ADVANCED COOLING SOLUTIONS

CE Immersion Cooling

Material Compatibility for Immersion Cooling

05/25/2022

Connect. Collaborate. Accelerate.

OPEN Compute Project®

OCP Material Compatibility Focus group ACS update 05/17/2022

ADVANCED COOLING SOLUTIONS

Current activities / Focus:

Material Compatibility in Immersion Cooling V1
Document edits and formatting

- Draft has been uploaded by PLs on Google drive
- Committee members are currently reviewing draft for edits/comments
- Expected to finalize the document by end of May 2022
- Expected IC approval for finalized copy of document by end July 2022

Rosters	
Punith Shivaprasad	Shell
John Bean	GRC
Sayan Sengupta	M&I Materials
Peter Cooper	Submer
Kevin Wirtz	Cargill
Phil Diffley	Liquid Stack
Volker Null	Shell
Stephen Pignato	3M
Mustafa Kadhim	Iceotope
Gustavo Pottker	Chemours
Kai Zhou	UL
Jimil Shah	TMGcore
David Thomas	NESTE

Connect. Collaborate. Accelerate.

Material Compatibility in Immersion Cooling V1 – Document Outline

ADVANCED COOLING SOLUTIONS

This document outlines guidelines related to Material Compatibility in immersion technologies, should be considered for implementation in Open Compute environments.

- Provides attention to details of all wetted components and materials that come into contact with dielectric fluids
- Is a guideline document and not a requirement
- Classifies common immersion fluids, defines material compatibility with the parameters and implications, and describes standard test procedures that IT component materials need to be tested
- Several generic fluid types available in market are listed and there remains considerable variability of specific fluids within each generic classification
- Qualitative assessments within this document shall be considered as informative and not to be taken as absolute compatibility between any specific fluid and material
- May be taken as recommendations or as guidelines for best practice when evaluating compatibility of immersion fluids

Material Compatibility in Immersion Cooling V1 – Document Outline

ADVANCED COOLING SOLUTIONS

- User groups for this document include fluid manufacturers, server and other Information Technology Equipment system OEMs, producers of immersion technologies and end users
- The burden of compatibility testing is anticipated to primarily fall on fluid manufactures, OEMs and producers of immersion technologies
- End users will also benefit from use of this document to gain better awareness of fluid compatibility topics
- Test standards applicable to specific compatibility attributes have been identified to assure standardized approach to material compatibility testing
- Summary matrix of various fluids versus wetted materials for relative compatibility has been reported

Material Compatibility in Immersion Cooling V1 – Document Outline

OPEN Compute Project®

ADVANCED COOLING SOLUTIONS

- Different fluids could be evaluated through compatibility testing for potential effects on system components, such as stiffening cable sheathing, removing identification markings, softening or dissolving adhesives or plastics, or interacting with metal components
- Criteria for material compatibility selection for the single- and two-phase fluids has been identified, irrespective of the application in terms of levels such as acceptable, unacceptable and case-by-case basis when tested against with different IT components
- Single phased fluids include Synthetic Hydrocarbons (HC) involving Gas-to-Liquid (GTL), Polyalphaolefin (PAO), Synthetic Esters, and Biobased hydrocarbon fluids such as Natural Esters and Bio-based Renewable hydrocarbons
- Fluorochemical fluids generally with lower boiling points involving Perfluoropolyether (PFPE), and Perfluorocarbons (PFCs) are classified under two-phase fluids

OPEN Compute Project®

ADVANCED COOLING SOLUTIONS

Key Highlights Reporting in the Document such as Testing Methodology for Single and Two-Phase Fluids

Methodology for Aging Test for Single and Two-Phase Fluids

Parameter	Value
Temperature (°C)	80*
Duration (Hours)	336
Fluid volume (Liters)	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
Fluid sample loading rates (%)	Even and Uneven shape Materials – 1% Max.
Sample-handling apparatus	Oven, forced draft, adjustable to 80°C ± 1°C
Sample container	Glass, fitted with glass or aluminum foil cover

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

Minimum Dielectric Requirements for Single and Two-phase fluids

Property	Unused fluid minimum requirements	Lifetime fluid minimum requirements
Dielectric strength	-	≥6 kV
Resistivity	≥2.00 GΩ	≥0.20 GΩ
Flash point (COC)	≥150 °C	≥150 °C
Auto ignition point	≥250 °C	≥250 °C
Sulphur content	<10 ppm	-
Acidity: hydrocarbons natural esters synthetic esters fluorocarbons	 ≤0.01 mg KOH/g ≤0.06 mg KOH/g ≤0.03 mg KOH/g ≤0.001 mg KOH/g	-
Odor (unsealed solutions only)	≤Slight	≤Slight

Table 1 Testing Requirements for Immersion Cooling Fluids

OPEN Compute Project®

ADVANCED COOLING SOLUTIONS

Dielectric strength, 1 mm (May be estimated based on 2,5 mm)	ASTM D 1816 (IEC 60156)	kV/mm (kV, est. kV/mm)
Dielectric Constant (Relative permittivity) *Measured at:* • *5 VAC* • *20 GHz and 40 GHz* • *20°C and 70°C*	*There is no prescribed method at this point. IEC 60247 may or may not provide a basis for this testing procedure* *NB: The high temperature 70°C test can be lowered in line with evaporation temperatures of 2-phase fluids*	#.## @# GHz and #°C
Loss tangent	*Data must be associated with tests conducted for Dielectric Constant with the referenced properties*	#.#### @# GHz and #°C
Resistivity	ASTM D1169	#.## GΩm
Maximum moisture content for dielectric breakdown	(100% Water saturation point, ASTM D1533-20)	# 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
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)
Vapor Pressure at 60°C	ASTM D2879	# mbar
Pour point	ASTM D 97 / ISO 3016	# °C

Connect. Collaborate. Accelerate.

Table 1 Testing Requirements for Immersion Cooling Fluids

OPEN Compute Project®

ADVANCED COOLING SOLUTIONS

Flash point Cleveland Open Cup (COC)	ASTM D 92 / ISO 2592	# °C
Fire point	ASTM D 92 / 2592	# °C
Auto ignition point	DIN 51794/ ASTM E659	# °C
Sulfur content	ISO 14596	#,# ppm
Acidity	IEC 62021-2 / IEC 62021-1	#.## mg KOH/g
NSF Nonfood Compounds certification	NSF certificate	Yes/No
Odor	n/a	{TDS spec}
Color	ASTM D 156 / ISO 2211	SDS{MSDS spec}

Hazard statements	GHS Classification	SDS{MSDS spec}
Specific Target Organic Toxicity (STOT) - single exposure	Safety Data Sheet	SDS{MSDS spec}
STOT - repeated exposure	Safety Data Sheet	SDS{MSDS spec}
Biodegradability	OECD 301	{MSDS spec}
Oxidation Stability	IEC 61125	Values per method
Global warming potential (GWP)	IPCC 2007	#.#
Ozone Depletion Potential	PNNL-16813	Yes/No

Criteria for Material Compatibility Selection

Type of Materials Tested	Fluid and Material Tested							
	ΔV%	ΔM%	ΔD%	Δcolor (material)	ΔBDV	ΔDDF	Acid Value	Δcolor (fluid)
Seals and ‘O’ Rings / Rubbers								
Gaskets and Jointings								
Metals								
Sleevings								
Plastics								
3D printed plastics								
Cables								
Hose / piping / cooling tubes								
Adhesives / Sealants								
Thermal Insulation								
Others								
Labels								

Compatibility Matrix Snapshot (WIP)

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

ADVANCED COOLING SOLUTIONS

Draft - OCP Material Compatibility Chart

Application	Compatible Materials	Esters (Synthetic)		Sythetic Hydrocarbons (GTL)		Synthetic Hydrocarbons		Perfluoronated Polyether (PFPE)		Perfluorocarbons (PFCs)	
		Notes: Compatibility assessment is carried out at 100°C which may impact the outcome, especially for plastics and elastomers. Elastomers can have variable composition so individual evaluations for large projects are worthwhile.	**Remarks**	Notes: In house test method performed on plastics, metals and elastomers at 100°C during 2 weeks. Other conditions based on ASTM 3455	**Remarks**	Notes: In house test method similar to ASTM 3455 but carried out at 75 C for 50 h.	**Remarks**	Notes: Compatibility testing vs Soxhlet extraction (ASTM D471) looking at swell and weigthing (weight change, elongation, mechanical properties and swell). Temperatures range from 70 up to 200 C. Time range from up to 850 hrs	**Remarks**	Notes: In house test method similar to ASTM 3455 but carried out at 75 C for 50 h.	**Remarks**
Seals and 'O' Rings / Rubbers	Nitrile Rubber (>35% Nitrile Content)	Acceptable		Acceptable		Acceptable	Unsure of nitrile content of this sample.			Acceptable	Unsure of nitrile content of this sample.
	Fluorocarbon Rubber (Viton/fluoroelastomers)	Acceptable		Acceptable		Acceptable		Acceptable	acceptable for most fluoronated rubbers (FKM). not fully fluoronated rubbers (FFKM)	Acceptable	
	Polyurethane Rubber	Acceptable		Acceptable			Not tested	Acceptable			Not tested
	PTFE (Teflon)	Acceptable		Acceptable		Acceptable		Acceptable		Unacceptable	Weight increased. BDV decreased and DDF increased.
	Nylon	Acceptable		Acceptable		Acceptable		Acceptable			Not tested
	EPDM	Marginally Acceptable		Unacceptable	Weight increase and dissolution	Unacceptable	Weight and volume increased.	Acceptable		Acceptable	DDF increased for electrolytic capacitors
	Silicone Rubber	Marginally Acceptable		Unacceptable	Weight and Volume increased	Marginally Acceptable	Weight and volume increased.	Acceptable		Marginally Acceptable	Weight increased
	Neoprene Rubber	Unacceptable		Unacceptable	Weight and Volume decreased	Marginally Acceptable	Weight and volume increased. Trade name for chloroprene.	Acceptable			Not tested
	Natural Rubber	Unacceptable			Not tested	Unacceptable	Weight and volume increased. BDV decreased.	Acceptable			Not tested
	CR (Chloroprene)	Unacceptable		Acceptable		Marginally Acceptable	Weight and volume increased	Acceptable			Not tested
Gaskets and Jointings	Cork Bonded with Nitrile (Nebar Grey and Nebar Purple)	Acceptable		Acceptable			Not tested	not tested			Not tested
	Cork Bonded with Neoprene Rubber (Nebar White and Nebar Orange)	Acceptable		Acceptable			Not tested	not tested			Not tested
	Nitrile	Unacceptable				Marginally Acceptable	Nitrile sheets: weight and volume increased, hardness decreased. BDV decreased and DDF increased.	Acceptable		Marginally Acceptable	Nitrile sheets: weight and volume increased, hardness decreased. DDF increased.
	Expanded PTFE		Not tested			Marginally Acceptable	Weight increased.	Acceptable			Not tested

Connect. Collaborate. Accelerate.