[WHITE PAPER: 3 BALLS FLOW METER]

[Ali Chehade, OVHcloud]

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Executive Summary

The Open Compute Project Foundation (OCP) is a global organization dedicated to advancing the development and adoption of computing infrastructure, fostering innovation in both hardware and software design. OCP is committed to assisting organizations in harnessing the advantages of open technologies and methodologies to realize their objectives.

The flow meter stands out as a crucial tool employed by liquid-cooled data centers (DCs) to effectively manage resources and enhance performance metrics, including Power Usage Effectiveness (PUE) for power consumption and Water Usage Effectiveness (WUE) for water consumption. Anticipating a substantial surge in demand for flow meters within DCs employing liquid cooling technology, there is an expected increase in capital expenditures (CAPEX) and rack costs.

In certain scenarios, a straightforward indication of liquid flow with adequate accuracy proves to be sufficient. Therefore, there is a need to design a new cost-effective industrial flow sensor. This white paper introduces a simple and reliable flow meter tailored for use in liquid-cooled racks within DCs. This innovation offers a notable advantage over expensive and sophisticated analog flow meters/indicators. The potential application of this solution within the Open Compute Project (OCP) Foundation holds promise for enhancing data center infrastructures.

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1. Introduction

A flow meter serves as a vital tool for measuring the volumetric or mass flow rate of a fluid. Various types of flow meters are available in the market, catering to diverse applications across different industries. The overall accuracy of a flow meter is contingent upon the specific conditions of its application.

In a liquid-cooled data center (DC), where achieving a comprehensive energy balance is crucial under varying operating conditions, employing flow meters in different locations, especially at the rack level, is highly recommended. Currently, the flow meter market faces challenges in achieving cost-effective manufacturing, impeding efforts to reduce capital expenditures for liquid-cooled data centers. Consequently, potential savings that DCs could achieve through reduced energy and water consumption with liquid-cooled technology may be compromised by the high costs associated with management tools installed on racks and within DCs, such as flow meters.

OVHcloud's research and development team has innovatively crafted a cost-effective flow meter specifically designed for use on liquid-cooled racks—the 3 balls flow meter. This solution offers distinct advantages over analog flow meters and various wheeled flow meters available in the market. Thus, the 3 balls flow meter concept holds considerable potential for the Open Compute Project (OCP) community.

2. Compliance with Open Compute Project Tenets

The 3 balls flow meter aligns with OCP tenets by fostering openness, enhancing efficiency, making a meaningful impact on the market, catering to scalability, and contributing to sustainability within the context of liquid-cooled data centers.

2.1 Openness

- The development of the 3 balls flow meter emphasizes an open approach by addressing a gap in the market related to cost-effective manufacturing of flow meters.
- The white paper demonstrates transparency in detailing the innovation and its advantages over existing solutions, fostering an open exchange of ideas and information.

2.2 Efficiency

- The 3 balls flow meter is designed to enhance efficiency in liquid-cooled data centers by providing flow readings under cost-effective solution.
- By focusing on a tool that can be deployed at the rack level, the contribution aims to optimize energy and water consumption, contributing to overall operational efficiency in data centers.

2.3 Impact

- The introduction of the 3 balls flow meter addresses a specific challenge in the flow meter market, potentially reducing capital expenditures for liquid-cooled data centers.
- The impact lies in enabling data centers to realize savings through optimizing flow rates inside servers and IT racks.

2.4 Scale

- The 3 balls flow meter is positioned as a scalable solution that can be utilized in various liquid-cooled racks across data centers.
- By presenting an innovative and cost-effective flow meter, the contribution is geared towards widespread adoption and implementation, aligning with the scalability tenet of OCP.

2.5 Sustainability

- Sustainability is addressed through the potential reduction in energy and water consumption achieved by implementing the 3 balls flow meter in liquid-cooled data centers.
- By offering a cost-effective alternative, the contribution contributes to sustainable practices by potentially lowering the overall environmental impact of data center operations.

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3. Description

3.1 Typical flow meter/indicator

Two categories of flow sensors can be utilized on IT racks: analog flow meters and simple flow indicators. Analog flow meters offer precise fluid flow metering but come with the requirements of cabling, electrical supply, maintenance, and a higher cost. In contrast, flow indicators, which are relatively more affordable, indicate the presence of flow in the circuit without providing the ability to measure the flow quantity. Consequently, manufacturers of IT racks often opt to install one or a very limited number of analog flow meters per rack and a flow indicator per server. **Table 1** shows and analog flow meter and a flow indicator, as well as their advantages and disadvantages.

Table 1. Typical rack flow meter/indicator.

<table>
<tr><td></td><td>Analog flow meter</td><td colspan="2">Flow indicator</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">  </td><td colspan="2">  </td></tr>
<tr><td>Cheap version</td><td>Expensive version</td></tr>
<tr><td>Advantages</td><td>Good precision</td><td>Cost effective (3 to 4 euros)</td><td>Handles high temperature and pressure (3 bars at 70°C)</td></tr>
<tr><td>Disadvantages</td><td>● Necessitates sophisticated filtering and maintenance.
● Expensive
● Bulky</td><td>● Cannot handle high temperatures and pressures (Max 2 bars at 50°C)
● Very low precision</td><td>● Expensive (35 to 45 euros)
● Very low precision</td></tr>
</table>

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	• Require shutoff valves for maintenance		

3.2 3 balls flow meter description

To overcome the drawbacks associated with market flow meters and indicators, OVHcloud has developed its own flow indicator using push-in fittings technology. This innovation aims to provide a solution for reading flow with a high level of precision. **Figure 1** shows a 3D drawing for the 3 balls flow meter. The latter is composed of a metallic structure containing 2 push-in fittings, a flexible pipe, 4 obstacles and 3 balls of different diameters.

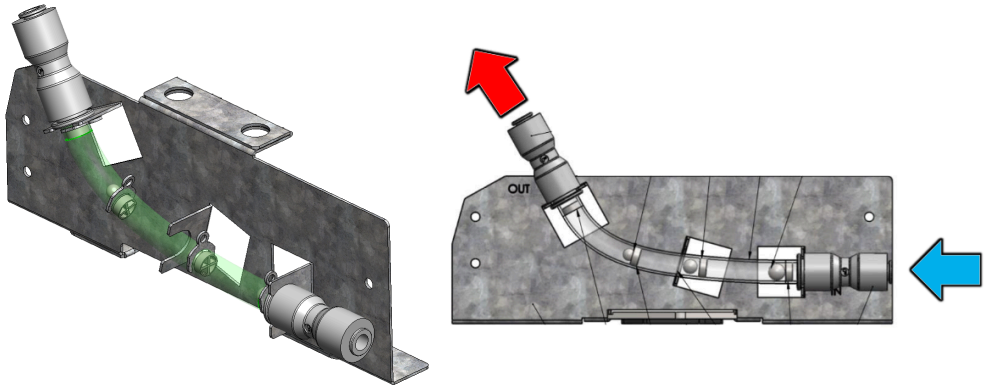

Figure 1. 3D drawing for the 3 balls flow meter.

The 3 balls flow meter has many advantages:

- Easy to integrate within a rack.
- No need for sophisticated filtering
- The flow indicator could be calibrated to provide the maintenance technician with an approximation of the flow.
- The main structure is magnetized and could be installed horizontally or vertically inside the rack.
- Maintenance free
- Cost effective.

3.3 3 balls flow meter: working principle.

The operating principle of the 3 balls flow meter is simple and follows the position of the 3 balls inside the pipe:

- Ball A: diameter of 7 mm
- Ball B: diameter of 6 mm
- Ball C: diameter of 5 mm

Each ball can move between 2 obstacles determining the range of motion of each of them as shown in **Figure 2**.

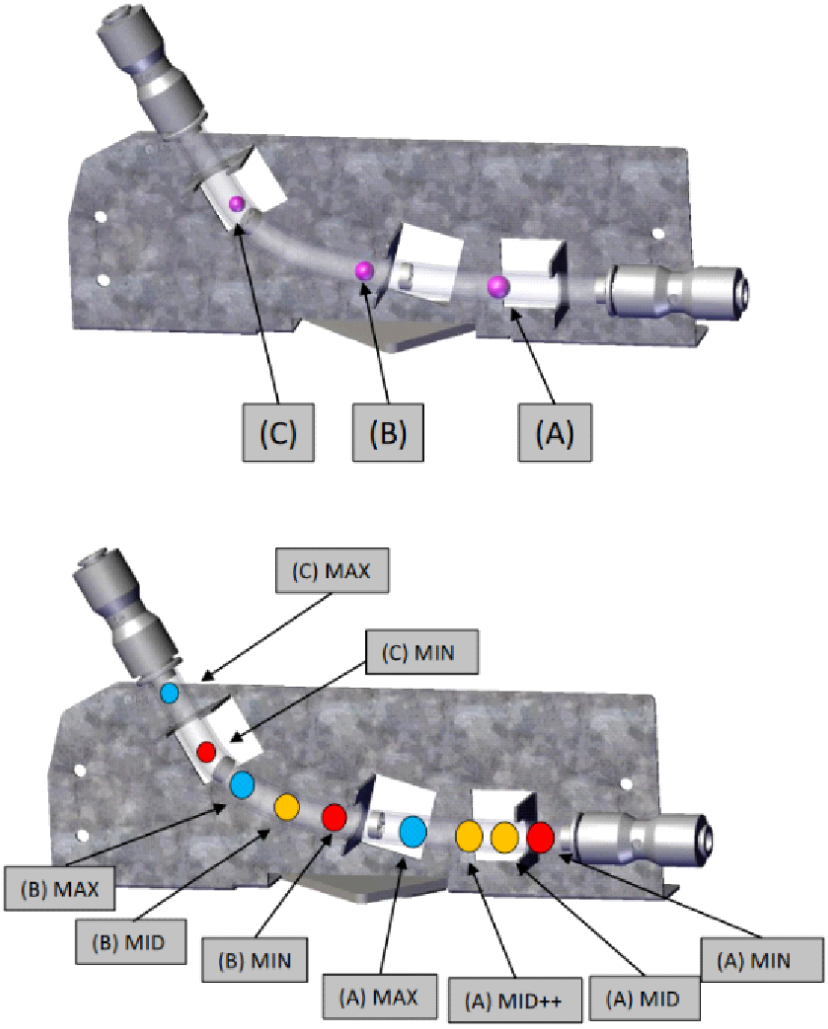

Figure 2. Range of motion of 3 the balls inside the 3 balls flow meter.

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Ball (A) can reach 4 different positions inside the pipe: MIN, MID, MID++ and Max. Ball (B) can reach 3 different positions: MIN, MID and MAX. Ball (C) can reach 2 positions: MIN and MAX. According to the different positions of these 3 balls, 14 different configurations can be extracted describing the flow rate value varying from 0 to 0.7 l/min or more. **Table 2** describes each configuration and its corresponding flow rate values.

Table 2. The different configurations of the position of 3 balls inside the 3 balls flow meter.

Flow rate		**Balls**		
l/min		(A) 7mm	(B) 6mm	(C) 5mm
>0.7		MAX	MAX	MAX
0.55		MAX	MAX	MIN
0.45		MAX	MAX	MIN
0.4		MAX	MID++	MIN
0.35		MAX	MIN	MIN
0.3		MAX	MIN	MIN
0.25		MAX	MIN	MIN
0.2		MAX	MIN	MIN
0.15		MAX	MIN	MIN
0.13		MAX	MIN	MIN
0.1		MAX	MIN	MIN
0.05		MID++	MIN	MIN
0.03		MID	MIN	MIN
0		MIN	MIN	MIN

Please note that additional or fewer positions per ball are possible. The number of balls and positions outlined in Table 2 provides a non-exhaustive example of what can be accomplished with this technology. In other words, the system can be configured with additional or fewer balls, and positions can be adjusted accordingly. Moreover, if required, an electronic apparatus can be incorporated to define each ball's position in each section for analog readings.

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4. Conclusion

This white paper introduces a straightforward and dependable 3 balls flow meter designed for application in liquid-cooled racks within data centers (DCs). This innovative solution presents a significant advantage over costly analog flow meters and low-precision flow indicators. It relies on push-in fittings technology, comprising a metallic structure housing 2 push-in fittings, a pipe, 4 obstacles, and 3 balls. Depending on the volumetric mass flow rate of the fluid (water), the balls move within the pipe, enabling the estimation of a specific flow. The utilization of this cost-effective and user-friendly flow meter has the potential to improve the capital expenditures (CAPEX) of liquid-cooled data centers.

5. Glossary

MIN: Minimum

MID: Middle

Max: Maximum

IT: Information Technology

DC: Data center

PUE: Power Usage Effectiveness

WUE: Water Usage Effectiveness

CAPEX: Capital expenditures

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6. License

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includes investing in strategic initiatives that prepare the IT ecosystem for major changes, such as AI & ML, optics, advanced cooling techniques, and composable silicon. Learn more at www.opencompute.org.

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