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& Cell Biology
Research**

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Microinjectors

Microincubators

Micromanipulators

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Dear Researcher:

Warner Instruments is proud to introduce our new Electrophysiology & Cell Biology Catalog. This catalog contains many new products for cell imaging, biosensing, microinjection, and electrophysiology.

NEW Products Featured Include:

- **PLI-100A Picoliter Microinjector** - With three positive and two negative pressure capabilities, the versatile PLI-100A is capable of large injections into capillaries or small injections into mammalian nuclei.
- **BioStat Multi-channel Potentiostat** - The BioStat is a software-driven, multi-mode potentiostat that can be used for measurement of pH, reactive oxygen species, and nitric oxide.
- **Compact Motorized Micromanipulator** - Linear amplifiers, used to drive the stepper motors, eliminate stray electromagnetic radiation; reducing noise and resulting in improved patch clamp and electrophysiology performance.
- **PFC-1 Proflow Chamber** - Computer designed gaskets optimized for well-defined, well-controlled shear-flow.
- **RC-49FS Perfusion Chamber with Field Stimulation** - Uses popular 18 mm round coverslip. The low profile design allows for low entry angle patch electrodes.
- **CL-200 Dual Channel Bipolar Temperature Controller** - Single control temperature adjustment, built-in protection for Peltier devices, open thermistor fault protection.
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- **ProgRes® Microscope Cameras** - These CMOS and CCD cameras are suitable for all contrast methods in light microscopy, C-Mount and USB2.0/FireWire interfaces. All ProgRes® cameras include CapturePro® image capture software.

Sincerely,

A handwritten signature in black ink, appearing to read 'Ralph Abate'.

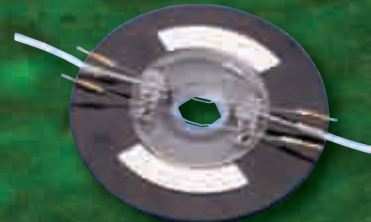
Ralph Abate
Business Manager, **Warner Instruments**



Cell Biology Research Catalog



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NEW RC-49FS Perfusion Chamber with Field Stimulation, p. 54



NEW PFC-1 Proflow Chamber, p. 57



NEW BioStat Multi-channel Potentiostat, p. 372



NEW Compact Motorized Micromanipulator, p. 297



NEW ProgRes[®] Microscope Cameras, p. 344



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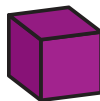
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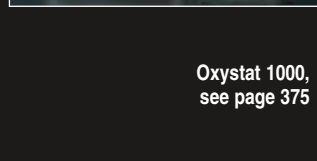
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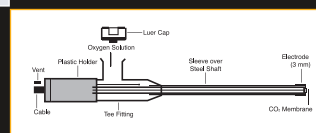
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W4 69-3054 Dual Channel inNO-T System

W4 69-3050
1 Channel inNO-T System

- Dual Channel System
- Uses 'amiNO' sensors which are up to 100 times more sensitive than other sensors
- First available NO system to have temperature compensation
- No base line drift due to temperature changes
- Combination NO meter and data acquisition system
- User friendly recording, playback and analysis software compatible with Windows 95/98, 2000, and XP
- Continuous recordings (over 1 month)
- Battery-powered benchtop/portable system
- 24 bit A/D converter
- System shipped complete with NO meter, software, 2 types of NO sensors, and calibration kit

Nitric Oxide Measurement System

The 'inNO-T' system is the most technologically advanced nitric oxide electrochemical detection system on the market today. It combines a nitric oxide configured potentiostat and a sophisticated software controlled data acquisition system in one compact battery powered unit. When used with the 'amiNO' series of NO sensors, this unit provides an NO detection sensitivity increase of up to 100 times that of any other electrochemical detection system. The battery powered design allows the unit to run continuously for up to 5 years, making it ideal for any electrically isolated and/or portable application.

The 'inNO-T' system is the first available nitric oxide system to include temperature compensation which further enhances the detection limits and data reliability by eliminating temperature dependent baseline drift. A temperature probe is supplied with each system.

The inNO-T system's internal 24 bit analog to digital converter and built in digital notch filtering allows for accurate, noise free, detection of nitric oxide levels of less than 0.01 nM. The 24 bit A/D technology also gives the unit a dynamic range in excess of 16,000,000 to 1. Its sophisticated control and analysis software can be linked to any computer system that utilizes Windows™ 95/98, 2000 or NT via the 'inNO's' internal RS-232 interface.

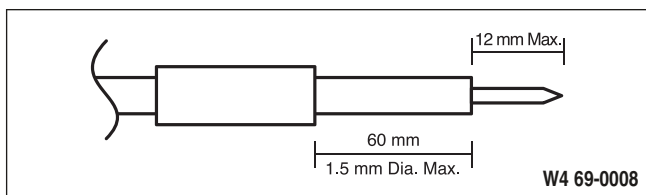
- All amiNO sensors are combination sensors, no external reference electrode is required
- Mechanically rugged membrane
- All sensors covered with proprietary triplecoat gas permeable membrane to guarantee selectivity and very fast response time
- All sensors completely shielded from environmental/electrical noise
- All sensors work the 'inNO-T' meter as well as many other currently available meters
- One calibration procedure, simple, easy, no expensive chemicals

Using state of the art combination NO sensor design, the 'amiNO' Series nitric oxide sensors increase the sensitivity of electrochemical nitric oxide measurement, by up to 100 times that of any existing electrochemical sensor on the market today.

amiNo sensors are the first NO sensors to break the 100 pA/nM barrier. This higher sensitivity greatly reduces measurement errors due to baseline drift associated with temperature changes. Baseline drift has been a particular concern with older technology sensors that not having the enhanced sensitivity characteristics of the 'amiNO' sensors.

Additionally the new 'amiNO' series adds newly designed sensor types for in vivo applications and large surfaces (cultured cells). Customized sensors are available upon request to meet specialized applications, call for details.

Warner Instruments offers 4 different Nitric Oxide Measurement Systems. Each system includes either a 1-channel or 2-channel inNO-T Temperature compensated meter, an amiNO-2000 sensor, SensoReady Electrode Polarizer and a temperature probe (for a complete listing of system components see chart on page 371). Each system is offered in either 115 or 230 VAC.



amiNO-7 Sensor

- 7 μm tip diameter
- Ideal for single cell measurements
- Metal alloy fiber
- Tip Volume ~ 500 μl

amiNO-30 Sensor

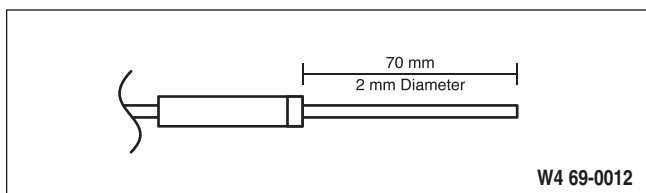
- 30 μm tip diameter
- For space restricted measurements
- Metal alloy fiber
- Tip Volume ~ 10 μl

amiNO-100 Sensor

- 100 μm tip diameter
- Extremely stable background
- Resists breakage
- To be used in restricted area and 'in vivo' measurements
- Very consistent & reproducible
- Tip Volume ~ 100 μl

amiNO-600 Sensor

- 600 μm tip diameter
- Exceptional sensitivity and baseline stability
- Very rugged membrane, flexible body
- Very durable
- Tip Volume ~ 4 μl

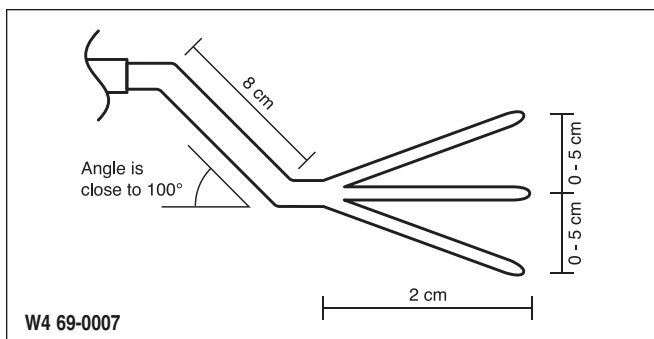


amiNO-2000 Sensor

- Flat 2 mm tip diameter
- Stainless steel/aluminum body
- Longest life NO electrode (user replaceable membranes)
- Tough enough for training new staff and students
- Used to measure high levels of NO as in drug solutions and macrophages
- Tip Volume ~ 250 μl

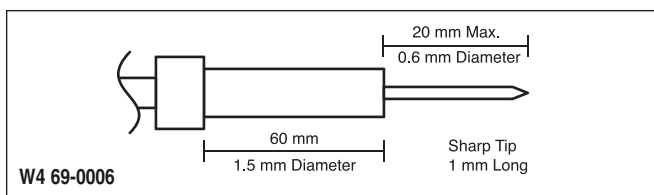
inNO-T

Nitric Oxide Measurement System (continued)



amiNO-FLAT Sensor

- 'Chicken foot' design to increase contact area
- Designed specially for measuring NO released from monolayer cultured cells and large flat tissues
- Rugged membrane
- Highest sensitivity
- Low background



amiNO-IV Sensor

- 600 μm tip diameter
- Very sharp metallic tip for insertion/penetration of tissue, no extra needles or catheters are needed, sensor is the needle
- Higher sensitivity, up to 100 times more sensitive than other commercially available sensors
- Sub nano-molar detection limit
- Special membrane survives numerous insertions
- Very stable, low background current
- Tip Volume $\sim 6\mu\text{l}$

Specifications

Current Scale	$\pm 2,500,000.0$ pA
Concentration Scale	$\pm 1,000,000.0$ nM
Resolution	0.01 nM (0.1 pA)
Screen Meter	7.5 digit meter
Recording Speed	1 to 1000 sec/div
Power	Replaceable battery
Dimensions, H x W x D	76 x 229 x 203 mm (3 x 9 x 8 in)
Temperature Range	0° to 50°C, inNO-T only
Temperature Resolution	0.01°C, inNO-T only
Temperature Sensor	< 0.50 mm tip, 120 mm long, inNO-T only

Please refer to the guide below to help you select the best sensor for your application. For additional assistance, please call Warner Instruments Technical Support*

**The selection guide below is based on design, sensitivity and economy. For example, amiNO-FLAT and amiNO-IV are the most sensitive but are also the most expensive. The amiNO-600 is less sensitive but is more economical.*

amiNO Sensor Selection Guide*

Application	First Choice(s)	Second Choice(s)
Measuring NO released from cells/large flat tissue	amiNO-FLAT	amiNO-600 or amiNO-IV
In vivo measurements and other insertion applications	amiNO-IV	amiNO-600
Measuring NO in small volumes or restricted space	amiNO-100	amiNO-7, amiNO-30 or amiNO-600
Measuring micro-molar levels of NO	amiNO-2000	amiNO-100 or amiNO-30
Following the decomposition of an NO producing compound	amiNO-600 or amiNO-100	amiNO-2000 or amiNO-IV
Measuring very low levels of NO (below 50 nM)	amiNO-600 or amiNO-IV	amiNO-100
Indirect measurement of Nitrate and Nitrite	amiNO-600, depending on expected level	amiNO-100 or amiNO-2000
Training new staff or students	amiNO-2000	amiNO-600

amiNO Sensor Performance Comparison and Ordering Information

Order #	Qty.	Model	Size	Typical Sensitivity	Competitor Typical Sensitivity
W4 69-0008	2	amiNO-7	7 µm	0.5-3 pA/nM (typical 1.5 pA/nM)	n/a
W4 69-0009	2	amiNO-30	30 µm	2-6 pA/nM (typical 4 pA/nM)	n/a
W4 69-0010	2	amiNO-100	100 µm	25 to 50 pA/nM (typical 35 pA/nM)	No Equivalent
W4 69-0011	2	amiNO-600	600 µm	150 to 250 pA/nM (typical 200 pA/nM)	No Equivalent
W4 69-0012	1	amiNO-2000	2 mm	Typical 1 pA/nM	Typical 1 pA/nM
W4 69-0006	2	amiNO-IV	600 µm	150 to 250 pA/nM (typical 200 pA/nM)	No Equivalent
W4 69-0007	1	amiNO-FLAT	See diagram	250 to 700 pA/nM (typical 400 pA/nM)	No Equivalent

inNO-T Nitric Oxide Measurement Systems, Sensors and Accessories

Order #	System Components	Premium System #1		Premium System #2		Premium System #3		Premium System #4		
		115 VAC, 60 Hz	230 VAC, 50 Hz	115 VAC, 60 Hz	230 VAC, 50 Hz	115 VAC, 60 Hz	230 VAC, 50 Hz	115 VAC, 60 Hz	230 VAC, 50 Hz	
W4 69-0012	amiNO-2000 Nitric Oxide Sensor, 2 mm Tip	•	•	•	•	•	•	•	•	
W4 69-0010	amiNO-100 Nitric Oxide Sensor, 100 µm Tip, pkg. of 2	•	•							
W4 69-0011	amiNO-600 Nitric Oxide Sensor, 600 µm Tip, pkg. of 2			•	•					
W4 69-0006	amiNO-IV Nitric Oxide Sensor, InVivo 600 µm Tip, pkg. of 2					•	•			
W4 69-0007	amiNo-FLAT Nitric Oxide Sensor, Flat 25 x 25 mm, pkg. of 1							•	•	
W4 69-0013	Electrolyte for W4 69-0012	•	•	•	•	•	•	•	•	
W4 69-0014	Replacement Membranes for W4 69-0012, pkg. of 4	•	•	•	•	•	•	•	•	
W4 69-0037	Nitrite Standard, 50 ml	•	•	•	•	•	•	•	•	
W4 69-0038	Calibration Vials, pkg. of 5	•	•	•	•	•	•	•	•	
W4 69-0016	SensoReady Electrode Polarizer	•	•	•	•	•	•	•	•	
W4 69-0029	Adapter, LIMO Connector to amiNO Sensor Connector	•	•	•	•	•	•	•	•	
W4 72-0460	Spin Bar Magnetic Stir Bar, 5 x 2 mm, pkg. of 5	•	•	•	•	•	•	•	•	
W4 72-1972	Magnetic Stirrer, 115 VAC	•		•		•		•		
W4 72-1973	Magnetic Stirrer, 230 VAC		•		•		•		•	
W4 72-1922	Electrode Holder and Stand	•	•	•	•	•	•	•	•	
W4 69-0052	Temperature Probe	•	•	•	•	•	•	•	•	
Systems										
	1-Ch inNO System with inNO-T Meter with Temp. Compensation	W4 69-3050	W4 69-3051	W4 69-3052	W4 69-3053	W4 69-0048	W4 69-0049	W4 69-0050	W4 69-0051	
	2-Ch inNO System with inNO-T Meter with Temp. Compensation	W4 69-3054	W4 69-3055	W4 69-3056	W4 69-3057	W4 69-3058	W4 69-3059	W4 69-3060	W4 69-3061	

Note: inNO and inNO-T are battery operated. Voltage selection is for Magnetic Stirrer. Call Harvard Apparatus Customer Service for Nitrate Reduction Products.

NEW Biostat Multi-Channel Potentiostat

nitric oxide



BioStat Multi-Mode Potentiostat

- Four independent optically isolated channels
- Easy to use software Windows® 2000 or later operating system
- Precise amperometric or voltammetric measurements
- Rugged compact design

The BioStat is a software-driven, multi-mode potentiostat that can be used for measurement of pH, reactive oxygen species, and nitric oxide.

The BioStat System is designed to be used with a wide range of electrochemical sensors and electrodes for measurement of reactive oxygen species and biologically significant molecules. This system allows precise amperometric (with two-electrode or three-electrode sensors for measurement of nitric oxide, oxygen, nitrite and nitrate, nitrosothiols, glutamate, etc.) or voltammetric (with sensors for measurement of pH, neurotransmitters, etc.) and temperature measurements to be made independently on up to four channels. Total electrical isolation of each channel ensures independent recording with ultra-low noise. The BioStat System can handle signals of either polarity, employing either two-electrode or three-electrode sensor configurations.

The BioStat System uses a robust high-quality all-metal case that provides exceptional stability and durability. The shielding of the case provides immunity from external interference and surface mount technology ensures reliability. Each system can be used flat on the bench or in a vertical configuration. Its extremely small size (about size of a paper-back book) requires little lab-bench space. The device is powered by an external universal AC power supply that provides 12 volts of DC power to the device.

pH, Oxygen, and Nitric Oxide Measurements

The BioStat is capable of receiving input from the Warner Instruments line of microminiature pH electrodes, oxygen sensors, and nitric oxide sensors. This flexibility is attained through the use of adapting connectors (such as BNC Triad, and Stereo to Triad connectors). The high input impedance of the BioStat is ideal for these sensitive applications.

Data Acquisition Software

The software takes less than 5 minutes to load from the CD onto any computer with the Windows® 2000 or later operating system. On-screen menus and pop-ups make it easy to use. The software provides comprehensive data analysis capability even while data is being collected. Data is easily exported to allow analysis using other software applications.

Although configured for biosensing measurements, the BioStat system is extremely versatile and can be used for any multi-channel, isolated data acquisition, such as multielectrode electrophysiological recordings.

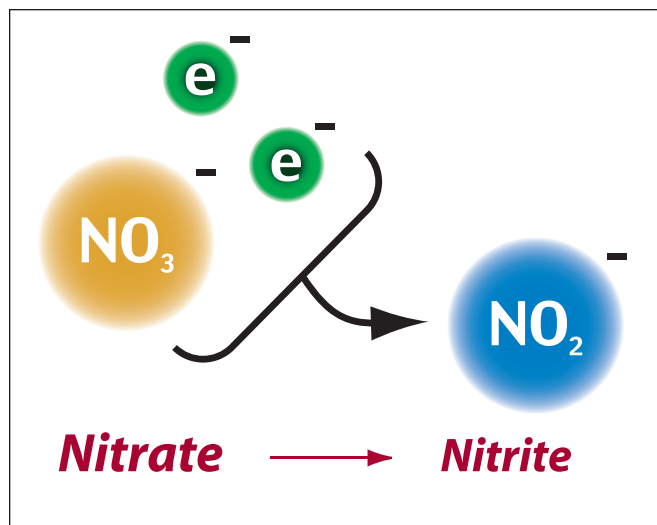
Specifications

Number of Channels	4
Electrode Configuration	2 or 3
Operational Modes	Amperometric, Voltammetric, Temperature
Input Signal Polarity	Bipolar
Input Signal Configuration	Single-ended
Range Settings:	
For Amperometric Mode	± 1 nA to ±1 mA
For Voltammetric Mode	± 5000 mV
For Temperature Mode	± 100°C
Measurement Accuracy:	
For Amperometric/Voltammetric Mode	0.1% x full scale (10 fA in nA range)
For Temperature Mode	± 0.1°C
Activation Voltage Range	-2000 mV to +2000 mV
Input Impedance	>1012 Ohm
Baseline Noise	10 ⁻⁶ x full scale of selected range [e.g. 1 fA for 1 nA range]
Resolution	10 ⁻⁵ x full scale of selected range
Operating System	Host Computer Windows® 2000 or Later
Power Supply	9 to 30 VDC 10 W unregulated
Instrument Dimensions	35 x 166 x 125 mm (1.4 x 6.5 x 5 in)
Weight	1.4 lb (0.65 kg)

Order # Product

W4 64-1750	Biostat Multi-Channel Potentiostat, Cables and Connectors
W4 64-1751	Temperature Electrode for Biostat
W4 64-1752	Triad Bare Connector for Custom Wiring Sensors
W4 64-1753	Adapter Triad to BNC
W4 64-1754	Adapter Triad to stereo phono 3.5 mm

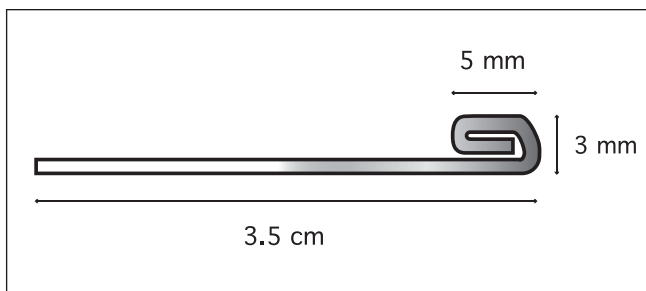
Nitrate Reductor



- Never needs reactivation, even after hundreds of samples!
- No need to bring the sample to the reductor; take the reductor to the sample. This eliminates the need for sample transfer which saves time and eliminates sample loss
- Can be used in any sample container such as a vial, tube, micro-plate well or spectrophotometric cell
- Very small; it can be used in 50 microliters or 5 milliliters
- 100% conversion in minutes
- Economical
- Reusable

The measurements of nitrate and nitrite anions in biological samples have gained more interest due to their association with the nitric oxide (NO) pathway. Since these ions are the oxidation products of NO, their presence can be used as an indicator of NO production activities.

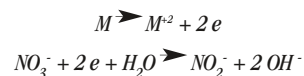
There are many methods available for both direct and indirect measurement of nitrite. Unfortunately, this is not the case for nitrate due to its different chemical reactivity. Therefore, most of the analytical procedures involving nitrate include its conversion to nitrite using either enzymatic reduction or cadmium-based reductors. These conversion procedures are tedious, time consuming, expensive, require multiple sample transfer, and suffer from diminished activity. The Nitrate Reductor is specifically designed to overcome these shortcomings.



Principle of Operation

Conventional bimetallic composition based reductors are based on copper-plated cadmium beads. The presence of copper metal alters the potential energy of the cadmium electrons enhancing the rate of their transfer to nitrate. Even though this design has been used successfully for many years, it has two main drawbacks. The loss of its catalytic activity after using it on a number of samples requires that the reductor be reactivated. The second problem deals with the difficulty in handling and utilizing the beads for use with very small sample volume containers to avoid diluting the sample because these beads are normally packed in a column.

Our nitrate reducing wire is based on a multi-metal alloy structure. This multi-metallic structure preserves the activity of the reductor and enhances the rate of electron transfer in these chemical reactions:



This alloy structure completely eliminates the need to reactivate the nitrate reductor. The design of the reductor in the form of a wire enables it to be used on very small sample volumes and removes the restriction of having to move your sample to a specialized container.

The reductor is available in two kit forms. The manual kit includes 6 reductors that can be used to reduce nitrate in 6 samples simultaneously. The motorized kit is a mixer/reductor combination. The mixer itself is the reductor! This system is ideal for use in sample containers where stirring is difficult and reduces nitrate faster than the manual kit. The motorized kit comes with a removable reductor and micro-sleeve enabling the user to utilize it as a micro-mixer in the lab.

Order #	Product
W4 69-0054	Manual Nitrate Reductor Kit, pkg. of 6

Dissolved Oxygen Meter and Electrodes

dissolved O₂

Dissolved Oxygen Meter

- Measures O₂ in liquids or gases
- Meter offers a "clean" function to reactivate the electrode
- Replaceable membranes

This dissolved oxygen measuring system utilized the latest technologies in electronic circuitry and chemical sensors. The 2 mm, stainless steel tipped oxygen electrode allows measurements in both the liquid and gas phases. A W4 69-0027 electrode is supplied with each system with two replacement membranes and electrolyte. The meter can display current, percentage, or PPM oxygen. The meter offers an activation function to restore the activity of the sensor without the need of polishing and conditioning. Stirrer and electrode stand not included.

Specifications

% O ₂	0 to 100%
PPM	0 to 20
Current Range	0 to 2000 nA
Resolution	0.1 PPM, 0.1 %
Accuracy	±1%
Recorder Output	Analog output 0 to 5 V
Electrode Response Time	Under 10 sec, 90% response in stirred solution
Display	3.5 digit LCD
Power	120/240 VAC
Dimensions	20.3 x 22.9 x 76.2 cm (8 x 9 x 3 in)
Shipping Weight	2 lb (1.5 kg)



W4 69-0026 Dissolved Oxygen Meter shown with Stirrer and Electrode Stand, not included

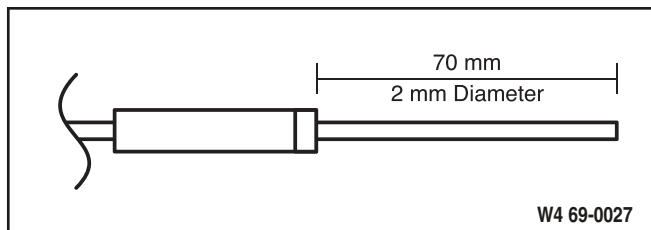
Order # Product

W4 69-0026	Oxygen Meter with Temperature Compensation and 2 mm Oxygen Electrode (W4 69-0027)
W4 69-0028	Replacement O ₂ Membranes, pkg. of 4
W4 72-1972	Magnetic Mini Stirrer, 110/115V - 50/60 Hz Stir Bar
W4 72-1973	Magnetic Mini Stirrer, 220/240V - 50/60 Hz Stir Bar
W4 72-1922	Electrode Holder and Stand

2 mm Oxygen Electrode

Specifications

Cable and Connector	3.5 mm x 6 ft (D x L)
Handle	6.4 x 50 mm (D x L)
Tip	Stainless steel, 2 x 70 mm (D x L) with flat sensing tip

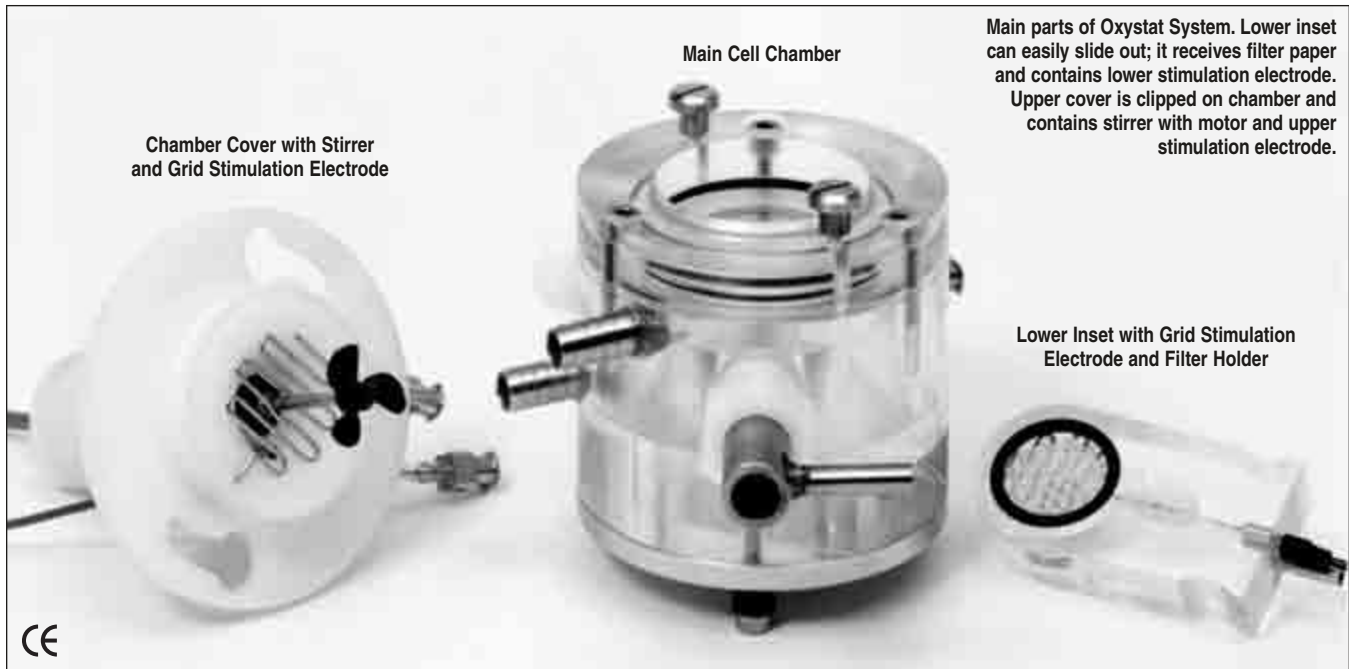


Order # Product

W4 69-0027	Oxygen Electrode, 2 mm
W4 69-0028	Replacement O ₂ Membranes, pkg. of 4

Oxystat 1000

Oxystat System for Oxygen Consumption Measurements



- Unique open system with 'feedback' for measuring oxygen consumption of cardiomyocytes, hepatocytes, and endothelial cells
- Measures as low as 0.1 mmHg
- Two operating modes possible:
 - Closed system oxygen consumption calculated from pO_2 reduction
 - Open system (measurement at constant pO_2) controlled addition of solution with known pO_2
- Electrical stimulation capabilities
- Fitting for fiber optics for easy Ca^{++} concentration or redox potential

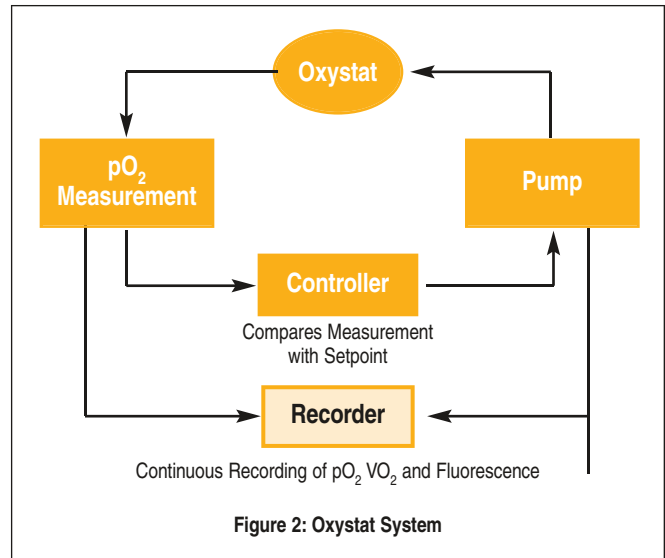
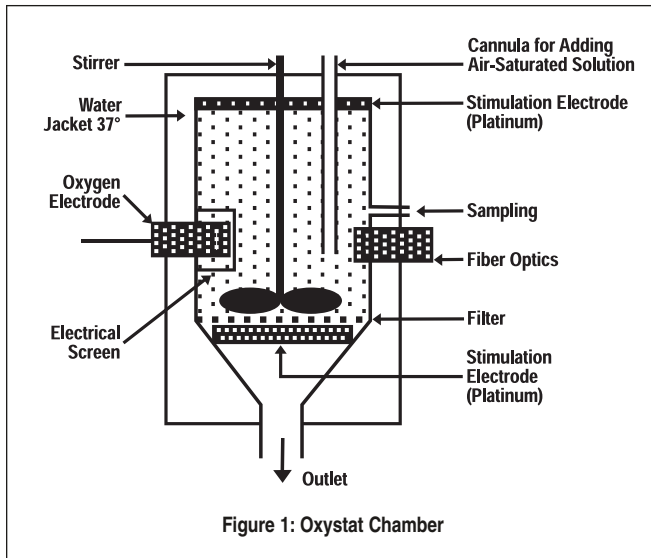
Application

The oxygen consumption VO_2 of small cell assemblies (e.g. papillary muscle) or of isolated cells has usually in the past been calculated from the reduction in the oxygen partial pressure (pO_2) in a 'closed system'. By contrast, the HSE-HA Oxystat operates as an 'open system with feedback'. The pO_2 (as the controlled variable) is maintained constant by the addition of solution with known pO_2 . VO_2 can be calculated from the volume added and the pO_2 . It is an important advantage of the method that the pO_2 is maintained virtually constant during the experiment. In this way the oxygen consumption can be measured under steady-state conditions at accurately defined pO_2 values, while at the same time also measuring metabolic parameters.



Oxystat 1000

Oxystat System for Oxygen Consumption Measurements (continued)



Oxystat System Components

The Oxystat 1000 System includes the following:

- **Oxystat Incubation Chamber with Stirrer**
- **Power Supply for HSE-HA Stirrers**
- **pO₂ Electrode**
- **Model 719 Control Unit with Amplifier and Pump**
- **Stimulator**
- **Thermocirculator**

All components must be purchased separately. In addition, a chart recorder or data acquisition system will permit recording of data for subsequent analysis.

The Oxystat chamber is an incubation chamber with a volume of 10 ml (Figure 1). Mechanical damage to cells during stirring of cell suspensions is an important disadvantage of other systems; as such, special attention has been paid to achieve a very gentle stirring action. Cells are introduced and the chamber filled with medium so as to be free from air bubbles (the venting cannula is used to remove air bubbles from the system). The pO₂ electrode measures the fall in chamber pO₂ due to the oxygen consumed by the cells. Since pO₂ measurement is significantly affected by temperature, the chamber is provided with thermostating.

Operation of the Oxystat

The HSE-HA Oxystat can operate similar to conventional setups as a 'closed system'. The oxygen consumption is calculated from the slope of the recorded pO₂ reduction. Since the chamber is very well screened against oxygen diffusion it is possible to measure pO₂ as low as 0.1 mm Hg. The new application, however, of the Oxystat is however an 'open system' with controlled addition of oxygen through the solution such that O₂ consumption is measured at constant pO₂.

The operation of the Oxystat as an open system is indicated in Fig. 2. The pO₂ signal is examined by the controller; if it differs from the preset value a pump is operated to introduce oxygen-rich solution into the chamber. This raises the pO₂ in the chamber back to the set value and the pump is then stopped again. As a result a flow equilibrium is established through which, despite the oxygen consumption of the incubated cells, the

chamber pO₂ is maintained close to the set value ($\pm 5\%$). The volume in the chamber is maintained constant since the additional volume flows away through an outlet filter. The volume introduced into the Oxystat to maintain the set pO₂ is used to calculate the oxygen consumption of the cells. A cannula permits withdrawal of samples for biochemical analysis without interfering with the measurement of oxygen consumption. As an option there is provision for fitting a fiber optic into the chamber for simultaneous measurement of additional parameters such as intracellular Ca⁺⁺ concentration or redox potential. Two platinum mesh fittings inside the chamber can be used for electrical stimulation of muscle cells to experimentally increase the O₂-consumption. A separate stimulator, see below, is required for this application.

Oxystat Measuring System Model 719

This system includes the Oxystat control unit and the pump. It consists of a titrator connected to the pO₂ meter. The volume is displayed and can be recorded.

Square Wave Stimulator G-270

It has been developed for the stimulation of isolated cardiomyocytes in suspension. The main specifications are:

- Output voltage 50 to 250 V
- Maximum output current 7 A
- Square wave biphasic stimulation pattern
- Stimulation width 10 to 255 μ sec
- Stimulation frequency 0.1 to 20.0 Hz

Oxystat 1000

Oxystat System for Oxygen Consumption Measurements (continued)

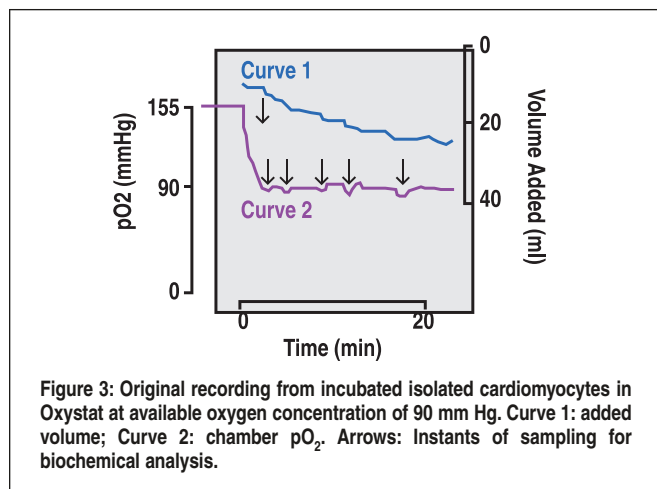


Figure 3: Original recording from incubated isolated cardiomyocytes in Oxystat at available oxygen concentration of 90 mm Hg. Curve 1: added volume; Curve 2: chamber pO₂. Arrows: Instants of sampling for biochemical analysis.

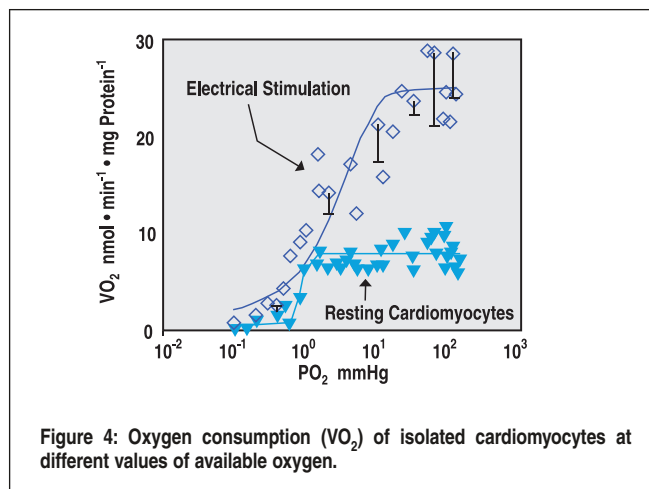


Figure 4: Oxygen consumption (VO₂) of isolated cardiomyocytes at different values of available oxygen.

Typical Recording

Fig. 3 shows an original recording. Isolated cardiomyocytes were incubated at a pO₂ of 90 mm Hg and seven samples were withdrawn consecutively for biochemical analysis. Curve 2 is the record of the pO₂ electrode. The electrode was calibrated with aerated solution (155 mm Hg). After the cells were added, the pO₂ in the chamber drops steeply. When the pO₂ falls below 90 mm Hg the controller starts the pump and aerated solution is added (curve 1) until the pO₂ has returned to its set value. The pump is operated more or less frequently depending on the O₂ consumption of the cells. From the solution volume added in unit time, i.e. the slope of curve 1, it is possible to calculate the oxygen consumption of the isolated cardiomyocytes. After taking the samples (0.8 ml each, arrows) the total quantity of cells in the chamber is reduced and less solution is required in order to maintain the chamber pO₂ at 90 mm Hg. The slope of curve 1 is correspondingly reduced.

Typical Application

The relationship between available oxygen and oxygen consumption of isolated cardiomyocytes has been investigated under different forms of stimulation (Fig. 4). Resting cardiomyocytes (triangles) have a constant oxygen consumption over a wide pO₂ range (1 to 120 mm Hg). It is only below a so-called 'critical pO₂', here at 1 mm Hg, that the oxygen consumption decreases with decreasing available oxygen. Electrical stimulation of the cells at a frequency of 9 Hz produces a 3-fold increase in oxygen consumption (rhombus). Here again the oxygen consumption remains constant over a wide pO₂ range. The critical pO₂ is raised to 10 mm Hg. Below this pO₂ the oxygen consumption decreases with decreasing available oxygen. Using the Oxystat system it could thus be shown that stimulation not only produces an increase in oxygen consumption but also that the critical oxygen value, below which the cells are in oxygen deficit, is displaced towards higher partial O₂ pressures.

References:

1) Stumpe T. and Schrader J.: Phosphorylation potential, adenosine formation, and critical PO₂ in stimulated rat cardiomyocytes, *Am.J.Physiol.* 273, H756-H766, 1997

Oxystat System

For a complete Oxystat System, please order one each of the following:

W4 73-0117, W4 73-0118 or W4 73-0119, W4 73-0120, W4 73-0122, W4 73-0124, W4 50-1932 or W4 50-1940

Order # Product

W4 73-0117	Oxystat Chamber, Thermostated, Volume 10 ml, with Built-In Stirrer, Requires W4 73-0118 or W4 73-0119 Power Supply for Stirrer
W4 73-0118	Power Supply for Stirrer with Adjustable Voltage, 115 VAC, 60 Hz
W4 73-0119	Power Supply for Stirrer with Adjustable Voltage, 230 VAC, 50 Hz
W4 73-0120	PO ₂ Electrode Type 2000-100
W4 73-0122	Oxystat Measuring System Controller Model 719, Includes Controller and to Connect pO ₂ Electrode; with Recording Outputs for pO ₂ , pO ₂ Drift and Volume, 115/230 VAC, 60/50 Hz
W4 73-0124	Square Wave Stimulator G270, for Biphasic Stimulation, 115/230 VAC, 60/50 Hz
W4 50-1932	Harvard Apparatus Thermocirculator, 115 VAC, 60 Hz
W4 50-1940	Harvard Apparatus Thermocirculator, 230 VAC, 50 Hz

Optional Accessories

W4 72-2987	2-Channel Flatbed Recorder, Economy Version, 250 mm Chart Width
W4 73-1523	Plugsys Minicase
W4 73-0210	OPPM Oxygen Partial Pressure Amplifier Module

929 and 782

Dissolved Oxygen Measurement and Respirometry System

Precision Dissolved Oxygen Measurement and Respirometry

Strathkelvin Instruments dissolved oxygen respirometry systems are based on ultra precise microcathode oxygen electrodes. The oxygen meters and interfaces are supplied with dedicated respirometry software. A choice of respirometer cells, with volumes from 50 microlitres to 3 ml, are available to meet most biomedical research applications.



6-Channel Oxygen Meter with Software, Model 929

- For closed chamber respirometry
- Flow respirometry
- Dissolved oxygen monitoring

The 929 is a complete system for replicate measurements of dissolved oxygen, together with data recording and analysis by computer. Use of this system will result in considerable time saving in both respiration experiments and in dissolved oxygen monitoring situations. The system is comprised of a microprocessor-based interface which accepts up to six 1302 microcathode oxygen electrodes, and dedicated Windows software. All operations are controlled from the computer screen, and output of recordings in chart recorder format to a printer is available.

The interface provides the polarizing voltage to the electrodes, amplifies the low-level signals, makes the A/D conversion, and feeds the resulting data stream to the computer. The system is a "virtual instrument" therefore there are no front panel controls. All operations are controlled by the computer. An illuminated front panel display provides information on the activity of the interface and displays readings from the electrodes when they are in use.

The 929 Oxygen System may be used with the Model RC 650 6-electrode Respirometer, see page 381. Details of the software are shown on the facing page. Software included (Not Windows 7 compatible).

Specifications

Resolution with 1302 Electrode	0.1% of air-saturated water
Polarizing Voltage	400-900 mV (anode connected to ground)
Power Requirements	100 to 250 VAC, 50 or 60 Hz
Dimensions	275 x 258 x 117 mm (11 x 11 x 4.5 in)

Order #	Model	Product
W4 69-3002	929	6-Channel Oxygen System

2-Channel Oxygen Meter with Software, Model 782

- Operates with 1 or 2 oxygen electrodes
- Interfaces to respirometry/monitoring software, or use as stand alone meter
- Use any unit of PO₂ or oxygen concentration
- Closed cell, flow-through respirometry and O₂ monitoring software included

This versatile new Oxygen Meter acts as both a stand alone oxygen meter, (displaying and storing oxygen values), or as an interface to respirometry or monitoring software running on a PC. It accepts inputs from either one or two Strathkelvin 1302 microcathode oxygen electrodes, and shows the oxygen values on a large liquid crystal display. The display will show units of either PO₂ (mm Hg; torr; KPa) or concentration (μmol/l; μg/l; mg/l; μl/ml; ml/l; ppm; or % saturation). When connected to the supplied software it can be used for either closed cell respirometry (using the MT200 mitocell; RC300 or RC350 respiration cell) or for flow respirometry (using the FC100 flowcell or MC100 microcell). Alternatively, the software can be used to monitor dissolved oxygen (as in isolated organ preparations). Details of the software are shown on the facing page. Not Windows 7 compatible.

Specifications

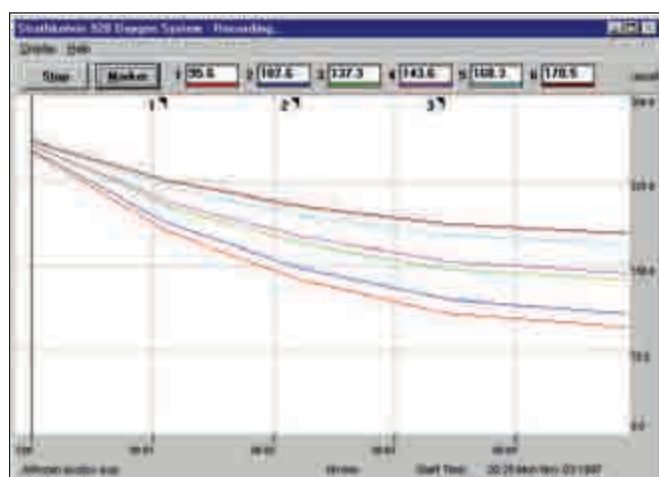
Resolution	0.01% of full scale
Repeatability	0.01%
Logging Capacity	2000 readings
Computer Interface	USB1
Power Requirements	5V, 1A from external plugtop power supply, 100-230 VAC, 47-63 Hz
Dimensions	185 x 135 x 105 mm (7.25 x 5.25 x 4.125 in)

Order #	Model	Product
W4 69-3001	782	2-Channel Oxygen Meter

Respirometry Software

Dissolved Oxygen Measurement and Respirometry System (continued)

respirometry



Chamber	Biomass (µg)	Vol (µl)
Chamber A	0.79	2.1
Chamber B	0.83	2.4
Chamber C	0.81	2.4
Chamber D	0.88	2.1

Start (Alfozan)	Length (Alfozan)	Chamber A Norm Rate (µmol/Wing)	Chamber B Norm Rate (µmol/Wing)	Chamber C Norm Rate (µmol/Wing)
0:00:41	0:02:06	27.937	36.251	
0:03:12	0:02:02	22.965	21.331	
0:05:35	0:02:33	14.181	15.79	

The software used in the 782 meter and the 929 system is functionally similar. The main difference is that the 929 displays up to 6 traces, while the 782 has a maximum of two.

The program has been written so that it is extremely user-friendly and quick to learn. It can be used for closed cell respirometry (with the MT200, RC300, RC350 or RC650), or flow respirometry (using the FC100 or MC100) or for monitoring dissolved oxygen (using the FC 100 or MC100). When used for respirometry experiments, it follows the familiar logical sequences of operations, from electrode calibration to recording and analysis. The program follows a sequence of 3 main stages: Setting up, Recording, and Analysis.

Setup

The setup screen is used for entering all of the details which the computer needs in order to record in the correct units, and to express the respiration rate, normalized to biomass units if required, in the desired units. All experimental details entered here are transferred through to the final calculated results report page. During setup, the cell volumes (for closed cell) and flow rate, electrode positioning (for flow respirometry), temperature of the experiment, scrolling speed of the traces during recording, and the instruction to print the recording screen to printer (if hard copy is required) are all entered. Many of these will not change from one experiment to the next, and it is only necessary to enter changes.

Recording

Clicking the 'Start' button initiates the recording process, and traces then scroll across the screen. If substrates, inhibitors or other solutions require to be added during the run, the position where this occurs can be recorded with a flag, and the nature of the addition is recorded on a drop down menu. At the termination of the experiment, the data are saved to a data file, and may be analyzed straight away if required.

Analysis

The data file, recorded traces, and event marker flags are recalled to the screen. If the recording has exceeded one screen width, it can be contracted to fit the screen, if required. Alternatively it is possible to scroll along long recording traces. Selector lines may be dragged to enclose specific parts of the trace. Thus if the traces show both control respiration

and changed respiration after adding a solution, the selector lines would be dragged to the control rate first and then to the changed rates.

In each case respiration rates (normalized if so designated) are calculated automatically by clicking the 'Calculate' button. The calculated rates are tabulated, together with the experimental details entered during Setup, on the report page. The results may be exported to a spreadsheet, word processing or statistics package. The Analysis screen and the Report page may be printed, if required.

When the software is used for dissolved oxygen monitoring, the Analysis screen which displays the recorded traces and the oxygen values at flagged points or at set times can be transferred to the Results and report page.

The program requires a computer with a minimum specification of: Pentium processor, 1 free serial port, 64 Mb RAM, Windows 95 or later (excluding Windows 7) and 4 MB hard disk space. A comprehensive Instruction Manual is supplied, which will be particularly valuable to anyone who is not familiar with respirometric work.

This software is supplied with the 6-Channel Oxygen System Model 929 and the 1-2 Channel Oxygen Meter. It is not available separately.

1302 and MT200/MT200A

Dissolved Oxygen Measurement and Respirometry System (continued)



Microcathode Oxygen Electrode

- May be used with or without stirring
- High output stability
- Very low rate of oxygen consumption
- Compatible with all Strathkelvin accessories

The 1302 is a Clark-type polarographic electrode with a 22 micron diameter platinum cathode and silver/silver chloride anode connected by a buffered potassium chloride electrolyte solution. In the normal configuration the cathode is covered with a relatively low permeability polypropylene membrane to allow the electrode to be used in unstirred solutions or where minimal stirring is required. This membrane gives a relatively slow response time. For rapidly respiring enzyme preparations, an electrode with a thin FEP membrane (W4 69-3004) is used. Rapid stirring is necessary. Electrodes are not temperature compensated and require thermally controlled environments to within 0.1°C. Electrodes are specifically designed for use in the MT-200 or MT200A. Electrode service kits provide all tools and parts, including membranes, needed to repair the electrodes. We recommend the purchase of an electrode kit with the purchase of the electrode.

Specifications

Response Time at 37°C:	
Polypropylene Membranes	18 sec for 90% change
FEP Membranes	6 sec for 90% change
Oxygen Consumption (Polypropylene Membranes)	0.5 to 3x10 ⁻¹⁰ mg O ₂ /min
Temperature Coefficient	2% per °C

Order #	Model	Product
W4 69-3006	SI130	1302 Oxygen Electrode with Polypropylene membrane
W4 69-3004	SI132	1302 Oxygen Electrode with FEP membrane
W4 69-3007	SI020	Polypropylene electrode service kit
W4 69-3005	SI021	FEP electrode service kit

Accessories and Replacement Parts

W4 69-3008	SI030	Electrolyte
W4 69-3014	SI045	Replacement polypropylene electrode jackets, pk 6
W4 69-3011	SI035	Replacement FEP electrode jacket, no membrane
W4 69-3010	SI025	FEP membranes, pk 15



Mitocell Miniature Respirometer

- Miniature respirometer for mitochondria and cell suspensions
- Integral magnetic stirrer
- Glass chamber with volumes of 50/100 µl (MT200) or 0.3/0.5/1.0 ml (MT200A), and good visibility of contents
- Transparent polycarbonate plunger
- Substrate and inhibitors may be injected directly into chamber

This MT200 and MT200A Mitocell Miniature Respirometer has a chamber volume of only 50 µl and was introduced for measurements on mitochondria isolated from biopsy samples. It can be used in any situation where sample size is limited. The base section contains an integral solid state, fixed speed magnetic stirrer. The 1302 microcathode electrode (W4 69-3006) is inserted from beneath the unit, and its projecting tip forms the base of the respirometer chamber. The glass chamber unit is surrounded by a water jacket through which constant temperature water is circulated. The respiration cell has a polycarbonate plunger with a central capillary through which solutions may be added during the course of a respiration run. Stainless steel magnetic spinbars are supplied together with a special 1 µl syringe supplied with MT200 and a 5 µl syringe with the MT200A for solution additions.

Order #	Model	Product
W4 69-3033	MT200	Mitocell Miniature Respirometer, 50/100 µl
W4 72-6186	MT200A	Mitocell Miniature Respirometer, 0.3/0.5/1.0 ml
W4 72-6187	SK205	Replacement Glass Top with Plunger for MT200
W4 72-6188	SK206	Replacement Glass Top with Plunger for MT200A
W4 98-2200	SK204	Stirbars for MT200, pk 6
W4 64-0421	MAG-22	Stirbars for MT-200A, pk 6

RC 650

Dissolved Oxygen Measurement and Respirometry System (continued)

respirometry



6 Cell Respirometer

- Ability to carry out replicate experiments, utilizing the advanced recording and analysis features of the Strathkelvin 928 system
- Integral unit complete with magnetic stirrer
- Good visibility of cell contents
- Variable cell volume

Designed for use with the Model 928 six channel oxygen meter. This respirometer is ideal for replicate respiration measurements of cell and microbial suspensions, as well as mitochondrial or enzyme preparations.

The respirometer consists of a sealed water bath containing six respirometer cells positioned above a six position magnetic stirrer. Electrode holders, each with a hole in its tip through which the membrane of the 1302 electrode protrudes, makes a sliding fit into the cells. A small slot runs the complete length of the holder and allows respiratory inhibitors or other solutions to be injected directly into the cell using an included fine bore needle.

The volume of individual cells may be set between 1 and 3 ml by rotating the knurled collar of the associated holder. The rear of the bath assembly contains 6 parking cells which are used to hold the electrode holders at a constant temperature while exchanging the contents of respiratory cells. Cells are sealed into the water bath by o-rings for easy removal and cleaning.

Specifications

Diameter of Cells	16 mm
Volume of Cells	1 to 3 ml (adjustable)
Cell	Precision bore glass
Electrode Holder	Black acetal, with peek tip
Bath	Clear and black acrylic
Magnetic Stirrer	6-position; 12 VDC from external plugtop power supply, 100-230 V, 47-63 Hz

Order #	Model	Product
W4 69-3021	RC 650	6 Electrode Respirometer*
W4 69-3006	SI130	1302 Electrode with polypropylene membrane
W4 69-3004	SI134	1302 Electrode with FEP membrane
W4 69-3007	SI020	Polypropylene Electrode Service Kit
W4 69-3005	SI021	FEP Electrode Service Kit

* Oxygen Electrode Service Kit should be ordered with Respirometer

RC 300/350 and MC 100

Dissolved Oxygen Measurement and Respirometry System (continued)

respirometry



Respiration Cells RC 300 and RC 350

- Small sample volume
- Good visibility of cell contents

These respiration cells are for small volume measurements of oxygen uptake rate by microbial suspensions, cell suspensions, mitochondria or enzyme preparations. The electrode holder (supplied with the cell) slides into one of two glass tubes fused into the glass water jacket. The second tube is used to park the electrode holder when changing solutions. A fine slot (1 x 1 mm) in the side of the holder allows air to escape when the holder is inserted into the cell. It may also be used to introduce other solutions during the course of a respiration run and a fine bore needle with luer fitting (included). A PTFE covered magnetic spinbar is provided and the cell should be located on a magnetic stirrer unit (not provided). For fast reactions, it is recommended that electrodes with FEP membranes (W4 69-3004) be used (electrodes sold separately).

Specifications

Model	RC 300	RC 350
Cell Diameter	13 mm	16 mm
Cell Volume	0.3 to 1.0 ml	1.0 to 3.0 ml
Cell	Glass	
Electrode Holder	Black acetal	

Order #	Model	Product
W4 69-3018	RC 300	Respiration Cell
W4 69-3019	RC 350	Respiration Cell
W4 69-3027	SK300	Replacement Glass for W4 69-3018
W4 69-3028	SK350	Replacement Glass for W4 69-3019
W4 69-3032	RC355	Spinal Needles for use with W4 69-3018 & W4 69-3019, pkg. of 3
W4 69-3006	SI130	1302 Oxygen Electrode with Polypropylene membrane
W4 69-3004	SI132	1302 Oxygen Electrode with FEP membrane



MicroCell Model MC 100

- For pO₂ measurement of blood or other fluids, or for micro flowcell use
- Small Sample Volume
- Flow through or spot measurement
- Exceptional visibility
- Easy access for cleaning

The all-glass sample chamber has a capacity of approximately 70µl. Samples are injected into the chamber through a 1mm stainless steel tube fitted with a fine PVC needle-locating collar. Alternatively, the cell can be used as a micro flowcell by connecting the outflow from a respiring preparation. The sample leaves the chamber through a glass Luer fitting to which a small bore flexible drainage tube can be connected. The sample chamber is completely surrounded by water circulated through the glass water jacket from a constant temperature bath. This provides good temperature regulation while providing excellent visibility of the contents of the chamber. The water jacket screws into an acetal base section and can be easily removed for cleaning. The microcathode electrode fits into the central electrode holder and the membrane at its tip forms the floor of the sample chamber. Electrode sold separately.

Specifications

Sample Chamber	70 µl
Overall Height	106 mm
Jacket and Cell	Glass
Base Section	Black acetal

Order #	Model	Product
W4 69-3016	MC 100	MicroCell Model

FC 100 and EH 100

Dissolved Oxygen Measurement and Respirometry System (continued)



Flow Cell FC 100

- For continuous in-line oxygen monitoring or for connection to flow-through respirometer chamber
- Easily disassembled for cleaning
- Good visibility of flowline

The acrylic chamber of the flowcell screws onto the electrode holder. Only the tip of the electrode projects into the water flow. The inlet and outlet tubes are made from stainless steel. The electrode holder is fitted with a collar for attachment to a vertical or horizontal (¼ to ¾ inch) diameter laboratory rod to enable the flowcell to be immersed below the surface of the constant temperature bath containing the respirometer chamber. Electrode sold separately.

Specifications

Material:	
Electrode Holder	Black acetal
Collar	Black acetal
Chamber	Clear acrylic
Inlet/Outlet	6 mm OD and 3 mm ID stainless steel

Order #	Model	Product
W4 69-3023	FC 100	Flow Cell
W4 69-3006	SI130	1302 Oxygen Electrode with Polypropylene membrane
W4 69-3004	SI132	1302 Oxygen Electrode with FEP membrane



General Electrode Holder EH 100

- For use with any of your own custom respiration chamber designs

The 1302 electrode should only be used with an electrode holder to prevent ground-leak damage. The EH100 electrode holder is a black acetal tube designed to allow a user to place the electrode into any self-designed respiration chamber. The holder positions the electrode so that its tip projects slightly from the end. An acrylic collar containing an o-ring on its inside surface is provided and this collar can be cemented over any 13mm hole to facilitate placement of the electrode holder in the respiration chamber.

Specifications

	Electrode Holder	Acrylic Collar
Dimensions	13 x 85 mm (D x L)	26 x 10 mm (D x L)
Holder Material	Black acetal	Clear acetal

Order #	Model	Product
W4 69-3024	EH 100	Electrode Holder
W4 69-3006	SI130	1302 Oxygen Electrode with Polypropylene membrane
W4 69-3004	SI132	1302 Oxygen Electrode with FEP membrane

Microminiature pH Electrodes

Model pHamp pH peramplifier

The pH preamplifier is a compact unity gain preamplifier designed to convert the high impedance mV signal of a pH electrode to a low impedance signal which can travel up to 1,000 feet over coaxial cable. Recommended for all applications using the pH electrodes below.

This rugged preamplifier is encapsulated in an epoxy filled stainless steel enclosure and uses BNC input and output connections. Powered from a lithium battery. Expected life is 5-years minimum.

Order #	Product
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W4 69-1625	pH pre-amplifier, battery powered
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This series of **micro pH, O₂ and CO₂ electrodes** has been specifically designed for use in various area of bioscience research. Their microminiature design and small sensing area allows them to be used for small area measurements. This series of pH electrodes have similar response characteristics to standard size, glass pH electrodes making them compatible with any standard pH meter. The pH series of electrodes come in a variety of configurations to fit every need.

Combination pH Electrode for Micro Wells

This a miniature combination pH/reference electrode has been designed to fit small perfusion chambers without effecting fluid exchange rates. It does not require an external reference electrode and the reference solution can be replaced. The electrode is stored wet.

Specifications IC-501

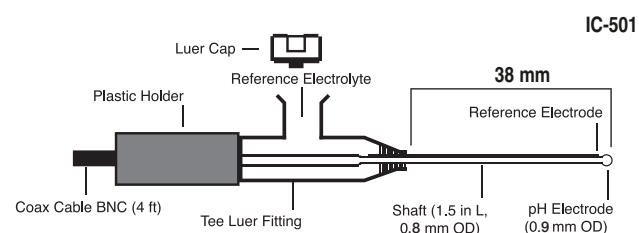
Response Time	~10 sec
Slope	55 mV per pH, range of 1 to 14
Impedance	200 MΩ
Stability	0.05 pH per day
Dimensions, L x D	38.1 x 0.75 mm (1.5 x 0.03 in)

Order #	Product
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W4 69-0494	Combination pH Electrode for Micro Wells, Model IC-501
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W4 69-1625	pH pre-amplifier, battery powered
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Smallest Sample Volume is 10 to 20 µl



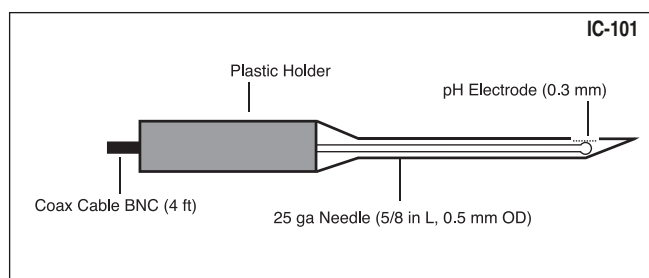
Microminiature pH Electrodes

Single pH Electrode in 25 Gauge Needle

This is a microminiature pH electrode mounted in the lumen of a fine hypodermic needle. This configuration allows for easy penetration and insertion of the electrode into all types of tissue for on-line/real time monitoring of pH. This pH electrode does not contain an external reference and an external reference electrode such as the W4 69-0490 or similar must be used. The electrode is stored dry.

Specifications IC-101

Response Time	~15 sec
Slope	55 mV per pH, range of 1 to 14
Impedance	1,500 M Ω
Stability	0.05 pH per day



Order # Product

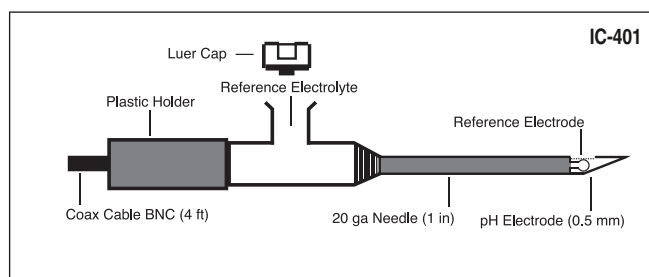
W4 69-0491	Single pH Electrode in 25 ga Needle, Model IC-101
W4 69-0490	Flexible Reference Electrode, see page 373
W4 69-1625	pH pre-amplifier, battery powered

Combination pH Electrode in 20 Gauge Needle

This is a miniature combination pH/reference electrode that is mounted in a 20 gauge stainless steel tube. The stainless steel tube provides protection to damage of the internal miniature glass pH sensor. It does not require an external reference electrode. The reference solution can be replaced. The electrode is stored wet. Tip length is 1.8 mm.

Specifications IC-401

Response Time	~10 sec
Slope	55 mV per pH, range of 1 to 14
Impedance	200 M Ω
Stability	0.05 pH per day
Dimensions, L x D	25.4 x 0.9 mm (1 x 0.035 in)



Order # Product

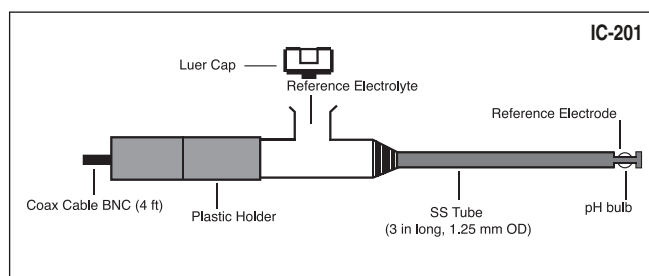
W4 69-0493	Combination pH Electrode in 20 ga Needle, Model IC-401
W4 69-1625	pH pre-amplifier, battery powered

Combination pH Electrode in 18 Gauge SS Tube

This miniature combination pH/reference electrode is mounted in an 18 gauge stainless steel tube. The stainless steel tube provides protection to damage of the internal miniature glass pH sensor. It does not require an external reference electrode. The reference solution can be replaced. The electrode is stored wet. Tip length is 1.5 mm.

Specifications IC-201

Response Time	~10 sec
Slope	55 mV per pH, range of 1 to 14
Impedance	200 M Ω
Stability	0.05 pH per day
Dimensions, L x D	76 x 1.25 mm (3 x 0.005 in)



Order # Product

W4 69-0492	Combination pH Electrode in 18 ga SS Tube, Model IC-201
W4 69-1625	pH pre-amplifier, battery powered

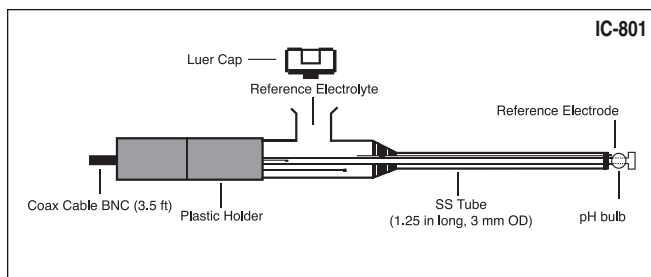
Microminiature pH Electrodes (continued)

Combination pH Electrode in 11 Gauge SS Tube

This miniature combination pH/reference electrode is mounted in an 11 gauge stainless steel tube. The stainless steel tube provides protection to damage of the internal miniature glass pH sensor. It does not require an external reference electrode. The reference solution can be replaced. The electrode is stored wet.

Specifications IC-801

Response Time	~10 sec
Slope	55 mV per pH, range of 1 to 14
Impedance	200 MΩ
Stability	0.05 pH per day
Dimensions, L x D	31.7 cm x 3 mm (1.25 x 0.1 in)



Order # Product

W4 69-0497 Combination pH Electrode in 11 ga SS Tube, Model IC-801

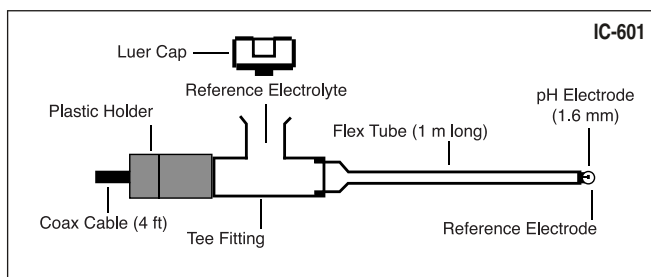
W4 69-1625 pH pre-amplifier, battery powered

Combination Gastroesophageal pH Electrode

This miniature combination pH/reference electrode has a long (3 foot) flexible tube to fit into the esophagus. It does not require an external reference electrode. The reference solution can be replaced. The electrode is stored wet.

Specifications IC-601

Response Time	~10 sec
Slope	55 mV per pH, range of 1 to 14
Impedance	200 MΩ
Stability	0.05 pH per day
Electrode OD	1.6 mm
Dimensions, L x D	91.4 cm x 1.6 mm (3 ft x 0.06 in)



Order # Product

W4 69-0495 Combination Gastroesophageal pH Electrode, Model IC-601

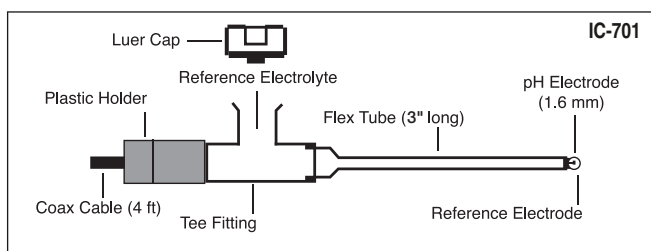
W4 69-1625 pH pre-amplifier, battery powered

Flexible Combination pH Electrode for Free Flap Surgery

This miniature combination pH/reference electrode has been specifically designed to be used in free flap surgery. It does not require an external reference electrode. The reference solution can be replaced. The electrode is stored wet.

Specifications IC-701

Response Time	~10 sec
Slope	55 mV per pH, range of 1 to 14
Impedance	200 MΩ
Stability	0.05 pH per day
Dimensions, L x D	91.4 x 1.6 mm (3 x 0.06 in)



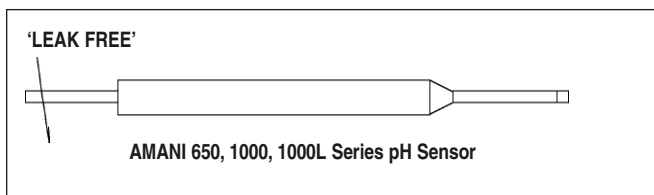
Order # Product

W4 69-0496 Combination pH Electrode for Free Flap Surgery Battery Operated Meter 10⁹Ω Input Impedance, Model IC-701

W4 69-1625 pH pre-amplifier, battery powered

AMANI

AMANI 'LEAK FREE' Microcombination pH Electrodes



The AMANI 'Leak Free' series of non-glass, micro pH electrodes are the latest development in our combination (built in reference) pH electrode line. The new technologies used in these electrodes provide superior sensitivity and stability. The 'Leak Free' non-porous reference junction eliminates the problems of clogged junction and adsorption of proteins and surfactants. They also have high resistance to chemical including hydrofluoric acid solutions.

With tip diameters starting as low as 650 μm , they are one of the smallest combination pH electrodes on the market today. Custom configurations of the AMANI series of pH combination electrodes are also available, please contact Technical Sales for further details.

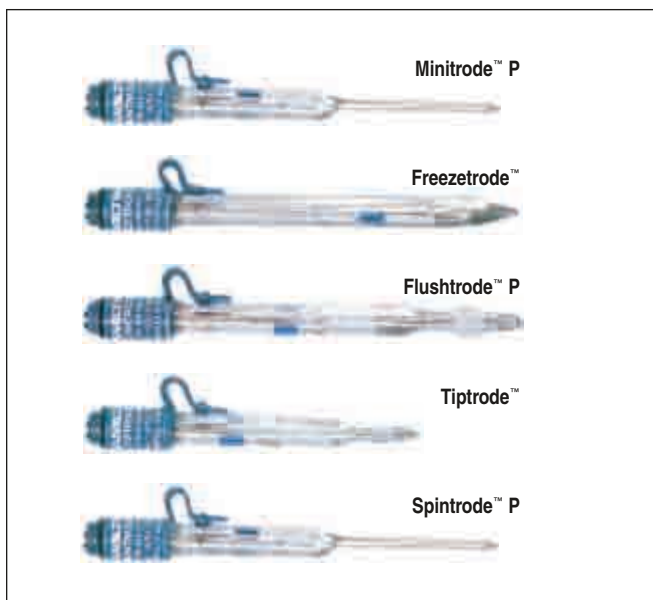
- Integrated 'LEAK-FREE' non-porous reference junction eliminates problems of clogged junction and adsorption of proteins and surfactants
- All plastic construction, unbreakable and tough — no glass!
- Can be used with any pH meter with BNC connector
- 'Zero' depth of immersion, just touch sample to flat tip
- Superior chemical resistant — can even be used in hydrofluoric acid solutions
- Tip diameter as small as 650 μm including reference electrode
- Standard Nernstian behavior
- Flexible version is available for use in restricted areas such as microscope stage
- Long working life
- Low cost
- Maintenance-free, dry or wet storage, no filling solutions needed

Specifications

Model	AMANI-650	AMANI-1000	AMANI-1000L
Tip Diameter	650 μm	1000 μm	1000 μm
Tip Length	20 mm (0.8 in)	20 mm (0.8 in)	75 mm (3 in)
Construction	All Plastic	All Plastic	All Plastic
Depth of Immersion	< 100 μm	< 100 μm	< 100 μm
Min. Sample Volume	250 nL	500 nL	500 nL
Response Time	< 3 sec, 90% response	< 3 sec, 90% response	< 3 sec, 90% response
Temperature Range	0° to 100°C	0° to 100°C	0° to 100°C
Internal Reference	Ag/AgCl	Ag/AgCl	Ag/AgCl
Slope	Nernstian	Nernstian	Nernstian
pH Range	0 to 14	0 to 14	0 to 14
Storage	Wet or dry	Wet or dry	Wet or dry
Connector	BNC	BNC	BNC
Electrode Holder	4.8 x 75 mm	4.8 x 75 mm	4.5 x 50 mm
OD x Length	(0.19 x 2.9 in)	(0.19 x 2.9 in)	(0.18 x 2 in)
Lead Wire	0.9 m (3 ft)	0.9 m (3 ft)	0.9 m (3 ft)
Order #	W4 69-0020	W4 69-0021	W4 69-0022

pH Electrodes

Protein Resistant pH Electrodes



- Ideal for determining pH in samples that contain protein
- Faster response times than traditional pH electrodes
- More accurate than traditional pH electrodes
- Longer electrode life — more economical
- Five styles available to meet most application needs
- pH range from 2 to 11

Measuring the pH of biological samples containing proteins is difficult. Proteins in solution can combine with silver ions from the electrolyte to clog the pH electrode diaphragm. This leads to long response times, inaccurate pH measurements, and eventually discarded electrodes. These protein resistant electrodes are designed for rapid, accurate, and reproducible pH measurements of protein containing solutions.

Unique to these pH electrodes is the specially formulated Protelyte™ reference electrolyte. Protelyte™ electrolyte prevents the precipitation of proteins on the electrode diaphragm. You get faster, more accurate, reproducible pH measurements of your samples. Select from five specialized electrodes. The best electrode for you depends upon your applications, physical size limitations, and temperature range. Each has a pH range of 2 to 11.

Minitrode™ P

The small size of this sensor makes it ideal for pH measurement of sample in microplates and microcentrifuge tubes. The sensor tip is 3 mm diameter with a usable length of 100 mm (3.9 inches).

Freezetrode™

This sensor is ideal for measuring the pH of samples stored in cold rooms. Select this sensor if your sample is between -20° to +80°C. It has a 12 mm diameter tip.

Flushtrode™ P

If your sample contains between 5 to 85% water, this is the ideal sensor for you. It is good for determining pH of buffer solutions. It has a 12 mm diameter tip.

Tiptrode™

This pH sensor was designed for pH measurements in applications requiring penetration of solid and semi-solid materials including: foods, gelatinous materials, and viscous buffers. It has a 6 mm tip.

Spintrode™ P

Use the SPINTRODE™ to determine the pH of samples in NMR tubes. The 3 mm diameter, 180 mm (7 inch) long sensor allows you to determine the pH without transferring the sample from the NMR tube.

These pH Electrodes are supplied individually and have S7 type connectors. To ensure the most accurate pH measurements, calibrate your electrodes with DURACAL™ Buffer Solutions, see facing page for more information.

Specifications

Order #	Electrode	Length	Outer Diameter	Temp. Range
W4 69-0070	Minitrode™ P	100 mm	3 mm	0° to 60°C
W4 69-0071	Spintrode™ P	180 mm	3 mm	0° to 60°C
W4 69-0072	Freezetrode™	120 mm	12 mm	-20°C to 80°C
W4 69-0073	Flushtrode™ P	120 mm	12 mm	10° to 50°C
W4 69-0074	Tiptrode™	25 mm	6 mm	0° to 80°C

Order # Product

Accessories

W4 69-0075	Protelyte™ Reference Electrolyte Solution, 100 ml
W4 69-0076	Electrode Storage Solution, 500 ml
W4 69-0077	Electrode Connecting Cable, BNC to AS7, 1 m (3.3 ft)
W4 69-0078	Electrode Connecting Cable, DIN to AS7, 1 m (3.3 ft)
W4 69-0079	Electrode Connecting Cable, Metrohm (Lemo) to AS7, Type F, 1 m (3.3 ft)
W4 69-0080	Electrode Connecting Cable, Metrohm (Lemo) to AS7, Type H, 1 m (3.3 ft)
W4 69-0081	Electrode Connecting Cable, Radiometer to AS7, 1 m (3.3 ft)
W4 69-0082	Electrode Connecting Cable, Standard US to AS7, 1 m (3.3 ft)

DURACAL™

pH and Redox Buffers

electrodes

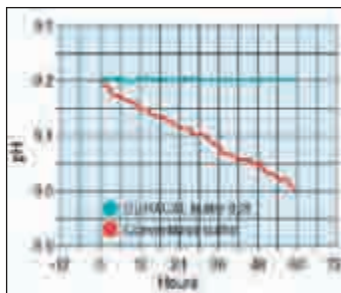


Figure 1



Step 1. Unscrew cap to access calibration compartment.

Step 2. Squeeze CALPAK™ bottle to force buffer into compartment



Step 3. Insert electrode for calibration.

Step 4. Turn CALPAK™ bottle on its side to dispose of used buffer.

Figure 2: Calibrating Electrodes in the CALPAK™ Dosing Bottle

- Stable, guaranteed 5 year buffer lifetime
- Unique time saving CALPAK™ dosing bottle
 - No more searching for suitable containers
 - No more cleaning
 - No more risk of contamination
- No wasted buffer, economical and easy to dispense only the required quantity of buffer for calibration
- Automatic buffer recognition with a majority of pH meters
- Certified, traceable to N.I.S.T.

Accurate, stable buffers are critical for the calibration of pH and redox electrodes to achieve accurate measurements, particularly with modern pH meters incorporating GLP functions for recording electrode performance. DURACAL™ pH and Redox Buffer solutions are the buffers you can trust. They offer you many advantages over traditional buffer solutions: guaranteed five year stability, excellent stability of even pH 9.21 in air, see Figure 1, automatic buffer recognition so you use the correct buffer to calibrate. All of this in a unique time saving, money saving dispensing bottle.

DURACAL Buffers are guaranteed for 5 years from the date of production. During this time they retain a high buffer capacity for fast, stable calibrations. The pH 7.00 buffer is less sensitive to ions while the pH 9.21 buffer provides stability superior to conventional buffers. See Figure 1 for a comparison of DURACAL™ and conventional buffer stability when subjected to prolonged air exposure.

The unique, easy-to-use, CALPAK™ dispensing bottle allow electrode calibration in the buffer bottle without contamination. In 4 easy steps, calibration is complete, see Figure 2. It's that simple! No more searching for a suitable container, no more cleaning, no more risk of contamination, and no more wasted buffer from overfilling a container. The composition of DURACAL™ Buffers has been optimized so the temperature function is similar to that of conventional buffers. This guarantees that the automatic buffer recognition of most pH meters can be used without any problems.

Duracal™ Buffers Specifications

	pH 4.01	pH 7.00	pH 9.21	pH 10.01	Redox +475 mV
pH	±0.02	±0.02	±0.02	±0.02	±5 mV
Solution Color	Red	Green	Blue	Yellow	Yellow
1 Bottle, 500 ml	W4 69-0083	W4 69-0084	W4 69-0085	W4 69-0086	W4 72-7140
Multipack (500 ml x 3)	W4 69-0088	W4 69-0089	W4 69-0090	W4 69-0091	—

Order # Product

W4 69-0092 Buffer Set, One 500 ml Bottle of 4.01, 7.00 and 9.21

W4 72-7141 Buffer Set, One 500 ml Bottle of 4.01, 7.00 and 10.01

Reference Electrodes

Leak-Free Reference Electrodes

The 'LEAK FREE' reference electrodes were developed to eliminate the problems associated with the use of conventional porous junction-based reference electrodes such as clogging, sample contamination, electrolyte loss, changing of ionic strength of the sample, and the difficulties with organic based solvents. They utilize a unique junction that is highly conductive ($< 10 \text{ K } \Omega$) but not porous. There is no solution migrating through the junction in either direction. The reference is totally leak free! The junction is resistant to most commonly used organic solvents. It offers excellent resistance to acetonitrile, DMSO, THF, MEK, acetone, dichloromethane, esters, alcohols, and ketones, hydrofluoric acid or common dilute acids and bases. Unlike conventional reference electrodes, there is no need to store them in concentrated chloride solution. If the electrode is left dry for a long period of time, it should be immersed in water for few hours to recover.

Two sizes of 'leak free' reference electrodes are available, see ordering chart below for details. Other custom configuration of the leak-free reference electrode are available, please consult with Harvard Apparatus Technical Sales Department.

Low-Leakage Reference Electrodes

The low-leakage reference electrodes are for use in applications where contamination would interfere with the application. The electrode junctions are resistant to most commonly used organic solvents. They offer excellent resistance to acetonitrile, DMSO, THF, MEK, acetone, dichloromethane, esters, alcohols, and ketones. Hydrofluoric acid or common dilute acids and bases have no effect on the on these electrodes.

Two low-leakage reference electrodes are available. One is 2 mm (0.08 in) in diameter and the second is 5 mm (0.2 in) in diameter. Other custom configurations of the low-leakage reference electrodes are available, please call the Harvard Apparatus Technical Sales Department.



Specifications

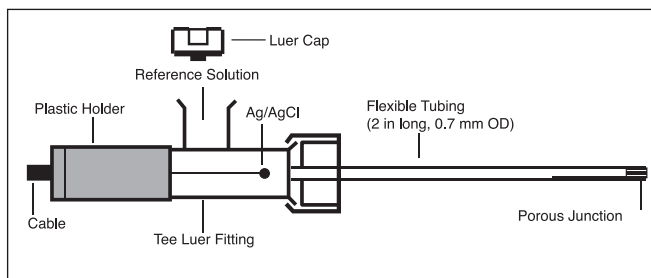
	Low-Leakage Reference Electrodes	Leak-Free Reference Electrodes	
Diameter	5 mm (0.2 in)	1 mm (0.04 in)	2 mm (0.08 in)
Length	130 mm (5.1 in)	100 mm (3.9 in)	65 mm (2.6 in)
Construction	PEEK*	PEEK*	PEEK*
Leakage Rate	5×10^{-12} l/min	0	0
Filling Electrolyte	3 M KCl	3 M KCl	3 M KCl
Electrical Connection	2 mm pin	1 mm gold	1 mm gold plated pin
Junction Resistance	$< 1 \text{ K } \Omega^{\dagger}$	$< 10 \text{ K } \Omega^{\dagger}$	$< 10 \text{ K } \Omega^{\dagger}$
Temperature Range	5° to 80°C	5° to 80°C	5° to 80°C
Storage	3 M KCl	Distilled water	Distilled water
Order #	W4 69-0025	W4 69-0053	W4 69-0023

* Polyether Ketone

\dagger In 1 M potassium chloride

Flexible Reference Electrode

This miniature flexible reference electrode is 3 inches long and has an outside diameter of 2 mm. It comes complete with a 4 foot long cable and is terminated with an alligator clip connector. Each unit comes pre-filled with the reference solution (3.0 M NaCl in 25% Glycerol) and it is stored dry. If refilling is ever required, reference solution can be injection into the side of the tee fitting and flexible tube portion of the electrode.



Order # Product

W4 69-0490 Flexible Reference Electrode

Model 863 Auto Chloridizer Kit



- Simple means to chloridize Ag/AgCl electrodes
- Environmentally safe

The Auto Chloridizer 863 is an electrolytic chloridation unit which provides a simple means for chloriding Ag/AgCl electrodes. It covers the surface of the silver electrode with an AgCl film insoluble in water. Unlike a purely chemical procedure, electrolytic chloridation does not involve the use of substances endangering the environment. It is normal practice to work with physiological saline solution (NaCl) as the electrolyte.

The electrolytic chloridation method also offers excellent reproducibility of the AgCl film at constant current density and chloridation time. The auto chloridizer operates with an electronically controlled constant-current source with current monitoring and error indication through an LED and error beep. During chloridation of a single Ag/AgCl electrode the unit is operated manually through the start/stop key.

For routine production of several identical electrodes, such as Ag/AgCl wires for glass microelectrodes, the unit offers a simple programming feature for the chloridation period in the repeat mode. First the learning mode is initiated by pressing the repeat key (for longer than 1 second) and then an electrode is produced manually using the start/stop key. All further electrodes are then prepared automatically according to the manual setting by pressing the repeat key. The end of the chloridation process is indicated by a beep and the current source is automatically switched off.

The counter electrode (cathode) used is a carbon-glass ceramic crucible. This material has a very high electrical conductivity, is inert physiologically, and is resistant to oxidation and corrosion. There is thus no contamination of the AgCl film through free metal ions, as is the case when using stainless steel as a cathode for example.

Specifications

Chloridation Current	Electronically controlled constant current source with current monitoring facility, and with low/medium/high selection by switch, corresponding to approx. 5/10/15 mA respectively
Chloridation Voltage approx.	Max. driving voltage of constant current source is 15 V and is therefore completely safe for user
Start/Stop	Manual operating mode start/stop for chloridation of single electrodes
Repeat	Automatic repetition of manually set chloridation procedure
Dimensions, H x W x D	15 x 6 x 12 cm (5.9 x 2.4 x 4.7 in)
Weight	750 g (1.7 lb)

Order # Product

W4 73-0004	HSE Auto Chloridizer Model 863, 115 VAC, 60 Hz
W4 73-0005	HSE Auto Chloridizer Model 863, 230 VAC, 50 Hz
W4 73-0006	Spare Crocodile Clips
W4 73-0007	Maintenance Kit for Silver Electrodes, Emery Paper and Scotch-Brite Cleaning Sponge, for Cleaning Silver Electrode before Chloridation



This microelectrode starter kit makes entry into microelectrode production technology easy for researchers who have not yet produced microelectrodes themselves. It contains all the necessary aids, components and consumables. A puller must be purchased separately, see pages 331 to 334. In addition to manual dexterity, which is always necessary, the system requires a binocular transmitted-light microscope with eyepiece graticule and up to 500X magnification for optical checking of the tip diameter.

The kit is suitable for producing intracellular microelectrodes using borosilicate glass capillaries with an integral filament, see pages 324 to 330. The filament makes microelectrode filling easy. Special filling devices, such as vacuum filling equipment, are therefore not required. In addition to a transport and storage container for completed microelectrodes, the kit also includes a specially developed electrolytic chloridation unit for producing an AgCl film on silver electrodes. Controlled application of the AgCl film through the selection of current density and chloridation period in the case of the electrolytic chloridation method, together with the good reproducibility of the AgCl film, readily justify the increased cost of purchasing the electrical chloridation equipment. By contrast, chemical chloridation involves less equipment but produces poorer chloridation results and has negative effects on the environment.

The kit includes:

Materials: Pack of 1.5 mm OD glass capillaries with filament, 10 m pure silver wire, 0.2 mm dia., fine solder wire, emery paper, Scotch-Brite cleaning sponge, KCl and NaCl powder, connecting pins for the microelectrodes, and sealing wax.

Tools: 18 W, 230 V miniature, curved soldering tweezers, straight soldering tweezers, fixation tweezers, clamping stand as aid for soldering the micro pins, electrolytic chloridation Auto Chloridizer, transport and storage container for micro-electrodes, special microelectrode holder with miniature socket, and illustrated book about the microelectrode technology.

Order #	Product
W4 73-0008	Microelectrode Starter Kit, 115 VAC, 60 Hz
W4 73-0009	Microelectrode Starter Kit, 230 VAC, 50 Hz

Ag-AgCl Electrodes

Why Silver-Silver Chloride (Ag-AgCl)?

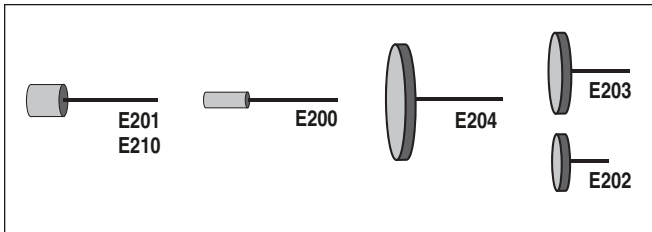
Ag-AgCl electrodes have long been recognized for their superiority in sensing bioelectric signals. The electrochemical properties of Ag-AgCl electrodes are such that biopotential waveforms are faithfully reproduced. Usually any offset potential - and this includes the electrode potential - is compensated (zeroed) before a recording. Long-term changes in the offset potential appear as baseline drift, and short-term changes as noise on the trace.

The quality of a Ag-AgCl electrode depends to a great extent on the formulation of the AgCl pellet. Our electrodes are made from very high purity materials. A careful proprietary process results in a

fine grain, homogeneous mixture of silver and silver chloride. A careful sintering process strengthens and stabilizes the entire electrode assembly.

Typical values of the key parameters, measured in 0.9% saline, between pairs of electrodes the same size are:

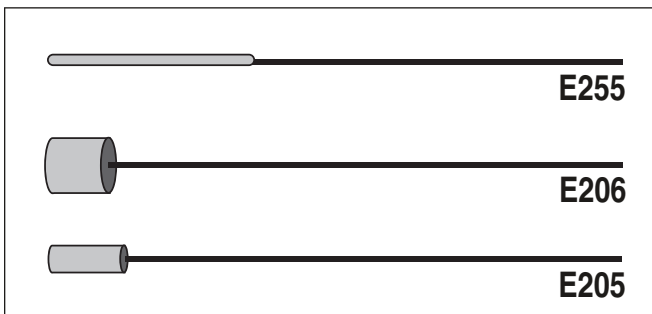
- 1) DC Offset Voltage: 180 μ V
- 2) Drift: 25 μ V/hour
- 3) Noise: 1 μ V peak-to-peak (0.1-1000 Hz with 50/60 Hz eliminated).



Ag-AgCl Pellet and Disc Electrodes

These six electrodes are ideally suited for making custom assemblies of skin electrodes and other bioelectric recording and stimulation apparatus. All have a pure silver wire (.25 mm diameter x 7 mm) embedded in the Ag-AgCl matrix. This wire can be easily soldered or twisted onto other wires.

Order #	Model	Product
W4 64-1304	E200	Pellet 1.5 x 3 mm (D x Thick)
W4 64-1305	E201	Pellet 2.0 x 4 mm (D x Thick)
W4 64-1313	E210	Pellet 2.0 x 2 mm (D x Thick)
W4 64-1306	E202	Disc 4.0 x 1 mm (D x Thick)
W4 64-1307	E203	Disc 8.0 x 1 mm (D x Thick)
W4 64-1308	E204	Disc 12.5 x 1 mm (D x Thick)



Ag-AgCl Pellet and Wire Electrodes

Pellet electrodes have a cylindrical pellet embedded on wire.

Wire electrodes have a uniform coating of Ag-AgCl over the last 10 mm of a 0.25 x 70 mm (D x L) wire. Maximum diameter of the Ag-AgCl matrix is 0.8 mm.

Note: All electrodes suitable for probing tissues.

Order #	Model	Product
W4 64-1309	E205	Pellet Electrode 1.0 mm D
W4 64-1310	E206	Pellet Electrode 2.0 mm D
W4 64-1317	E255	Wire Electrode 0.8 mm D

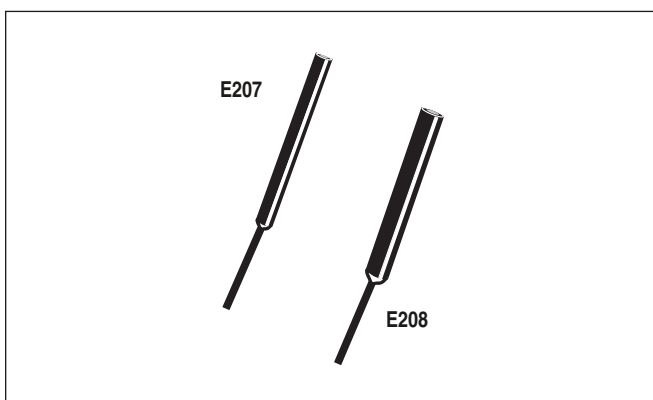
Electrodes, Probes and Reference Cells



Disc Electrodes With Lead Wires

These disc-type electrodes are made with a flexible 20 cm lead wire attached to the back. The connection is encapsulated so that only the surface and edges of the electrode can make electrical contact. These electrodes can be used as direct-contact skin electrodes, or subcutaneously in temporary applications on research animals.

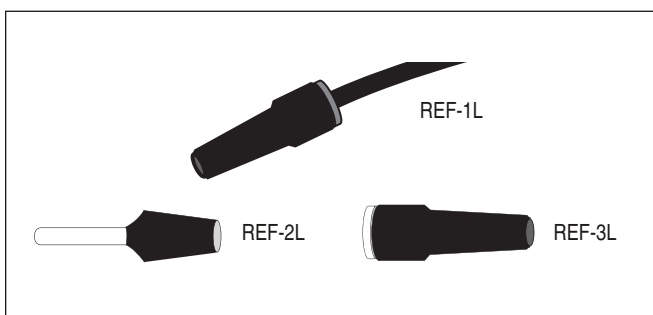
Order #	Model	Product
W4 64-1314	E242	Disc Electrode 4.0 mm D
W4 64-1315	E243	Disc Electrode 8.0 mm D
W4 64-1316	E244	Disc Electrode 12.5 mm D



Flat Tip Probes

Ag-AgCl cylinders, encapsulated in sturdy, insulating epoxy tubes; these probes are ideal for use in ionic solutions. They can be resurfaced frequently with fine sandpaper. Terminated with a 2 mm tinned copper wire for connection to your leads.

Order #	Model	Product
W4 64-1311	E207	Sensor Tip 2 x 4 mm (D x Thick) Epoxy Tube 3.5 x 25 mm (D x L)
W4 64-1312	E208	Sensor Tip 2 x 4 mm (D x Thick) Epoxy Tube 5 x 50 mm (D x L)

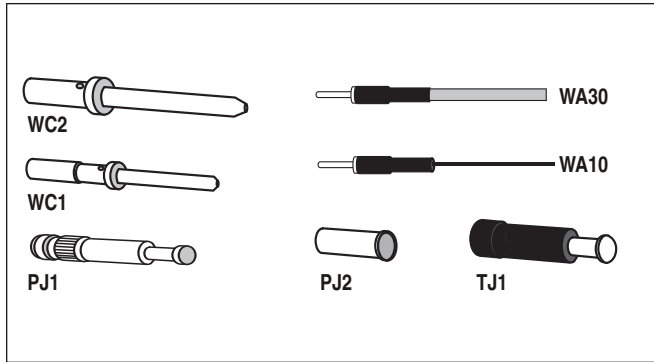


Reference Cells

Ag-AgCl electrodes are epoxy encapsulated in a plastic shell. They can be used as preparation references or as ground electrodes. Approximately 4.5 mm D, they are available with 2 mm pin, 2 mm jack and wire connection. All have a Luer taper for convenient mounting in chambers and other devices.

Order #	Model	Product
W4 64-1301	REF-1L	Reference Cell with 2 m Wire
W4 64-1302	REF-2L	Reference Cell with 2 mm Pin
W4 64-1303	REF-3L	Reference Cell with 2 mm Jack

Plugs, Jacks and Silver Wire



Plugs and Jacks

An assortment of gold-plated 1 mm plugs and jacks, with or without wires. Useful for grounding, shielding, etc.

Order #	Model	Product
W4 64-1325	WC1-10	1 mm Pin, pkg. of 10
W4 64-1326	WC2-5	2 mm Pin, pkg. of 5
W4 64-1322	PJ1-10	1 mm Jack, Uninsulated, pkg. of 10
W4 64-1323	PJ2-5	2 mm Jack, Uninsulated, pkg. of 5
W4 64-1324	TJ1-3	1 mm Jack, Teflon® Insulated, pkg. of 3
W4 64-1328	WA30-5	1 mm Pin with 30 cm, 26 ga. Insulated Wire, pkg. of 3
W4 64-1327	WA10-5	1 mm Pin with 10 cm, .25 mm D, Bare Silver Wire, pkg. of 2 For Bilayer Headstage

Silver Wire

Made of annealed silver 99.99% pure. Supplied for the convenience of researchers to fashion their own electrodes.

Order #	Model	Product
W4 64-1318	AG8W	Silver Wire, 2 m, 0.20 mm (.008") D, L, No Insulation
W4 64-1319	AG10W	Silver Wire, 2 m, 0.25 mm (.010") D, L, No Insulation
W4 64-1320	AG15W	Silver Wire, 2 m, 0.37 mm (.015") D, L, No Insulation
W4 64-1321	AGT10W	Silver Wire, 2 m, 0.25 mm (.010") D, L, Teflon® Insulation

Notes:

electrodes

notes

Biosensing

contact information

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Subsidiaries

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