Suggested changes to ACS Immersion documents

Document usage

This document is used to collect contributions to the ICS Immersion workstream within the OCP ACS charter.

Use the table provided in "New contributions" to suggest content, updates, edits or insights to the workstream. ACS Immersion Requirements

Document location:

OCP ACS Immersion Requirements Rev 2 - Review

New contributions

The following topics will be scheduled for discussion in the ACS Immersion workstream calls.

Include the target document in the suggested change. If the relation to current document efforts is unclear, make sure to mention this.

Please submit suggestions for evaluation in the following table

Name	Document	Suggested change/update	Evaluation remarks
Don Mitchell	Immersion Requirements - Uptime factors	Thermal Ride Through	Should a minimal thermal ride through and EOP time be part of immersion recommendations?
Rolf Brink	Immersion Requirements	Require BIM models	Per request of ACF and Cooling project

Backlog

Name	**Suggested change/update**	**Evaluation remarks**
Mark dansie /Rolf Brink	Classifications for output temperatures (Ashrae W3-5 style, but for exhaust) Assigned to Jack Kolar JK response: If the temperatures will be needed for a FWS or “DHS” at a higher level, then 1) should we add levels above “W5” such as “W6” & “W7” perhaps at 65 or 75? Then 2) should we not also discern between the incoming FWS water that cools the system and the OUTGOING water that will be harvested, perhaps by a heat recovery mechanism? ALSO: Should there be some distinction made between the FWS temperatures and the TCS levels, even to the point of rating that difference or “approach”?	Redirect to ACF project.

Reallocation of contributions

Name	**Suggested change/update**	**Evaluation remarks**

Resolved contributions

Name	Suggested change/update	Evaluation remarks
~~Nigel Gore~~	~~General: Change reference for water to "facility coolant".~~ ~~Update to "Facility liquid"~~	~~Original consideration for water is to ensure water-based compatibility. "Coolant" potentially allows liquids which may be incompatible (corrosion, leakage, thermal) with (some) immersion technologies.~~
~~John Bean~~	~~6.2~~ ~~Any solution must be able to deal with water circuits with (negative) pressure driven water partial vacuums down to 50 kPA (absolute) circuits up to 800 kPa (gauge). Both pain plain water and glycol mixtures up to 50% should be supported, as well as any other OCP compliant coolant definition which is defined in the OCP standards for facility infrastructures. *(to be defined)* Filtration and water quality management are managed by the OCP standards for facility infrastructures *(to be defined)* and not required as part of the immersion solution. Any higher filtration requirements should be integrated in the solution or addressed with a closed secondary circuit system.~~	~~Best practice to specify vacuum as absolute pressure not "negative pressure" and we should state value for depth of vacuum~~ ~~RB: Feels like "correction" instead of addition (like typo). Perhaps there is a way to allow corrections on approved documents. Should discuss this "technicality" with OCP committee.~~ ~~Negative pressure to be corrected to partial vacuum.~~ ~~50 kPa to be submitted for future submission~~
~~Rolf Brink~~	~~***Pressure drop - ASHRAE W2**~~	~~Suggest change to W3 for consistency.~~
~~Jessica Gullbrand~~	~~The terminology used here is the same as used by ASHRAE when discussing cooling~~	

	~~solutions. The terminologies are:~~ • ~~Datacom Equipment Cooling System, DECS, is the cooling system within the rack. DECS does not extend outside of the rack.~~ • ~~Technology Cooling System, TCS, is the cooling system from the Cooling Distribution Unit (CDU) to the rack and from the rack to the CDU.~~ • ~~Facilities Water System, FWS, is the facility cooling system. The definition of FWS is extended in this document to also include other cooling liquids in addition to water.~~	
~~Nigel Gore~~	~~Liquid cooling within the datacenter is the process where heat is removed by a liquid rather than air. When a liquid is in direct contact with the electronics this is liquid immersion cooling. There is a variety of liquid immersion technologies available to cool Information Technology Equipment (ITE) within the data center. The common denominator for each immersion system is that a dielectric liquid is used to completely immerse the heat generating electronic components. This dielectric liquid is thermally conductive with poor electrical conductivity making it possible for use with electronic components. The dielectric liquid comes into direct contact with the electronic components to capture and transport the heat to data center facility heat rejection equipment. The range of heat rejection method varies by facility and require interfaces to connect to the cooling system.~~	~~This is a revision to the Introduction on page 5 of the immersion requirments document~~

	~~The terminology defined by ASHRAE assists with determining the classification of liquid cooling infrastructure.~~ • ~~Datacom Equipment Cooling System (DECS)is the cooling system within the rack. DECS does not extend outside of the rack and contains a combination of dielectric fluids, heat exchangers, coils of evaporators in combination with self-driving (passive) or pumped circulation methods, valves, interconnects and control electronics.~~ • ~~Technology Cooling System, TCS, is the cooling system that is within the IT space within liquid cooling this is a dedicated loop system supported typically by a Cooling Distribution Unit (CDU) to one or more liquid immersion enclosure(s). Fluids used within the TCS vary and can be ethylene glycol or propylene glycol water mixture, pure treated water, refrigerants or dielectrics. A heat exchanger in combination with ancillary equipment is used to transfer the heat between the TCS and DECS to the Facility Water System (FWS)~~ • ~~FWS, is the facility cooling system and contains the heat rejection plant equipment and could include a cooling tower, pumps, chiller units, Direct Expansion or dry coolers to disperse the heat to atmosphere.~~	

~~Nigel Gore~~	~~A TCS is usually designed for 100 kW or more, whereas an integrated heat exchanging device is usually designed for 10-100 kW cooling capacity.~~	~~This statement is incorrect, suggest removal~~
~~Nigel Gore~~	~~Add water reference to ashrae~~	
~~Nigel Gore~~	~~Page 7~~ • ~~Any liquid system may only be placed in a well-ventilated room;~~	~~This is not required for enclosed chassis systems that utilise single phase immersion.~~ ~~Suggested Change~~ • ~~Any open bath liquid immersion system may only be placed in a well-ventilated room;~~
~~Nigel Gore~~	~~kN/m², Bare solution filled with liquid, incl. FWS interfaces~~	~~Clarification required to confirm if this FWS or TCS~~
~~Nigel Gore~~	~~Page 17 and 18 FWS is confused with TCS, clarification required with rewrite.~~	
~~Nigel Gore~~	~~Add references~~ ~~ASHRAE. 2014. Liquid cooling guidelines for datacom equipment centers, second edition. Atlanta: ASHRAE.~~ ~~ASHRAE.2019. Water-Cooled servers common designs, components, and~~	

<table>
<tr><td></td><td>~~processes, White Paper. Atlanta: ASHRAE~~</td><td></td></tr>
<tr><td>~~Wiwynn
Sunny~~</td><td>~~4.3 Liquid management:~~
~~Immersion liquid should avoid generating excess of substances which have been listed on **IEC 60721-3.**~~
<table>
<tr><th>Environmental parameter</th><th colspan="2">IEC 60721-3
3C1 Maximum value</th></tr>
<tr><td>Sulphur dioxide SO_2</td><td>0.1</td><td>mg/m^3</td></tr>
<tr><td>Hydrogen sulphide H_2S</td><td>0.01</td><td>mg/m^3</td></tr>
<tr><td>Chlorine Cl_2</td><td>0.1</td><td>mg/m^3</td></tr>
<tr><td>Hydrogen chloride HCl</td><td>0.1</td><td>mg/m^3</td></tr>
<tr><td>Hydrogen fluoride HF</td><td>0.003</td><td>mg/m^3</td></tr>
<tr><td>Ammonia NH_3</td><td>0.3</td><td>mg/m^3</td></tr>
<tr><td>Ozone O_3</td><td>0.01</td><td>mg/m^3</td></tr>
<tr><td>Nitrogen oxides NO_2</td><td>0.1</td><td>mg/m^3</td></tr>
</table></td><td>~~More information in next call April 30 May 14. (environmental conditions)~~

~~Approved, more elaboration and review needed to achieve proper content~~</td></tr>
<tr><td>~~Wiwynn
Sunny~~</td><td>~~2.Wetted material list(offer a reference for SI verification)~~
~~In order to ensure the signal integrity in immersion cooling, the measurement of *eye diagram should meet the following specification:~~
<table>
<tr><th></th><th>Data rate</th><th>Eye height</th></tr>
<tr><td>PCIe G3</td><td>16G</td><td>>34mV</td></tr>
<tr><td>PCIe G4</td><td>32G/s</td><td>>19mV</td></tr>
</table>~~*eye diagram: An eye diagram is a common indicator of the quality of signals in high-speed digital transmissions.~~
~~SI test:~~
~~Goal: To verify the signal integrity(S parameter) in dielectric liquid.~~
~~Evaluation method:~~
~~•Check the S parameter to ensure the loss and impedance is within the specification.~~</td><td>~~Will be discussed in focus group call on April 23th May 7th.~~

~~To be taken into the IT Gear spec focus group.~~</td></tr>
</table>

	~~•Check the eye diagram to ensure the signal integrity is within the specification.~~ ~~The experiment will follow the following steps: (Use PCIe test item for example)~~ ~~1. Assemble the DUT and connect the test fixture.~~ ~~2. Turn on and set the oscilloscope to default settings.~~ ~~3. Turn on the DUT. Load the pattern generator tool and generate the test pattern signal.~~ ~~4. Capture the signal and save it as binary file (.bin) by using the oscilloscope.~~ ~~5. Test the saved waveform by using software SigTest.~~ ~~6. Check the test result and make sure the result is within the specification.~~	
~~Wiwynn Sunny~~	~~Should MTBF and MTTR be taken into consideration for immersion tank?~~	~~Approved exploration of topic for next paper.~~ ~~Too hard to implement due to industry level and abilities of providers. Re-focus to availability framework including potential metrics. I.e. How much time is available between cooling failure and actual overheating?~~ ~~n+1 availability?~~
~~Inflectiontech/ DCF project Mark Dansie~~	~~Facility Water System (FWS), is the liquid facility cooling system and contains the heat rejection plant equipment (e.g. cooling towers, pumps, chiller units, dry coolers or district heating grids).~~	~~For the liquid to be useful for a district heating system (DHS) my understanding is that liquid temperatures should be in the range of 65 - 75 deg Celcius. I would suggest guidelines are added to this~~

	~~*Note: Within OCP, the facility water system is not limited to water based liquids.*~~	~~document on whether useful temperatures can be achieved for DHS.~~
~~Rolf/Husam~~	~~Air changes requirement metric for vendor~~	~~Suggest adding metric: Amount of air changes required per hour or day for ventilation purposes.~~
2020/4/22 Raúl Álvarez - Jaime Pita (Thermodynamics) - Submer	~~Whitepaper - Design Guidelines for Immersion-Cooled IT Equipment, 1. Material Compatibility, 1.2 Components to Check for Compatibility and Material Source of Contaminant, Table, Heatsinks row, Potential Issue column: Add "Also different thermal performance is expected."~~	~~Minor correction, I've processed this one. Tx.~~
~~2020/4/22 Raúl Álvarez - Jaime Pita (Thermodynamics engineering) - Submer~~	~~OCP ACS Immersion Requirements Rev 2, 3. Glossary~~ ~~Specific heat and Volumetric expansion should be defined by Kelvin, not by degrees Celsius~~	~~Absolute Thermodynamics scale.~~ ~~Correct, and minor correction done. Tx.~~
~~2020/4/22 Raúl Álvarez - Jaime Pita (Thermodynamics engineering) - Submer~~	~~OCP ACS Immersion Requirements Rev 2, 4. Immersion technology definitions~~ ~~"Liquid cooling within the data center is the process where heat is removed by a liquid rather than air.", change "heat is removed" by "heat is extracted"~~	~~Correct and minor correction done. Tx.~~
~~2020/4/22~~	~~Whitepaper - Design Guidelines for~~	~~Processed. Not fully approved, but~~

~~Raúl Álvarez - Peter Cooper (Chemical engineering) - Submer~~	~~Immersion-Cooled IT Equipment, 1. Material Compatibility,1.4 Material Compatibility for Single-Phase Immersion Cooling (Fluorochemical Fluids):~~ ~~"Clean fluorochemical fluids, therefore show excellent compatibility by traditional material compatibility tests like ASTM D471, D2240, etc. In real-world immersion cooling applications, the fluorochemicals will become contaminated with hydrocarbons such as dioctyl phthalate (DOP) that is extracted from polyvinyl chloride (PVC) wire insulation or silicone oils extracted from silicone polymers, solder flux, or thermal interface materials, for instance.~~ ~~"~~ ~~"Such issues are rare, however, and a discussion of material compatibility with fluorochemicals is typically irrelevant, at least in the context of single-phase immersion."~~	~~changes have been made to address a potential issue.~~
~~2020/4/22 Raúl Álvarez - Jaime Pita (Thermodynamics engineering) - Submer~~	~~Whitepaper - Design Guidelines for Immersion-Cooled IT Equipment,,2. Thermal Design~~	~~The heat is not removed from, it's extracted to another medium~~
~~2020/2/21 Macick, DCX~~	*~~Immersion Requirements~~* ~~7.3 Minimum dielectric requirements changes:~~	~~Dielectric strength has been discussed. The stated numbers indeed relate to kV/2.5mm.~~

	• ~~Dielectric strength (assumed IEC 60156) MIN requirements set to >3 kV/mm (air) and common >35 kV/2.5mm. However common requirement for dielectric fluid is approx 60 to 70kV/mm and basic minimum requirement for most insulating oils is approx >35 kV/2.5mm~~ • ~~Commonly req flash point described as >200°C . Reality is it's around 140-160, mostly approx 150C. Should be changed. Also please define if OC or CC~~ ~~Flash point definition and properties table - please confirm if open or closed cup~~	~~Discussion must take place to synchronise used metrics in electronic development.~~ ~~Flashpoint discussion has led to motion to increase minimum value to 170°C and keep the recommended 200°C as a reference point.~~
~~2020/4/22 Raúl Álvarez - Jaime Pita (Thermodynamics engineering) - Submer~~	~~Whitepaper - Design Guidelines for Immersion-Cooled IT Equipment,2. Thermal Design, 2.1 Heat transfer optimization~~ ~~"Common single-phase dielectric liquids have specific heat properties ranging between 1300 J/kgK (Fluorocarbon) and 2300 J/kgK (Hydrocarbon), while air has a specific heat value of 1000 J/kgK.~~ ~~"As the specific heat metric suggests (J/kg*K), the specific heat relates to the weight (kg) of the liquid.(a)~~ **~~This is where the density of the liquid is of importance.~~**~~"~~ ~~(a) "Immersion in dielectric liquids results in greatly reduced heat transfer surface areas as the liquids are able to absorb heat much more~~	~~(a) The surface area parameter is related to the Newton's Law of Cooling for forced convection or natural convection problems, but this development for the conclusion is vague and with no explanation at all.~~ ~~(b) Data backing this up?~~ ~~(c) Again the surface area is linked to the Specific Heat capabilities with no explanation.~~ ~~(d) This reduction factor has no evidence.~~ ~~(e) Is not the density but the heat capacity of the medium~~

	~~effectively than air."~~ ~~(b) "It is however not simply a matter of stating that the surface area can be reduced with a factor of 1400 as this would require identical flow rates to air cooling."~~ ~~(c) "The higher density of the dielectric liquids compared to air means that the flowrate can and will be greatly reduced."~~ ~~(d) Add "velocity" to "(...) (density, viscosity, specific heat etc.)(...)"~~	
~~2020/4/22 Raúl Álvarez - Peter Cooper (Chemical engineering) - Submer~~	~~*Immersion Requirements*~~ ~~OCP ACS Immersion Requirements Rev 2, 5. Quality and safety requirements, 5.3 Liquid management~~ ~~"Single-phase systems should not exceed the minimum evaporation temperatures, unless vapor can be contained within the technical solution" What would the minimum evaporation temperature be? Evaporation is a continuum and there is no cut-off temperature as implied here, please remove.~~ ~~"Each operator must be trained on the properties of each dielectric liquid in use within the facility." What would the specific training be in this case?~~	~~*Suggest to change this to a standard property such as vapour pressure, noack volatility, or similar measures of evaporation.*~~ ~~*The training reference is not quantified. This is up to the liquid vendor, immersion system vendor or system integrator. In other words, whomever supplies immersion to an end-user. As long as the training covers the properties of the liquid, the risks of interacting with it, the best practices and what to do in case of calamities.*~~ ~~*Ideally these points should be made clear in the document*~~
~~2020/4/22 Raúl Álvarez - Jaime Pita (Thermody~~	~~OCP ACS Immersion Requirements Rev 2, 7. General standards, 7.1 Measurement units~~ ~~Temperatures should be in K.~~	~~*Temperatures can be used both in °C and K. °C is used in reference to specific temperature ranges while K is used to calculate dT or energy properties. They can be swapped because they are*~~

~~namics engineering) - Submer~~		*~~identical units, both part of SI.~~* *~~I suggest adding K to this description.~~*
~~2020/4/22 Raúl Álvarez - Peter Cooper (Chemical engineering) - Submer~~	~~OCP ACS Immersion Requirements Rev 2, 7. General standards, 7.1 Measurement units 7.3 Minimum dielectric requirements~~ ~~Dielectric strength (commonly req.) >35 kV/mm is a very high value, check the measurement unit to see if this is kV/2.5mm. Nevertheless the value is very high.~~ ~~Check if minimum req. Fire point >200ºC is correct. Fire point tends to be 10 to 15 degrees higher than the flash point, meaning that this minimum req is not consistent with the minimum flash point. Propose changing to 160.~~ ~~Sulphur contents figures are way too low for what's measurable.~~ ~~Safe handling training level: How's this defined exactly? What does "Novice" or "Expert" mean?~~ ~~Hazard statements are not incremental or decremental, and have additional clauses on top of them. Avoid this kind of usage.~~	~~Maciek DCX: reading replies. Industrial standard for dielectric fluid is more than 35kV/mm currently. Could not recognise lower value in available fluids.~~ ~~Rolf if 150 is set minimum for Flash point and Fire point starts 10c higher what sense is to keep >200c fire point.~~ ~~This is Incorrect information. Firepoint is much higher than flashpoint.~~ ~~Dielectric strength has been discussed. The stated numbers indeed relate to kV/2.5mm.~~ ~~Discussion must take place to synchronise used metrics in electronic development.~~ ~~Flashpoint discussion has led to motion to increase minimum value to 170°C and keep the recommended 200°C as a reference point.~~
~~2020/4/22 Raúl Álvarez - Peter Cooper~~	~~OCP ACS Immersion Requirements Rev 2, 7. General standards, 7.1 Measurement units 7.4 Required liquid specifications~~ ~~Include Dielectric Dissipation Factor (IEC~~	

~~(Chemical engineering), Jaime Pita (Thermodynamics engineering) - Submer~~	~~60247) and Acidity/Neutralisation Index (IEC 62021)~~ ~~Dielectric strength measurements units are usually in kV/2.5mm as per IEC 60156 test method.~~ ~~For Biodegradability, use OECD 301 as a broad standard.~~ ~~7.6 Dielectric fluid quality management guidelines~~ ~~On Prevention/remediation particles of fiber, change a "Continuous filter system" to periodic monitoring and filtration as suggested by Engineered Fluids.~~	
~~Wiwynn Sunny~~	~~OCP ACS Immersion Requirements Specification:~~ ~~L7.Datacenter Interface requirements:~~ ~~Fluid operating condition:~~ ~~Fluid quality:~~	~~Use input for harmonization efforts.~~ ~~1-Transferred to DC and harmonisation~~

Parameter	Value	Comments
Operating Temperature Range	2C to 60C	Assumes ASHRAE W3, 2~3degC approach in CDU

Parameters	Value	Source	Comments
Corrosion inhibitor	Required	ASHRAE	
Biocides	Required	ASHRAE	
Sulfides	<1 ppm	ASHRAE	
Sulfate	<10 ppm	ASHRAE	
Chloride	<5 ppm	ASHRAE	
Bacteria	<100 CFU/mL	ASHRAE	

~~*Inflectiontech/ DCF project Mark Dansie*~~	~~*Facility Water System (FWS), is the liquid facility cooling system and contains the heat rejection plant equipment (e.g. cooling towers, pumps, chiller units, dry coolers or district heating grids).*~~ ~~*Note: Within OCP, the facility water system is not limited to water based liquids.*~~	~~*For the liquid to be useful for a district heating system (DHS) my understanding is that liquid temperatures should be in the range of 65 - 75 deg Celcius. I would suggest guidelines are added to this document on whether useful temperatures can be achieved for DHS.*~~ ~~*Classifications for output temperatures (Ashrae W3-5 style, but for exhaust)*~~ ~~*1-Transferred to DC and harmonisation*~~ ~~*2-Transferred to IT gear specs*~~
~~*Intel/Jessica*~~	~~*http://eehpcwg.lbl.gov/sub-groups/infrastructure/tue-team*~~	~~*New guidelines to consider in harmonisation. To be referred to from immersion productions.*~~ ~~*1-Transferred to DC and harmonisation*~~
~~2020/08/24 Larry Kosch (GRC)~~	~~Mechanical Design section (p.7).~~ ~~One of the most impactful chassis design considerations is the method to enable removing a chassis from an immersion bath. Alex McManis added 'can be optimized to be'. Many systems designed for air can be used in an immersion environment with minor modifications. The IT gear designed for immersion could be similar to an air cooled system with the minor modifications (hence the 'can be optimized to be' comment).~~	
~~2020/08/24 Larry Kosch (GRC)~~	~~Power supply section (p.9)~~ ~~Regarding discussion about thermal shut-down, it would be ideal if alarms be based on chip temperatures rather than ambient temperatures OR ambient temp~~	

	~~sensors be offset when using immersion cooling.~~	
~~2020/08/24 Larry Kosch (GRC)~~	~~Storage (p.10)~~ ~~Regarding vibration impacting performance, Alex McManis added comments to the document suggesting 'Vibration should be kept within IT vendor limits."~~ ~~What data is available? In an air cooled environment, usually the vibration source that impacts HDD performance comes from fans so is this still a problem when fans are not part of an immersion system design?~~	
~~2020/08/24 Larry Kosch (GRC)~~	~~Compatibility (p.11)~~ ~~Alex McManis added comments to the document indicating~~ ~~(1) Conformal coating is a mitigation for many components.~~ ~~(2) For labels, other mitigations could be to cover with coolant resistant tape, use etched label~~	
~~2020/08/24 Larry Kosch (GRC)~~	~~High speed optical network cabling (p.10)~~ ~~Alex McManis added a comment to the section. Connectors using silicon photonics have no air gap.~~	
~~07/12/2020 Sayan (M&IM)~~	~~3.0. Glossary~~ ~~(a) Use IUPAC definition of Hydrocarbons~~ ~~(b) Add IUPAC definition of Esters~~	
~~07/12/2020 Sayan (M&IM)~~	~~4.1. Single and two-phase~~ ~~(a) First Line - Add "Esters (synthetic and natural)" or "Synthetic Esters".~~	

~~07/12/2020~~ ~~Sayan (M&IM)~~	~~5.3. Liquid Management~~ ~~(a) Point No. 8 - Single-phase fluids start evaporating before the fluid boiling point is reached. This should be considered specially for chassis-level hybrid systems to avoid pressure build-ups.~~ ~~(b) Add a point on FILTERS in the system to prevent contamination of the fluid with dust, charged air-borne particles, material additives etc.~~	
~~07/12/2020~~ ~~Sayan (M&IM)~~	~~7.2. Comparison Metrics~~ ~~(a) Liquid Category - "Esters (natural and synthetic)" to be added.~~	
~~07/12/2020~~ ~~Sayan (M&IM)~~	~~7.3. Minimum Dielectric Requirement~~ ~~(a) Add 'Test Standard' for each parameter~~ ~~(b) Flash and Fire Point - Specify test standard - Open Cup or Closed Up. Open cup figure could be 5-15 deg C higher than Closed cup.~~ ~~(c) Add:~~ ~~For Single Phase fluids:~~ ~~a) Oxidation Stability Value - >300 and >350~~ ~~b) Biodegradability - Inherently Biodegradable and Readily Biodegradable~~	

	~~c) Moisture Tolerance - ? (TBD)~~ ~~(d) Hazard Statement (H304) - Not sure this makes sense as a minimum requirement. Is it acceptable when maintenance staff comes in contact with the fluid? Might be better to separate this and have an "Acceptable Hazard Code" list, with description of required safeguards or PPE.~~	
~~07/12/2020~~ ~~Sayan (M&IM)~~	~~7.4. Required Liquid Specifications~~ ~~(a) Biodegradability - Should be general OECD 301 instead of "B". Different materials could need different standard A-F for testing biodegradability.~~ ~~(b) Specific Heat – Unit to be changed to J/Lit*K. (volumetric is more relevant for immersion)~~ ~~(c) For 1-Phase Fluids, ADD -~~ ~~1) Vapour Pressure at 60 deg C.~~ ~~2) Evaporation Rate at 60 deg C.~~ ~~3) Maximum moisture % for dielectric breakdown (Moisture stability)~~ ~~4) Oxidation Stability Value~~ ~~5) Ozone Depletion Potential (ODP)~~	

~~07/12/2020 Sayan (M&IM)~~	~~7.6. Dielectric fluid quality management guidelines~~ ~~(a) Change headings to Single Phase and Two-Phase instead of Hydrocarbons and Fluorocarbons respectively.~~	
~~Requirements group~~	~~*Immersion Requirements*~~ ~~Possible recommendations:~~ • ~~installing a raised platform in front of the immersion tank that can allow for easy extraction of servers.~~ • ~~deploying a labor-saving hoisting interface (manual, assisted or fully automated)~~	~~**RB: Second item included in high serviceability. Should we consider adding first point as well?**~~
~~Rick Margerison~~	~~*Immersion Requirements*~~ ~~While more susceptible in two-phase cooling, water temperature deltas (specifically inlet) should be monitored and maintained to ensure inlet water is not “too” cool as to mitigate condensation internal to the 2PIC tank in addition to inclusion for a desiccant as well. May fall into the chapters of “high safety” and not here.~~	~~Not yet processed. To be considered.~~
~~Rolf Brink~~	~~Document requirements for filtration of dielectric fluid~~	~~*Discussion started in call August 3, 2021. John Bean to formulate initial requirement statement.*~~
~~JIN-BAEK, KIM~~	~~Monitoring and quality control method for two representative hydrocarbon and fluorocarbon types of immersion cooling liquid. In other words, standardized~~	~~*@Team, please consider this additional request.*~~

	~~methods and necessary equipment or parts should be standardized for fluids with different characteristics. For example, engine oil filters in automobiles, smoke detectors, etc. Then the equipment (server, chiller, etc.) manager will be able to purchase and replace the necessary consumables from anywhere in the world.~~	
~~Don Mitchell~~	~~FWS requirements - Is there a reason/benefit to defining FWS requirements for Immersion vs an FWS requirements for all ACS?~~	~~*Recommend FWS requirements (pressures, purities, contents…) be common to all ACS solutions.*~~

Declined contributions

~~**Name**~~	~~**Suggested change/update**~~	~~**Evaluation remarks**~~
~~Nigel Gore~~	~~4.1: Add integrated CDU pump operational measurement (L/min) to minimum specs~~	~~Currently part of high safety. Evaluate impact for technology compliance.~~
~~Jessica Gullbrand~~	~~Chapter 6: I think this section is premature and should be removed and aligned between Advanced Cooling projects. If not removed, recommended update of glycol mixtures up to 55% (versus 50%)~~	~~To be evaluated in collaboration with ACS harmonization efforts.~~
~~Nigel Gore~~	~~Section 5.2 page 9 there is a large low res graphic interfering with this page~~	~~Already resolved.~~
~~Nigel Gore~~	~~Page 8~~ ~~The word FWS appears to have been recently inserted and intermixed the terminology which could be in contradiction to industry.~~ ~~The FWS Management and control should be considered outside of the scope with limited inputs in terms of operational management reporting and control~~	~~This refers to the solution side FWS interfaces and therefore falls within the solution domain.~~
~~Nigel Gore~~	~~Page 18~~ ~~Large low res image to be removed or replaced with correct image.~~	~~Already resolved~~
~~2020/1/21 Revised~~	~~**ACS Immersion Requirements:**~~	

~~by Wiwynn Jimmy 2019/12/16 Wiwynn Jimmy~~	~~**Safety**~~ • ~~Robust top lid support structure is required to prevent invisible danger, such as accidentally touch and break the support rod result in lid close rapidly to pinch and hurt user.~~ • ~~Electrical lid-opening should have physical mechanism to cut off power to avoid lid abnormally being closed while servicing because of wrong manipulate or software issue.~~	
~~2020/2/21 Maciek, DCX~~	~~HA requirements~~ • ~~- N+1 or 2N cooling capability (N+1 or 2N availability) - Dual heat exchangers or CDUs;" seems like overkill for HA minimum requirements. Doubling active components as pumps - correct. But requireing N+1/2N to passive components as heat exchangers (as minimum requirement to have HA solution) does not make sense. Would change to N+1 or 2N pumps~~ • ~~Integrated non-IT power measurement - would remove integrated. Different strategies and options for power measurement, does not have to be integrated with immersion enclosure~~	~~*"High availability" is an OPTIONAL classification and requires compatibility with 2N cooling circuits. This means that FWS interfaces must remain separated, thus factoring in N+1 or 2N heat exchangers (or CDU's) to prevent mixing of separate FWS systems.*~~
~~2020/4/22 Raúl Álvarez - Jaime Pita~~	~~Whitepaper - Design Guidelines for Immersion-Cooled IT Equipment, 1. Material Compatibility, 1.2 Components to Check for Compatibility and Material Source of~~	~~Heatsinks that are designed for air-cooling usually perform better in immersion cooling.~~

~~(Thermodynamics engineering) - Submer~~	~~Contaminant, Table, Heatsinks row, Mitigation column: Replace with: "Remove if not required;~~ ~~Ignore if component is tolerant for aimed temperatures;~~ ~~Replace with optimised thermal design for immersion.~~ ~~Redesign of heatsinks."~~	~~This has been discussed. The document is aimed at designs which are purely for liquid. Therefore heatsinks should be designed accordingly as well. Even through air-designs may work well, further improvements can be expected with liquid optimised designs.~~
~~2020/4/22 Raúl Álvarez - Jaime Pita (Thermodynamics engineering) - Submer~~	~~OCP ACS Immersion Requirements Rev 2, 6. Feature classifications, 6.4, High Availability requirements~~ ~~"N+1 or 2N cooling capability (N+1 or 2N availability);~~ ~~Dual heat exchangers or CDU;~~ ~~N+1 availability may be addressed or supplemented with ride through capabilities to address at least 30 minutes of operation without cooling. (Ride Through availability)"~~ ~~Rewrite this so it's not that much specific for Asperitas solution. 30 minutes of operation without cooling is a figure not attainable by any means on a high heat LIC solution. 10 Minutes would be an attainable figure.~~	~~*Thanks for the input.*~~ ~~*This is part of an OPTIONAL high availability classification.*~~ ~~*10 minutes is not a timeframe which can qualify for "high availability".*~~ ~~*Further context:*~~ ~~*In any solution, it is the IT platform and the applied load which determines the thermal load and ride through capabilities. Not the tank or rack itself. If this is balanced and designed to allow sufficient time for any required repair, it should qualify for high availability.*~~ ~~*The ability to design this into the solution credits towards high availability. Explicit elements can be achieved with most immersion systems.*~~ ~~*30 minutes is not referring to anything else than a reasonable time period to respond to a problem and implement a possible fix for a circuit issue. A good argument can be made that this time frame is too short, but*~~

		~~extending it will put the bar too high for most technologies.~~
~~2020/4/22 Raúl Álvarez - Peter Cooper (Chemical engineering), Jaime Pita (Thermodynamics engineering) - Submer~~	~~OCP ACS Immersion Requirements Rev 2, 7. General standards, 7.1 Measurement units 7.4 Required liquid specifications~~ ~~About Density, it would be nice to have a fixed temp close to room temp so that data could be quickly compared between fluids without needing to do a calculation.~~ ~~7.6 Dielectric fluid quality management guidelines~~ ~~Remove hygiene wording as it is misleading in this context.~~ ~~Remove the sentence "Mineral oils should be avoided. Only synthetic liquids should be used." As it is too prescriptive.~~ ~~On Prevention/remediation particles of fiber, change a "Continuous filter system" to periodic monitoring and filtration as suggested by Engineered Fluids.~~ ~~9. Immersion related uptime factors, 9.1 Ride through~~ ~~The concept of dielectric Ride Trough is misleading and should be rephrased or discarded. There's no way that a fluid will be able to maintain a system for days.~~ ~~If the FWS ride trough is not a requirement for immersion, remove it from the document.~~	

	~~9.3 Cooling infrastructure.~~ ~~Remove/rephrase "Immersion systems can typically tolerate higher fluid temperatures compared to air." The fluid has more Specific Heat than air and hence absorbs more energy into its particles. The visible result is a temperature drop from an air condition with the same amount of heat applied.~~	
~~2020/4/22 Raúl Álvarez - Jaime Pita (Thermodynamics engineering) - Submer~~	~~Whitepaper - Design Guidelines for Immersion-Cooled IT Equipment,,2. Thermal Design~~ ~~Replace "removed with" with "extracted with"~~ ~~Replace "a flow" with "buoyancy currents"~~ ~~Note (a) About " A turbulent flow is more efficient in removing heat than a laminar flow.~~ ~~"~~ ~~Replace "an unsteady flow" with "turbulent"~~	~~(e) Depending on the morphology / geometry, sometimes laminar behaviour is more effective.~~
~~2020/4/22 Raúl Álvarez - Jaime Pita (Thermodynamics engineering) - Submer~~	~~Whitepaper - Design Guidelines for Immersion-Cooled IT Equipment,2. Thermal Design, 2.1 Heat transfer optimization~~ ~~"With immersion cooling, a liquid is in contact with the entire IT gear and its printed circuit board, and this liquid creates a thermal pathway for cooling of all components. Therefore, many low-power components that may require a heat sink in~~	~~This depends on the morphology of the chip and its power.~~ ~~Specific heat value of air = 1005 J/kgK :~~ ~~https://socratic.org/questions/what-is-the-specific-heat-of-air~~ ~~(f) This statement is misleading. Mixing up density with heat capacity concepts can lead to an~~

	~~air cooling, can usually be immersed without a heat sink.”~~ ~~“Common single-phase dielectric liquids have specific heat properties ranging between 1300 J/kgK (Fluorocarbon) and 2300 J/kgK (Hydrocarbon), while air has a specific heat value of 1000 J/kgK.~~ ~~“As the specific heat metric suggests (J/kg*K), the specific heat relates to the weight (kg) of the liquid.(a)~~ **~~This is where the density of the liquid is of importance.~~**~~”~~ ~~(f) Table, Joules/Litre Column~~ ~~(g) Table, Volume/kg of air~~ ~~(h) “The result of this is a much smaller surface area requirement for heat transfer within liquid as compared to air.”~~ ~~(i) “Note the almost identical thermal capability of Hydrocarbons and Fluorocarbons in this comparison.”~~ ~~(j) “Immersion in dielectric liquids results in greatly reduced heat transfer surface areas as the liquids are able to absorb heat much more effectively than air.”~~ ~~(k) “It is however not simply a matter of stating that the surface area can be reduced with a factor of 1400 as this would require identical flow rates to air cooling.”~~ ~~(l) “The higher density of the dielectric liquids compared to air means that the flowrate can and will be greatly reduced.”~~	~~error when reading the consequences of each effect.~~ ~~(g) Both three calculations show wrong units (they are missing Kelvin)~~ ~~(h) Volume/kg of air = 816.32 L at sea level~~

	~~Add "velocity" to "(...) (density, viscosity, specific heat etc.)(...)"~~	

~~Non-responsive items~~

~~**Name**~~	~~**Suggested change/update**~~	~~**Evaluation remarks**~~
~~2020/1/21 Revised by Wiwynn Jimmy~~ ~~2019/12/16~~ ~~Wiwynn Jimmy~~	~~**ACS Immersion Requirements:**~~ ~~*6.5 High Serviceability requirements*~~ ~~Serviceability should be considered for all immersion systems. The serviceability features include service height, weight, movability, components replaceability and labor saving mechanism.~~ ~~**High Serviceability systems** include at least the following features and capabilities:~~ • ~~Service height of tank should be considered, for vertical service tank, it should be lower than half of floor height, but horizontal service tank don't have limitation.~~ • ~~Overall weight of tank should be taken into account, designer can freely put components as dense as possible, but that should lower floor loading limitation and consider extract method.~~ • ~~Tank movability should be considered. Wheels or metal pallet~~	~~Accommodate horizontal lids, not assume rods to be present.~~ ~~Automatic detection of obstructions.~~ ~~Move to best practices.~~

	~~beneath the tank, or can split the tank into small part for easier transfer.~~ • ~~Hotswap design on sensors and actuators can be replaced directly without power off.~~ • ~~Passive and massive components such as tube, condenser can be exchanged by maintainer when tank stop working.~~ • ~~For upper side servicing without using and labor-saving mechanism, the blade height, distance and weight should be heeded, the operator's stature, age should be considered. Below link for reference: https://dined.io.tudelft.nl/en/reach-envelopes/tool~~	
~~2020/2/21 Maciek, DCX~~	~~5. Quality and safety requirements - i would add:~~ • ~~Reference materials and guidance on directives, standards and health & safety regulations in regards to hot fluid handling.~~ • ~~Check health and safety regulations for hot fluid handling in Workplace (clothing / attire etc)~~ • ~~The same for dealing with evaporating fluorochemical fluids. There is possibility for inhalation and long term exposure to airborne chemical hazards which would be regulated in the workplace~~	~~Check legal requirements and standards and include it in the documentation to be on the safe side especially in regards to workplace regulations.~~

~~2020/2/21 Maciek, DCX~~	~~Suggest including basic maintenance procedures for insulating/ dielectric oils long term maintenance procedures as mentioned in the comment on rev 2 , page 25 . Some references for standards for insulating oil maintenance~~ • ~~https://standards.ieee.org/standard/C57_106-2015.html~~ • ~~https://standards.ieee.org/standard/C57_106-2006.html~~ • ~~https://webstore.iec.ch/publication/2110~~ • ~~http://ppapco.ir/wp-content/uploads/2019/07/PAPER-Revised-IEC-Standards-for-Maintenance-of-In-Service-Insulating-Oil-PahlavanpourPaper-2004.pdf~~ ~~Describe best practices for the maintenance of fluids (just examples below):~~ • ~~a proper procedure for preparing the equipment for immersion,~~ • ~~Specific build of the enclosures - lid required, not open tanks~~ • ~~Heat transfer fluid testing procedures with minimum times for , maintenance procedure in place, trained employees~~ • ~~basic filtering station and dielectric breakdown tester or complete testing kit on site.~~ - ~~pads or epoxy grease)~~ - ~~BEC for fluorochemical fluids~~	~~*Was discussed in the community call and further input was requested. Input is still pending.*~~

	- ~~Dedicated coatings for sealing capacitors and other PCB components~~ - ~~Firmware modifications: Fan missing errors, thermal shutdown and OTP mods~~	
~~2020/2/21 Maciek, DCX~~	• ~~Sensor quality reporting; - what does it mean?~~ • ~~High resiliency safety protocol implementation with false alarm prevention. - - what does it mean?~~ ~~Above question aim to limit mandatory features to achieve not over engineered and cost effective system~~	~~*Be aware that this relates to the OPTIONAL "High Safety" classification only. It is NOT mandatory, unless you wish to qualify and market your technology as a "High Safety" solution.*~~ ~~*-Sensor quality reporting refers to the quality of the sensor. "Sensor failure" is a good example.*~~ ~~*I.e. If there are 2 sensors which can trigger a disruptive safety feature together and one has failed, the system is prone to failure due to a single sensor controlling the behavior.*~~ ~~*-False alarm prevention relates to the ability of a system to confirm an alarm situation with multiple sensors.*~~ ~~*I.e., 3 thermal sensors reporting 20°C and one reporting 100°C in the same area should not trigger a high temperature alarm.*~~
