

Data Center Cooling: A transition from Air to Liquid Cooling to Meet Growing Industry Demands

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HEAT EXCHANGER TEST FACILITY

MECHANICAL ENGINEERING



Cooling in Data Centers - Overview

GW Scale Data Center



Racks in Data Center



Cold Plates in a Rack



Image Source: Boyd

- Artificial Intelligence is leading to the development of next generation Gigawatt-scale data centers

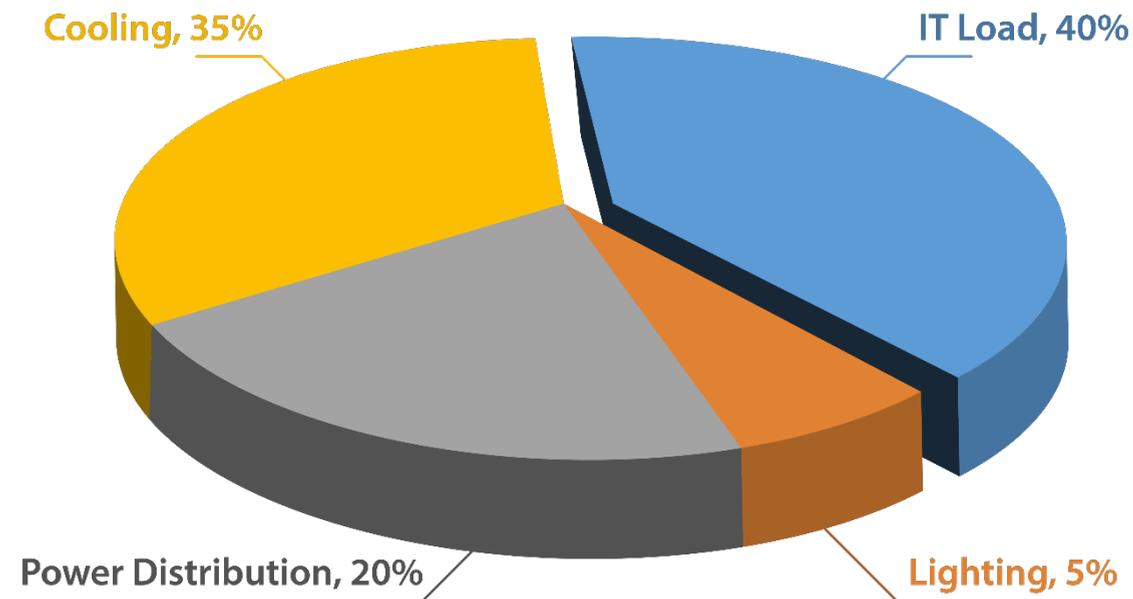
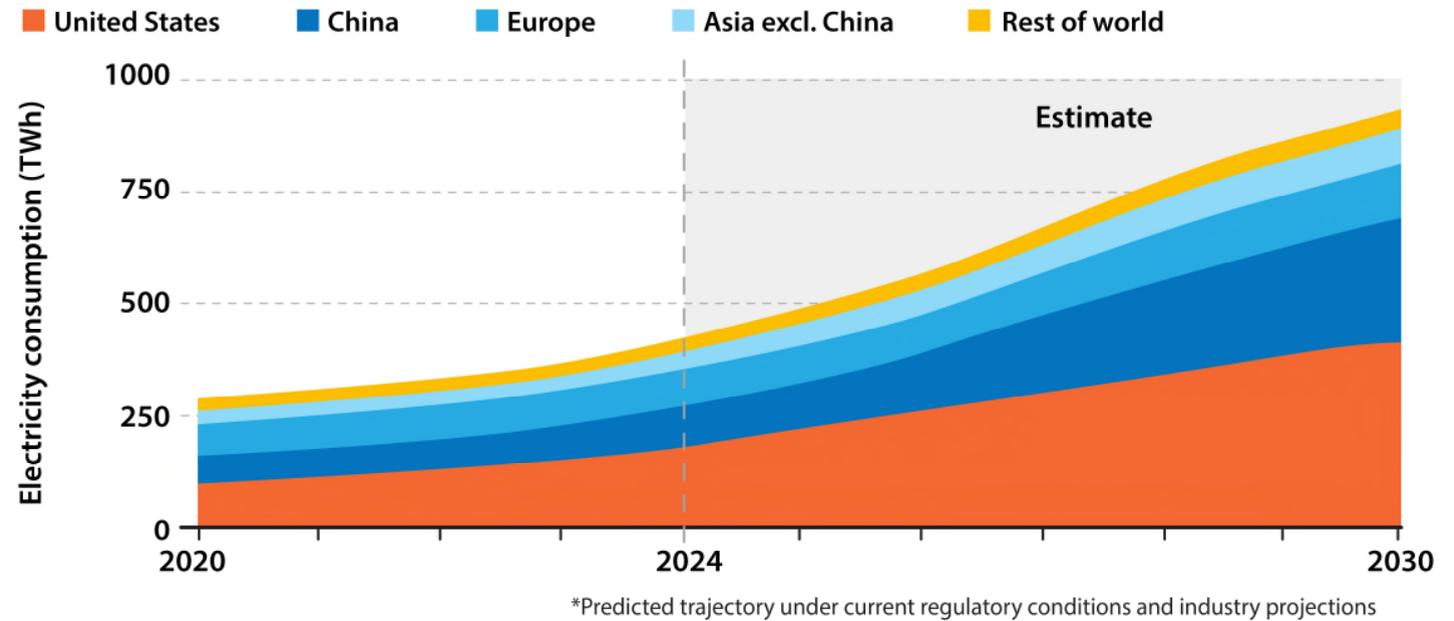
Cooling in Data Centers - Overview

Quick Facts

- 35-50% of power consumed by data centers is used for cooling
- Data center power consumption is set to surge 12% by 2028
- Driven by increased socket and Thermal Design Power of CPUs, GPUs, and AI accelerators

DATA-CENTRE ENERGY GROWTH

China and the United States are predicted to account for nearly 80% of the global growth in electricity consumption by data centres up to 2030*.



Data Center Cooling Classifications

Air Cooling

Indirect Liquid Cooling

Direct Liquid Cooling

CRAC 60 kW/rack CRAH

200 kw/rack
Cold Plate

Immersion Cooling

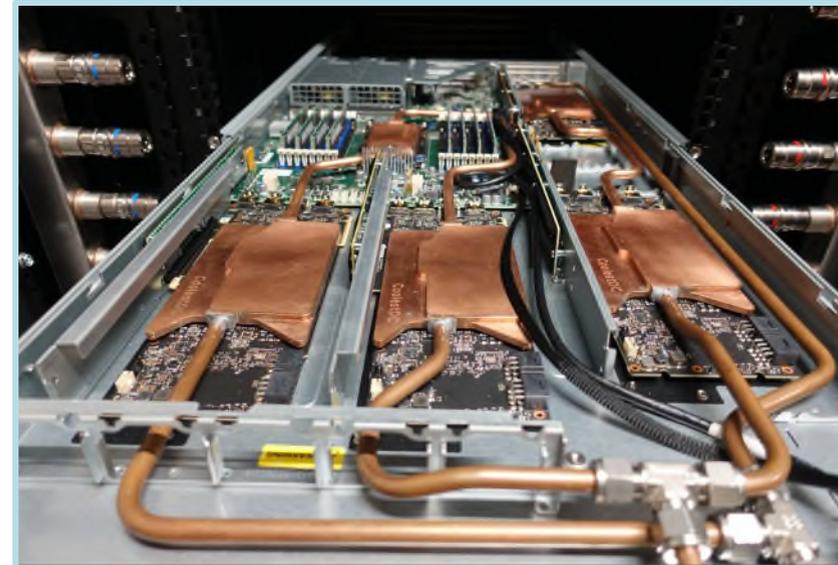


Image Source: AI Green Bytes

RDHX

SCHX

Spray Cooling

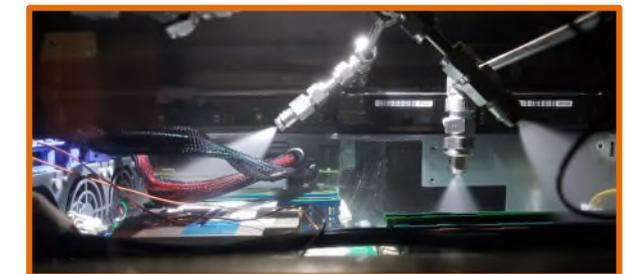


Image Source: CoolestDC

Image Source: Nanyang Technical University (NTU)

Single-Phase Flow

Two-Phase Flow



Liquid Only

Gas & Liquid

Jet Impingement

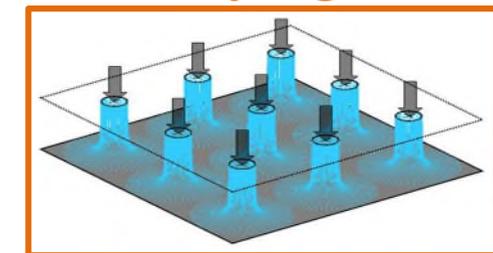


Image Source: The Cooling Technologies Research Center (CTRC)

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Image Source: Stulz



Data Center Cooling Technology – Testing and Evaluation

Heat Exchangers

Configured capacities up to 6.8 MMBTU/hr (2 MW)

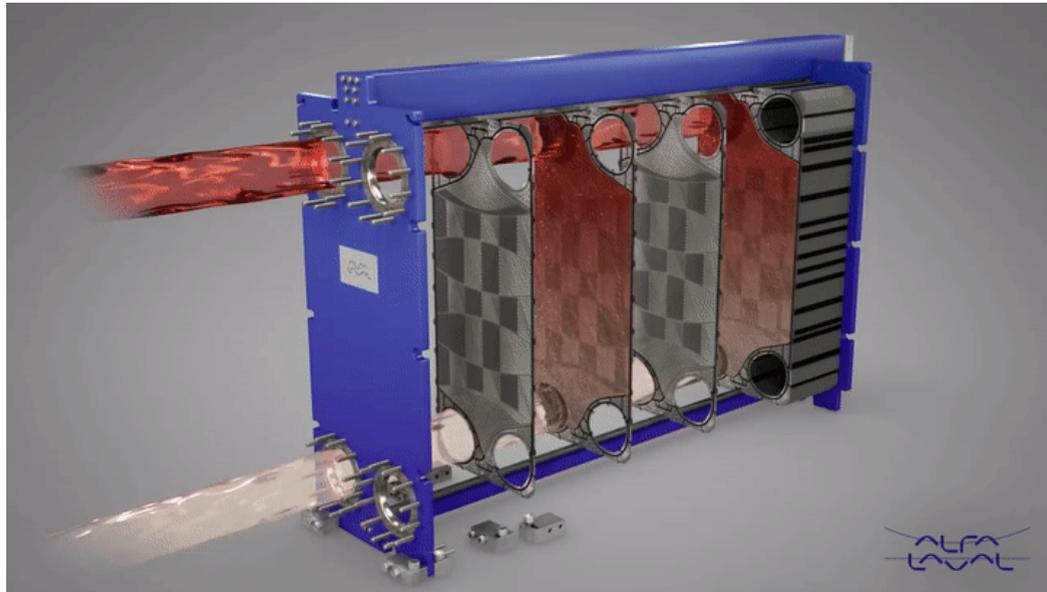


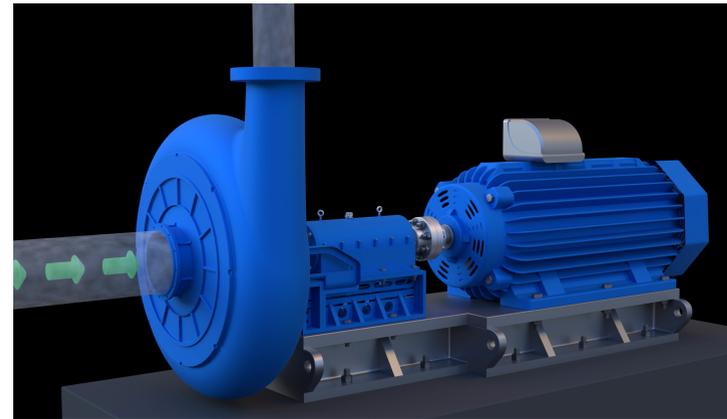
Image Source: Armstrong Fluid Technology



Image Source: Alfa Laval

Pumps

Centrifugal and Inline pumps with flow capacities up to 1,200 gpm



Pressure-Independent Control Valves

Controllable valves for regulating flow



Image Source: Danfoss

Variable Frequency Drives

Tested for Harmonics



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Data Center Liquid Cooling Hardware

Coolant Distribution Unit and Mechanical Equipment Skids

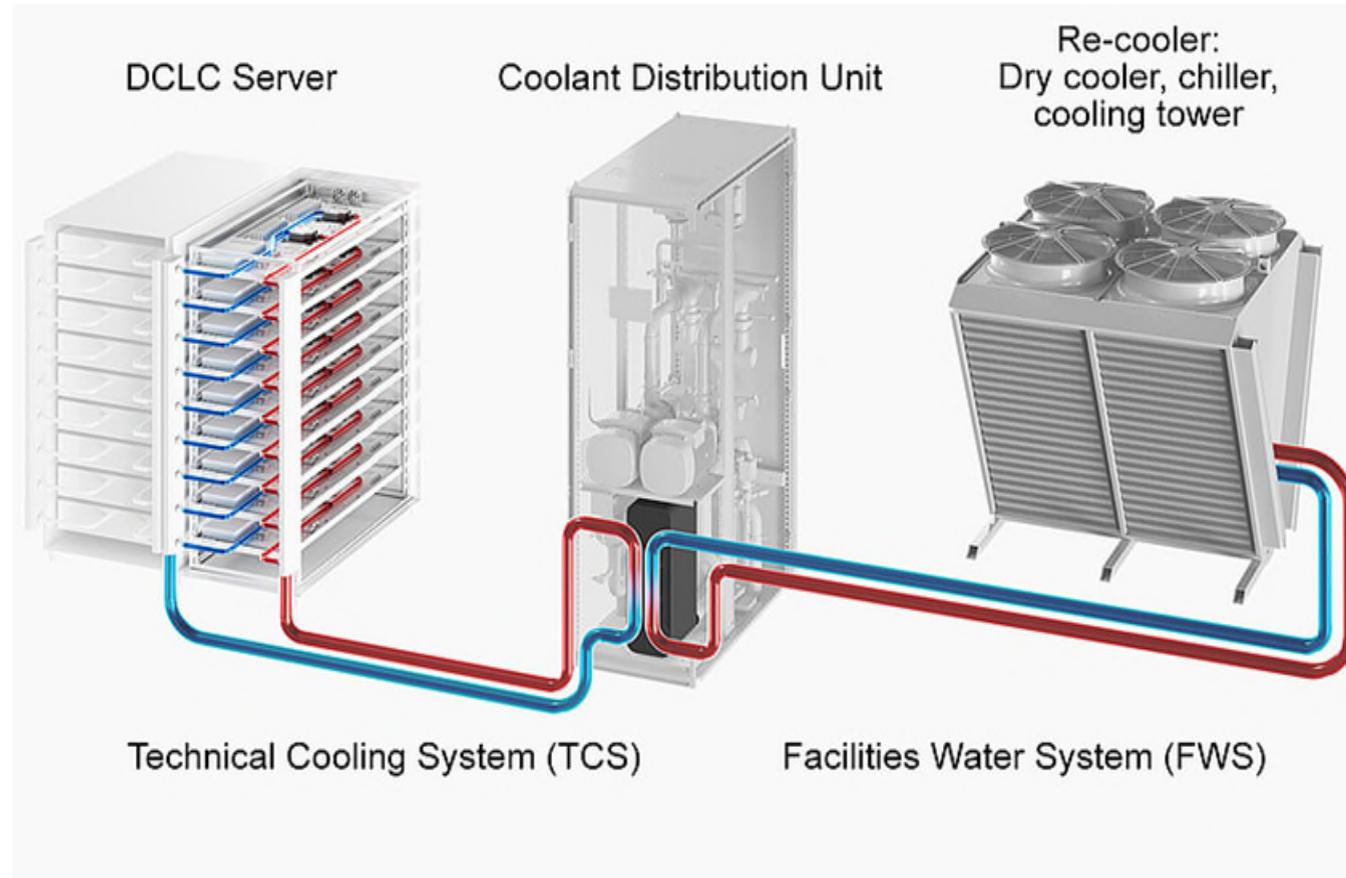


Image Source: Stulz



Image Source: nVent

Heat Exchanger and CDU Test Facilities

Medium-Scale HX Loop <1 MW

Facility Specs:

<u>Property</u>	<u>Value</u>
Nominal Pipe Size	3-inch Carbon Steel
Flow Capacity	250 gpm (1,000 lpm)
Heating Capacity	625 kw (upgradable to 1 MW)
Cooling Capacity	282-ton Chiller
Filtration	25-micron filter

- Built with guidance from
 - ANSI/AHRI Standard 401(SI)
- 1-sec data acquisition system
- Program-controlled valves and VFD
- Best-In-Class / High-Accuracy Instruments



Pictures of actual setup and test at SwRI



Heat Exchanger and CDU Test Facilities

Large-Scale HX Loop (1 MW+)

Facility Specs:

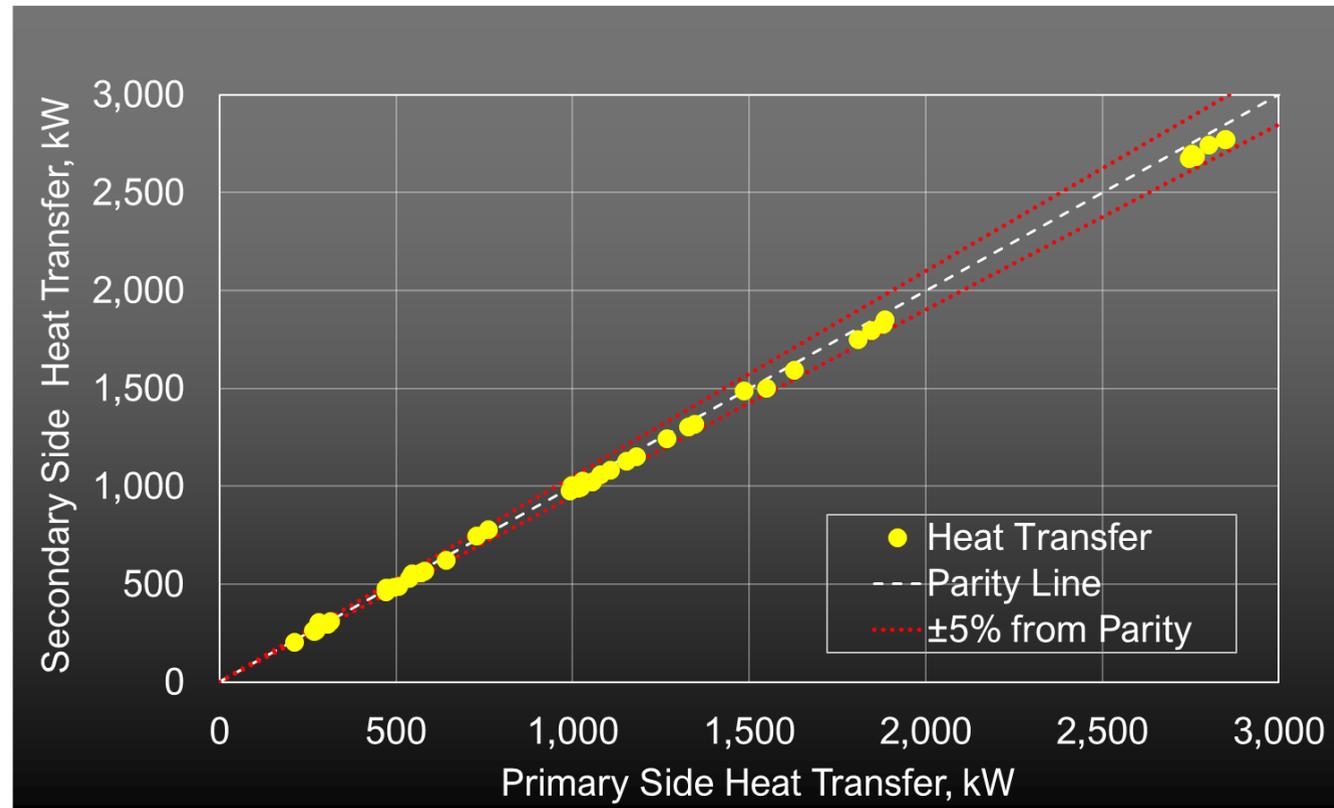
- Access to Pressurized City Natural Gas Line
- Current Configuration:
 - **Fixed components**
 - Built with guidance from
 - ANSI/AHRI Standard 401(SI)
 - ANSI/HI 2.6-2000 (pump testing)
 - 6-inch 304 Stainless-Steel Loop
 - 25-micron high-flow filtration system
 - Up to 1,500 gpm (~5,600 lpm) both sides
 - 1-sec data acquisition system
 - Program-controlled valves and VFD
 - Best-In-Class / High-Accuracy Instruments
 - Capable of Handling Dual Test Units
 - **Variable -- Rental (upgradable to 5 MW+)**
 - 3MW of heating (Steam Boiler) and cooling (Air-cooled Chillers)

Pictures and videos of actual setup and test at SwRI

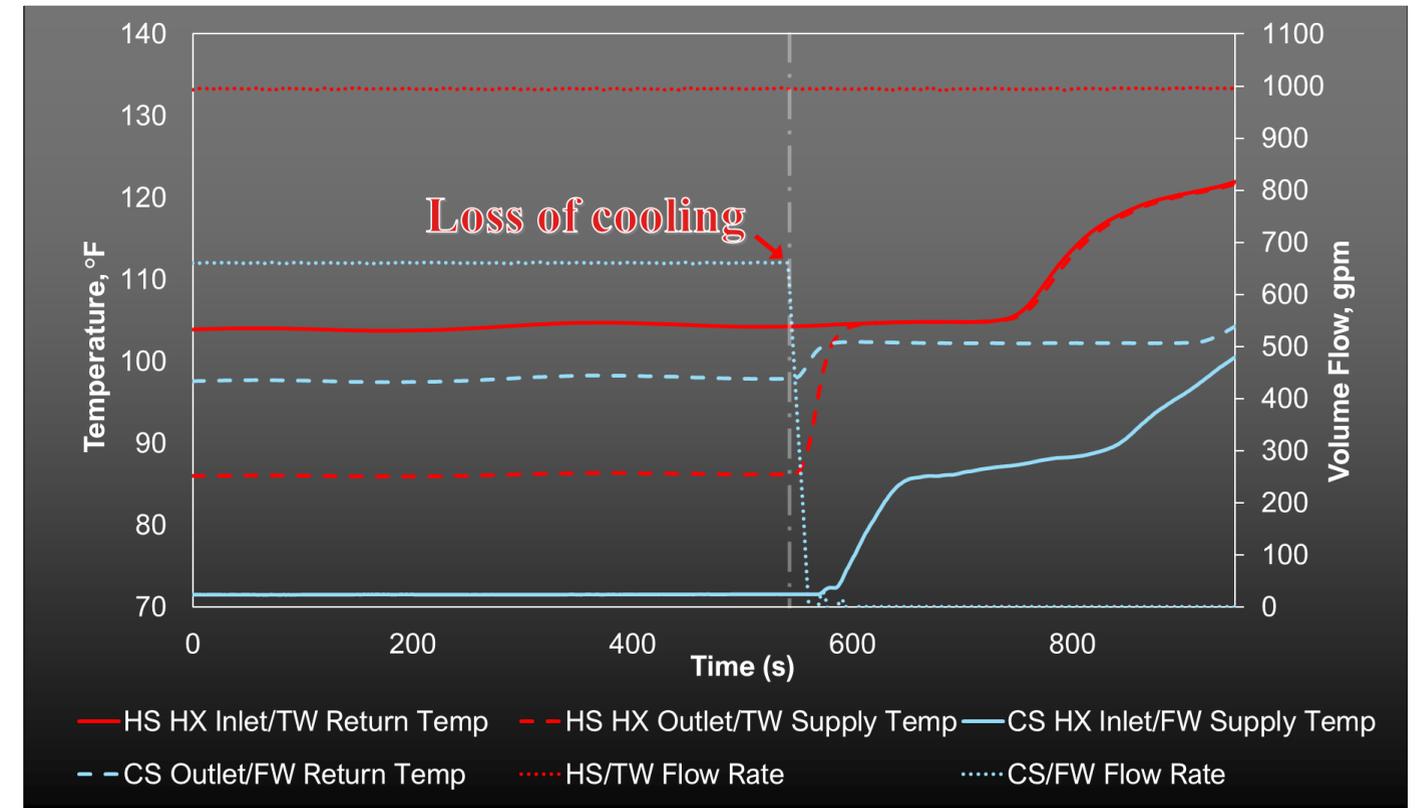


Steady-State and Transient Thermal-Performance Testing

Thermal Performance Test



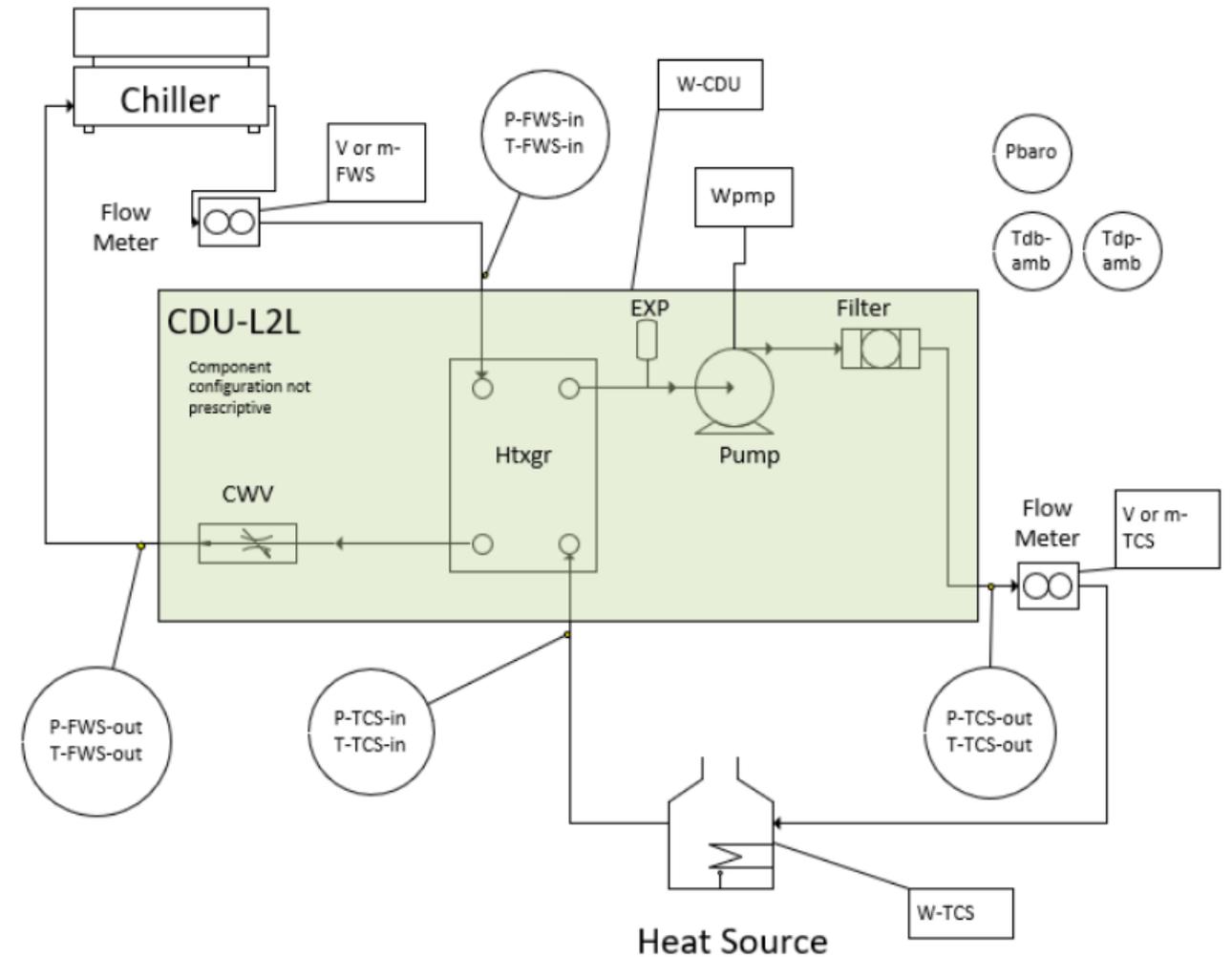
Loss of Cooling Transient Test



Steady-State and Transient Thermal-Performance Testing

Test to latest industry standard and client-specific tests

- ANSI/AHRI Standard 401(SI) - HX testing
- ANSI/HI 2.6-2000 - Pump testing
- ASHRAE 127-2020- CDU testing
- *Member of ASHRAE TC 9.9 mission-critical technical sub-committee and we actively refine and draft standards for the data center industry*

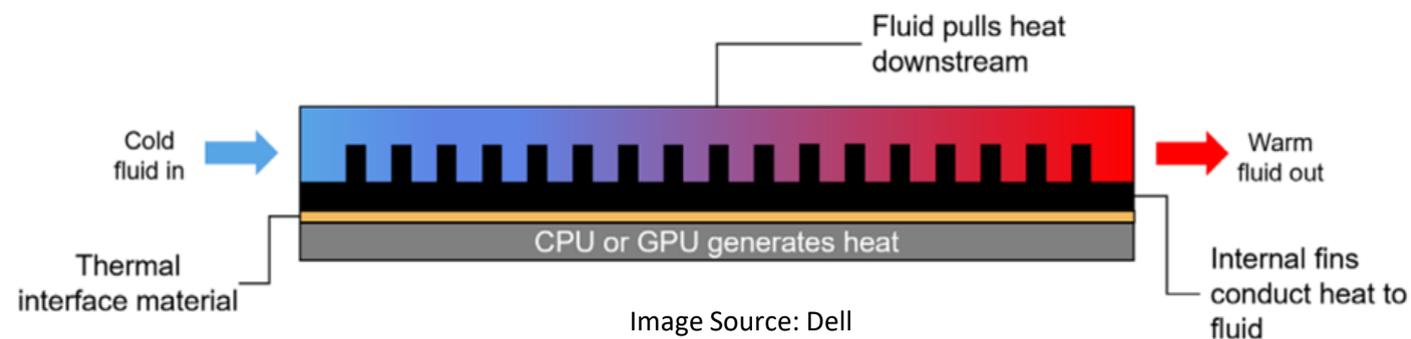
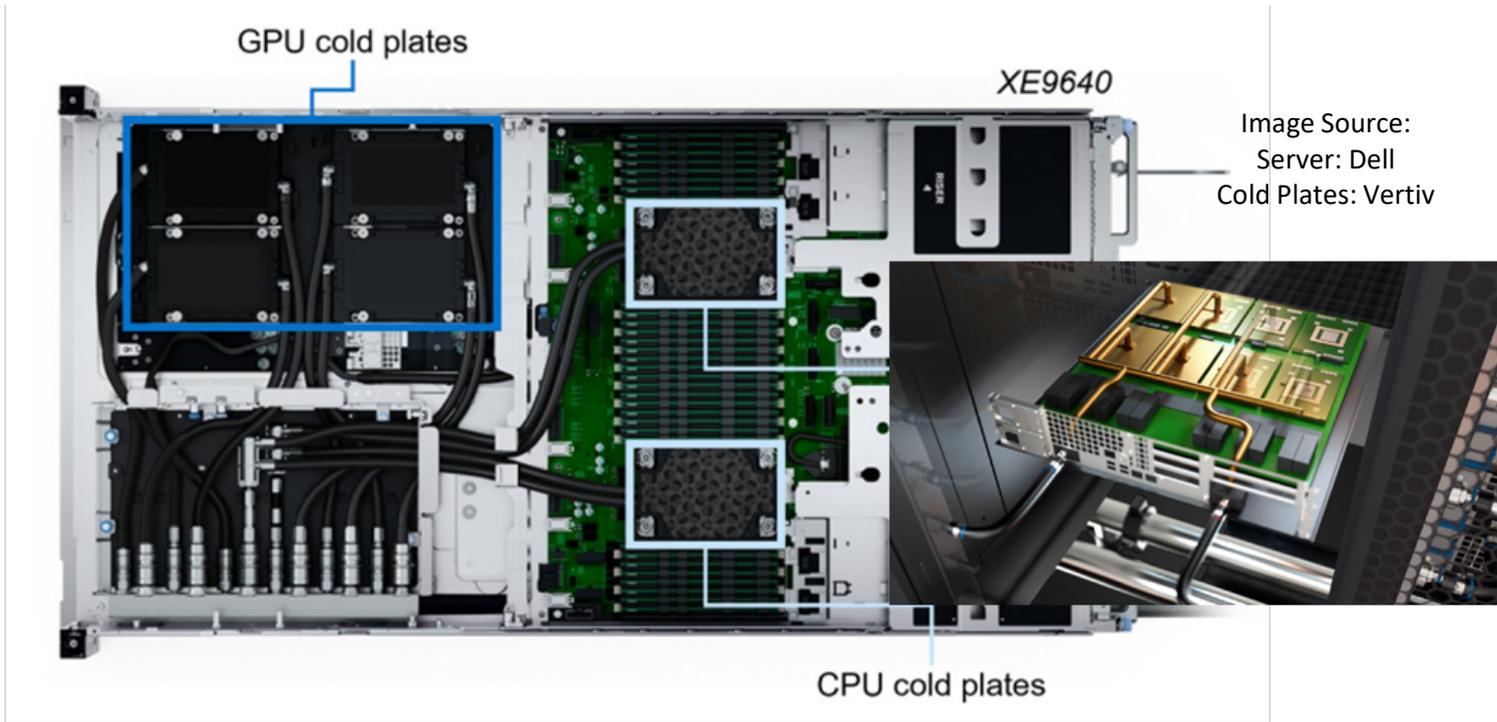


ASHRAE 127 Testing Requirements for Liquid-to-Liquid CDUs

Current R&D and Test Facility Work

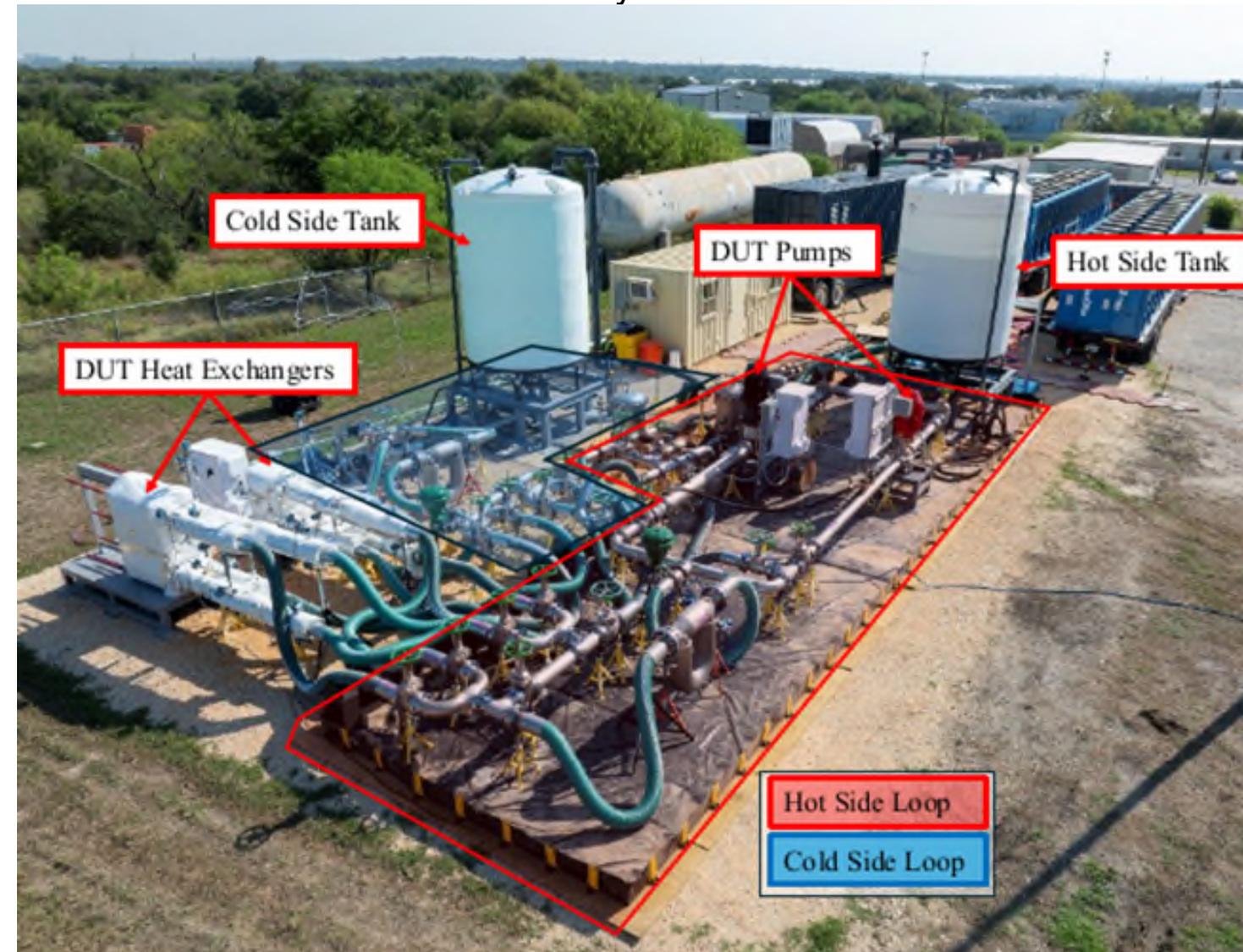
Two-Phase Direct-to-Chip Cooling – Server-Level Thermal Design

Internal Research project to develop and test novel cold plate for two-phase direct-to-chip cooling and handle high heat flux densities of future AI chips and Accelerators



Large-Scale Heat Exchanger Test Facility Upgrades

Development of an upgraded state-of-the-art permanent 5 MW HX and CDU test facility with enclosure



Summary

