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SEMINAR 23: Data Center and IT Equipment Liquid Cooling: Performance Capabilities, Implementation and Emerging Technologies

Considerations of Non-Conventional Liquid Cooling Immersion Technologies

Learning Objectives

- Understand the basic implementation differences and thermal performance advantages of liquid cooled ITE.
- Describe the performance and density advantages of liquid cooled ITE and understand the trends in ITE highlighting the limitations of current cooling solutions as well as why liquid cooling is being implemented.
- Introduce the ASHRAE liquid cooling classes and the impact these classes have on the data center design.
- Demonstrate liquid cooling using real world case studies to understand the advantages and challenges of implementing liquid cooling.

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- * ESTCP: Environmental Security Technology Certification Program

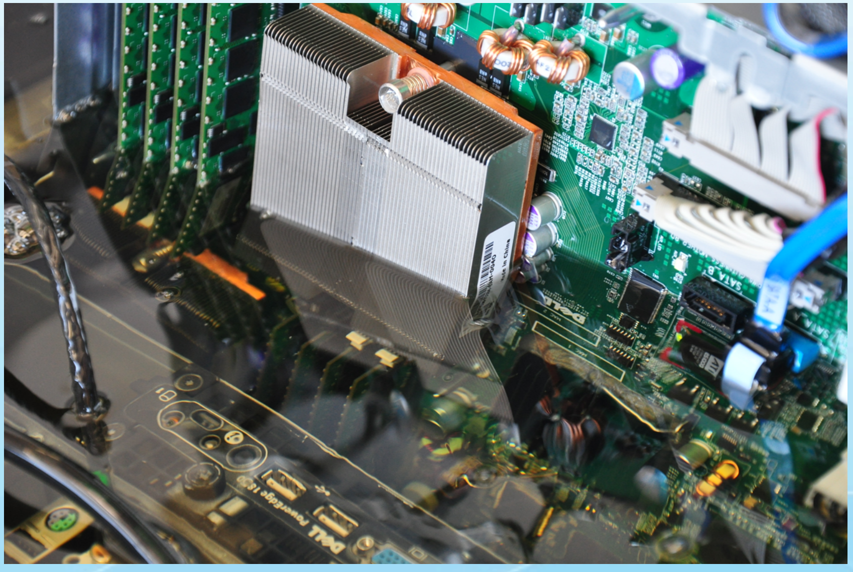
Overview

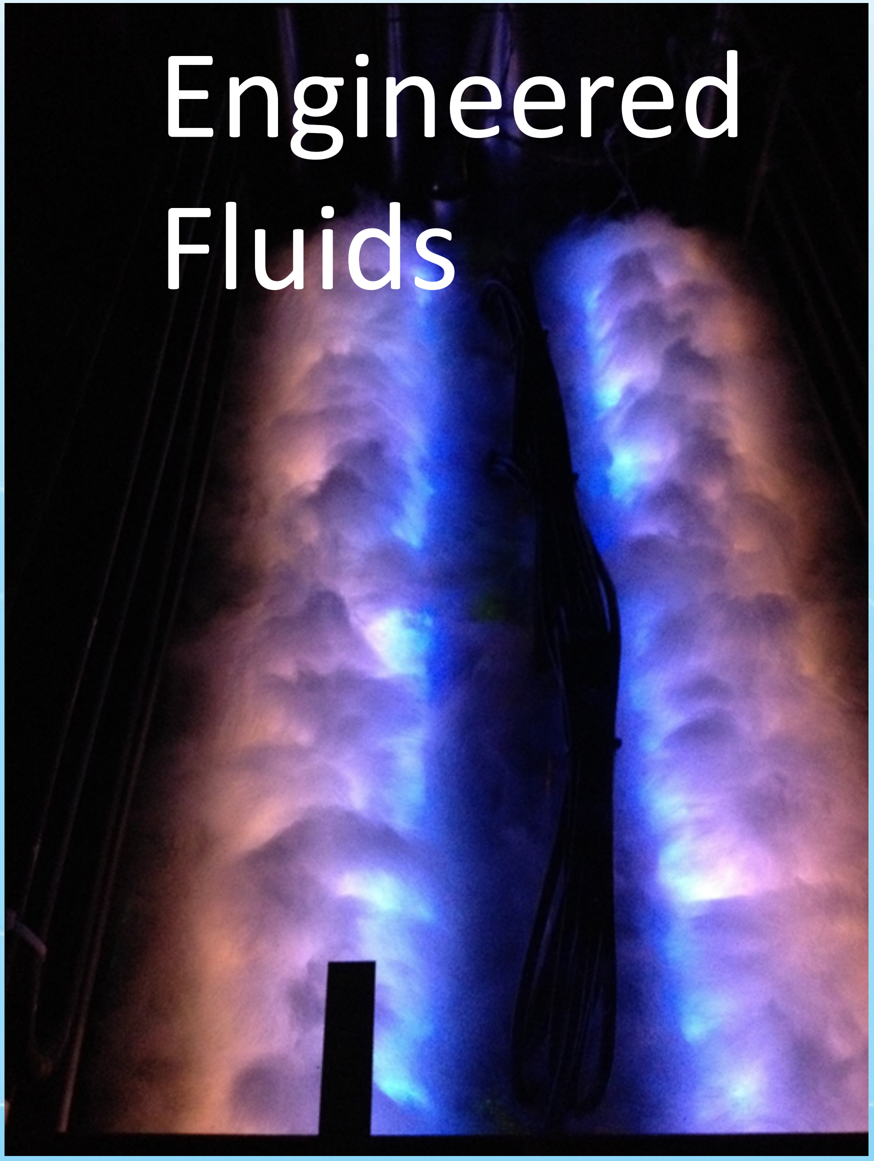
- Immersion cooling types
- Compare and contrast immersion and direct liquid cooling
- Immersion Cooling Benefits
- Immersion Cooling Challenges
- Case Study
- Opportunities and Next Steps for Immersion

Immersion cooling fluid properties & types

- Characteristics
  - Dielectric
  - Thermal / Fluid Properties
- Engineered Fluids
  - Two Phase
  - Single Phase
- Oils
  - Types

Immersion in use





Immersion Benefits

- Cools everything in the bath
- Selectable fluid temperatures
- Low PUE and ITUE
- Free cooling opportunity
- Heat recovery opportunity
- Platform design options
  - Do very little (e.g. TIM changes, seal hard drives, boiling enhancement, thermal management changes)
  - Go wild (current form-factors driven by airflow path, many opportunities exist for denser, cheaper designs)

Immersion Challenges

- Material compatibility
- Fluid costs
  - Engineered Fluids – expensive
    - Evaporative loss minimization critical to TCO
  - Oils – reasonable
- Service Model
- Platform management
- Platform configuration
- Warranty

Qualitative Comparisons

Disclaimer:

The values on this slide are solely the opinions of the presenter, are site dependent, and likely never agreed to by a large group.

The key message is that **EACH SITE** must consider *all* these factors in their decisions and do their own analysis. There is no best answer for all.

	Immersion Oil	Immersion Engr Fluids	Direct Liquid	Liq Air Combo	Air	Comments
Thermal Performance	++	+++	++	+	0	Two-phase advantages
Serviceability	---		--	--	0	Oil messy, 2 phase evaporates
CapEx – IT/Facility	+/++	--?/+++	--/++	-/--	0	Fluid cost
OpEx – IT/Facility	++/+++	++?/+++	++/++	+/+	0	Fluid replacement cost
Efficiency – PUE/ITUE	++/+++	+++/+++	++/+++	0/+	0	Several good choices
Reliability – IT/Facility	+++/++	++/++	+/++	--/-	0	Lower = good, stable = good
Optimization - Efficiency	++	+++	+	0	0	Reduce leakage, reduce ITUE
Optimization - Performance	++	+++	++	+	0	Higher speeds w/ cooler chips
Energy Reuse Potential	++	+++	++	+	0	% removed & quality of heat
Water Savings	++	+++	++	0	0	Free cooling w/o evaporation
High density in Legacy DC	++	+	+	+++	0	Ease of adding to older DC
Application in new DC	+++	+++	+++	-	0	Two flavors of cooling suffers
Market Ready/Risk	--	---	-	-	0	Will change with time
Noise	+++	+++	+++	+	0	Ahhhh, thank you
Air Corrosion	+++	+++	+	+	0	Direct still exposes IT to air

0 = baseline   + = better   - = worse

Qualitative Comparisons

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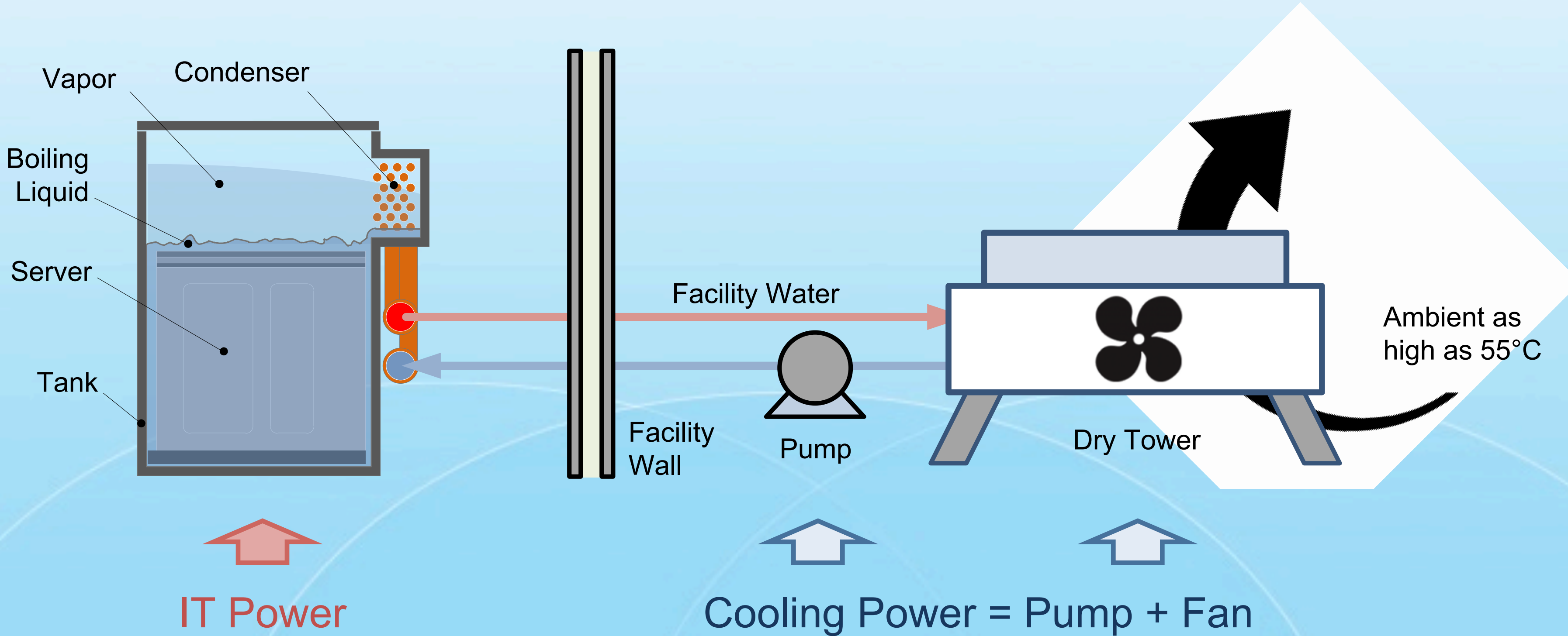
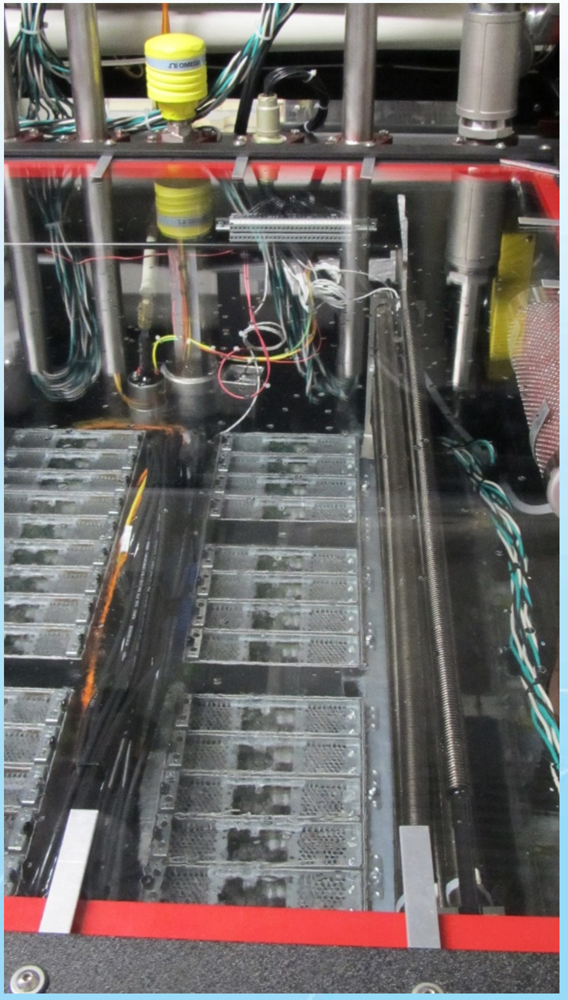
Case Study: Open bath liquid immersion cooling using engineered fluids



- ❑ Goal is to evaluate energy savings potential using immersion

Cooling temperatures

- Immersion systems can cool at relatively high cooling temperatures
  - 49 ˚C & 61 ˚C boiling point options depending on fluid
  - Both are "cool" compared to chip temperatures
- Dry coolers (no water use ☺) can condense engineered fluids easily in most climates
- Cooler temperature can drive performance ***OR*** warmer temperature can optimize energy re-use
  - Case study using 49 ˚C



OFF

IDLE

LINPACK RUN

Insert Movie Here

Energy Performance

$$PUE{\downarrow}cooling = IT + TankControls + DryCoolerFan + LoopPump\ /IT$$

$$ITUE{\downarrow}cooling = IT + internalITcooling/IT$$

$$TUE{\downarrow}cooling = ITUE \times PUE$$

Initial Results

$$PUE_{cooling} = IT + TankControls + DryCoolerFan + LoopPump\ /IT$$

$$PUE_{cooling} = 20.930 + 0.0719 + 0.144 + 0.254\ /20.930 = 1.022^{*}$$

$$ITUE_{cooling} = IT + internalITcooling/IT = 1.00$$

$$TUE_{cooling} = ITUE \times PUE = 1.022$$

**We are up and running,
and seeing energy benefits**

* Current results using fixed speed (100%) fans and pumps

Immersion cooling eliminates compressor based systems

Eliminate chillers and CRAC units

Eliminate cooling towers & evaporative water loss

Reduce number of pumps

Eliminate server fans

More hours of “Free cooling”

Simplified controls

Reduced maintenance cost

Cooling systems can be much simpler

Case Study Expected Benefits

- Capital cost savings
- Improved reliability
  - Elimination of potential points of failure
  - Temperature stability improving reliability
- Energy savings (IT and infrastructure)
- Enables high density computing and close interconnection of processors
- In the future, electronics can be optimized for immersion for even better performance
- More potential for heat reuse
- Additional applications – e.g. aviation, military

Immersion Next Steps

- Complete the DoD Evaluation
  - Performance & TCO
- Continue to explore chemical compatibilities
- Evaluate other issues
  - Signal Integrity
  - Optical interconnect
- Track market adoption and performance
- Consider immersion-optimized platforms
  - What new designs might this enable?

Conclusions

- General
  - Immersion cooling can offer a wide range of new design opportunities and optimizations
  - Work continues to explore how to bring it more main-stream
- Case Study
  - Engineered fluids are well suited to the high density of HPC
  - Minimizing fluid loss will be very important to TCO success
  - We expect learn a lot around system design and material issues in our test

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Questions?

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