A Chemical Perspective on Liquid Cooled Data Centers

OCP Educational Webinar Series

November 13th, 2025

Dell'Oro Group | PFX Performance Fluid Experts Group

OPEN Compute Project®

Community-driven hyperscale innovation for all

A Chemical Perspective on Liquid Cooled Data Centers

Our webinar presenters:

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OCP Foundation

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Data Center Liquid Cooling Markets
Dell'Oro Group

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Director of Electrification Technology
PFX Group

Agenda Overview

- AI Liquid Cooling: It’s Non-Negotiable
- Problem: Anxiety around deploying liquid cooling at scale
- Solution: A basic understanding of D2C fluid chemistry
- Industry validated, future ready: SOLUTHERM OAT PG 25
- Take Aways and Eliminating Confusion: Ask Solutherm!
- Live Q&A

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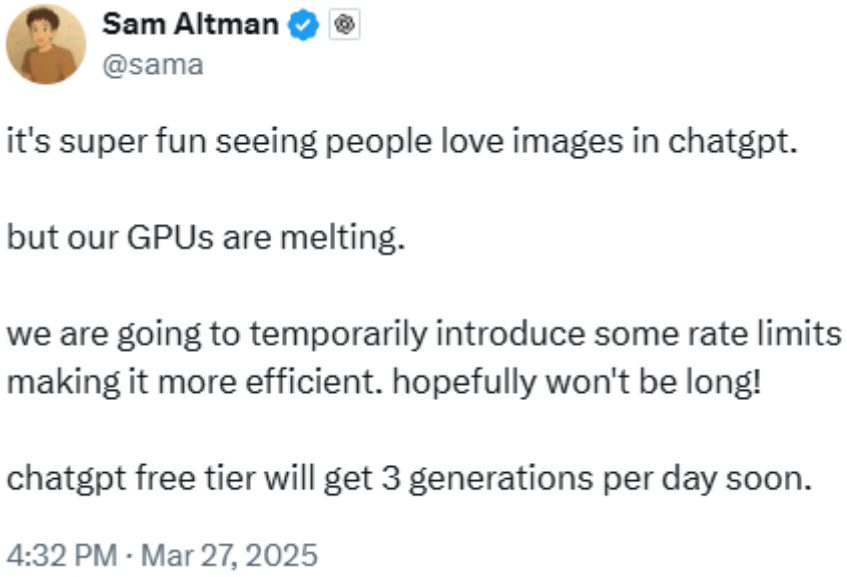
Why do we need liquid cooling?



Sam Altman
@sama

it's super fun seeing people love images in chatgpt.

but our GPUs are melting.

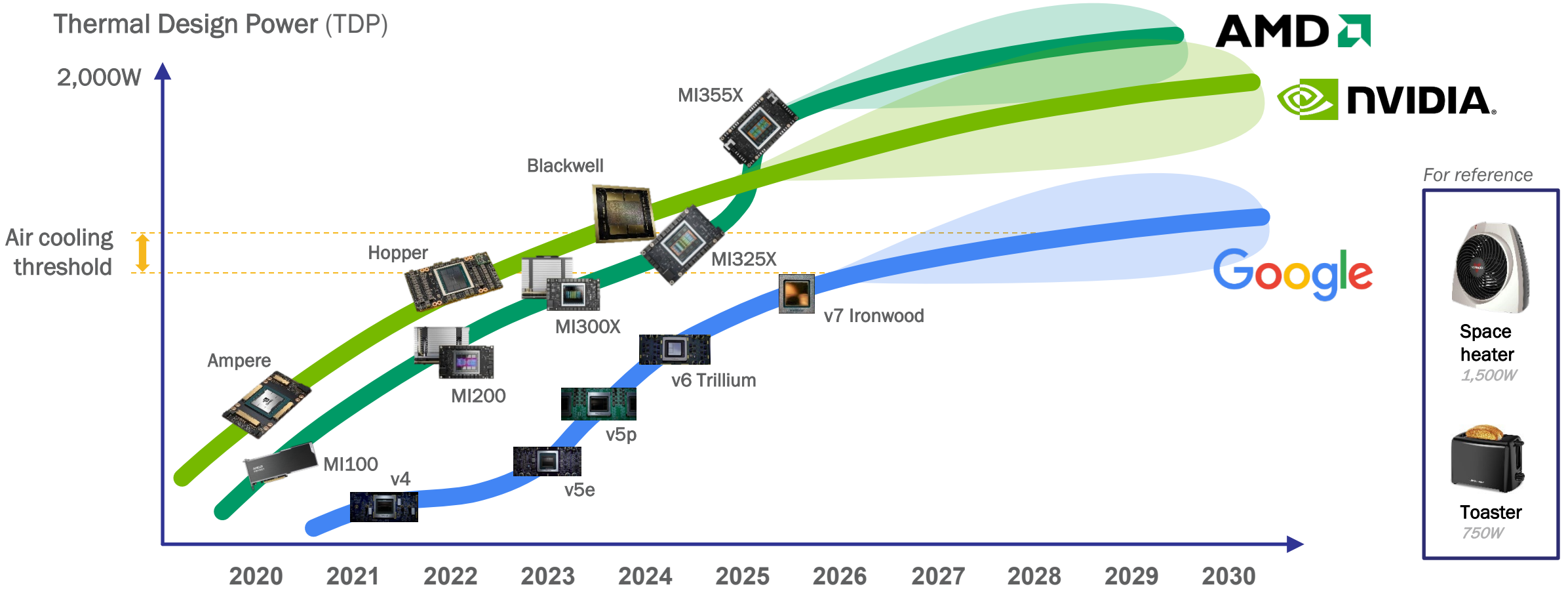
we are going to temporarily introduce some rate limits while we work on making it more efficient. hopefully won't be long!

chatgpt free tier will get 3 generations per day soon.

4:32 PM · Mar 27, 2025

Source: X

TDP of accelerators is on the rise and expected to continue growing beyond 2,000W until…?



Note: Date refers to start of shipment of product or launch date, depending on data availability.
Source: NVIDIA, AMD, Google, Dell'Oro Analysis.

Dell'Oro Group

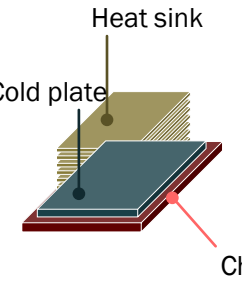
More accelerators need to be crammed in small footprints to optimize GPU utilization

DGX H100/200

Available from 2022

8	*GPUs per server*
4	*servers per rack*
32	*GPUs per rack*

8U server

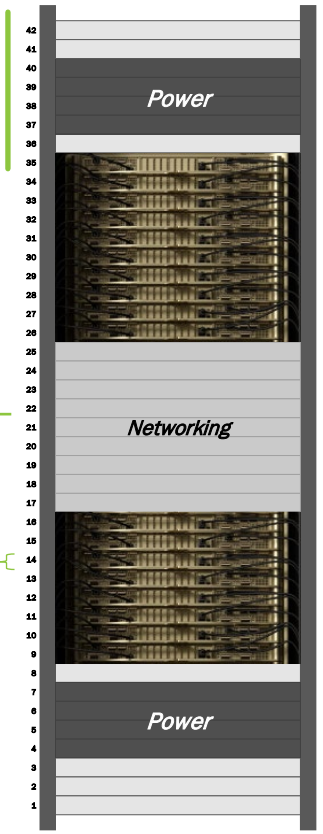


GB200/300 NVL72

Oberon rack

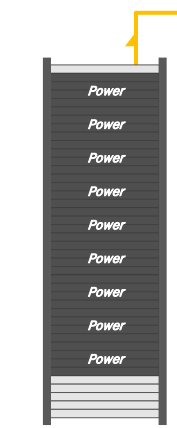
Available from 2024

4	*GPUs per tray*
18	*trays per rack*
72	*GPUs per rack*



1U tray

1 Liquid cooling has allowed AI servers to slim down to smaller form factors.



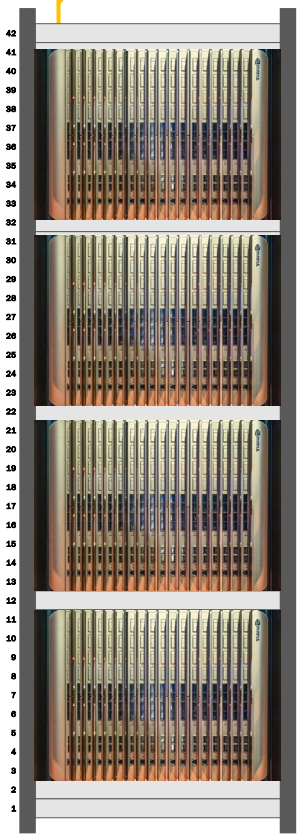
Power sidecar rack

VR300 NVL576

Kyber rack

Available from 2027

2	*GPUs per blade*
18	*blades per chassis*
4	*chassis per rack*
144	*GPUs per rack*



2 DC power architectures are now moving power infrastructure to side-cars freeing up space for more compute in racks.

Source: NVIDIA, Dell'Oro Analysis.

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More accelerators need to be crammed in small footprints to optimize GPU utilization

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*Available from **2022***

- **8** *GPUs per server*
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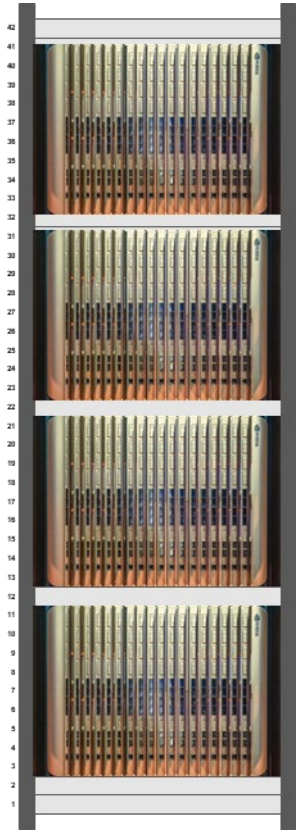


Source: NVIDIA, Dell'Oro Analysis.

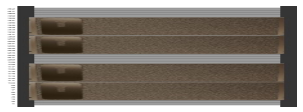
Densities are soaring with higher TDP chips and more chips in the rack

Distributed IT/ small data centers

3-15kW
per rack

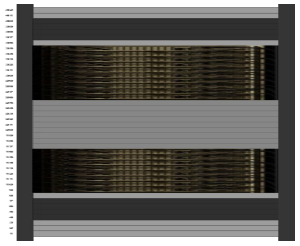
Large data centers non-AI workloads

8-30kW
per rack



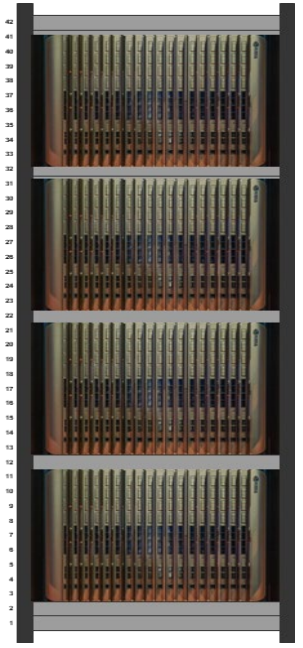
DGX H100/200

42-48kW
per rack



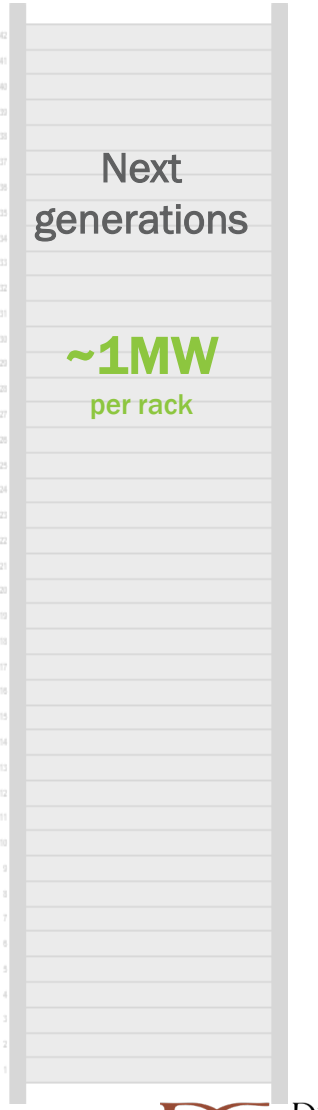
GB200/300 NVL72
Oberon rack

~130kW
per rack



VR300 NVL576
Kyber rack

~500kW
per rack



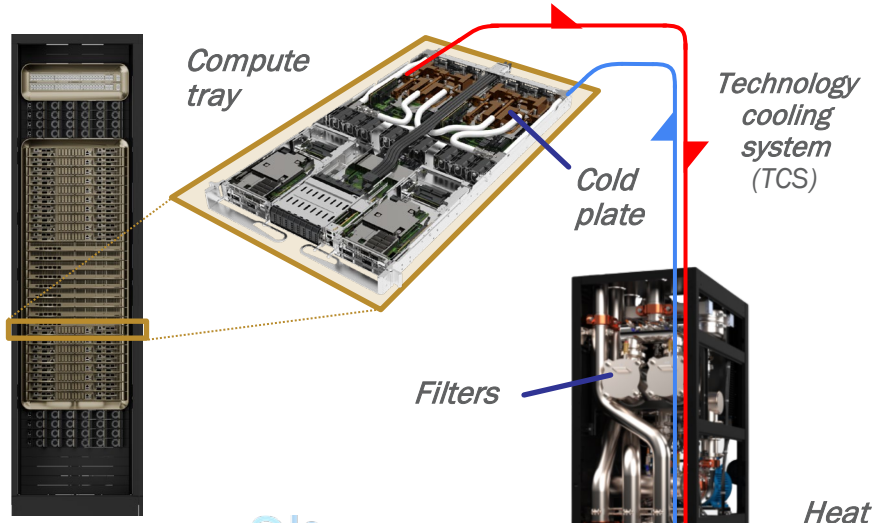
Next generations

~1MW
per rack

Source: NVIDIA, Dell'Oro Analysis.

Two different LC technologies have been gaining ground to enable high-density AI racks

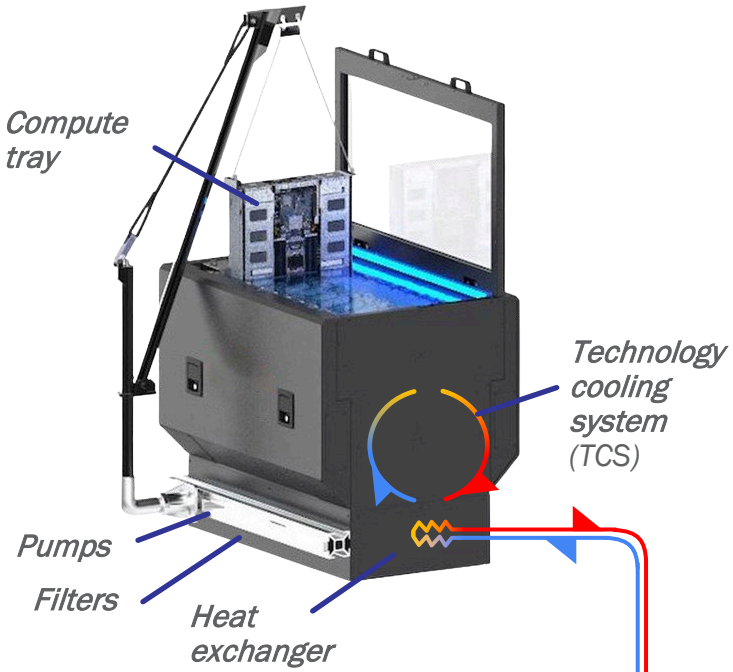
Direct liquid cooling



Air cooling

Perimeter, containment solutions, RDHx

Immersion cooling



Heat rejection to outdoors or reuse

Chillers, dry-coolers, water towers, heat pumps

Facility water system (FWS)

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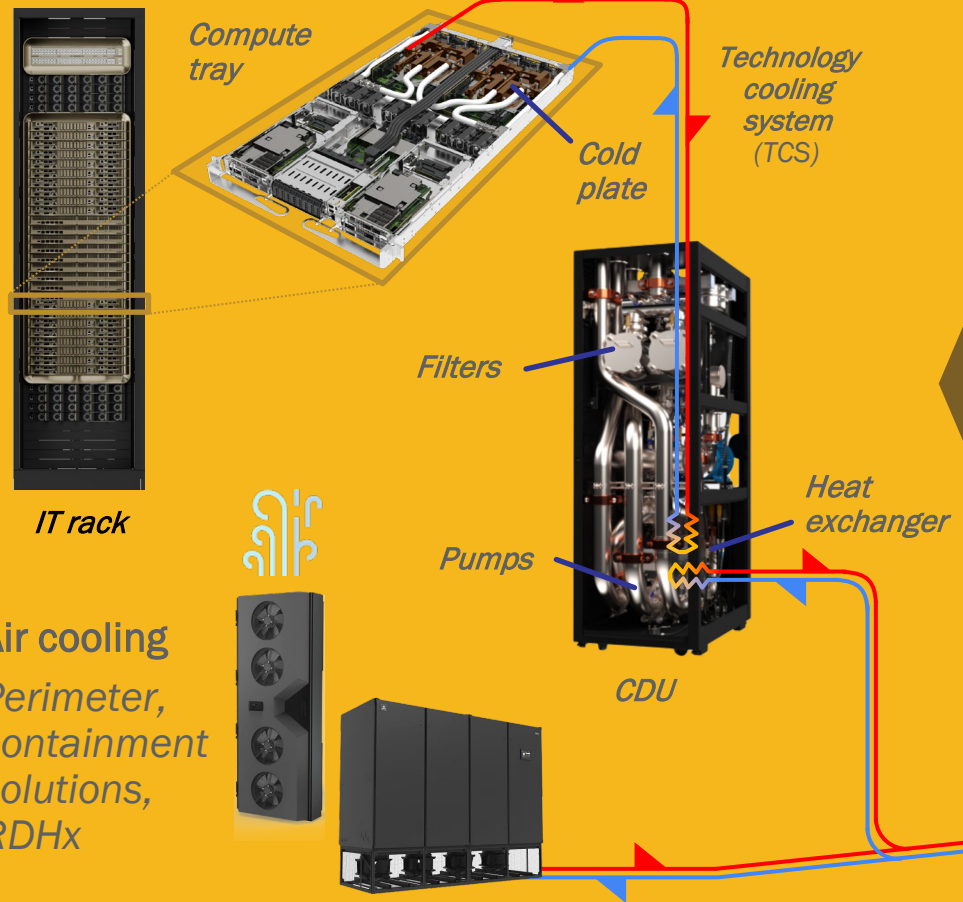
Two different LC technologies have been gaining ground to enable high-density AI racks

Direct liquid cooling



Air cooling

Perimeter, containment solutions, RDHx

Dominant technology in AI deployments

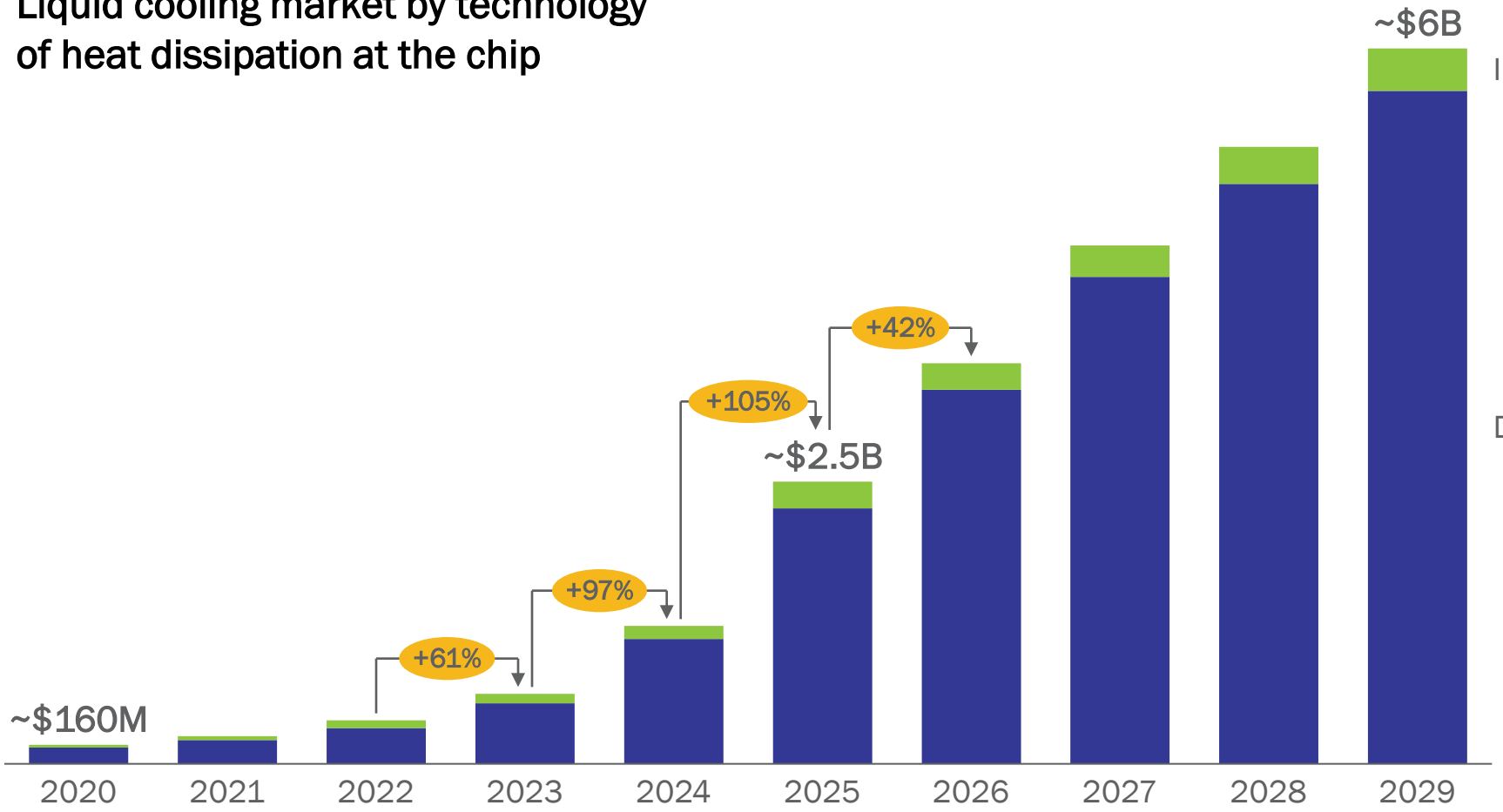
Heat rejection to outdoors or reuse

Chillers, dry-coolers, water towers, heat pumps

Dell'Oro Group

LC is expected to be $6B market by 2029, with DLC establishing itself as the de facto standard

Liquid cooling market by technology of heat dissipation at the chip



	CAGR (25-29)
Immersion	12%
Direct Liquid	27%

Source: Dell'Oro Group DCPI 5-Year Forecast (July-2025).

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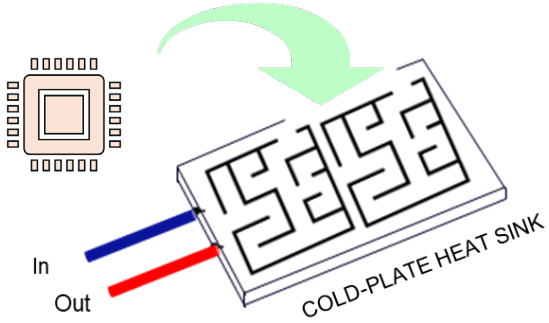
How is Liquid Cooling Deployed?

Architecture: Direct to Chip (DTC)
Fluid: PG-25 or Water



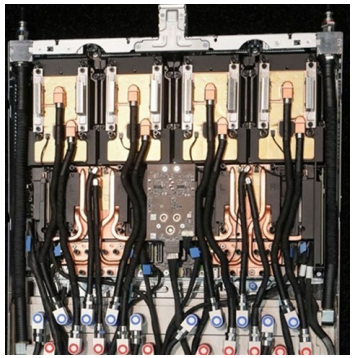
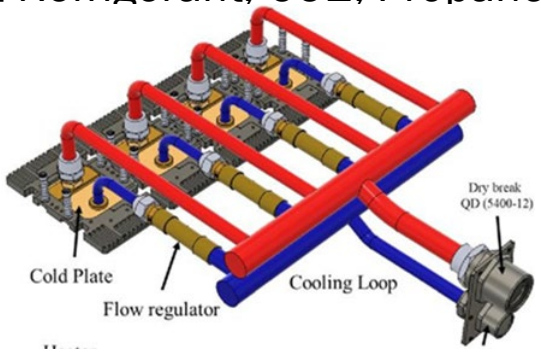


Image Credit: NVIDIA Rubin Ultra

Architecture: 2-Phase DTC
Fluid: Refrigerant, CO2, Propane, etc.



Architecture: 1-Phase Immersion
Fluid: Hydrocarbon, ester, fluorocarbon

Architecture: 2-Phase Immersion
Fluid: Fluorocarbon

In March 2024:
NVIDIA Disrupts Data Center Cooling

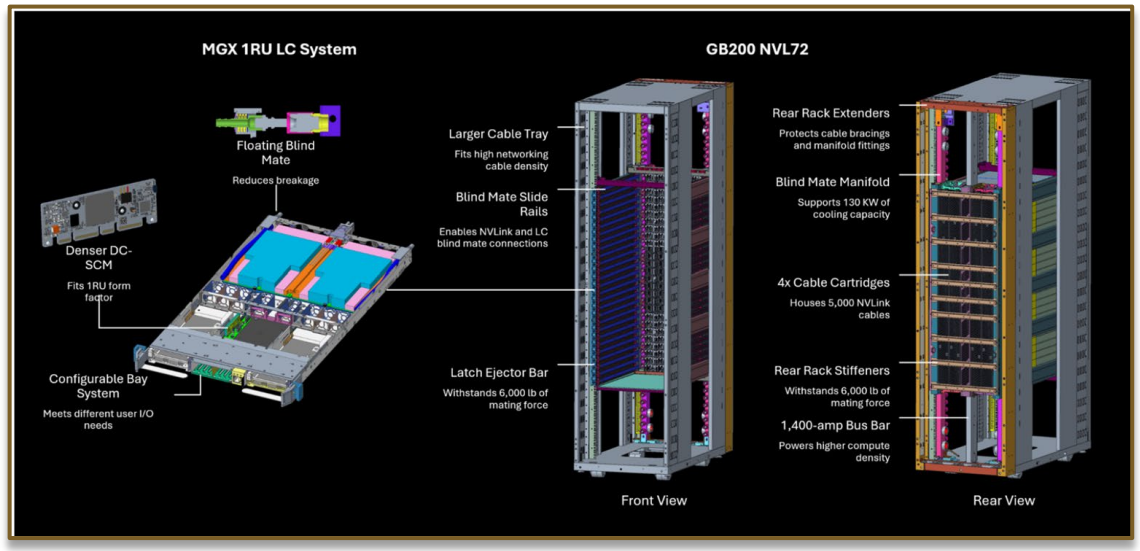
Data Center / Cloud

NVIDIA Contributes NVIDIA GB200 NVL72 Designs to Open Compute Project

OPEN Compute Project®

Key Features of NVL72:

- 72 NVIDIA GB200 GPUs
- 36 Grace CPUs
- 13.5 TB of HBM3e memory
- **Integrated liquid cooling**



CoreWeave

SUPERMICRO

ASUS

HPE

Direct-to-Chip Coolant FAQ

Acceptable Fluids (Industry Standards)

- What fluid do I use?
- What are the thermal/physical properties?
- What is an acceptable inhibitor chemistry?

Condition monitoring/service

- How do we ensure fluid health in-service?
- How/when should we sample?
- Who is equipped to analyze & report sample health?

Interoperability

- My system has Fluid X, can I add Fluid Y?
- Is this inhibitor compatible with this one?
- I accidentally mixed fluids… what now?

Agenda:
Solution: A basic understanding of D2C fluid chemistry

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Industry Collaboration and Standards Groups

ASHRAE TS 9.9

- Founded 1959
- ASHRAE = American Society of Heating, Refrigerating and Air-Conditioning Engineers
- TC9.9: Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment
- Engineering and infrastructure requirements for facilities
- Specifications for acceptable heat transfer fluids (treated water).

Open Compute Project

- Founded 2011
- OCP Project: Cooling Environments & Liquid Cooling
- Specific focus on data center TCS (secondary loop) cooling systems and fluids
- Existing OCP “guidelines”
- New document: **Base Specification for Single-Phase Propylene Glycol-Based Fluids (PG 25)**

ASTM

- Founded 1898
- ASTM = American Society for Testing and Materials
- ASTM D15.30: Sub-committee on Industrial Heat Transfer Fluids/HVAC
- ASTM D8040: **Standard Test Method for Corrosion Test for Heat Transfer Fluids in Glassware**
- ASTM D8039: **Standard Specification for Heat Transfer Fluids (HTF) for Heating and Air Conditioning (HVAC) Systems**

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Community-driven hyperscale innovation for all

OCP PG-25 Base Specification

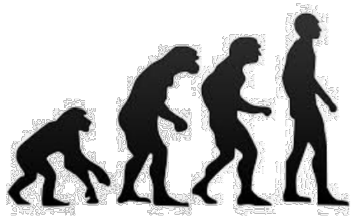
What it is

- A base specification that build upon existing OCP guidelines
- Industry developed through intercompany collaboration
- Provides more prescriptive requirements to protect the industry
- Piece of mind for non-chemists/chemical engineers when choosing a TCS fluid

What it addresses

- Product composition
- Material purity
- Ready-to-use
- Dilution water
- Physical properties
- Uniformity
- Corrosion performance
- Thermal stability
- Foaming tendency
- Transportation
- Documentation
- Product maintenance and support

Evolution of Glycol-based Thermal Management Technology



Pre 1920s: Water: Poor freeze point, corrosive, and leads to bacterial growth

1926 Glycol introduced as HTF: better freezing pt, no bio-growth, still corrosive

First inhibitor additives: IAT – Inorganic Additive Technology.

Forms protective film that wears over time. Very poor hard water stability

1980s Push for longer lasting protection led to OAT – Organic Acid Technology

First "long-life" coolant tech. Enabled aluminum as a material of construction

2000s – HOAT - Hybrid OAT Technology

Lower treat rates of IAT make their way back into OAT, leading to more stable, longer-life, quicker acting corrosion protection

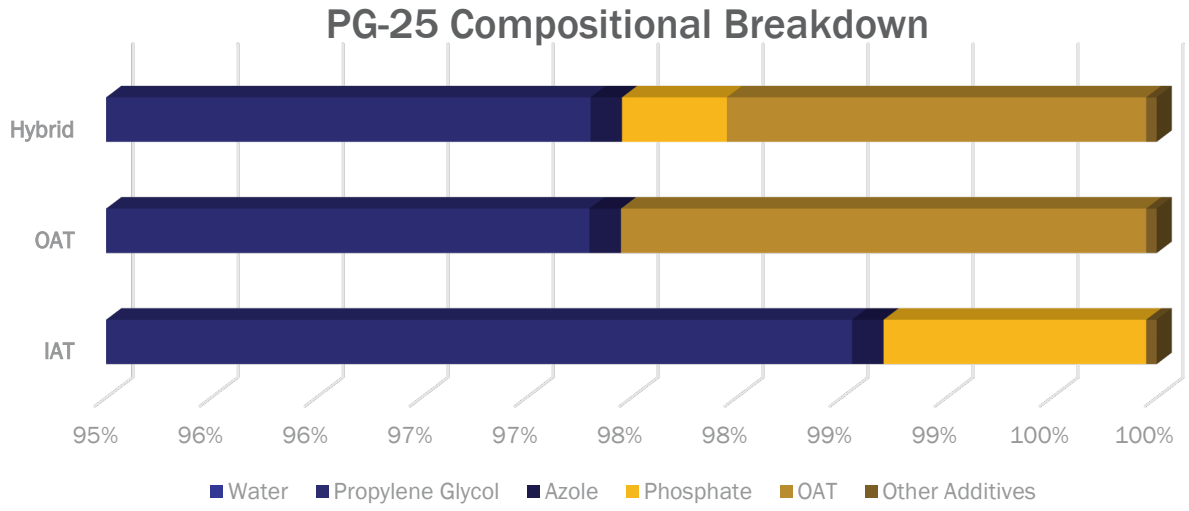
2020s+

- Propylene glycol gains popularity where toxicity is a concern
- Environmental trends such as "BNAP " free (boron, nitrite, amine, phosphate)
- Heat transfer improvers such as nano tech start to be explored

Coolant Inhibitor Chemistry Overview

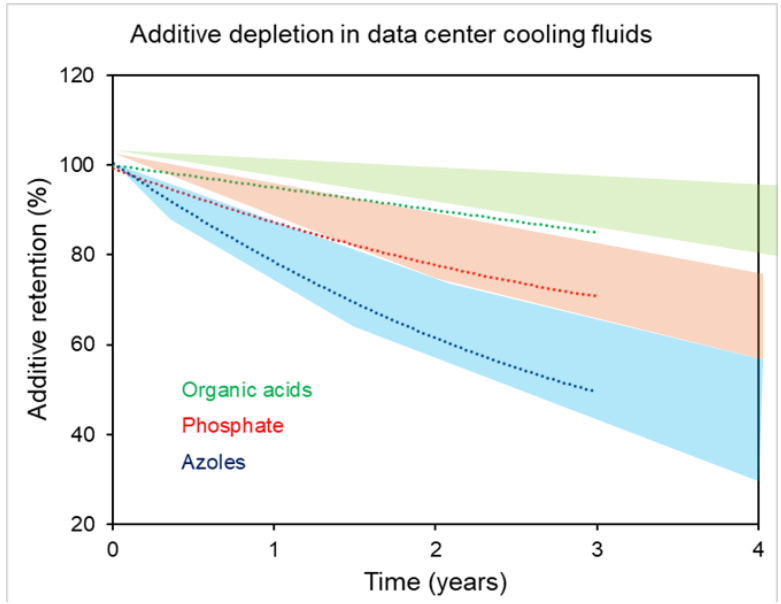
IAT = Inorganic Acid Technology

- Original coolant inhibitors were based on inorganic compounds: phosphate, silicate, borate, etc.
- IATs are fast acting corrosion inhibitors coat surface instantaneously
- Relatively short inhibitor life-time
- Inorganic inhibitors may be unstable and sensitive to contaminants or impurities



HOAT = Hybrid Organic Acid Technology

- Modern coolants use long-lasting organic acid inhibitors.
- OAT-based coolants are commonly hybridized with a small amount of phosphate, silicate, or borate.
- Hybrid OAT technology gives fast acting protection of IAT and longevity of OAT.
- Superior stability towards Ca^{2+} and Mg^{2+} impurities from hard water or elastomer fillers



Poll Question

What is your biggest concern with deploying direct-to-chip liquid cooling?

a) Choosing the right coolant for my system (material compatibility)
b) Coolant leaks damaging expensive compute hardware
c) Monitoring the health of the fluid/system during operation
d) Having the design and operational expertise for liquid cooling systems

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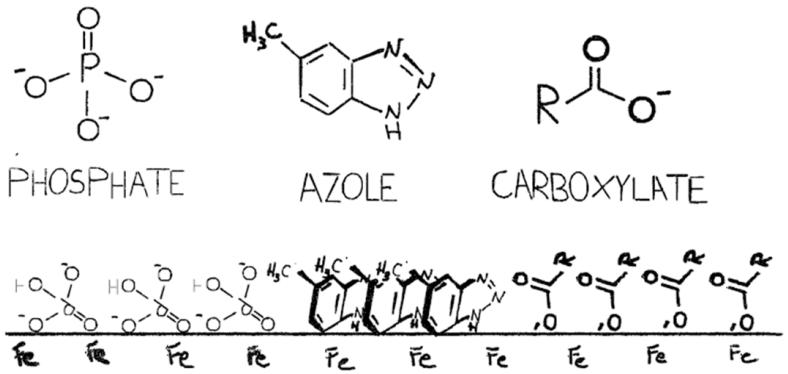
Data Driven PG-25 Chemistry Comparison



Standardized Corrosion Testing – ASTM D8040

- **Standard test method:** for evaluating the corrosive effects of heat transfer fluids (HTFs) on metal specimens
- **Conditions:** 336h (2 weeks) at 88°C under aeration (100mL/min) + corrosive salt mix
- **Corrosive salts:** 99mg/L Na_2SO_4, 110mg/L NaCl, 92g/L $NaHCO_3$

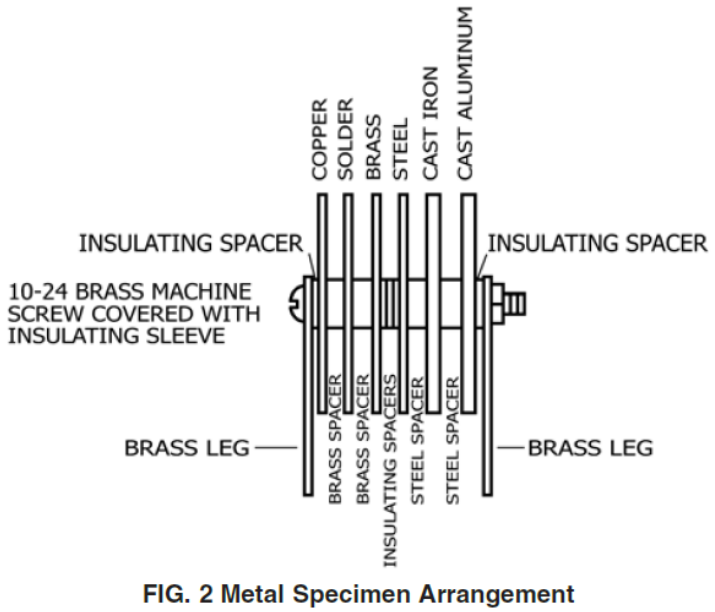
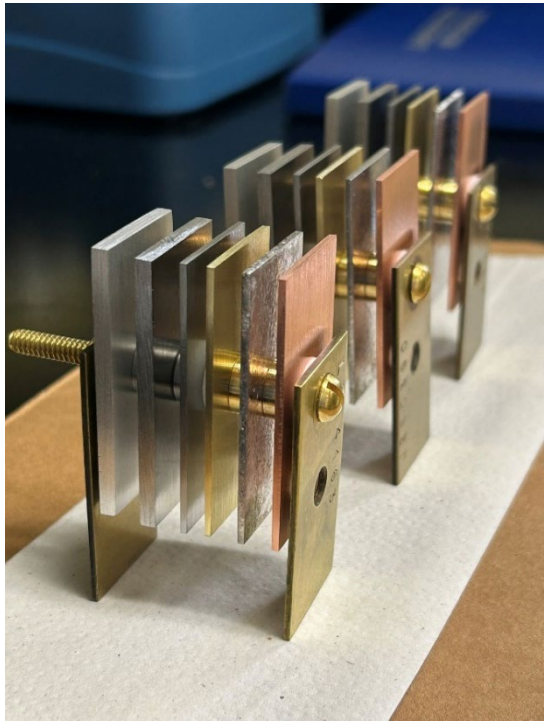


FIG. 2 Metal Specimen Arrangement

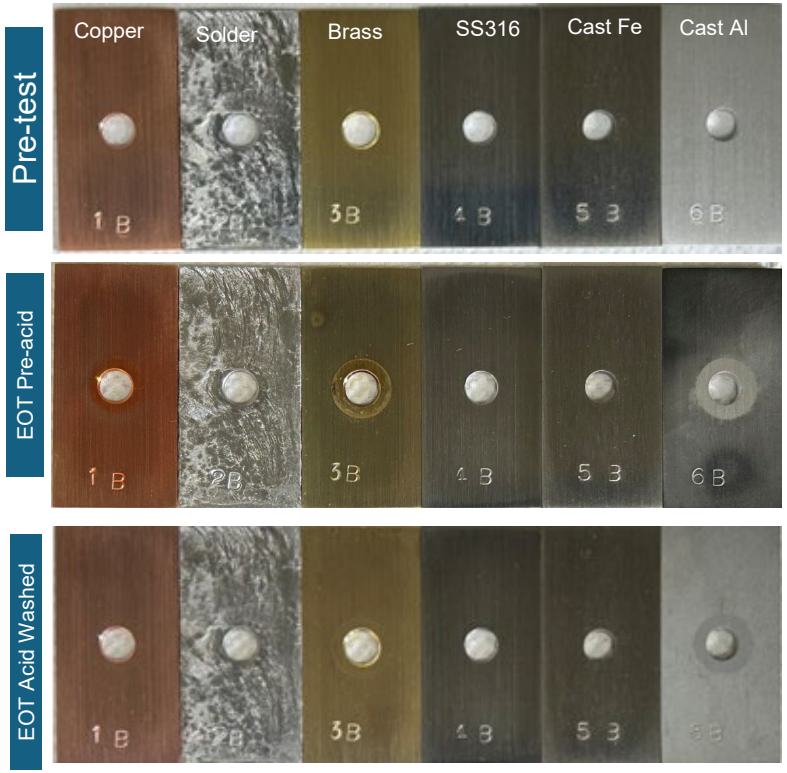


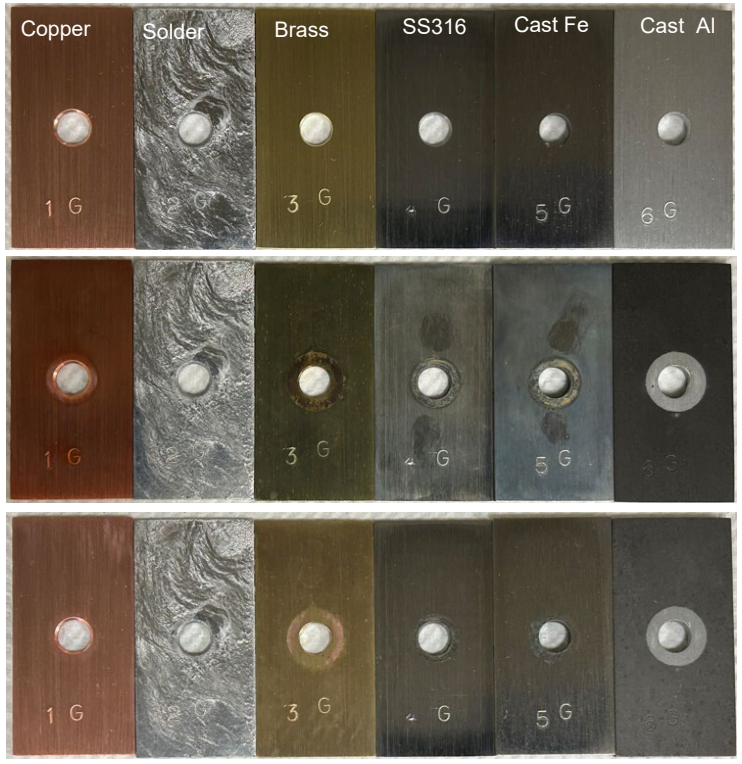
Data Center Fluid Solutions Corrosion Protection

OAT PG25

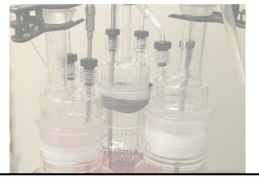
IAT PG-25-A

IAT PG-25-B





Data Center Fluid Solutions Corrosion Protection



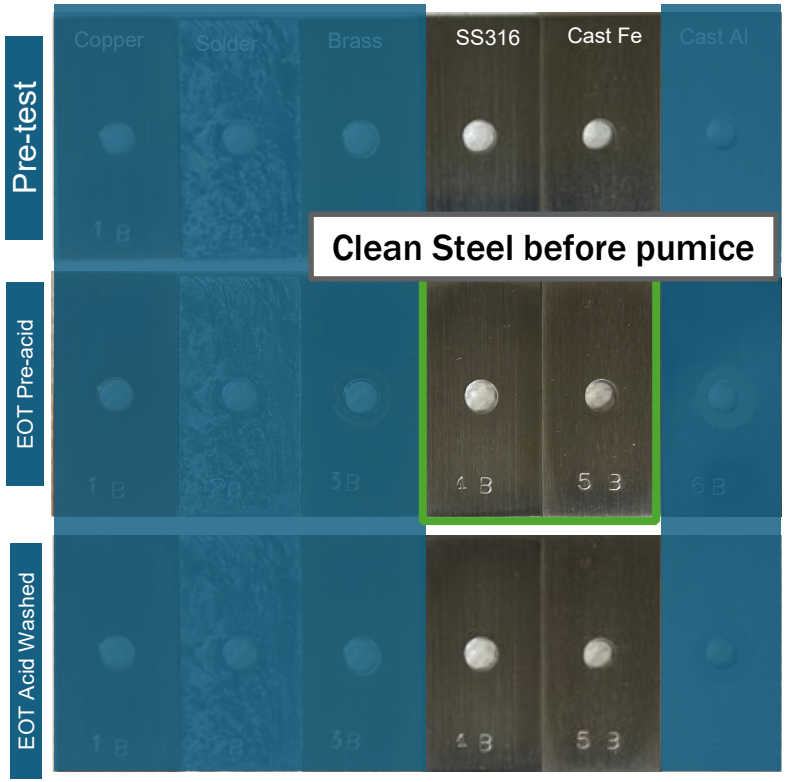
ASTM D8040 Weight Loss Values (mg)				
	OAT PG-25	IAT PG-25-A	IAT PG-25-B	ASTM Limits (mg)
Copper	0	2	2	10
Solder	0	2	1	30
Brass	0	2	2	10
Stainless Steel	-1	0	-1	10
Cast Iron	-2	-2	-7	10
Cast Aluminum	1	5	38	30

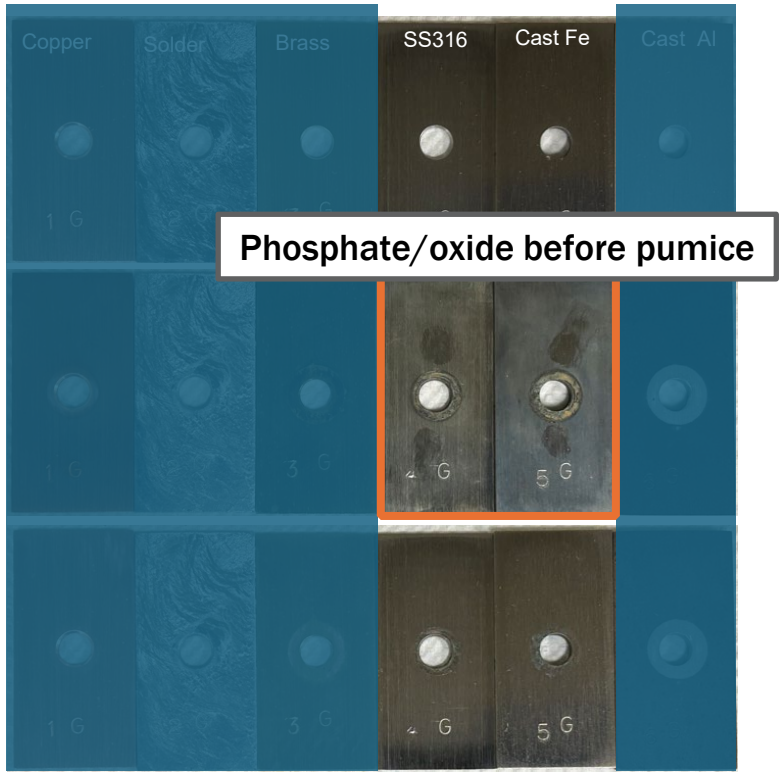
Data Center Fluid Solutions Corrosion Protection

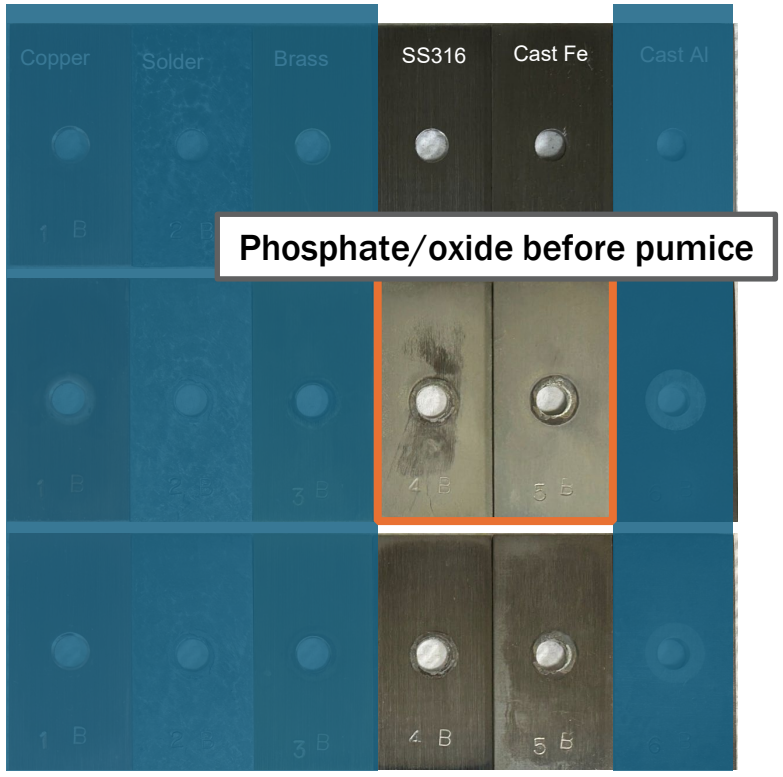
OAT PG25

IAT PG-25-A

IAT PG-25-B







Data Center Fluid Solutions Corrosion Protection

OAT PG25

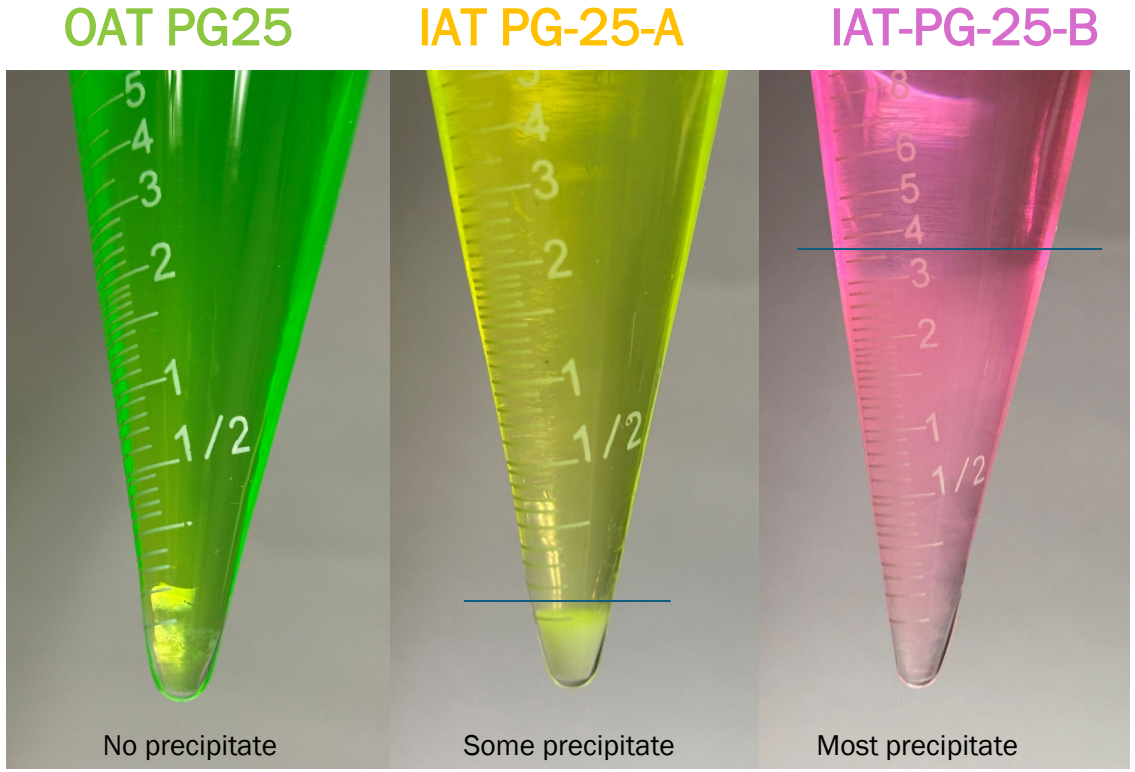
IAT PG-25-A

IAT PG-25-B

Hard Water Stability – Resisting Ca and Mg

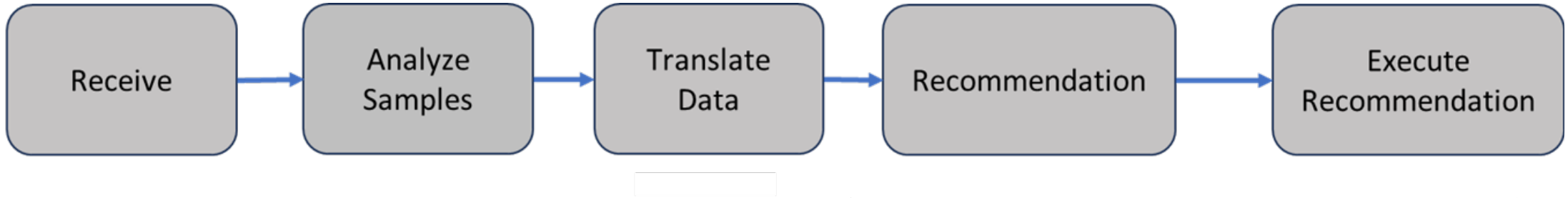
Minerals (Ca, Mg, Si, etc.) can interact with inhibitors (phosphate) and form precipitates known as "scale"

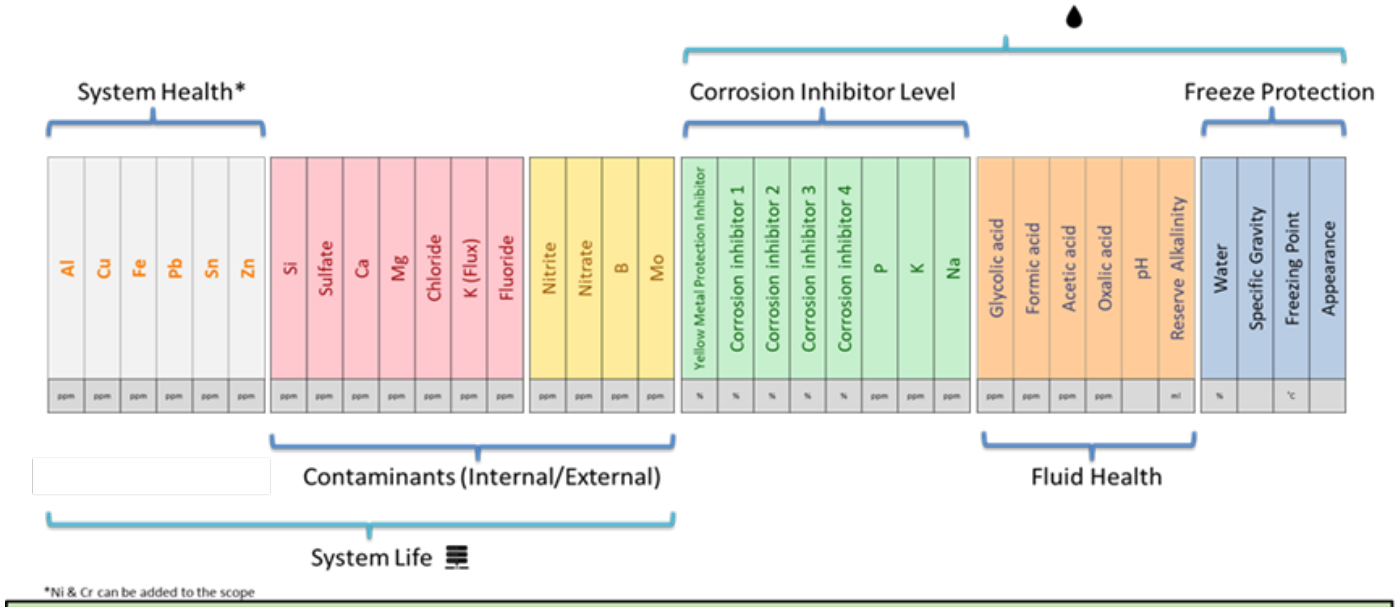
- Ca, Mg, & Si are common impurities in secondary loop systems
- Fluid must have some tolerance for impurities without forming precipitate that can clog filters, scale surfaces
- Modified HWS test:
  - Addition of 30ppm Ca + 30ppm Mg
  - Oven at 90°C/1h
  - Sedimentation for 10days/RT
- New **OCP** base spec for PG25 fluids only requires 15ppm Ca + 15ppm Mg



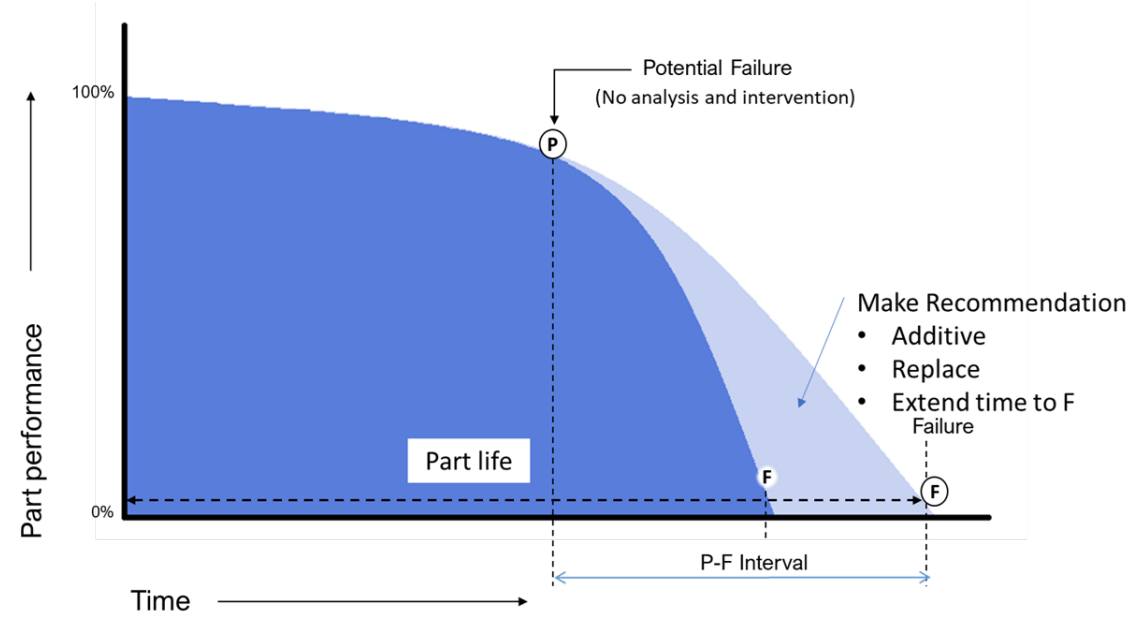
OAT PG-25 tolerates >2x the OCP limit for stability against hard water ions

Fluid Health and Condition Monitoring





To ensure system and fluid health, sampling and analysis is recommended at a regular cadence



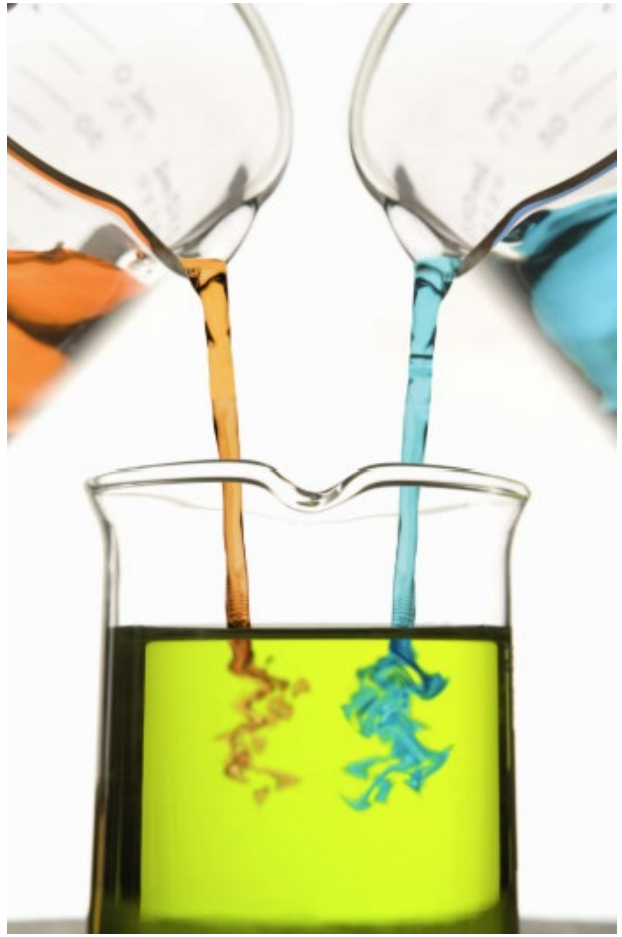
“Can We Mix Fluid Types”

Why would you want to?

- ODM flush fluid differs from commissioning fluid
- Co-locations
- Derisking supply chain
- Emergency top-off/replacements
- Operator error

Why should you try to avoid it?

- Fluid additives are optimized for each formulation
- Laboratory testing cannot mimic all real-world scenarios
- In-service monitoring complexities
  - Which fluid provider tests the fluid?
  - What specification is it tested to?
  - How does one recommend corrections?

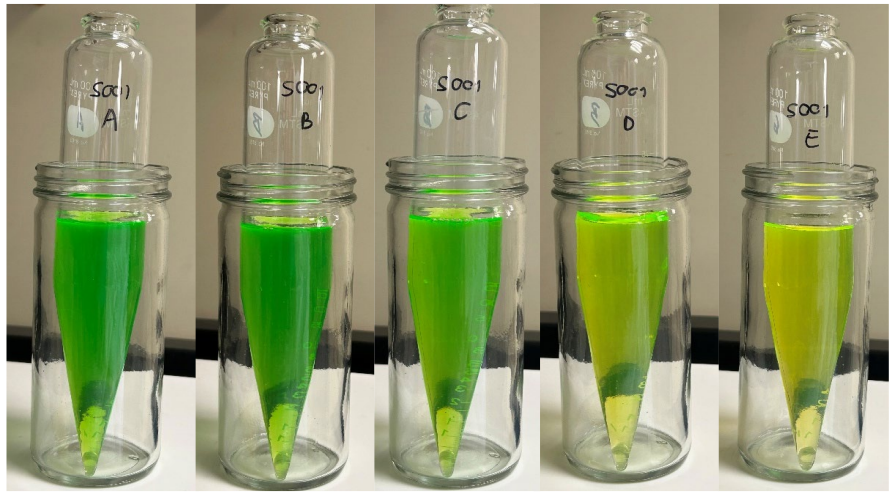


What does the data say?

Fluid Mixing Investigation

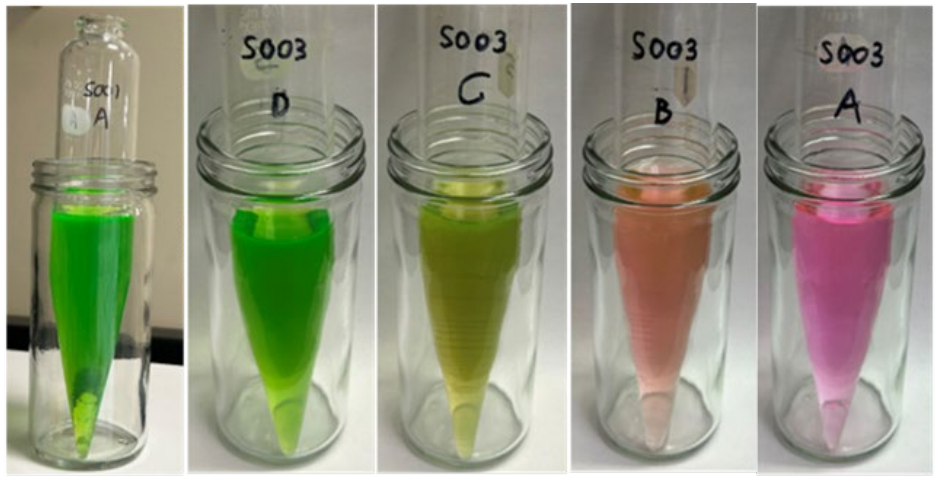
Fluid 1: OAT PG-25 – Organic acids + low phosphate + azole
Fluid 2: IAT PG-25-A – High phosphate + azole
Fluid 3: IAT PG-25-B – High phosphate + azole

Stable across all mixing ratios



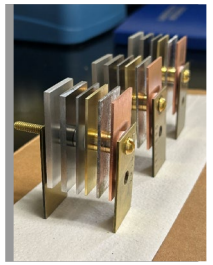
OAT PG25	100%	90%	50%	10%	0%
IAT PG-25-A	0%	10%	50%	90%	100%

Stable across all mixing ratios



OAT PG25	100%	90%	50%	10%	0%
IAT PG-25-B	0%	10%	50%	90%	100%

Mixing Impact on Corrosion Protection



OAT PG-25 + IAT PG-25-A

	ASTM D8040 Glassware Corrosion Test for Mixed Fluid Types			
Metal	**OAT PG25**	**90/10 OAT:IAT-A**	**50/50 OAT:IAT-A**	**IAT PG-25-A**
Cu C1100	1	1	3	1
Solder ASTM	1	1	0	7
Brass	1	1	1	2
Steel	0	0	0	1
Cast Fe	0	-2	-2	0
Cast Al	-1	0	0	0
(negative values means weight increase)				

OAT PG-25 + IAT PG-25-B

Metal	**OAT PG25**	**90/10 OAT:IAT**	**50/50 OAT:IAT**	**IAT PG-25**
Cu C1100	1	0	1	2
Solder ASTM	1	1	1	1
Brass	1	1	1	2
Steel	0	0	0	-1
Cast Fe	0	-1	-1	-7
Cast Al	-1	0	2	38
(negative values means weight increase)				

Mixing Conclusions

- The industry needs guidance for unavoidable instances where fluids must be mixed
- Fluid mixing should be evaluated on a fluid-by-fluid basis. Generalizations about mixing fluid types should not be made
- Mixing OAT PG-25 with two commercial IAT PG-25 products shows no mixing incompatibilities and no negative effects on corrosion protection via ASTM D8040
- Mixing causes challenges for in-service fluid health monitoring and should be avoided when possible.

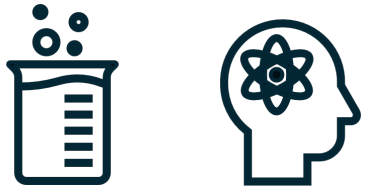
Agenda:
Industry validated, future ready: SOLUTHERM OAT PG 25

- AI Liquid Cooling: It's Non-Negotiable
- Problem: Anxiety around deploying liquid cooling at scale
- Solution: A basic understanding of D2C fluid chemistry
- Industry validated, future ready: SOLUTHERM OAT PG 25
- Take Aways and Eliminating Confusion: Ask Solutherm!
- Live Q&A

PFX - Technology First Approach

PFX PERFORMANCE FLUID EXPERTS GROUP™

Product Development



- 3 R&D facilities:
  - Danbury, CT
  - Cincinnati, OH
  - Nisku, Canada
- Develop products for new and existing markets
- In-house formulation development with robust IP portfolio
- PhD Chemists and Engineers
- Maintains OEM technical relationships

Product Support

- 3 fully equipped analytical laboratories across North America + 2 in Europe + 1 in Australia
- Existing coolant analysis program available to customers
- Expert sample analysis and remediation recommendations for data centers
- Material compatibility testing available (rubber/elastomer & metallic)
- Technical training sessions for customers & liquid cooling deployment teams

Industry Leaders

ASHRAE ASTM OPEN Compute Project®

- Active OCP members in liquid cooling and related workstreams
- Active ASHRAE 9.9 Technical Committee Members
- Chair SAE's EV Low Conductivity Thermal Management Task Force
- Collectively chair five ASTM D15 Coolant and Related Fluids committees

OPEN Compute Project®

Solutions and Services for Data Center Thermal Management

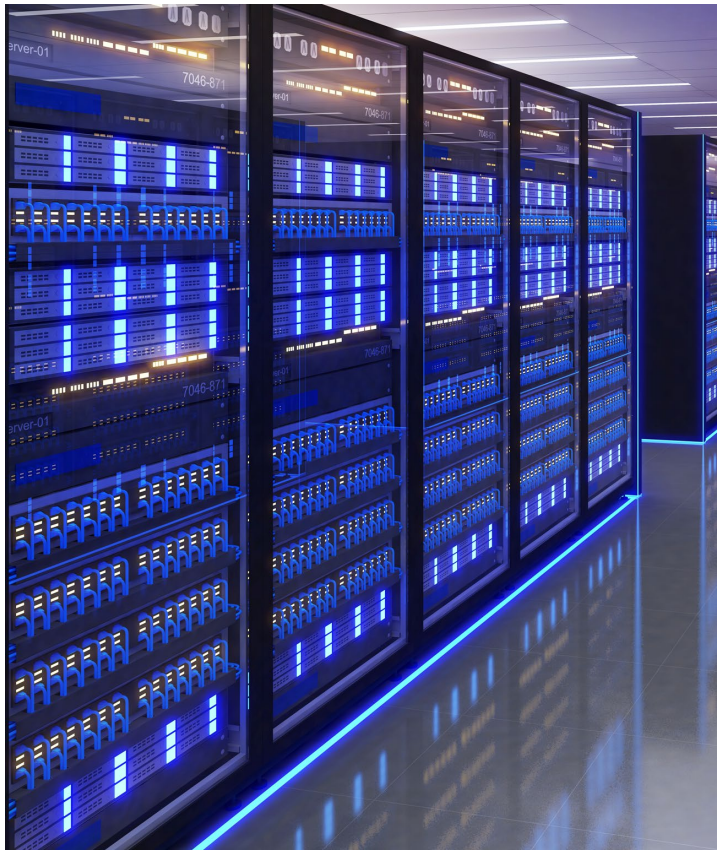
PFX PERFORMANCE FLUID EXPERTS GROUP™

Community-driven hyperscale innovation for all

PFX Solution – The *Original* Data Center OAT PG 25

SOLUTHERM™ THERMAL MANAGEMENT SOLUTIONS

- Formulated with a Low-Phosphate Organic Acid Technology
- Broad Global Regulatory Compliance
- Low Foaming
- OCP-Inspired
- Long Life
- Ready-to-use



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Solutions and Services for Data Center Thermal Management

PFX PERFORMANCE FLUID EXPERTS GROUP™

Community-driven hyperscale innovation for all

PFX Solution – The *Original* Data Center OAT PG 25

SOLUTHERM™
THERMAL MANAGEMENT SOLUTIONS

REMEDIATION
In-use testing & remediation options

RECOMMENDATIONS
Recommendations & formulation selection for continued use

REPORTING
Full expert data reporting

MAINTENANCE
System & fluid maintenance

PREDICTIVE ANALYSIS
Predictive analysis for when fluid will reach end of life

MAXIMIZE UPTIME
Technical guidance & reliability for maximum system uptime

PFX Solution – Solutherm™

Solution: Reference designs for IT hardware; OCP workgroups for fluid standard

Base Specification for Single-Phase
Propylene Glycol-Based Fluids
(PG 25)

The RIGHT Product: Solutherm™ OAT PG 25 Direct-to-Chip Data Center Coolant

Agenda:
Take Aways and Eliminating Confusion: Ask Solutherm!

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Take Aways

- Liquid cooling is now a mainstream technology. Latest chips and most AI deployments are native liquid-cooled.
- Despite becoming widespread, liquid cooling still brings new challenges to data centers.
- Capabilities in designing and maintaining liquid cooling systems are now essential to data center designers and operators.
- As the lifeblood of liquid cooling systems, the choice of fluid in the technology cooling system (TCS) is fundamental—and can have important consequences to the lifetime, resiliency and TCO of a liquid cooling solutions.
- There are many fluid options available, but PG25 has been establishing itself as the standard solution for single-phase direct-to-chip liquid cooling. But even within PG25, there are many options and trade-offs to be considered.
- Support from experts in fluid chemistry and condition monitoring has become a go-to for data centers.

Live Q&A

James Kelly
VP Market Intelligence and Innovation
OCP Foundation

Alex Cordovil
Research Director, Data Center Physical Infrastructure,
Data Center Liquid Cooling Markets
Dell'Oro Group

Tom Corrigan, PhD
Director of Electrification Technology
PFX Group

Thank you for attending

A Chemical Perspective on Liquid Cooled Data Centers

OCP Educational Webinar Series

November 13, 2025

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Community-driven hyperscale innovation for all