OCP Harmonization

Jessica Gullbrand & Rolf Brink
Cold Plate & Immersion Work Stream Leads
Advanced Cooling Solutions
Liquid Cooling Terminology
Liquid Cooling Terminology

Develop OCP specific or use existing? F.ex. ASHRAE

ASHRAE terminology:
• Condenser Water System (CWS)
• Facility Water System (FWS)
• Technology Cooling System (TCS)
• Datacom Equipment Cooling System (DECS)
Liquid Cooling Terminology

Worked with ASHRAE representatives to clarify the definitions

Liquid Loop Definitions

- ASHRAE’s recommendation: eliminate DECS and use TCS

Figure from ASHRAE 2014. Liquid Cooling Guidelines for Datacom Equipment Centers, Book 4
Liquid Cooling Terminology

Cold Plate & Immersion Work Streams

- ASHRAE’s FWS extended to also include other cooling liquids than water
- TCS used and DECS not used
Cooling Liquid Quality
Cooling Liquid Quality

Something for OCP to develop liquid quality requirements?

References:
ASHRAE 2014, Liquid cooling guidelines for datacom equipment centers, second edition, Atlanta ASHRAE

EEHPCWG 2019, Open specification for a liquid cooled server rack, draft version https://docs.google.com/document/d/14OkMv_q28Aw9KBlRkFIMSLuQmeT-2p2Gy81zoT706XI/edit

ASHRAE 2019, Water-Cooled servers common designs, components, and processes, White Paper, Atlanta ASHRAE

Note: ASHRAE only considering water with additives cooling liquids!
Baseline water comparison for Cooling loop April 2019
Prepared for EEHPCWG by Nigel Gore

This document compares water quality guidelines issued by industry bodies for the Technology Cooling System (TCS)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum Limit or Range</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EEHPCWG</td>
<td>ASHRAE TCS</td>
</tr>
<tr>
<td>TSS</td>
<td>1 ppm</td>
<td>&lt;3 ppm</td>
</tr>
<tr>
<td>pH</td>
<td>7.6-10.3</td>
<td>7 to 9***</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Calcium</td>
<td>50 ppm</td>
<td>&lt;20 ppm**</td>
</tr>
<tr>
<td>Magnesium</td>
<td>50 ppm</td>
<td>--------</td>
</tr>
<tr>
<td>Silica</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Chloride</td>
<td>25 ppm</td>
<td>&lt;5 ppm</td>
</tr>
<tr>
<td>Sulfate</td>
<td>25 ppm</td>
<td>&lt;10 ppm</td>
</tr>
<tr>
<td>Iron</td>
<td>1.0 ppm</td>
<td>--------</td>
</tr>
<tr>
<td>Copper</td>
<td>0.5 ppm</td>
<td>--------</td>
</tr>
</tbody>
</table>

**/***2014 Ashrae Datacom series 4 Liquid Cooling Guidelines for Datacom equipment discrepancy with 2019 Water-cooled Servers whitepaper
pH on TCS 8.0 to 9.5 (7 to 9)
Calcium on TCS <0 ppm (<20 ppm)
Baseline water comparison for Cooling loop April 2019
Prepared for **EEHPCWG by Nigel Gore**

In addition to Baseline water specifications stated the following parameters are mentioned as areas of best practice and consideration.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum Limit or Range</th>
<th>ASHRAE TCS</th>
<th>ASHRAE FWS</th>
<th>IBM DECS</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turpidity</td>
<td>&lt;20 NTU</td>
<td>&lt;20 NTU</td>
<td>&lt;1 NTU</td>
<td></td>
<td>The measure of particles in a fluid that affect the clarity of water. Quantitative determination of Turbidity defined by ISO 7027-1:2016</td>
</tr>
<tr>
<td>Conductivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>According to Ashrae is a measurement of Mineral content in the water, high conductivity is an indicator of bacterial degradation of the nitrite.</td>
</tr>
<tr>
<td>Filtration</td>
<td>&lt;50 µm</td>
<td>&lt;50 µm</td>
<td></td>
<td></td>
<td>Filtration considerations for the TCS loop, with maintenance schedules, up to 50 µm dependent on particulate size and cold plate fin width design.</td>
</tr>
<tr>
<td>Strainers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>To purge sediment from a TCS loop, design considerations to consider strainer or side stream filters.</td>
</tr>
<tr>
<td>Commission of system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Water treatment with chemical flush of the TCS loop.</td>
</tr>
<tr>
<td>Bacteria</td>
<td>&lt;1000 CFU/mL</td>
<td>&lt;100 CFU/mL</td>
<td>&lt;1000 CFU/mL</td>
<td></td>
<td>Maintain systems to limit bacteria count below 1000 CFU/mL</td>
</tr>
<tr>
<td>Chlorine, Chlorine dioxide, bromine</td>
<td>Avoid</td>
<td>Avoid</td>
<td></td>
<td></td>
<td>Materials to avoid within TCS loop.</td>
</tr>
</tbody>
</table>
FWS Parameters
**FWS Parameters**

<table>
<thead>
<tr>
<th>To add to current OCP ready list:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rack grounding point location</td>
<td></td>
</tr>
</tbody>
</table>

**Additional items for ACS**

<table>
<thead>
<tr>
<th>Cooling</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid interfaces per solution</td>
<td>1x feed+return 2x feed+return</td>
</tr>
<tr>
<td>Pipe sizes</td>
<td>1&quot; BSP 1,25&quot; BSP 1,5&quot; BSP 2&quot; BSP</td>
</tr>
<tr>
<td>FWS liquid heat capacity</td>
<td>{Specify}</td>
</tr>
<tr>
<td>FWS liquid viscosity</td>
<td>{Specify}</td>
</tr>
<tr>
<td>FWS circulation method</td>
<td>Pressure drive Flowrate Other (specify)</td>
</tr>
<tr>
<td>FWS default flowrates</td>
<td>{Specify}</td>
</tr>
<tr>
<td>FWS Supply temperature</td>
<td>{Specify}</td>
</tr>
<tr>
<td>FWS desired return temperature</td>
<td>{Specify}</td>
</tr>
<tr>
<td>FWS pressure (gauge)</td>
<td>50-100 kPa 100-400 kPa 400-800 kPa</td>
</tr>
</tbody>
</table>
Leakage Detection & Mitigation
Leakage Detection & Mitigation

How important is it?

• Is it a significant concern?
• What are the concerns?
• Documentation or information about potential leaks?
• What type of detection is preferred?
• What type of mitigation is preferred?
Performance Metric
Performance Metric

PUE versus TUE for liquid cooling

PUE = Power usage effectiveness

TUE = Total PUE, “PUE” type metric

ITUE = PUE for the IT equipment
Performance Metric

PUE

\[ PUE = \frac{Total \ Data \ Center \ Annual \ Energy}{Total \ IT \ Annual \ Energy} \]

- Introduced in 2006 by Malone and Belady
- Developed and agreed to by EU Code of Conduct, DOE, EPA, Green Grid, ASHRAE, etc…

https://eehpcwg.llnl.gov/assets/as_tue_a_new_look_at_pue.pdf
Performance Metric

PUE Definition

\[
\text{PUE} = \frac{\text{Total Energy}}{\text{IT Energy}} = \frac{\text{Cooling} + \text{PowerDistribution} + \text{Misc} + \text{IT}}{\text{IT}} = \frac{a + b}{d}
\]
Performance Metric

but PUE isn't perfect, consider.....

\[
PUE = \frac{\text{pwr} + \text{fan}_{DC} + (\text{IT} + \text{fan}_{IT})}{\text{IT} + \text{fan}_{IT}}
\]
Three variations...

\[ PUE_a = \frac{\text{pwr} + \text{fan}_{\text{DC}} + (\text{IT} + \text{fan}_{\text{IT}})}{(\text{IT} + \text{fan}_{\text{IT}})} \]

\[ PUE_b = \frac{\text{pwr} + (\text{IT} + \text{fan}_{\text{IT}})}{(\text{IT} + \text{fan}_{\text{IT}})} \]

\[ PUE_c = \frac{\text{pwr} + \text{fan}_{\text{DC}} + \text{IT}}{\text{IT}} \]

\[ PUE_b < PUE_a < PUE_c \text{ but is (b) best?} \]

We don’t know....
Performance Metric

**ITUE**

\[
ITUE = \frac{\text{total energy into the IT equipment}}{\text{total energy into the compute components}} = \frac{g}{i}
\]
Performance Metric

\[ PUE = \frac{\text{Total Energy}}{\text{IT Energy}} = \frac{a + b}{d} \]

\[ ITUE = \frac{\text{Total Energy}}{\text{Compute Energy}} = \frac{g}{i} \]

\[ TUE = ITUE \times PUE = \frac{a + b}{i} \]
Performance Metric

Does it work?

a) both fans

\[ TUE_a = \frac{pwr + fan_{DC} + fan_{IT} + compute}{compute} \]

b) IT fans only

\[ TUE_b = \frac{pwr + fan_{IT} + compute}{compute} \]

c) bldg fan only

\[ TUE_c = \frac{pwr + fan_{DC} + compute}{compute} \]

The lowest TUE yields the lowest energy use. Yes, it works!
Heat Reuse
Datacentre energy is “HOT”

Data Centers As A Solution To Climate Change?

February 27th, 2019 by Robyn Purchia

At Facebook, we aim to minimize our energy, emissions and water impact, while embracing the responsibility and opportunity to impact the world beyond our operations.

The opportunity

When we announced the construction of our Odense Data Center in 2017, we were determined to build one of the most advanced, energy-efficient data centers in the world. The new facility will feature our latest hyper-efficient hardware, cooled using outdoor air through indirect evaporative cooling technology and powered by clean and renewable wind energy.

This facility will also be unique because of infrastructure to capture and use waste heat. Cooling the High-Performance Computing Center of Atlanta, Tech Square
Temperature chaining

- Serial implementation of the infrastructure

- Low volume displacement: 500% dT=20% flowrate
  - high Δp: Small, more powerful pumps
  - Small pipes

- 3-stage cooling for low water volume
  - Down to 40 °C, Free-air
  - Between 32-40 °C, Free-air/Adiabatic
  - Between 28-32 °C, Chiller

Reuse value

• Main goal: fixed temperature determines value
  - Absolute temperature determines value
  - 40-50°C heating households, swimming pools etc.
  - 50-70°C Local distribution district heating
    (Gen4 heat grids roll-out in Europe)
  - 70-100°C Longer distance distribution

• Secondary goal: Volume determines reuse propensity
  - Heat is expressed in Joules (GJ)
  - 1 MW=1 MJ/s, 1MWh=3.6GJ
  - In Europe, 1 GJ= € 18.1 ($ 20.3)
  - 100 MW facility heat potential: €571K/year ($ 640K)

(source: european-district-heating-price-series-energiforskrappreport-2016-316)
Backup
Liquid Cooling Terminology

Worked with ASHRAE to clarify their definitions

Figure from ASHRAE 2019. Water-Cooled servers common designs, components, and processes, White Paper.
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Worked with ASHRAE to clarify their definitions

Figure 7  Non-CDU liquid cooling system within a data center.

Figure from ASHRAE 2019. Water-Cooled servers common designs, components, and processes, White Paper

RFU = rack filtration unit
FFU = facility filtration unit
Global average PUE: 1.70

Global estimated PUE breakdown:
- Cooling: 37%
- Power: 2%
- Other: 2%
- ICT: 59%
- Fans (10%): 5%
- PSU (10%): 5%
- Information (65%): 49%

IT efficiency 2.04
- Information: 49%
- Cooling + IT fans: 42%
- Power incl IT PSU: 7%
- Other: 2%
Efficient PUE: 1.12

Global estimated PUE breakdown

- ICT: 89%
- Cooling: 6%
- Power: 4%
- Other: 1%
- Fans (10%): 7%
- PSU (10%): 8%
- Information (65%): 74%

IT efficiency 1.34

- Cooling + IT fans: 14%
- Power incl IT PSU: 11%
- Other: 1%
- Information: 74%