A look at the X-Chip

The revolution in pH measurement in the food industry from Mettler Toledo

For many food industry processes, pH plays a key role. pH identifies the complete implementation and speed of processes, it provides information on whether a recipe has been completely met, and defines the properties of fresh and wastewater. Various pH measurement technologies have been developed to fulfill all these tasks. Now, a single sensor that meets all the food industry's requirements has come onto the market: the X-Chip, made specifically for the food industry.

pH technology

Historically, the first earliest commercially available sensors were developed for penicillin production, reacting very quickly to pH changes and resisting high temperatures and pressures.

However, different substrates can cause issues. Glass is often used in measuring pH, using very thin, pH-sensitive glass membranes. H+ ions attach themselves to these membranes in a gel layer that forms on the membrane and results in a potential difference to the sensor's reference electrode. Glass sensors measure well but are not popular in food production due to the risk of glass breakage. Even if they indicate damage immediately, it is difficult to ensure that all glass fragments have been removed from production equipment.

Another solution is enamel electrodes. To extend the operating time between cleanings, the electrolyte in these electrodes is pressurised and "rinses" the surface from the inside out so that conductive contact is ensured. The enamel surface can be cleaned with the usual cleaning-in-place (CIP) cleaning agents and temperatures. After CIP, however, it takes a long time to regenerate the system so that it displays accurate values again.

The sensors do not break due to rapid temperature changes, as with glass electrodes, but since they are complex to manufacture, they are quite expensive. Enamel sensors must be handled very carefully, and if an electrode is mechanically damaged, chipped enamel has a similar effect to glass.

One further option is an ISFET (ion-sensitive field effect transistor), but the ion-sensitive layer on the measuring electrode is not resistant to hot caustic. If the ISFET electrode is not removed before CIP, the coating suffers to a degree that prevents the sensor from being calibrated. These sensors also suffer from drift and must be calibrated far more frequently than glass sensors.

Development of pH sensors from 1950s glass sensor to modern InPro X1

pH in food processing

A low pH value in food and drinks not only provides potential protection against microorganisms but also influences taste and freshness. Many processes such as enzymatic reactions, work faster or more comprehensively in certain pH ranges, and metabolic processes such as fermentation are accompanied by pH changes. Knowing the current pH value makes it possible to speed up, slow down, even out or even automatically end the process at the desired result. Sampling and lab measurements are often taken for this purpose.

However, not only do lab measurements take time, but sample properties may also change before the measurement has been done. This means the actual pH value in the process is not the one measured in the lab, and should not be used for process control decisions.

With in-line measurement, in addition to more consistent product quality, production time and energy savings are made possible by tighter process control. It also helps with the quality data recording for traceability if values are available digitally during the entire production process. In-line pH measurement is sensitive and will rapidly detect pH changes if, for example, cleaning agents get into the product. Thus, the X-Chip sensor is a perfect solution for this Critical Control Point (CCP) task.

X-Chip development

Mettler Toledo R&D engineers have now developed a completely new pH sensor that meets all the expectations of the food industry:

- Material and construction reliably prevent particles from migrating or breaking into the product
- CIP-cleanable and permanently installed, reducing installation and operating effort
- A sensor that is cleaned along with the production system and will always have the same hygienic status as the rest of the system
- High availability due to low maintenance and simple operation.

The result is the InPro™ X1 HLS pH sensor with X-Chip technology.

Proof of the sensor's basic requirements for simple, effective cleaning is given by the sensor's EL1 hygienic design certificates from EHEDG and 3A. The materials are safe for contact with food by meeting EN 1935/2004 standards and FDA requirements 21CFR177ff.

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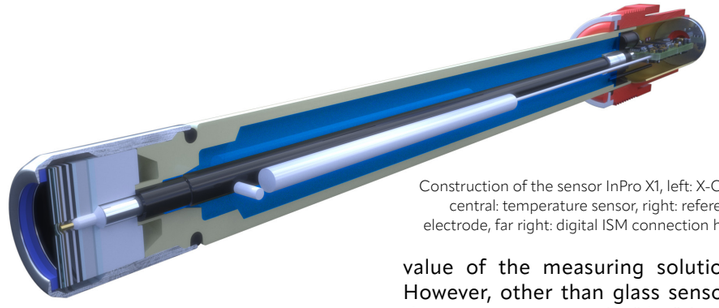


Construction of the sensor InPro X1, left: X-Chip, central: temperature sensor, right: reference electrode, far right: digital ISM connection head

An equipment test developed by the US Army (MIL-STD-810H), where the device is repeatedly dropped several times onto a stainless-steel plate from a height at defined angles, was also passed, with the sensor's head, Peek body and the X-Chip completing this without any problems.

The performance of a new electrode must be measured against the best glass electrodes available. The X-Chip uses the same potentiometric measuring principle as pH-sensitive glass. However, the surface of the X-Chip, made of lithium silicate, is bonded to a metal layer in a composite construction. Breakage and the loss of parts of the X-Chip can be almost entirely ruled out in the process, and if it occurred would lead to an alarm.

The X-Chip has direct contact with the measuring medium. A gel layer forms at the contact point, to which H+ ions can attach, creating a charge, the strength of which depends on the pH value of the medium (the potential of this surface is proportional to the pH value of the measuring solution). However, other than glass sensors, the sensor can remain "dry" in the system over the weekend at normal humidity without the X-Chip having issues when it starts up again.

The sensor's reference system uses Argenthal technology. The reference cartridge protects the silver/silver chloride wire against sulfation, and the electrode body around it is filled with food grade liquid electrolyte under pressure. This overpressure ensures that the ceramic membrane remains permeable for charge transfer. The measuring electrode, on the other hand, does not require an electrolyte; here, the X-Chip measures directly, which has a positive effect on the response time.

The body is made of Peek polymer and a Fluoroprene XP O-ring seals the sensor's titanium tip against the base body. The tip holds the X-Chip and also acts as a solution ground and to prevent measurement noise. For temperature compensation, temperature in the electrode is measured with a thermocouple.

The concept supports cleaning with CIP. No tensions arise in the material that could lead to damage in the event of rapid temperature changes, and cleaning media do not harm the sensor. On the contrary, they actually help to keep the surfaces open for charge transfer. The sensor also measures during and after cleaning and always shows the current pH value.

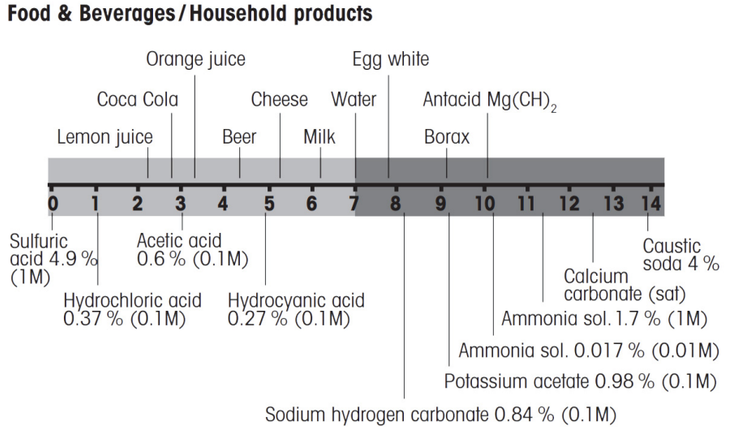
The InPro X1 HLS uses the digital Intelligent Sensor Management (ISM™) technology to transmit the measured values and predictive diagnostics information from the sensor to the transmitter digitally and without signal loss. The diagnostics ensure the user is always aware of the sensor's status and when it will need to be calibrated or replaced. With the maintenance requirement displayed as a remaining number of days, maintenance work can be scheduled during non-production times, and avoid unplanned process interruptions.

Installation

A sensor with X-Chip technology is installed with a simple process fitting such as the InFit 761/NC. The steady holder saves in the first installation, but also later in operation, compared to a retractable version. Since its reference is filled with liquid, an installation angle of >15° must be used to ensure the electrolyte is always in contact with the medium. The electrode then only extends into the process to just above the reference. Mounted with an Ingold, SMS, DIN11851, clamp or Varinline connection, it is easy to clean. It thus does not adversely affecting the process or the cleaning of the food plant and is also 3A and EHEDG certified.

Conclusion

In 24 months of field testing prior to its market launch, the X-Chip has proven that it fully meets expectations: fast, reliable, low maintenance, and unbreakable. It is not damaged by CIP cleaning, the electrode can be installed in a system with a standard process connection and does not require any further equipment to protect or clean it. ISm predictive diagnostics allow calibration and replacement to be planned for when they will be required. pH measurement performance is on par with the best glass sensors. DII



Overview, different pH values in food and beverage