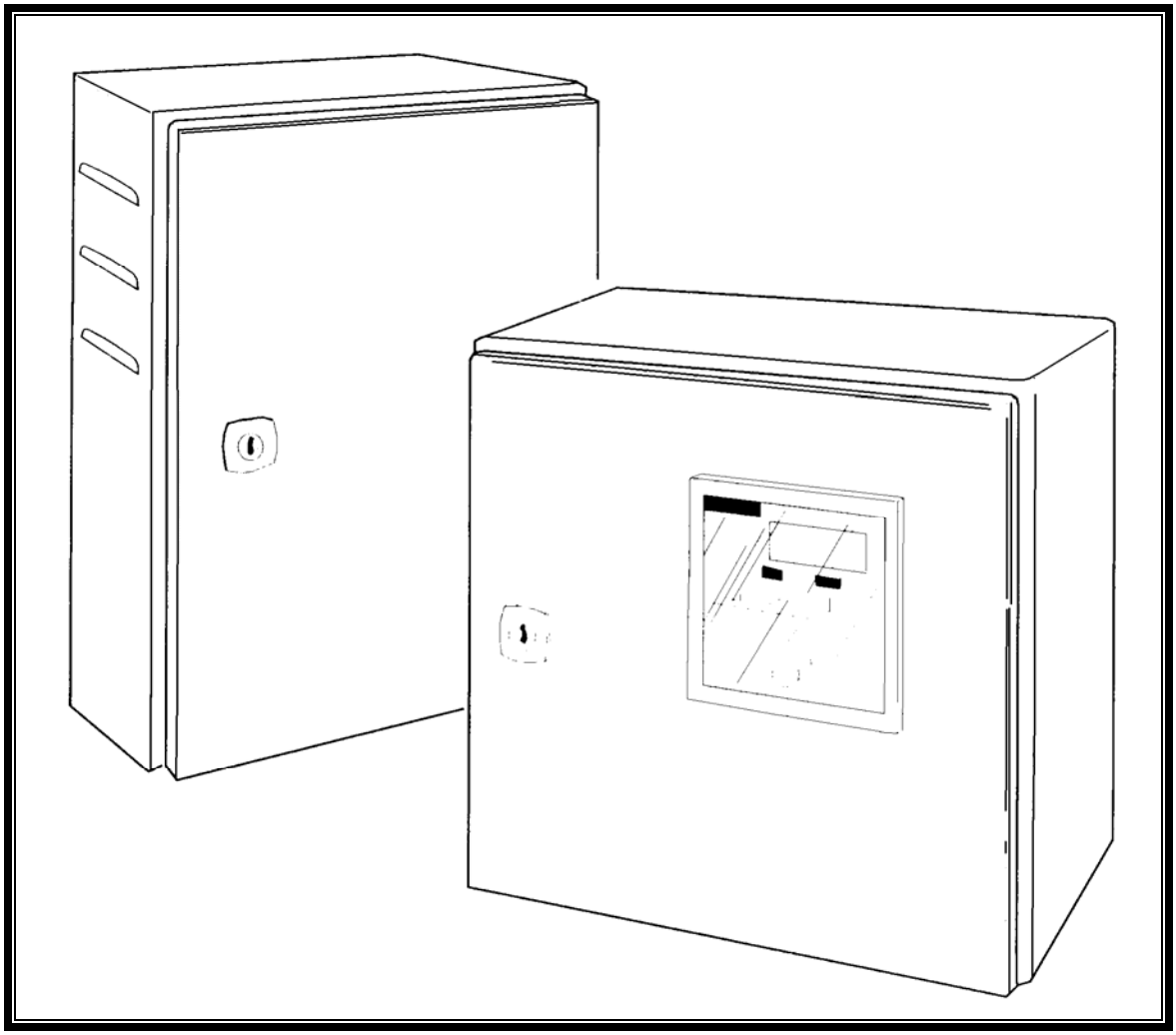
Waltron L.L.C. AQUALERT® DIVISION



µAI-9030 SERIES
SODIUM ION MONITOR
INSTRUCTION MANUAL

TABLE OF CONTENTS 9030

1 INTRODUCTION

1.1 GENERAL

The model µAI-9030 is a microprocessor controlled on-line monitor for measuring sodium in steam raising plants. Sampling points include mixed bed outlets in water treatment plants, extraction pump discharge, boiler feed, boiler drum and steam.

Two range groups are available:
0.01ppb to 1ppm
1.0 ppb to 100ppm

with current output automatically switched to cover two decades within one group at any one time.

1.2 DESCRIPTION

1.2.1 SENSOR UNITS

The sensor unit is in a metal case which houses the liquid handling equipment. Pipework carrying the sample is mounted on a panel, bolted to the back of the unit with four M6 captive bolts.

The pre-amplifier and the container for the buffer are mounted on the sensor unit door. The junction box, convenient for the electrical connection of the electrode pair, is also mounted on the door.

The liquid handling section contains a clear, acrylic flowcell in which the sodium ion responsive electrode and the calomel reference electrode measure the sample. The flowcell also houses a temperature sensor for temperature correction of electrode output.

The correct pH value of the sample is achieved by pre-treating it with an alkaline vapor.

Calibration is carried out using standard solutions of a known value under the control of the transmitter unit.

A drain cup is provided to collect used sample and overflow, allowing for a single drain connection.

1.2.2 TRANSMITTER UNIT

The transmitter unit is in a metal case of similar construction to that of the sensor unit with a chassis unit supporting circuit boards and other electrical sub-assemblies.

Microprocessor electronics control the functions of the transmitters. The three main functions of the Sodium Analyzer are:

- interpret and display a reading of sodium received from the sensor unit,
- control the calibration sequence,
- provide various outputs to remote equipment.

Displays are three-digit, seven-segment light emitting diodes (l.e.d.) which show the level of sodium and operational information. Furthermore, the operator can see when the instrument is in the calibration mode, and when the calibration has not been successful.

On the left hand side of the transmitter unit are six access holes. These holes are sized to accept cable glands for the interconnect cable, alarm signals, current outputs and alternating current (a.c.) power cable.

2 INSTALLATION

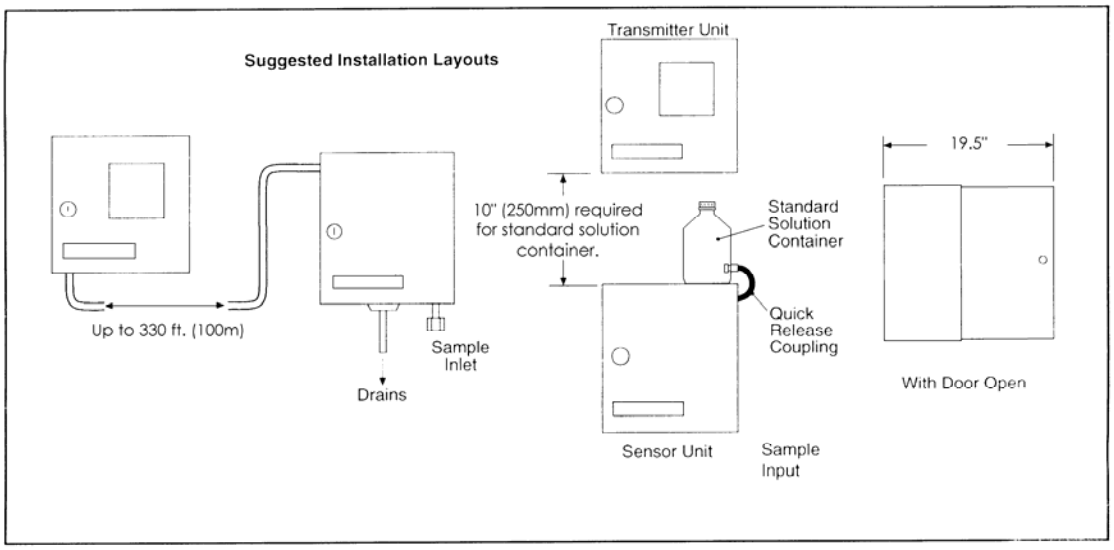
2.1 MOUNTING OF UNIT

2.1.1 LOCATION AND LAYOUT

Mount the sensor and transmitter units in a clean, vibration-free area, avoiding direct radiant heat, sunlight and drafts. Avoid areas containing chlorinating equipment.

Sensor units should be mounted no more than 33 feet (10 meters) from their associated sample coolers.

FIGURE 2.1 MOUNTING ARRANGEMENTS

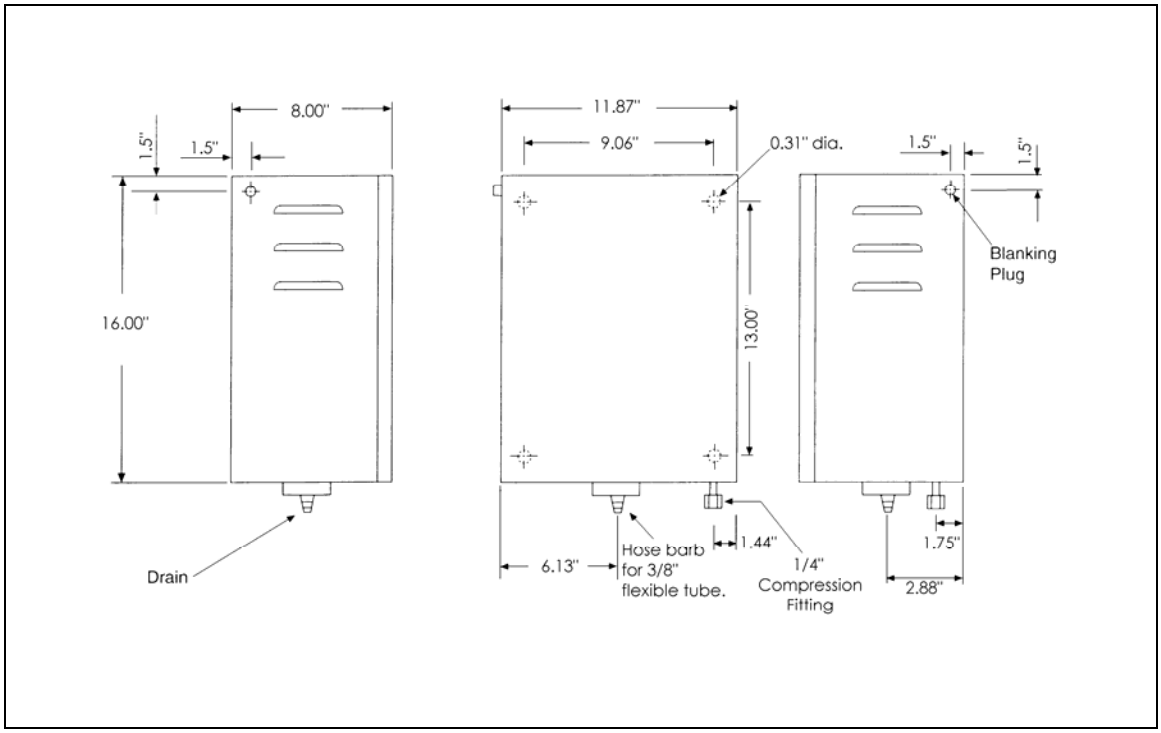


2.1.2 SENSOR UNITS

Mount the sensor unit in the wall using four 5/16" or 1/4" bolts on 9.06" X 13.00" centers.

Refer to Figure 2.1 Mounting Arrangements for correct positioning of transmitter and sensor units.

FIGURE 2.2 SENSOR UNIT DIMENSIONS AND INSTALLATION

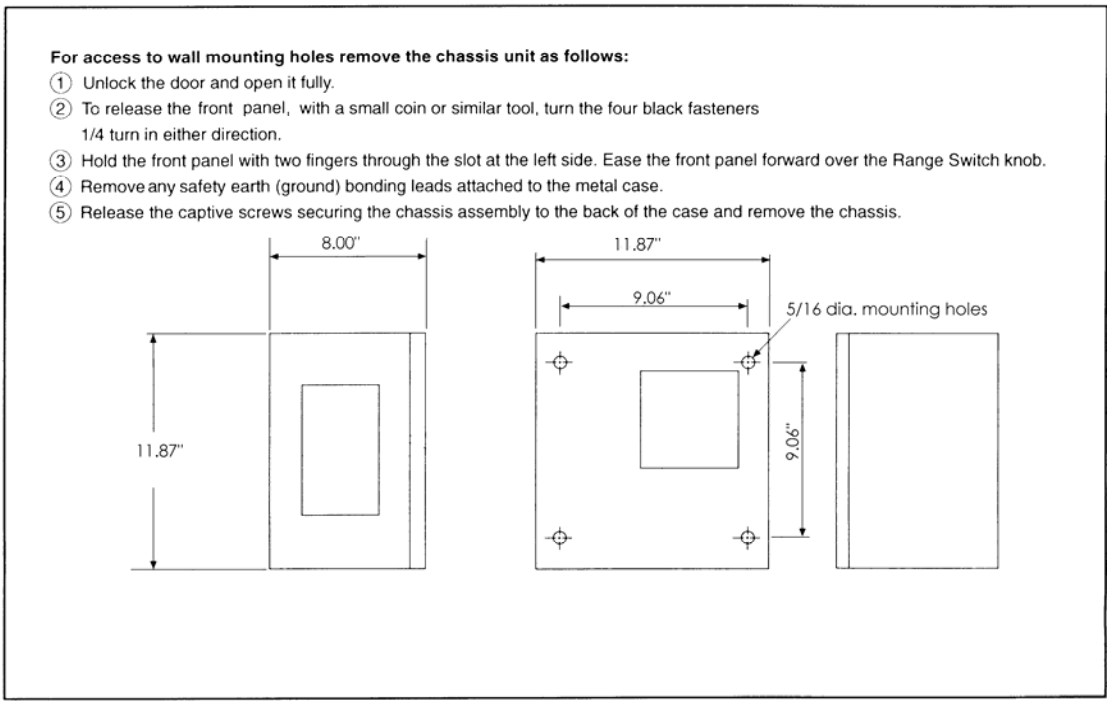


2.1.3 TRANSMITTER UNITS

The transmitter may be mounted next to or up to 330 feet (100 meters) away from the sensor unit. If the transmitter is mounted directly above the sensor unit, allow at least 10 inches (250mm) separation between the units for access to the standard solution containers - see Fig. 2.1. Also allow sufficient space on the left hand side of the transmitter unit for connection of cables to the unit via the access plate & holes.

Wall mount using four 5/16" or 1/4" bolts on 9.06"X 9.06" centers. Sufficient access space, as detailed previously, must be left for making cable connections to the transmitters and for the mounting of standard solution containers.

FIGURE 2.3 TRANSMITTER UNIT DIMENSIONS AND INSTALLATION



For access and fitting of the transmitter unit, proceed as follows:

- Unlock the door and open fully.
- To release the face panel, use a small coin or similar tool to turn the four plastic fasteners ¼ turn in either direction.
- Hold the face panel with two fingers through the slot at the left hand side. Ease the face panel forward over the Range Switch knob.
- Remove any safety ground (earth) leads attached to the metal case.
- Release the captive screws securing the chassis assembly to the back of the case and ease the chassis forward.
- After recording the position of the connection blocks on the circuit boards - remove the connection blocks from the analog board by applying force outwards from the face of the analog

board. To remove the connector from the PSU board, slide the connector sideways towards the vertical edge of the board.

- Loosen the associated screws to release the three wires from the main power input connector.
- Remove the chassis.
- Secure the transmitter case to the wall by four 5/16" or 1/4" bolts.

Note. Before fitting the chassis unit and connecting it to the main power supply, check that the voltage selector is set to the correct value. Refer to Chapter 3 Start-Up for procedures required before start-up.

Caution. When replacing the connection terminal blocks, make sure that the blocks are aligned correctly to cover all the associated connecting pins.

- With the transmitter case secured to a wall or panel, line up the chassis to the case and wire the mains connection.
- Fit the connection blocks onto the circuit boards.
- Fit the chassis unit, secure it with the captive screws and replace any earth (ground) bonding leads.
- Position the face panel and secure it with the four plastic fasteners.

2.2 SAMPLE REQUIREMENTS

WARNING.
Do not exceed the maximum pressures and temperatures specified.
If you use pressure-reducing equipment, install a pressure relief valve between your equipment and the sample inlet to the monitor for safety purposes.

Bring the sample to the temperature and pressure suitable for measurement using sample coolers and pressure reducing equipment- see Chapter 8.

2.3 EXTERNAL PIPING CONNECTIONS

2.3.1 INLET

The sample should be connected to the sensor unit using ¼" o.d. tubing of stainless steel or rigid plastic. Connect this to the sample inlet coupling on the right hand side of the bottom of the case.

The inlet tube should be of sufficient wall thickness to withstand the highest sample pressure, and pipe lengths should be kept short.

Where particulate matter is present (e.g. magnetite in boiler samples), fit a 60 micron sample filter to the sample line.

A shut-off valve (not supplied with the monitor) is necessary in the sample unit.

2.3.2 DRAIN

The drain from the cup at the bottom of the sensor unit case consists of a hose barb suitable for 3/8" bore plastic or rubber tubing. Alkaline effluent from the monitor and overflowing sample drains through this single connection.

2.4 ELECTRICAL CONNECTIONS

⃠WARNING.
Although some instruments are have internal fuse protection, you must use a suitably rated external protection device, such as a fuse or miniature circuit breaker (MCB).

Switch **OFF** the power supply and high voltage power-operated control circuits before making any connections.

This equipment operates on alternating current electricity. Always take suitable safety precautions to avoid the possibility of an electric shock.
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2.4.1 SENSOR UNITS

The prefabricated, eight conductor cable connecting the sensor unit to the transmitter unit arrives in place from our factory. This avoids the need to open the pre-amplifier box which could admit moisture, and because of the very high source impedance of the sodium measuring

electrode (up to 500 Mohm, at sample temperature of 5°C), would effect the instrument's performance.

You may mount the transmitter either next to the sensor unit or up to 330 feet (100 meters) away. This allows sufficient space on the transmitter unit's left-hand side. The access plate and holes on the left hand side allow room for the connection cables to the unit.

Extend the cable by placing a junction box adjacent to the sensor unit, and by using the required length of 8-conductor cable. You can specify the length of the cable you'll need at the time of order.

2.4.2 TRANSMITTER UNIT

To gain access to make the necessary connections, proceed as follows:

- Remove the four screws securing the access plate to the left hand side of the transmitter case. Fit suitable cable glands through the 7/8" diameter holes. Insert the cables necessary for the supply, output signals, alarms and remote function, if used.

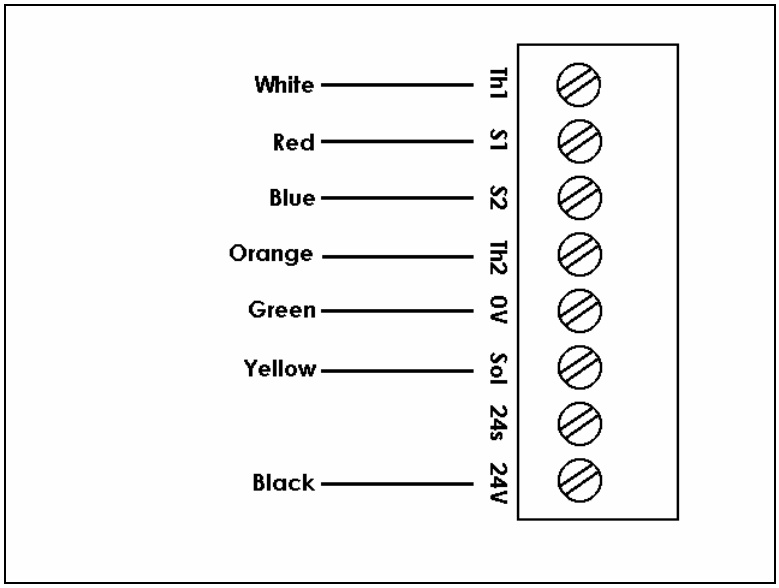
- Open the transmitter's door and remove the face panel.

- Make sure the interconnect cable from the sensor unit is long enough to reach the transmitter easily. The cable should terminate on terminal block TB3 on the analog board.

- Push the end of the cable through a gland in the left hand side of the transmitter case.

- Noting that the shield drain wire terminates at Pin 10 of TB2 on the analog board, attach the remainder of the cable end to the terminal block TB3, following the wiring diagram shown in Fig. 2.4. You may pull the terminal block away from the pins on the board if required.

FIGURE 2.4 WIRING THE INTERCONNECT CABLE TO TRANSMITTER



2.4-2 TRANSMITTER UNIT

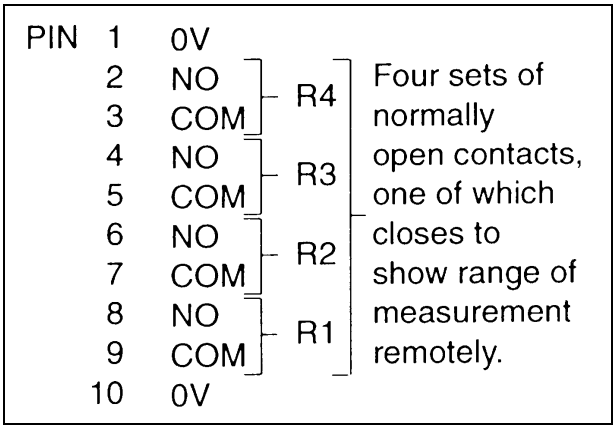
Caution. The terminal block for the sensor unit connection has eight terminals, yet there are 12 pins on the board. Make sure that you choose the correct eight pins for the connection. These are marked in the PCB, with a separate silk-screened “box

2.4.3 WIRING OF BOARDS

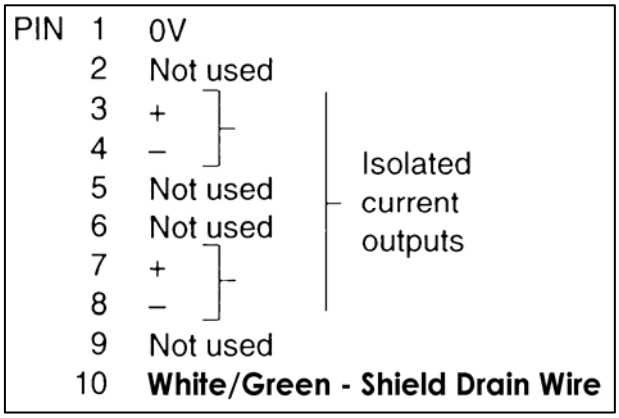
Pass any remaining cables through the appropriate glands. Note that Pin 1 of each block is nearest the top of the case. Prepare the cable ends and attach them to the terminal blocks as follows.

Digital Board (nearest front panel): No Terminations

Analog Board TB1 (top left edge)

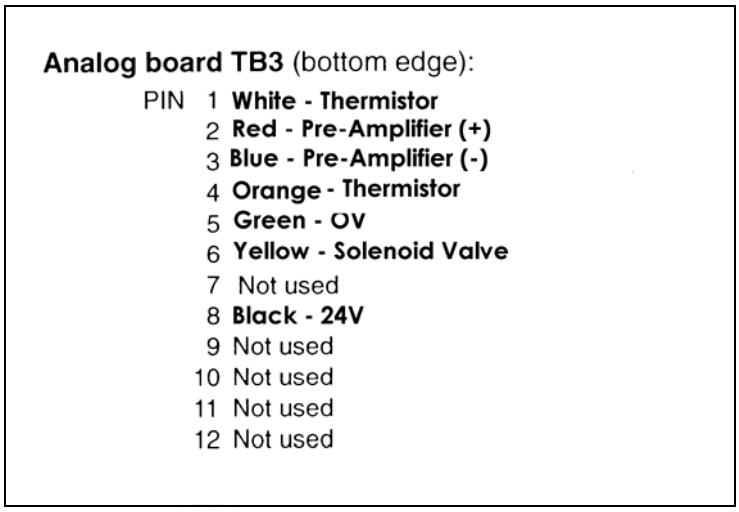


Analog Board TB2 (middle left edge)

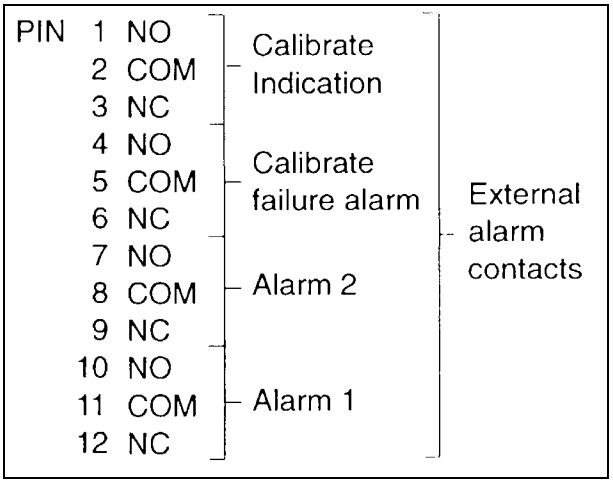


2.4.4 WIRING OF BOARDS

Analog Board TB3 (bottom left edge)



PSU Board TB3



Chassis

A voltage selector is next to the power supply terminal block. Set this voltage selector to the correct voltage **before** connecting the instrument to the power supply. Make sure that all of the gland nuts are tightened.

⊘**WARNING.** Connecting the power supply earth (ground) ensures the safety of your personnel, reduction of the effects of Radio Frequency Interference (RFI), and correct operation of the power supply interference filter

2.5 REMOTE EQUIPMENT

2.5.1 RECORDERS

The choice of two different isolated recorder output signals enables you to use the instrument with a wide variety of recording and data processing equipment. The load requirements are shown in Chapter 8, and the positions of the circuit board switches are given in Chapter 4.

2.5.2 RANGE INDICATION

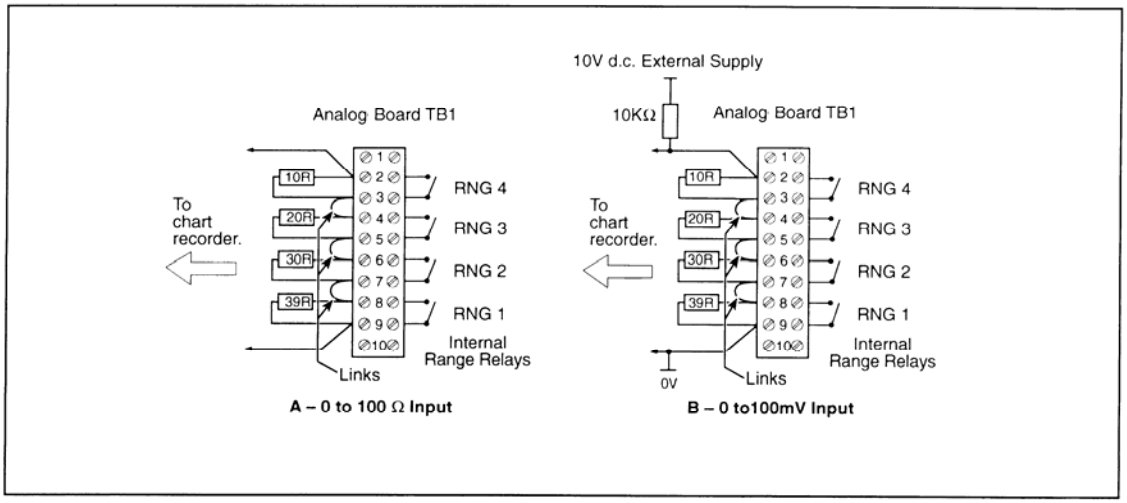
The remote range indication relays (TB1 connections) can be used in several different arrangements to suit the requirements of the installation. The relays can, for example, be wired directly into a PLC or data logger, but if you use a recorder, you'll need a method of indicating the set range. A 2-pen recorder is necessary; pen 1 indicating the sodium concentration as above and pen 2 recording the instrument range.

Suitable range recorder input can be achieved using a resistor network, connected as shown in the two examples in Fig. 2.5 and consists of four ¼ watt resistors.

Other arrangements should be designed to suit the requirements of the system.

Make sure that all external equipment is set up and working according to the relevant instructions supplied with it.

FIGURE 2.5 RESISTOR NETWORK FOR 'AUTO' REMOTE RANGE INDICATION RECORDERS



3 START UP

- ✓ Open the transmitter unit door and remove the face panel. Verify that the switch next to the battery is set to "ON". Replace the face panel and secure with the four plastic fasteners.
- ✓ Power up the monitor at the external source and set the Range Switch to "AUTO".
- ✓ Remove the cover to the electrode junction box – see Figure 4.2 Layout of Sensor Unit.
- ✓ Unpack the sodium electrode and carefully remove the rubber cover. Remove the cylindrical plastic holder from the central chamber and slide the electrode fully into the holder. Carefully screw the holder, with electrode, into the center chamber of the flow cell so that the electrode bulb passes through the 'O' ring. Position the electrode so that when the plastic holder is tightened against the 'O' ring, the bulb of the electrode is just above the bottom of the chamber.
- ✓ Unpack the reference electrode and remove the rubber cover. Remove the silicone rubber sleeve that is covering the filling hole. Remove the supplied 'O' ring and fit the 'O' ring over the electrode body. Carefully position the electrode centrally in the right hand chamber of the flowcell. Insert the electrode just deep enough so that the shoulder above the ceramic plug is touching the water.
- ✓ Connect both electrode terminals in the electrode junction box mounted on the door. Connect as follows:
  - ✓ Reference Electrode lead- 'REF'
  - ✓ Sodium Electrode co-ax inner- 'Na^+'
  - ✓ Sodium Electrode co-ax braid- 'SCR'
- ✓ Replace the electrode junction box cover.
- ✓ Fill the buffer solution container with Ammonium Hydroxide - see Chapter 6.
- ✓ Open the shut-off valve upstream of the sensor unit and adjust the valve until sample is overflowing from the constant head unit. The maximum and minimum flow rates are given in Section 8.
- ✓ Allow at least one hour before going on to the next step.
- ✓ Set up the transmitter as described in Section 4.2.
- ✓ Carry out a calibration as detailed in Chapter 5.
- ✓ The monitor is now in operation. The lamp adjacent to the number display indicates the units of measurement.
- ✓ If required, turn the range switch to one of the "Non-Auto" ranges.
- ✓ Press the "ALARM 1" button and use the "UP/DOWN" buttons to set to the desired value. Repeat for "ALARM 2".

4 PRINCIPLE OF OPERATION

4.1 SENSOR UNIT

A flow schematic is shown in Fig. 4.1 and the physical layout of the sample unit is shown in Fig. 4.2.

FIGURE 4.1 SCHEMATIC FLOW DIAGRAM

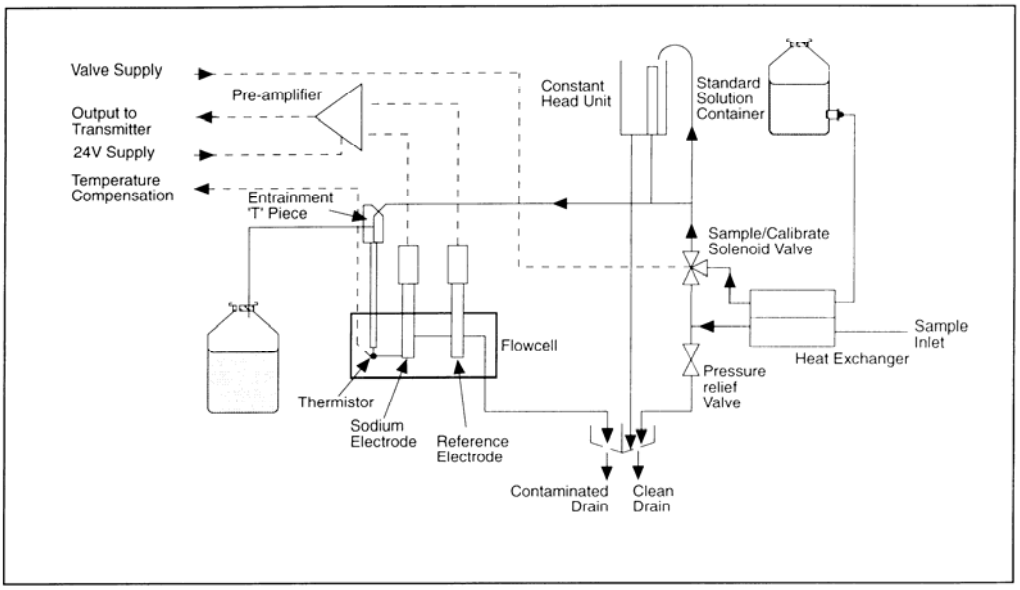
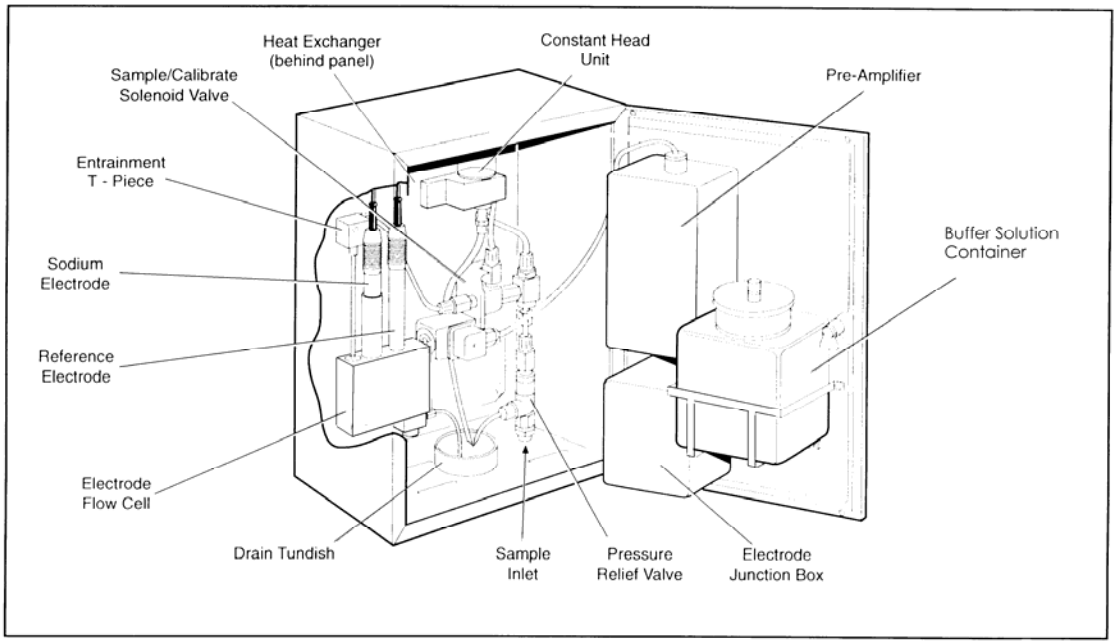


FIGURE 4.2 LAYOUT OF SENSOR



The sample enters the compression fitting at the bottom of the case and passes through one half of a heat exchanger, which is used during the calibration sequence to bring the standard solution temperature close to the temperature of the sample solution. This minimizes calibration time.

From the heat exchanger, the sample passes through a solenoid valve to the constant head unit. Here, the constant head unit stabilizes the effect of changes in sample pressure and flow-rate. A small tube overflowing into the constant head on one side ensures self-starting when the sample is lost. This tube also enables the monitor to function over a wide range of sample flow rates.

The sample is then delivered to the Entrainment 'T' and stainless steel entrainment tube. An alkaline vapor buffer is added to the sample to raise the pH value before flowing past the sodium and reference electrodes mounted in the flowcell. The sample leaves the flowcell and is passed to the drain at the bottom of the case.

The potential developed between the sodium ion-responsive electrode and calomel reference electrode is logarithmic with respect to changes in sodium ion concentration. The signal from the electrode pair travels to a junction box and to a voltage-to-current pre-amplifier whose

output is connected to the transmitter unit via the interconnection cable.

A temperature sensor, fitted into the flowcell, detects the temperature of the sample. The sensor, connected to the transmitter unit, compensates for changes in output from the electrode pair over a range of 41°F to 131°F (5°C to 55°C).

Calibration of the monitor is controlled by the microprocessor. After you connect the calibration tube to the standard solution container, press the "CAL" button on the transmitter unit. This action energizes the solenoid valve on the liquid handling panel to change over from sample to standard solution. The standard solution first passes through the second half of the heat exchanger. Then the solution is presented to the electrode pair via the constant head unit and the vapor entrainment tube.

The solenoid valve is closed to the sample during a calibration sequence, but under sample pressure, the pressure relief valve will open. The valve will allow the sample to pass through the heat exchanger, thus bringing the standard solution to a similar value to that of the sample.

4.2 TRANSMITTER UNITS

4.2.1 ELECTRONIC CHASSIS

The chassis contains three circuit boards:

- ✓ **Digital Board-** Behind the faceplate, containing the central processor unit, front panel controls and the display.
- ✓ **Analog Board-** Middle board, containing the analog input and current output circuitry.
- ✓ **PSU Board-** Rear board, containing the power supply and output relays.

4.2.2 CIRCUIT BOARD FUNCTION SWITCH

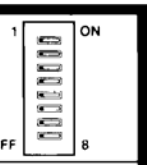
A series of eight ON/OFF switches in a dual-in-line package is sensed by the microprocessor and provides controlling functions for the alarms, output current and calibration – see Table 4.1.

TABLE 4.1 CIRCUIT BOARD FUNCTION SWITCH

Waltron Ltd.
AQUALERT DIVISION

μAI 9030
SODIUM ION ANALYZER

N1223-080A



FUNCTION		SW1 1	2	3	4	5	6	7	8
Output Current (mA)	0-10 0-20 4-20	ON OFF OFF	ON OFF ON						
Current Output	Linear Logarithmic			OFF ON					
Low Cal. Solution	Standard Sample				OFF ON				
Range Group	1.0 ppb-100ppm 0.01 ppb-1 ppm					OFF ON			
Std. Soln. Default	100-1000 ppb 50-500 ppb						OFF ON		
Alarm 2	Normal Fail-safe							ON OFF	
Alarm 1	Normal Fail-safe								ON OFF

FIGURE 4.3 LOCATION OF ITEMS ON DIGITAL BOARD

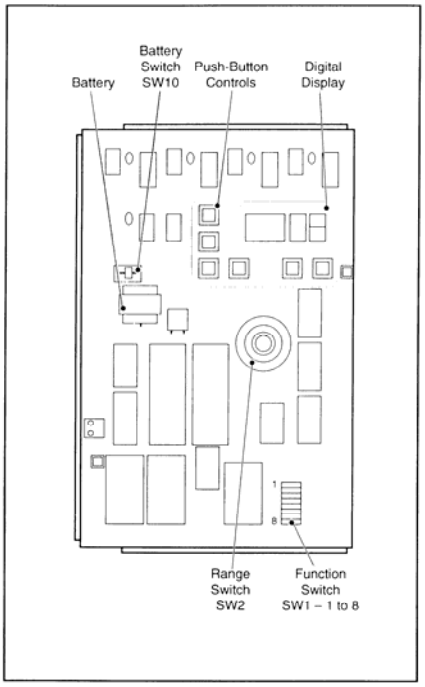


TABLE 4.2 RANGE GROUPS

Note. When the High Range Group (Group One), the upper range value indicated on the range control must be multiplied by 10 to determine the output range.

The two ranges groups are:

1.1 Range	Group One- High x 10 (SW1-5 Off) 0.1 ppb- 10 ppm	Group Two- Low x 1 (SW1-5 On) .01 ppb – 1 ppm
1	1 ppm-10 ppm	10 ppb-1 ppm
2	100 ppb-1 ppm	1 ppb-100ppb
3	10 ppb-100 ppb	0.1 ppb-10 ppb
4	1 ppb-10 ppb	.01 ppb-1 ppb

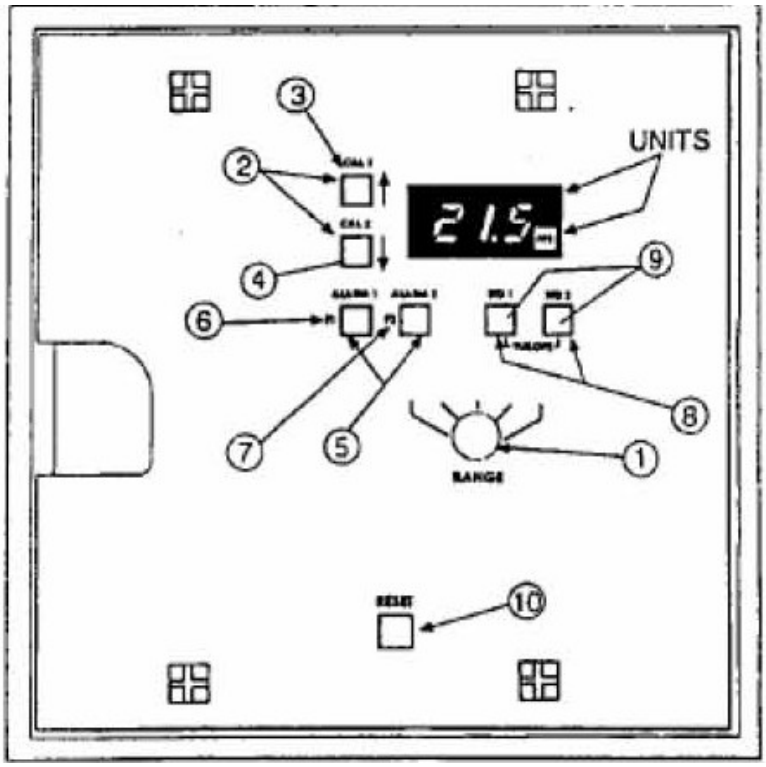
Note. Electronically, this is the lowest concentration which can be displayed; however, it is unlikely to be achieved in practice. Low concentration sodium measurements depend on sample and electrode conditions
.

4.2.3 FRONT PANEL CONTROLS

The controls, mounted on the front circuit board in the chassis, protrude through holes in the faceplate. The chassis is secured to the faceplate by four plastic fasteners.

A 3-digit red l.e.d. display shows the sodium level in ppm or ppb, as indicated by a lamp in the display. The controls have the following functions:

FIGURE 4.4 TRANSMITTER UNIT FRONT PANEL



1. **RANGE switch ←**: Positions 1, 2, 3 and 4 are the manual ranges within the 5 decade preset range selected on SW1, - see Section 3.2.3. Position 5 (AUTO) automatically switches to a range suitable for the sodium level being measured within the overall preset range. Remote range indication is provided.

2. **SET VALUE ↑**: These buttons (⇑ and ⇓ arrows) increase or decrease the value displayed on the digital indicator; used for setting the alarms and standard solution values.

3. **CAL 1 →**: When the button is pressed, a primary calibration sequence is initiated. Pressing CAL 1 during a calibration for at least five seconds cancels the sequence, displaying 'Abt'.

4. **CAL 2 ↓**: When the button is pressed, a secondary calibration sequence is initiated. Pressing CAL 2 during a calibration for at least five seconds cancels the sequence, displaying 'Abt'.

5. **Alarm 1/Alarm 2 °**: Used in conjunction with the SET VALUE (⇑ and ⇓ arrows) buttons to set the values at which the alarm relays operate.

6. **F1 ±**: Pressing this button during a calibration sequence, displays the output from the sodium electrode.

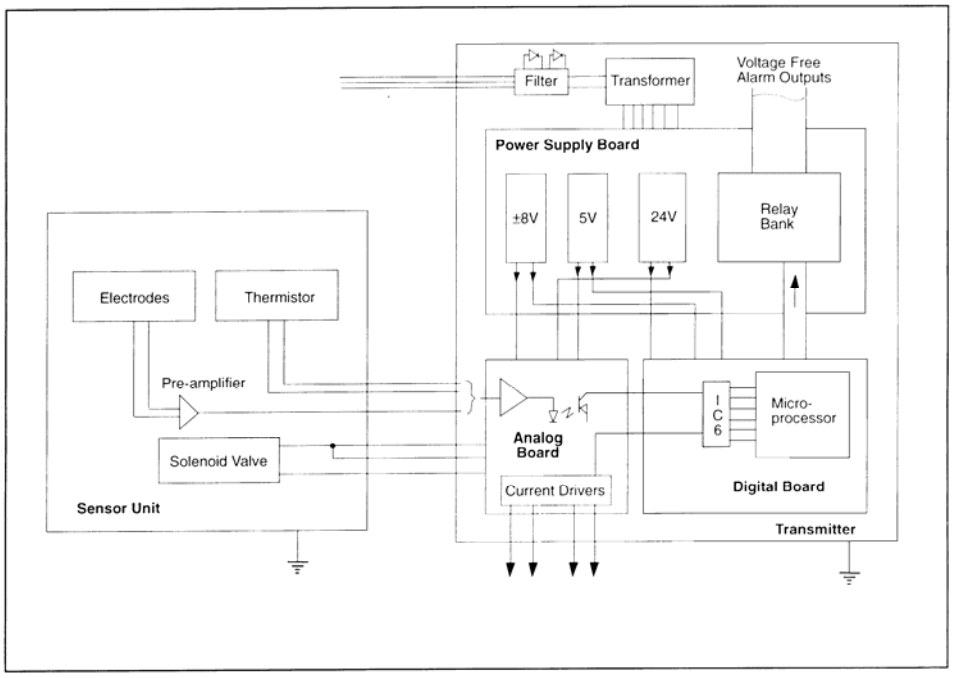
7. **F2 ″**: Holding this button while pressing and releasing RESET defaults the calibration slope value to 100% and the zero offset to zero.

8. **STD 1/STD 2 ≥**: Used in conjunction with SET VALUE (⇑ and ⇓ arrows) buttons to set the values of the standard solutions into the instrument.

9. **SLOPE ×**: Pressing STD 1 and STD 2 together gives an indication of the electrode % slope value, which was calculated during the last TWO POINT CALIBRATION.

10. **RESET ∝**: Used to regain control of the instrument in the unlikely event of a malfunction due to high supply transient, etc. (this button is not visible when the cabinet door is closed).

FIGURE 4.5 SIMPIFIED BLOCK DIAGRAM



4.2.4 ALARMS

Note. The alarms cannot be set during a calibration sequence.

Waltron Ltd. has provided two sodium concentration alarm control relays, each having one pair of changeover contacts rated at 2A, 250Vac (non-inductive). Alarms 1 and 2 are designated as low and high alarms respectively. Display these values by pressing the appropriate buttons on the front panel, and adjust by pressing the "SET VALUE" buttons.

Terminal connections for alarms are shown in Section 2.4. The switches SW1.7 and SW1.8 determine contacts which are closed in non-alarm conditions - see Section 4.2-2.

Functions are as follows:

- ✓ In "NORMAL" the relays are de-energized, i.e. NC contacts are closed.
- ✓ In "FAIL-SAFE" the relays are energized, i.e. NO contacts are closed. If the power source fails, both external alarms, sound to indicate malfunction.
- ✓ Two other sets of relay contacts are provided: One set changes over during a calibration sequence; and the other set changes over to indicate a failure to calibrate.

4.2.5 ANALOG OUTPUTS

Two identical isolated current outputs are available. You may set both outputs to one of the three current ranges using switches "SW1.1" and "SW1.2". In each case, the upper current limit corresponds to the full-scale reading of the range displayed on the front panel.

Note. If "SW1.1" is set to "ON" and "SW1.2" is set to "OFF", no valid output is produced.

The two current outputs cover five decades of sodium concentration divided into four overlapping ranges. The overall range is determined by the "RANGE GROUP" selected by the position of "SW1.5".

Within the selected “RANGE GROUP” both available current outputs represent two decades of sodium concentration at any one time. The “RANGE SWITCH” on the front panel manually selects RANGES 1 to 4, but in “AUTO” mode the monitor switches automatically between these ranges as the sodium concentration varies. Note the following points about ranges:

- ✓ The range selection only refers to the current output, as the digital display covers the full range capability of the monitor.

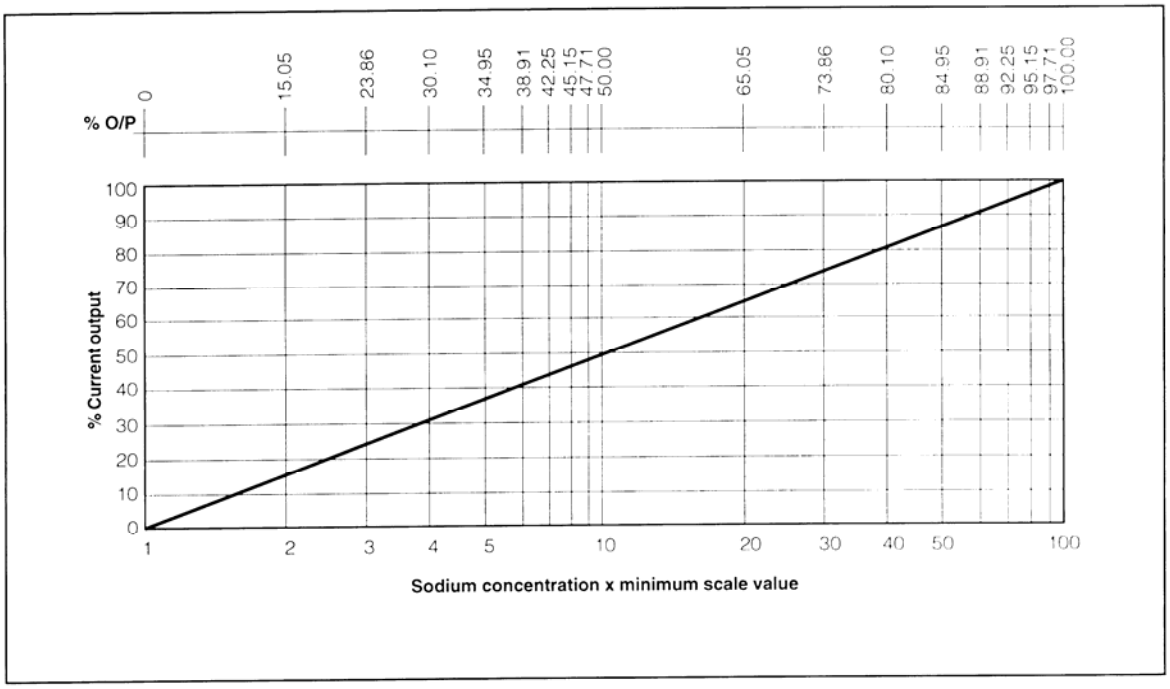
- ✓ If the concentration exceeds the individual range or RANGE GROUP selected, the digital display flashes - (reading) - ‘out’ - (reading) - ‘out’. In every other way the monitor functions normally.

- ✓ In “AUTO”, as the **concentration increases**, switching to the next range takes place at 100% of the current output, giving a 50% output on the upper range (10% in linear output). When the **concentration decreases**, switching takes place at 0% of the current output, giving a 50% output on the lower range (10% in linear output). This difference gives a range switching hysteresis of one decade.

At all times the current output range can be monitored or recorded remotely using the four remote “RANGE INDICATION RELAY” contacts.

The outputs can be set to “LOGARITHMIC” or “LINEAR” (determined by the position of SW1.3). When the “LOGARITHMIC” output is selected, the output represents two decades of concentration (e.g. 0.1 - 10ppb, 1 - 100ppb, etc.). When the LINEAR output is selected the output represents zero to the full scale reading (e.g. 0 - 10ppb, 0 - 100ppb, etc.).

FIGURE 4.6 LOGARITHMIC CURRENT OUTPUT



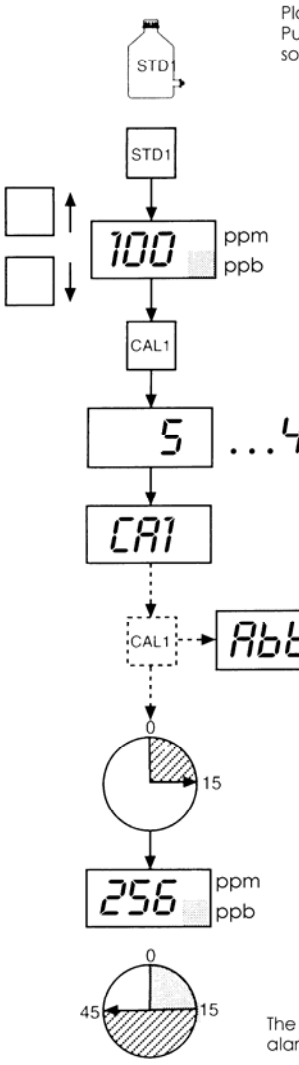
5 CALIBRATION PROCEDURE

Before starting an automatic calibration sequence, rinse the solution containers with high-purity water and fill them with fresh standard solution. If a single point calibration is to be done, only one solution (Low Calibration Solution) is required. If a two point calibration is to be done, the lower solution should be used first.

Depending on the operating conditions, either a single or two point calibration can be done. The slope of the sodium electrode is relatively stable; therefore frequent two point calibration may be unnecessary. Single point calibration should be performed weekly. A two point calibration should be carried out monthly. A suitable schedule must be determined to suit the operation conditions.

5 CALIBRATION PROCEDURE 9030

5.1 SINGLE POINT CALIBRATION



Place the container of standard solution on a shelf, or on the top of the sesnor unit- see Figure 2.1 or 2.2. Push the standard solution tube snap connector (right hand side of the sensor unit) inot the standard solution container.

PRESS the 'STD1' button.

ENTER the concentration value of the standard solution by using the ↓ ↑ buttons.

PRESS and HOLD 'CAL1' through the following display count-down.

COUNT-DOWN SEQUENCE prevents a calibration sequence starting if the 'CAL1' button is accidentally pressed momentarily.

RELEASE the 'CAL1' button when 'CA1' is displayed, to start the calibration sequence.

PRESS and HOLD 'CAL1' button at any time during the calibration sequence to stop the sequence.
RELEASE the 'CAL1' button when 'Abt' is displayed. Normal operation, i.e. monitoring sample, is resumed using the calibration constants from previous complete calibration sequences.

After fifteen minutes the microprocessor reads the output from the electrode pair, plus the temperature, then calculates the zero correction required to bring the reading to the preset standard solution concentration.

The displayed reading now reverts to sodium concentration.

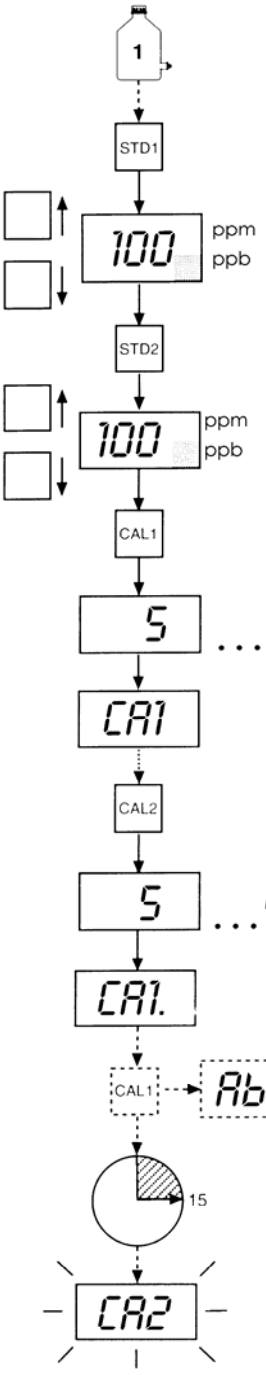
The solenoid valve is de-energized allowing sample to flow through the electrode flowcell.

The 'RUN' (sample) mode is resumed and 30 minutes are allowed for the system to recover before the alarms are made active and the remote CAL relay i s de-energized.

5.2 TWO POINT CALIBRATION

The following full calibration sequence takes approximately 60 minutes.

5 CALIBRATION PROCEDURE 9030



Place the container of standard solution on a shelf, or on the top of the sensor unit- see Figure 2.1 or 2.2. Push the standard solution tube snap connector (right hand side of the sensor unit) into the standard solution container.

PRESS the 'STD1' button.

ENTER the concentration value of STANDARD SOLUTION 1, by using the ↓ ↑ buttons.

PRESS the 'STD2' button.

ENTER the concentration value of STANDARD SOLUTION 2, by using the ↓ ↑ buttons.

PRESS and HOLD 'CAL1' through the following display count-down.

COUNT-DOWN SEQUENCE prevents a calibration sequence starting if the 'CAL1' button is accidentally pressed momentarily.

RELEASE the 'CAL1' button when 'CA1' is displayed, to start the CALIBRATION sequence.

During the calibration sequence (approximately 15 minutes), PRESS and HOLD 'CAL2' through the following display count-down.

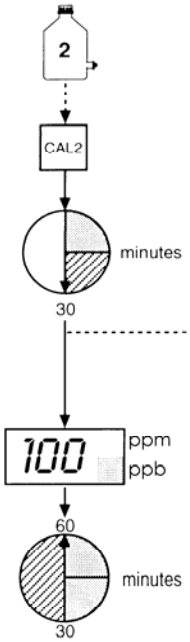
COUNT-DOWN SEQUENCE prevents a calibration sequence starting if the CAL2 button is accidentally pressed momentarily.

Decimal Point is illuminated to indicate that a Two Point Calibration has been requested.

PRESS and HOLD 'CAL1' button at any time during the calibration sequence to stop the sequence.
RELEASE the 'CAL1' button when 'Abt' is displayed. Normal operation, i.e. monitoring sample, is resumed using the calibration constants from previous complete calibration sequences.

After 15 minutes, the microprocessor reads the output from the electrode pair, plus the temperature, then calculates the zero connection required to bring the reading to the preset standard solution concentration.

A flashing 'CA2' is displayed at the end of the One Point calibration sequence.



Disconnect the standard solution tube snap connector (right hand side of the sensor unit) from the STD1 container and remove the container. Place the container of STD2 solution on the shelf provided, or on the top of the sensor unit – see Fig.2.1 or 2.2. Push the standard solution tube snap connector into the STD2 standard solution container.

PRESS 'CAL2' button to continue the sequence.

✶ **Note**. The two point calibration will be cancelled if the 'CAL2' button is not pressed within 15 minutes after the end of the first calibration.

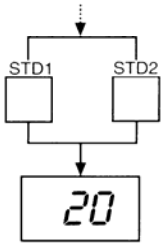
Fifteen minutes after the 'CAL2' button is pressed, the microprocessor reads the output plus the temperature from the electrode pair, then calculates the slope correction required to bring the reading to the second preset standard solution concentration – see – Calibration Parameters, below.

CALIBRATION SEQUENCE ends if the slope value is above 83% – see Calibration Parameters, below. The display reverts to showing the sodium concentration.

The solenoid valve is de-energized, allowing the sample to flow through the electrode flowcell.

The 'RUN' (sample) mode is resumed and 30 minutes are allowed for the system to recover before the alarms are made active and the remote CAL relay is de-energized.

5.3 CALIBRATION PARAMETERS



PRESS STD1 and STD2 together to display an indication of the electrode % slope value, which was calculated during the last TWO POINT CALIBRATION. If the slope value falls below about 83%, the external CAL FAIL alarm is activated and 'CF' is displayed. This indicates that the sodium electrode requires attention.

6 MAINTENANCE

6.1 CHEMICAL SOLUTIONS

The buffer and standard solutions detailed in this section are required to keep the monitor operating. Solutions should be stored in plastic bottles and should be freshly made just before use.

6.2 BUFFER SOLUTION

⃠WARNING. These buffers are mildly toxic and hazardous, and should be handled with care.

Two alternative reagent solutions may be used, depending on the required lower limit of measurement. Concentrated ammonia solution, which provides adjustment of sample pH to 10.7 is suitable for measurements of sodium ion to approximately 0.5ppb. At concentrations below 0.5ppb, hydrogen ion interference becomes significant and a reagent of 50% diethylamine solution should be used. This adjusts the sample pH to 11.2 - 11.5 and enables measurements to be made to concentrations below 0.5ppb.Concentrated ammonia solution - 1 liter

⃠WARNING. This buffer should only be handled under a fume hood. It causes burns and is irritating to the eyes, respiratory system and skin. Wear rubber gloves and eye protection. In warm weather pressure increases in the bulk container of ammonia and the cap must be released with care.

Waltron Ltd. recommends a 35% w/v solution (0.88 s.g.) is recommended, but lower concentrations, to a minimum of 29% w/v (0.89 s.g.), can be used. Refer to section 5.4.2 which relates sodium concentration and pH.

Note. Waltron L.L.C. offers Ammonium Hydroxide in a 2.5 liter container. Part N1234-116.

Diethylamine Solution - 50%

⊘**WARNING**. Diethylamine is an extremely inflammable and irritating colorless liquid with a strong smell of ammonia. It should be handled with care at all times. The following points should also be noted:

Avoid breathing vapor and avoid contact with skin and eyes.

Work under a fume hood, wearing rubber gloves and eye protection.

In the event of a fire, extinguish with water spray, foam, dry powder or carbon dioxide.

If a spill occurs, shut off all possible sources of ignition, and instruct others to keep at a safe distance. Mop up spill with plenty of water, diluting greatly. Ventilate the area well to evaporate any remaining liquid and dispel vapor.

Effluent from the monitor contains diethylamine (if this buffer is used). Contact with it should also be avoided.

Put 500ml of high purity water into the buffer container and carefully add 500ml of analytical reagent grade diethylamine $(C_2H_5)_2NH$. Swirl the solution and allow it to cool to room temperature before fitting the container cap.

6.2.1 STANDARD SOLUTIONS

The following instructions refer to the preparation of 100ppb and 1ppm sodium, LOW and HIGH standard solutions respectively, but any concentrations can be prepared within the measuring range selected by appropriate dilution of the stock solution.

Three liters of each standard solution are required:

Note.
- ✓ Waltron LL.C. offers Sodium Standard, 100 ppb, in a 5 gallon container. Part Number N1234-544.
- ✓ Waltron L.L.C also offers Sodium Standard, 1 ppm, in a 5 gallon container. Part Number N1234-545.

Three liters of each standard solution are required:

Dissolve 2.543(±0.001)g of analytical reagent grade sodium chloride in approximately 100ml high purity water. Transfer this solution to a one liter

volumetric flask and make up to the 1 liter mark with more high purity water to give a stock solution of 1000ppm sodium ions. Store in a plastic container.

Pipette 10ml of this solution to a one liter volumetric flask. Make up to the 1 liter mark with high purity water to give a solution of 10ppm sodium ions.

Pipette 20ml of the 10ppm solution into a two liter volumetric flask and make up to the 2 liter mark with high purity water to give the LOW standard solution of 100ppb sodium ions. Transfer this solution to the bottle labeled Low Calibration Standard.

Transfer 200ml of the 10ppm solution into a two liter volumetric flask and make up to the 2 liter mark with high purity water to give the HIGH standard solution of 1ppm sodium ions. Transfer this solution to the bottle labeled High Calibration Standard.

- ✓ Do not prepare static sodium solutions of less than 50ppb because low concentration solutions rapidly become contaminated and change in concentration.

- ✓ Although the HIGH and LOW standard solutions are typically one decade apart in sodium concentration, any concentration difference can be used within the constraints of i) above and the need to have a significant change in electrode output to achieve an accurate calibration.

Note. High purity water is water containing less than 2ppb sodium ions and a specific conductivity of less than approximately 0.2µS/cm.

6.2.2 ETCHING SOLUTION

Note. Waltron L.L.C. offers the solution under our Part Number N1234-543, Sodium Electrode Regeneration Solution, 2 oz size.

For use on applications where the sample sodium concentration is below 1ppb - see also Section 6.2.2.

⃠**WARNING**. Sodium Fluoride is toxic. Avoid inhaling the dust and prevent contact with skin and eyes. Wear a dust mask, rubber gloves and eye protection. When prepared, the etching solution contains 0.1M Hydrofluoric acid (0.2% HF). Take care to prevent contact with skin and eyes.

Dissolve 5.0 (±0.2)g analytical grade sodium fluoride, NaF, in approximately 400ml high purity water. Add to this solution 20 (±0.2)ml 5M acetic acid*, CH3COOH, and dilute to 1 liter.

Note. 5M acetic acid can be prepared from concentrated acid by adding 144 (±1)ml analytical reagent grade glacial acetic acid (1.05 s.g.) to 500ml of high purity water.

⃠**Warning**. Prepare the acetic acid solution under a fume hood and take the appropriate precautions when handling concentrated acids.

6.2.3 SALT BRIDGE SOLUTION

Note. Waltron L.L.C. offers a stock solution of 3.0 M Potassium Chloride in a 2oz. size. Part Number N1234-547.

This solution is required for refilling the calomel reference electrode at extended intervals. This solution should be stored in a tightly sealed plastic bottle. The electrode is most conveniently filled using the supplied eyedropper or a syringe.

6.3 SCHEDULED SERVICING

The following procedures are guides to the maintenance requirements of the monitor. The procedure chosen depends on the particular installation and sample conditions.

6.3.1 WEEKLY

If the monitor is continuously running at high concentrations, greater than 100ppb, a weekly Single Point Calibration is recommended. See Section 5.1 Single Point Calibration.

6.3.2 MONTHLY

- ✓ Replace the bottle of buffer solution. The level of solution should not be allowed to fall below about three-quarters full. On low ambient

temperature installations and for low sodium concentrations, the solution may require replacement more frequently.

✓ Check the level of reference electrode filling solution; refill as required.

✓ The following procedures should be carried out:

1. When the sodium concentration is above 1ppb, carry out a Two Point Calibration - see Section 5.2; note the slope value.

2. When the sodium concentration is below 1ppb, apply the following reactivation/etch procedure before carrying out a Two Point Calibration:

Note. When used for prolonged periods at low concentrations, leeching of sodium ions from the electrode surface accelerates the aging process of the electrode which is shown by poor response time, low slope value and a limitation to respond to low levels. Calibration may then be in error because of slow response and poor reproducibility. The reactivation procedure minimizes problems from these sources.

✓ Remove the sodium electrode from the flowcell and slide off the sleeve and 'O' ring; it is not necessary to detach the electrode lead.

✓ Prepare two plastic beakers, one containing about 50ml of etching solution, the other about 200ml high purity water.

✓ Dip the electrode in the etching solution for 60 (±5) seconds; then rinse in high purity water.

Caution. It is important not to exceed the etching time or the performance of the electrode may be permanently degraded.

✓ Dispose of the etching solution by diluting to waste with plenty of water. Use fresh etching solution each time.

Fit the 'O' ring and sleeve and return the electrode to the flowcell. Prior to performing a calibration, run the monitor for one to two hours on low level sodium sample. No further calibration should be needed until the next reactivation procedure.

This procedure must be carried out at regular monthly intervals and the process started as soon as a new electrode is put into service.

Note. It is extremely difficult to recover an 'old' electrode.

As the buffer solution, is replaced monthly, the following procedure should be carried out 24 hours after replenishment to allow pH stability to be achieved.

This procedure applies to both ammonia and amine buffered systems.

6.3.3 QUARTERLY

Check the condition of all plastic tubing; replace it as required. Clean the flowcell to remove any deposits.

6.4 SHUT DOWN PROCEDURE

- ✓ Close the sample valve upstream of the monitor.
- ✓ Remove the buffer container and safely dispose of the solution. Rinse the containers thoroughly.

> ⊘**WARNING**. For safe handling instructions of buffer solutions refer to Chapter 6.

- ✓ Fill the calibration solution container with high purity water and do a single point calibration to flush the system.
- ✓ Remove the electrodes and follow procedure in Section 6.3.1.
- ✓ Use a syringe to flush all tubing with high purity water. This removes any particulate deposits.
- ✓ Switch off the main power supply to the Transmitter Unit.
- ✓ SW10 should be set to 'OFF' if the instrument is to be out of commission for longer than a week.

6.4.1 STORAGE OF ELECTRODES

Fill the rubber teat, supplied with the **sodium electrode**, with 1ppm sodium containing a few drops of concentrated ammonia solution - see Chapter 6 for safe handling of ammonia solutions. Push the teat over the end of the electrode. Fill the rubber teat supplied with the **reference electrode** with salt bridge solution and push the teat over the end of the electrode. Refit the filling hole plug to seal the refill aperture.

Note. Do not let either electrode dry out.

6.5 UNSCHEDULED SERVICING

Abnormal operation is shown on the l.e.d. display as follows:

Fault & Possible Cause:

Display shows 'CA1' or 'CA2':
Normal display when calibration sequence is taking place. Display shows flashing 'CA2' when waiting for CAL2 button to be pressed to start calibration on second solution.

Display flashes (reading) - 'out':
Sample concentration exceeds the range group selected.

Display shows 'CF':
Calibration Fail - the monitor was unable to achieve a successful calibration.

Display shows 'Hot':
Sample temperature has risen above 55°C - check cause.

6.5.1 CALIBRATION FAIL ALARM

A Calibration Fail condition occurs after a TWO POINT CALIBRATION when the calculated slope value is less than 83%. This could be caused by a number of factors which should be investigated. Some indication of the problem can be obtained by displaying the slope value (%) by pressing STD1 and STD2 buttons simultaneously.

6.6 Slope values just below 83%

- ✓ Check that vapor bubbles are emerging from the bottom of the stainless steel entrainment tube.
- ✓ Check the condition of the reagent solution.
- ✓ Reactivate the sodium electrode, - see Sections 6.1-3 and Section 5.2-2. If the slope value is not improved following a further calibration, the electrode should be replaced.

6.7 Very low or 0% slope

- ✓ Check the operation of the solenoid valve.

- ✓ Check flow of standard solution through flowcell.
- ✓ Check the level of the salt bridge solution in the reference electrode.
- ✓ Check for open circuit reference electrode by substituting it with an electrode of known performance.
- ✓ Check all electrical connections in the electrode junction box and interconnect cable.

6.7.1 MALFUNCTIONS OF THE MONITOR

These may produce many effects after calibration, some of which produce the following:

- ✓ Abnormal slope % values - see Section 4.2-4.
- ✓ Display alternates between (value) and 'out'. A very large offset from the electrode takes the reading beyond the range of the monitor.

Any unpredictable problems may be due to the standard or buffer solutions. If doubts exist about the integrity of these solutions, they should be replaced with freshly prepared solutions in the early stages of the fault finding investigations.

The accuracy of the monitor is controlled by the condition of all the solutions involved, one or more of which can be incorrectly made or contaminated.

Measuring the pH of the effluent from the flowcell indicates adequate buffering. The minimum pH depends on the minimum sodium concentration, but the pH value is calculated as:

6.7.2 MALFUNCTIONS OF THE MONITOR

pH must be greater than pNa + 3, so ideally at:

- ✓ 100ppb Na+, the pH must be greater than 8.4
- ✓ 10ppb Na+, the pH must be greater than 9.4
- ✓ 1ppb Na+, the pH must be greater than 10.4
- ✓ 0.5ppb Na+, the pH must be greater than 11.4

Note. If the buffer is allowed to become completely exhausted, the reading may be very erratic due to the lack of ionic strength adjustment of the high purity sample.

Mechanical components involved with liquid handling should be systematically checked for leaks or blockages as this changes the chemical conditions around the electrodes. Most problems are found to be associated with the chemistry and the liquid handling section.

6.7.3 REPLACEMENT OF PLASTIC TUBING

Over time, certain sections of plastic tubing require replacement due to leakage, blockages, or poor condition. To avoid this occurrence, refurbish the liquid handling panel every twelve months including the replacement of all plastic tubing. Use only the correct size and type of tube - see Section 6.

Two specific sections of tubing are critical:

- ✓ The tube found between the constant head unit and the entrainment 'T' piece: Cut 3" (100mm) of the 1mm I.D. silicon rubber tubing and fit onto the tube connectors. The tube should be taut; any changes to this tube interfere with the flow and self starting characteristics.

6.7.4 SIMPLE ELECTRONIC CHECK

Check the ability of the Pre-amplifier and the Transmitter Unit to respond to an input in the following way:

Disconnect the electrode leads from the terminals in the junction box on the Sensor Unit door.

Connect a millivolt source to the electrode terminals:

- ✓ negative to 'Na+'
- ✓ positive to 'REF'
- ✓ line 'REF' to 'SCR'

Connect a 10 kΩ resistor across terminals TH1 and TH2 in the Transmitter Unit to simulate 25°C.

Hold F2 and press RESET to set to the default calibration parameter values.

Inject 200mV and wait for two minutes.

Note the reading on the display.

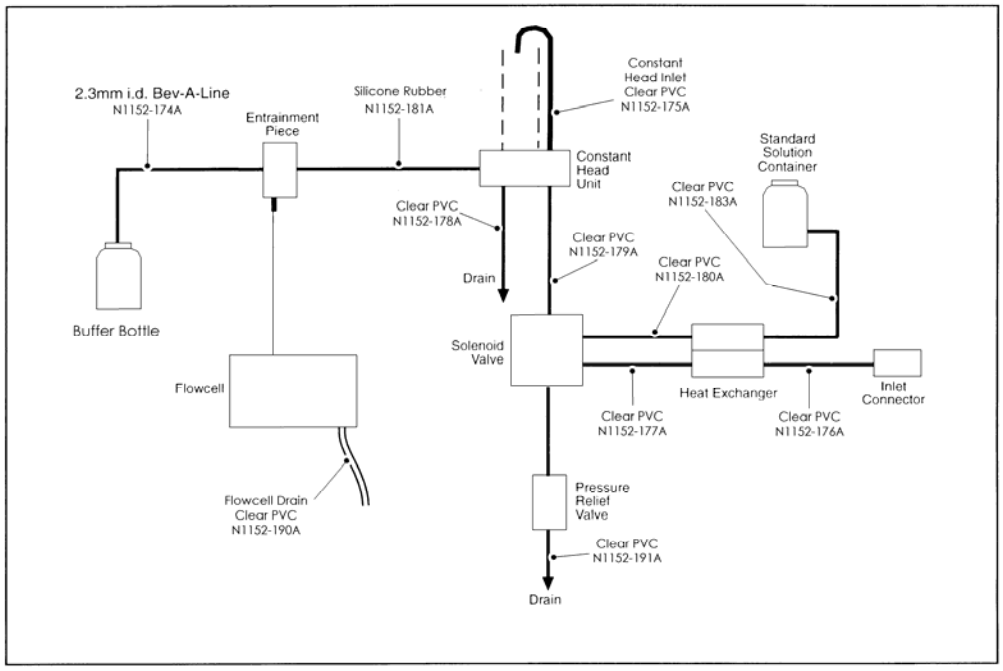
Inject 259mV and wait for two minutes.

The reading should decrease by approximately one decade, e.g. from 95ppb to 9.5ppb. The exact change in reading is not important because this test is simply to check that the electronics respond to changes in input voltage.

000A further 59mV decreases the reading by one decade.

The same procedure can be carried out using a pH simulator, injecting millivolts or equivalent pH values. Each pH unit change gives about one decade change on the display. A pH simulator also has the advantage of being able to check input insulation - see manufacturers manual for the simulator.

FIGURE 6.1 PART NUMBERS OF PLASTIC TUBING



7 SPARE PARTS

7.1 RECOMMENDED SPARE PARTS

PART NUMBER	DESCRIPTION
N3500-067	Sodium Standard (1 liter 100 ppm)
N3010-168	Electrode, Low Level Sodium
N3010-171	Electrode, Reference
N3500-322	Kit, Retubing & O'Ring
N1234-544	Sodium Standard, 100 ppb (5 gal.)
N1234-545	Sodium Standard, 1000 ppb (5 gal.) - (1 ppm)
N1234-543	Sodium Electrode Regeneration Solution (2 fl.oz.)
N1234-547	3.0 M Kcl Reference Electrode Filling Solution
N1234-116	29% Ammonium Hydroxide (2.5 L)
N3500-069	Sodium Concentration #2 (1 Liter)
N1234-579	99% Di-Isopropylamine (1 Gallon)
K1092-025	Fuse, 2A Ceramic
N3500-323	Sodium Expendable Kit (tubing, electrode regeneration
	solution and reference filling solubtion)

7.2 STRATEGIC SPARE PARTS

PART NUMBER	DESCRIPTION
N3500-069	Sodium Concentration #2 (1 Liter)
N1234-579	99% Di-Isopropylamine (1 Gallon)
N3010-170C	Thermistor, Flow Cell
K3500-201	Resistor Kit of Remote Range Indication
K1080-151	Illuminated Push Switch
K2014-419B	Digital Circuit Board
K2014-401C	Analog Circuit Board
K2014-402B	Power Supply Circuit Board
N2554-062A	Flow Cell Complete Assembly (Less Electrode)
N2552-098B	Solenoid Valve Assembly
N2554-065B	Constant Head Unit Assembly
N1152-169	Pressure Relief Valve
K1086-160	Cable, 8 Conductor, Shielded
N3500-322	Kit, Retubing & O'Ring
N1053-106A	Earthing Tube
K3400-008	Sentry 8-Point Sample Sequencer
K1148-004	4-Point Manifolded (120V) Sampling Valve
K1148-008	8-Point Manifolded Sampling Valve
K1138-633	8-Point Sample Inlet Connections (1/8" OD Swagelok)

K1138-634	8-Point Sample Outlet Connections (1/8" x 1/8")
K3500-357	Kit, Sentry Sample Sequencer - 8pt
K3500-358	Kit, Sentry Sample Sequencer - 4pt
K1152-200	Nupro Filter, Stainless Steel, 60 Micron
N1142-149C	Low Standard Calibration Bottle
N1142-150C	High Standard Calibration Bottle
N1142-096	Pipette, 10ml
N1142-095	Pipette, 1ml
N1142-164	Flask, 1000ml, Volumetric
N3500-352	Ref. Electrode/Resevoir Kit
N2554-067C	Heat Exchange Assembly
N2554-066A	Entrainment "T" Assembly
K2004-255	Power Cord Assembly (6 ft.)
K2004-242A	Interconnect Cable Assembly - 6 ft. ($2.00 each
	additional foot)
K1058-180	Latch (with Key)
N7500-003A	Test Strip, 9030

8 SPECIFICATIONS

Ranges	0.01ppb to 1ppm or 0.1ppb to 10ppm internally selectable.
Accuracy	±10% of concentration or ±0.1ppb, whichever is the greater (when sample temperature is within ±5°C of calibration temperature).
Reproducibility	±5% of concentration or 0.1ppb (whichever is the greater) at constant temperature.
Response Time	1 to 100ppb - less than 4 minutes for a 90% step change; 100 to 1ppb - less than 6 minutes for a 90% step change.
Outputs	Two isolated current outputs in the range 0 to 10, 0 to 20 or 4 to 20mA. Maximum impedance 1000Ω. Logarithmic or linear.
Remote Range	Four voltage-free contacts rated 125 Vac.
Indication	0.4A non-inductive
External Alarms	Two normal or fail-safe, high and low concentration alarms. Calibration Mode indication. Calibration Fail indication. All voltage free 250Vac, 2A non-inductive.
Calibration	Manual initiation of automatic calibration sequence. Calibration frequency 1 to 4 weeks depending on operating conditions.
Battery Backup	10 years.

8.1 INSTALLATION INFORMATION

Sample Temp.	41°F to 131°F (5°C to 55°C).
Sample Flow	50 ml/min. to 500 ml/min.
Sample Press.	Minimum 2 psi (0.14 bar).
Ambient Temp.	32°F to 131°F (0°C to 55°C)
Dimensions of Sensor Unit	11.87" wide x 16.0" high x 8.0" deep
Mounting for Sensor Unit	Four Holes ∅0.34" each, 9.1" hor. X 13.0" vert.
Weight of Sensor Unit	24¼ lb. (11 kg.)
Connections to Sensor Unit	Sample Inlet - ¼" compression fitting; Sample Outlet - ½" hose barb
Dimensions of	11.87" wide x 11.87" high x

8 SPECIFICATIONS 9030

Transmitter Unit	8.0” deep
Mounting for Transmitter Unit	Four Holes ∅0.34” each, 9.1” hor. X 9.1” vert.
Transmitter Unit	24¼ lb. (11 kg.)
Electrical Conn.	Via access glands as required
Power Supply Requirements	100-120/200-240Vac, 50/60 Hz, 100VA.
Power Supply Tolerances	Voltage +10%/-20%; Frequency min. 47Hz, max.65Hz.
Case Protection Transmitter Unit	IP55.
Maximum Distance between Sensor & Transmitter Unit	330 ft. (100 meters).

ppm (mg/l)	Fluoride	Ammonia as N	Ammonia as NH3	Ammonia as NH4+	Nitrate as N	Nitrate as NO3	Sodium
0.0001							-449.8
0.0005							-407.1
0.001							-388.7
0.005							-346.0
0.01							-327.6
0.05		96.4	101.8	103.3			-284.8
0.1	302.0	78.0	83.4	84.9			-266.4
0.2	283.6	59.6	65.0	66.5	-54.6		-248.0
0.3	272.8	48.9	54.2	55.8	-65.3		-237.3
0.4	265.2	41.2	46.6	48.1	-73.0		-229.6
0.5	259.3	35.3	40.6	42.2	-76.9		-223.7
0.6	254.4	30.5	35.6	37.4	-83.7		-218.9
0.7	250.3	26.4	31.7	33.3	-87.8		-214.8
0.8	246.8	22.6	28.2	29.7	-91.4		-211.2
0.9	243.7	19.7	25.0	26.5	-94.5		-208.1
1	240.9	16.9	22.2	23.8	-97.3	-136.8	-205.3
2	222.4	-1.5	3.8	5.4	-115.7	-155.2	-186.9
3	211.7	-12.3	-6.9	-5.4	-126.5	-166.0	-176.1
4	204.0	-19.9	-14.6	-13.0	-134.1	-173.5	-168.5
5	198.1	-25.8	-20.5	-18.9	-140.0	-179.5	-162.6
6	193.3	-30.7	-25.3	-23.8	-144.9	-184.4	-157.7
7	189.2	-34.8	-29.4	-27.9	-149.0	-188.5	-153.6
8	185.6	-38.3	-33.0	-31.4	-152.5	-192.0	-150.1
9	182.5	-41.4	-36.1	-34.5	-155.6	-195.1	-147.0
10	179.7	-44.2	-38.9	-37.3	-158.4	-197.9	-144.2
20	161.3	-62.6	-57.3	-55.7	-176.8	-216.4	-125.8
30	150.5	-73.4	-66.1	-66.5	-187.6	-227.1	-115.0
40	142.9	-81.0	-75.7	-74.1	-195.2	-234.8	-107.4
50	137.0	-87.0	-81.6	-80.1	-201.2	-240.7	-101.4
60	132.1	-91.8	-86.5	-84.9	-206.0	-246.5	-96.6
70	128.0	-95.9	-90.6	-89.0	-210.1	-249.5	-92.5
80	124.5	-99.4	-94.1	-92.5	-213.6	-253.2	-88.9
90	121.4	-102.6	-97.2	-95.7	-216.8	-256.3	-86.8
100	118.6	-105.4	-100.0	-98.5	-219.6	-259.1	-83.0
200	100.2	-123.8	-118.4	-116.9	-236.0	-277.5	-64.6
300	89.4	-134.5	-129.2	-127.6	-248.7	-288.3	-53.9
400	81.5	-142.2	-136.9	-135.3	-256.4	-295.9	-46.2
500	75.8	-148.1	-142.8	-141.2	-262.3	-301.8	-40.3
600	71.0	-152.9	-147.6	-146.0	-267.1	-306.7	-35.4
700	68.9	-157.0	-151.7	-150.1	-271.2	-310.8	-31.4
800	63.4	-160.6	-155.3	-153.7	-274.8	-314.3	-27.8
900	60.2	-163.7	-158.4	-156.6	-277.9	-317.4	-24.7
1000	57.4	-166.5	-161.2	-159.6	-280.7	-320.2	-21.9
5000						-363.0	