Immersion Requirements Document

Revision 1.0

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Introduction

This document outlines the requirements related to Immersion technologies which may be considered for implementation in Open Compute environments. It contains guidelines, best practices and requirements for liquid immersion technologies which must be followed before applying for any OCP logo.

The requirements have been formulated in such a way that most known current technologies will be able to comply with this document, while at the same time allowing this "young" industry to keep coming up with innovative new ways of bringing efficiency and allowing access to all of these technologies into the data center space.

The information in this document should be considered a baseline. Updates to the content are foreseen and will be managed and evaluated by the OCP ACS Immersion workstream.

Please suggest change proposals or content additions in the following document:

"Suggested changes to ACS Immersion documents"
https://drive.google.com/open?id=1vXaiFskJUy1zsOZZ8OsPFXnQw4xF08ZLYOlRiftcpc0

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2. Revision History

Revision	Date	Comments
1.0	*May 20, 2019*	*First publication*

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- Nigel Gore, Iceotope
- John Bean, Schneider Electric
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3. Glossary

This glossary provides definitions **within the context** of immersion technology within data centers.

Aerosol	A suspension of fine solid particles or liquid droplets, in air or another gas.
Auto ignition point	The lowest temperature at which a substance spontaneously ignites in normal atmosphere without an external source of ignition. Also referred to as autoignition temperature or kindling point.
Containment strategy	A set of measures to prevent any spillage of liquid into the (work) environment.
DECS	Datacom Equipment Cooling System, the cooling system within the rack or tank.
Dielectric liquid	A liquid which functions as an insulating substance to allow the immersion of electronics with the purpose of heat transfer.
Dielectric strength	The maximum electric field that the material can withstand under ideal conditions without breaking down.
Dripless connectors	A type of pluggable liquid connector which eliminates drips and is able to withstand long term use.
Dynamic viscosity	The ease in which a substance flows in Pascal-second (Pa.s). It is also referred to as poise or centipoise (cP).
Electrochemical potential	A thermodynamic measure of chemical potential that does not omit the energy contribution of electrostatics.
Enclosed chassis	Solution type with which dielectric liquid is circulated through a sealed server chassis.
Evaporation temperatures	Temperature at which vaporization occurs on the surface of a liquid as it changes into gas.
Fire point	The lowest temperature at which the vapour of that fuel will continue to burn for at least 5 seconds after ignition by an open flame.
Flash point	The lowest temperature at which vapours of the material will ignite, when given an ignition source.
Fluorocarbons	Organofluorine compounds consisting of carbon and fluorine. Sometimes also referred to as PFC's.
FWS	Facility Water System, a liquid circuit which allows the transport of heat throughout a facility.

Galvanic corrosion	An electrochemical process in which one metal corrodes preferentially when it is in electrical contact with another, in the presence of an electrolyte.
GWP	Global Warming Potential, a measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon, relative to carbon dioxide.
Hydrocarbons	Organic compounds consisting of hydrogen and carbon. Also referred to as oils.
MSDS	Material Safety Data Sheet is a document that lists information relating to occupational safety and health for the use of chemicals.
Open bath	Solution type with which dielectric liquid is shared across multiple electronic systems in a horizontal bath style container and an open liquid-air interface.
Partial vacuums	A FWS which runs below environment pressure (partial vacuum) to prevent water leaking outward when a leak occurs.
Pour point	The temperature below which the liquid loses its flow characteristics.
Redfish	Data center Infrastructure Management (DCIM) application which is used within OCP environments.
Single-phase	Liquid application in which the state of matter is not intended to change.
Specific heat	The amount of thermal energy (Joules) which is required to be added to 1 kg of a substance to achieve a 1°C temperature increase.
STOT	Specific Target Organ Toxicity, indicates which bodily organs are most likely to be affected by exposure to a substance.
TCS	Technology Cooling System, a closed liquid circuit which allows the transfer of heat from an immersion system to the FWS.
TDS	Technical Data Sheet is a document that lists all required technical information for chemicals.
Thermal conductivity	A measure of the ability of a substance to conduct heat.
Thermal loss	Amount of energy which is not contained by a cooling solution.
Two-phase	Liquid application in which the state of matter is designed to change from liquid to gas and back.
Vapor	A substance in the gas phase at a temperature lower than its critical temperature, which means that the vapor can be easily condensed to a liquid by increasing pressure on it or by reducing the temperature.
Volumetric expansion	A coefficient of thermal expansion. The rate of expansion of a material with a 1°C temperature increase.

4. Immersion technology definitions

Liquid cooling within the data center 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 electronics 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.

The dielectric liquid is thermally conductive with good insulating properties (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 the data center facility heat rejection equipment. A range of heat rejection methods varies by facility and requires interfaces to connect to the cooling system. 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 or tank. DECS does not extend outside of the rack and contains a combination of dielectric fluids, heat exchangers, CDU's, 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 which is typically supported by a Cooling Distribution Unit (CDU) to one or more liquid immersion systems. Fluids used within the TCS vary. Currently used liquids include ethylene or propylene glycol water mixtures, pure treated water, refrigerants and varying dielectric liquids. A heat exchanger is used to transfer the heat between the DECS/TCS to the Facility Water System.
- 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.*

The main immersion technology differentiators between liquid technologies are based on single- or two-phase, enclosed chassis and open bath.

4.1 Single- and two-phase

In general, there are two main liquid categories which are both chemical in nature. Hydrocarbons (i.e. mineral, synthetic or bio oils) and fluorocarbons (i.e. fully engineered liquids). Dielectric liquids are divided into single- and two-phase applications.

- Single-phase uses a circulation method for the dielectric liquid across hot electronic components and to a heat exchanging approach.
- Two-phase immersion uses a low-temperature evaporation process to cool hot electronics and transfer the heat out of the liquid. The gas is cooled again by a heat exchanging method to allow return flow into the larger liquid volume.

4.2 Enclosed Chassis

Enclosed chassis require dripless connectors to interface to the individual chassis. These chassis are usually based on traditional rack style implementations.

The dripless connectors usually require a TCS to protect the flow integrity through relatively small pipes and connectors.

The TCS usually facilitates multiple racks at once.

4.3 Open Bath

The “open” aspect refers to the “open” liquid-air interface and thus surface tension between the liquid and the air being a distinctive element.

Open bath systems are tanks which contain a larger body of dielectric liquid where electronics are immersed into the bath. Multiple electronic assemblies are sharing the same liquid. This liquid can be based on single- or two-phase technology.

Regardless of the term, open bath systems can be fully sealed, but are always opened from the top to service IT equipment.

The FWS for open bath immersion systems is either connected to a TCS or to an integrated heat exchanger or CDU which is part of the tank.

4.4 Hybrid

There are numerous solutions in the industry already with unique and diverse approaches. These may not always fit in any designated definition. Depending on which aspect is relevant, these strategies may be positioned as any overlapping definition.

5. Quality and safety requirements

5.1 Certification markings

Each immersion technology must comply with all certification regulations which are applicable to the geographic location where it is implemented. These requirements are different for each territory.

I.e.

- United States UL and FCC markings (depending on the systems used);
- European Union requires CE certification;
- Local countries will require additional certifications which must be complied with.

For a full overview of certification marks for any region, please refer to https://en.wikipedia.org/wiki/Certification_mark.

5.2 Mechanical safety requirements for any immersion technology

Emergency and disaster procedures must be defined for each technology.

- Any system must be safe to use in relation to normal server maintenance activities by any non-skilled operator. Electrical systems must be shielded from access.
- Horizontal busbars must remain undamaged by uncontrolled server placement or falling objects.
- Any electrical circuit must be fully certified in line with requirements which apply in the geographical region in which it is implemented;
- Any electrical assembly must be easily accessible by electrical engineers and documented with full schematics;
- Proper spill management measures must be available at all times. Leak trays, condensers, sealant material but also absorbent materials. Potential hazardous fumes must be contained or ventilated outside human workspace;
- Any installation must contain an interface for electrical grounding;
- There may not be any potential for the creation of aerosol during operation or maintenance. (moving parts within dielectric liquid).

5.3 Liquid management

Based on the liquid type, a full risk assessment must be in place before implementation within a data center environment.

Liquid containment measures must be implemented in line with industry standards. This involves leak prevention, leak containment and spill management measures, materials and procedures.

The following standards apply to immersion technologies within data centers:

- Any open bath liquid system may only be placed in a well-ventilated room, as specified in related MSDS documentation provided by the dielectric liquid provider;
- Any known dielectric liquid must be prevented from entering any sewage system;
- Any disposal of dielectric liquid must be organized though appropriate disposal procedures;
- Any immersion implementation must follow a containment strategy which complies with local regulations for the dielectric liquid type. I.e. dual-hull or leak trays with the capacity of at least the largest container (include volume of interconnected containers);
- Sufficient spill management and absorption materials must be present to manage a catastrophic spill from the full contents of the largest tank which is present on-site;
- A means to release pressure must be present for any enclosed system, including a full containment strategy for any released liquid;
- Two-phase usage and other “highly evaporative liquid” based implementations should prevent any gas leakage out into the atmosphere;
- Single-phase systems should not exceed the minimum evaporation temperatures, unless vapor can be contained within the technical solution;
- Full liquid documentation must be present within the room where the systems are installed (MSDS & TDS);
- Full health and safety documentation must be present;
- There should be a minimum of one person present with training related to spill management;
- Each operator must be trained on the properties of each dielectric liquid in use within the facility.

6. Management and monitoring

Any immersion system requires a management system which can be used to monitor the performance and/or condition of the technology. This system must comply with Redfish reporting and data collection.

6.1 Standard management requirements

Each immersion system must have at least the following management features:

- Thermal monitoring and reporting of dielectric liquid at least at 2 locations:
  - Input (or bottom of open bath);
  - Output (or top of open bath).
- Warning system in case of overheating with at least 2 warning levels (warning, critical);
- TCS or DECS pump operational status (if any).

6.2 Thermal Optimized requirements

Some technologies apply intelligent features for optimizing data center thermal infrastructures. These features are based on managing flow rates, temperatures and pressures. These systems are classified as Thermal Optimized Systems. These can be used in thermal cascades to enable reusable heat or otherwise increase cooling efficiency.

Thermal optimized systems required at least the following features:

- Power measurement on all electrical input into the dielectric liquid;
- Thermal monitoring of the FWS at each input and output interface;
- Flow Rate monitoring and control of each FWS input/output combination;
- Controlled TCS or DECS variable speed dielectric pump (if any).

6.3 High Safety requirements

Some technologies include a high level of safety for the electronics, facility or end user. These systems are classified as High Safety Systems. The safety mechanisms include multiple failure detections and automatic safety mechanisms to protect the safety and integrity of the electronics inside, as well as the facility and operator from any likely failure scenario.

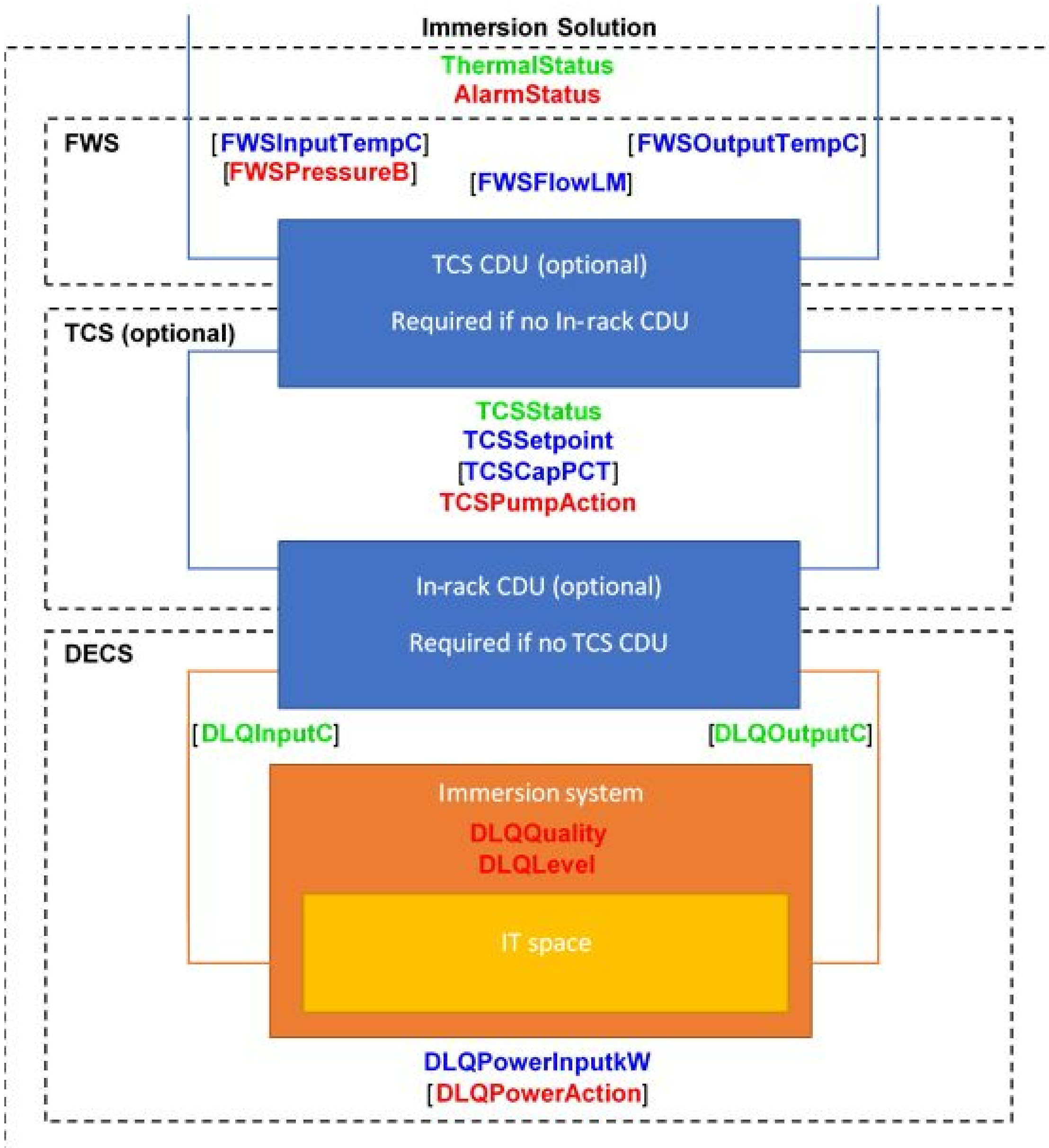
High safety systems include at least the following additional features and capabilities:

- Full reporting and logging of all sensory information;
- Dielectric water or quality detection;
- Dielectric volume/content/level detection;
- Pressure sensing, reporting and logging of each FWS input/output combination;;
- Safety shut off features on each FWS input/output combination;
- Admin pump control;
- Admin power control of all electrical input into the dielectric liquid;
- Full fault reporting and alerting to DCIM based on Redfish;
- Sensor quality reporting;
- High resiliency safety protocol implementation with false alarm prevention.
- Automated safety responses of the immersion system to protect immersed electronics and facility with either of the following controls:
    - Power-off;
    - FWS shut-off;
    - Pump shut-off (if any).

6.4 Redfish definitions

Immersion units will be placed in the DCIMCOOLING domain as that is the highest correlation for these devices. Optionally linked ICT related equipment may be placed in their respective domains and linked via the link fields.

Legend:
[1] **Green**: Minimum requirement
[2] **Blue**: Thermal Optimized requirement
[3] **Red**: High Safety requirement



Below is an annotated example for an immersion system which is defined at CDU or integrated tank level. Shown items are the generalized items which each immersion technology should follow. Additional sensors can be added as the arrays shown below allow.

Legend:

[1] **Green**: Minimum requirement
[2] **Blue**: Thermal Optimized requirement
[3] **Red**: High Safety requirement
[4] **Orange**: suggested but not (yet) required items

Immersion Solution Data

[4] "**Name**" : "ABC123",
[4] "**Brand**" : "ABC123",
[4] "**Model**" : "ABC123",
[4] "**SerialNumber**" : "1234567",
[4] "**FWRevision**" : "3.4.5",
[4] "**HWRevision**" : "1.5",
[4] "**ManufactureDate**" : "03012019",
[4] "**PhysicalLocation**" : {<...>}, --*Descriptor of physical location of the Immersion Unit*
[4] "**Links**" : {<...>}, -- *Links to other items within the Redfish Network*

[3] "**AlarmStatus**" : ["<Alarm Status>"],
-- *Array of all alarm statuses of the Immersion Unit*
[1] "**ThermalStatus**" : "Warning",
-- *Thermal system status, shows total thermal status of the ImmersionUnit.*
-- *Must include options: "Normal", "Warning" and "Critical"*
[4] "**Setpoint**" : ["<temp sensor w SetPoint URI>"],
--*Array of setpoints for the ImmersionUnit, can be setpoints for entire unit*
--*FWS, TCS or Dielectric liquid*
[4] "**Sensors**" : "<sensors collection URI>",

Facility Water System

[2] "**FWSInputTempC**" : ["<sensor URI>"],
-- *Array of temperature sensors for the FWS coolant loop(s).*
-- *Required at all inputs for Thermal Optimized systems*
[2] "**FWSOutputTempC**" : ["<sensor URI>"],
-- *Array of temperature sensors for the FWS coolant loop(s).*
-- *Required at all outputs for Thermal Optimized systems*
[2] "**FWSFlowLM**" : ["<sensor URI>"],
-- *Array of flow sensors in the FWS coolant loop(s) in liters/minute.*
-- *Required at all interfaces for Thermal Optimized systems*
[3] "**FWSPressureB**" : ["<sensor URI>"],
--*Array of pressure sensors in bar.*
--*Required at all FWS interfaces for High Safety systems*

Technology Coolant System (Optional)

[1] "**TCSStatus**" : "1",
-- *Status of TCS, must show running status between 0 and 1 (i.e. 1/0: on/off, RPM or other)*
[2] "**TSCSetpoint**" : "75",
-- *Setpoint of the TCS*

```
4 "TCSSupplyTempC"            : ["<sensor URI>"],
        -- TCS input temperature sensors
4 "TCSReturnTempC"            : ["<sensor URI>"],
        -- TCS output temperature sensors
2 "TCSCapPCT"                 : ["<sensor URI>"],
        -- TCS load (i.e. pump capacity) in percentage
3 "TCSPumpAction"             : "<Actions that affect TCS pump">,
        -- Actions to change TCS pump mode (auto, run, manual etc.)
        -- Only reachable under high security level
```

Dielectric Liquid

```
1 "DLQInputC"                 : ["<sensor URI>"],
        -- Temperature of the immersion liquid at the output (top) location in the dielectric liquid,
        -- array for all sensors
1 "DLQOutputC"                : ["<sensor URI>"],
        -- Temperature of the immersion liquid at input (bottom) location in the dielectric liquid
        -- array for all sensors
3 "DLQQuality"                : "Normal",
        -- Shows quality of dielectric liquid
3 "DLQLevel"                  : "Normal",
        -- Shows level of DLQ, e.g. "Lowlow", "Low", "Normal", "High", "Highhigh"
2 "DLQPowerInputkW"           : "18.4",
        -- Total electrical input into the dielectric liquid
3 "DLQPowerAction"            : ["<Actions that affect DLQ power delivery">],
        -- Actions to change power delivery to dielectric liquid equipment.
        --Only reachable under high security level
```

Sensor, status, link, actions and other items are setup the same as the default redfish implementation.

7. General standards

To allow comparison between different technologies, several metrics and classifications are defined, which can be adopted by each technology.

None of the comparison standards are meant to apply quality, maturity or suitability figures. They are merely given as tools to allow proper qualification by end-users and buyers.

7.1 Measurement units

Due to varying shapes, sizes and fundamental different properties regarding surface area and special planning, immersion systems cannot be compared to traditional racks. From a technology point of view, a single tank can be considered a rack, but with a non-comparable footprint. To make the technologies comparable, all used metrics are based on the International System of Units (SI). Wherever required or commonly accepted, a metric prefix may be applied to ensure workable number formats. (i.e. kg, kN, mm, GJ, etc.)

The following units are used for all immersion technology definitions:

- Distance: meters (m)
- Surface area: square meters (m^2)
- Volume: Cubic meters (m^3) or liters (l)
- Power: Watt (W)
- Temperatures: Degrees Celsius (°C)
- Temperature Delta: Degrees Celsius or Kelvin (°C or K)
- Pressure: Pascal (P)
- Pressure drop: Kilopascal (kPa)
- Flow Rate: Volume indication per time index (hour, minute or second) m^3/h, l/m, l/s
- Weight: Grams (g or kg)
- Static load (construction): Newtons per square meter (kN/m2)
- Thermal energy: Joules (J)

7.2 Comparison metrics

The following metrics may be requested or defined for positioning and comparison between any immersion solution. Any metric which is marked with * should be considered a **requirement for positioning**:

Specification	**Format**
***Rack type**	Rack/Tank
***Solution type**	Single-phase/two-phase
Liquid category	Hydrocarbon/Fluorocarbon

Liquid type	Commodity/Proprietary
Compliancy (combinations may apply)	Standard, Thermal optimized, High safety
"--" Density (highest possible with coldest facility coolant)	*kW/m², #°C "--" density*
● Compute Density *kW per single rack/tank floorspace*	(Bare rack kW)/(Rack surface), #°C *Rack/Tank capacity only, at specified lowest temperature for unique solution
● Solution Density *kW per full solution floorspace*	(#Full rack kW)/(#Rack+1CDU surface), #°C *Must include required spacing for infrastructure on and between Racks/Tanks/CDU's *May use optimal rack/cdu count and spacing
● Solution footprint *Whitespace area reserved for solution*	(Rack kW)/(Rack+CDU+service area surface), #°C *Must include required spacing or access area per rack (I.e. servicing, airflow, traffic etc. front&back) *May account for shared service area with large deployments.
ASHRAE density (add W1-5) *W(1-5) Compute density* *W(1-5) Solution density* *W(1-5) Solution footprint* ***W3 solution footprint required**	Density figures with fixed cooling temperatures, equal to the maximum ASHRAE definitions for each class. *W1: 17°C* *W2: 27°C* *W3: 32°C* *W4: 45°C* *W5: 55°C*
Power per fluorocarbon liquid volume	kW/m^3
Static load	kN/m^2
● Bare solution	kN/m^2, Solution without liquid (as delivered)
● ***Full solution**	kN/m^2, Bare solution filled with liquid, incl. liquid interfaces
● IT solution	kN/m^2, Full solution including est. IT weight to 100% load
***Height clearance**	m (to ceiling) *Incl. clearance for lid, servicing mechanisms etc.
Non-IT power/kW	W/kW_{IT}, Power consumption per kW IT (I.e. pump, CDU)
Non-IT power overhead/m^2	W/m^2, Generic overhead (i.e. management, monitoring, lights)

Thermal loss to air Air temp equal to cooling temp, max density.	#% (Thermal efficiency - 100%-#%)
***Pressure drop - ASHRAE W3**	Max load at 32°C, preferred dT
***Maximum pressure rating**	Bar
***Maximum flow rating**	L/s
***Temperature delta rating (min-max)**	#-# °C or °K
Highest temperature tolerance	# °C or °K
IT chassis type	Enclosed/Immersion-optimized/Air
Max IT chassis form factor	15/19/21/custom", 1U/2U/any/custom
Chassis capacity	#U
IT brand compatibility	Proprietary (own), Agnostic, {brand name}

7.3 Minimum dielectric requirements

The following table presents the minimum requirements which must be met for any dielectric liquid to facilitate the safe operation of electronics. The specifications and requirements may be radically different for varying applications and technological solutions.

Property	**Minimum req**	**Commonly req**
Dielectric strength over lifetime	>3 kV/mm (air)	>35 kV/mm
Flash point	>150°C	>200°C
Fire point	>200°C	>250°C
Auto ignition point	>250°C	>300°C
Odor (unsealed solutions only)	None	Slight
Sulphur content	<0,01 ppm	<0,001 ppm
Safe handling training level	Novice	Varying
Hazard statement	Equal or less than H304	Equal or less than H304 ("May be fatal if swallowed and enters airways")

7.4 Required liquid specifications

In addition to full MSDS and TDS documentation, the following summarized specifications must be available for anyone who needs to evaluate health and safety protocols, fire safety or electronics compatibility and any recipient (users or customers) or operators.

Specification	**Format**
Dielectric strength	# kV/mm
Flash point	#°C
Fire point	#°C
Auto ignition point	#°C
Pour point	#°C
Vapor free operation (see text)	#°C
Odor	{TDS spec}
Color (ASTM D1524)	{MSDS spec}
Sulphur content	# ppm
Specific heat	# J/kgK
Thermal conductivity	# W/mK
Density at any °C	#kg/m^3 @ #°C
Volumetric expansion	#/°C
Dynamic viscosity curve (or list following)	Graph
• 0°C	# mPas
• 20°C	# mPas
• 40°C	# mPas
• 60°C	# mPas
Certification type	Food grade/none/other
Hazard statements	{MSDS spec}
STOT - single exposure	{MSDS spec}
STOT - repeated exposure	{MSDS spec}

Aspirations toxicity	{MSDS spec}
Global warming potential (GWP)	#
Biodegradability	{MSDS spec}

7.5 Required available documentation

For any immersion technology, the following documentation must be available for data center facilities, end users and operators (at least at a conceptual level):

- Certification compliance documentation;
- Liquid (spill) management procedures (may be part of MSDS);
- Fire management documentation (may be part of MSDS);
- User manual;
- Service manual.

8. Data center Interface requirements

Each immersion technology is required to interface with a common FWS. This interface needs to conform to OCP standards. The following specifications for FWS are implemented and required for each applied technology.

8.1 Input/output differentiation

Each immersion system FWS interface must be clearly visually marked as inlet or outlet.

- Inlet:
  - provisioned with blue color (paint, tape or other);
- Outlet:
  - Provisioned with either yellow, orange when part of a thermal cascade, or red color when connected to the FWS.

8.2 FWS compatibility

All solutions must be able to deal with any FWS with partial vacuums down to 50 kPA (absolute) and pressures up-to 800 kPa (gauge). Both 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.

8.3 Galvanic interface properties

If a solution contains a metal interface which connects to another metal interface at the FWS, the solution interface should be specified with an electrochemical potential difference of NO MORE than 0.15V as compared to the FWS interface. If this difference is higher, a strategy towards preventing galvanic corrosion must be applied.

If multiple metallic materials are applied in direct contact with a metallic coolant circuit and one or more materials are outside the galvanic compatibility bandwidth, anodes are recommended.

For an overview of corrosion potentials of different materials, please refer to:

http://www.atlassteels.com.au/documents/TN7-Galvanic_Corrosion_rev_Aug_2010.pdf

9. References

- Allowable metric prefixes
  https://en.wikipedia.org/wiki/Metric_prefix

- ASHRAE. 2014. Liquid cooling guidelines for datacom equipment centers, second edition:
  https://www.ashrae.org/technical-resources/bookstore/datacom-series

- ASHRAE.2019. Water-Cooled servers common designs, components, and processes:
  http://tc0909.ashraetcs.org/documents/ASHRAE_TC0909_Water_Cooled_Servers_11_April_2019.pdf

- Corrosion potentials of different materials
  http://www.atlassteels.com.au/documents/TN7-Galvanic_Corrosion_rev_Aug_2010.pdf

- Example of certification guidelines compliance
  https://www.cemarkingassociation.co.uk/technical-documentation/

- Example of spill management documentation:
  https://smah.uow.edu.au/content/groups/public/@web/@ohs/documents/doc/uow136688.pdf

- Galvanic corrosion background:
  https://en.wikipedia.org/wiki/Galvanic_corrosion

- Global certification compliance requirements:
  https://en.wikipedia.org/wiki/Certification_mark

- Global warming potential
  https://en.wikipedia.org/wiki/Global_warming_potential

- International System of Units:
  https://en.wikipedia.org/wiki/International_System_of_Units

- Liquid classifications descriptions:
  https://en.wikipedia.org/wiki/Hydrocarbon
  https://en.wikipedia.org/wiki/Fluorocarbon

- MSDS sample:
  https://lubricoil.com/userfiles/file/ondina/Ondina_X_415_(MSDS-eng).pdf

10. About Open Compute Project

The Open Compute Project Foundation is a 501(c)(6) organization which was founded in 2011 by Facebook, Intel, and Rackspace. Our mission is to apply the benefits of open source to hardware and rapidly increase the pace of innovation in, near and around the data center and beyond. The Open Compute Project (OCP) is a collaborative community focused on redesigning hardware technology to efficiently support the growing demands on compute infrastructure. For more information about OCP, please visit us at http://www.opencompute.org