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PREFACE

Electric discharge
The EXAxt analyser contains devices that can be damaged by electrostatic discharge. When servicing this equipment, please observe proper procedures to prevent such damage. Replacement components should be shipped in conductive packaging. Repair work should be done at grounded workstations using grounded soldering irons and wrist straps to avoid electrostatic discharge.

WARNING

Installation and wiring
The EXAxt analyser should only be used with equipment that meets the relevant IEC, American or Canadian standards. Yokogawa accepts no responsibility for the misuse of this unit.

CAUTION

The Instrument is packed carefully with shock absorbing materials, nevertheless, the instrument may be damaged or broken if subjected to strong shock, such as if the instrument is dropped. Handle with care.

Although the instrument has a weatherproof front construction, the transmitter can be harmed if the body becomes wet. Do not use an abrasive or organic solvent in cleaning the instrument.

Notice
Contents of this manual are subject to change without notice. Yokogawa is not responsible for damage to the instrument, poor performance of the instrument or losses resulting from such, if the problems are caused by:

- Incorrect operation by the user.
- Use of the instrument in incorrect applications.
- Use of the instrument in an inappropriate environment or incorrect utility program.
- Repair or modification of the related instrument by an engineer not authorised by Yokogawa.

Warranty and service
Yokogawa products and parts are guaranteed free from defects in workmanship and material under normal use and service for a period of (typically) 12 months from the date of shipment from the manufacturer. Individual sales organisations can deviate from the typical warranty period, and the conditions of sale relating to the original purchase order should be consulted. Damage caused by wear and tear, inadequate maintenance, corrosion, or by the effects of chemical processes are excluded from this warranty coverage.

In the event of warranty claim, the defective goods should be sent (freight paid) to the service department of the relevant sales organisation for repair or replacement (at Yokogawa discretion). The following information must be included in the letter accompanying the returned goods:
- Part number, model code and serial number
- Original purchase order and date
- Length of time in service and a description of the process
- Description of the fault, and the circumstances of failure
- Process/environmental conditions that may be related to the failure of the device.
- A statement whether warranty or non-warranty service is requested
- Complete shipping and billing instructions for return of material, plus the name and phone number of a contact person who can be reached for further information.

Returned goods that have been in contact with process fluids must be decontaminated/disinfected before shipment. Goods should carry a certificate to this effect, for the health and safety of our employees. Material safety data sheets should also be included for all components of the processes to which the equipment has been exposed.
1. INTRODUCTION AND GENERAL DESCRIPTION
The Yokogawa EXAxt PH150 is a 4-wire panel mounted converter designed for industrial process monitoring, measurement and control applications. This instruction manual contains the information needed to install, set up, operate and maintain the unit correctly. This manual also includes a basic troubleshooting guide to answer typical user questions.

Yokogawa can not be responsible for the performance of the EXAxt analyzer if these instructions are not followed.

1-1. Instrument check
Upon delivery, unpack the instrument carefully and inspect it to ensure that it was not damaged during shipment. If damage is found, retain the original packing materials (including the outer box) and then immediately notify the carrier and the relevant Yokogawa sales office.

Make sure the model number on the textplate affixed to the side of the instrument agrees with your order. Examples of the text plate is shown below.

![Figure 1-1. Textplate](image)

NOTE:
The textplate will also contain the serial number and any relevant certification marks. Be sure to apply correct power to the unit, as detailed on the Textplate.
1-2. Application
The EXAxt converter is intended to be used for continuous on-line measurement of pH &/or ORP in industrial installations. The unit combines simple operation and microprocessor-based performance with advanced self-diagnostics and enhanced communications capability to meet the most advanced requirements. The measurement can be used as part of an automated process control system. It can also be used to indicate operating limits of a process, to monitor product quality, or to function as a controller for a dosing/neutralisation system.

Yokogawa designed the EXAxt analyzer to withstand industrial environments. The controller may only be installed in a panel mounted configuration. The front panel forms an IP65 water tight seal against the flat face of the panel. Integral mounting clamps can be operated from the front of the panel. Sensors should normally be mounted close to the converter in order to ensure easy calibration and peak performance. If the unit must be mounted remotely from the sensors, WF10 extension cable can be used, up to a maximum of 50 meters (150 feet), with a BA10 junction box, and up 10 meters standard sensor cable.

The EXAxt is delivered with a general purpose default setting for programmable items (see Chapter 5). While this initial configuration allows easy start-up, the configuration should be adjusted to suit each particular application. An example of an adjustable item is the type of temperature sensor used. The EXAxt can be adjusted for a number of different types of temperature sensors.

Details provided in this instruction manual are sufficient to operate the EXAxt with all Yokogawa sensor systems and a wide range of third-party commercially available probes. For best results, read this manual in conjunction with the corresponding sensor instruction manual.

Yokogawa designed and built the EXAxt to meet the CE regulatory standards. The unit meets or exceeds stringent requirements (see section 2) without compromise, to assure the user of continued accurate performance in even the most demanding industrial installations.
2. General specifications of EXAxt PH150

A) Inputs specifications
   - One high impedance input (≥ 10^13 Ω). One low impedance input (≥ 10^8 Ω). One temperature input. One liquid earth input.

B) Input ranges
   - pH: -2 to 16 pH
   - ORP: -1500 to 1500 mV
   - rH: 0 to 55 rH
   - Temperature: Pt100, -30 to 140ºC
   - (5k1, -30 to 140ºC)
   - (6k8, -30 to 140ºC)
   - NTC10k, -20 to 140ºC
   - NTC 8k55, -10 to 120ºC
   - 3kBalco, -30 to 140ºC

C) Accuracy
   - pH input: ≤ 0.01 pH
   - ORP input: ≤ 1 mV
   - Temperature: ≤ 0.3 ºC (≤ 0.4 ºC for Pt100)
   - mA output circuits: ≤ 0.02 mA
   - Ambient temperature influence: ± 0.01% /ºC

D) Transmission Signals
   - General: Two isolated outputs of 4-20 mA, DC with common negative. Maximum load 600 Ω.
   - Control function: Linear or 21-step table for pH, temperature, ORP or rH. PID control. Burn up (21.0mA) or burn down (3.6mA) to signal failure.

E) Contact outputs
   - General: Two SPDT relay contacts with display indicators.
   - Switch capacity: Maximum values 100 VA, 250 VAC, 5 Amps. Maximum values 50 Watts, 250 VDC, 5 Amps.
   - Status: High/Low process alarms, selected from pH, ORP, rH and temperature. Configurable delay time and hysteresis.
   - Control function: On / Off
   - PID duty cycle or pulsed frequency control.
   - FAIL alarm

F) Temperature compensation

G) Calibration
   - Semi-automatic 1/2/3 point calibration using pre-configured NIST, US, DIN buffer tables 4, 7 & 9, or with user defined buffer tables, with automatic stability check. Manual adjustment to grab sample.

H) Serial Communication
   - Bi-directional HART digital communication, superimposed on mA1 (4-20) signal.

I) Logbook
   - Software record of important events and diagnostic data readily available in the display.

J) Display
   - Graphical Quarter VGA (320 x 240 pixels) LCD with LED backlight and touchscreen. Plain (English) language messages, with choice of alternative languages.

K) Shipping details
   - Package size w x h x d: 180 x 161 x 243 mm (7.1 x 6.3 x 9.6 inch)
   - Package weight: app. 1.1 kg (2.4lbs)

L) Housing
   - Enclosure: High quality chemical resistant plastic front 96x96 mm. SS housing behind the panel depth 98 mm behind the panel (121 mm including cover)
   - Mounting: Panel-mounted design in a standard DIN-size 92x92 mm cutout.

M) Power supply
   - 85-265 VAC (47-63 Hz) 10VA max
   - 9.6-30 VDC 10W max

N) Regulatory compliance
   - EMC: Meets directive 89/336/EEC Emission conform EN 55022 class A
   - Immunity conform IEC 61000-6-2
   - Low Voltage: Meets directive 73/23/EEC Conform IEC 61010-1, UL3111-1 and CSA 22.2 No. 1010.1, Installation category II, Pollution degree 2 Certification for cCSAs, Kema Keur and Geprüfte Sicherheit

O) Environment and operational conditions
   - Ambient temperature: -20 to +55 ºC
   - Storage temperature: -30 to +70 ºC
   - Humidity: Up to 90% RH at 40 ºC (non-condensing)

Environmental protection: IP65 (NEMA 4X) front panel, IP20 behind the panel
   - Data protection: EEPROM for configuration data and logbook. Lithium cell for clock.
   - Watchdog timer: Checks microprocessor.
   - Power down: Reset to measurement.
   - Automatic safeguard: Auto return to measuring mode when touchscreen is untouched for 10 min.

<table>
<thead>
<tr>
<th>Model Code</th>
<th>Suffix Code</th>
<th>Option Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH150</td>
<td>A</td>
<td>85 - 265 VAC power supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>9.6 - 30 VDC power supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>Second language - German</td>
<td></td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>Second language - French</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>Second language - Japanese</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L- AA</td>
<td>Second language - Spanish</td>
<td></td>
</tr>
<tr>
<td></td>
<td>/TAG</td>
<td>Always AA</td>
<td></td>
</tr>
</tbody>
</table>

Tagnumber
3. INSTALLATION AND WIRING

3-1. Installation site
The EXAxt converter should be installed as close as possible to the sensor to avoid long
cable runs between sensor and converter. In any case, the cable length should not exceed
60 meters (200 feet). Select an installation site where:

- Mechanical vibrations and shocks are negligible
- No relay/power switches are in the direct environment
- Access is possible rear of the unit for wiring
- The transmitter is not mounted in direct sunlight or severe weather conditions
- Maintenance procedures are possible (avoiding corrosive environments)

The ambient temperature and humidity of the installation environment must be within the
limits of the instrument specifications. (See chapter 2).

3-2. Mounting and dimensions
Refer to fig. 3-1 to 3-5. Note that the EXAxt has integrated mounting clamps:
The EXAxt uses an integral mounting clamp at each corner, driven by screws operated from
the front panel, fig. 3-1.
- Ensure that the clamp “fingers” are backed off a few millimeters more than the thickness
  of the panel, fig. 3-2.
- Insert the unit through the mounting hole (Square hole, 92 x 92 tol.+0.5/-0mm), fig. 3-3-1.
- Rotate the unit slightly anti-clockwise to allow the clamp fingers to pass through the panel.
- Rotate the unit clockwise slightly (back to square) and tighten the 4 screws to hold it in
  place, fig. 3-3-2 and fig. 3-3-3.
- Tighten the screws progressively to ensure that the panel seal seats evenly, fig. 3-3-4.
Fig. 3-4. Housing dimensions and layout

Fig. 3-5. Panel mounting cut-out
3-3. Preparation
The power/output connections and the sensor connections should be made in accordance with the scheme shown in Figure 3-6. The terminals are of a plug in style for ease of wiring.

3-4. Cables, terminals and safety cover
The EXAxt 150 is equipped with terminals suitable for the connection of finished cables in the size range: 0.13 to 2.5 mm² (26 to 14 AWG). Forked or pin crimps can be used to terminate the cables.

Safety Note:
When the wiring of the power/contact connections has been completed the clear safety cover should be clipped into place.

Figure 3-6. Rear view showing connection

⚠️ Caution - Risk of electric shock

⚠️ Caution - See section 3.7 and 3.8 for correct wiring
3-5. Wiring the power supply
Make sure the power supply is switched off. Also, make sure that the power supply is correct for the specifications of the EXAxt and that the supply agrees with the voltage specified on the textplate.
Local health and safety regulations may require an external circuit breaker to be installed. The instrument is protected internally by a fuse soldered to the printed circuit board. The fuse rating is dependent on the supply to the instrument.

Fuse ratings are:
For the DC version 1 A
For the AC version 125 mA
250 Volt, Time-lag T, IEC60127

3-6. Wiring the Relay Contacts
Connect the relay contacts having regard to the use to which the relays are put. The voltage and current being switched should determine the type of wire used. Because the relays may be used to switch higher voltages, there is a cover for the terminal block (and mains supply terminals) that should be clipped in place when the wiring is completed. This is to prevent electric shock to unwary personnel.

<table>
<thead>
<tr>
<th>Action</th>
<th>S1, S2</th>
<th>FAIL</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power OFF</td>
<td>NC</td>
<td>NC</td>
<td></td>
</tr>
<tr>
<td>Power ON</td>
<td>NC</td>
<td>NC</td>
<td></td>
</tr>
<tr>
<td>Alarm OFF</td>
<td>NC</td>
<td>NC</td>
<td></td>
</tr>
<tr>
<td>Power ON</td>
<td>NO</td>
<td>NO</td>
<td>■</td>
</tr>
<tr>
<td>Alarm ON</td>
<td>NO</td>
<td>NO</td>
<td>■</td>
</tr>
</tbody>
</table>

3-8. Normally open and normally closed
3-7. Wiring the Current Outputs

The current outputs should be connected using shielded twisted pair signal cable. The screen (shield) should be connected to ground (at one end only).

**Note:** The HART signal is super imposed on mA1. When using this signal, attention should be paid to the load resistance. In some cases a separate load resistor will be needed, across which the HART signal can be read. In this case a 250 Ω resistor should be used.

---

**Figure 3-9. Connection diagram**

- **Caution - Risk of electric shock**
- **Caution - See section 3.7 and 3.8 for correct wiring**
3-8. Wiring of sensors

Generally, signals from pH sensors are at low voltage and current level, with a very high source impedance. A lot of care must be taken to avoid interference. Before connecting sensor cables to the transmitter, make sure that following conditions are met:

- the sensor cables are not mounted in tracks together with high voltage and/or power switching cables
- only standard sensor cable or extension cable is used
- the transmitter is mounted within the distance of the sensor cables (max. 10 m) + up to 50m WF10 extension cable.
- the setup is kept flexible for easy maintenance and retraction of the sensors in the fitting.

Refer to figure 3.10, for sensor wiring drawings. Refer also to the relevant sensor instructions.

The EXAxt 150 can be used with a wide range of commercially available sensor types from Yokogawa and other manufacturers. The sensor systems from Yokogawa fall into two categories, the ones that use fixed cables and the ones with separate cables.

To connect sensors with fixed cables, simply match the terminal numbers in the instrument with the identification numbers on the cable ends.

PD20, PF20, PR20 and PS20 fittings and sensors are all in the category of fixed cables.

For separate Yokogawa sensors and the WU20-PC cables follow the scheme of figure 3.10. This also applies to sensors from other suppliers.

3-8-1. Using the EXAxt PH150 with sensor systems without solution ground.

The use of the solution ground enhances the measurement by removing noise and helping to avoid earth loops. It is possible to use the PH150 without a solution ground for simple electrode systems. An additional disadvantage is that this eliminates the reference impedance checking diagnostic.

The configuration below is used to eliminate the solution ground. Mind to disable reference impedance check in **Commissioning>> Error configuration>> Error 3/3**

Note: This is the simplest configuration. 13 & 14 are interconnected and form the reference input. The measuring input is still on 15. Other cables may provide additional screens: refer to the sensor instructions for connections.
3-8-2 PH20, FU20 & FU25 sensors for pH/ORP/rH

pH/ORP/rH measurement
When using a glass, reference and metal electrode or a 4 in 1 sensor like the PH20, FU20 and FU25, one can measure both pH and ORP at the same time. The Platinum electrode doubles as a liquid earth (solution ground) electrode. Configure the EXAxt PH150 for sensor type “pH & ORP” using
Commissioning >> Sensor setup>> pH+ORP

As this sensor combination enables simultaneous measurements, select the process values of interest:
Commissioning >> Measurement setup>> Main parameter>>

<table>
<thead>
<tr>
<th>pH Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORP Only</td>
</tr>
<tr>
<td>pH + ORP</td>
</tr>
<tr>
<td>pH + rH</td>
</tr>
<tr>
<td>rH Only</td>
</tr>
</tbody>
</table>

3-12. Sensor wiring diagrams (for pH/ORP/rH measurement)
4. OPERATION OF EXAxt PH150

4-1. Main display functions

Pressing the button changes the display into a graphical mode in which the average measured value is shown on a time scale. The “Live” value is also digitally displayed in a text box. The time scale (X-axis) and the primary value scale (Y-axis) are set in the “DISPLAY SETUP” menu. The full screen displays a trend of 51 points that represent the average of the selected time interval. The analyzer samples the measurement every second. The trending graphic also shows the maximum and minimum measured value in that interval.

For example, if the time scale is set to 4 hours, then the trend is shown for 4 hours prior to the actual measurement. Each point on the trend line represents the average over \(4\times60\times60/51 = 282\) measurements (seconds).

4-2. Trending graphics.

4-3. Zoom in on details

This button gives access to the diagnostic information of the analyzer. The following messages will appear under normal (default) conditions:

4-3-1. ZERO = calibrated sensor offset in mV. Theoretically, the sensor reads 0 mV in a buffer solution with the same pH value as the Isopotential pH value of the sensor (default 7.00 pH). The ZERO value indicates the condition of the sensor. If the value exceeds +/- 120 mV (or user defined limits) an error message is displayed after calibration and the calibration is rejected. The trend of ZERO drift during the lifetime of the sensor is used to predict the lifetime of the sensor. ZERO can also be displayed in pH units and then it represents the pH value where the sensor output is 0 mV at 25 °C. Go to: Commissioning >> Measurement >> Commissioning >> Measurement >> Calibration Settings >> Zero and Slope Units

4-3-2. SLOPE = calibrated efficiency of the sensor unit in percentage of theoretical slope of the sensor unit. The theoretical slope follows from the NERNST equation and is 59.16. The SLOPE can be calibrated only after a two-point calibration in buffer solutions with a different pH value. A low slope indicates that the sensor is not clean or it indicates a bad sensor. If the calibrated slope exceeds the range 70-110% (or user defined limits) then the calibration is rejected and an error message is shown.

The SLOPE can also be displayed as mV/pH value at 25 °C if the user has defined this variable as mV/pH in Commissioning >> Measurement >> Calibration Settings >> Zero and Slope Units
4-3-3. ITP = This is the pH value at which the sensor has the same mV output independent on the process temperature. This value is determined by the sensor manufacturer and it is 7.00 mV for most sensors based on electrolyte filled pH Glass. This value may change over time and it can be calibrated by 3-point calibration method in which the buffer solution that has a pH much different from the (expected) ITP value is measured at an elevated temperature as well. If the manufacturer specifies an ITP different from 7.00, the user can program this value in the menu: Commissioning >> measurement setup >> calibration settings >> zero/slope/ITP.

4-3-7. ACTUAL mA2 = the current output in mA of the second current output, which is defined as mA2. The range and function of this mA output can be set in Commissioning >> output setup >> mA2

4-3-8. Last calibrated = the date on which the last sensor calibration is done. The displayed value of the ZERO is the result of this calibration. The displayed value of Slope is not necessarily calibrated on this date: only if the last calibration was a 2-point calibration. It is unlikely that the displayed value of the ITP is the result of this calibration. A 3-point calibration is done rarely, since it must be done under well controlled lab. conditions.

4-3-9. Calibration due = the date when the calibration must be done according to the settings of the maintenance timer. This is based on scheduled maintenance procedures. The maintenance intervals are set in menu: setup >> Commissioning >> measurement setup >> calibration settings >> limits and timing

4-3-10. Projected calibration = the date when the predictive maintenance function expects that recalibration of the sensor unit is necessary for good measurement accuracy. The analyzer checks the reference impedance every hour. If a clean increase of reference impedance is observed, the user is notified when a next calibration should take place. Prior to calibration the sensor should be well cleaned and rinsed.

4-3-11. Projected replacement = the date when the predictive maintenance function expects that replacement of the sensor is necessary for good measurement accuracy. After each calibration the slope, zero and reference impedance are logged. Aging of the sensor can be detected from this data. If a negative trend is observed, the user is notified when the sensor should be replaced. Good predictions are only achieved with good calibration data. Prior to calibration the sensor should always be well cleaned and rinsed and the calibration procedures strictly observed.
4-3-12. **Device ID** = serial number of the analyzer

4-3-13. **Software revision** = the revision level of the software in the instrument

If you contact the local sales/service organization the ID and software revision information is necessary information. Without that information it is impossible to help you. It is also very useful to report all the information that you find on the zoom-in display.

4-3-14. **DD revision** = the HART device revision

4-4. **Information function**

In this field an information sign ![i], a warning sign ![w] or a fail sign ![f] can appear. Pushing this button, the user gets detailed information about the status of the sensor or the instrument if applicable. See troubleshooting (chapter 9) for further details.

4-5. **Secondary- Primary Value display switch**

Pressing on this text block automatically switches the secondary value to the main display (Large font size).

4-6. **Setup-Calibration & Commissioning**

By pressing the setup ![settings] key, you get access to the operating system of the analyzer based on menus and submenus. Browse through the list using the ![down] key till you find the required menu and press the ![down] key to enter this menu. It is also possible to press on the ![left] or ![right] symbol found beside the menu item.
4-7. Matrix Interpolation
Temperature compensation matrix.

1. A minimum number of values is required to make interpolation possible.
   The highlighted values markes as are mandatory to enter.

   \[
   \begin{array}{c|ccccc}
   \hline
   & T_{\text{ref}} & T_1 & T_2 & T_3 & T_4 & T_5 \\
   \hline
   \text{Sol1} & S_1T_r & S_1T_1 & & & & S_1T_5 \\
   \text{Sol2} & & & & & & \\
   \text{Sol3} & & & & & & \\
   \text{Sol4} & & & & & & \\
   \text{Sol5} & S_5T_r & S_5T_1 & & & & S_5T_5 \\
   \hline
   \end{array}
   \]

2. T_{\text{ref}} (reference temperature) is defined in the Temperature Compensation menu. If T_{\text{ref}} is between T_1 an T_5 then the value of T_{\text{ref}} needs to be entered as T_2 or T_3 or T_4.

3. For every S_xT_x that is entered the following values become mandatory to enter:
   S_{xT_r}, S_{xT_1}, S_{xT_5} and T_x.

   \[
   \begin{array}{c|ccccc}
   \hline
   & T_{\text{ref}} & T_1 & T_2 & T_3 & T_4 & T_5 \\
   \hline
   \text{Sol1} & S_1T_r & S_1T_1 & & & & S_1T_5 \\
   \text{Sol2} & & & & & & \\
   \text{Sol3} & S_xT_r & S_xT_1 & & S_xT_x & & S_xT_5 \\
   \text{Sol4} & & & & & & \\
   \text{Sol5} & S_5T_r & S_5T_1 & & & & S_5T_5 \\
   \hline
   \end{array}
   \]
5. MENU STRUCTURE COMMISSIONING

EXAxt PH150
Execute:
- Calibration
- HOLD
Setup:
- Commissioning
- Change language
- Service

Commissioning

Sensor setup
- Sensor type: pH

Measurement setup
- Measurement: pH & ORP
  - Temperature settings
  - Temp. compensation
  - Calibration settings
  - Impedance settings

Output setup
- mA1: Output
- mA2: Output
- S1: Alarm
- S2: Fail
  - Configure Hold

Errors 1/3
- pH too high: Warn
- pH too low: Warn
- Temperature too high: Warn
- Temperature too low: Warn

Configure logbook
- Sensor logbook
  - Setting logbook - mA
  - Setting logbook - contact
- Erase logbook: Calibration
- Erase? No

Advanced setup
- Defaults
- Tag
- Passwords
- Date / time
- Test QIC
- HART

Display setup
- Main display
  - Trend Graph Screen:
    - X-axis: Timing
    - Y-axis: Limits
  - Auto Return: 10 min
5-1. Sensor Setup
Sensor type
The sensor connection to the terminals is determining the setting of this parameter. Three selections can be made here.

pH: Only pH needs to be measured. The glass electrode is connected to terminal 15 and the reference is connected to terminal 13.

ORP: Only ORP needs to be measured. The metal is connected to terminal 15 and the reference is connected to terminal 13. Liquidearth is connected to terminal 14. If there is no LE terminal 13 and 14 are shortcutted and no sensor diagnostics possible.

pH+ORP: When pH and ORP should be measured simultaneously the glass electrode is connected to terminal 15 and the reference is connected to terminal 13. The metal electrode is connected to terminal 14. In this setup it is also possible to measure rH, where the glass electrode is used as a reference to the metal measuring electrode. For rH measurement the reference electrode is not necessary. When left out, terminal 13 and 14 are shortcutted.

Note: This setting determines the menu structure throughout the instrument

5-2. Temperature Setting
Temp. Element
Selection of the temperature sensor used for compensation. The default selection is the Pt1000 Ohm sensor, which gives excellent precision with the two wire connections used. The other options give the flexibility to use a very wide range of other sensors.

Unit
Celcius or Fahrenheit temperature scales can be selected to suit the user’s preference.

5-3. Temperature Compensation
Two types of methods can be used here. Automatic when a temperature element is used. Select one of the Temp. elements used. The other is a manual set temperature, which represent the temperature of the process. The latter is used when temperature measurement is difficult and temperatures do not vary much.

Reference Temperature
Choose a temperature to which the measured pH value must be compensated. Normally 25°C is used, therefore this temperature is chosen as default value.

Process Temperature Compensation
TC In addition to the procedure described in section 5-2-4 it is possible to adjust the compensation factor directly. If the compensation factor of the sample liquid is known from laboratory experiments or has been previously determined, it can be introduced here. Adjust the value between -0.1 to 0.1 pH/ºC. In combination with the reference temperature setting a linear compensation function is obtained, suitable for all kinds of chemical solutions.

Matrix The EXAxt is equipped with a matrix type algorithm for accurate temperature compensation in various applications. Select the range as close as possible to the actual temperature/pH range. The EXAxt will compensate by interpolation and extrapolation. Consequently, there is no need for a 100% coverage. See section 4-7 for matrix interpolation.

NEN6411 is standard NEN NORM and applicable for many applications. It’s used for pH compensation in water applications using a glass electrode. The calculation is valid for all strong acids and strong bases. The main application is in demiwater and boiler feed water/condensate.
These selections will influence a number of choices and defaults throughout the whole menu.

In the selection boxes defaults are shown with a black background.

Generally defaults are shown with their ranges and possible choices.
5-4. Calibration Settings

General
Calibration settings for a pH analyzer involve slope (sensitivity), zero (aspot) and ITP(isothermal point). The following figure shows the pH value to the mV output of the sensor. Characteristic for pH measurement is an offset also known as aspot [mV] or zero [pH] and a Slope [mV/pH]. For an ideal sensor the theoretical slope is 59.16 mV/pH at 25°C. Slope can be entered in mV/pH or as a percentage of the theoretical slope (100% corresponds to 59.16 mV/pH). ITP is where the output of the sensor does not change with temperature. Note that slope and zero are defined at 25°C.

![Calibration Parameters](fig_5-1.png)

**Units**

Zero (aspot) unit
Zero is an alternative to Asymmetry Potential. This method conforms to the DIN standard for instruments IEC 60146-2. Zero is defined in pH or mV.

Slope (sensitivity) unit
Slope can be defined in mV/pH or defined as percentage of theoretical slope at 25°C.

**Limits and timing**

Zero (aspot) High, Low
During calibration the new zero is checked for exceeding these low and high limits. Narrowing the band will prevent bad calibrations procedures and calibration of bad sensors, which results in higher accuracy. The default values should be adjusted to suit the application and the “users” criterion.

Slope (sensitivity) High, Low
During calibration the new slope is checked for exceeding these low and high limits. Narrowing the band will prevent bad calibrations procedures and calibration of bad sensors, which results in higher accuracy. The default values should be adjusted to suit the application and the “users” criterion.

**Stabilisation time**

During calibration, the value should be stable within 0.01 pH over this stabilisation time period. When the pH value is not stable within 10 minutes, calibration is aborted.

**calibration Interval**

The interval in which a new calibration must take place. If the interval is exceeded the instrument will give a warning or a fail (user definable in error configuration 2/3).

**Buffers**

Calibration is done using standard calibration buffers. Our preference goes to NIST buffers for highest accuracy, but the user is free to select US, DIN or define his own. The standard buffers can be found in Appendix A.

Zero (aspot)/Slope (sensitivity)/ITP values can be entered directly in this section. These data can be provided by the manufacturer of the probe, or by the users laboratory etc. They are determined independently of the measuring loop. Also see 4-3-1, 4-3-2 and 4-3-3.

**NOTE:** it is not necessary to enter this data in most cases as the EXAxt automatically does this while performing a calibration. The feature is used in the case of special electrode systems and where calibration in the process environment is not possible.

5-5. Impedance setting

Reference impedance High, Low
The EXAxt has an impedance check, capable of monitoring the impedance of all sorts of sensor systems. In order to “fine tune” this diagnostic tool it is necessary to set it up to match the sensors used.

The system is set to measure high impedances on input 15 (the one normally used for the pH glass sensor input) and low impedances on input 13 (the one normally used for the reference input).

In applications that have a tendency to leave deposits on the electrodes and to clog the reference sensor junction there is the possibility to use the impedance check (set error configuration) on the reference sensor to initiate an alarm when one of the limits is exceeded.
5-6. mA Output Setup

General
The general procedure is to define the function (control, output, Simulate, off) of the output and the process parameter connected to the output first. Available process parameters depend on selected sensor type and measurement setup.

mA1/mA2
Off : When an output is set off the output is not used and will give an output of 4 mA
Control : A selection of P- PI- or PID control
Direction: : Reverse
If the Process variable increases to the Setpoint (Process variable too high) the output of the controller is decreased (reverse action).
: Direct
If the Process variable increases to the Setpoint (Process variable too high) the output of the controller is increased (direct action).
Output : Linear or table output
Simulated : Percentage of output span:
normal span of outputs are limited from 3.8 to 20.5 mA

Burn set Low or High will give an output of 3.6 resp. 21 mA in case of Fail situation.

Fig 5-2. Direct/Reverse action
5-7. Contact Output Setup
S1/S2
Each Switch (contact) has 4 functions. When a Switch is set to off the Switch is not used.

Control: A selection of P- PI- or PID control
Alarm: Low or high value Limits monitoring
Hold: A hold contact is energised when the instrument is in HOLD
Fail: A Fail contact is energised when a fail situation occurs. Fail situations are configured in section 5-9. For SOFT Fails the contact and the display LED are pulsating. For HARD Fails the contact and the display LED are energized continuously.

**Hard Fail Only**
The contact reacts to Hard Fails Only
**Hard + Soft Fail**
The contact reacts to Hard and Soft Fails

Simulate: The contact can be switched on/off or a percentage of output can be simulated. This percentage is a analogue value and represents the on time per second.

5-8. Configure Hold
General
Hold is the procedure to set the outputs to a known state when going into commissioning. During commissioning HOLD is always enabled, outputs will have a fixed or last value. During calibration the same HOLD function applies. For calibration, it is up to the user if HOLD is enabled or not.

**Note!** When leaving Commissioning, Hold remains active until switched off manually. This is to avoid inappropriate actions while setting up the measurement
A Soft Fail enables the fail contact pulse.

A Soft Fail is shown on the display only.

Setpoint: 7.00 pH
Direction: Reverse
Pulse freq: 0.10 pH
Delay time: 0.0 s
Expiry time: 0.0 s

Hard Fail only

A Soft Fail enables the fail contact pulse.
A Soft Fail is shown on the display only.

Similarly structured to S1.
5-9. Error Configuration
Errors 1/3 ~ 3/3
Error message configuration. Two different types of failure mode can be set.

Hard fail gives a steady FAIL flag in the display, and a continuous contact closure. All the other contacts (controls) are inhibited and a Fail signal is transmitted on the outputs when enabled.

Soft fail gives a flashing FAIL flag in the display, and the relay contact is pulsed. The other contact (controls) is still functional, and the controller continues to work normally. A good example is a control time-out for a soft fail. A warning that the regular maintenance is due, should not be used to shut down the whole measurement.

5-10. Logbook Configuration
General
Logbook is available to keep an electronic record of events such as error messages, calibrations and programmed data changes. By reference to this log, users can for instance easily determine maintenance or replacement schedules.

In configure Logbook the user can select each item he is interested in to be logged when the event occurs. This can be done for three separate logbooks. Each logbook can be erased individually.
5-11. Advanced setup

Defaults
The functionality of the EXAxt allows to save and load defaults to come to a known instrument setting. The EXAxt has both factory and user defined defaults. After a “load default” the instrument will reset.
The following parameters are not included in a reset:

1. X-axis timing
2. Auto return (10 min / disabled)
3. Tag
4. passwords
5. date and time
6. language
7. the contents of all logbooks
8. HART parameters (address, tag, descriptor, message)

Tag
A tag provides a symbolic reference to the instrument and is defined to be unique throughout the control system at one plant site.

Passwords
Calibration and Commissioning may be separately protected by a password. Default both passwords are empty. Entering an empty password results in disabling the password check. A password can contain up to 8 characters.

Date/time
The Logbooks and trend graph use the clock/calendar as reference. The current date and time is set here. The current time is displayed in the “zoom” menu.

Note! The fixed format is YYYY/MM/DD HH:MM:SS

Test QIC
This menu enables the customer to execute the Quality Inspection test as described in the QIS (attached in this IM).

HART
The address of the EXAxt in a HART network can be set. Valid addresses are 0...15.
After the defaults are loaded, the instrument will reset.
5-12. Display Setup

Main Display
The main display consists of three lines with Process Values. Each line is user definable with the restriction that each line should have a different Process Value. The default settings can be defined here. By pressing one of the two smaller process values, this will become the main process value in the main screen. Autoreturn will cause the main display to go to default setting.

See also 4.5 Secondary to Primary Value display Switch.

Note! Configuration possibilities in the main and secondary display lines are determined by the choices made in the menu items 8 Measurement setup >> Main parameter and >> Measurement setup >> Configure sensor

Additional text
Each process value can be given an additional text containing up to 12 characters per text. This text is displayed on the main display next to the process value. This way the user can distinguish separate measurements.

X-axis Timing
The time range of the trend graph can be set from 15 minutes up to 1 day.

Y-axis Limits
The ranges for each measurement need to be set according the application.

Auto Return
When Auto return is enabled, the converter reverts to the measuring mode (main display) from anywhere in the configuration menus, when no button is pressed during the set time interval of 10 minutes.
Time Span (x) = 1 hour
6. QUICK SETUP FOR THE EXAxt PH150

A) Check power supply voltage on the instrument side label
   DC 9.6 - 30 Volts
   AC 85 - 265

B) Make appropriate connections to power supply, but do NOT switch on.

C) Connect the sensor in accordance with its instructions, and the wiring diagram found in section 3, in this manual.

D) The unit can now be powered and the measuring function tested if so desired, or the connections for current output and relay contacts can be made, and the commissioning completed as a single task.

E) The temperature sensor is set as a PT1000 by default. If the sensor has another temperature compensator, select this by pressing on the “Setup” button and following

Commissioning >> Measurement setup >> Temperature setting >>

In this screen you will see

Temperature element Pt1000
Unit °C

Touch the PT1000 box or the key when PT1000 is selected, and a drop down menu will appear.

Pt1000
Pt100
5k1
3kBalco
8k65
350
NTC10k
6k8

The correct temperature sensor can now be selected by simply touching it, or using the scroll and enter keys.

F) mA 1 default is a linear 4-20 mA output, ranged -2 to 16 pH
mA 2 default is a linear 4-20 mA output, ranged 0-100°C
To change current output settings follow the routing Commissioning >> Output setup >> mA 1 (& mA 2 if needed).

G) S1 default is a High alarm with setpoint 16 pH
S2 default is Fail alarm as a fault signal
To change contact output settings follow the routing Commissioning >> Output setup >> S 1 (& S 2 if needed).

The display/configuration interface is designed to be simple and intuitive to use, however, full instructions are to be found in sections 4 & 5 of this manual.
7. Calibration

7-1. Calibration check with buffer solutions.
The following tips will help to produce a good calibration.

1. Before starting a calibration, make sure the electrode system is properly cleaned so that the electrodes are fully functional. They must then be rinsed with clean water to avoid contamination of the calibration solution.
2. Always use fresh buffer solutions to avoid the possibility of introducing errors from contaminated or old solutions. Buffers supplied as liquids have a limited shelf life, especially alkaline buffers, which absorb CO₂ from the air.
3. Yokogawa strongly recommends NIST (primary) buffer standards in order to ensure the best accuracy and best buffer capacity is available. Commercially adjusted buffers (e.g. 7.00, 9.00 or 10.00pH) are a compromise as a standard, and are often supplied without the temperature dependency curve. Their stability will never be as good as NIST solutions.

NOTE: NIST (formerly NBS) buffers are available as consumable items from any Yokogawa sales office under the following part numbers:

6C232 4.01 pH at 25°C
6C237 6.87 pH at 25°C
6C236 9.18 pH at 25°C

Each packet makes 200 ml of solution when dissolved in good quality distilled water.

Always ensure that the sensors are properly conditioned, clean and filled with the correct electrolyte solution (if appropriate) before starting a calibration. Refer to section 8 (Maintenance), and to the sensor instructions for details.

7-2. Manual calibration mode

The unit is adjusted to agree with the value of a known solution. This may be a buffer solution or a known process sample. The user determines the pH value, the temperature influence and the stability.

1- A single point can be set to adjust only the zero (asymmetry).
2- A second point can be set to determine the slope (sensitivity).
3- A third point can be set to determine the ITP (iso-thermal point).

See section ITP calibration Section 4-3-3 and 4-3-8

WARNING
3-point calibrations require laboratory conditions.
For normal measurement a zero/slope calibration is the best choice.

7-3. Automatic calibration mode

The PH150 will provide prompts to aid the user to make a good calibration. High quality buffer solutions must be used for best results. The user selects the buffer type that he is using in the calibration menu. The buffer set is selected in Commissioning>> Measurement>> Calibration setting>> Buffers
See also Appendix 1.

The PH150 uses internal buffer tables and the sensor temperature input to determine the exact calibration values. The EXAxt also determines the stability (drift), and the calibration will be rejected unless it is within limits. The PH150 records the values internally, and uses them to calculate the final calibration.

1- A single point can be set to adjust only the zero (asymmetry).
2- A second point can be set to determine the slope (sensitivity).
3- A third point can be set to determine the ITP (iso-thermal point).

See section ITP calibration Section 4-3-3 and 4-3-8
7-4. Sample calibration mode

This mode is used first to record an instantaneous value for a grab sample. The sample value is held in memory, and normal measurement and control can continue, while the sample is analyzed. Following the analysis re-enter the "Sample" calibration mode. The original value (from memory) is displayed. The recorded reading is simply adjusted to agree with the analyzed value. The sample mode eliminates the calculation usually needed for this kind of calibration. Only a single (zero) point calibration is possible in the sample mode.

7-5. Temperature Calibration

In order to make the most measurements, it is important to have a precise temperature measurement. This affects the display of temperature, and the output signal when used. More important, however, is the temperature compensation, and calibration accuracy.

The temperature of the sensor system should be measured independently with a high precision thermometer. The display should then adjusted to agree with the reading (zero offset calibration only). For best accuracy this should be done as near to the normal operating temperature as possible.

ORP & rH Calibration Modes

7-6. ORP & rH Calibration

The calibration modes for ORP or rH are the "Manual" and the "Sample" modes. "Manual" calibration can be used for either single or 2 two point calibrations. "Sample" calibration is only a single point as it is with in pH measurement. Temperature calibration is the same in all modes, where a temperature sensor is used.

Note: The non-availability of well defined buffer solutions for ORP and rH eliminates the automatic calibration option.

7-7. Operation of Hold Function During Calibration

EXAxt PH150 has a HOLD function that will suspend the operation of the control/alarm relays and mA outputs.

During calibration, the user may choose to enable HOLD so that the output signals are constant. Some users will choose to leave the outputs "live" to record the calibration event. This has implications for pharmaceutical manufacture, for example, where an independent record of calibrations is mandatory.

The route for HOLD setup is Commissioning >> Output setup >> Configure Hold

7-8. ITP Calibration.

EXAxt PH150 can be calibrated to accept different ITP (iso-thermal point) values. The ITP of Yokogawa sensors is pH 7. Other sensors can have other values, and indeed, this value can change somewhat as the sensor ages. To take account of the differences, an ITP calibration is provided.

![Fig 8-1.](image-url)
It works as follows:-
A standard 2-point calibration is performed to determine zero and slope. The two points obtained determine line (1) in Fig 8.1.
A third point is then calibrated with the buffer furthest from the ITP at high temperature. This is combined with the known relationship of slope with temperature to give line (2) in Fig 8.1. 
Sufficient information is now known for the EXAxt to calculate the precise ITP, which is at the intersection of lines (1) & (2) in Fig 8.1.

Notes: ITP calibration is only appropriate when exceptional accuracy is needed from the measurement, or where the sensor has an ITP deviating from the nominal 7 pH. In most cases it is sufficient to use a nominal setting. The value for sensors supplied by Yokogawa is pH 7 unless otherwise specified.
8. MAINTENANCE

8-1. Periodic Maintenance

Display
The front of the unit is sealed to IP65 (NEMA 4X). In normal operation EXAxt will be sealed to the flat panel front, with a built in gasket. Behind the panel, the unit has an IP20 rating.

The converter requires very little periodic maintenance, except to make sure the front window is kept clean in order to permit a clear view of the display and allow proper operation of the touchscreen. If the window becomes soiled, clean it using a soft damp cloth or soft tissue. To deal with more stubborn stains, a neutral detergent may be used.

NOTES:
Never use harsh chemicals or solvents. In the event that the window does become heavily stained or scratched, refer to the parts list (Chapter 10) for replacement part numbers.

The nature of the EXAxt PH150 is that the panel environment should protect the back of the instrument. Exposure of this part of the unit to moisture may result in problems. This is especially true because of the high impedance sensors that the pH measurement uses. This should be borne in mind when working behind the panel.

Battery
The EXAxt analyzer contains a logbook feature that uses a clock to provide the timings. The instrument contains a lithium cell (battery) to support the clock function when the power is switched off. The cell has an expected working life of 10 years. Should this cell need to be replaced, contact your nearest Yokogawa service center for spare parts and instructions.

Fuse
There is a circuit board mounted fuse protecting the instrument. If you suspect that this needs to be replaced, contact your nearest Yokogawa service center for spare parts and instructions.

8-2. Periodic Maintenance of the Sensor

NOTE:
Maintenance advice listed here is intentionally general in nature. Sensor maintenance is highly application specific.

To perform correctly, pH sensors should be clean. This may be an obvious statement, but it has some implications for routine maintenance. The user should consider the reason behind a drift seen in a pH sensor system, rather than to blindly recalibrate frequently, and hope to thus minimize the errors. Most drift in pH systems can be traced to fouling or deposits of some sort building up on the sensor. It is often the case that a simple frequent cleaning regime can replace a (too) frequent calibration with the associated saving in labor and costly calibration solutions.

Neutralization processes where lime or soda is used to raise the pH are well known for causing coatings and blocking reference junctions with the insoluble hydroxides that are precipitated. In such an application, daily washing of the sensors in a dilute acid will yield a far better performance than a daily buffer calibration. It will also take a fraction of the time.

Each application should be judged on it's own merits, some will have greasy deposits that will need a soapy solution to clean, some may even require organic solvents to remove resinous deposits. In any case, avoid harsh chemicals like concentrated acids and abrasive cleaners as these will destroy the conditioning of the sensors, and will require a re-hydration period before full function is restored. After cleaning the sensors, and prior to a calibration, always rinse thoroughly in distilled water to ensure that there is no residue of the cleaning medium to contaminate your calibration solution.

NOTES:
Some applications will poison simple sensors with non-reversible chemical changes. These systems do not improve with cleaning. If you suspect that your system is one of these, contact your local Yokogawa sales office or representative for advice. An alternative sensor type will improve the performance.
Where a refillable (flowing electrolyte) reference system is employed, make sure that the reservoir is kept topped up. The rate of electrolyte consumption will again be process dependent, so experience will show how often you must refill. Pressurized systems need to be regularly checked to ensure that the pressure is adequate.

Periodic re-calibration of the sensor system is necessary to ensure best accuracy. This takes into account the aging of the sensors, and the non-recoverable changes that take place. These processes are slow, however. If frequent re-calibration is needed, it is usually because the cleaning technique is not effective, the calibration is not well executed or the pH readings are temperature dependent. Monthly calibrations should be sufficient for most applications.

If a film remains on the pH sensor after cleaning, or if the reference junction is partly plugged, measuring errors can be interpreted as a need for re-calibration. Because these changes are reversible with correct cleaning, or adjustment of the electrolyte flow through the junction, make sure that these items are correct before recalibrating the system.
9. TROUBLESHOOTING

9-1. General
The EXAxt is a microprocessor-based analyzer that performs continuous self-diagnostics to verify that it is working correctly. Error messages resulting from faults in the micro-processor systems itself are monitored. Incorrect programming by the user will also result in an error, explained in a message, so that the fault can be corrected according to the limits set in the operating structure. The EXAxt also checks the sensor system to establish whether it is still functioning properly.

In the main display screen is a "Status Information" button that will show

- **For information**
- **For warning** - a potential problem is diagnosed, and the system should be checked.
- **For FAIL**, when the diagnostics have confirmed a problem, and the system must be checked. This button gives access to a status report page, where "The most applicable error" will be displayed. ("No errors" is displayed during proper operation)

- **Explanation**: Description or error message and possible remedies
- **Advanced troubleshooting**: Error code screen that is used in conjunction with the service manual. This data will also be needed in the event that you request assistance from a Yokogawa service department.

What follows is a brief outline of the EXAxt troubleshooting procedures including possible causes and remedies.

9-2. Calibration check
The EXAxt PH150 converter incorporates a diagnostic check of the adjusted slope or zero value during calibration. If the adjusted value stays within 80-120% of the factory value, it is accepted, otherwise, the unit generates an error message, and the calibration is rejected.

9-3. Predictive Maintenance
EXAxt has a unique prediction feature. Calibration, and reference impedance data are stored in software data logbooks. This data is then used to calculate a prediction for maintenance purposes.
See section 4-3-10

9-4. Poor calibration technique
When the calibration data is not consistent this fact is used as a diagnostic tool. The significance of this error message is to require the user to improve his calibration technique. Typical causes for this error are attempting to calibrate dirty sensors, calibration solution contamination and poor operator technique.

9-5. Error displays and actions
All errors are shown in the "Main Display" screen, however, the EXAxt makes a distinction between diagnostic findings. The error messages may be set to OFF, WARN or FAIL. For process conditions where a particular diagnostic may not be appropriate, the setting OFF is used. FAIL gives a display indication only of that the system has a problem and inhibits the relay control action, and can be set to trigger the "Burn" function. "Burn-up or Burn-down" drives the mA output signal to 21 mA or 3.6 mA respectively.
10. SPARE PARTS

Table 10.1 Itemized parts list

<table>
<thead>
<tr>
<th>Item no</th>
<th>Description</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Front cover kit. xx150 (cover, hinge(s) &amp; label)</td>
<td>K1547SA</td>
</tr>
<tr>
<td>2</td>
<td>Terminal kit xx150 (power, input, output &amp; relay contacts)</td>
<td>K1547SB</td>
</tr>
<tr>
<td>3</td>
<td>Terminal protect. cover. xx150</td>
<td>K1547SC</td>
</tr>
<tr>
<td>4</td>
<td>Panel fixing set (screws, clamps &amp; washers, 4 each per set)</td>
<td>K1547SD</td>
</tr>
<tr>
<td>5</td>
<td>Panel seal</td>
<td>K1547SE</td>
</tr>
</tbody>
</table>

Fig. 10-1. Exploded view
NEN Temperature compensation Matrix

1.1.1 Water compensation

Using the NEN6411 norm temperature compensation can be calculated and is applicable for many applications. It’s used for pH compensation in water applications using a glass-electrode. The calculation is valid for all strong acids and strong bases. The main application is in de-mineralized water and boiler feed water/condensate.

The uncompensated pH value is:

\[ \text{pH}_{\text{uncomp}} = -\log \left( c \left[ H_3O^+ \right] \right) \Rightarrow \frac{c}{[H_3O^+]} = 10^{-\text{pH}_{\text{uncomp}}} \]

where:

\[ c \left[ H_3O^+ \right] \cdot c \left[ OH^- \right] = K_w \Rightarrow \frac{c}{[OH^-]} = \frac{K_w}{c \left[ H_3O^+ \right]} \]

The following relation can be derived (at reference-temperature):

\[ \left( c \left[ H_3O^+ \right] - d \right) \cdot \left( c \left[ OH^- \right] - d \right) = K_{w_{\text{@ref-temp}}} \]

where:

\[ K_{w_{\text{@temp}}} = 10^{-A} \quad A = \frac{4471.33}{t + 273.15} + 0.017053 \cdot (t + 273.15) - 6.0846 \]

Where: t, ref-temp = temperature expressed in: °C

The compensated pH value is:

\[ \text{pH}_{\text{ref}} = -\log \left( 10^{-\text{pH}} - d \right) \]

**formula: 3.1.1.1**

where d: = concentration change

for d, the next equation can be solved:

\[ d = \frac{\left( 10^{-\text{pH}} + \frac{K_{w_{\text{@temp}}}}{10^{-\text{pH}}} \right) - \left( \frac{K_{w_{\text{@temp}}}}{10^{-\text{pH}}} \right)^2 - 4 \cdot \left( K_{w_{\text{@temp}}} - K_{w_{\text{@ref-temp}}} \right)}{2} \]

**formula: 3.1.2.2**

Where:

\[ K_{w_{\text{@temp}}} = f(Temps) \]
\[ K_{w_{\text{@ref-temp}}} = f(RefTemps) \]
NEN 6411 pH Temperature Relationship for Strong Acids and Bases

\[
\begin{array}{c}
\text{pH at Reference Temperature} \\
\text{pH at Process Temperature}
\end{array}
\]
## Appendix 1

### Buffer Tables

#### NIST

<table>
<thead>
<tr>
<th>°C</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
<th>55</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>95</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.68pH</td>
<td>1.668</td>
<td>1.670</td>
<td>1.672</td>
<td>1.675</td>
<td>1.679</td>
<td>1.683</td>
<td>1.688</td>
<td>1.691</td>
<td>1.694</td>
<td>1.700</td>
<td>1.707</td>
<td>1.715</td>
<td>1.723</td>
<td>1.743</td>
<td>1.766</td>
<td>1.792</td>
<td>1.806</td>
</tr>
</tbody>
</table>

#### DIN 19267 (German buffers) so called: technical buffer solutions

<table>
<thead>
<tr>
<th>°C</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
</tr>
</thead>
</table>

#### US technical buffers

<table>
<thead>
<tr>
<th>°C</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
<th>55</th>
<th>60</th>
</tr>
</thead>
</table>

#### FREE PROGRAMMABLE (Default Settings based on rounded NIST values).

| °C | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 |
|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|

The freely programmable table is populated with a basic set of data to provide a start for the user configuration. This table is intended for the user to be able to choose his buffer solutions to suit his own preference. The data concerning the pH temperature characteristic will need to be obtained from the supplier of the buffers.

Note: Yokogawa recommend the use of NIST (primary buffer standards) rather than buffers which have been adjusted by the addition of acid or alkaline materials to the buffer composition. In this was the customer gets a recognized standard, as well as the best buffer capacity (the ability to resist pH change with contamination).

Packs of NIST buffer powders are available from all Yokogawa sales offices and representatives. Each pack contains 5 sachets of powder, each sufficient to make 200 ml of solution when dissolved in good quality distilled water. The part numbers to order are as follows:

- Pack of 5 sachets buffer powder 4.01 pH at 25°C  Part No. 6C232
- Pack of 5 sachets buffer powder 6.87 pH at 25°C  Part No. 6C237
- Pack of 5 sachets buffer powder 9.18 pH at 25°C  Part No. 6C236
Introduction

The test equipment needed is:

**BOX 1**: Resistor decade to simulate the temperature sensor, maximum value 100 kΩ, adjustable in steps of 0.1 Ω, minimum accuracy 0.1 %.

**mV source**: To simulate the pH and ORP voltage, adjustable between –1500 mV up to +1500 mV in steps of 1 mV, minimum accuracy 0.1 %.

**2 fixed resistors**: To simulate the load resistance of the mA-output value: 300 Ω, accuracy 1 %.

**Multimeter**: To measure DC currents up to 30 mA, minimum resolution 0.01 mA, (preferably 2) minimum accuracy 0.05 % of reading.

**Sensor cable**: PC10 – LH2

Connect the PH150 as shown in the figure below. The decade box (BOX 1) to terminals 11 & 12 to simulate the temperature input. Set decade box 1 to simulate 25 °C, see tables below for the value for the selected sensor.

If this box has an earth connection, connect this to terminal 12.

Connect the mV source to the input terminals, + (positive) to 15 with screen to 16, - (negative) to 13 with screen to 17, link terminal 14 to the negative terminal of the mV source.

The output terminals are connected through the 300 Ω load resistor to the mA meter.

(Note: current outputs may be measured in turn with the same meter, or simultaneously if two meters and load resistors are available).
1. Introduction

Final testing begins with a visual inspection of the unit to ensure that all the relevant parts are present and correctly fitted. After switching on the power to the unit, 5 minutes should be allowed for warm-up, and to stabilise the instrument completely before taking measurements.

The Device ID. and Software revision are shown on the display after pressing the Zoom button \(\text{Zoom} \) and two times the Enter button \(\text{Enter} \).

2. Safety tests

During the production test procedures, the insulation is tested between terminal 3, the supply earth, and power terminals 1 and 2. The test used applies the following criteria:

- **AC instruments** - 2.1 kV DC, <1 mA, for >1 min.
- **DC instruments** - 0.7 kV DC, <1 mA, for >1 min.

The outputs are also tested for isolation from earth \(\geq 9.5 \, \Omega\).

3. Functional tests

During the production test procedures, the following tests are executed as functional test:

- Visual check during startup
- Check for the correct language
- Voltage and current check
- Contact relay operation check
- Input contact operation check

The checkbox ‘Functional test’ on the QIC form is used for the result of these checks.

The Contact Relay operation check can also be executed separately:

- Press Setup button \(\text{Setup} \)
- Go to **Commissioning**
- Go to **Advanced setup**
- Go to **Test QIC**
- Set Key to ‘Factory Mode’
- In the ‘Test QIC’ menu, set **Contacts** to ‘Check’
- In the next menu the simulated value to S1 and S2 (at the same time) is set to On or Off, by setting **Command** to ‘Next value’.
- Press Back button \(\text{Back} \) to return to the ‘Test QIC’ menu.
- Set Quit test to ‘Yes’
- Press Home button \(\text{Home} \) to return to normal operation.

**Note:** if you do not set Quit test to ‘Yes’, and return by only pressing the Home button, or even by the Auto Return timer, the Normal operation will not operate properly!

Communication test HART

During the production test procedures, the communication via the HART protocol is tested using specialized equipment.

Date / time test

During the production test procedures, the clock is set and a check is performed to verify that it is running.

The actual date and time of the instrument is shown on the display after pressing the Zoom button \(\text{Zoom} \) once.
4. **Accuracy Test – pH / ORP Input**
This test can be executed, independent from the current settings of the instrument.
- Press Setup button
- Go to Commissioning
- Go to Advanced setup
- Go to Test QIC
- Set Key to ‘Factory Mode’
- Set mV Input to ‘Check’

Connect mV-source between #15(+) and #13,14(-), according to the table below and read the mV value on the LCD.

<table>
<thead>
<tr>
<th>Input [mV]</th>
<th>-1500</th>
<th>-750</th>
<th>-250</th>
<th>-100</th>
<th>0</th>
<th>+100</th>
<th>+250</th>
<th>+750</th>
<th>+1500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>-1500</td>
<td>-750</td>
<td>-250</td>
<td>-100</td>
<td>0</td>
<td>+100</td>
<td>+250</td>
<td>+750</td>
<td>+1500</td>
</tr>
<tr>
<td>(± 1 mV)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Press Back button to return to the ‘Test QIC’ menu.

During production test procedures also the pH and Reference input accuracy are tested, as well as the pH accuracy with a 1000 MΩ shielded resistor to simulate Glass Impedance.

5. **Accuracy Test – Temperature Input**
In the ‘Test QIC’ menu, set Temperature to the temperature element of which you want to test the accuracy.
Next vary the settings on BOX 1 as listed below and check the readings on the display.

<table>
<thead>
<tr>
<th>Temp [ºC]</th>
<th>-10ºC</th>
<th>25ºC</th>
<th>75ºC</th>
<th>120ºC</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt1000</td>
<td>960.9</td>
<td>1097.4</td>
<td>1290.0</td>
<td>1460.6</td>
<td>± 0.3 ºC</td>
</tr>
<tr>
<td>Pt100</td>
<td>96.1</td>
<td>109.7</td>
<td>129.0</td>
<td>146.1</td>
<td>± 0.4</td>
</tr>
<tr>
<td>5k1</td>
<td>4457.4</td>
<td>5100.0</td>
<td>6018.0</td>
<td>6884.2</td>
<td>± 0.3</td>
</tr>
<tr>
<td>3kBalco</td>
<td>2538.0</td>
<td>3000.0</td>
<td>3660.0</td>
<td>4254.0</td>
<td>± 0.3</td>
</tr>
<tr>
<td>8k55</td>
<td>47000.0</td>
<td>8550.0</td>
<td>1263.0</td>
<td>343.0</td>
<td>± 0.3</td>
</tr>
<tr>
<td>350</td>
<td>309.0</td>
<td>350.0</td>
<td>408.6</td>
<td>461.4</td>
<td>± 0.3</td>
</tr>
<tr>
<td>NTC10k</td>
<td>55298.0</td>
<td>10000.0</td>
<td>1480.1</td>
<td>388.6</td>
<td>± 0.3</td>
</tr>
<tr>
<td>6k8</td>
<td>5943.2</td>
<td>6800.0</td>
<td>8024.0</td>
<td>9125.6</td>
<td>± 0.3</td>
</tr>
</tbody>
</table>

Press Back button to return to the ‘Test QIC’ menu.

6. **Impedance check**
During production test procedures Glass and ORP(metal) Impedance checks are performed.
Also the accuracy of the Reference Impedance is tested.

7. **Accuracy & Linearity Check mA output circuits**
In the ‘Test QIC’ menu, set mA output to ‘Check’.
In the next menu the simulated mA values to mA1 and mA2 (at the same time) can be selected, by setting Command to ‘Next value’.
During production test procedures the also the ripple at 12.0 mA is tested and the mA-value at 22.0 mA, with a 600 \( \Omega \) resistor instead of the normal 300 \( \Omega \).

- Press Back button \( \Rightarrow \) to return to the ‘Test QIC’ menu.
- Set Quit test to ‘Yes’
- Press Home button \( \Rightarrow \) to return to normal operation.

**Note:**
If you do not set Quit test to ‘Yes’, and return by only pressing the Home button, or even by the Auto Return timer, the Normal operation will not operate properly!

### 8. Overall Accuracy Test

The overall accuracy test is executed in normal operation mode, but it requires a number of settings to be modified. It is recommended that the current instrument settings are recorded before this overall accuracy test is executed.

The required settings are (see IM how to change):
- **sensor type** = pH
- **temp. element** = Pt1000
- **temp. comp.** = None
- **mA1:**
  - process parameter = pH
  - output – linear
  - 0% value = 0 pH
  - 100% value = 14 pH
- **mA2:**
  - process parameter = temperature
  - output – linear
  - 0% value = 0°C
  - 100% value = 100°C
- **S1:**
  - process parameter = pH
  - alarm
  - setpoint = 7 pH
  - direction = high
- **S2:**
  - fail

Set BOX1 and the mV-source to the values in the table below.

<table>
<thead>
<tr>
<th>Simulated Output mA</th>
<th>Tolerance mA</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.00</td>
<td>± 0.02</td>
</tr>
<tr>
<td>8.00</td>
<td>± 0.02</td>
</tr>
<tr>
<td>12.00</td>
<td>± 0.02</td>
</tr>
<tr>
<td>16.00</td>
<td>± 0.02</td>
</tr>
<tr>
<td>20.00</td>
<td>± 0.02</td>
</tr>
<tr>
<td>22.00</td>
<td>± 0.02</td>
</tr>
</tbody>
</table>

Read the pH and Temperature values on the Display. Measure the Actual mA-values and Contact settings using the multimeter(s).
<table>
<thead>
<tr>
<th>PH</th>
<th>mA1</th>
<th>S1</th>
</tr>
</thead>
<tbody>
<tr>
<td>mV</td>
<td>Reading [pH]</td>
<td>Toler. [pH]</td>
</tr>
<tr>
<td>414.4</td>
<td>0 ± 0.05</td>
<td>4.00 ± 0.08</td>
</tr>
<tr>
<td>0</td>
<td>7.00 ± 0.05</td>
<td>12.00 ± 0.08</td>
</tr>
<tr>
<td>-414.4</td>
<td>14.00 ± 0.05</td>
<td>20.00 ± 0.08</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature</th>
<th>mA2</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000.0</td>
<td>0 ± 0.4</td>
<td>4.00 ± 0.08</td>
</tr>
<tr>
<td>1194.0</td>
<td>50.0 ± 0.4</td>
<td>12.00 ± 0.08</td>
</tr>
<tr>
<td>1385.0</td>
<td>100.0 ± 0.4</td>
<td>20.00 ± 0.08</td>
</tr>
<tr>
<td>3000.0</td>
<td>- 0</td>
<td>20.50 ± 0.02</td>
</tr>
</tbody>
</table>

The tolerances specified relate to the performance of the PH150 in the controlled environment of the testing facility. Production testing is carried out in combination with a specially calibrated automatic test equipment (ATE). In the field, the accuracy and linearity of the test equipment affects the error in the reading. As much as an additional 0.1 mA may be seen in the mA output readings.

**Note:**
The testing of the PH150 is carried out under controlled environmental conditions. The end user may well find that his ambient conditions varies considerably from the ones noted in this certificate. In this case it is necessary to refer to the General Specification sheet for the details of ambient temperature, drift, etc.
# Quality Inspection Certificate

## Model PH150 pH and ORP Converter

### 1. Instrument description

- **Model:**
- **Device ID:**
- **Tag:**
- **Order:**
- **Software Revision:**

### 2. Safety tests

- **Dielectric strength**
- **Bonding**
- **Insulation**

### 3. Functional tests

- **Functional tests**
- **Communication test HART**
- **Date / time test**

### 4. Sensor input

<table>
<thead>
<tr>
<th>pH</th>
<th>2.00</th>
<th>0.00</th>
<th>2.00</th>
<th>4.00</th>
<th>7.00</th>
<th>10.00</th>
<th>12.00</th>
<th>14.00</th>
<th>16.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORP</td>
<td>-1500</td>
<td>-750</td>
<td>-250</td>
<td>-100</td>
<td>0</td>
<td>100</td>
<td>250</td>
<td>750</td>
<td>1500</td>
</tr>
</tbody>
</table>

### 5. Temperature input

<table>
<thead>
<tr>
<th>Tolerance</th>
<th>Pt1000</th>
<th>Pt100</th>
<th>5k1</th>
<th>3kBalo</th>
<th>8k55</th>
<th>350</th>
<th>10kNTC</th>
<th>6k8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>± 0.3</td>
<td>± 0.4</td>
<td>± 0.3</td>
<td>± 0.3</td>
<td>± 0.3</td>
<td>± 0.3</td>
<td>± 0.3</td>
<td>°C</td>
</tr>
<tr>
<td>Reading [°C]</td>
<td>-10</td>
<td>25</td>
<td>75</td>
<td>120</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6. Impedance

- **Glass impedance**
- **ORP impedance**
- **Reference impedance**

<table>
<thead>
<tr>
<th>kΩ</th>
<th>Reading</th>
<th>Toler.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>± 0.5 kΩ</td>
<td>± 0.5 kΩ</td>
</tr>
<tr>
<td>50</td>
<td>+ 2</td>
<td>± 2</td>
</tr>
<tr>
<td>100</td>
<td>+ 2</td>
<td>± 2</td>
</tr>
<tr>
<td>500</td>
<td>+ 15</td>
<td>± 15</td>
</tr>
<tr>
<td>1000</td>
<td>± 20</td>
<td>± 20</td>
</tr>
</tbody>
</table>

### 7. mA output

- **Simul. mA**
- **Actual mA1**
- **Actual mA2**
- **Toler.**

<table>
<thead>
<tr>
<th>pH</th>
<th>mA1</th>
<th>mA2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.00 mA</td>
<td>4.00 mA</td>
</tr>
<tr>
<td>7.00</td>
<td>12.00 mA</td>
<td>12.00 mA</td>
</tr>
<tr>
<td>14.00</td>
<td>20.00 mA</td>
<td>20.00 mA</td>
</tr>
</tbody>
</table>

### 8. Overall test

- **pH**
- **mA**
- **S1**

<table>
<thead>
<tr>
<th>Resistance [Ω]</th>
<th>Calculated</th>
<th>Reading</th>
<th>Toler.</th>
<th>Calculated</th>
<th>Actual</th>
<th>Toler.</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000.0</td>
<td>0°C</td>
<td>4.00 mA</td>
<td>± 0.08</td>
<td>0.08</td>
<td>open</td>
<td>0.08</td>
<td>open</td>
</tr>
<tr>
<td>1194.0</td>
<td>50.0</td>
<td>12.00 mA</td>
<td>± 0.08</td>
<td>0.08</td>
<td>open</td>
<td>0.08</td>
<td>open</td>
</tr>
<tr>
<td>1385.0</td>
<td>100.0</td>
<td>20.00 mA</td>
<td>± 0.08</td>
<td>0.08</td>
<td>open</td>
<td>0.08</td>
<td>open</td>
</tr>
</tbody>
</table>

### 9. Approval

- **Date:**
- **Approved by:**
- **Ambient temp.:** °C
- **Humidity:** % RH