In-Situ Inc.

TENSIONOMETER 300E

OPERATION & MAINTENANCE MANUAL

March 2010

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In-Situ Inc.

Contents

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1 INTRODUCTION

This manual covers all the information required to make Gas Pressure Measurements with the Tensionometer 300E, to perform routine maintenance, and to make the basic calculations for dissolved gas analysis.

The operator is an important factor in obtaining accurate field measurement of total gas pressure. We therefore suggest that this manual be studied carefully and consulted periodically during your course of operation. It is designed to serve both as a start-up guide and as a permanent reference for the operation and care of the 300E.

Throughout the operator's manual you will see the following symbols.

The check mark highlights a tip about a convenient feature of the Tensionometer 300E

The exclamation point calls your attention to a requirement or important action that should not be overlooked

UNPACKING AND INSPECTION

Open the carrying case and check for the following items:

- Digital Meter
- Probe with 5 m cable (blue)
- External monitor cable set (black)
- Quick Start Flow Chart
- Calibration sheet
- In-Situ software/resource CD with operator's manual, gas calcu - lator spreadsheet and technical papers on Gas Supersaturation

Handle the probe with care. A severe blow can damage the internal pressure transducer.

Your Tensionometer 300E was carefully inspected before shipping. Check for any physical damage sustained during shipment. Notify In-Situ and file a claim with the carriers involved if there is any such damage; do not attempt to operate the instrument.

DO NOT ATTEMPT TO TAKE THE PROBE APART. It contains special seals and delicate components. ***Disassembling voids all warranties.***

SERIAL NUMBER

The serial number appears on the side of the 300E meter and on the probe body. These components are calibrated as a set and are designed to be used together. We recommend that owners keep a separate record of this number. In-Situ maintains complete records of original owner's names and serial numbers.

WHAT WE PROVIDE

WARRANTY PROVISIONS

In-Situ Inc. warrants the 300E for one year, and warrants membrane cartridges for 30 days, from date of purchase by the end user against defects in materials and workmanship under normal operating conditions. To exercise this warranty, contact Technical Support for a return material authorization (RMA) as outlined on page 7. Complete warranty provisions are posted on our website at www.In-Situ.com.

***TIP:** Maintenance and calibration plans are available for U.S. customers. Consult your In-Situ Representative for more information.*

HOW TO CONTACT US

Technical Support: 800 446 7488

Toll-free 24 hours a day in the U.S. and Canada

Address: In-Situ Inc.
221 East Lincoln Ave.
Fort Collins, CO 80524
USA

Phone: 970 498 1500

Fax: 970 498 1598

Internet: www.in-situ.com

e-mail: support@in-situ.com

TO OBTAIN REPAIR SERVICE (U.S.)

If the 300E fails to function properly, review this manual to make sure you are operating it correctly. If repair is required, you can help assure efficient servicing by following these guidelines:

1. Call or e-mail In-Situ Technical Support (support@in-situ.com). Have the product model and serial number handy.

2. Be prepared to describe the problem including how the instrument was being used and conditions noted at the time of the malfunction.

TIP: Please keep your RMA number for future reference.

3. If Tech Support determines that service is needed, they will ask that your company pre-approve a specified dollar amount for repair charges. When the pre-approval is received, Tech Support will assign an RMA (Return Material Authorization) number.

4. Clean the 300E and cable. Decontaminate thoroughly if it has been used in a toxic or hazardous environment. See the Cleaning Guide - lines and form on page 9.

5. Carefully pack your 300E in its original shipping box, if possible. Include a statement certifying that the instrument and cable have been decontaminated, and any supporting information.

6. Mark the RMA number clearly on the outside of the box with a marker or label.

7. Send the package, shipping prepaid, to

   In-Situ Inc.
   Attn: Repairs_
   221 East Lincoln Ave.
   Fort Collins, CO 80524

The warranty does not cover damage during transit. We recommend the customer insure all shipments. Warranty repairs will be shipped back prepaid.

Outside the U.S.

Contact your international In-Situ distributor for repair and service information.

If an instrument returned for servicing shows evidence of having been deployed in a toxic or hazardous environment, Customer Service personnel will require written proof of decontamination before they can service the unit.

GUIDELINES FOR CLEANING RETURNED EQUIPMENT

Please help us protect the health and safety of our employees by cleaning and decontaminating equipment that has been subjected to any potential biological or health hazards, and labeling such equipment. Unfortunately, *we cannot service your equipment without such notification.* Please complete and sign the form on page 9 (or a similar statement certifying that the equipment has been cleaned and decontaminated) and send it along to us with each returned instrument.

- We recommend a good cleaning solution, such as Alconox ®, a glassware cleaning product available from In-Situ (Catalog No. 0029810) and laboratory supply houses.

Decontamination & Cleaning Statement

Company Name____________________ Phone __________

Address ____________________

City __________ State ______ Zip ________

Instrument Type__________ Serial Number__________

Contaminant(s) (if known) ____________________

Decontamination procedure(s) used ____________________

Cleaning verified by __________ Title __________

Date __________

In-Situ Inc.

2 DESCRIPTION & THEORY OF OPERATION

The Tensionometer 300E is a compact, handheld field instrument that checks for supersaturation by measuring the total pressure of all gases dissolved in water—nitrogen, oxygen, carbon dioxide, argon, and so forth.

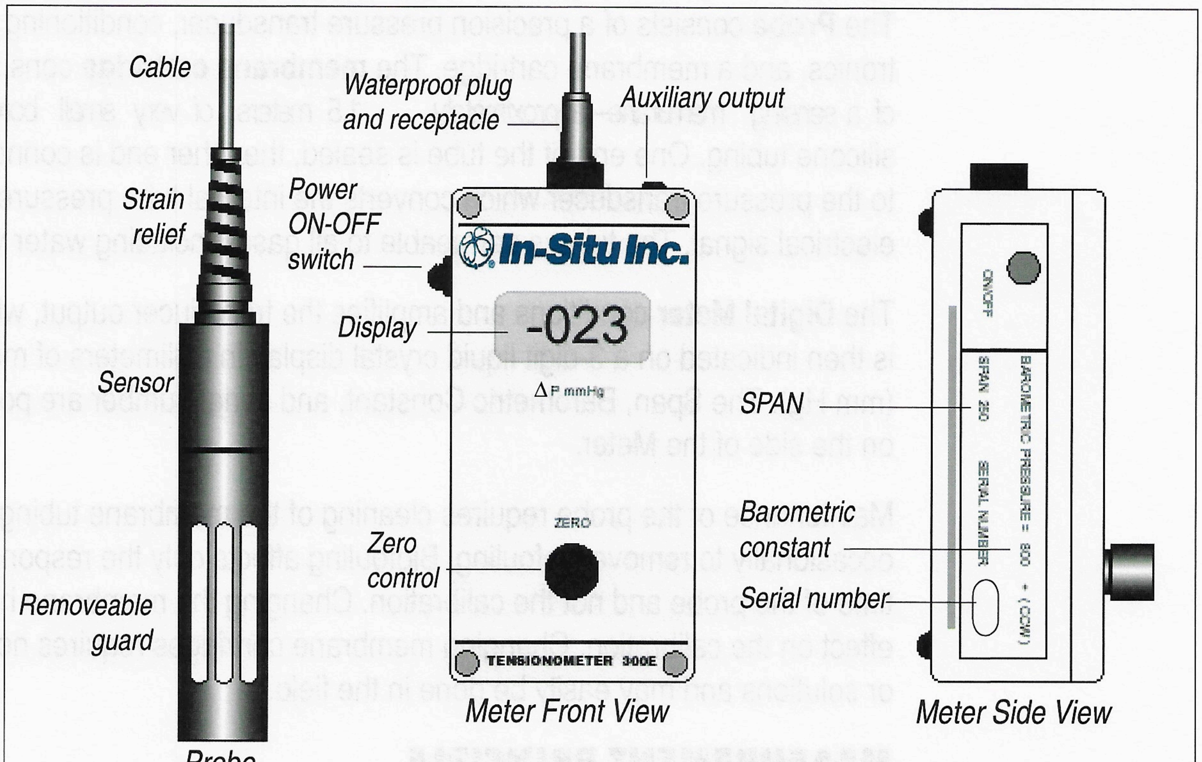
SUPERSATURATION

Supersaturation is the condition that exists when the total dissolved gas pressure in water is greater than the atmospheric pressure at the surface of the water. This can occur below dam spillways or waterfalls, in city water supplies or well water, or as the result of temperature variations or algae blooms. Faulty pump systems in hatcheries and fish farms are also a likely place for supersaturation problems to occur. Many fish kills in rivers and hatcheries have been traced to supersaturation.

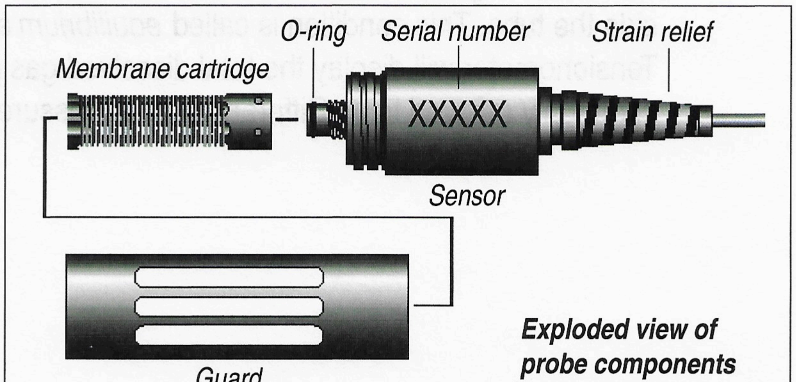
The probe-cable assembly should be used only with the digital meter that has the same serial number. Inaccurate pressure readings may result if used with other 300E digital meters.

SYSTEM DESCRIPTION

The 300E consists of a **Probe** with a 5-meter cable, and a **Digital Meter**. The components are factory-calibrated as a set and are designed to be used together.



Tensionometer 300E system components



Exploded view of probe components

The **Probe** consists of a precision pressure transducer, conditioning electronics, and a membrane cartridge. The **membrane cartridge** consists of a sensing membrane—approximately 1.5 meters of very small bore silicone tubing. One end of the tube is sealed, the other end is connected to the pressure transducer which converts the internal tube pressure to an electrical signal. The tube is permeable to all gases including water vapor.

The **Digital Meter** conditions and amplifies the transducer output, which is then indicated on a 3-digit liquid crystal display in millimeters of mercury (mm Hg). The Span, Barometric Constant, and serial number are posted on the side of the Meter.

Maintenance of the probe requires cleaning of the membrane tubing occasionally to remove biofouling. Biofouling affects only the response time of the probe and not the calibration. Changing the membrane has no effect on the calibration. Changing membrane cartridges requires no tools or solutions and may easily be done in the field.

MEASUREMENT PRINCIPLE

When the probe is immersed in water, gases effuse through the tubing wall until the gas pressure inside the tube is equal to the gas pressure outside the tube. This condition is called *equilibrium* and when reached, the Tensionometer will display the total dissolved gas pressure in the water, commonly referred to as Differential Gas Pressure (ΔP).

ABOUT ΔP

The Tensionometer 300E displays Differential Gas Pressure (ΔP) in millimeters of mercury (mm Hg).

Differential Gas Pressure is defined as the difference between the atmospheric pressure at the surface of the water and the sum of all the partial pressures of the gases, including water vapor, dissolved in the water.

- If the pressure (ΔP) is **positive**, the water is said to be **super-saturated**.
- If the pressure (ΔP) is **negative**, the water is said to be **under-saturated.**

ΔP (mm Hg) is the standard reporting unit; however, it is sometimes useful to report the measurement in percent saturation. A simple calculation will convert the ΔP into % SAT. See the calculations in the Appendix, or use the gas calculator spreadsheet included on the CD.

ΔP is used primarily to allow determination of a safe depth for fish to escape the effects of supersaturated water. For a bubble to form, the ΔP of the dissolved gases must be higher than the confining hydrostatic pressure. For instance at a depth of one meter in fresh water, ΔP needs to exceed 73 mm Hg. At two meter depth it would be approximately 140 mm Hg, and so on. This is why at shallow depths even low values of ΔP can be lethal.

PRODUCT SPECIFICATIONS

Measurement Range:	∆P Differential Gas Pressure, ± 750 mm Hg
Resolution:	1 mm Hg
Accuracy	
∆P:	± 1 mm Hg over operating temperature range
Barometer:	± 6 mm Hg
Equilibrium Time:	5 minutes to 90% of final value in 11°C water
Operational Temperature	
Probe:	0°C to +45°C (32°F to 113°F)
Meter:	-20°C to +40°C (-4°F to 104°F)
Storage Temperature	
with membrane:	0°C to +60°C (32°F to 140°F)
without membrane:	-40°C to +60°C (-40°F to +140°F)
Maximum Depth	
Measurement:	53 meters (173 ft)—limit of accurate measurement
Pressure sensor:	60 meters (196 ft)—damage to the sensing element may occur beyond this depth, voiding warranty
Environmental Rating:	Meter IP65—water-resistant, not submersible
Batteries:	2 x 9V alkaline
Battery Life:	150-200 hours @ 20°C (68°F)
Low Battery Indication:	13.8 VDC (approximately 15 hours left in batteries)
Display:	3 digit liquid crystal
External Monitor:	1 mm Hg = approx. 0.002 volts. See individual calibration sheet for additional information

REPLACEMENT PARTS

REPLACEMENT PARTS	Catalog No.
Membrane Cartridge	70-020
9V Battery (1)	2101-0001
Refurbishment of returned membrane cartridge*	70-020RW

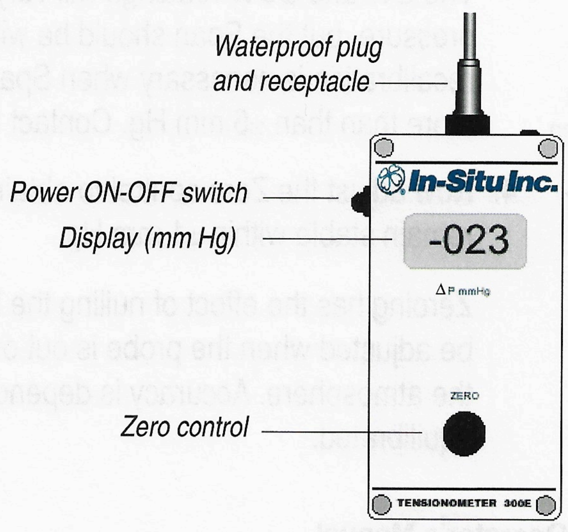
* *Call Tech Support for an RMA number; see page 7 for details.*

3 GETTING STARTED

This section provides a quick overview of the initial steps necessary to get the Tensionometer 300E ready to measure gas pressure.

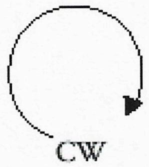
CONNECTIONS

1. Connect the probe to the meter, ensuring the plug seats properly into the socket.
2. Turn on the power. The digital display should stabilize to a value in a few moments and remain within ±1 mm Hg of that value.

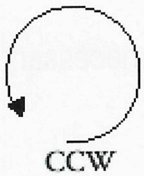


CALIBRATION AND OPERATION CHECK

To check calibration and operation:



1. With the power ON, rotate the Zero control fully clockwise (CW), and note the reading, including the sign.
2. Rotate the Zero control fully counterclockwise (CCW) and again note the reading, including the sign.



3. Derive the Span from the following equation:

$$\text{SPAN} = \text{CW} - [\text{CCW}]$$

For example:

$$\text{CW} = 210$$
$$\text{CCW} = -40$$
$$\therefore \text{SPAN} = 210 - [-40] = 250$$

The CW and CCW readings will vary as a function of barometric pressure, but the Span should be within ±2 mm Hg of 250. Factory recalibration is necessary when Span values vary from 250 mm Hg by more than than ±6 mm Hg. Contact In-Situ as described on page 7.

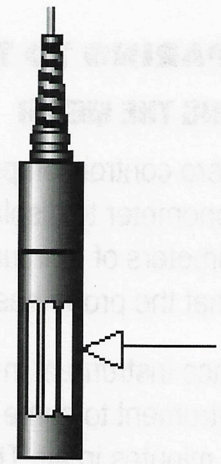
Factory recalibration is necessary when Span values vary from 250 mm Hg by more than ±6 mm Hg.

4. Now adjust the Zero control to obtain a 000 reading. The value should remain stable within ±1 mm Hg.

Zeroing has the effect of nulling the barometric pressure. This should be adjusted when the probe is out of water and has equilibrated with the atmosphere. Accuracy is dependent on how well the probe has equilibrated.

5. As an additional check, exhale over the tubing as illustrated by the arrow in the figure below. This will cause a brief positive 2 or 3 mm Hg increase in pressure because of the increase in temperature of the gas inside the tube.

   If the membrane is wet when you blow across the tubing it will evaporate the water and lower the temperature inside the tubing. In this case a drop of 2 or 3 mm Hg will result.



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4 OPERATION

PREPARING TO TAKE MEASUREMENTS

ZEROING THE METER

The Zero control compensates for local barometric pressure, enabling the Tensionometer to display the Differential Gas Pressure (ΔP) of the water in millimeters of mercury (mm Hg). Before adjusting the Zero control, be sure that the probe has reached **Barometric Equilibrium.**

Handle the probe with care. A severe blow can damage the internal pressure transducer.

1. Place instrument in the vicinity of your measurement and allow the instrument to come to ambient barometric pressure. This may take 20-25 minutes in air. The 300E does not need to be powered during this stabilization period.
2. Turn the instrument ON. Observe the reading on the display. Wait a few more minutes for the reading to stabilize.
3. Adjust the Zero knob until the display shows 000.

- The probe is at barometric equilibrium if the 000 reading is stable within ±1 mm Hg over a five-minute period.

Once barometric equilibrium has been reached, you are ready to take a water measurement.

TAKING A WATER MEASUREMENT

1. Be sure the instrument is at barometric equilibrium and the display has been zeroed and is stable, as described above.

2. Fully submerge the probe in the water to be sampled.

   If the water is warmer than the air temperature, expect an immediate positive reading of a few mm Hg. If the water is colder than ambient, a negative reading will occur.

3. Agitate the probe at least once a minute.

4. After about 3-5 minutes note the reading.

   During the first 5 minutes, the reading will reach approximately 90% of its final value. Continue to agitate the probe every minute.

   Equilibrium is reached when the pressure inside the sensing membrane is equal to the pressure outside. As equilibrium is approached, the reading over a five-minute period should be stable within 2 mm Hg. If the pressure increases only slightly—say 1 or 2 mm Hg—between one-minute readings, then you are close enough to equilibrium.

5. When the display has stabilized, record the reading. This value is the **difference** (ΔP) between the total dissolved gas pressure and the local ambient barometric pressure in mm Hg.

6. Remove the probe and proceed to the next measurement . There is no need to zero the instrument but if you wish to re-zero be sure the probe has reached barometric equilibrium, as described earlier in this section.

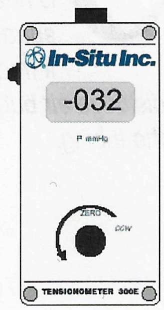
TIP: *If the probe is near the surface, agitate it frequently to dislodge air bubbles from the tubing.*

TIP: *Power may be turned OFF at any time without affecting either the zero setting or the water reading. If you turn off the instrument to conserve battery power, allow a 20 second warm up before reading the display again.*

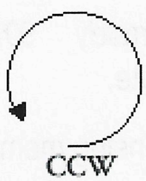
MEASURING BAROMETRIC PRESSURE

When calculating total gas pressure TGP (%) and Nitrogen N (%), local barometric pressure must be known. By following a simple procedure the 300E can measure barometric pressure accurately and display it in millimeters of mercury (mm Hg).

Before making a barometric measurement, allow the probe to reach barometric equilibrium in the air. Once the reading has stabilized, the pressure inside the probe sensing membrane is equal to the barometric pressure—in other words, the 300E is responding as an accurate barometer.



To calculate barometric pressure,



1. Rotate the Zero control fully counterclockwise and note the pressure reading.
2. Use that value in the following equation to obtain Local Barometric Pressure:

$$\text{Barometric Pressure} = \text{Barometric Constant} + (\text{CCW})$$

Where: CCW = Tensionometer reading with Zero control fully counterclockwise

Barometric Constant posted on side of Tensionometer (see Checking the Barometric Constant for additional details)

Example

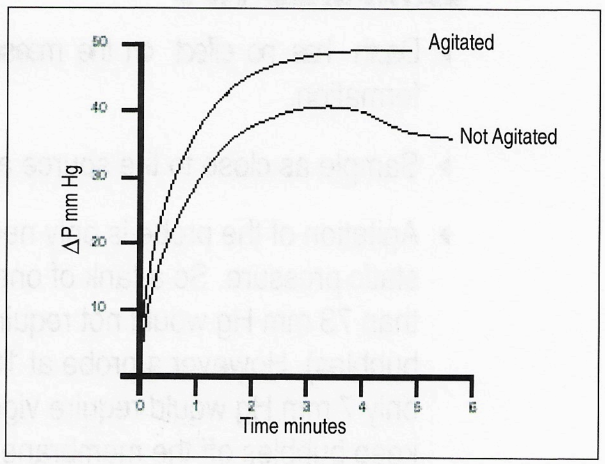
$$\text{CCW} = -032$$

$$\text{Barometric Constant} = 800$$

$$\therefore \text{Barometric Pressure} = 800 + (-032) = 768 \text{ mm Hg}$$

FACTORS AFFECTING ACCURACY

- **Bubble Formation.** The accurate measurement of ΔP depends in part on a pressure equilibrium between gases dissolved in the water and gases inside the sensing membrane. However, when the probe is used in relatively shallow supersaturated water, bubbles soon form on the tubing, promoted by reduced surface tension at the water-tubing interface and the presence of gas nuclei. Once a bubble has formed, a three-phase pressure system exists between the water, the tubing, and the bubble. Pressure inside the bubble is roughly equal to the water pressure over it. In this case, a net flow of gases will occur across the tubing into the bubble, where gas pressures are usually lower than in the water. Therefore, bubbles on the silicone tubing usually increase in size and number, thereby reducing the gas pressure from both the instrument and the water; this collectively can result in erroneously low estimates of ΔP and bias all calculations dependent on it. The values can be as much as 20% low, as shown in the graph below.



ΔP versus time in supersaturated water, comparison between agitated probe (top line) and not agitated (lower line)

-38 (762) =(756) 756.5

To observe this phenomenon leave the probe in supersaturated water for five minutes without agitating it. (Warm tap water is usually supersaturated.) A magnifying glass will show the very fine bubbles forming on the membrane.

- Dirt, oil, or algae buildup on the membrane will slow response time. See Section 6 for cleaning recommendations.
- Improper setting of the Zero control. See the procedure on page 18.

FACTORS AFFECTING RESPONSE

- Water temperature affects response time; higher temperatures shorten the response time as the gas has higher thermodynamic energy. Conversely, lower temperatures retard the response time.
- Restrictions anywhere in the membrane will extend the response time and cause low readings.

SAMPLING TIPS

- Depth has no effect on the measurement except for the issue of bubble formation.
- Sample as close to the source as possible.
- Agitation of the probe is only necessary if the ΔP exceeds the hydro - static pressure. So a tank of one meter depth with gas pressures lower than 73 mm Hg would not require agitation of the probe (to remove bubbles). However a probe at 100 mm depth with gas pressures of only 7 mm Hg would require vigorous back and forth movement to keep bubbles off the membrane.

***TIP:** If in doubt as to the Zero setting, remove the probe from the water and allow it to reach barometric equilibrium, re-zero, and repeat the water measurement.*

Remember, whenever adjusting the Zero control be sure that the probe has been allowed to reach barometric equilibrium.

- Once the Tensionometer has been zeroed, re-zeroing during the course of your measurements is often unnecessary. If, however, you suspect the barometric pressure is changing rapidly, then re-zeroing the instrument will be necessary every two hours.

  To re-zero during measurements:

  1. Remove the probe from the water and allow it to reach barometric equilibrium (about 25 minutes in air).
  2. Adjust the Zero control for a stable 000 reading.

- If the Zero control is accidentally moved during the course of your measurements, remove the instrument from the water and re-zero.

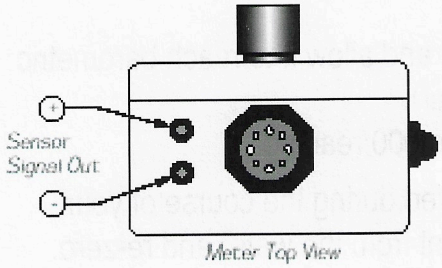
- To help in identifying the equilibrium point, we suggest plotting a graph of pressure versus time. Equilibrium is reached after about three minutes. The reading may then climb slowly, perhaps 1 mm Hg every five minutes, but that slight increase can be disregarded, except in high-accuracy situations.

- Some users provide a quasi automatic system consisting of a sampling bucket supplied with water continuously through a hose. This works well provided no heating or cooling of the sampled water occurs. Some caution is necessary if a pump is used to transport the water through the hose. **Use only a submerged pump;** this will minimize differences in gas pressures between the inlet and outlet. The water circulating in the bucket is enough to prevent bubble formation on the membrane.

- Aeration attempts to equilibrate the dissolved gas pressure with the atmosphere.

USE OF CHART RECORDER OUTPUT

The external monitor output is situated next to the probe cable connector on the meter. RED is the positive output, BLACK is ground. Use the supplied plugs for connecting to the output monitor.



The external monitor output may be connected directly to a chart recorder or other analog recording device. A hard copy can be very useful for measurements and for long-term monitoring.

The external monitor provides a voltage output directly proportional to the reading.

1 mm Hg = .002 volts output (approximately). Check the calibration sheet for exact conversion.

5 CALIBRATION

The pressure sensing element of the 300E is factory-calibrated. No user calibration is possible or necessary.

TIP: Many customers return their tensionometer once a year for a checkup which includes calibration. Contact In-Situ Technical Support for the cost of this service.

CHECKING THE SPAN

The overall calibration of the 300E can easily be verified by checking the Span reading. See page 16 for the procedure.

If the reading differs from the posted Span on the side of the meter by more than ±6 mm Hg, then calibration is necessary.

Since an accurate pressure source is required for calibration it is recommended that the 300E be returned to In-Situ Inc. Contact Technical Support as described on page 7.

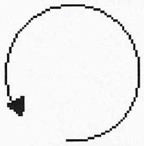
BAROMETRIC PRESSURE (BP) CALIBRATION

CHECKING THE BAROMETRIC CONSTANT

TIP: Ask for local station pressure in mm Hg, <u>not corrected to sea level</u>.

1. To calibrate, an accurate barometer is required—preferably a mercury barometer. Use airport metrological information with caution. Local conditions can vary dramatically, especially if your site is some distance from the airport.

2. Rotate the Zero control fully counterclockwise.



CCW

3. Calculate the Barometric Constant from the following equation:

CONSTANT = BP – (CCW)

Where:

BP = barometric pressure in mm Hg

CCW = Tensionometer reading in mm Hg with Zero control set fully counterclockwise

Example

BP = 760 mm Hg, from an accurate barometer

CCW = –50 mm Hg, from the Tensionometer display

∴ Barometric Constant = 760 –(–50) = 810 mm Hg

4. Post this new value on the side of the meter and use it in all further calculations.

6 CARE & MAINTENANCE

DO NOT ATTEMPT TO TAKE THE PROBE APART. It contains special seals and delicate components. Disassembling voids all warranties.

Do not store the probe in a sealed plastic bag.

Repairs or servicing not covered in this manual must be carried out by the manufacturer. Contact In-Situ as described on page 7.

THE PROBE

- Store the probe out of direct sunlight and protect it from excessive moisture. **Do not store the probe in a sealed plastic bag.**
- If the probe has been used in brackish, dirty, or otherwise contaminated water, be sure to rinse the probe in clean water after use, and clean the membrane. **Do not let contaminants dry on the probe surface.**

THE SENSING MEMBRANE CARTRIDGE

The membrane cartridge, if handled carefully, can last indefinitely. Membranes with five years' field usage have been tested and found to have characteristics identical to those of new membranes. The most significant factors that will deteriorate the tubing are direct sunlight, dirt buildup, and biofouling.

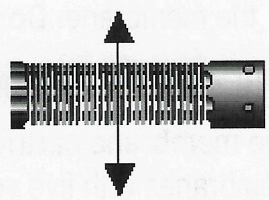
CLEANING THE MEMBRANE CARTRIDGE

If the probe is being used in brackish, dirty, or otherwise contaminated water, be sure to clean the membrane cartridge regularly. This can be done without removing the cartridge from the probe.

We recommend you leave the membrane cartridge attached to the probe for cleaning. If removed, take care to prevent water from entering the open end of the cartridge.

Be very careful to brush only in the direction indicated.

1. Insure the meter is powered off.
2. Carefully remove the slotted guard by turning counterclockwise. Leave the membrane cartridge attached to the probe.
2. Prepare a warm soapy solution in a 500 mL beaker or similar container. Use a mild, non-oily soap.
3. Submerge the membrane cartridge in the warm soapy solution.
4. Using a SOFT toothbrush gently stroke the membrane filament as shown below. This will remove most attached dirt and debris. Do not pinch the membrane against the support. **Use care, as the membrane material is sensitive to nicks and abrasions.**



- Biofouling may be removed by rinsing in a dilute solution of common household bleach (4 parts water to 1 part bleach).
- Do not soak in any chemical solution for more than one minute.
- **Never use strong acid or alkaline solutions.**

5. Rinse thoroughly in clean water.

REMOVING THE MEMBRANE CARTRIDGE

To replace the membrane cartridge, or check for moisture in the tubing, first remove the cartridge from the probe.

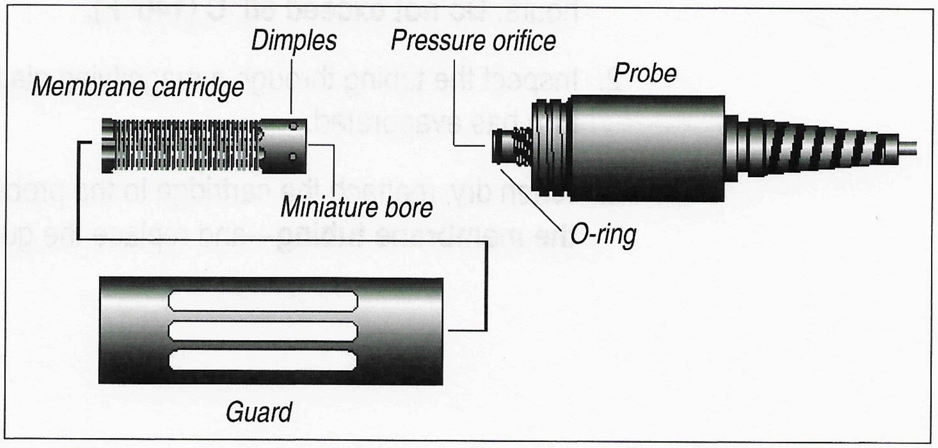
1. Insure the meter is powered off.
2. Carefully remove the slotted guard by turning counterclockwise.
3. Using your thumb and forefinger, grip the membrane cartridge at the dimples, located at the probe end. Gently unscrew the assembly, **taking care not to touch the membrane tubing.** Place the cartridge in a safe clean area.

To avoid permanent damage to the sensor, do not put anything into the pressure sensor orifice.

If the miniature bore is blocked, the membrane cartridge will need to be replaced.

While the cartridge is off—

- Inspect the face of the pressure orifice on the probe. If any beads of moisture appear on the surface, gently remove them with a tissue. **Do not put anything into the small hole.**
- Inspect the cartridge where it fits onto the probe. It should be clean and free of moisture. Carefully remove any debris or moisture with a tissue. **Be sure the miniature bore is not blocked.** If the bore is clogged or plugged, the entire membrane cartridge will need to be replaced.



LEAKY MEMBRANE

If the membrane appears to be leaking, replace the entire cartridge.

As an emergency measure, the leak may be temporarily repaired: Allow the membrane to dry completely, apply a small dab of silicone glue to the leak, and allow 24 hours for a full cure. Replace the membrane cartridge as soon as possible.

REMOVING WATER CONDENSED IN THE MEMBRANE

If the probe is left in water for long periods, water vapor will eventually effuse through the membrane wall where it can condense and create pockets of water. This will affect the response and the accuracy of your readings.

To dry the membrane:

1. Remove the membrane cartridge from the probe as described above and place it on a clean, dry, warm surface—between 35° and 55° C (95° to 131°F)—**out of direct sunlight** for a day or two.

   Alternatively, the cartridge may be placed in a warm oven for a few hours. **Do not exceed 60° C (140° F).**

2. Inspect the tubing through a magnifying glass to ensure that all moisture has evaporated.

3. When dry, reattach the cartridge to the probe—**take care not to touch the membrane tubing**—and replace the guard.

REPLACING THE MEMBRANE CARTRIDGE

The response and integrity of the membrane can be checked when you replace the cartridge.

1. Remove the old membrane cartridge from the probe as described above.
2. Attach the probe to the meter, turn on the power, and zero the display.
3. Mount the new membrane cartridge. As the o-ring on the probe engages the cartridge you will see an **increase** in the reading.
4. Tighten the cartridge until it seats. The display should read a value greater than 250 mm Hg.
5. As gas effuses through the membrane, the displayed value will **decrease**. This equilibrium takes about 2-5 minutes.
   - If the reading stays at its upper value, there is a constriction in the membrane.
   - If the reading drops too quickly (< 1.5 minutes), a leak in the membrane is possible.

If the reading fails to equilibrate or drops too quickly, replace the membrane cartridge.

If the membrane is constricted or leaky, the membrane cartridge should be replaced. If you don't have a spare, contact In-Situ Technical Support as described on page 7.

GENERAL RESPONSE CHECK

The response of the 300E may be checked at any time without dismantling the probe. Rise and decay curves if plotted will approximate the shape of a natural log function.

1. Fill a small container, such as a drinking glass, with plain seltzer or carbonated water at room temperature.
2. Turn on the Tensionometer and zero the display.
3. Submerge the probe until the membrane is fully immersed. The displayed value should rise rapidly.

Do not exceed 700 mm Hg.

Do not exceed 700 mm Hg or possible membrane damage could occur. Remove probe from solution quickly if this value is approached.

4. Remove the probe from the solution and rinse in clean water.

BATTERY REPLACEMENT

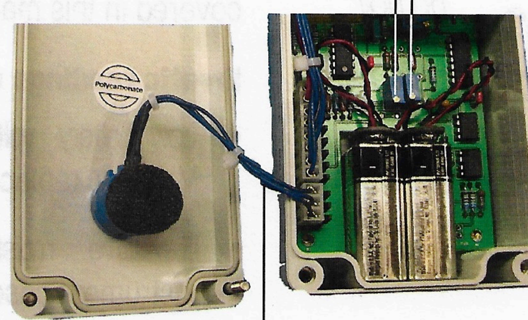
Replace the batteries at least once a year with 9V alkaline batteries. They are readily available from electronic suppliers, or from In-Situ Inc. (Catalog No. 2101-0001). Two are required.

To replace the batteries:

1. Loosen the screws at all four corners of the meter cover with a screwdriver (either type).

2. Gently remove the cover. Be careful not to detach the harness wires.

Do not touch the calibration screws when replacing the batteries.



3. Pull each 9V battery out and unplug the connectors. Attach new batteries to the battery connectors as marked, and press the new batteries into place.
4. Close the cover—be careful not to pinch the wires—and tighten the screws.

***TIP:** Do not leave exhausted batteries in the meter. If the unit is not being used for long periods, remove the batteries.*

Fresh batteries will provide a total of 18 volts. The batteries will operate the unit for approximately 150 hours. Under normal conditions this should operate the 300E for one year.

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7 TROUBLESHOOTING

If the Tensionometer 300E fails to respond to the procedures in the Operations section, several checks can be made. Repairs or servicing not covered in this manual must be carried out by the manufacturer.

DO NOT ATTEMPT TO TAKE THE PROBE APART. It contains special seals and delicate components. Disassembling voids all warranties.

Erratic readings or instrument fails to zero

- Low battery voltage. The sum of the two 9 V batteries must exceed 11 V. If low, replace the batteries. See Battery Replacement in Section 6.
- Excessive moisture in meter. Look for condensation or water in the instrument case. Allow to dry thoroughly.
- Water in the connectors. Disconnect and allow to dry thoroughly.
- Cable disconnected or damaged. If cable is damaged contact In-Situ as described on page 7.
- Pressure transducer damaged. Contact In-Situ as described on page 7.

Meter reading stuck on a high value (> 600)

- Probe plug disconnected. Ensure plug is seated properly and the locking ring is tightened.
- Broken wire in the probe cable. Contact In-Situ as described on page 7.

- Failed transducer. Contact In-Situ as described on page 7.

Span reading inaccurate

- If instrument is otherwise functioning normally, calibration will be necessary. Contact In-Situ as described on page 7.

Instrument zeros but no reading in water

- Water may be at equilibrium with air. This actually happens. Check another sample.

If you are in doubt about the condition of your membrane cartridge, contact In-Situ as described on page 7. Accuracy of ALL your measurements depends on it.

- Place probe in warm water. If still no reading, membrane may be restricted. Replace the membrane cartridge. Or contact In-Situ as described on page 7.
- Water condensed in membrane. See drying instructions in Section 6.

Instrument takes too long to reach equilibrium

- Dirty or oily membrane. Refer to cleaning instructions in Section 6.
- Water condensed in membrane. See drying instructions in Section 6.

Readings increase then decrease even though water has not changed

- Bubbles forming on the membrane surface. Agitate to remove. They can be quite stubborn.

Readings seem to follow the depth of the probe

- Leaky membrane. Replace the cartridge. See temporary membrane repair recommendations in Section 6.

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APPENDIX: CALCULATIONS

TIP: A spreadsheet for doing the calculations is included on the In-Situ software/resource CD with the 300E.

This Appendix covers the most common dissolved gas computations. It is not the intent of this manual to give an exhaustive treatment of dissolved gas calculations. For a comprehensive treatment of dissolved gas analysis as it relates to aquaculture, we recommend the following publication:

Colt, J., 1984, reprinted 2002. *Computation of Dissolved Gas Concentrations in Water as Functions of Temperature, Salinity, and Pressure.* A handbook of equations and data for aquaculturists, physiologists, power-plant operators, river managers, and anyone concerned with gas concentrations and supersaturation. Special Publication 14 of the American Fisheries Society.

Available from:

American Fisheries Society
5410 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814-2199
Phone: (301) 897-8616
www.fisheries.org

TERMS USED IN SAMPLE CALCULATIONS

BP = Local Barometric Pressure, mm Hg. Obtain from 300E (see Measuring Barometric Pressure in Section 4) or other accurate source

ΔP = Tensionometer reading, mm Hg

C_{O_2} = DO = Dissolved Oxygen Concentration, mg/L

B_{O_2} = Bunsen coefficient for Oxygen as a function of temperature

- For fresh water use Table 2 (located on CD)
- For saline water use Table 4 (located on CD)

P_{H_2O} = Vapor pressure of water as a function of temperature, mm Hg

- For fresh water use Table 1 (located on CD)
- For saline water use Table 3 (located on CD)

T = temperature, °C

VALUES USED IN SAMPLE CALCULATIONS

T = 13.9° C

BP = 760.0 mm Hg

ΔP = 38.0 mm Hg

C_{O_2} = DO =7.39 mg/L

B_{O_2} = 0.03503

P_{H_2O} = 11.91 mm Hg

ΔP **Total Differential Gas Pressure**

Once zeroed, the Tensionometer displays ΔP in mm Hg directly.

TGP (%) **Total Gas Pressure as a Percent of Local Barometric Pressure**

$$TGP\ (\%) = \left[\frac{BP + \Delta P}{BP}\right] \bullet 100$$

$$= \left[\frac{760 + 38}{760}\right] \bullet 100$$

$$= \boxed{}$$

N_2 (%) **Saturation of Nitrogen Gas**

Also includes argon, carbon dioxide, and other inert gases present.

$$N_2\ (\%) = \left[\frac{BP + \Delta P - 0.5318\left(\frac{DO}{B_{O_2}}\right) - P_{H_2O}}{0.7902\ (BP - P_{H_2O})}\right] \bullet 100$$

$$= \left[\frac{760 + 38 - 0.5318\left(\frac{7.39}{}\right) - 11.91}{0.7902\ (760 - 11.91)}\right] \bullet 100$$

$$= \boxed{114\ \%}$$

O_2 (%) **Saturation of Oxygen**

$$O_2\,(\%) = \left[\frac{0.5318\left(\dfrac{DO}{B_{O_2}}\right)}{0.20946\,(BP - P_{H_2O})}\right] \bullet 100$$

$$= \left[\frac{0.5318\left(\dfrac{7.39}{\quad}\right)}{0.20946\,(760 - 11.91)}\right] \bullet 100$$

$$= \boxed{71.59\ \%}$$

ΔP_{N_2} **Differential Pressure of Nitrogen in mm Hg**

Also includes argon, carbon dioxide, and other inert gases present.

$$\Delta P_{N_2} = BP + \Delta P - 0.5318\left(\frac{DO}{B_{O_2}}\right) - P_{H_2O} - 0.7905\,(BP - P_{H_2O})$$

$$= 760 + 38 - 0.5318\left(\frac{\quad}{0.03503}\right) - 11.9 - 0.7905\,(760 - 11.9)$$

$$= \boxed{82.53\ \text{mm Hg}}$$

ΔP_{O_2} **Differential Pressure of Oxygen in mm Hg**

$$\Delta P_{O_2} = 0.5318 \left(\frac{DO}{B_{O_2}} \right) - 0.20946 \, (BP - P_{H_2O})$$

$$= 0.5318 \left(\frac{7.39}{} \right) - 0.20946 \, (760 - 11.9)$$

$$= \boxed{-44.507 \text{ mm Hg}}$$

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