional boundary layer resistance. The entire liquid volume acts as a contiguous heat sink, not just the pipe wall.

## 3. Material Compatibility (The "Gallium Table")

| Material | Compatibility | Corrosion Rate | Guidance |
|---|---|---|---|
| Aluminum | POOR | >10.0 mm/yr | Not recommended for use. |
| Copper | VERY GOOD | <0.002 mm/yr | Suitable for long-term use or with proper surface prep or Ni-plating. |
| Stainless Steel | EXCELLENT | <0.001 mm/yr | Highly robust; standard for tubing and pump housings. |
| Nickel | EXCELLENT | <0.001 mm/yr | Ideal barrier for cold plates. |
| Titanium | EXCELLENT | <0.001 mm/yr | Recommended for high-temp or high-reliability zones. |
| Polymers | EXCELLENT | N/A | Most plastics, glass, and seals are essentially non-reactive. |

© 2026 Molten Dynamics. All rights reserved. Proprietary and Confidential.

moltendynamics.com

info@moltendynamics.com