Intel Open IP 浸沒式冷卻參考設計

供應鏈的驗證整合與合作分享

Supply Chain Integration, Validation and Collaboration

intel

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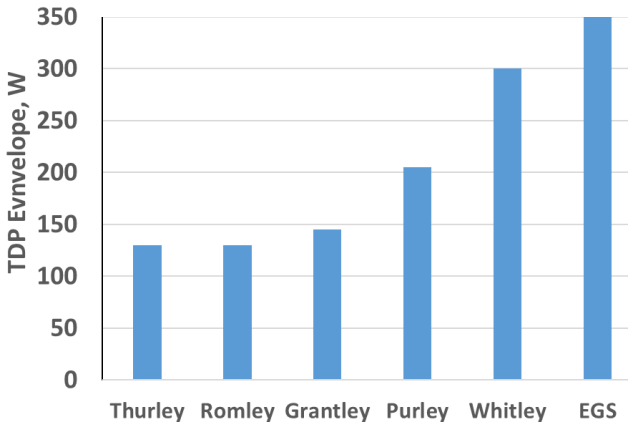
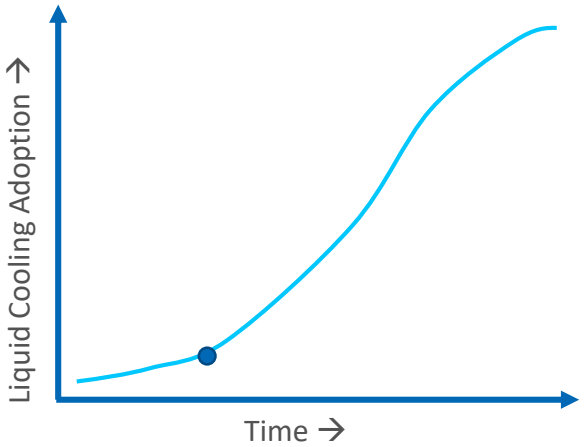
Agenda

- Liquid Cooling Key Drives & Forecast
- Advanced Cooling Solutions Journey
- Open IP Immersion Cooling Roadmap Update
- 2023 Goal
  - 4U deployment kit update
  - Edge AAIC solutions
  - Synthetic Oils continuous work in progress
  - Innovated immersion cooling server heat sink
  - Optical AOC for immersion cooling update
- Ecosystem Collaboration
- Call to Action

Drivers of Liquid Cooling

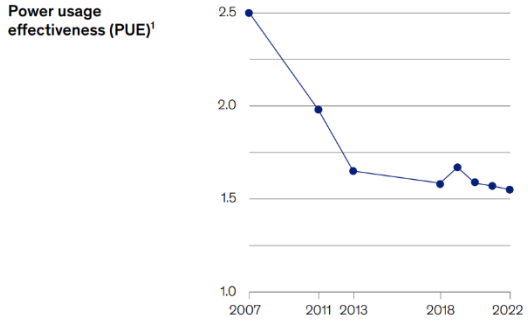
Component Power





Sustainability and Regulatory

Gains in power usage efficiency have stalled during the past decade.



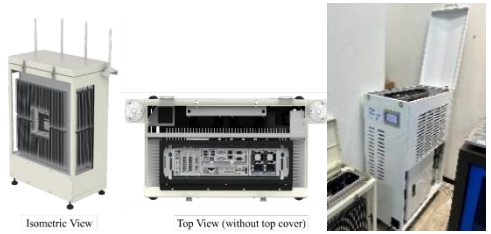
[1]A measure that shows the amount of power used by the computing equipment in a data center relative to its total energy consumption. The closer PUE is to 1, the more efficient a data center's power usage is.
Source: Uptime Institute Intelligence

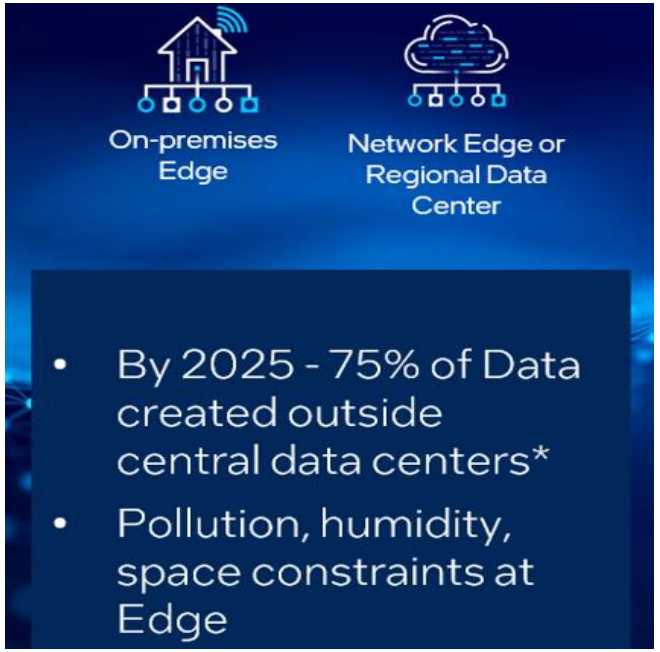
McKinsey & Company

Recent Examples of Legislation to Reduce Environmental Impact	
Amsterdam	• PUE* limits on data centers • Moratorium on new licenses until environmental impact assessed – city wants heat re-use
Singapore	• Restrictions on new builds due to land use, energy
Santa Clara, CA	• On-site generation must use non-fossil fuels
Shanghai	• New data centers must have PUE* 1.3 or less
European Union	• New rules governing server energy use when idle, thermal reporting and recyclability

** PUE – Power Usage Effectiveness Source: Uptime Institute Intelligence, October 2018*

Edge Growth





Data Center Liquid Cooling Forecast

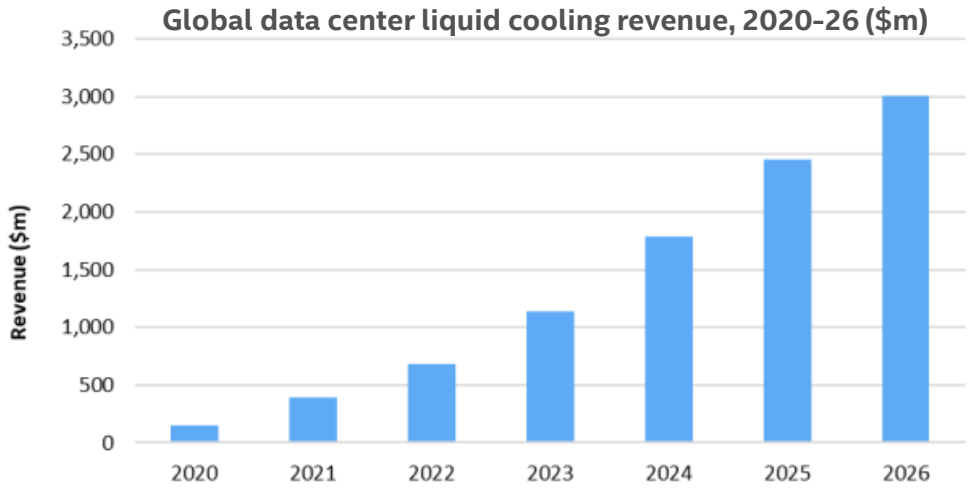
- Omdia market forecast data center thermal management market revenue to grow at a 17.5% CAGR from 2021 – 2026, on track to reach $11.6bn

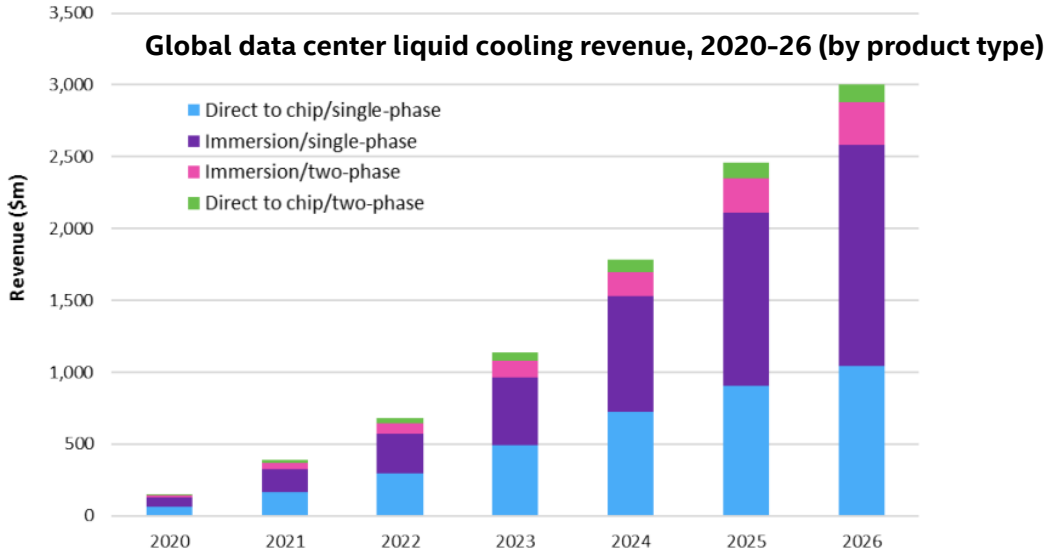
- Liquid cooling market revenue to top $3bn (to cool 26% server TAM) by 2026
- By 2026, immersion liquid cooling will represent more than 60% of data center liquid cooling revenue

	2020	2021	2022	2023	2024	2025	2026	CAGR 2021–26
Total data center thermal management	4,390	5,187	6,096	7,152	8,481	10,008	11,611	17.50%
Liquid cooling	152	391	679	1,134	1,781	2,457	3,005	50.40%
Liquid cooling to total ratio	3.50%	7.50%	11.10%	15.90%	21.00%	24.50%	25.90%	

Source: Omdia

Source: Omdia Data Center Thermal Management Market Analysis - 2022





Advanced Cooling Solutions Journey

2018

Purely

1) Data center intelligent power management

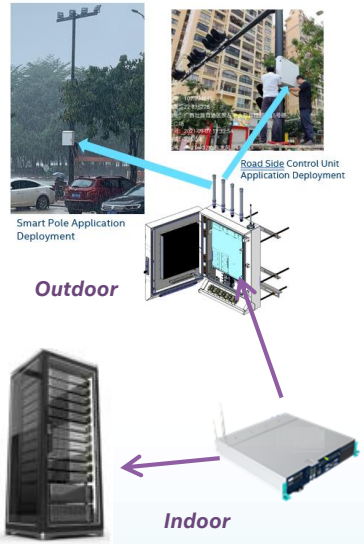
PUE Saving

2019

Purely Refresh

1) Cloud edge server

✓ Indoor
✓ Outdoor



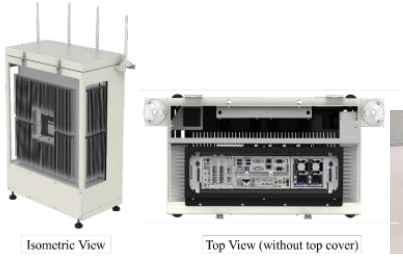
Outdoor

Indoor

2020

Whitley

1) Cloud edge immersion
2) Eagle Stream modular server prototype



Edge Immersion

Inventec Edge Immersion

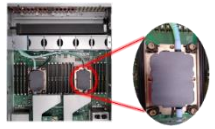
2021-2022

Eagle Stream

1) Cloud edge hybrid cooling POC
2) Closed loop water cooling
3) Open IP immersion cooling reference solutions

Modular Prototype

Hybrid cooling



Server Closed Loop Water Cooling

Cost Effective AI Cold Plate

2023 & beyond

Next Gen Intel® Xeon® Platform

1) **Continue adv cooling tech**
2) **Optimizing modular server arch**

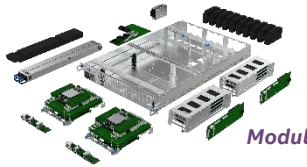
4U WAIC for in lab test

12U

Edge AAIC Standalone

48U

Open IP Immersion Cooling Reference Systems



Modular Server

Data Center Compute at the Edge – Storage, Networking, computing, security, AI

Modular Architecture -- regardless server form factor & cost effective

Advanced cooling -– air cooling alternatives

All product plans and roadmaps are subject to change without notice.

Advanced Cooling Roadmap

Cloud Edge Adv Cooling

Hybrid Cooling

Capacity ~1kW

- Xeon SP server extended temp & IP65
- Data Center compute at the edge for AI inference
- Air, water, and Immersion

Open IP Single Phase Immersion Cooling Ref Solutions

Phase 1 - TDP 500W

- Xeon SP modular architecture
- Tank uniform flow field design & modular scalable
- CDU redundant features & monitoring system

Cloud Edge & Open IP Single Phase Enhanced

Phase 2 TDP 700W

- **Phase 1 features plus**
- **Innovated heat dissipation efficiency**
- **Optimal for Xeon SP liquid cooling SKU**
- **Data center digital twins intelligent management**

Open IP Single Phase Enhanced Next Gen

Phase 3 TDP 800W+

- Phase 2 features plus
- Advanced heat dissipation efficiency
- Heat recovery energy management

Open IP Two Phase Liquid Cooling

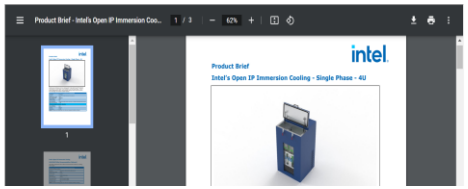
TDP >1000W

- New Coolant immersion cooling development
- Two Phase Cold Plate total solutions

All product plans and roadmaps are subject to change without notice.

Intel Open IP Immersion Cooling Server Deployment Kit

- 4U@10 kW – Water Assisted Immersion Cooling (WAIC)
- In Lab Validation - Server, Coolant, & Material Compatibility
- Single Phase-Product Brief 4U
  - Now on Intel.com, ID: 765932



- User guide on Intel.com soon
  - Installation and operation
  - Validated partner solutions updates
- Current Intel Open IP immersion cooling Collaboration Partner
  - OxM: Foxconn, Inventec, Compal, UfiSpace, Accton (server & switch in tank design, validation & debug…)
  - CSP: OPPO, Softbank, KDDI
  - Coolant: Dow, FastCool, Perstorp, Chevron (coolant reliability, server cable compatibility, grease compatibility…)
  - HSK supplier: Mandala (sample available), Microloops, Forcecon, Auras, Cooler Master (design concept)
  - Optical module AOC: Formerica, JPC (sample available)

Intel Open Ip Immersion Cooling Edge to Data Center

4U@7 kW and 2U@3 kW Air Assisted Immersion Cooling (AAIC)

- Agile for DC Workload Tuning with Immersion Cooled Server and Xeon Based Processors
- For Cloud Edge Immersion Cooling System Ready for Production

Dimension=L 878 mm x W 658 mm x H 1230 mm

4U@7 kW AAIC

Dimension=L 878 mm x W 570 mm x H 1230 mm

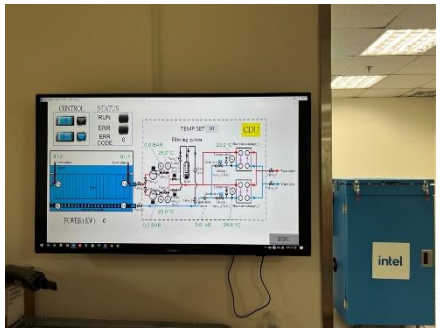
2U@3 kW AAIC

Synthetic Oils Continuous Work in Progress

- Material Compatibility
- Safety Requirements for Data Center Deployment
  - Flash point safety certification by 3rd party lab
  - Integrated IDC safety management
- Synthetic Oil Life Cycle

Continue coolant optimization for real world deployment
with friendly environment & cooling performance

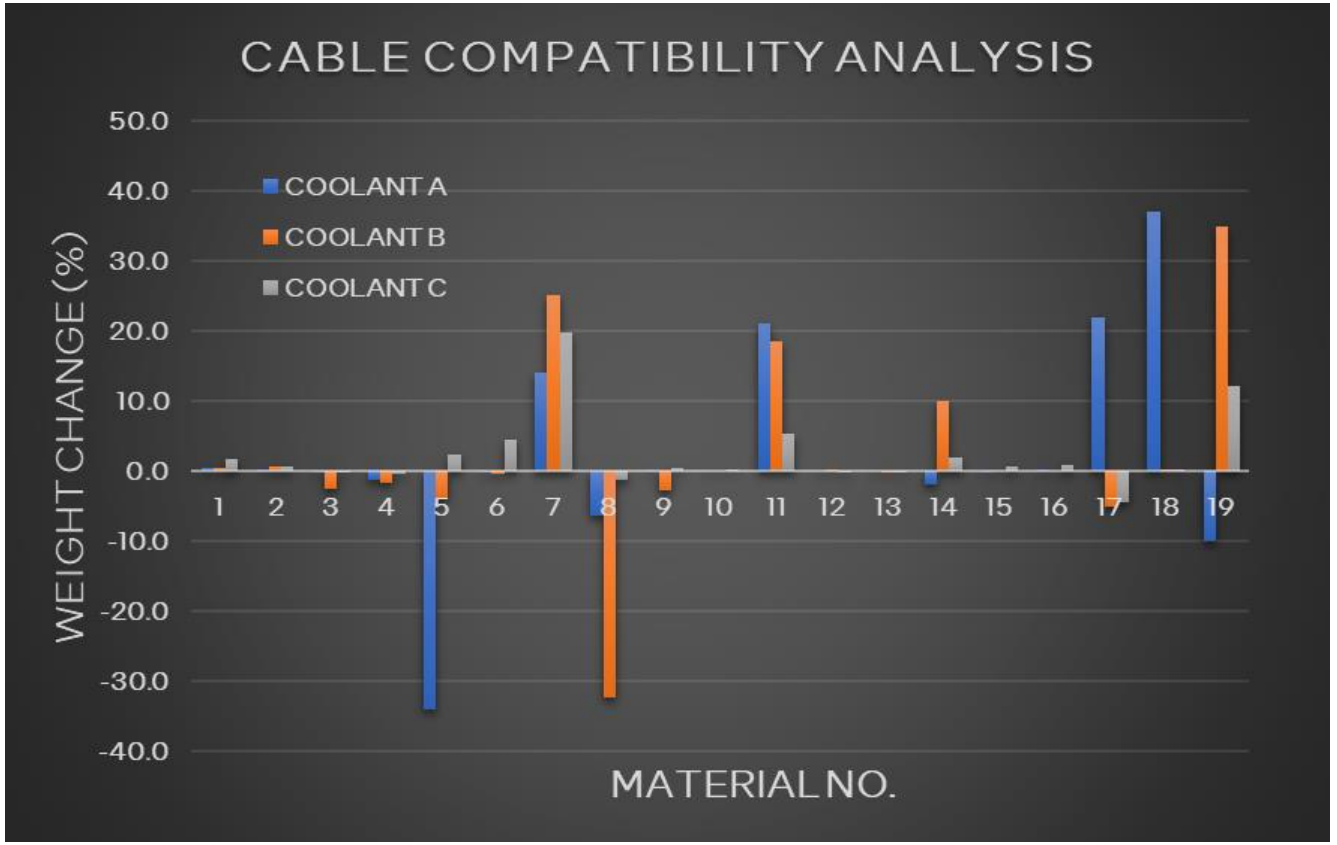
Intel Open IP Test Environment



Evaluating material compatibility in synthetic oils with Intel Open IP immersion cooling system

Key Components for Immersion Cooling:
Material Compatibility

Aging for Coolant A, B, and C	
No	Cable Material
1	PBT+LCP+Gold & Tin plated terminal
2	PA66+Gold plated terminal
3	PCB FR4
4	PA66
5	Polyester Fabric & Acrylic Glue
6	PET
7	Ethylene-vinyl acetate copolymer + flame retardant
8	Teflon
9	Stainless steel
10	Nickel-plated stainless steel
11	Polyamide
12	PBT (halogenated)
13	PBT (Halogen Free)
14	PVC
15	Gold plated terminal
16	Tin plated terminal
17	PVC+Cu
18	FKM
19	EPDM



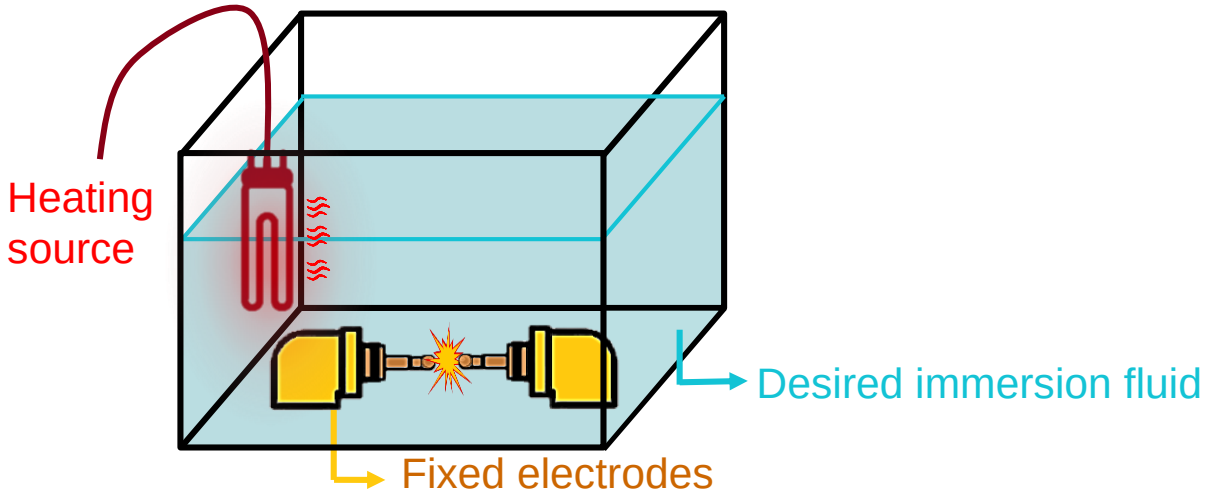
- Cycling tests for coolant composition analysis
- Cable material alternatives or coolant tuning

Coolant Safety & Life Cycle

工業技術研究院
Industrial Technology Research Institute
Material and Chemical Research Laboratories(MCL)
Electronic and Optoelectronic System Research Laboratories (EOSL)

Safety Verification POC

1. Place controlled heating source that can generate very high temperature instantaneously
2. The electrodes are installed in the test container and a spark is generated by applying a momentary high voltage
3. Repeat the experiment several times to confirm reproducibility and stability



Coolant Working-Life Monitoring

1. Periodic testing of coolant properties is required.
2. Important test item：color, viscosity, dielectric constant, loss tangent, acidity, specific heat capacity, flash point, break down voltage…etc.

Plan for Third-party Verification Service

- Test item：viscosity, acidity, specific heat capacity, flash point (open/closed cup), pour point, thermal conductivity, break down voltage, dielectric constant (1、10GHz), loss tangent (1、10GHz), metal composition analysis, thermogravimetric analysis, volume resistance, surface tension.
- Immersion Coolant Compatibility 、Aging、safety

Integrated IDC Safety Management - Demo

ONEWORK
one work one Platform

Combine Coolant Safety & IDC Management to Meet the Deployment Criteria

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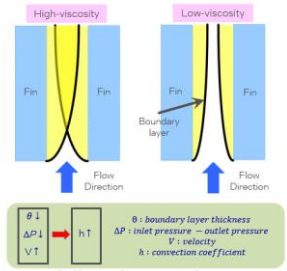
Innovated Immersion Cooling Server Heat Sink

Intel HSK Design Concept



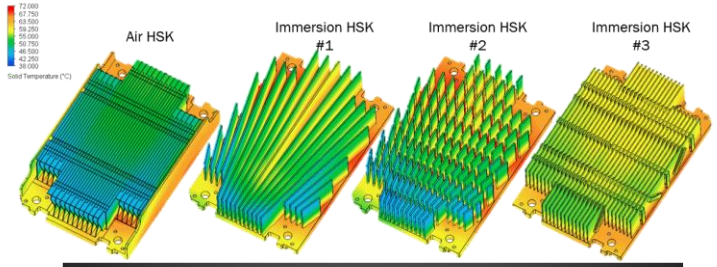
Fluorinated fluid simulation parameters

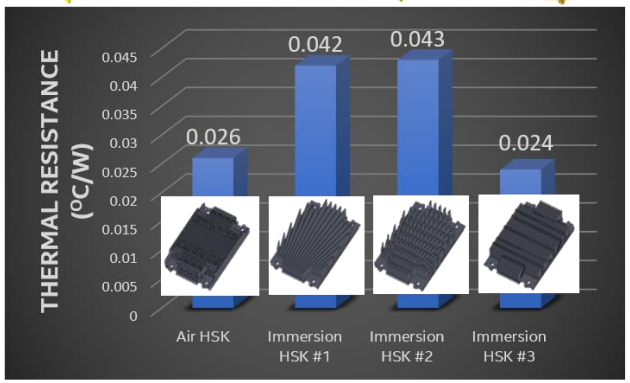
- Thermal conductivity 0.065 W/mK
- Density 1855 kg/m^3
- Absolute viscosity 4.1 centipoise
- Specific heat 1100 J/kgK

+

Simulation

JOTACTIC 捷策動能





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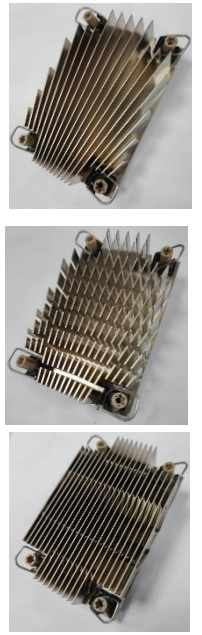
Manufacture

Mandala Hoang Long Development Co., Ltd.



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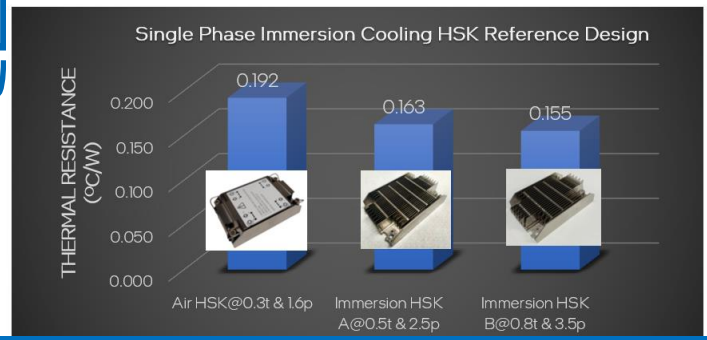
Output

- IEEE, joint white paper
- HSK design guide
- Sample ready for verification
- Calibrate simulation parameters



Case Study: Synthetic oil, Kinematic Viscosity: 35 mm^2/s @ 40 °C

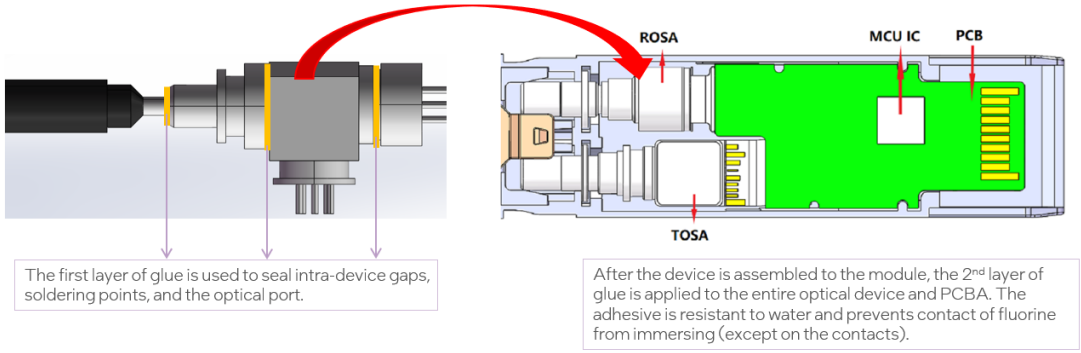
Foxconn Industrial Internet

Samples validating now in Intel Open IP immersion cooling system

Continue to bring up more partner solutions

Key Components for Immersion Cooling:
Active Optical Cable (AOC) Solution

AOC Transceiver



Sample Available Now

Advantages Sealing Technology

- Complete protection against water and fluorine
- The optical cable is halogen-free and corrosion-resistant
- Supports direct immersion or spraying
- The seal can effectively block cooling liquid from entering the optical circuit, with no adverse affects on the optical circuit

Validating in Intel Open IP immersion cooling system

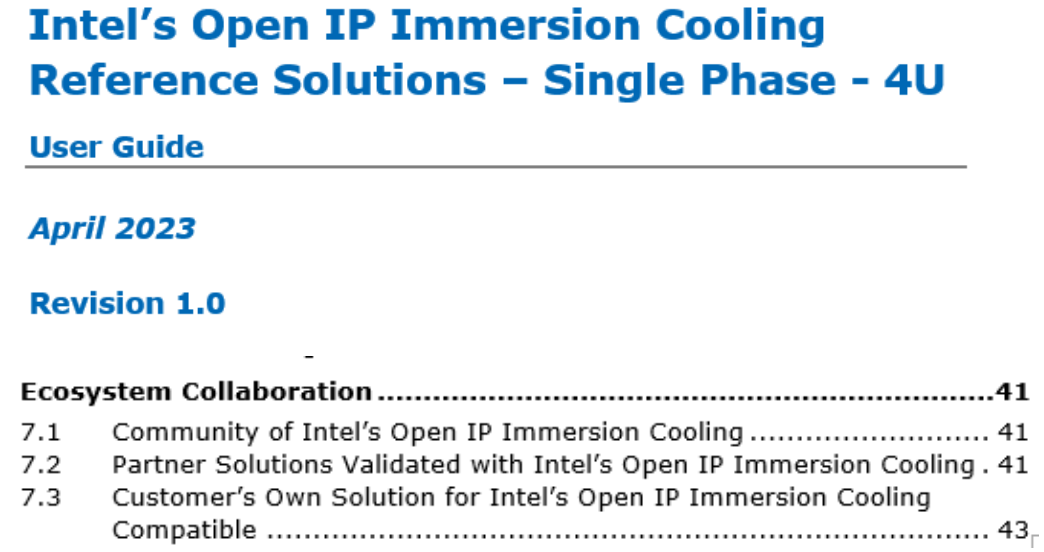
Ecosystem Collaboration

Grow the community

Step 1 → Ecosystem partners joint validation

Step 2 → Partner solutions validated for Intel's Open IP Immersion Cooling

Step 3 → Customer's own solution for Intel's Open IP immersion cooling compatible



Intel's Open IP Immersion Cooling Reference Solutions – Single Phase - 4U

User Guide

April 2023

Revision 1.0

Document to be published to Intel.com

Ecosystem Collaboration

7.1 Community for Intel's Open IP Immersion Cooling

Intel is launching Open IP immersion cooling solutions and reference design, collaborating with ecosystem partners to meet the industry needs and create a three-win situation among Intel, ecosystem partners and the environment.

The community is to activate the entire ecosystem, and to accelerate the real deployment to meet energy saving and carbon reduction. The community welcome the ecosystem partner solutions adopt Intel Open IP immersion cooling reference design for joint validation.

Figure 7.1-1. Intel's Open IP Immersion Cooling Community

7.2 Partner Solutions Validated for Intel's Open IP Immersion Cooling

Intel Open ecosystem to ecosystem partners collaboration for validated & proven partners solutions ready to meet end customer's requirements. The table provides with the information for server and key components that have been verified with Intel Open IP immersion cooling reference systems.

This table will continue to be maintained to expand the cooperation of the ecosystem.

Table 7-2. Server System information

Server System			
Company	Description	Part Number	Remark
Compal	Eagle Stream	SR120-2	
Foxconn	Eagle Stream	D-5222	
Inventec	Eagle Stream	K880G6	

Table 7-3. Key Component Solution Information

Key Component			
Company	Description	Part Number	Remark
Acer Synergy Tech Corp	System integration Provider		
DOW	DOWSIL	Experimental candidate	Long term required for Safety & Life Cycle
PERSTORP	POE	Experimental candidate	Long term required for Safety & Life Cycle
Chevron	PAO	Control candidate	
Mandala	4U10kW WAIC	A19I04W10D0100A	
	12U15kW WAIC	A19I12W15D0100A	
	48U60kW WAIC	A19I48U60D0100A	
	2U3kW AAIC	A19I02W03D0100A	
	4U7kW AAIC	A19I007D0100A	
Switch Providers			To be updated
Mandala	Convex-louver heat sink module	A13HE01A0209Z	
Mandala	Convex-louver fin	A13HEA1A0100Z	
Optical Cable Providers			To be updated

Document will be published to Intel.com

Call to Action

Let’s work together to

- Develop liquid cooling solutions for optimum power usage, lower PUE, and better TCO
- Build partner solutions to accelerate ecosystem readiness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