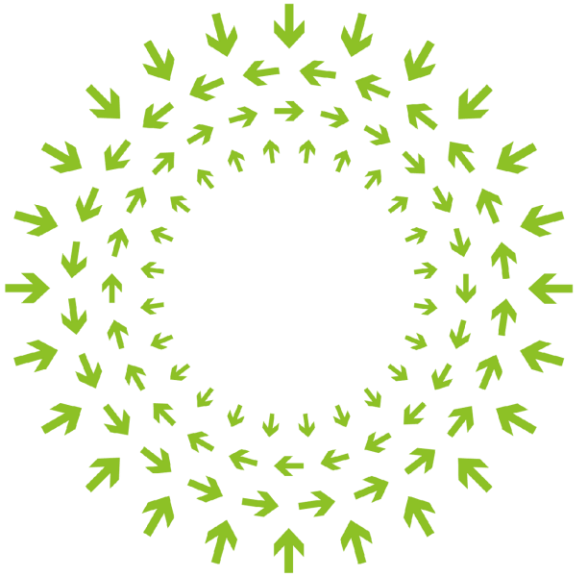

OPEN Compute Project

Cooling Environments – Cold Plate

Rope Leak Sensor Base Specification

Revision 1.0.0

Base Specification
Effective 02/02/2026

Authors: Berhanu Wondimu, Zhikui Ren, Yuehong Fan, David Zhou (Intel Corporation)

Contributors: Casey Winkel, Dan Surratt (Intel Corporation), Aneesh Jaydeep, Daniel Placzek (CoolIT Systems), Xiaoxin Xu (Envicool), Andy Liu (Thermal Control Technology), Will Leong (PermAlert), Liu Yi (Gredmann Group), Tsutomu Ashizawa (Tatsuta Electric)

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1.1. Acknowledgements

The authors would like to acknowledge leak sensor vendors (CoolIT Systems, Thermal Control Technology, PermAlert, Envicool, Gredmann Group, and Tatsuta Electric) for their collaboration to align and standardize the product. Special thank you to the OCP community members, who reviewed and provided valuable feedback to improve the quality of the content.

2. Compliance with OCP Tenets

2.1. Openness

This base specification is devised to standardize on some of the critical features of a leak sensor to enable open collaboration between vendors and liquid cooling ecosystem partners. Normalization on the product allows ingredient suppliers and system integrators to share information openly and develop solutions using standard products in the market.

2.2. Efficiency

Sharing information helps to improve efficiency in product development and saves cost. Ingredient vendors and solution integrators can align on product specification and integration to streamline their development process and improve quality.

2.3. Impact

A leak detection device is one of the critical ingredients needed for direct liquid cooling technology using water-based coolant fluids. Therefore, impact of OCP specification on this device is important in the proliferation of liquid cooling in data centers. Standardization of leak sensors will reduce design complexity and improve availability in the market.

2.4. Scale

Standardization on product features and specifications will improve adaptability and scalability throughout the ecosystem. This document will help to minimize design complexity and enable more vendors to provide solutions for the global market.

2.5. Sustainability

This OCP specification is put together in collaboration with several leak sensor vendors with a goal of improving sustainability and adaptability of the product in the market. Normalization of key features of the product will help to reduce the amount of customization which has been a challenge for system integration. The use of liquid cooling is also a more sustainable cooling solution that traditionally used air cooling.

3. Change Log

Date	Version #	Author	Description
02/02/2026	1.0.0	All	Initial release

4. Scope

This document defines technical base specifications for a leak sensor rope used in single-phase Direct to Chip (DTC) liquid cooling of Information Technology Equipment (ITE) using water-based coolant fluids. The goal of this document is to specify the product features and interfaces for use in liquid cooled ITE. Sensor suppliers must meet basic requirements stated in this document to ease installation and configuration but are not limited to innovating and optimizing their product for differentiating themselves from their competition. This base specification is devised for general liquid cooling ecosystem enabling, not to narrow down the product options in the market. Application of leak sensor rope may be extended to other products containing electrical circuit and fluid flow mechanism, such as, Coolant Distribution Units (CDU), chillers, rack manifolds, etc.

5. Overview

Advanced chips (CPU, GPU, etc.) used to process heavy workloads like Artificial Intelligence (AI) applications require adequate cooling for maximum performance. Therefore, transition from traditional air cooling to liquid cooling is inevitable to meet the demands of high Thermal Design Power (TDP) processors. Some of the challenges in liquid cooling transformation is risk of coolant fluid leaks inside the ITE. Thus, leak detection and mitigation systems are crucial for liquid cooled servers using water-based coolants (water or propylene glycol) [1, 2]. Conventional leak sensor products in the market are bulky and difficult to use in a server environment [3]. This specification is devised to standardize on some of the design and interface features and functionalities of leak sensor rope to fit the datacenter liquid cooling application.

5.1 Design Specification

Conventional leak sensor rope available in the market has three main parts (see figure 1):

1. Leak sensor rope – is a contact-based leak detecting part of the sensor which changes electrical state (resistance, capacitance, etc.) when exposed to water-based fluids.
2. Power cable – is an electrical cord used to provide power to the sensor.
3. Electrical circuit – is an electrical circuit board that translates the change in state of a leak sensor to a recognizable signal by the Data Acquisition (DAQ) system such as Tach/frequency output. Note that some implementations may integrate the electrical circuit into the main ITE board.

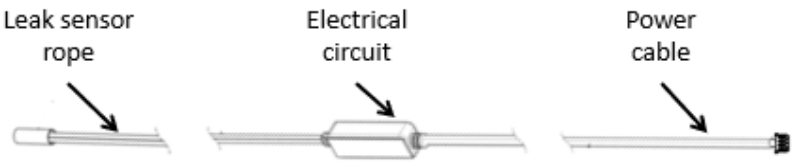


Figure 1 – Example of a leak sensor rope

Each of these parts of the leak sensor rope must be designed to meet form, fit and functional requirements of the product. In this document, a 1U form factor server node is assumed as the target system for leak sensor application due to the challenges in space constraints. Larger size server chassis have more space to implement leak sensor rope solutions, which makes it easier for installation. Details on product and application specifications are presented in sections below.

6. Regulatory Requirements

Leak sensor products shall have applicable certifications complying with GEO specific safety and environmental regulations. These requirements may vary based on customer use case or location. Most common safety and environmental regulation certifications are UL, CE, ROHS, REACH, etc.

7. Physical Specifications

Physical specifications (shape, size, weight, etc.) of the leak sensor will depend on application requirements of the ITE product. As a general guideline, smaller size and conformal shape are easier to accommodate in most product applications. This section discusses only features of the leak sensor rope, which are crucial for the application. Details on physical features of the product and material of construction are left to the discretion of the vendors for the purpose of enabling competition and product differentiation.

7.1 Mechanical

Mechanical design of the leak sensor rope may vary from vendor to vendor and application to application. However, basic feature size and shape must be similar to maintain compatibility and enable the liquid cooling ecosystem in data centers. General recommendations are listed in Table 1 based on sensor drawing shown on Figure 2.

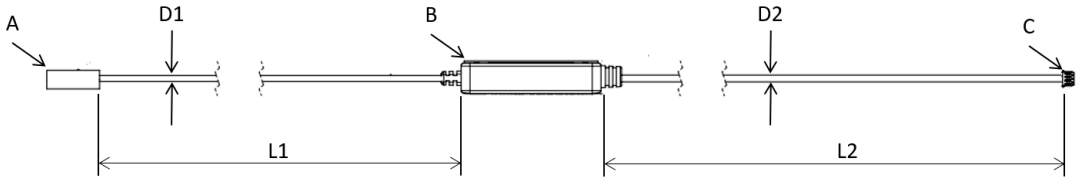


Figure 2 – Example of leak sensor rope drawing

Table 1 – Features and dimensions of leak sensor rope

Features	Description	Notes
A	Insulation/Shrink wrap	Recommended
B	Electrical circuit package	Required for signal processing
C	Connector for board interface	Required (4-pin connector)
D1	Rope sensor size (diameter)	Smaller size is recommended

D2	Electrical power cord size	Smaller size is recommended
L1	Sensor rope length	Application dependent
L2	Power cable length	Application dependent
Weight	Overall weight	Small size & low weight recommended

7.2 ITE Compatibility

ITE compatibility is one of the requirements that dictates leak sensor design and implementation. Most conventional leak sensor ropes available in the market are rigid, bulky and not fully compatible for ITE application. Leak sensor rope must be flexible to route along the coolant flow tubes and intricate cold plate interfaces. Rope sensor must be installed below the tube and fittings to detect a leak when it occurs. Absorbent tape wrapped around the sensor and tube/fitting assembly will help in capturing leaks to improve detectability. This specification outlines essential features of the sensor for ITE compatibility and ease of installation (see table 2). Figure 3 shows an example of leak sensor rope installation in a liquid cooled ITE.

Table 2 – Sensor specification for server compatibility

Features	Specification	Notes
Sensor rope	Optimized for size and flexibility with minimum bend radius to ease installation	Recommended
Power cable	Optimized for size, power, and flexibility with minimum bend radius to ease installation	Recommended
Electrical circuit package	Miniaturized to fit in small space inside the server chassis (assume compact 1U formfactor)	Recommended
Sensor rope surface/texture	Must be flexible (low bend radius) & adhere to tube and cold plate surface and absorbent tape	Recommended
Ease of serviceability	Must comply and stay intact with the cold plate loop during repair/service	Recommended
Wear & fatigue resistance	Must be resistant to wear & cyclic loading	Recommended

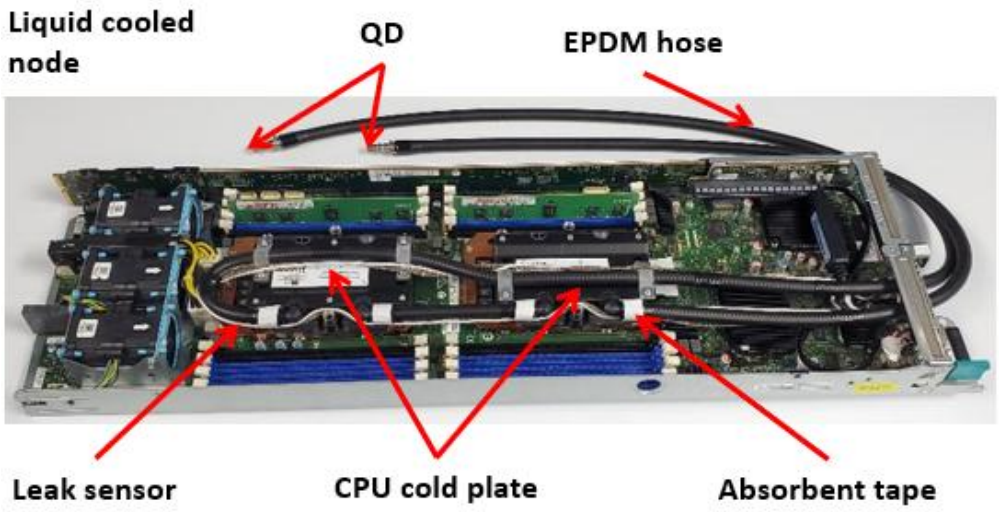


Figure 3 – Example of leak sensor rope installation in a liquid cooled server/node

8. Electrical Requirements

Current liquid cooling solution deployments require numerous customizations to integrate off-the-shelf leak sensor rope into the server. Leak sensor rope standardization is important to align product vendors with system integrators to co-engineer the best product for the application. Table 3 includes essential electrical features and specifications of the leak sensor to meet server application requirements and for ease of installation and configuration.

Table 3 – Sensor electrical specifications

Features	Specification	Notes
Interface	4-pin wire connector	Required
Input supply voltage	3.3 – 12 Vdc ± 10% of rated voltage	Required
Output signal	Tach output (open drain or open collector)	Required
Power requirement	Low power consumption	Recommended
Status indicator	LED light	Recommended

9. Environmental Requirements

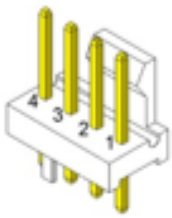
The leak sensors must meet application requirements of a liquid cooled server. Table 4 defines environmental conditions of the product (operating and non-operating) and required specifications to comply with this specification. Component level safety and reliability testing must be performed by the sensor vendor to guarantee performance through the life of the product.

Table 4 – Sensor environmental specifications

Features	Specification	Notes
Operating temperature range	0 ºC – 85 ºC	Required
Non-operating (shipping & handling) temperature range	-40 ºC – 85 ºC	Required
Relative humidity	0% – 95%	Required

10. Interface Requirements

The leak sensor interface to the motherboard must be different from other devices or components installed on the ITE (such as CPU fan) to avoid confusion and connection mistakes. The sensor specification requires the use of a standard 4-pin wire terminal interface to meet current and past generation ITE requirements [4]. The sensor may be retrofitted to existing server products, which have available fan header terminals for installation. However, this requires modification of the connector to match the board interface. Figure 4 illustrates 4-pin wiring designation of the leak sensor rope used for liquid cooled servers.



Pin #	Description	Color code
1	GND	Black
2	PWR	Red
3	Sense	Yellow
4	Presence	Blue

Figure 4 – Pin definition for a 4-pin wire connector

10.1 Sensor Signal

Leak sensors must be able to detect a coolant fluid leak as well as malfunction/faulty signal and communicate to the ITE management tool. Table 5 shows connector pin definition and signal output for sensor condition.

Table 5 – Sensor signal specifications

Pin #	Sensor condition	Signal	Notes
1	Ground connection		
2	Power connection		
3	Normal operating condition (leak not detected)	Frequency (e.g. 50 -100Hz)	Required
	Leak detected (Tach output)	Low	Required
	Leak sensor issue (open circuit)	High	Required
4	Leak sensor power cable presence	Low	Required
	Leak sensor power cable absence	High	Required

11. Onboard Power Specification

The server board is assumed to have a minimum voltage of 3.3 VDC (standby/idle mode) or normal operating voltage of 12 VDC when connected to a power source. Therefore, the leak sensor must be able to operate within these conditions.

12. Material of Construction

Leak sensor material of construction is left to the discretion of the suppliers. However, it must be made of materials approved for the application. The product must meet environmental and regulatory requirements and obtain proper certifications for use in ITE.

13. Firmware Configuration

Firmware configuration is often done through the Board Management Controller (BMC) and it depends on the sensor type and specification. Details of the sensor specification must be aligned with the electrical specifications of the ITE and coolant type during product selection and

must be optimized to detect and communicate the signal with the controller when leak condition occurs.

14. Leak Mitigation/Hardware Management

Leak sensor triggers a leak event when it contacts a liquid regardless of the amount of leak (it is discrete signal for leak or no leak). Once a leak event is detected by the sensor, the mitigation plan depends on safety requirements of the application and varies from user to user. Figure 5 shows an example of server level leak mitigation setup for a liquid cooled ITE. Some applications may opt to use a timer to distinguish between a potential false alarm and an actual leak before interrupting operation or shutting down the equipment. However, if the equipment is configured for immediate shutdown upon detecting a leak, then you won't see a second tree branch depicted in Figure 6. When leak is detected the board management controller (BMC) / Complex Programmable Logic Device (CPLD) must execute the mitigation plans (such as sending alarm/notification, shutdown ITE, etc.) to protect the equipment from damage. Leak mitigation plans can be extended beyond the ITE level and may include interrupting flow from the rack manifold or Coolant Distribution Unit (CDU), which is outside the scope of this specification. Note that rope leak sensors are reusable after completely drying. If not fully dry, then the ITE may not restart when powered on or show faulty signal if it is configured right.

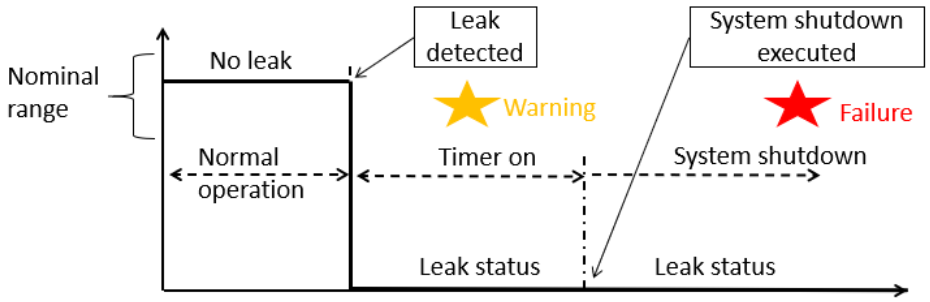


Figure 5 – Example of leak mitigation sequence of events to protect the ITE

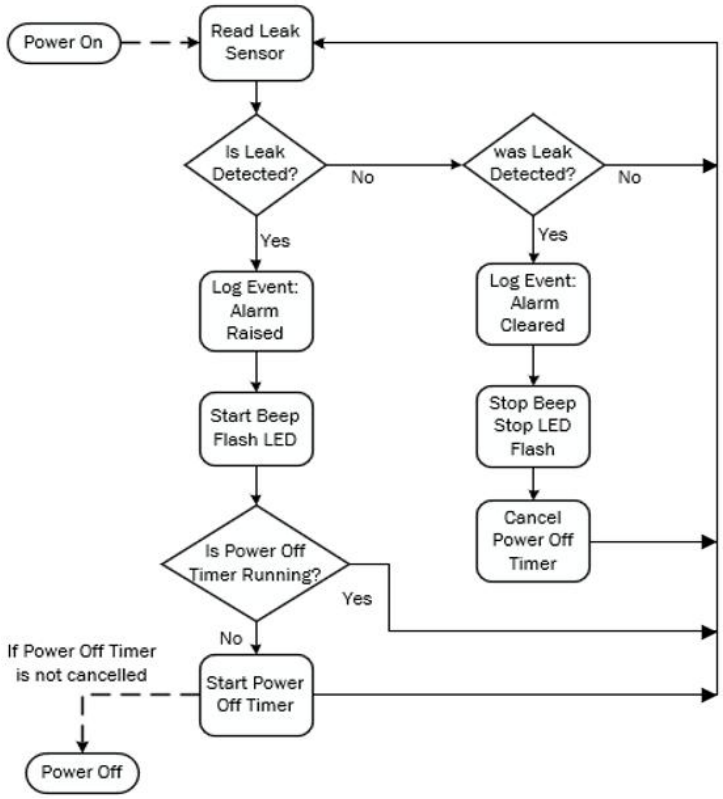


Figure 6 – Example of BMC setup flow chart for leak detection and mitigation mechanism shown in Figure 5

15. False Alarm Reduction Techniques

Leak sensor rope is not a perfect solution to prevent ITE damage due to coolant fluid leak. But it can be helpful if set up and configured correctly. Below are some techniques that can be used to reduce leak sensor false alarms:

- Set the “leak detected” set point away from the “nominal range” during threshold setting (see figure 5)
- Use more than one leak sensor for redundancy if possible
- Verify there is no source of moisture or condensation inside the ITE
- Verify the operating temperature of the leak sensor is not exceeding the manufacturer’s specification, which may drift the leak sensor signal (tach output) to cause a false alarm or faulty signal

16. Glossary

Direct Liquid Cooling (DLC)	A method of cooling electronic components where liquid coolant is directly applied to the components.
Direct-to-Chip (D2C or DTC) Cooling	A liquid cooling method that involves circulating a coolant in direct contact with the heat-generating components, such as processors and memory modules, to efficiently absorb and transfer heat away.
Information Technology Equipment (ITE)	The physical hardware and devices such as computers, servers, networking devices, and peripherals used in information technology for data management and processing.
Coolant Distribution Units (CDUs)	A piece of equipment used in liquid cooling systems that is responsible for pumping and conditioning the coolant before it is distributed to the components being cooled.
Central Processing Unit (CPU)	The electronic processing unit of a computer where mathematical calculations are performed.
Graphic Processing Unit (GPU)	In modern contexts, especially in data centers, a Graphics Processing Unit (GPU) is a specialized processing unit designed for handling massive parallel computations efficiently.
Artificial Intelligence (AI)	An interdisciplinary field, usually regarded as a branch of computer science, dealing with models and systems for the performance of functions generally associated with human intelligence, such as reasoning and learning.
Thermal design power (TDP)	Thermal Design Power (TDP) is a metric used by manufacturers of computing components, primarily CPUs and GPUs, to specify the amount of heat a component is expected to generate under maximum or high load conditions.
Data Acquisition (DAQ)	The process of collecting, measuring, and digitizing data from physical phenomena using sensors and instrumentation for monitoring, analysis, or control in systems.
Universal Quick Disconnect (UQD)	A standardized connector that allows for the fast and secure disconnection and reconnection of fluid lines, commonly used in liquid cooling systems.

Liquid Cooling	A method of cooling which uses liquid to extract heat from components without using air as a medium.

Ethylene Propylene Diene Monomer (EPDM)	A synthetic rubber, commonly used in seals, gaskets, and insulation materials.

Ground (GND)	A reference point in an electrical circuit from which voltages are measured, typically serving as the return path for electric current.

Power (PWR)	In electrical schematics, "PWR" denotes a power supply net or connection point used to deliver electrical energy to components within a circuit.

Baseboard Management Controller (BMC)	A specialized microcontroller embedded on a server motherboard that enables out-of-band monitoring and management of the system, including power control, temperature sensing, and remote diagnostics

Complex Programmable Logic Device (CPLD)	A programmable logic device used for implementing custom logic circuits within a system

17. References

1. Keegan Yaroch, John Cuthbert, David Miller, Sean Sivapalan, Sean Barlett, “Guidelines for using propylene glycol-based heat transfer fluids in single-phase cold plate-based liquid cooled racks”, OCP, 2022.
2. Dale Sartor, F. Philip Yu, Craig Myers, Sean Barlett, Sean Sivapalan, “Guidelines for using water-based heat transfer fluids in single-phase cold plate-based liquid cooled racks”, OCP, 2022.
3. Michael Berktold, Jessica Gullbrand, Fred Rebarber, Nigel Gore, Matthew Archibald, Michael Thompson, Cam Turner; “Leak Detection and Intervention”, Rev. 1.0; Open Compute Project (OCP); ACS cold plate; 2021.
4. https://allpinouts.org/pinouts/connectors/motherboards/motherboard-cpu-4-pin-fan/

18. About Open Compute Foundation

The Open Compute Project (OCP) is a collaborative Community of hyperscale data center operators, telecom, colocation providers and enterprise IT users, working with the product and solution vendor ecosystem to develop open innovations deployable from the cloud to the edge. The OCP Foundation is responsible for fostering and serving the OCP Community to meet the market and shape the future, taking hyperscale-led innovations to everyone. Meeting the market is accomplished through addressing challenging market obstacles with open specifications, designs and emerging market programs that showcase OCP-recognized IT equipment and data center facility best practices. Shaping the future includes investing in strategic initiatives and programs that prepare the IT ecosystem for major technology changes, such as AI & ML, optics, advanced cooling techniques, composable memory and silicon. OCP Community-developed open innovations strive to benefit all, optimized through the lens of impact, efficiency, scale and sustainability. Learn more at www.opencompute.org.

Appendix A - Checklist for IC approval

Item	Status	Link to detailed explanation
Has this contribution been presented to an OCP Project group during a project call or engineering workshop?	Yes	If “No”, please state the reason.
Approval by Project Leads	Yes	If “No”, please state the reason.
Is this contribution entered into the OCP Contribution Portal?	Yes	If “No”, please state the reason.
Was it approved in the OCP Contribution Portal?	Not yet	Document is recently complete and ready for review now