N_2O Wastewater Sensor

User Manual

UNISENSE
ENVIRONMENT

N_2O Wastewater Sensor Manual

UNISENSE ENVIRONMENT

Version: May 2026

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1. WARRANTY

1.1 N_2O Wastewater Sensor Heads

N_2O Wastewater Sensor heads are considered consumables and Unisense Environment guarantees that they will work according to the specifications for 4 months from the date of receipt.

THE LIMITED SENSOR WARRANTY SHALL UNDER NO CIRCUMSTANCES INCLUDE PHYSICAL DAMAGE TO THE TIP OF THE SENSOR.

The limited sensor warranty will terminate immediately if the sensors are not examined and tested immediately upon receipt. Unisense Environment will replace defective sensors if they have been tested according to the instructions in the manual within 14 days of receipt of the sensor(s).

The Customer shall notify Unisense Environment of any defect that occurs during the Warranty Period no later than five (5) business days after discovery of the defect, or after the defect should have been discovered by the Customer. The limited sensor warranty does only apply to defects that are discovered before the Warranty Period or reported to Unisense Environment within five (5) business days of being or should have been discovered.

If a defect arises and the Customer submits a valid claim to Unisense Environment in accordance with the section above, Unisense Environment will replace the sensor free of charge or refund to the Customer any amounts paid to Unisense Environment for the sensor. The replacement of the sensor or the refund of amounts shall be the Customer's sole remedy in case of a defect in a sensor.

For replacement of a defective sensor the Customer must contact Unisense Environment for a return authorization and thereafter return the sensor to Unisense Environment for inspection in the original sensor box and packed in accordance with instructions given by Unisense Environment staff.
Under no circumstances may the sensors be used in human diagnostic or therapeutic procedures.

Replacement of Sensor Heads:
Unisense Environment replaces sensor heads that have been damaged during transportation provided that:

- The sensors were tested immediately upon receipt as specified in the General Terms of Sale and Delivery and the manual.
- The sensors are returned to Unisense Environment for inspection within two weeks
- The sensors are packed correctly during the return shipment to Unisense Environment (contact sales@unisense.com for instructions).

A standard N_2O Wastewater Sensor Head is working correctly (at 21 degree Celsius=room temperature) if:

- The raw signal for zero nitrous oxide (in tap water or air) is below 3% after being mounted and turned on for >12 hours.
- If the slope after calibration is larger than ~15%
- It has a response time of <65 seconds

1.2 Calibration Kit

The N_2O Calibration Kit is a consumable with a lifetime of 6 months as noted on the kit.

1.3 N_2O Wastewater Operator Console, N_2O Wastewater Connector Unit and Accessories

N_2O Wastewater Operator Console, N_2O Wastewater Connector Unit and accesories are covered by a 1-year limited warranty.

2. MANUFACTURER AND CONTACT INFORMATION

If you wish to order additional products or if you encounter any problems and need scientific/technical assistance, please contact our sales and support team. We strive to respond to your inquiry within one working day.

E-mail: sales@unisense.com
Tel: +45 8944 9500

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Further documentation and support is available on our website: unisense-environment.com
Note: If you find errors in this manual or have suggestions for improvements, please contact us.

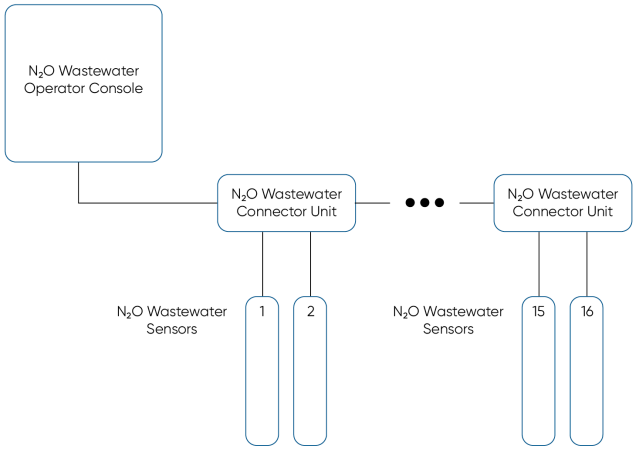
3. APPLICATION & COMPONENTS

3.1 Application

Unisense Environment's N_2O Wastewater Sensor is designed to measure nitrous oxide (N_2O) directly in wastewater where it can monitor nitrous oxide concentrations online 24/7 as well as calculate nitrous oxide emissions. The main application is to measure in the aerated or non-aerated liquid phase of an activated sludge process or other types of biological wastewater treatment.

3.2 Components

The N_2O Wastewater System is comprised of an N_2O Wastewater Operator Console, an N_2O Wastewater Connector Unit and 1 or 2 N_2O Wastewater Sensors. One N_2O Wastewater Operator Console can manage up to 16 sensors.



N_2O Wastewater System setup and connections overview

The N_2O Wastewater Operater Console is used to manage and calibrate the nitrous oxide measurements. It can also be used for calculating the nitrous oxide emission rate with input from the aeration system. Unisense Environment advises setting up emission calculations directly in the WWTP SCADA as it provides maximum flexibility in data handling and process control.

By default the N_2O Wastewater Operator Console is delivered with a 4-20mA and Modbus/TCP output that can be connected directly to the WWTP's control system. Another option is to connect the sensor to the SCADA system via -DP interface. Nitrous oxide measurements can furthermore be downloaded to a USB stick and be interpreted on a computer and a CSV-file, using any analytic software, e.g. Python.

N_2O Wastewater Operator Console

The N_2O Wastewater Sensor consists of 3 components: Sensor Head (1), Sensor Body (2) and Sensor Cap (3).

N_2O Wastewater Sensor

The N_2O Wastewater Sensor Body contains an N_2O digital amplifier, a temperature sensor and is delivered with a standard 7 m cable. The N_2O Wastewater Sensor Body and Sensor Cap are made of robust, surface-protected aluminium. The N_2O Wastewater Sensor Cap protects the N_2O Wastewater Sensor Head which is an extremely sensitive, electrochemical N_2O sensor with a detection limit of <0.005 mg N_2O-N per litre. For detailed specifications see 10. N_2O Wastewater Sensor Specifications

IMPORTANT: Never leave the N_2O Wastewater Sensor Body out in the open without an N_2O Wastewater Sensor Head or black closure cap that it is shipped with. Alternatively cover well with e.g. a waterproof plastic bag. Water intrusion will damage electrical connections.

The N_2O Wastewater Operator Console can be mounted at a relevant spot at the WWTP using the already installed mounting brackets. Furthermore, the sensor can be secured by connecting a chain to the Sensor Chain Loop in the end of the sensor.

The N_2O Wastewater Connector Unit connects up to 2 N_2O Wastewater Sensors to the N_2O Wastewater Operator Console. A status LED on the N_2O Wastewater Connector Unit provides information about the N_2O Wastewater Sensors connection. Furthermore the LED allows for a screenless calibration on site.

N_2O Wastewater Connector Unit

By default, the Unisense N_2O Wastewater System consists of:

- N_2O Wastewater Sensor Body with Temperature sensor
- 7 m cable attached to sensor
- N_2O Wastewater Sensor Cap
- N_2O Wastewater Sensor Head
- N_2O Wastewater Operator Console (with 4-20 mA and Modbus TCP/IP (default)
- N_2O Wastewater Connector Unit
- N_2O Calibration kit

Optional equipment:

- Extra cable (total length up to 30 m for each sensor)
- Chain

4. GETTING STARTED

4.1 Mounting & connecting the N_2O Wastewater Sensor System

1. Find the correct location for the N_2O Wastewater Sensor, N_2O Wastewater Operator Console, and N_2O Wastewater Connector Unit, and mount it safely, e.g. by using the Pipe Mounting Kit or in a suitable cabinet.

2. The N_2O Wastewater Operator Console may be connected to the SCADA system of the WWTP. This will enable real time display of data in the SCADA system and logging of data together with other sensor data.

3. Remove the protective sticker from the N_2O Wastewater Operator Console screen.

4. Connect the N_2O Wastewater Operator Console to a power supply. The sensor measurements will be recorded in the N_2O Wastewater Operator Console as soon as the sensors are connected through a N_2O Wastewater Connector Unit.

5. Set the Modbus Bus Termination Switch inside the N_2O Wastewater Connector Unit. Termination should be enabled only when the sensor is located at the physical ends of the Modbus line of N_2O Wastewater Connector Units and otherwise be OFF to ensure proper signal integrity and reliable communication. See more in 7.1 Modbus Bus Termination Switch.

6. Use the DIP-switches inside the Connector Unit to configure the correct Modbus address for the N_2O Wastewater Sensor *before* connecting the sensors. See 7.2 Setup Sensor Channels.

7. Connect the N_2O Wastewater Connector Unit to the N_2O Wastewater Operator Console. See 7. N_2O Wastewater Connector Unit

8. Connect up to two N_2O Wastewater Sensors per N_2O Wastewater Connector Unit. See Step-by-Step Guide: Installing the N_2O Wastewater Sensor Head.
   It is recommended to place the N_2O Wastewater Sensor in the wastewater using the Sensor Chain Loop to avoid strain on the cable.

9. Let the sensors stabilize sitting in a bucket of tap water for 12 hours (e.g. overnight), until the signal is stable and the Raw Signal is below 2%. The raw signal is read under Sensor Data on the N_2O Wastewater Operator Console.

10. Continue with calibration of the sensors.

4.2 Calibration of the sensor

A two-point calibration is used to make the sensor operational. See the Step-by-Step Guide: N_2O Calibration.

In addition, note the following points:

- Calibration must take place at the same temperature as the wastewater which the sensor will be placed in. The calibration will be valid with minimal error for wastewater temperatures ±3°C of the calibrated temperature.
- The sensor is calibrated using Unisense Environment's N_2O calibration kit or similar equipment.
- A sensor must be calibrated at least every 2 months or if the wastewater temperature changes more than 3°C.
- A graduated beaker is recommended to measure out the 4L of water precisely.
- It is recommended to use two insulated buckets for holding the calibration liquid in order to ensure a stable temperature. By having one bucket for the zero solution and one for the standard, one can also perform the calibration of two sensors in a row using only one standard ampule.
- Furthermore, a digital thermometer is recommended for calibration.

IMPORTANT: The built-in temperature sensor is located in the middle of the N_2O Wastewater Sensor. Make sure it is submerged in water during calibration.

5. N_2O WASTEWATER SENSOR

5.1 Mounting the N_2O Wastewater Sensor

The N_2O Wastewater Sensor must be placed so that the entire metal body of the sensor is submerged in water. It is recommended to support the sensor's cable by mounting a chain along the cable and attaching it to the Sensor Chain Loop. The sensor must be placed in such a manner that it will not hit the tank wall or any other hard objects that could break the sensor. Possible changes in flow direction as well as the possibility of taking the sensor out of the water for calibration should be considered when placing it.

WARNING: Do NOT fix screws or any kind of metal directly onto the N_2O Wastewater Sensor as this will damage the surface protection of the aluminium by galvanic corrosion. Use only plastic material in contact with the sensor.

5.2 Placement of the N_2O Wastewater Sensor

The recommended measuring point for the N_2O Wastewater Sensor is in the activated sludge process or alternative biological nitrogen removal process. More precise placement depends on the type of WWTP, e.g. whether the system has bottom aeration or surface aeration.

The sensor should be placed right below the water surface, fully submerged at all times.

IMPORTANT: The sensor is sensitive to mechanical damage. Use proper mounting and placement to make sure it does not suffer e.g. from banging into a wall or similar.

Alternating processes: In an alternating WWTP, the wastewater is typically fed continuosly to multiple, connected tanks. The oxic and anoxic periods occur in the same tank. Typically, one sensor would be placed in each tank.

Recirculation plants: In a recirculation plant, the aerobic nitrification tank is separated from the denitrification process. It is suggested to place one sensor in each of the 2 process tanks: one by the outlet of the anoxic zone and the other 1/3 into the aerated zone.

Bottom aeration: In a plant with bottom aeration in only parts of the tanks, the sensor should be placed about 1/3 downstream in the aeration area. If two sensors are available in the same tank, one could be placed before and one above the bottom aeration.

Surface aeration: In plants with surface aeration, it would be appropriate to place the sensor right before the surface aeration rotor. If a second sensor is available, it can be placed in another part of the process that is not affected by the aeration.

Side-stream processes: The reject water from sludge dewatering typically contains high concentrations of ammonium and a low COD-content. These conditions provide a high potential for N_2O formation. The nitrogen is primarily removed through anaerobic ammonium oxidation (Anammox process) also called the deammonification process. In reject water tanks, the wastewater is aerated with a low dissolved oxygen setpoint, so that about half of the ammonium is oxidized to nitrite and the other half is consumed through reaction with nitrite in the Anammox process. N_2O can be used as a proxy for nitrite, which is more difficult to measure in real time. In these plants, one sensor should be placed in each process water tank.

5.3 Connection of the N_2O Wastewater Sensor

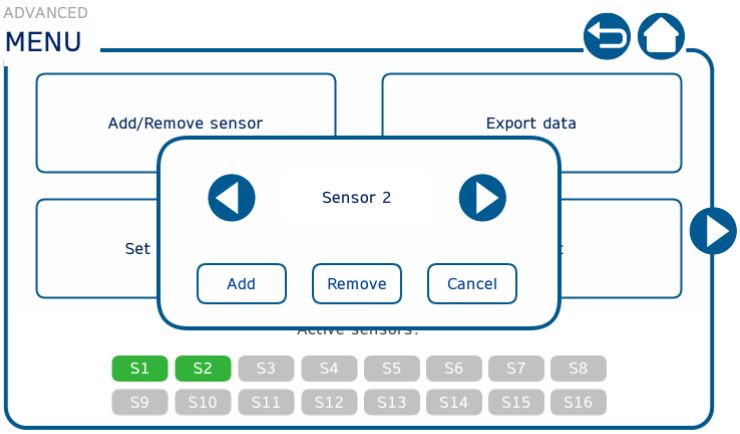
The N_2O Wastewater Sensor is connected to the N_2O Wastewater Operator Console, through the N_2O Wastewater Connector Unit.

Make sure that the N_2O Wastewater Connector Unit is connected to the N_2O Wastewater Operator Console, and that the Modbus Bus Terminal Switch is set correctly. See 7. N_2O Wastewater Connector Unit for more information on how to install the N_2O Wastewater Connector Unit.

The DIP-switch inside the N_2O Wastewater Connector Unit must be set *before* connecting the N_2O Wastewater Sensor. See 7.2 Setup Sensor Channels. There is a DIP-switch for each sensor, and make sure to set both of them if two sensors are connected.

At the end of the sensor's cable there is a binder plug that can be plugged directly into the N_2O Wastewater Connector Unit. As soon as the sensor is plugged in, it is connected.

To complete the connection, the sensor must be added to the N_2O Wastewater Operator Console. Go to the menu to add the sensor. The sensor you want to add corresponds to the address set on the DIP-switch. Example: When the Modbus address is set to 4 on the DIP-switch, it will be Sensor 4 on the N_2O Wastewater Operator Console.



5.4 Installing and pre-polarization of the N_2O Wastewater Sensor

Install an N_2O Wastewater Sensor head, making sure that O-rings on the head and the aluminium tube are lubricated. See Step-by-Step Guide: Installing the N_2O Wastewater Sensor Head for details.

When you connect the sensor to the N_2O Wastewater Connector Unit and add it to the N_2O Wastewater Operator Console, it will automatically start a 30-minute pre-polarization.

During pre-polarization, the raw signal will increase quickly. Afterwards the sensor switches to polarization. At this point, the raw signal will drop quickly at first, then decrease more slowly until it reaches a stable, low level. Wait until the signal is stable and below 2%. This may take up to 12 hours. During both pre-polarization and polarization, keep the sensor in a bucket of tap water.

If the signal does not stabilize or if it is too high, please go to 10. Troubleshooting in this manual or contact sales@unisense.com.

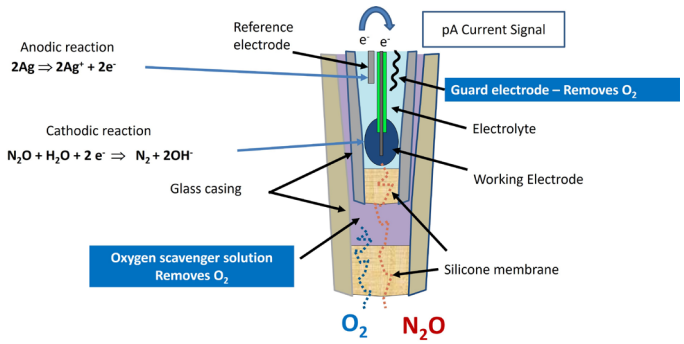
5.5 The construction of the N_2O Wastewater Sensor

The N_2O Wastewater Sensor Body contains the electronics and ensures that the sensor is automatically polarized as soon as it is connected to a powered N_2O Wastewater Operator Console. The N_2O Wastewater Sensor Body also contains a temperature sensor that is placed in the middle of the N_2O Wastewater Sensor Body. The N_2O Wastewater Sensor Body (2) and N_2O Wastewater Sensor Cap (3) are made of robust, surface protected aluminium.

The three components of the N_2O Wastewater Sensor:
N_2O Wastewater Sensor Head (1), N_2O Wastewater Sensor Body (2) and N_2O Wastewater Sensor Cap (3)

The N_2O Wastewater Sensor Head (1) is a Clark-type sensor with an internal reference, a cathode, a guard cathode, and a front oxygen trap with reducing medium. It removes oxygen so that this does not interfere with the nitrous oxide measurements. When the N_2O Wastewater Sensor Head is connected to the N_2O Wastewater Sensor Body, the cathode and the guard cathode in the N_2O Wastewater Sensor Head are polarized against the internal reference. The depletion of oxygen from the electrolyte starts when the sensor head is connected but takes a while to be reduced to a stable background level. Therefore, the signal for zero nitrous oxide will be decreasing over the first hours after a sensor head is connected, and it is recommended to leave a newly connected N_2O Wastewater Sensor Head to polarize overnight before calibration is performed.

Nitrous oxide enters the sensor through a silicone rubber membrane in the center of the 0.5 mm diameter glass sensor tip. Inside the sensor, nitrous oxide is reduced to N_2 which generates an electrical current. This is the sensor signal.



View of the sensor tip showing the measurement principle of the N_2O sensor

5.6 Calibration

Calibration of the sensors can be done using the N_2O Calibration Kit or similar equipment. It should be performed at least every 2 months and also if the process temperature deviates by more than 3°C for more than a few days.
Recalibration is not needed or recommended in case of short term temperature drops, e.g. due to heavy rain.

N_2O Calibration Kit

The N_2O Calibration Kit is used for a 2-point calibration of the N_2O Wastewater Sensor. It contains enough standard solution for 3 calibrations.

The two-point calibration can be performed on the N_2O Wastewater Operator Console or screenless with the N_2O Wastewater Connector Unit. See the Step-By-Step Calibration Guides.

For High Range Sensor Heads, note the modifications described in the Calibration for Standard, Medium and High Range Sensor Heads guide at unisense-environment.com/manuals.

A graduated beaker is recommended to measure 4L of water precisely. It is recommended to use two insulated buckets for holding the calibration liquid in order to ensure a stable temperature. By having one bucket for the zero solution and one for the standard, one can also perform the calibration of two sensors in a row using only one standard ampule. Furthermore, a digital thermometer is recommended for calibration.

The N_2O Wastewater Sensor responds linearly to nitrous oxide within its dedicated working range. Therefore, only a two-point calibration is needed. This is done by exposing the N_2O Wastewater Sensor to two concentrations of N_2O, zero, and one known concentration of N_2O. Tap water is used for the zero point and the N_2O Calibration Kit will give 0.94 mg N_2O-N/L, which is suitable for a Standard Range N_2O Sensor Head.

The sensor signal for N_2O is dependent on temperature. Therefore, the calibration should be performed at a temperature close to the measurement temperature. By default, the concentration value is compensated for a temperature ± 3 °C from the calibration temperature.

IMPORTANT: Do not place the Standard Range N_2O Wastewater Sensor in a nitrous oxide concentration of more than 1.5 mg N_2O-N/L, as this will damage the sensor.
The recommended calibration concentrations for non-standard N_2O Wastewater Sensors can be found in 11. Specifications.

Unisense Environment offers a standard N_2O Wastewater Sensor and a High Temperature N_2O Wastewater Sensor.
The sensors are available with:

- Standard Range (0-1.5 mg N_2O-N/L)
- Medium Range (0–9 mg N_2O-N/L)
- High Range (0–110 mg N_2O-N/L).

The standard N_2O Wastewater Sensors are designed to operate at temperatures between 0-27°C. The High Temperature N_2O Wastewater Sensor is designed to operate at temperatures between 27-40°C.

The N_2O Wastewater Sensors must never be exposed to N_2O concentrations above their working range as this will damage the sensor. When using high range sensors on a 4-20 mA connection, the output ranges must be changed on the N_2O Wastewater Operator Console.

For details on calibrating the alternative sensor heads see the Calibration for Standard, Medium and High Range Sensor Heads guide at unisense-environment.com/manuals.

Target values for calibration (standard range head, at room temperature):
Slope: 15-150%
Zero value: >-0.5

5.7 Autozero

The measuring range of the sensor is extended into the negative, giving a maximum sensitivity at very low concentrations. If the sensor reads steady values between 0.00 and -0.05 N_2O-N mg/L for 15 min, the Autozero feature will set this as new baseline. If the values are continuously lower than -0.05, Autozero will raise an alarm indicating the need to perform a new two-point calibration.

5.8 Replacement of an N_2O Wastewater Sensor Head

Unisense Environment guarantees a lifetime of 4 months for the N_2O Wastewater Sensor Head. However, the typical lifetime of the N_2O Wastewater Sensor Head is 6 months. For obtaining continuous data series, we recommend replacing the N_2O Wastewater Sensor Head every 6 months.

IMPORTANT: Never leave the N_2O Wastewater Sensor Body out in the open without an N_2O Wastewater Sensor Head or black closure cap that it is shipped with. Alternatively cover well with e.g. a plastic bag. Water intrusion will damage electrical connections.

N_2O Wastewater Sensor Heads cannot be stored, therefore they are made to order. Prescheduled shipment of N_2O Wastewater Sensor Heads can be arranged with every order. See the Step-By-Step Guide: N_2O Wastewater Sensor Head Replacement

5.9 Temperature Sensor

The measurement of the N_2O concentrations is temperature-dependent, and the N_2O concentration measurements are, therefore, temperature corrected. The N_2O Wastewater Sensor has a built-in temperature sensor.

As the temperature sensor is placed inside the aluminium housing, it responds slowly to changes outside the sensor body. The temperature sensor is factory calibrated and does not need further calibration.
During nitrous oxide measurements, it is important that the entire sensor (both the N_2O Wastewater Sensor Head and the N_2O Wastewater Sensor Body) is completely submerged in water. Only the black top of the sensor may be visible above the water.

5.10 Interferences

Avoid exposing the sensor to high concentrations of Hydrogen Sulfide (H_2S), as this can influence the sensitivity of the sensor. Nitric Oxide (NO) can also interfere with the sensor's signal, but concentrations high enough typically only occur in special cases during research experiments. If you suspect the sensor is broken, repeat the calibration and read 10. Troubleshooting.

6. N_2O WASTEWATER OPERATOR CONSOLE

The N_2O Wastewater Operator Console can be installed outside, next to the wastewater treatment process. The Pipe Mounting Kit makes mounting easy for example on the rails of a boardwalk. Alternatively, it can be mounted in a cabinet.

N_2O Wastewater Operator Console

Data from the sensors will always be logged on the N_2O Wastewater Operator Console (for 2 sensors data storage for app. 1 year is available) but may also be sent directly to a SCADA system. The available protocols are 4-20 mA analog output, Modbus TCP/IP (default), Modbus Serial (optional), and Profibus-DP (optional). See 10. Specifications for details. Data stored on the N_2O Wastewater Operator Console may be downloaded to a USB memory stick for analysis on a PC with the PCA3000 software (license required).

The N_2O emission rates may be calculated on the N_2O Wastewater Operator Console, if the aeration rate is delivered via a 4-20 mA input.

For further information, please see the N_2O Wastewater Operator Console Manual available at www.unisense-environment.com.

6.1 Connections

The N_2O Wastewater Operator Console's, most frequently used connectivity options are described below:

Power supply: The N_2O Wastewater Operator Console must be connected to a power supply (AC 100 to 240 V, 24V 2.5 A).

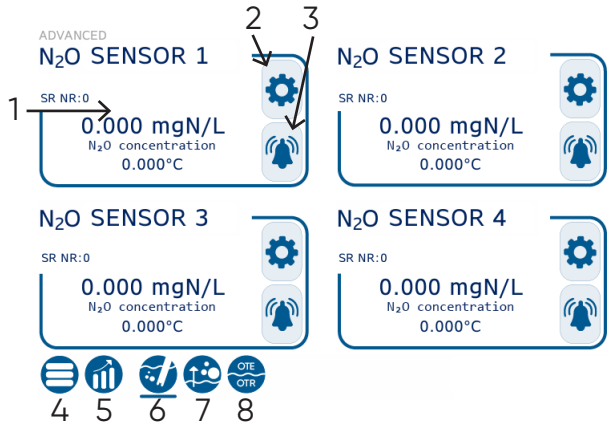
N_2O Wastewater Connector Unit and Sensor connections: The N_2O Wastewater Connector Unit is connected through the plugs in the N_2O Wastewater Operator Console. The N_2O Wastewater Sensors are connected through the N_2O Wastewater Connector Units sensor channels located on the underside of the N_2O Wastewater Connector Unit. The plug for sensor 1 is to the left and the plug for sensor 2 is to the right.
Install a suitable cable according to the required specifications: for distances up to 100 m (in total), use a 2×2×0.5 mm² twisted pair cable with overall shield (OS), and for distances up to 200 m (in total), use a 2×2×0.75 mm² twisted pair cable with overall shield (OS).

Output (4-20 mA): The nitrous oxide measurements and nitrous oxide emission rates can be sent directly from the N_2O Wastewater Operator Console to the SCADA system with 4-20 mA outputs. In the default settings, 4 mA corresponds to 0 mg N_2O-N/L and 20 mA corresponds to 2 mg N_2O-N/L. When using high range sensor heads, consult the Specification Guides: Changing Analogue Signal Output (high range sensors) for alternative settings.

Modbus TCP:
Modbus TCP: Modbus TCP can be used as an alternative communication protocol. See Modbus TCP/IP Register Documentation for a description and setup guide.

6.2 Navigation

The N_2O Wastewater Operator Console provides the option to connect and operate up to 16 sensors.

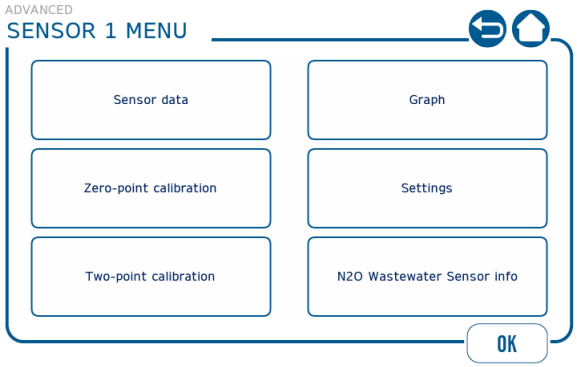


From the Sensor Main Screen (6), it is possible to go to: Sensor Information (1), Sensor Menu (2), Sensor Alarm (3), Menu (4), Graphs (5), Sensor Main Screen (6), Emission Main Screen (7), OTE/OTR Screen (8).

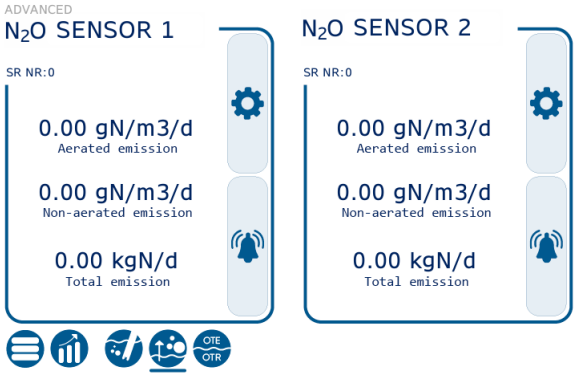
Under Sensor Information (1), you will find the key details for each device, including the current device status, raw measurement values, and the most recent calibration data.

In the Menu (4), you can log in with different access levels (Operator, Advanced, or Service), configure the system time, add or remove sensors, and access additional system settings.

Under Graphs (5), you can display and monitor live data from the selected sensors in graphical form.



The Sensor Menu (2) provides access to sensor-specific functions, including calibration options, settings, and other relevant sensor information.



The Emission Main Screen (7) encompasses all functionalities available on the Sensor Main Screen (6), with the distinction that it presents emission-specific data, including total emissions, prominently on the primary interface and under the Sensor Information.

7. N_2O WASTEWATER CONNECTOR UNIT

The N_2O Wastewater Connector Unit connects up to 2 N_2O Wastewater Sensors to the N_2O Wastewater Operator Console. A status LED on the N_2O Wastewater Connector Unit provides information about the sensors connection. Furthermore, the LED allows for a screenless calibration on site.

N_2O Wastewater Connector Unit

The N_2O Wastewater Connector Unit is easily mounted, for example, on the rails of a boardwalk. Up to two sensors can be connected to the N_2O Wastewater Connector Unit, each sensor connected via a 5 m cable. A cable of varying length is used between the N_2O Wastewater Operator Console and the N_2O Wastewater Connector Unit.

Additional N_2O Wastewater Connector Units can be installed in a serial connection. Up to 8 N_2O Wastewater Connector Units can be linked to each N_2O Wastewater Operator Console, allowing for a total of 16 sensors.

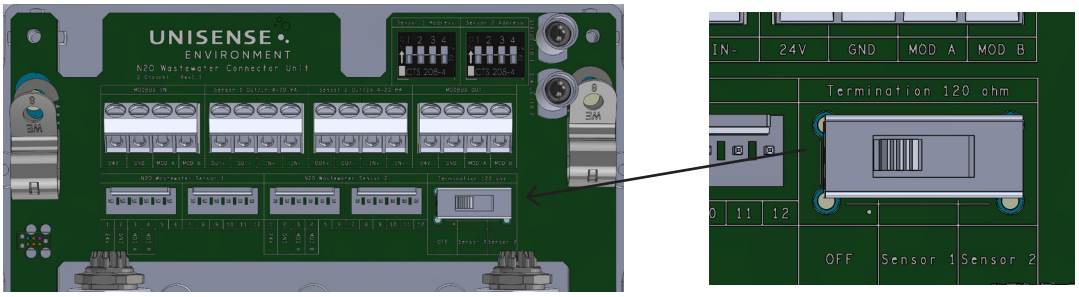
To identify whether power is supplied to the N_2O Wastewater Connector Unit, the LED will light up green shortly after the power is turned on. If it does not light up, there is a fault in the connection to the N_2O Wastewater Connector Unit.

7.1 Modbus Bus Termination Switch

Berfore connecting the sensors, the Modbus Bus Termination Switch inside the N_2O Wastewater Connector Unit must be set. Termination should be enabled only when the sensors are located at the physical ends of the Modbus line of N_2O Wastewater Connector Units and otherwise be in OFF to ensure proper signal integrity and reliable communication.

The Modbus Bus Termination Switch on the connector unit located at the physical end of the Modbus line must be enabled.
- If *1* sensor is connected to the last N_2O Wastewater Connector Unit, set the Termination Switch to Sensor 1.
- If *2* sensors are connected, set the Termination Switch to Sensor 2.

Ensure that the Modbus Out connector is fitted with a plug when the unit is the last one in the row, in order to protect against water ingress.

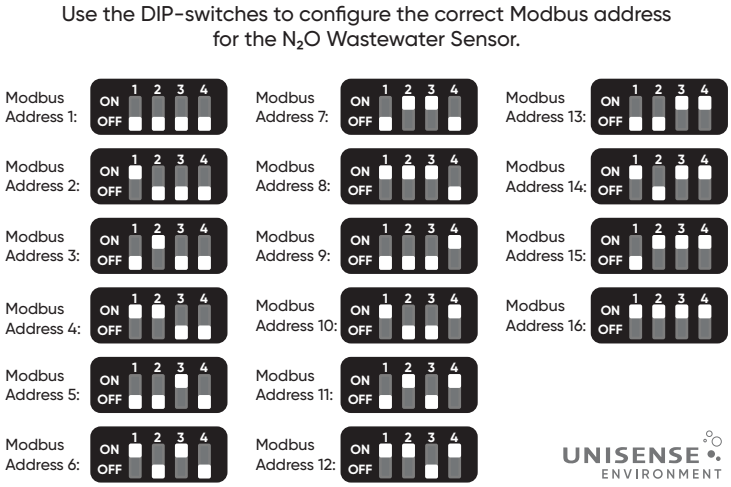


The Modbus Bus Termination Switch. From the left: OFF, Sensor 1, Sensor 2

7.2 Setup Sensor channels

Use the DIP-switches inside of the N_2O Wastewater Connector Unit to configure the correct Modbus address for the N_2O Wastewater Sensor.

There are two dip switches in the N_2O Wastewater Connector Unit. One for each of the sensors that can be connected. Be sure to set the correct channel for the correct sensor. Instructions and a visual representation for finding the correct addresses is also inside the N_2O Wastewater Connector Unit.



The DIP-switch must be set to the right address before connecting the sensor. When the sensor is connected and added on the N_2O Wastewater Operater Console, the status LED on the N_2O Wastewater Connector Unit will blink blue. If the connection fails, the LED will turn solid red.

7.3 Screenless calibration

A simple two-point calibration can be performed using the N_2O Wastewater Connector Unit's status LEDs in combination with the sensor's motion detection.

This method allows you to calibrate the sensor without using the N_2O Wastewater Operator Console, making it possible to perform the calibration directly at the sensor location, regardless of the distance to the N_2O Wastewater Operator Console.

During the process, the status LED guides you through each step using specific colors and flashing patterns.

For detailed instructions, see the Step-by-Step Guide: Screenless Calibration.

8. STORAGE AND CLEANING

8.1 The N_2O Wastewater Sensor

When the sensor is not used, it should be stored safely in the protection box, it is delivered in. However, long-term storage (more than 2 months) of the sensor head is not recommended.

Once the sensor has been in contact with wastewater, it should not be left to dry, to avoid biofilm drying up on the tip. If it should leave the wastewater and be used again at a later stage, store it with the tip in a bucket of water.

Handling: The N_2O Wastewater Sensor Head is made of glass and is therefore sensitive to mechanical force. When handling the sensor, e.g. while taking it out of the wastewater for calibration or during installation, make sure to avoid any impact (e.g. knocking on the railing or the side of the calibration bucket) which may damage the instrument.

Cleaning of glass tip: Being placed in wastewater, biofilm can develop on the N_2O Wastewater Sensor Body and Cap and the N_2O Wastewater Sensor Head. From years of practical experience, it is known that the presence of biofilm on the N_2O Wastewater Sensor Head does not interfere with measurements. This is because the outer sensor tip will stay free from biofilm due to its pointy geometry. Therefore, manual cleaning of the glass electrode is almost never necessary. If biofilm does develop on the outer tip of the sensor, it should be removed with running water and/or gentle wiping with soft tissue. Always wipe away from the tip.

External cleaning: Before re-calibrating the sensor, the bulk of biofilm accumulated on the N_2O Wastewater Sensor Body and Cap (if present) and any larger objects (rags, hairs etc.) should be removed. This is done manually, by carefully rubbing the surface of the body with a soft brush or sponge - Making sure to not touch the sensor tip in the process. Cleaning should be assisted by rinsing with water.

While this cleaning procedure may not remove all biofilm present, it will suffice to ensure a stable calibration.
If ragging is a constant issue at the site, removal of debris might be necessary more often to ensure that the tip of the sensor is exposed to the bulk liquid.

The debris on the left picture should be removed, while thesensor tip on the right does not need to be cleaned before calibration. If the outer tip is fouled, clean only with running water and soft tissue, always wiping away from the tip.

8.2 The N_2O Wastewater Operator Console

The N_2O Wastewater Operator Console must be protected against sun, wind and weather. Cleaning is done using tap water, mild soap, and a very soft brush.

8.3 The N_2O Wastewater Connector Unit

Cleaning is done using tap water, mild soap, and a very soft brush.

10. TROUBLESHOOTING

Problem	Raw Sensor Values above 2% in air or tap water.
Possible cause	Air bubble in the tip of the N_2O Wastewater Sensor.
Solution	1. Remove the air bubble by lifting the sensor above your head (tip pointing up) and give it a big "shake" downwards - as you would with an old-fashioned mercury thermometer. Be careful not to break the sensor. Find a video guide at unisense-environment.com/video-guides. 2. If the raw Sensor Value remains high, it may be due to very small air bubbles in the tip. These may be removed from the tip by placing it in degassed water. For this, boil a few liters of water for about 10 min. Let the water cool down to ambient temperature without stirring and place the sensor in this water for 1 hour.
Problem	Raw Sensor Value is constantly high (99-100%) or low. No reaction to N_2O.
Possible cause	1. The tip of the sensor or the sensor membrane is broken, likely due to physical damage. 2. Water has entered between the sensor body and sensor head, often due to mishandling. 3. N_2O Wastewater Operator Console is faulty (e.g. loose wiring)
Solution	1. Replace sensor head. If in doubt, return the faulty sensor head to Unisense Environment for inspection*. 2. Test if the problem is with sensor body or controller by switching around two sensor body cables. Wait 30 min for the polarization procedure to take place. If applicable, return sensor body to Unisense Environment for repair*. 3. If possible, check if all wiring in console is correct and not loose. If no result, return the N_2O Wastewater Operator Console to Unisense Environment for repair*.
Problem	N_2O concentration value (mg N_2O-N/L) fluctuates strongly when sensor is in tap water.
Possible cause	The previous calibration is faulty.
Solution	Start a two-point calibration and press 'Reset Calibration', this will reset the calibration. Make a new two-point calibaration afterwards.
Problem	Baseline drift: baseline at < -0.01 or > 0.01 mg/L. (Mind that negative numbers are logged in SCADA as zeros, so a baseline drift towards negative values can be identified in SCADA by measuring zeros for a long time, not by negative numbers.)
Possible cause	1. The N_2O Wastewater Sensor Head is more than 6 months old. 2. The wastewater temperature has changed more than 3°C since the last calibration.
Solution	1. Exchange the sensor head. 2. Perform a two-point calibration.
Problem	Increase of baseline over time.
Possible cause	1. N_2O Wastewater Sensor Head is more than 6 months old or has been exposed to elevated N_2O over long time. 2. N_2O Wastewater Sensor has been used at high temperature (<35°C)
Solution	1. Replace sensor head. 2. Consider a High Temperature version of the sensor head.
Problem	Slow response time: e.g. after 10 min waiting the measurement value is still increasing in the high concentration calibration liquid.
Possible cause	1. Sensor head is more than 6 months old. 2. Presence of an air bubble in the sensor tip.
Solution	1. Replace sensor head. 2. Perform air bubble procedure from top of this list.

Problem	High slope after calibration (> 75%).
Possible cause	1. Faulty calibration. 2. Sensor head is more than 6 months old.
Solution	1. Perform another two-point calibration. 2. Replace sensor head

Problem	Sensor Body and Sensor Cap have started to corrode.
Possible cause	The corrosion protective layer on the aluminium sensor body (the anodization) has deteriorated and/or the sensor is in direct contact with another metal which will cause galvanic corrosion.
Solution	Replace the corroded parts and make sure that the sensor is not in direct contact with any other metal when it is in water.

Problem	The N_2O Wastewater Sensor can be calibrated, but the calibrated nitrous oxide concentration does not appear in the overview window. The temperature value is fluctuating.
Possible cause	There is a fault in the temperature sensor, located in the sensor body.
Solution	Test if the problem is with the sensor body by switching it to the other channel on the console. If issue can be located to sensor body, return it to Unisense Environment for repair*.

Problem	No temperature reading is given on controller (---).
Possible cause	There is a fault in the temperature sensor, located in the sensor body.
Solution	Test if the problem is with the sensor body by switching it to the other channel on the controller. If issue can be located to sensor body, return it to Unisense Environment for repair*.

Problem	The touchpad reacts in an imprecise way.
Possible cause	The calibration of the touchpad is off.
Solution	Run a screen calibration by going to the menu: /Calibrate touchscreen and follow the prompts. This may need to be repeated several times.

*Always contact Unisense Environment before returning equipment.

If you experience other errors or problems and you need technical assistance, please contact us at sales@unisense.com (we strive to respond within one working day).

11. SPECIFICATIONS

N_2O Wastewater Sensor Body

Material	Anodized aluminium alloy. Robust design in aluminium alloy casing (6063-T6) and black POMacetyl copolymer
Dimensions & weight	60mm x 390mm (D x L), 1,2 kg
Mounting	Chain Loop and stainless steel chain kit
Power Supply	24V DC from N_2O Wastewater Connector Unit
Communication	ModbusRTU (Slave)
N2O signal	1 x temp. compensated N_2O value (N_2O-N [mg/L] or ppm)
Temperature	1 x temperature (°C or °F)
Emission Rates	1 x Emission calculations (N_2O-N [mg/m³/d]) with dynamic input parameters
	Emissions from anaerobic, anoxic and aerobic zones
Emission Parameters	$k_La_{N_2O}$, v_{gas}
Aeration Metrics	Based on digital input of DO_{liq}, DO_{air} and air flux, these are calculated: OTR, OTE, OUR, $k_La_{O_2}$, αF, SOTR, SOTE, AE, SAE
Datalogger	Sensor and emission data (+2 years days data)
	Calibration and sensor logbook (+ 1 year logbook)
Sensor Health	Sensor & calibration status: needs calibration, needs replacement, warnings & errors
	Diagnostic data: Raw and calibration signals

N_2O Wastewater Sensor Head

Material	Alloy connector, glass sensor Black POM acetyl copolymer	
Measurement method	Electrochemical, clark type	
Measuring range	Standard Range: 0-1.5 N_2O-N mg/L	Auto setup
	Medium Range: 0-9 N_2O-N mg/L	Auto setup
	High Range: 0-110 N_2O-N mg/L	Auto setup
Detection limit	Standard Range: 0.005 N_2O-N mg/L	
	Medium Range: 0.03 N_2O-N mg/L	
	High Range: 0.4 N_2O-N mg/L	
Response time	< 65 sec	
Expected lifetime	> 6 months	
Calibration	2-point calibration, every second month	
Temperature Working Range	Replaceable N_2O Sensor head for either 0-27°C or 27-40°C	
Digital E²PROM Enabled	Storage of sensor specific data, factory and calibrations, remaining lifetime	

N_2O Wastewater Operator Console

Material	Stainless steel cabinet (IP67)
Dimensions & weight	300mm x 300mm x 150mm (LxWxD), 6.5 kg
Mounting	Panal mounted
Power supply	AC 100 to 240 V ±10%; 50..60Hz, 60W
Cable requirements	2×2×0.5 mm² twisted pair cable with overall shield (OS) for distances up to 100 m 2×2×0.75 mm² twisted pair cable with overall shield (OS) for distances up to 200 m
Communication	ModbusRTU (Master to Connector Unit and N_2O Sensors)
Sensor Input Digital	Full digital support & communication from up to 16 sensors
	PLC/SCADA. Full data access via Modbus TCP/IP Optional: ProfiBusDP or ModbusRTU (Slave)
N_2O sensor support	Up to 16 N_2O sensors and 8 Connector units per console

N_2O Wastewater Connector Unit

Material	Surface-mounted case made of plastic (ABC) IP67
Dimensions & weight	150mm x 100mm x 60mm (L x W x D), 0.5kg
Mounting	Multiple holes for surface or pipe mounting
Power Supply	24V DC, 2.5A from N_2O Wastewater Operator Console
Communication	ModbusRTU (Master & Slave) with Console and Sensor
Sensor Output Analog	1 (optional 3) x configurable and user scaled output signals (Analog 4-20mA)
Sensor Input Digital	Optional: 1 x MODBUS RTU Slave (DO sensors), tank and aeration dimension
Sensor Input Analog	Air flow (Nm3/h, m3/h), User scaled input signal, (Analog 4-20mA)

System Certifications

Certificates	CE, FCC, CSA, UKCA, CB certificate (Certificates pending)
Safety	Safety Assessment
Environmental	REACH/RoHS Conformity

N_2O Wastewater Sensor Head replacement

A Step-by-Step Guide to changing the Sensor Head

Step 1 – Unscrew Sensor Cap

1. Hold the Sensor downwards.
2. Hold the Sensor Body with one hand and turn the Sensor Cap counterclockwise.
3. Lift up the Sensor Body. The Sensor Head sits in the Sensor Cap.

Step 2 – Remove the Sensor Head

4. Place the Sensor Cap with the Sensor Head on a stable surface.
5. Hold down the Sensor Cap with one hand while carefully pulling out the Sensor Head.
6. Slowly pull out the Sensor Head. Be careful not to hit the Sensor Head.

Step 3 – Insert new Sensor Head

7. Together with the Sensor Head you find a small pack of lubricant for the O-rings.
8. Apply grease to the two O-rings. One on the Sensor Head and one inside the Sensor Cap
9. Hold onto the Sensor Cap with one hand and gently push the Sensor Head into the Sensor Cap.
10. Press it all the way down.

Step 4 – Assemble Sensor

11. Bring the Sensor Body over the Sensor Head and Cap.
12. While still pointing the sensor downwards screw the Sensor Cap back onto the Sensor Body.

Step 5 – Let it stabilize

13. When the Sensor Head is connected to the Sensor Body let it stabilize overnight before proceeding with the calibration procedure.

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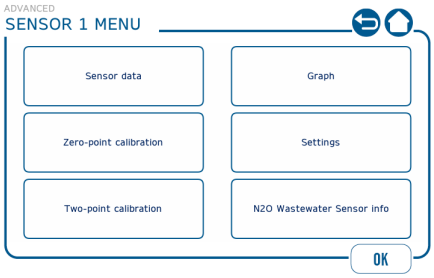
Zero-point Calibration

A Step-by-Step Guide Using the Operator Panel

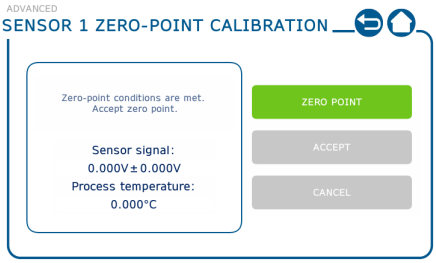
Step 1 – Start Zero-point Calibration

1. Go to the menu of the N_2O Wastewater Sensor you want to calibrate. Click the 'Manage button' ⚙ to go to the menu.
2. Click on the **Zero-point Calibration** button to start the calibration.



Step 2 – Zero Point

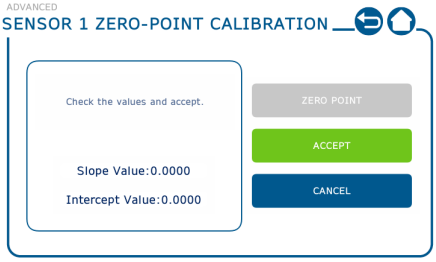
3. Place the N_2O Wastewater Sensor in tap water *without* N_2O in it.
4. The sensor is measuring the concentration in the water to set the zero point. This may take a few minutes.
5. When the **Zero Point** button goes from *orange* to *green* the Zero point conditions are met.
6. Accept the Zero point values by clicking the green **Zero Point** button.



Step 4 – Accept Calibration

7. Confirm the Slope Value and the Intercept Value and click **Accept** to accept the calibration.

The calibration is completed and you can now place the N_2O Wastewater Sensor in the wastewater tank.



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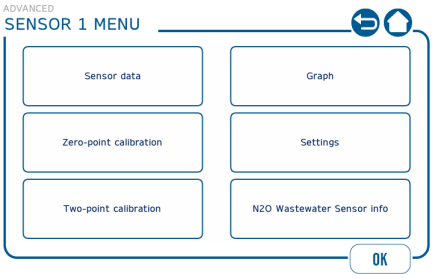
Two-point Calibration

A Step-by-Step Guide Using the Operator Console

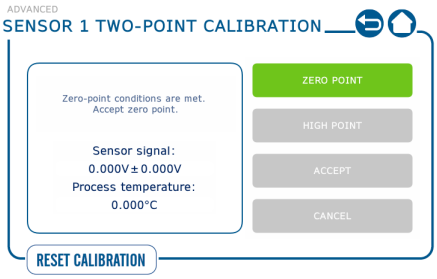
Step 1 – Start Two-point Calibration

1. Go to the menu of the N_2O Wastewater Sensor you want to calibrate. Click the 'Manage button' ⚙ to go to the menu.
2. Click on the **Two-point Calibration** button to start the calibration.



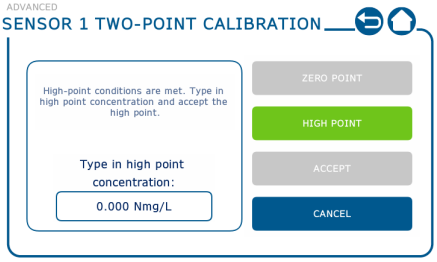
Step 2 – Zero Point

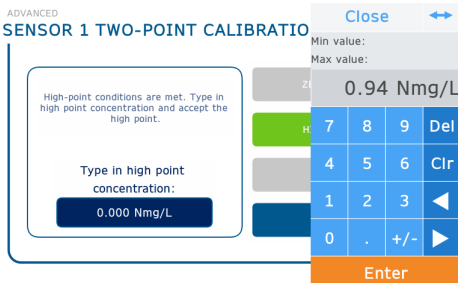
3. Place the N_2O Wastewater Sensor in tap water *without* N_2O in it.
4. The sensor is measuring the concentration in the water to set the zero point. This may take a few minutes.
5. When the **Zero Point** button goes from *orange* to *green* the Zero point conditions are met.
6. Accept the Zero point values by clicking the green **Zero Point** button.



Step 3 – High Point

7. Place the N_2O Wastewater Sensor in a stable bucket with 4 liters of tap water. Add 5 ml of the calibration solution to achieve a **0.94 mgN/L N_2O** concentration and stir for 10 seconds!
8. The sensor is measuring the concentration to find the concentration value. This may take a few minutes.
9. When the **High Point** button goes from *orange* to *green* the high-point conditions are met.
10. Click the button with the concentration to type **0.94 Nmg/L**. Press **Enter**.
11. Click the green **High Point** button to accept.

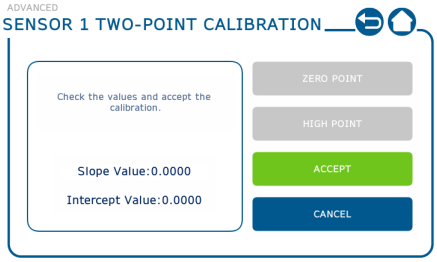




Step 4 – Accept Calibration

12. Confirm the Slope Value and the Intercept Value and click **Accept** to accept the calibration.

The calibration is completed and you can now place the N_2O Wastewater Sensor in the wastewater tank.



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Screenless Two-point Calibration

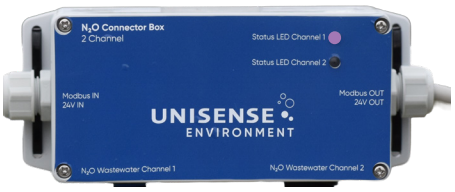
A Step-by-Step Calibration Guide

Perform a screenless calibration by following these instructions and the corresponding status LED on the N_2O Connector Unit.

Step 1 – Initiate calibration

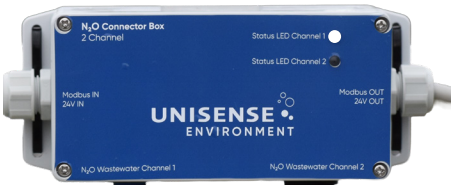
1. **Blinking blue:** The sensor is in measurement mode.
2. Hold the N_2O Wastewater Sensor vertically (sensor tip upward) for 10 seconds.
3. **Steady violet:** The calibration has started.

Note: Tilting the N_2O Wastewater Sensor up again for 10 seconds at any time cancels the calibration.



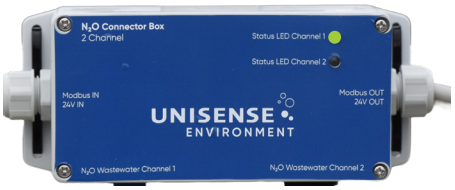
Step 2 – Zero Point

4. Place the N_2O Wastewater Sensor in tap water without N_2O in it.
5. **Blinking violet:** The sensor is measuring the concentration in the water to set the zero point. This may take a few minutes.
6. **Turning white:** The zero point has been set.



Step 3 – Reference Point

7. Place the N_2O Wastewater Sensor in a stable bucket with 4 liters of tap water. Add 5 ml of the calibration solution to achieve a **0.94 mgN/L N_2O** concentration and stir for 10 seconds!
8. **Blinking white:** The sensor is measuring the concentration to find the concentration value. This may take a few minutes.
9. **Steady green:** The reference point conditions have been met.
10. The calibration is completed and you can now place the N_2O Wastewater Sensor in the wastewater tank. The LED will be blinking blue to confirm the sensor is in measurement mode.



Cancel calibration

You can cancel the calibration by:

- hold the N_2O Wastewater Sensor vertically (sensor tip upward) for 10 seconds.
- hanging the N_2O Wastewater Sensor vertically (tip down) for 30 min, e.g. placing it back into the wastewater.

In both cases, you will cancel the calibration, and the N_2O Wastewater Sensor returns to measurement mode (blinking blue).

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