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Material Compatibility Workstream for Immersion Cooling – Advance Cooling Solutions Update

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NOVEMBER 9-10, 2021

Material Compatibility Workstream for Immersion Cooling – Advance Cooling Solutions Update

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OCP Material Compatibility Focus Group

Rosters	
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Peter Cooper	Submer
Kevin Wirtz	Cargill
Brian	Solvay
Phil Diffley	Liquid Stack
Volker Null	Shell
Stephen Pignato	3M
Mustafa Kadhim	Iceotope
Gustavo Pottker	Chemours
Kai Zhou	UL

Current Activities /Focus List:

- Compatibility matrix snapshot
- Material compatibility matrix completion
- Criteria for material compatibility (one approach proposed)
- Test methods for aging test for single phase fluids
- Required liquid specifications
- Minimum dielectric requirements for fluid
- Signal Integrity specifications

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Compatibility Matrix Snapshot (WIP)

Material list is growing, process underway evaluate which materials may be removed for now

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Draft - OCP Material Compatibility Chart					
Application	Compatible Materials	Esters (Synthetic)		Sythetic Hydrocarbons (GTL)	
Seals and 'O' Rings / Rubbers	Nitrile Rubber (>35% Nitrile Content)	Acceptable	Acceptable	Acceptable	Weight increases, (ΔW<5% when 1 month duration, and ΔW<10% when 6 months duration.)
	Fluorocarbon Rubber (Viton/fluoroelastomers)	Acceptable	Acceptable	Acceptable	Weight and Volume increase(both change are less than 5%)
	Polyurethane Rubber	Acceptable	Acceptable	Acceptable	Weight and Volume increase(both change are less than 5%)
	PTFE (Teflon)	Acceptable	Acceptable	Acceptable	Weight and Volume increase(both change are less than 5%), almost no change after test.
	Nylon	Acceptable	Acceptable	Acceptable	This type is not tested, read across.
	EPDM	Marginally Acceptable		Unacceptable	Weight increase(ΔW is about 50% when 2 weeks duration, ΔW is about 60% when 1 month duration, ΔW is about 70% when 3 months duration, then EPDM is almost disoved in fluid when 6 months duration.

Google Sheet Link

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Material Compatibility Matrix Completion

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Esters Synthetic	HC Synthetic GTL	HC Synthetic	PFPE	Esters Natural	PFCs
65.7%	82.9%	63.8%	48.6%	72.4%	88.6%

Note -
PFPE - Perfluoronated Polyether
PFC – Perfluorocarbons

Group Discussion

- Required liquid specifications
- Minimum dielectric requirements

Link to 4.1 and 4.2

Material Compatibility Criteria Selection

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- Recommended proposed criteria (%) is related to testing single and two-phase dielectric fluids
- Material compatibility criteria for each of the IT components tested and inputs were received from fluid suppliers and IT components manufacturers
- One approach was selected by the committee as criteria for material compatibility, and it is based on the application independent
- In Appendix of the OCP guidance document, there will be listing of a table consisting of following physical properties such as:

  (a) Volume Change (b) Mass Change (c) Shore Hardness for Polymers (d) Color for Fluid (e) Breakdown Voltage (f) Dielectric Dissipation Factor (DDF) (g) Acid Value (h) Color for Material

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Criteria for Material Compatibility Selection (Application Independent)

Type of Materials Tested	Fluid and Material Tested							
	ΔV%	Δm%	ΔShoreD%	ΔColor(material)	ΔBDV	ΔDDF	Acid Value	ΔColor(fluid)
Seals and 'O' Rings / Rubbers								
Gaskets and Jointings								
Metals								
Sleevings								
Plastics								
3D printed plastics								
Cable								
Hose / piping / cooling tubes								
Adhesives / Sealants								
Thermal Insulation								
Others								
Labels								

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Material compatibility specification limits set as (a) Acceptable (<10%), (b) Case-by-case basis (10%-20%) and (c) Unacceptable (>20%) for all the parameters (including for fluids and materials).

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Test methods for accelerated aging test method for single phase fluids

Parameter	Value
Temperature (°C)	80
Duration (h)	336
Fluid volume (L)	0.8
Fluid properties to measure (pre- and post-test)	Color, breakdown voltage, DDF, Acid value
Sample properties to measure (pre- and post-test)	Dimensions, weight, color, Shore D hardness
Sample surface area (cm^2) – Fluid loading rates (%)	Even shape materials – 2% and Uneven shape materials – 10% maximum
Sample-handling apparatus	Oven, forced draft, adjustable to 80 °C ± 1 °C
Sample container	Glass, fitted with aluminum foil cover

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*Unless decomposition temperature of material is <80ºC, then perform test at lower temperature

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Required Liquid Specifications

Specification	Test method(s)	Format
Dielectric strength, 1 mm	ASTM D 1816	kV/mm
(May be estimated based on 2,5 mm)	(IEC 60156)	(kV, est kV/mm)
Dielectric Constant (Relative permittivity) measured at 5VAC for frequencies at 20 GHz and 40 GHz tested at 20°C and 70°C respectively	*This method is to be modified with the given frequencies and temperatures *The high temperature test can be lowered in line with evaporation temperatures of 2-phase fluids	@# GHz and #°C
Loss tangent	*In line with the adjusted test parameters for dielectric constant	@# GHz and #°C
Flash point COC	ASTM D 92 / ISO 2592	°C
Fire point	ASTM D 92 / 2592	°C
Auto ignition point	DIN 51794/ ASTM E659	°C
Pour point	ASTM D 97 / ISO 3016	°C
Odor	n/a	{TDS spec}
Color	ASTM D 156 / ISO 2211	{MSDS spec}
Sulphur content	ISO 14596	ppm
Specific heat capacity	ASTM E 1269	kJ/kg*K @ 40°C
Thermal conductivity	ASTM D 7896	W/m*K @40°C
Density at any °C	ISO 12185	kg/m3 @ #°C
Volumetric expansion	ASTM D 1903	/°C

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Required Liquid Specifications Contd.,

Specification	Test method(s)	Format
Kinematic viscosity curve (or list following)	ASTM D7042	Graph
0°C		mm^2/s (cSt)
20°C		mm^2/s (cSt)
40°C		mm^2/s (cSt)
60°C		mm^2/s (cSt)
NSF Nonfood Compounds Certification	NSF Certificate	Yes/No
Acidity	IEC 62021-2 / IEC 62021-1	mgKOH/g
Hazard statements	GHS Classification	SDS{MSDS spec}
STOT - single exposure	Safety Data Sheet	SDS{MSDS spec}
STOT - repeated exposure	Safety Data Sheet	SDS{MSDS spec}
Global warming potential (GWP)	IPCC 2007	NA
Biodegradability	OECD 301	{MSDS spec}
Vapour Pressure at 60°C	ASTM D2879	mbar
Maximum moisture content for dielectric breakdown	(100% Water saturation point, ASTM D1533-20)	ppm
Oxidation Stability	IEC 61125	Values per method
Ozone Depletion Potential	Reference	Yes/No

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Minimum Dielectric Requirements for Single and Two-Phase Fluids

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Property	Unused fluid minimum requirements	Lifetime fluid minimum requirements
Dielectric Strength	>15 kV	>15 kV
Resistivity	>2 GΩm	<0.2 GΩm
Flash Point (COC)	>150 °C	>150 °C
Auto Ignition Point	>250 °C	>250 °C
Sulphur Content	<10 ppm	
Acidity:		
hydrocarbons	≤0.01 mg KOH/g	
natural esters	≤0.06 mg KOH/g	
synthetic esters	≤0.03 mg KOH/g	
fluorocarbons?	NA	
Odor (unsealed solutions only)	≤Slight	≤Slight

Signal Integrity (SI) Specifications

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Recommended following parameters that impact SI should be reported:

1. Dielectric Constant (Relative Permittivity) at 20 GHz and 40 GHz measured at 20ºC and 70ºC test temperatures respectively

Note - High temperature test can be lowered in line with evaporation temperatures of two-phase fluids

2. Loss tangent - In line with the test parameters set for dielectric constant

Call to Action

- How to get involved in the Project/Sub-Project Community

You can find the wiki page here for more details:
https://www.opencompute.org/wiki/Rack_%26_Power/Advanced_Cooling_Solutions_Immersion_Cooling

- Where to find additional information (URL links)

Please subscribe to the mailing list here:
http://lists.opencompute.org/mailman/listinfo/opencompute-acsimmersion

Please reach out to us - John.Bean@ocproject.net;
Punith.Shivaprasad@ocproject.net

Thank you!

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Open Discussion