ISO-80

Isolated differential amplifier

INSTRUCTION MANUAL

Serial No._____

1100

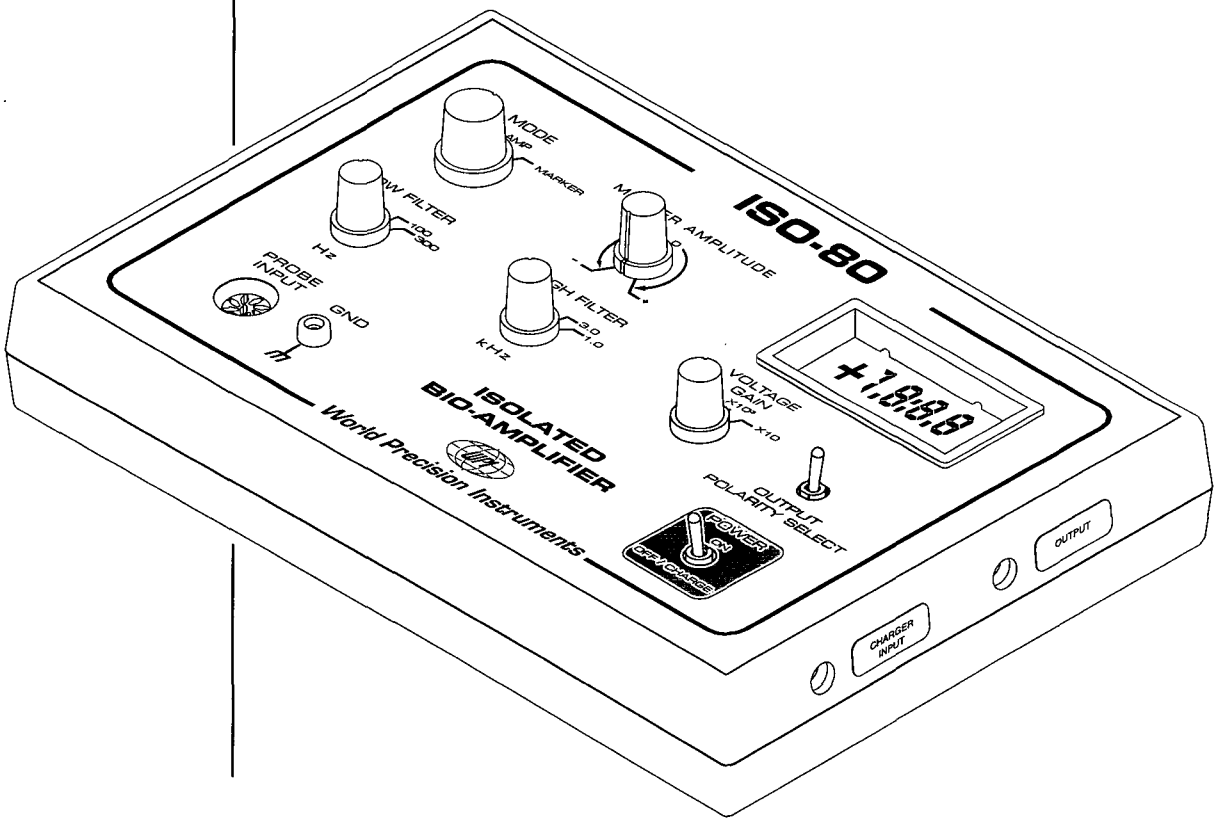
World Precision Instruments, Inc.

Contents

Introduction

Thank you for purchasing WPI's popular ISO-80 amplifier. Although some users will be very experienced in the use of such amplifiers, it is nevertheless strongly recommended that all users familarize themselves with the various operations of the ISO-80 by taking the time to read this manual.

The ISO-80 is a high performance isolated differential amplifier designed for extracellular recording of nerve/muscle cell action potentials *in vitro* and *in vivo*. Other functions include the ability to measure electrode impedance and to generate current for applications such as; tissue marking, stimulation and electrode cleaning. Similar to WPI's model DAM80, from which it has evolved, it is basically a battery-powered low noise differential amplifier, with the advantages of having complete electrical isolation from Mains power and Ground lines.



Operation

The ISO-80 has three basic modes of operation, which are selected using the **MODE** switch on the upper left-hand side of the instrument:

AMP—voltage amplification;
Z—electrode impedance measurement;
MARKER—tissue marking.

The **POWER** switch, located on the lower right of the instrument must first be in the **ON** position.

In the **AMP** mode, the amplified voltage is made available for external recording or data acquisition at the **OUTPUT** socket on the right-hand side of the instrument. The operation in both **Z** and **MARKER** modes can be monitored on the liquid crystal display (LCD). **OUTPUT** is disabled in the **Z** and **MARKER** modes.

A very high impedance probe is provided and is plugged into the **PROBE INPUT** socket. Electrodes for connection to the preparation/subject under test are inserted into two sockets—one red, one black—on the probe.

Amplifying Mode

The standard amplify mode is set by switching the **MODE** switch to **AMP** and the **POWER** switch to **ON**. The **MODE** switch should initially be left at **AMP**. The level of amplification is set using the **VOLTAGE GAIN** knob. This selects gains of **100**, **1000**, or **10,000**. The user is advised to start with this set to **100**.

Filter Settings

The amplifier can amplify voltages which vary at frequencies extending from 5 Hz up to 10 kHz. *To set the frequency band of measurement, the **LOW FILTER** and **HIGH FILTER** control knobs are used.*

Low Filter

This sets the lowest frequency signal that will be amplified. It would for example be typically 5 Hz for ECG and EEG measurements. For nerve-action voltage amplification, the 10 Hz setting would normally be used, whereas for brain *in vivo* recordings the 300 Hz would be suitable. It is advisable always to set the **LOW**

FILTER to a frequency no lower than is really necessary. This will reduce the risk of interference by low frequency noise signals. Note also that it is important that the recording instrument be able to handle signal frequencies at least as low as that set by the **LOW FILTER**—an oscilloscope, for example, would be set to its DC mode.

High Filter

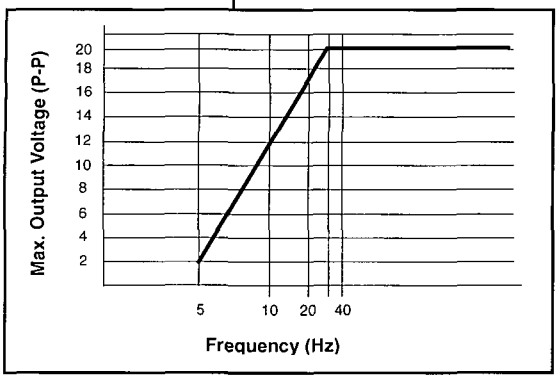
This is used to set the highest frequency signal that will be amplified—the higher the rate of variation of the signal being measured the faster the response required of the amplifier. The amplifier's fastest response is at the 10KHz setting. Note also that the recording instrument must be able to handle signal frequencies at least as high as that set by the **HIGH FILTER** control.

Important: Intrinsic electronic noise in all circuits is greater the wider the frequency band used. This band is set by the **LOW** and **HIGH FILTER** controls. Accordingly, the user should always use the minimum band that produces acceptable quality recordings. For ECG and EEG setting the **LOW FILTER** to 5 Hz and the **HIGH FILTER** to 0.1 kHz would for example be adequate. Having an unnecessarily greater bandwidth will only increase the amount of intrinsic noise on the recordings and also increase the risk of interference by external signals.

Output

The amplified signal is available at the **OUTPUT** jack on the instrument side. A recorder, oscilloscope or data acquisition system may be connected to this jack using a cable provided in the accessories pack. The polarity of the output can be set using the **OUTPUT POLARITY SELECT** toggle. In normal operational mode (*i.e.*, amplification) this would be set to "+"

Fig. 1 — Maximum Output vs. Frequency



Output Limits

The maximum output available depends on the frequency of the voltage signal being amplified. For signals of frequency above 30 Hz the full range of output voltage is available: ±10 volts or 20 volts peak to peak (P-P) for an AC signal. Below 30 Hz the

maximum output available decreases as the frequency decreases. The relationship is shown in Fig 1.

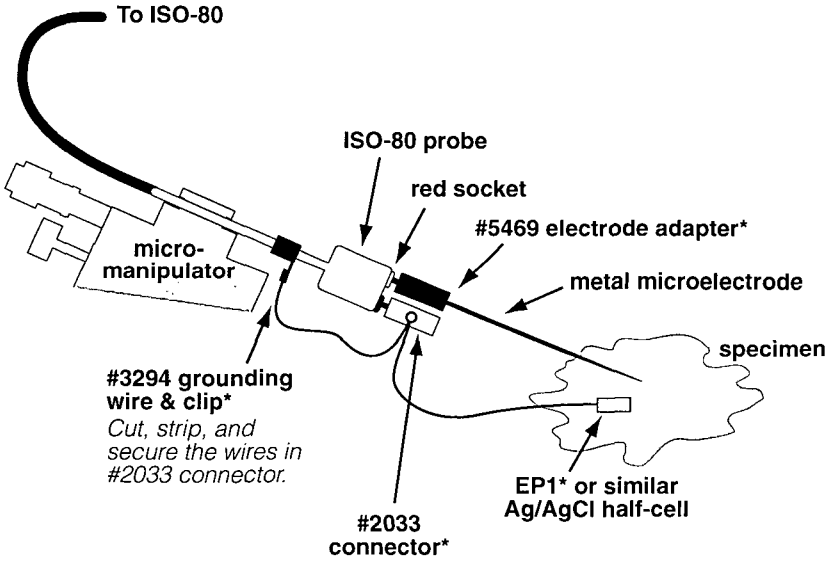
To avoid error when measuring very low frequency signals the amplification must be set so that the maximum available output level is not exceeded. For example, the maximum available output at a frequency 10 Hz is 12 volts P-P. Hence, with an input signal of 10 mV P-P at 10 Hz, the maximum setting of the **VOLTAGE GAIN** control would be 1000, which would give an output of 10Volts P-P. If the voltage gain were set to 10,000, the output would not be 100 Volts P-P, but would be limited to 12 Volts P-P.

If extra gain is required at very low frequencies, this can usually be obtained using the controls on the recording device (*e.g.*, data acquisition) connected to the ISO-80.

Modes of Amplification

Voltages from specimens may be amplified in either of two ways—single ended or differentially. The latter is to be recommended where there is a risk of external electrical interference. In either mode, the risk of interference is reduced if electrode leads are kept to an absolute minimum length. Screened leads would also reduce susceptibility to electrical noise/mains-pickup.

Fig. 2 — Single-Ended Amplification



*These parts are included with the Iso-80.

Single-Ended Amplification

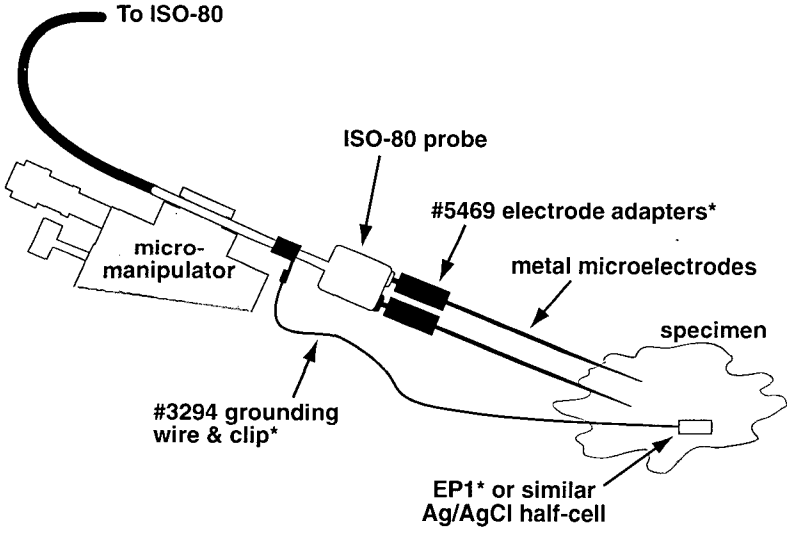
Amplifying single-ended is illustrated in Fig 2. Here one electrode (the working electrode) is plugged into the red socket on the probe and connected to the test

specimen. To complete the electrical circuit and to provide a return path for electrical current, a second electrode (the reference electrode) is connected to the Black probe socket, which in turn is connected to the probe handle. The probe handle is the ground of the amplifier circuits—CIRCUIT GROUND. A short lead and a clip for the probe handle are provided for making this connection.

Interference Effects

In all laboratories supplied with Mains power there is a finite risk of interference from signals flowing in the power lines. The interfering signals are usually at a frequency of 50 Hz or 60 Hz and are picked up by any electrical equipment in the area, by a process of electromagnetic induction. Such signals that are picked up on the measuring electrodes will be amplified together with true input voltages and then appear on the recordings. Whether this is significant or not depends upon the level of activity in the Mains power lines, the length of the input wires to the equipment, and on the sensitivity of the measuring equipment. Should it be a problem at the test site, it might be necessary to set up the specimen and electrodes in a shielded enclosure—a Faraday cage, for example, connected to Circuit ground. Alternatively, the differential mode of amplification should be used.

Fig. 3a — Differential Amplification



*These parts are included with the Iso-80.

Differential Amplification

Fig. 3a illustrates the set-up for differential amplification. Here, electrodes from both the red and black sockets on the probe are connected to the specimen. Again, it is necessary to connect the specimen site to Circuit Ground via the probe

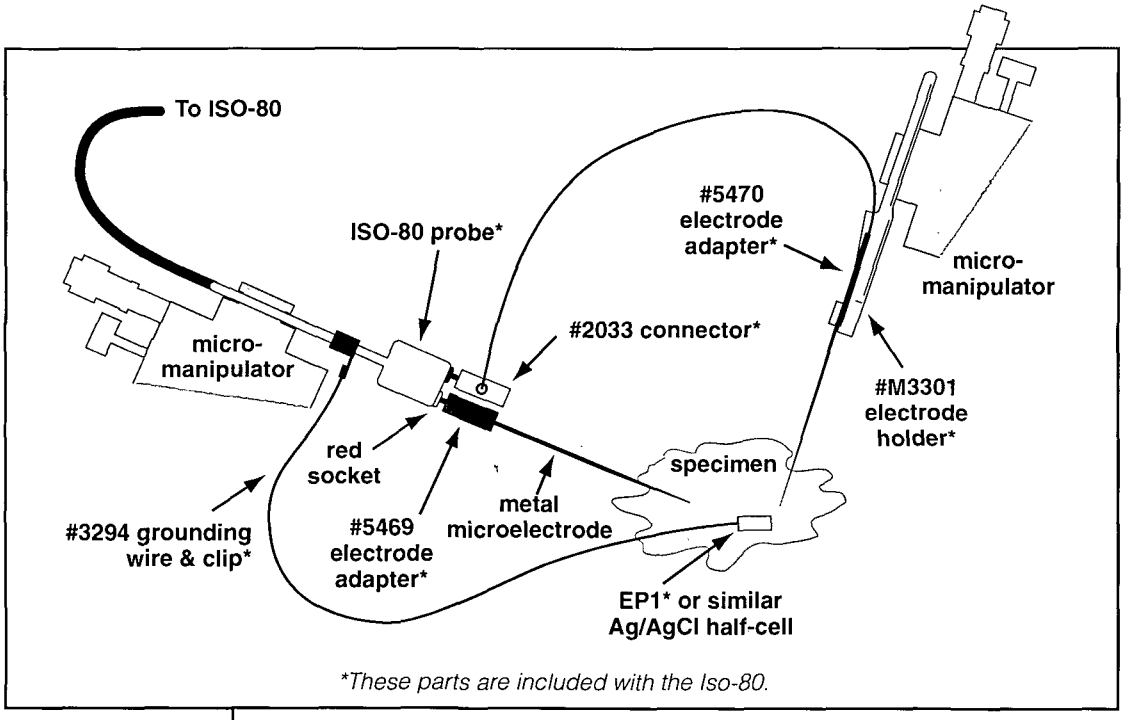


Fig. 3b — Differential Amplification — alternate configuration

handle. Fig. 3b shows an alternate setup in which the second microelectrode is separately secured, allowing independent placement of the two electrodes. In either set-up, the difference between the voltages at the two electrodes is amplified. Local interference will again be picked up on both electrodes, but in roughly similar amounts on each. By amplifying the voltage difference at the electrodes, these signals will be largely cancelled out. If the interference in the area is particularly strong so that its effect even after differential amplification is a problem, again a shielded enclosure should be used.

Measuring Electrode Impedance: the Z Mode

Electrode impedances in the range 100 K to 20 Mohms may be checked with the ISO-80 **MODE** switch set to **Z**. The ISO-80 achieves this measurement internally by supplying a small (20 nA peak-to-peak) current, alternating at 300 Hz, to the electrode connected to the red (non-inverting) input socket of the probe. A reference electrode is used to complete the current path back to the CIRCUIT GROUND of the ISO-80. While the instrument is delivering current into the probe, an audible tone is emitted. Electrode impedance is displayed on the ISO-80 liquid

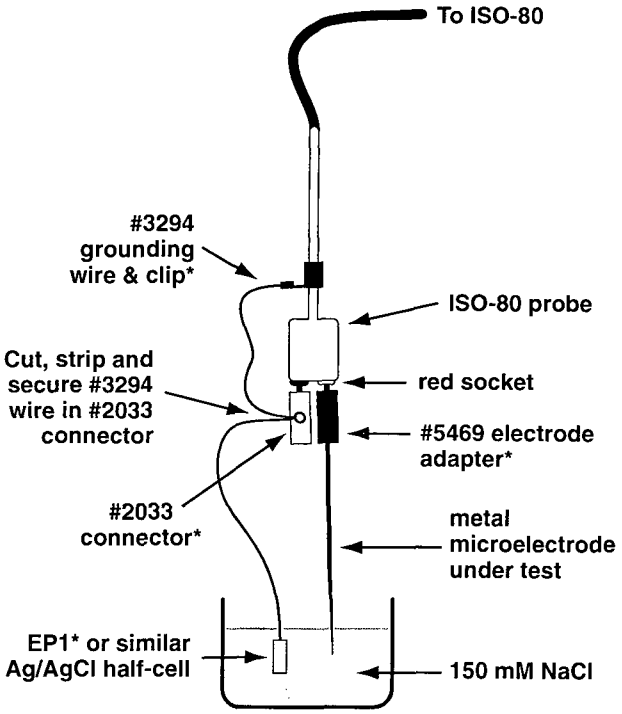


Fig. 4 — Electrode Impedance Test

crystal display (LCD). The amplifier output is disabled in the **Z** mode, and no signal will be seen.

Electrode impedance may be measured *in situ*, that is, with the electrode and probe connected to the preparation or in a special test set-up. Measurement *in-situ* is made in the normal recording set-ups, as shown in Figures 2 and 3. Note that in the differential amplification configuration, only the electrode in the red socket can be measured. To make the measurement, check that the POWER switch is at **ON** then set the **MODE** switch to **Z**. Electrode impedance is then shown on the LCD. The audible tone will cease when the **MODE** switch is set to **AMP**.

The test set-up is shown in Fig 4. To connect up, the test electrode is inserted into the red socket on the probe. The black socket is connected to CIRCUIT GROUND (clip on the probe handle or the **GND** jack socket on the instrument panel). The electrode under test is inserted in a 150 nM NaCl solution. A silver wire reference electrode (provided in the accessories pack) is inserted in the same solution and is also joined to CIRCUIT GROUND. To make the measurement, check that the POWER switch is at **ON** then set the **MODE** switch to **Z**. Electrode impedance is then shown on the LCD. The audible tone will cease when the **MODE** switch is set to **AMP**.

Generating Marker Current: the Marker Mode

Marker current is passed through the red (non-inverting) input socket of the probe, then to the recording electrode *in situ*, that is, with the electrode and probe connected to the preparation. Either the single-ended (Figure 2) or differential (Figure 3) configuration may be used. Note that, in the differential amplification configuration, marker current only passes through the electrode in the red socket.

There are two ways to generate a Marker current. The first way uses the internal **MARKER** current generator facility built into the ISO-80 circuit design. The second way is to use an external voltage source via the **EXTERNAL CURRENT CONTROL INPUT**. Note: *The current generated using the internal source is a DC current. That generated using an external source can be either AC or DC, depending on the source used.*

Using the ISO-80 Internal Current Generator

Marker currents up to 20 µA are available with the **MODE** switch set to **MARKER.** The magnitude of the current delivered is adjustable using the **MARKER AMPLITUDE** knob and is displayed on the LCD. An audible tone is emitted during the time that the instrument is delivering current.

To initiate current, confirm first that the **POWER** is set to **ON**, that the **MODE** switch is set to **MARKER** and that the **MARKER AMPLITUDE** control knob is set to **0**. Adjust the **MARKER AMPLITUDE** control to achieve the required current as displayed on the LCD.

Using the ISO-80 External Current Control Input

Current may be controlled by an external voltage source via the **EXTERNAL CURRENT CONTROL INPUT** socket on the side of the instrument. The actual current generated depends on the magnitude of the voltage applied. The scale factor used is 100 mV = 1 µA. Note the voltage applied must be within the range 0 volts to +/- 2 volts. The voltage may be either D.C. or an A.C. pulse, sine wave, or other wave form. Again, as when using the internal current source, the **POWER** switch must be **ON** and the **MODE** switch set to **MARKER.**

NOTE: **when using the External Input there is no electrical isolation**.

Maximum Current Level

In either the internal current source or external current control modes, the maximum current that is available is dependent on the impedance of the electrode used. The greater the impedance of the electrode, the lower the available current. With an electrode impedance of Z megohms The relationship is:

$$Imax = \frac{10}{Z} \text{microamps}$$

For example, with a 1 Mohm electrode, the maximum current (**MARKER AMPLITUDE** control turned to maximum) is 10 microamps.

Power Supplies

Power is provided by two 9-volt rechargeable batteries. With the ISO-80 in full continuous operation, the batteries should last for 20 to 24 hours before re-charging is necessary. A **LOW BAT** indication on the LCD will show this. A charging time of typically 6 hours will restore the batteries to full charge, though if the batteries have been totally discharged (*e.g.*, after several months of shelf storage without use), about 10 hours charging time may be necessary.

When recharging is necessary, the charger is plugged into the **CHARGER INPUT** socket on the side of the instrument and the POWER switch is set to **OFF/ CHARGE**

The batteries are located in the base of the instrument. To gain access, remove the two screws securing the 8 x 6 cm battery hold cover on the underside of the ISO-80 case.

Specifications

INPUT IMPEDANCE	$>10^{11}$ Ohms // 8 pico-farads (typical)
INPUT LEAKAGE CURRENT	50 pico-amperes maximum
GAIN	100, 1000, 10000
COMMON MODE REJECTION	100 dB typical; 5 Hz to 100 Hz
NOISE, REFERRED TO INPUT	2 micro-volts RMS, 5 Hz – 10 KHz
FILTER SETTINGS	
Low-Pass	100 Hz, 1 KHz, 3 KHz, 10 KHz
High-Pass	5, 10, 100, 300 Hz
MAXIMUM OUTPUT VOLTAGE	30 Hz to 10 KHz: 20 Volts peak-to-peak 5 Hz: 3 Volts peak-to-peak
ELECTRODE IMPEDANCE MEASUREMENT RANGE	100K to 20 Megohms
CURRENT INJECTION RANGE	
Elect. Impedance ≤0.5 Megohm	0 to ± 20 microamperes
Elect. Impedance = 1 Megohm	0 to ± 10 microamperes
Elect. Impedance = 2 Megohms	0 to ± 5 microamperes
EXTERNAL CURRENT INJECTION CONTROL INPUT	
Scale Factor	10 microamperes per volt
Frequency Range	DC to 10 kHz
Voltage Range	-2.0 to +2.0 volts
OUTPUT IMPEDANCE	600 Ohms
DISPLAY	3½ Digit LCD
POWER	Two 7.5 Volt Nickel-Cadmium batteries
EXPECTED BATTERY LIFE	20 hours with fully charged batteries
INPUT PROBE (Provided)	Gold plated housing, 1.13" x 0.88" x 0.38" (30 x 23 x 10 mm) with 3.5" (L) x 0.25" diam. (88 x 6.35 mm) shaft. 5-ft (1.5 m) connecting cable. Input connectors are "mini-banana" spaced 0.50" (12.7 mm).

Packing List

Your ISO-80 shipping box will contain the following:

WPI Part #	Description	Quantity
ISO80	Amplifier	1
ISO-80P	Probe	1
3545	Charger, 120VAC, U.S. Plug	1*
3546	Charger, 240VAC, CEE Plug	
3547	Charger, 240VAC, British Plug	
CBL102	Cable, BNC to 3.5mm Plug	1
5469	Adapter, Electrode, .031 inch	2
13388	Adapter, Mini-Banana to 2 mm	1
3294	Wire, Ground	1
2033	Connector, Mini-Banana, Black	1
2034	Connector, Mini-Banana, Red	1
2035	Connector, Mini-Banana, Turret	2
M3301EH	Electrode Holder	1
5470	Adapter, Electrode, .031 to wire	1 pkg.
EP1	Electrode, Ag/Agcl, 1 mm.	1

**Shipped with appropriate part.*

Warranty

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of one year* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

The foregoing obligations set forth in this paragraph are in lieu of all obligations and liabilities, including all warranties of merchantability or otherwise, expressed or implied or statutory, and state WPI's entire and exclusive liability and purchaser's exclusive remedy for any claim of damages in connection with the sale or furnishing of all equipment, including design, suitability for use, operation, or installation. There are no warranties which extend beyond the description of the face hereof. In no event shall WPI be liable for any special or consequential damages.

Warning: This equipment is not designed or intended for use on humans.

** Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.*

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DECLARATION OF CONFORMITY

We: World Precision Instruments, Inc.
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USA

as the manufacturers of the apparatus listed, declare under sole responsibility that the product(s):

Title: ISO 80 System

to which this declaration relates is/are in conformity with the following standards or other normative documents:

EMC: EN 50082-1:1992

and therefore conform(s) with the protection requirements of Council Directive 89/336/EEC relating to electromagnetic compatibility.

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