Cooling Environments





Immersion Project

Advancing Immersion Cooling Safety: From Fluid Qualification to System Compliance

Mark Olson *Principal Chemist, UL Solutions*

Lizzy Fernando *Product Manager, UL Solutions*

OCP BRONZE™ Member

Role of Industry Standards

- Provides guidelines for consistent design, security and operations that meet current and future technological needs
- Issues requirements on how a code or regulation can be met
- Critical for safety of components, subassemblies and systems
- Can be voluntary or mandatory
- Can be used regionally or globally
- Developed and maintained by Standard Development Organizations (SDO)

Two Paths to Safety

Traditional Standards

- Used for established and well-understood technologies
- Developed through multiyear consensus process
- Based on industry-accepted and proven requirements
- Provides long-term, stable industry alignment

Outline of Investigation (OOI)

- Used for emerging technologies not yet covered by standards
- Quick development to support innovation and deployment
- Based on UL Solutions technical expertise and knowledge
- Enables timely certification and the foundation for future standards

IEC 62368-1: Immersion Cooling Requirements

- IEC 62368-1 is the recognized international standard that applies to information and communication technology equipment and is critical for safety in data centers
- Most current version is 4th edition published by IEC on May 26, 2023
- Immersion cooling fluids are called “Insulating Liquids” in the standard
  - Critical component in the standard
  - Insulating liquid used as a safeguard shall not break down due to overvoltages, including transients that enter the equipment, and peak voltages that could be generated.
  - No clear compatibility requirements for materials (only 60-day system-level compatibility test)
- Key Gap: Existing standards evaluate electrical safety but provide limited guidance on long-term material compatibility.

From fluid qualification to system compliance

Evaluation of fluid properties → UL 2417 Certification → System design review → IEC 62368-1 end-product Certification

Goal: Standardized fluid qualification data that enables faster, safer system certification.

UL 2417: Immersion Cooling Fluid Requirements

- UL 2417: Outline of Investigation for Immersion Cooling Fluids for Use with Information and Communication Technology Equipment was published on January 14, 2025
- Contains required testing with minimum performance values that align with IEC 62368-1 requirements for insulating liquids as well as optional tests
- Certified UL 2417 immersion cooling fluids are published on the UL Product iQ® database for visibility and to demonstrate compliance with the standard
- Establishes a repeatable baseline for immersion cooling fluid qualification
- This standard does not address fluid compatibility, a future OOI is in development to address this

UL 2417: Required Testing

Test Name	Test Method	Requirement
Autoignition temperature test	ASTM E659	≥ 300°C
Flash point test	ASTM D93 (Procedure A)	≥ 135°C
Dielectric breakdown test	ASTM D1816	≥ 6 kV/mm
Qualitative infrared analysis	UL 746A	For fluid identification purposes

UL 2417: Optional Testing

Single-phase:

- Moisture (ASTM D1533)
- 100% Water Saturation (ASTM D1816 and ASTM D1533)
- Kinematic Viscosity and Density (ASTM D7042)
- Sulfur Content (ISO 14596)
- Total Acid Number (ASTM D664)
- Oxidative Stability (ASTM D1934 Procedure B)

Two-phase:

- Lower Flammability Limit (ASTM E681)
- Acidity in Two Phase Immersion Cooling Fluids (AHRI 700 Appendix C)

UL 2417B: Direct-to-Chip Fluid Requirements

- To extend the same framework of UL 2417, later this year we will be publishing a new OOI UL 2417B to evaluate direct to chip liquid coolants
- The intended scope is to cover water and water/glycol-based coolants used in direct-to-chip data center applications.
- Focus will be on performance testing and not compatibility
- Proposed testing may include the following:
  - Autoignition Temperature (ASTM E659)
  - Oxidative Stability/Corrosion (ASTM D8040)
  - Glycol Percentage (Gas Chromatography)
  - Kinematic Viscosity and Density (ASTM D7042)
  - pH Test (ASTM D1287)
  - Freezing Point

UL 4303: Liquid Cooling Hoses and Tubing

- This year a new OOI UL 4303 was published to evaluate hoses and tubing used in direct to chip liquid cooling
- The scope covers hose and tubing performance across a range of safety and durability criteria, including:
  - Mechanical properties, such as tensile strength, elongation and compression set
  - Pressure performance, including working pressure, proof pressure and burst pressure
  - Environmental durability, including heat aging and ozone resistance
  - Fluid compatibility through exposure to coolant fluids
  - Dimensional stability, including bend radius and deformation behavior
  - Flammability through testing to UL 94, Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

Call to Action

- Continue to seek knowledgeable industry experts that can help advance OCP work with standards organization and regulatory bodies
- Interested parties should reach out to the Industry Liaison Team leads
  - **Kelley Mullick** Kelley.Mullick@ocproject.net
  - **Maryam Mohagheghi** Maryam.Mohagheghi@ocproject.net
- Meets every 3rd Thursday of the month
  - 8am-9am PT/10am-11am CT/17:00-18:00 CET via Zoom call
- Stay engaged with UL Solutions as we continue to write new OOIs and they evolve to consensus-based standards: Contact Mark or Lizzy

Thank You!

Mark Olson

Mark.M.Olson@ul.com

http://www.ul.com

Lizzy Fernando

Elizabeth.Fernando@ul.com

