Pressure and Temperature Stable Online Sensor for Water Quality Monitoring

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The chlorine sensor packaging was modified to withstand a demanding cycling pressure and temperature accelerated aging test. A significant improvement was demonstrated, which should allow on-line disinfectant monitoring in warm sanitary water.

There is a growing concern about legionella bacteria and other pathogen microorganisms in places such as hotels, hospitals, swimming pools, leisure centers and senior citizen homes. Disinfection of sanitary hot water distribution systems is one of the prevention methods, which is increasingly being applied. On-line disinfectant monitoring for such applications requires a sensor able to withstand water at elevated pressures and temperatures.

Microelectrode arrays integrated on silicon chips are well suited for on-line monitoring of disinfecting agents [1]. Their utilization in warm and hot water (50 – 60°C) under pressure (3 – 6 bar) imposes, however, a considerable stress on the packaging of the sensor. A test program was therefore initiated to establish the sensor stability.

The amperometric oxidant measurement is based on a three-electrode set-up, comprising a microelectrode array as working electrode, a counter electrode and a reference electrode. Typically measured currents are in the nA range, it is therefore critical that the packaging is water tight and provides a high insulation resistance between all electrodes.

Various test conditions were used to evaluate the sensor stability, including:

- Storage in water at elevated temperature (70°C)
- Storage in water at elevated pressure (20 bar)
- Cycling water pressure and water temperature (6 bar/80°C/15 min ⇔ 0 bar/10°C/15 min).

A good overall stability over 2000 hours of storage at 70°C was obtained. Some sensors, however, failed the test due to leakage currents between working and counter electrodes. Furthermore, thermal cycling tests resulted in an unacceptable increase in leakage current for all sensors after more than ~10 cycles. The source of the problem was identified as being a loss of adhesion of a polymer resin.

Modification of the original design was therefore undertaken, and, in a second phase, two modified packages (#2, #3) were compared to the original one (#1).

The improvement in performance achieved in particular by design #3 is illustrated in Figure 1. In the cycling temperature/pressure test, the electrical resistance of design #3 remained above the measurable limit of 500 MΩ after 30 cycles, while the original packaging (#1) and to a lesser extend, the second version (#2), exhibited a limited stability under these severe test conditions.

A view of the new sensor package front head is shown in Figure 2.

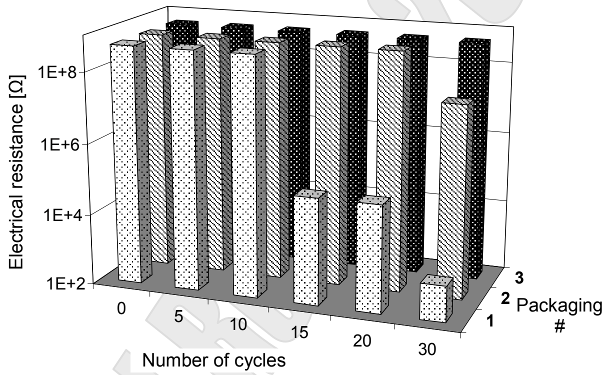

Figure 1: Insulation resistance vs. number of temperature/pressure cycles. Comparison of original sensor packaging (#1) with improved versions (#2 and #3).

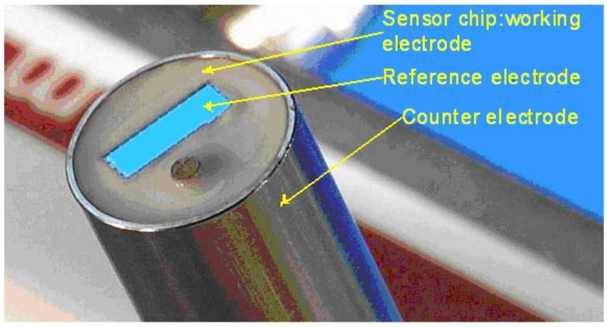

Figure 2: Front view of improved packaging

The stability of the miniaturized Ag/AgCl reference electrode, integrated in the sensor head, was also verified under the same test conditions. No degradation was observed in storage or in dynamic tests. This electrode shows a potential drift lower then 50 mV in the 20 – 70°C temperature range, which is suitable for amperometric detection.

In a following phase, field tests will be undertaken to demonstrate the long-term feasibility of on-line disinfectant monitoring in pressurized hot water distribution systems.

[1] J. Gobet, Ph. Rychen, Ch. Madore, N. Skinner, H. van Buel, F. Jaggi, "Development of an On-Line Chlorine Sensor for Water Quality Monitoring in Public Distribution Networks", Water Science and Technology: Water Supply 1 (2001) 211

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