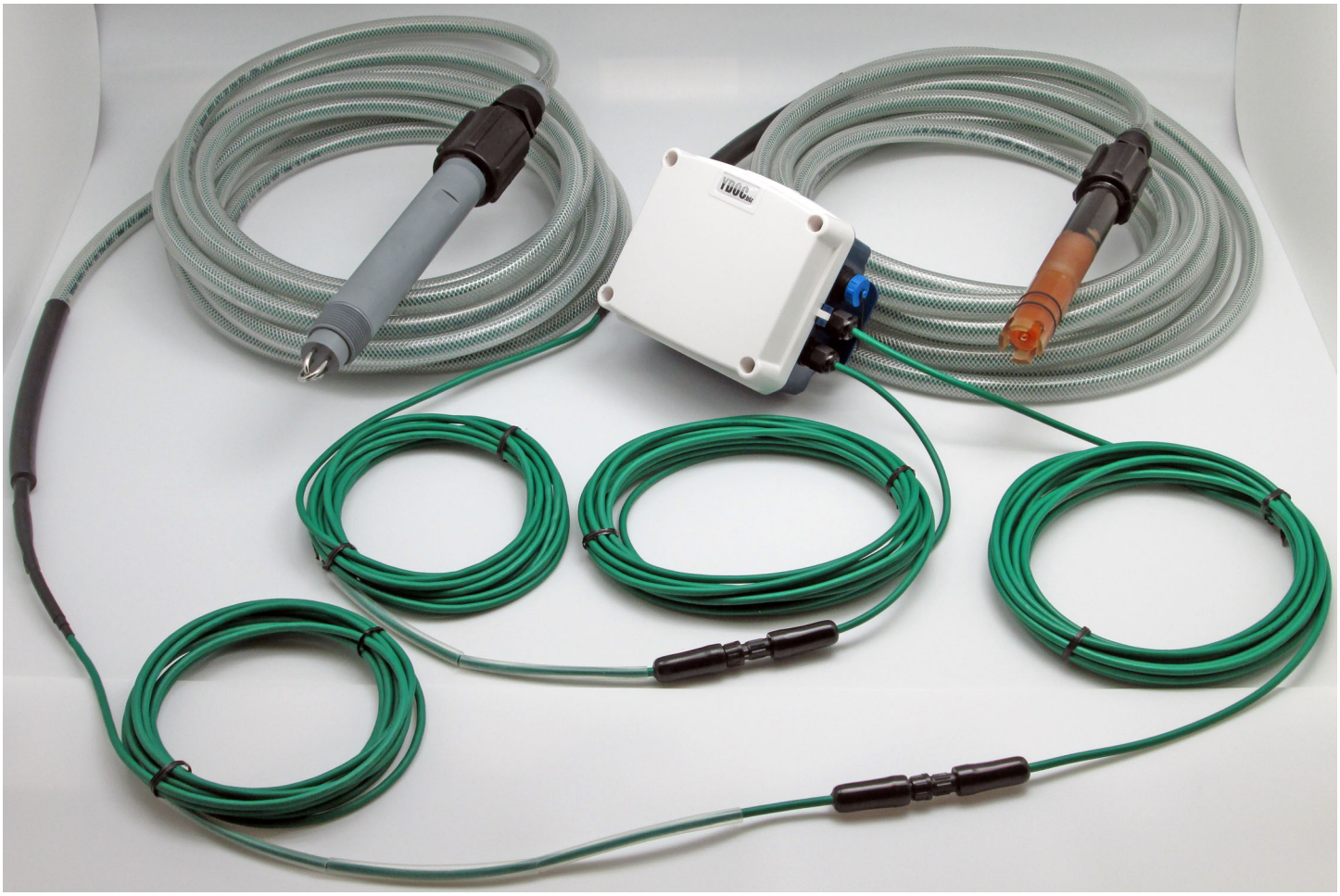
Measurement & Datalogging of pH, ORP & Conductivity in Sewer Lines Down in Manhole for Discharge Compliance



The Problem

- A publicly owned treatment works (POTW) facility wanted to ascertain the origination source that caused pH excursions in the water sent to their treatment plant that did not appear in the pH compliance reports provided from facilities that were performing pH monitoring in fulfill of their discharge permits.
- After some evaluation of the situation, it was determined that the nature of the worst violations were coming from facilities that had not applied for discharge permit at all but were unlawfully discharging untreated waste. This facilitated a need to come up with a different method to investigate the root causes.
- The second most common cause appeared to be from plants where their pH monitoring system reporting invalid data that they were in compliance but in reality, how of compliance due to improper or erroneous maintenance and calibration of the installed pH systems. For example, if a pH sensor was broken or shorted the sensor would typically report a pH of 7 at all times and thus would appear to be in compliance if periodic calibrations were not performed to ensure that the sensor was operational.
- Both of these two root causes are difficult to solve for different reasons. Violators that discharged without ever obtaining a permit are generally likely to be smaller facilities overall but take in aggregate can cause serious capacity and design problems to the city water treatment plant. The second issue regarding facilities that would otherwise appear to be compliance but are in reality out of compliance is in some ways even a more insidious problem since it gets at some core limitations at the heart of the pH compliance and discharge process itself. In short, a more modern smart industrial internet of things solution was required.

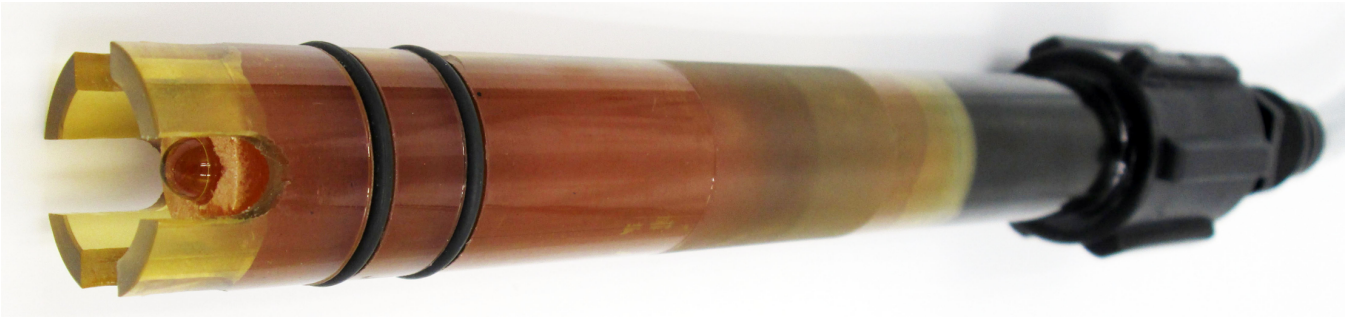
In order to narrow the field of locations where these discharge violations were occurring meant gaining the ability to measure underground at locations often without any power available in a reliable and cost-effective manner that the existing staff from the city could manage over a long period of time that entailed minimal additional maintenance burden. In some cases a SCADA was available for interface (usually with radio telemetry) while in other installation locations no SCADA at all was available so datalogging needed to be integral to the measurement package itself. While many battery powered pH sensors with integral datalogging were available none could endure the conditions of the sewer water down in a manhole without the need for very frequent cleaning and replacement and all such sensors died when they underwent a sustained period of dryness as is always potentially possible for a given sewer line. For industrial sensors that performed somewhat slightly better in these conditions the power consumption of the mating industrial pH transmitter was such that it necessitated very frequent visits to the installation sites for swap out of very large and heavy batteries that were either or both time-consuming & cumbersome to swap-out in the field.

The Solution

The most critical locations of interest had neither no power available nor any SCADA to which the measurement data could be interfaced. To minimize the cost of finding the location of discharge violations fully self-contained battery powered smart digital measurement systems were installed. These locations were also the ones typically without any power or SCADA available at spots accessible only through a manhole into the sewer line. These field portable installations could be moved further and further upstream away from the treatment plant until the excursions were detected and the location of the events could be narrowed to a manageable search area. The point where the initial excursion was detected was followed into the branches until grid area of the source could be narrowed down such the number of facilities to be visited was minimized. Monitoring both pH & ORP helped to better find the locations of all potential discharge violations. A conductivity sensor was required to confirm that the pH & ORP sensors were wetted at the time the measurement was taken to confirm the integrity of the reading obtained. Very many unique features available only from ASTI were required to ensure the measurement goals could be achieved.

UNIQUE ASTI ONLY FEATURES REQUIRED FOR THESE APPLICATIONS:

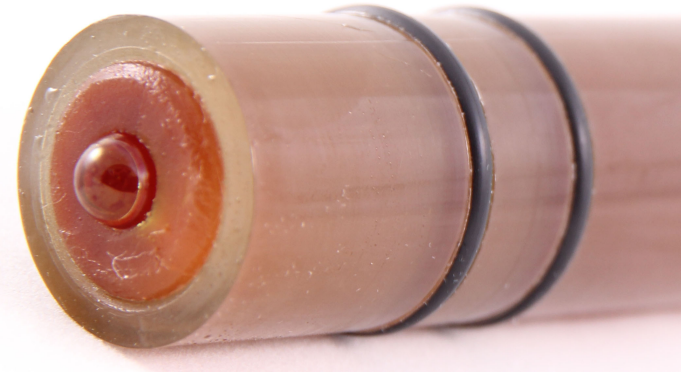
1) Unique Extreme Dehydration Resistant reference system for intermittent wet/dry operation in sewer line.

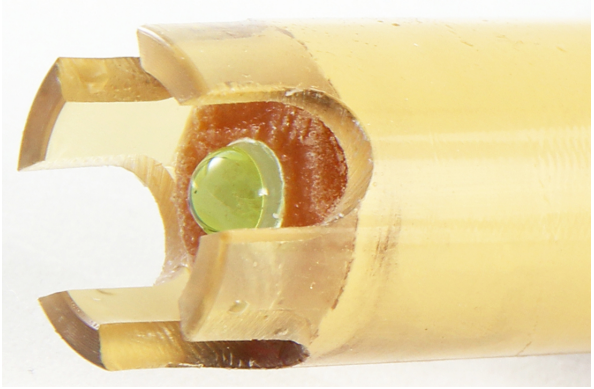


This is the ONLY line of industrial grade heavy-duty severe service pH sensors suitable for intermittent wet and dry operation including prolonged exposure to dry conditions (i.e. sewer line is empty). In the case that the frequency of the dry condition is frequent enough to question the validity of the obtained pH (and ORP) values a fully submersible contacting conductivity sensor with an open geometry, which is not prone to having entrapped neither air bubbles nor fouling easily, can be used. In this case the conductivity sensors installed will yield the pH & ORP readings as "Valid" if the reading is above zero (wet condition) and "Invalid" if it reads exactly or very near zero (dry condition). The extreme dehydration resistant pH & ORP sensors will deliver a response in the absence of wetted sample (dry in air condition) but the reading will be invalid as it is the result of ambient noise. Both the pH/ORP sensor & conductivity sensor need to be installed together for locations that can be intermittent wet and dry to ensure validity of the obtained pH/ORP sensor readings.

This special style of pH sensor or ORP sensor that can operate in an intermittent wet and dry basis is invoked with the "Extreme Dehydration Resistant" option which is indicated by an "E" in the alpha prefix of the ASTI pH sensor or ORP sensor part number. This novel "Extreme Dehydration Resistant" functionality is accomplished by means of a completely water-free solid-state conductive polymer reference technology that is built upon the foundation of over three decades of proven field service of the core reference design concept. This "Extreme Dehydration Resistant" style is ideal for situations where it cannot be ensured that the sensor will stay wetted due to restrictions of the process installation scheme or very limited operator availability such as in rather remote locations. The "Extreme Dehydration Resistant" feature requires mating with a suitably configured ASTI supplied pH transmitter or ORP transmitter to ensure valid results.

2) Unique ASTI only ultra-rugged low-profile break-resistant parabolic pH glass minimizes damage from both handling and process field conditions.





The mechanical strength of the parabolic pH glass configuration is owing to both the thickness of the pH glass element as well as the parabolic shape. The result is incredibly robust durability even with mechanical wear in process from heavy abrasive slurries and installations with large foreign contaminants present for measurement such as sewers down in a sump through a manhole as required for this application. While many flat-style pH elements are often used for such installation types this pH glass configuration is inherently delicate and prone to damage even with careful use. Accidents such as dropping onto a solid surface will generally not break the parabolic style pH glass. The ability to resist breakage from hard contact with the pH glass element can significantly reduce the cost of ownership for installations were breakage poses a prohibitive hurdle to making the ongoing costs for maintenance difficult to support and enables rigorous cleaning of the pH glass element when it becomes extremely fouled from build-up.

3) Submersible Smart Open Geometry Conductivity Sensors are cost effective & not prone to fouling.

The smart digital submersible conductivity sensor is used to confirm that the extreme dehydration resistant pH and ORP sensors are wetted at the time that the intermittent measurements are taken. This is necessary since when the pH & ORP sensors are dry in air and not wetted there will be an open circuit present and so the numbers obtained would be invalid. Having the conductivity sensor present at the same location is a reliable and simple means to confirm that there is liquid present since it will ready zero when it is dry in air. In addition knowing the conductivity at the time the measurement was taken also helps to understand the nature of the sample in terms of ionic strength and possible electrolyte composition. Since these locations are not frequently visit at remote locations the very open geometry of this K=0.1/cm cell constant sensor greatly minimize the possibility of fouling that would impair the readings. The standard range mode operation is recommended for use up to 2,000 microSiemens/cm and the high range mode is recommended for use up to 10,000 microSiemens/cm. It is possible toggle between the standard range mode and high range mode in the field since this is a software selectable choice.

4) Calibration of smart digital sensors with portable battery powered handheld communicator (a.k.a. HHC).

Since these are smart digital sensors can be pre-calibrated at any location of convenience and hot-swap plug and play exchanged in the field with the NEMA 6P rated waterproof connectors. This means that no special training at all is required for the swap-out of ASTI smart digital pH, ORP & conductivity sensors in the field.

This ability to hot-swap plug and play such smart sensors in the field with zero used action required is a unique ASTI only feature which is very critical for ease of field maintenance such that only one technician familiar with calibration is needed to support very many remote installation points as is often the case for cities that are faced with fiscal limitations. The smart digital pH, ORP and conductivity sensors can be calibrated at any location in the lab or field and installed at any another location. Calibration can be achieved with just one Windows PC or handheld communicator (HHC) no matter how many remote field installations point exist. In addition to hot-swap of pre-calibrated sensors offset adjustments can be made while the sensors are left installed in service (a.k.a. in-situ calibration) with the waterproof snap connector moved from the datalogger to the handheld communicator and then offset calibration mode to change the reading to the desired value.

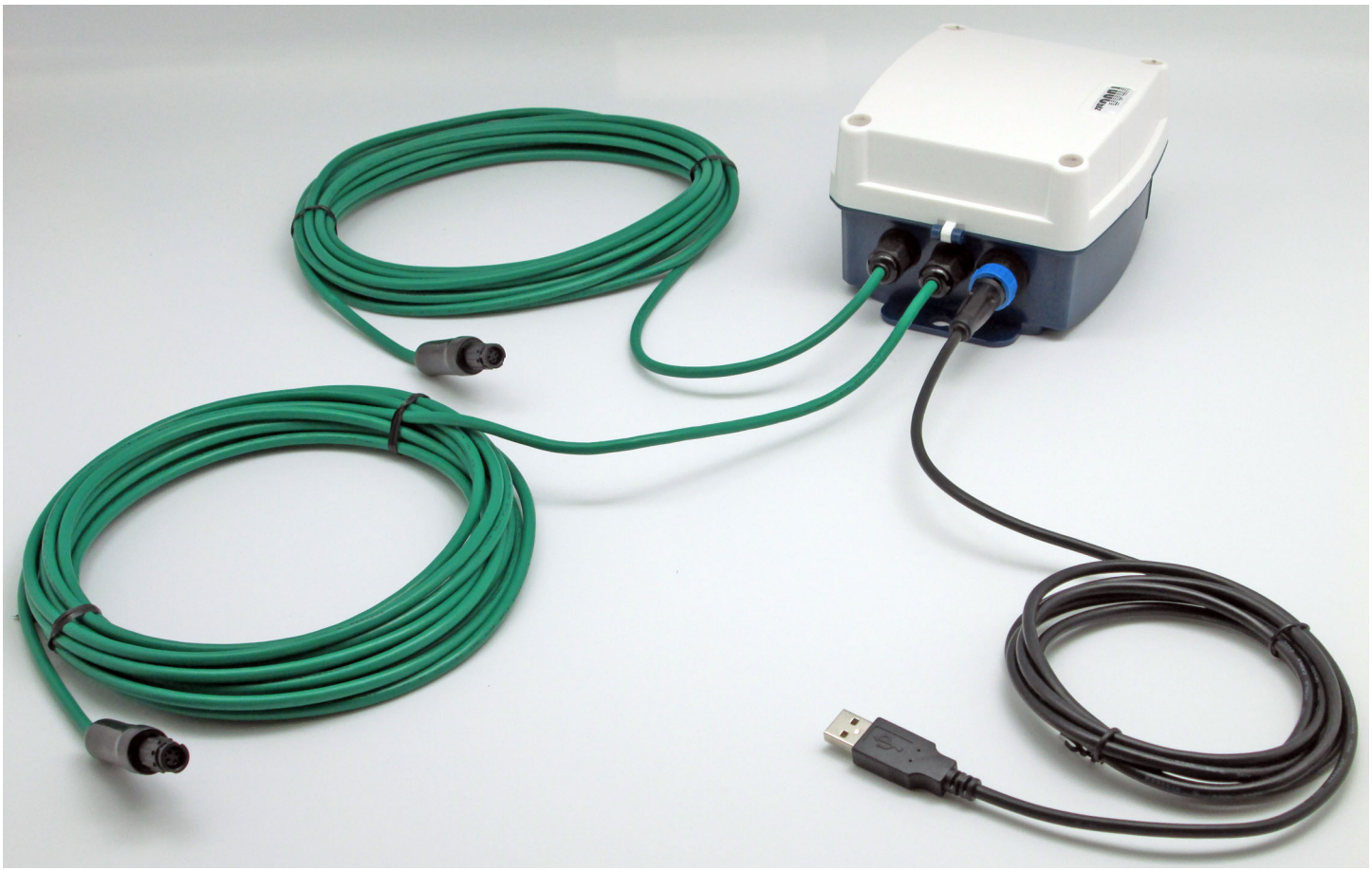
5) Unique ASTI pH, ORP and Conductivity sensor assemblies with waterproofing "B" seals are fully submersible without the use of a standpipe.

These fully submersible waterproof sensors allow for easy removal and installation of the pH sensors in even the deepest manhole installation locations by lowering and removing the sensor holding only the braid reinforced vinyl tubing (no immersion tube or guiderod is required) while ensuring that intrusion of corrosive agents, moisture and/or water on the back of the sensor cable did not cause erroneous reading or premature aging of the sensor. This yields very long service lifetime with quite low maintenance needs.

The fully submersible feature is achieved by means of the factory installed waterproofing "B" sealing including 20 feet (6 meters) of rugged braid reinforced thick vinyl tubing and 40 feet (12 meters) of cable complete. More remote locations can be supported by NEMA 6P fully waterproof snap to snap extension cables with a max of 3,280 feet (1,000 meters) between the sensor and mating ultralow power datalogger. Since the communications are RS-485 MODBUS RTU in nature there is not degradation of signal even with long cable runs or else in location with potential interference present.

The smart digital conductivity sensor shown above is the AST50 style smart digital conductivity sensor using a CPVC sensor body and insulator material of construction. Alternatively, the AST60 style smart digital conductivity sensor is also available with a KYNAR sensor body and TEFLON insulator material of construction. While 316SS electrodes come standard there are upgrade options available for titanium and Hastelloy C-276 materials of construction for the wetted electrodes in cases where the 316SS is not suitable. Similarly, while the EPDM material of construction for the elastomer is standard there are upgrade options available for Viton, AFLAS and Kalrez materials of construction in cases where the EPDM is not suitable. While the configuration shown above in the K=0.1/cm cell constant is suitable for more application using either the standard range (up to 2,000 µS/cm) or high range operation mode (up to 10,000 µS/cm) the AST50 and AST60 sensors are also available in cell constant configurations of K=0.2/cm, K=1.0/cm and K=2.0/cm. The recommended conductivity ranges in standard and high range mode scaling linearly with the cell constant meaning that the K=2.0/cm can go up to 40,000 µS/cm in standard mode and 200,000 µS/cm in high mode.

6) Special ultralow power datalogger records pH, ORP, conductivity and temperature readings for very long periods of time without replacing batteries for low maintenance installations. Logged data is downloaded locally via USB as well as being accessed remotely via integral 4G wireless connectivity of datalogger.



The ultralow power datalogger intermittent powers on the connected smart digital sensors and records the readings. Using a sampling frequency of once every 5 minutes to record the pH, conductivity and temperature values the integral 3 each SAFT-LSH20 3.6 V Primary lithium-thionyl chloride (Li-SOCl2) high power batteries the supported lifetime of such a configuration is over 1 year if the data is to be downloaded only locally via USB. If the data is to be transmitted wireless using the integral 4G wireless modem the service lifetime would need to be adjusted accordingly. Similarly increasing or decreasing the sampling frequency would modify the total service lifetime from the referenced one-year period of time.

The ML-N417DS datalogger from YDOC is modified by the ASTI factory such that it is supplied complete with pre-installed waterproof extension cables for up use with the mating submersible pH & conductivity sensors as well as a waterproof USB port which can be used to view and modify the configuration as well as downloading of logged data. The ultralow power datalogger is preconfigured to log pH, conductivity and temperature right out of the box with zero additional user configuration required. Custom sampling frequency can be accommodated without extra cost. Data integration to remotely access and view logged data is available at additional cost.

TYPICAL CONFIGURATION:

Model: **ML-N417DS-3LI-2EA-SCG-HiQ4F-6m-TL-HiQDT-pH-EC**
Short Description:
Battery-Powered Ultralow Power Datalogger for HiQDT MODBUS pH and Conductivity Sensor with Verizon Wireless Communications (Data Plan & Data Integration Not Included in Standard Package)
Long Description:
* Serial port to act as RS-485 MODBUS RTU master to HiQDT RS-485 MODBUS RTU sensor slaves
* Two (2) each HiQ4F-6m-TL 20 feet female snap to tinned lead waterproof extension cables installed into datalogger assembly with ¼"MNPT waterproof sealing cable glands.
* One (1) each waterproof USB port with mating extension cable for field configuration and/or download of logged data
* Datalogger is preconfigured to record pH, conductivity and temperature values from connected HiQDT pH and conductivity sensors. If desired computed units of salinity (PSU) and total dissolved solids (TDS) ppm can be recorded as well as the temperature compensated conductivity in microSiemens/cm (µS/cm)
* Integral 12VDC power supply energizes HiQDT sensors as defined in sampling frequency of datalogger configuration
* 4G modem North America and 3G fallback for use on the Verizon wireless network (data plan is separate)
* 3 Each Primary Li-SOCl2 cell 3.6V D-size lithium battery powered (SAFT-LSH 20) with safety electronics
* Estimated battery lifetime for 3 each SAFT LSH20 3.6V Lithium D cell batteries datalogging pH, conductivity & temperature values once every 5 minutes is at least one (1) year. Expected battery lifetimes can be computed upon request if data is to be transmitted wireless as well as for different sampling rates.

Addition information about this datalogger can be obtained by reviewing the webpage linked below:

https://www.ydoc.biz/low-power-2G-3G-4G-datalogger-ML-x17.html

Model: **PNXGRE 5331-HiQDT-12m-WPB/25**
Short Description:
Smart digital RS-485 MODBUS RTU pH sensor with extreme dehydration resistance junction for wet/dry operation; Fully Submersible to 25 feet with 40 feet of integral cable overall
Long Description:
* Smart Digital Extreme Dehydration Resistant Fully Submersible pH Sensor with 4 each thick protective tines
* Integral RS-485 MODBUS RTU communications with isolated RS-485 MODBUS RTU master
* ACCU-TEMP fast response Pt1000 TC option; Thick-wall break resistant parabolic pH glass option
* 12 meters (40 feet) cable complete with HiQ4M NEMA 6P rated quick disconnect snap connector
* Waterproofing "B" Fully Submersible to 25 feet depth with factory installed integral braid-reinforced vinyl tubing seal

Model: **AST50-0.1-HiQDT-12m-WPB/25**
Short Description:
1"-1" MNPT Industrial Smart Digital Inline/Immersion Contacting Conductivity Sensor with K=0.1/cm Cell Constant & Integral RS-485 MODBUS RTU Communications with 12 meters (40 feet) integral cable & waterproof HiQ4M Snap Connector full submersible to 25 feet
Long Description:
* AST50 1" MNPT Process Connection Suitable for Connection to 1" FNPT Conduit
* CPVC Material of Construction for sensor body & insulator, 316SS material of construction for electrodes
* Max 100 psig @ 95 degrees Celsius rating for inline installation, Max 85 degrees Celsius for fully submersible installation
* K=0.1/cm Cell Constant Contacting Cell with Integrated Pt1000 Temperature Compensation Element
* Integrated isolated smart digital HiQDT-CON-ISO sensor board programmed & calibrated for K=0.1/cm cell constant
* 12 meters (40 feet) cable complete with HiQ4M NEMA 6P rated quick disconnect snap connector
* Waterproofing "B" Fully Submersible to 25 feet depth with factory installed integral braid-reinforced vinyl tubing seal

Model: **HHC**
Short Description:
Handheld Communicator for HiQDT RS485 MODBUS RTU Smart Digital Sensors; Integral 9V Battery Energizes Sensors; 5 feet integral cable with HiQ4FP female snap connector

Last Revised February 5, 2021