THORNTON
Leading Pure Water Analytics

Part No. 52201072

High Performance Dissolved Oxygen Sensors Instruction Manual

58 037 204 - 58 037 207
58 037 404 - 58 037 407
58 037 010 (357-210)
58 037 202 (367-210)

METTLER TOLEDO

IMPORTANT SAFETY INFORMATION

This manual includes safety and critical information with the following designations and formats:

WARNING: POTENTIAL FOR PERSONAL INJURY.

CAUTION: possible product damage or malfunction.

NOTE: important operating information.

Part 34 100 2016, a 25mL bottle of O_2-Electrolyte included with the 52 201 067 dissolved oxygen probe has an associated **Material Safety Data Sheet** included with this sensor. Maintain a copy of the MSDS in your material safety file.

INTRODUCTION

This manual covers installation, operation and maintenance of the Mettler-Toledo Thornton High Performance Dissolved Oxygen (DO) Sensors. For information on the measuring instruments, consult their respective manuals.

The dissolved oxygen sensor consists of:

- 52 201 067 analog DO Probe or 52 003 821 ISM DO Probe, and electrolyte bottle
- 58084012 (17490) Flow housing with 1/4" NPTF ports
- DO Preamplifier with 770MAX or 2000 sensors, or VP cable with M300 sensors, or AK9 cable with M300 ISM sensors.

For a complete measurement system with model 2000 or 770MAX Instruments, a patch cord is also required. The sensors for M300 instruments include a cable identified below.

Complete Sensor	Preamp or cable	Instrument
58037010 (357-210)	58037011 (357-201) preamp	770MAX
58037201 58037202 58037203 58037204	52300107 1 m cable 52300108 3 m cable 52300109 5 m cable 52300110 10 m cable	M300
58037404 58037405 58037406 58037407	100000102 1 m cable 100000302 3 m cable 100000502 5 m cable 100001002 10 m cable	M300 ISM
58037202 (367-210)	580370203 (367-201) preamp	2000

These sensors are designed for monitoring low concentrations of dissolved oxygen in power plant, semiconductor, and pharmaceutical pure water samples and similar applications. They provide long-term operation with minimal maintenance.

OVERVIEW OF OPERATION

These DO sensors use a gas permeable membrane to separate the sample from the electrochemical cell inside. Oxygen diffuses through the membrane in direct proportion to the partial pressure of oxygen outside the sensor. The cathode and anode inside the probe are polarized with a voltage to enable the electrochemical reaction of oxygen. Oxygen is reduced at the cathode while the anode is oxidized, producing a small current in direct proportion to the amount of oxygen reacting. The very small current developed by these sensors allows them to have a long life with low maintenance.

A guard ring electrode around the cathode prevents extraneous oxygen either from within the probe or from the sides of the membrane from causing a response. This enables especially rapid response to low ppb samples after air calibration or other exposure to high oxygen concentrations.

Temperature compensation adjusts for the changing permeability of the membrane with temperature. In addition, the instrument uses the temperature value to convert the oxygen partial pressure signal to a dissolved oxygen concentration value by compensating for the changing solubility of oxygen with temperature.

For calibration, the probe is normally removed from the flow housing for exposure to air which provides a standard oxygen partial pressure. An instrument setting (with M300 or 2000 instrument) or automatic atmospheric pressure measurement (with 770MAX instrument) accounts for differences in barometric pressure during calibration.

ISM Models

5803740X model sensors include Intelligent Sensor Management with the measurement circuit, analog to digital conversion and extensive memory contained within the sensor. The integrated ISM functionality allows extensive monitoring of the sensor. Stored in the sensor are the serial number, type of sensor, order number, calibration data and temperature exposure data.

When starting up, the following processes are initiated automatically: digital communication, plug & measure, pre-calibration, predictive maintenance.

INSTALLATION

The sensor location should be in a protected indoor area with reasonably stable and uniform temperature with no radiant sources of heat such as steam pipes nearby.

Sample line design and installation must preserve the integrity of the very low DO concentrations to be measured. Fittings, flowmeters and all connections must be gas tight to prevent aspirating traces of air which would cause erroneous readings.

Stainless steel sample lines are recommended to prevent permeation of oxygen into the sample. If a length of flexible line must be used, make it as short as possible (< 3 ft, 1 m), thick walled and of a material with low permeability such as PVDF, polypropylene or Nylon. Silicone and PVC (Tygon) are NOT recommended for low ppb samples.

IMPORTANT: Before installation, the probe electrolyte solution must be replaced to correct for any drying in storage and to achieve full response and stability. Follow the Service Procedure.

The sample system should be able to provide between 50 and 1000 mL/min flowrate.

1. Mount the flow housing, allowing room above the probe for convenient removal for calibration as shown in Figure 1.
2. For models with preamp, mount the preamp box using the mounting holes and hardware appropriate for the panel. Orient the preamp box with the probe cable coming out of the top. See Figure 1. The preamp box must be earth grounded, either by mounting screws fastened to a grounded panel or by a user-supplied earth ground cable. Locate the preamp above or to the side of the housing to keep any dripping water away from the preamp. The distance between the probe and preamp must be less than the 3 ft (1 m) cable length between them. Connect the patch cord from the instrument (not included with sensor) to the bottom connector of the preamp box.
3. Flush the upstream sample line at high flowrate to remove any debris and/or corrosion products before connecting the flow housing.
4. Install appropriate fittings to the 1/4" NPT ports of the flow housing using PTFE tape or pipe sealant.

CAUTION: Tighten fittings only one turn past hand tight. Do not over-tighten or the flow housing tapered pipe threads may be stripped.

5. Connect the sample line and drain to the fittings. **The bottom port is the inlet.**

CAUTION: Use a second wrench when connecting the sample line to a compression fitting to prevent over-tightening the pipe thread into the flow housing and possibly stripping the threads.

6. **IMPORTANT:** Be sure the electrolyte solution has been replaced in the probe before proceeding. Connect the cable to the connector of the probe by rotating until the they are aligned and the parts slide together. Tighten the connector by hand only.
7. Remove the protective cap and Install the probe in the flow housing. Set the sample flowrate at 50 – 1000 mL/min. Save the cap for protection when the probe is removed from the flow housing.
8. After at least 6 hours of powered operation including at least an hour of acclimation to the process sample, perform an air calibration as described below.
9. For 58 037 202 (367-210) models only, find the Adder (A) value from the label on the preamp VP cable. Enter that value as the Adder (A) in the Model 2000 transmitter via MENUS / Edit Sensor Cal to compensate for any offset in the preamp circuit.

CALIBRATION

Calibration of the probe calculates new calibration constants for the sensor—an Adder (zero or offset) and a Multiplier (span or slope). The Cell Adder is normally near zero, accounting primarily for zero offset in the electronics. The Multiplier is nominally 1.0 and is recomputed whenever an air calibration is performed.

Calibration data for the 58 037 204 - 58 037 207 sensors used with the M300 is accessed via the CAL / Edit mode.

Calibration data for the 58 037 010 (357-210) sensor used with the 770MAX is stored in non-volatile memory and can be viewed under the Measurements / Page Down menu for the appropriate channel.

Calibration data for the 58 037 202 (367-210) sensor used with the Mettler-Toledo Thornton 2000 instrument can be viewed at any time under the MENUS / Edit Sensor Cal menu as described in the 2000 instruction manual.

For most applications, air provides the most reliable standard for calibration. Its composition is consistent and requires compensation only for barometric pressure. Because the electrical zero of the probe coincides very closely with zero DO concentration, a one-point air calibration is normally sufficient.

The probe is exposed to air which provides a standard oxygen partial pressure. An instrument setting or measurement accounts for differences in barometric pressure during calibration.

NOTE: For rated stability, the probe must be connected to a powered instrument for at least 6 hours before calibrating or measuring to assure full polarization of the internal electrodes. If this is not possible, calibrate at startup and again after 6 hours.

When the equipment will be used as portable instrumentation and power is frequently disconnected, use an accessory Polarization Module to maintain probe polarization while power is off.

Air Calibration Procedure

1. For highest accuracy with a Mettler-Toledo Thornton M300 or 2000 instrument, determine the atmospheric pressure existing on site based on an accurate barometer. (For a 770MAX system, a built-in electronic barometer automatically measures and compensates for atmospheric pressure.)
2. Activate the HOLD function in the instrument, if required, to prevent activation of alarm relays and to hold analog outputs at their current value.
3. Shut off the sample flow to the flow housing.
4. Remove the probe from the housing by loosening the red threaded sleeve and blot the tip of the probe dry with a soft lint-free tissue.
5. Hang the probe in open air, away from heat sources and wait for stable DO and temperature readings—typically about 10 minutes.
6. Step through the instrument CALIBRATION menu to set the barometric pressure (M300 and 2000 instruments only). Perform a one-point air calibration.
7. When complete, reinstall the probe in the flow housing and tighten the threaded sleeve.
8. Cycle the sample flow on and off to remove any retained bubbles. Restore flow to 50 – 1000 mL/min.
9. When the measurement has returned to its normal value and is stable, deactivate the HOLD function in the instrument or allow it to time out.

Electrical Zero Calibration Procedure

With sensors using a preamp, an electrical zero can be performed to eliminate offset in the preamplifier. Electrical Zero Calibration can usually be done more reliably than the System Zero Calibration Procedure below. Refer to the 770MAX or 2000 Instrument instruction manual for details.

System Zero Calibration Procedure

System zero calibration is rarely required with this sensor which has its electrical zero very close to zero concentration. If system zero calibration is attempted, a true zero calibration standard is required.

NOTE: Improper zero calibration is a frequent source of measurement error. The best standard is nitrogen of 99.995% purity which can be slowly fed through the flow housing in place of the sample. Sulfite solutions may not reach a true zero—see the Zero Verification section following.

1. Be sure the instrument and probe have been powered for at least 6 hours previous to calibration. Activate the HOLD function to disable the relays and to hold analog outputs at their current value.
2. Shut off the sample flow to the flow housing.
3. Connect pure nitrogen to the inlet of the flow housing.
4. Wait for a completely stable reading—typically an hour. Verify that the reading is acceptably close to zero.
5. Step through the instrument CALIBRATION menu to perform a zero calibration.
6. When complete, disconnect the nitrogen and perform an air calibration if needed.
7. Reinstall the probe in the flow housing and restore sample flow.
8. When the measurement has returned to its normal value, deactivate the HOLD function in the instrument or allow it to time out.

Zero Verification

A zero verification may be performed with a sulfite solution. It is not recommended to calibrate in this solution since it sometimes produces a concentration of 1-3 ppb rather than a true zero. Use the same procedure as for nitrogen zero calibration except use the following zero solution in a narrow-mouth flask or bottle in which the DO probe has been immersed.

A stock solution of 500 mg/L of cobalt chloride ($CoCl_2$) in deionized or distilled water may be made and stored up to 2 years.

The final zero DO solution consists of adding 10 grams of sodium sulfite (Na_2SO_3) to 200 mL of the above stock solution. This must be made up fresh within 60 minutes of use since air will oxidize and deactivate it.

Calibration Diagnostics

The Adder is recalculated whenever a zero calibration is performed. The displayed value is in nanoAmps and is typically within ± 0.2 for a functioning probe and preamp. The Multiplier is recalculated whenever an air calibration is performed and is typically within 0.5 to 2.0 for a functioning sensor.

The instrument manual describes how to display the raw probe current in normal operation, which is nominally -350 nA in air.

PROBE STORAGE

Store the probe at room temperature with the protective cap in place. For long term storage, more than 3 months, remove the electrolyte and rinse internal parts with deionized water. Allow to dry and re-assemble. The electrolyte must then be replaced before reinstalling.

SERVICE

Cleaning

Any accumulation of solids on the membrane surface or in the flow housing should be washed off or cleaned briefly with an agent suitable for removing it. If physical cleaning is needed, use a lint-free cloth or tissue that will not clog the protective membrane screen. The frequency of cleaning will vary widely, depending on the content of the sample and must be established by experience.

WARNING: USE STANDARD PRE-CAUTIONARY MEASURES IN HANDLING ANY ACIDS USED FOR CLEANING.

Service Indications

The electrolyte should be replaced at startup or later if response to a near-zero solution or gas is not low enough or fast enough. After 2 minutes in a very low oxygen sample, the reading should drop below 10% of the air reading. After 10 minutes, the reading should drop below 1%. (e.g. readings in air are near 8000 ppb so in 10 minutes, response should be below 80 ppb.)

The membrane body and electrolyte should be replaced if a visual inspection shows signs of mechanical damage. They should also be replaced if the sensor has a slow response, shows instability or if the sensor cannot be calibrated.

The complete probe should be replaced if a visual inspection shows a crack in the glass of the interior body or if the sensor shows leakage current. (With electrolyte and membrane body removed and the internal body carefully dried there should be a zero reading.)

Service Procedure

WARNING: THE DO PROBE CONTAINS A FEW DROPS OF ALKALINE ELECTROYTE. CONTACT OF ELECTROLYTE WITH MUCOUS MEMBRANE OR EYES IS TO BE AVOIDED. THEREFORE WEAR SAFETY GLASSES FOR DISASSEMBLY. IF SUCH CONTACT OCCURS, THE AFFECTED AREA SHOULD BE WELL RINSED WITH WATER. IN THE CASE OF ACCIDENT, OR SHOULD ADVERSE SIGNS APPEAR, GET IMMEDIATE MEDICAL ATTENTION.

Perform probe disassembly only in a clean work area.

1. Unscrew the cap sleeve from the probe shaft and carefully pull it off the sensor.
2. Eject the membrane body from the cap sleeve by pushing it from the end with the flat finger tip. (Before electrolyte is refilled, the membrane body must be removed from the cap sleeve.)
3. Rinse the interior body with demineralized water and carefully dab it dry with a paper tissue.
4. Examine the O-rings visually for mechanical defects, and replace if necessary.
5. Half-fill the membrane body with electrolyte.

NOTE: The electrolyte bottle is equipped with a special pouring system. To ensure proper functioning, hold the bottle vertically, upside-down.

6. Make sure that all air bubbles are removed from the membrane body. Air bubbles can be removed by carefully tapping on the membrane body.
7. Slip the membrane body over the interior body while holding the sensor in a vertical position. The excess electrolyte will be displaced and must be absorbed with a paper tissue.

NOTE: No electrolyte, sample media or contamination may be present between the membrane body and the cap sleeve. Be sure both parts are clean and dry.

8. Carefully slip the cap sleeve over the fitted membrane body, holding the sensor in a vertical position and screw it tight.
9. After changing electrolyte or membrane body, the sensor must be repolarized for 6 hours and recalibrated.
10. Place the system in operation. Because of the major disturbance of this service, stable measurement in the low ppb (µg/L) range may require several hours to achieve.

After a day, re-calibrate to restore full accuracy.

Troubleshooting

One of the most common problems with DO measurement is air leaks into the sample. This results in higher than actual, flow-sensitive readings. A simple test for this is to raise the flowrate about 50%. If the DO reading decreases significantly, this is evidence of a leak since the higher flowrate dilutes the leak. If this is observed, check and tighten all fittings, flowmeters, valves, etc upstream of the sensor.

Decreasing DO reading with increasing flowrate may also occur if an excessively gas-permeable sample line is used. Shorten the gas-permeable length or change materials of the sample line.

An *increase* in DO reading at higher flowrate may indicate the original flowrate was inadequate or the membrane was coated. Clean the membrane as described in the Service/Cleaning section.

Refer to the Calibration Diagnostics section for information on acceptable probe signal range.

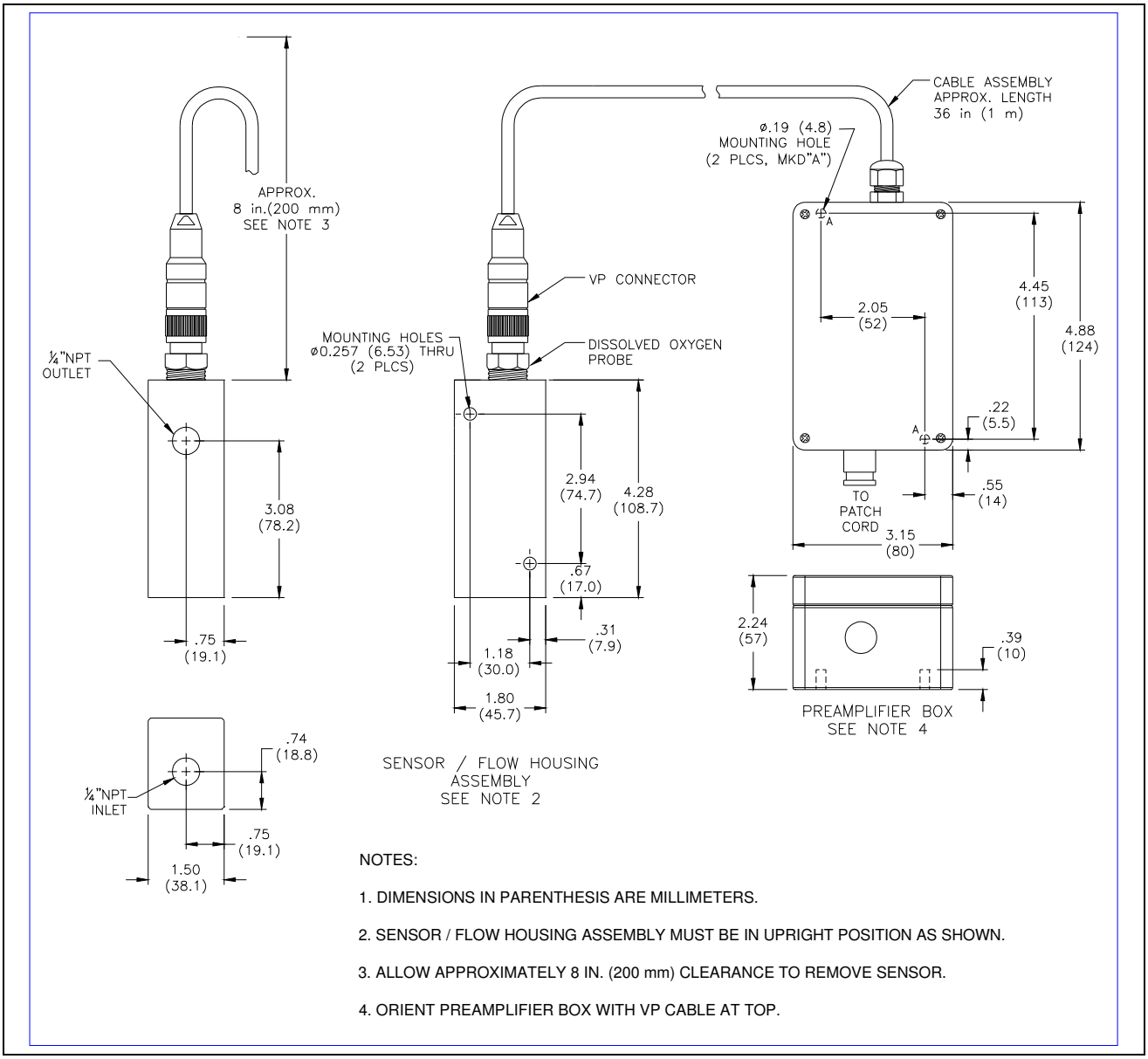

Figure 1 — Mounting and Dimensions of Mettler-Toledo Thornton Dissolved Oxygen Sensors. Model 58 037 20X and 58 037 40X Sensors do not use the preamp shown and instead include a longer VP or AK9 cable that connects directly to the M300 or M300 ISM Instrument, respectively.

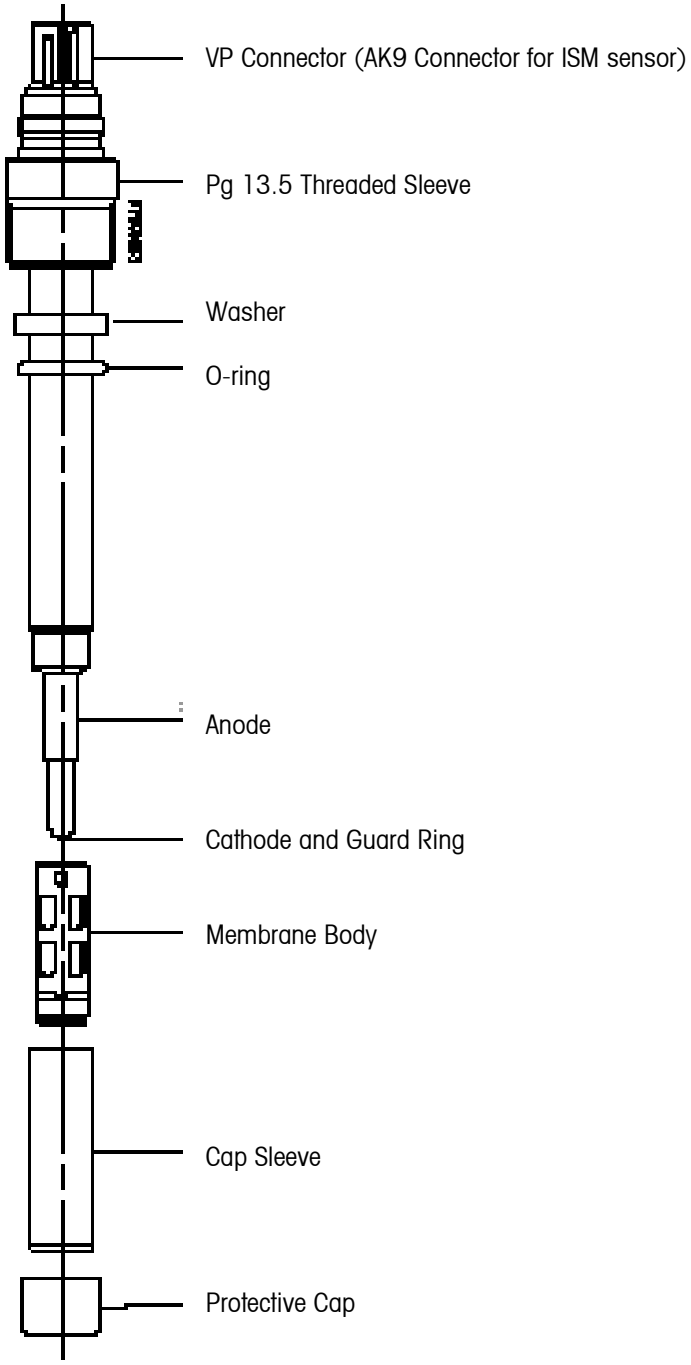

Figure 2 - Probe Component Identification for Maintenance Purposes

SPECIFICATIONS

Sample Flowrate	50 – 1000 mL/min
Sample Temperature:	0 – 60 °C (32 – 140 °F) for compensation; can tolerate 100 °C (212 °F)
Sample Pressure:	0 – 5 bar (0 – 72 psig)
Sample Connections:	1/4" NPTF
Wetted Materials:	polyacetal flow housing, polyphenylene sulfide probe, PTFE membrane (reinforced with stainless steel mesh and silicone rubber), Viton and silicone rubber o-rings
Cable length:	
M300 & M300ISM	up to 33 ft (10 m)
770MAX	up to 300 ft (91 m)
2000	up to 200 ft (61 m)
Weight:	0.5 lb (1 kg)
System Accuracy:	±1% of reading or 1 ppb, whichever is greater
Response Time:	98% response in 90 seconds
Measurement Range:	0 – 10,000 ppb (µg/L) with auto-ranging

SPARE PARTS

Replacement probe (analog)	52 201 067
Replacement ISM probe	52 201 209
Electrolyte (25 mL bottle)	34 100 2016
Membrane kit including electrolyte, 4 membranes and o-ring sets	52 200 024
Single membrane body	52 200 071
Replacement preamp for 2000 Instrument	58 037 203 (367-201)
Replacement preamp for 770MAX Instrument	58 037 011 (357-201)
Replacement flow housing	58 084 009 (17490)
Replacement VP cables for M300 Instrument	
1 m	52 300 107
3 m	52 300 108
5 m	52 300 109
10 m	52 300 110
Replacement AK9 cables for M300 ISM Instrument	
1 m	100000102
3 m	100000302
5 m	100000502
10 m	100001002
Accessory Polarization Module (analog sensor)	52 200 893

OXYGEN SOLUBILITY

Air-saturated water at 1 atmosphere, 760 mmHg

Temperature (°C)	Oxygen Concentration (mg/L)
0	14.57
1	14.17
2	13.79
3	13.43
4	13.08
5	12.74
6	12.42
7	12.11
8	11.82
9	11.53
10	11.26
11	11.00
12	10.75
13	10.50
14	10.27
15	10.05
16	9.84
17	9.63
18	9.43
19	9.24
20	9.06
21	8.89
22	8.72
23	8.55
24	8.39
25	8.24
26	8.10
27	7.95
28	7.82
29	7.68
30	7.55
31	7.43
32	7.31
33	7.19
34	7.07
35	6.96
36	6.85
37	6.74
38	6.63
39	6.53
40	6.43
41	6.33
42	6.23
43	6.13
44	6.04
45	5.94
46	5.85
47	5.76
48	5.66
49	5.57
50	5.48

ALTITUDE VS PRESSURE

If calibration is performed at high elevations and a barometer is not available, this table provides an approximate atmospheric pressure setting.

Altitude (ft)	Altitude (m)	Atmospheric Pressure (mmHg)
-500	-152	773
0	0	760
500	152	747
1000	305	734
2000	610	708
3000	914	682
4000	1219	666
5000	1524	642
6000	1829	619

WARRANTY

This Warranty is given expressly and in lieu of all other warranties, express or implied. The Buyer agrees that there is no warranty of merchantability and that there are no other warranties, express or implied, which extend beyond the description on the face of this agreement.

Mettler-Toledo Thornton, Inc. (hereinafter referred to as The Company) warrants to the original Buyer each electrode, component, or instrument manufactured and/or sold by The Company to be free from defects in material and workmanship in normal use and service for a period of one (1) year from shipment, unless expressly stated otherwise by the product packaging or expressly agreed to in advance by the Company. The obligation of The Company under this warranty is limited to repair or replacement of the defective product at The Company's discretion. All warranty claims shall be returned to The Company pursuant to The Company's Returned Goods Authorization program. Shipping costs (including return shipping) are the responsibility of The Buyer. The Company assumes no responsibility for any direct or indirect costs associated with removal of defective products, or re-installation of replacement products. The Company shall not be responsible for damage to any electrode, component, or instrument resulting from misuse, negligence, accident or resulting from repairs, alterations, or installations made by any person or firm not duly authorized by The Company. No agent is authorized to assume for The Company any liability except as above set forth. The Company warrants that services will be performed in a workmanlike manner in conformity with standard industry practice. Should any nonconformity be detected within 30 days after the work is completed and prompt notification is made by Buyer in writing to the Company, Company will supply the necessary service, direction, or consultation to correct the nonconformity.

Returned Goods Policy: A Returned Material Authorization (RMA) number must accompany all returned goods. This authorization is obtained by calling our Technical Service (800) 510-7873 or (781) 301-8600. All transportation costs on authorized returns must be prepaid. Authorized replacement parts sent prior to receipt and evaluation of merchandise being returned will be invoiced in full. Credit will be issued only after the returned part is received and evaluated by factory personnel. The Company is not responsible for products returned without proper authorization.

Factory Restocking Charge: Items returned to The Company more than 30 days after shipment will be subject to a 25 % restocking charge, plus any additional charges for refurbishment to salable condition. The Company will not accept returns more than 90 days after shipment, unless returned under warranty or for non-warranty repair.

Special Products: Cancellation or return of special products will not be accepted.

Disclaimer of Damages:
In no event shall The Company be liable for any type of special consequential, incidental or penal damages, whether such damages arise out of or are a result of breach of contract, warranty, tort (including negligence), strict liability or otherwise. Such damages shall include, but not be limited to loss of profits or revenues, loss of use of the equipment or associated equipment, cost of substitute equipment, facilities, down time costs, increased construction costs or claims of The Buyer's customers or contractors for such damages. The Buyer agrees that in the event of a transfer, assignment, or lease of the equipment sold hereunder The Buyer shall secure for The Company the protection afforded to it in this paragraph.

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