Instruction Manual

IM/8237_6

Carbon Dioxide Monitor

8237

ABB

The Company

We are an established world force in the design and manufacture of instrumentation for industrial process control, flow measurement, gas and liquid analysis and environmental applications.

As a part of ABB, a world leader in process automation technology, we offer customers application expertise, service and support worldwide.

We are committed to teamwork, high quality manufacturing, advanced technology and unrivalled service and support.

The quality, accuracy and performance of the Company's products result from over 100 years experience, combined with a continuous program of innovative design and development to incorporate the latest technology.

The UKAS Calibration Laboratory No. 0255 is just one of the ten flow calibration plants operated by the Company and is indicative of our dedication to quality and accuracy.

EN ISO 9001:2000

Cert. No. Q 05907

EN 29001 (ISO 9001)

Lenno, Italy – Cert. No. 9/90A

Stonehouse, U.K.

0255

Electrical Safety

This equipment complies with the requirements of CEI/IEC 61010-1:1993 "Safety requirements for electrical equipment for measurement, control, and laboratory use". If the instrument is used in a manner NOT specified by the Company, the protection provided by the instrument may be impaired.

Symbols

One or more of the following symbols may appear on the equipment labelling:

⚠	**Warning –** Refer to the manual for instructions	⎓	Direct current supply only
	Caution – Risk of electric shock	~	Alternating current supply only
	Protective earth (ground) terminal		Both direct and alternating current supply
⏚	Earth (ground) terminal		The equipment is protected through double insulation

Information in this manual is intended only to assist our customers in the efficient operation of our equipment. Use of this manual for any other purpose is specifically prohibited and its contents are not to be reproduced in full or part without prior approval of the Technical Publications Department.

Health and Safety

To ensure that our products are safe and without risk to health, the following points must be noted:

1. The relevant sections of these instructions must be read carefully before proceeding.
2. Warning labels on containers and packages must be observed.
3. Installation, operation, maintenance and servicing must only be carried out by suitably trained personnel and in accordance with the information given.
4. Normal safety precautions must be taken to avoid the possibility of an accident occurring when operating in conditions of high pressure and/or temperature.
5. Chemicals must be stored away from heat, protected from temperature extremes and powders kept dry. Normal safe handling procedures must be used.
6. When disposing of chemicals ensure that no two chemicals are mixed.

Safety advice concerning the use of the equipment described in this manual or any relevant hazard data sheets (where applicable) may be obtained from the Company address on the back cover, together with servicing and spares information.

CONTENTS

1 INTRODUCTION

1.1 Description

The Model 8237 Carbon Dioxide Monitor is a microprocessor based analyser using a gas sensing membrane probe to monitor the level of CO_2 in cooling water samples in AGR Nuclear Power Stations.

1.2 Training

Due to the specialised nature of the above instrument, it is recommended that, where the end users personnel have had no previous experience of maintaining this equipment, training be provided by this Company.

Such training is available via the local Company in the UK, or Overseas Agent elsewhere and may be carried out either on the users premises or at the factory.

1.3 Location and Function of Main Components – Fig. 1.1

Monitoring of carbon dioxide involves the addition of an acid reagent to liberate bicarbonate ions in the sample as carbon dioxide gas. The gas sensing probe responds to the partial pressure and hence the concentration of carbon dioxide gas.

The 8237 carbon dioxide monitor has a liquid handling section in the lower half of a moulded plastic enclosure, and the electronics section in the upper portion.

Sample inlet and drain connections are at the base of the instrument. A peristaltic pump, mounted centrally, proportions sample and reagent through a mixing and reaction coil to a flow-through cap at the end of a gas sensing probe where the measurement takes place.

To maintain optimum measurement accuracy, it is necessary to carry out two point calibration by introducing 'low' and 'high' standard solutions of known concentration. The 8237 monitor uses solenoid valves to introduce these solutions automatically at programmable intervals under the control of the microprocessor.

Access to the probe, pump and calibration solution containers is by means of a hinged acrylic door, which is held open or closed by use of a push/push latch. The instrument case is also hinged to allow access to the electronics section, guard tubes and solenoid valves etc. for maintenance.

The electronics section consists of a microprocessor unit situated at the top left which controls the instrument functions, and a user junction box for all external electrical connections, at the top right behind the hinged case.

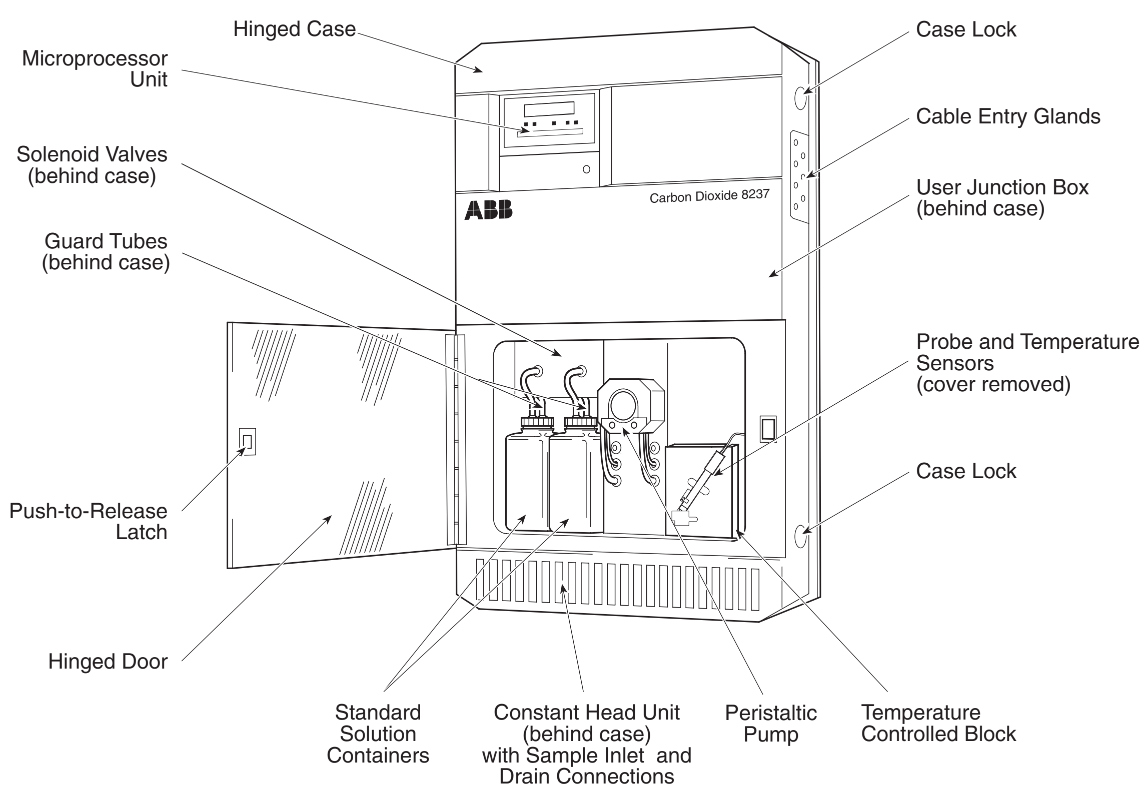


Fig. 1.1 Location of Instrument Components

2 INSTALLATION

2.1 Accessories

1 x reagent bottle
4 x calibration bottles
1 x 8237 probe kit
1 x spares kit

2.2 Location

The monitor should be installed in a clean, dry, well ventilated and vibration-free location giving easy access, and where short sample lines can be used. Rooms containing corrosive gases or vapours (e.g., chlorination equipment or chlorine gas cylinders) should be avoided. It is also advisable to have adjacent drains near ground level, so that the waste outlet from the monitor can be as short as possible, together with maximum fall. Power supplies should also be adjacent. Ambient temperature: within the range 5 to 40°C.

2.3 Mounting – Fig. 2.1

The monitor has a moulded plastic case, mounted onto a flat metal panel. To provide access, the case is hinged on the left hand side and has two lockable catches on the right hand side to hold the case in position in normal operation.

One keyhole slot is provided at the top of the flat panel to provide easy mounting on a wall or framework. Two further fixing holes are provided at the bottom of the flat panel. All holes are designed to take 8mm bolts or studs.

Mains and signal cables are connected through cable glands in the User Junction Box on the right hand side with the exception of the optional serial interface which connects directly into the Microprocessor Unit. Sample and drain pipework are brought in through the bottom of the case.

2.4 Sampling Requirement

In addition to being as close as possible to the monitor, the sampling point must provide a thoroughly mixed representative sample. The sample must also conform to the following conditions:

a) Sample flowrates must be between 5ml min^{-1} and 1250ml min^{-1}.

b) Sample temperature should be within 20°C of the ambient temperature and within the range 0 to 40°C.

c) Particles must be less than 10mg l^{-1} and the size must not exceed 60 μm. Above these levels it is essential that the filter supplied is fitted in both the sample and emergency inlets.

2.5 Sample Connections – Fig. 2.2

The inlet and outlet pipe connections are both located at the bottom of the case. A 6mm (1/4 in) hose adaptor is provided for the sample inlet and a 9mm (3/8 in) hose connection for the drain. The inlet pipe must be of an inert, low gas permeability material such as flexible p.v.c. (NOT silicone rubber), whereas the outlet pipes may be of any flexible, inert material. The inlet pipe must incorporate a shut-off valve at its upstream end, while the drain outlet pipe should be short, venting to atmosphere as soon as possible.

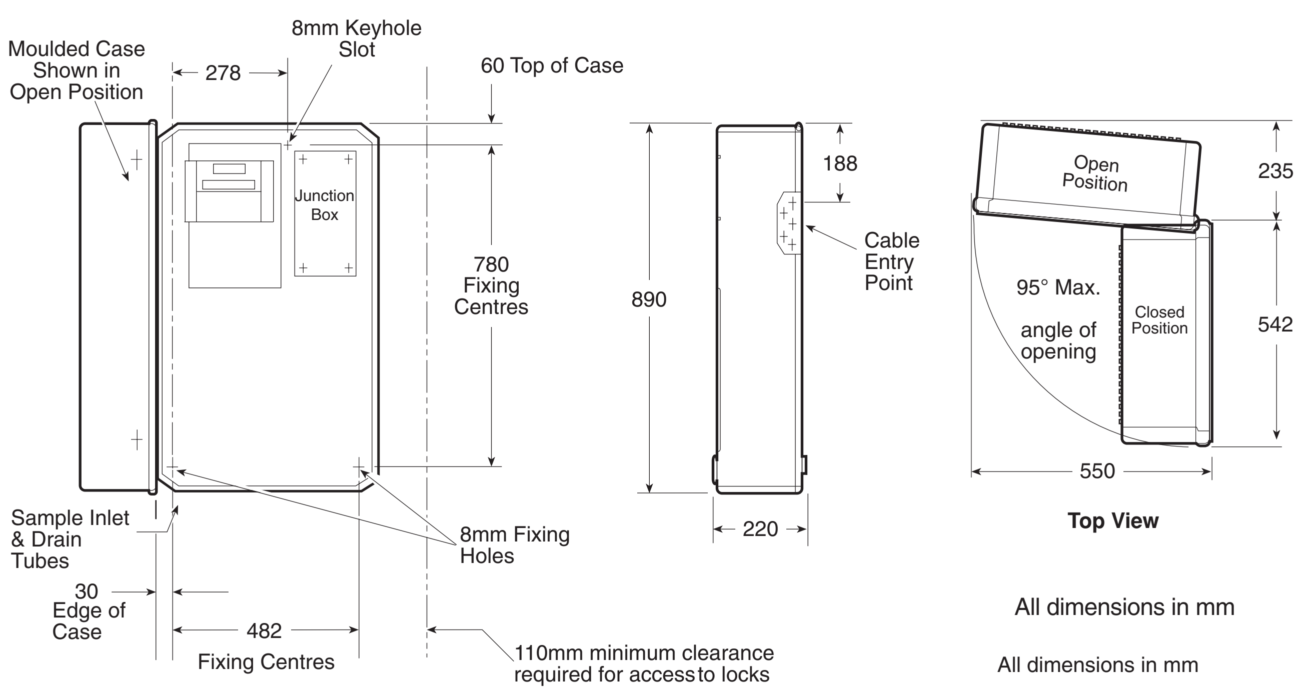


Fig. 2.1 Overall Dimensions and Mounting Details

2.6 Connections, General

Warnings.

- A disconnecting device such as a switch or circuit breaker conforming to local safety standards must be fitted to the final installation. It must be fitted in close proximity to the instrument within easy reach of the operator and must be marked clearly as the disconnection device for the instrument.
- Although certain instruments are fitted with internal fuse protection, a suitably rated external protection device, e.g. a 3A fuse or miniature circuit breaker (m.c.b.), must also be fitted by the installer.
- Remove all power from supply, relay and any powered control circuits and high common mode voltages before accessing or making any connections.
- The power supply earth (ground) **must** be connected to ensure safety to personnel, reduction of the effects of RFI interference and correct operation of the power supply interference filter.
- The power supply earth (ground) **must** be connected to the earth (ground) stud on the junction box case – see Fig. 2.3.
- Use cable appropriate for the load currents. The terminals accept cables up to 14AWG (2.5mm^2).
- The instrument conforms to Mains Power Input Insulation Category III. All other inputs and outputs conform to Category II.
- All connections to secondary circuits must have basic insulation.
- After installation, there must be no access to live parts, e.g. terminals.
- Terminals for external circuits are for use only with equipment with no accessible live parts.
- The relay contacts are voltage-free and must be appropriately connected in series with the power supply and the alarm/control device which they are to actuate. Ensure that the contact rating is not exceeded. Refer also to Section 2.8 for relay contact protection details when the relays are to be used for switching loads.
- Do not exceed the maximum load specification for the selected analog output range.
  The analog output is isolated, therefore the –ve terminal must be connected to earth (ground) if connecting to the isolated input of another device.
- If the instrument is used in a manner not specified by the Company, the protection provided by the equipment may be impaired.
- All equipment connected to the instrument's terminals must comply with local safety standards (IEC 60950, EN61010-1).

Notes.

- An earthing (grounding) – stud terminal is fitted to the junction box case for bus-bar earth (ground) connection – see Fig. 2.3.
- Always route signal output and mains-carrying/relay cables separately, ideally in earthed (grounded) metal conduit. Use twisted pair output leads or screened cable with the screen connected to the case earth (ground) stud.

  Ensure that the cables enter the analyzer through the glands nearest the appropriate screw terminals and are short and direct. Do not tuck excess cable into the terminal compartment.
- Ensure that the IP65 rating is not compromised when using cable glands, conduit fittings and blanking plugs/bungs (M20 holes). The M20 glands accept cable of between 5 and 9mm (0.2 and 0.35 in.) diameter.

2.7 External Electrical Connections – Fig. 2.3

The external electrical connections are to be found in the User Junction Box with the exception of the optional serial interface which is connected directly into the Microprocessor Unit. The cables are passed through the cable glands on the right hand side of the junction box which are adjacent to the internal electrical terminals.

> Caution. Slacken the terminal screws fully before making connections.

The connections are as follows:

a) Mains input 115V (110 to 120V) or 230V (220 to 240V). The mains voltage is selected by means of the voltage selector – see Fig. 2.3.

b) Current outputs 1 and 2 – two independent current outputs for external recording or control. One output is supplied as standard, the second is supplied as an optional extra – see Fig. 2.4 for details regarding current output range.

> **Information.** Because the current output is isolated, the negative terminal **must** be connected to earth (ground) if connecting to the isolated input of another device.

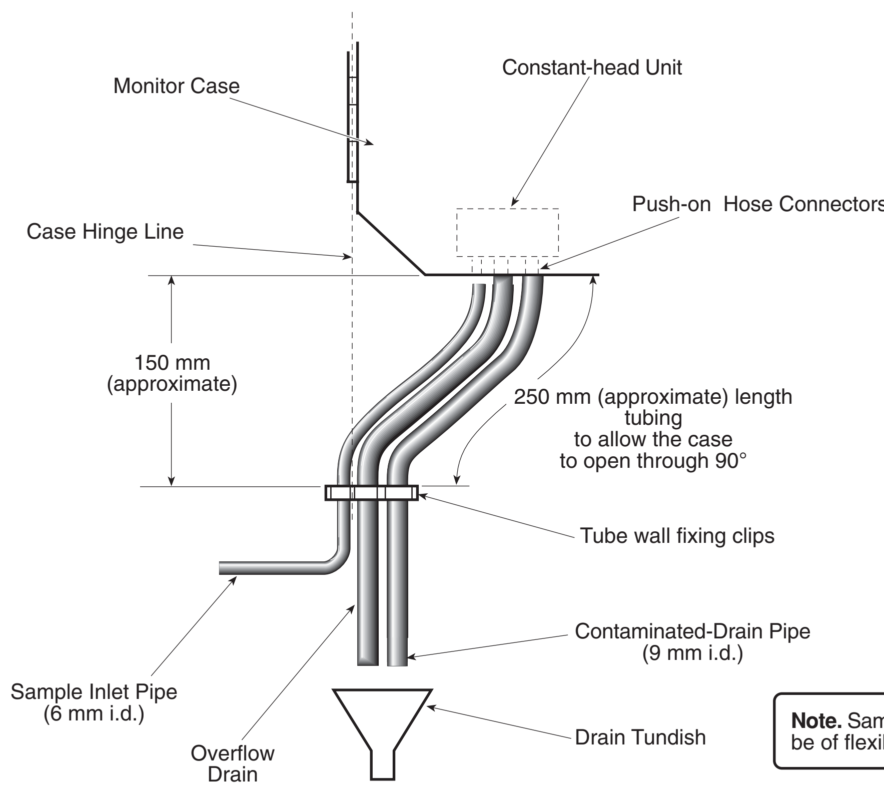
c) Relay 1 and 2 – two concentration alarms.

d) Relay 3 – calibration mode indication. This indicates when the instrument is off line during a calibration.

e) Relay 4 – instrument 'OUT OF SERVICE' indication. This indicates that the monitor readings are suspect and it is in need of attention.

f) Relay 5 – 'OUT OF SAMPLE' – indication of loss of sample.

g) Optional serial interface – connected into the Micro-processor Unit. See supplementary instruction manual for details



> **Note.** It is essential that all sample pipework to the monitor is kept as short as possible to reduce the effects on the sample due to the presense of algæ which can build up. This problem is particularly acute in the pipework between the filter and the monitor because of the small sample flow. Small bore tubing is essential, e.g. 6 mm i.d.

> **Note.** Sample pipework should be of flexible PVC.

Fig. 2.2 Sample Connections

2.8 Relay Contact Protection and Interference Suppression – Fig. 2.5

If the relays are used to switch loads on or off the relay contacts can become eroded due to arcing. Arcing also produces radio frequency interference (r.f.i.) which can cause instrument malfunctions and incorrect readings. To minimize the effects of r.f.i., arc suppression components are required; these are resistor/capacitor networks for a.c. applications, or diodes for d.c. applications. These components can be connected either across the load or directly across the relay contacts.

For **a.c. applications** the value of the resistor/capacitor network depends on the load current and inductance that is switched. Initially fit a 100R/0.022μF RC suppressor unit (part no. B9303) as shown in Fig. 2.5A. If the instrument malfunctions the value of the RC network is too low for suppression and an alternative value must be used. If the correct RC suppressor unit cannot be obtained, contact the manufacturer of the switched device for details of the RC unit required.

For **d.c. applications** fit a diode as shown in Fig. 2.5B. For general applications use an alternative IN5406 type (600V peak inverse voltage at 3A – part no. B7363).

> **Note.** For reliable switching the minimum voltage must be greater than 12V and the minimum current greater than 100mA.

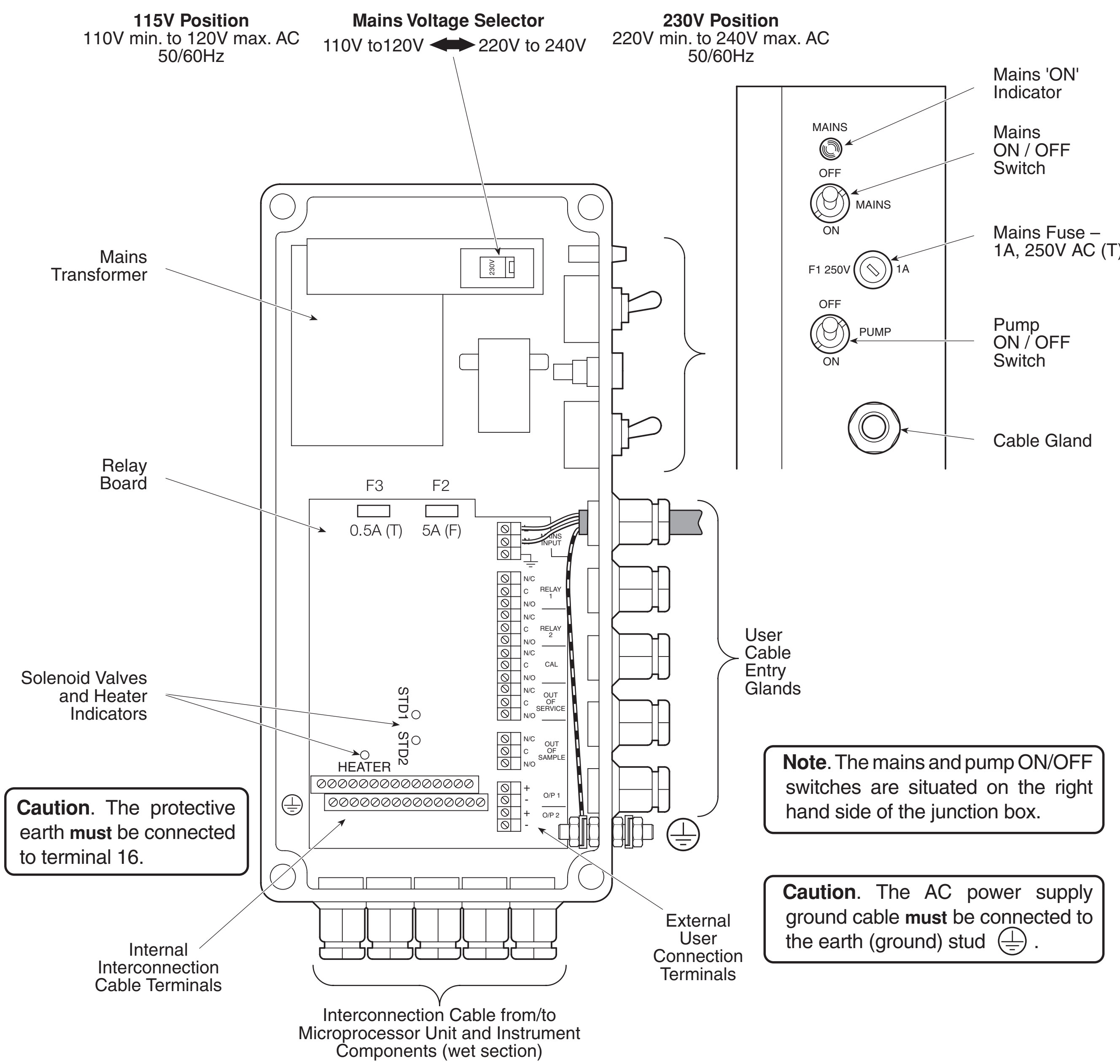


Fig. 2.3 Location of User Junction Box Components

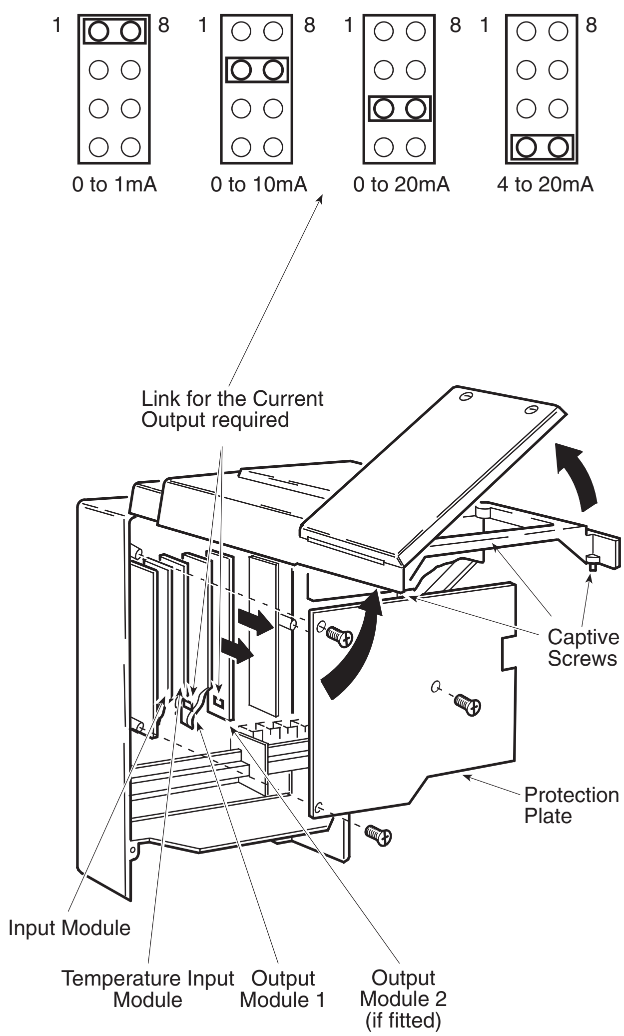


Fig. 2.4 Selecting The Current Output Range

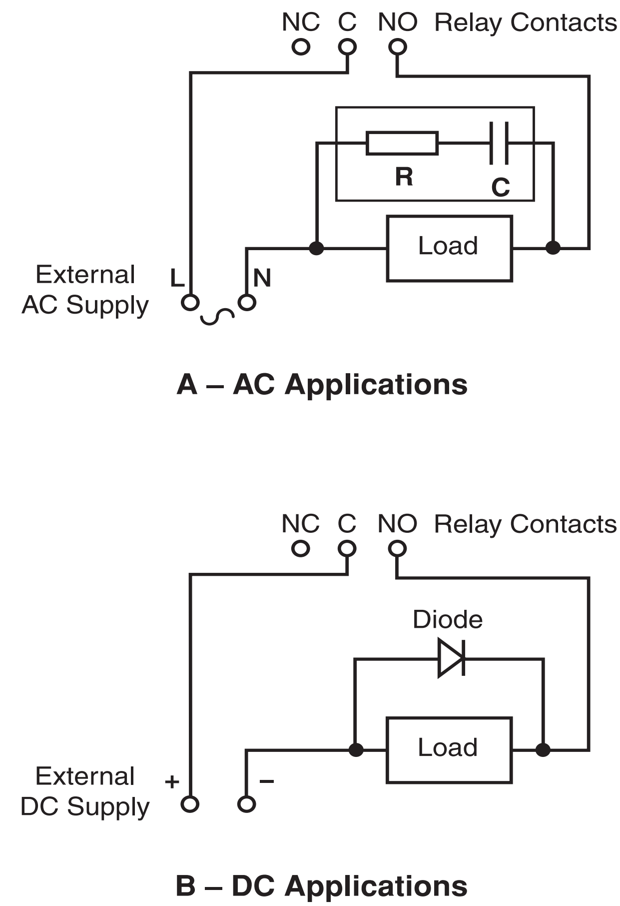


Fig. 2.5 Relay Contact Protection

3 SETTING UP

Note. Before proceeding any further, ensure that all switches are set to OFF on the right hand side of the electronics unit – see Fig. 2.3.

a) Ensure that all external electrical and plumbing connections have been made correctly.

b) Fill the guard tubes with soda lime crystals (self-indicating). The guard tubes clip onto the rear face of the enclosure and breather tubes pass through grommeted holes and then to the standard solution bottles.

c) Fill reagent and standard solution bottles and connect them the the monitor. (See Section 8.1 for details of these solutions.)

d) Assemble and fit the probe according to the instructions in Sections 8.2.5 and 8.2.6.

e) Connect the electrical supply and switch on.

Note. The temperature controlled block requires up to half an hour to reach the normal control temperature. During this time, 'Temp. Control Error' is indicated on the display. Any calibrations are prevented by the microprocessor during this time.

f) Verify that there is an adequate supply of sample to the monitor constant head unit.

g) Fit the pump platen on the peristaltic pumps (see Section 8.2.7) and switch the pumps on with the switch on the side of the monitor. Note that the peristaltic pumps rotate, and check that sample and reagents are being drawn into the monitor by observing the progress of any small bubbles present in the inlet tubes.

h) Run the monitor for at least one hour to allow the temperature to stabilize, solutions to be pumped into the system and to purge the air from the pipework. Check for any leaks around the pipe connections and rectify as necessary.

i) If the monitor exhibits good stability, i.e. ±2% of reading, carry out a calibration – see Programming Page.

j) Check the condition of the sample filter and replace it if necessary. Ensure that new filters are fitted correctly by taking note of the flow directions indicated on the filter bodies.

4 LIQUID HANDLING SECTION

4.1 Principle of Operation

Neither bicarbonate ion content nor total carbon dioxide can be measured directly in an untreated sample, since the probe can respond only to free carbon dioxide gas. The bicarbonate ions must therefore be converted to free carbon dioxide by adjusting the pH of the sample solution to a value less than 3.4. This is effected by addition of a sulphuric acid solution to the sample before it is presented to the probe.

The gas sensing probe in the 8237 Monitor contains a glass pH electrode whose pH sensitive glass membrane forms a slightly convex tip and a robust long-life reference electrode. The two electrodes are combined into a single assembly and are connected as a pH measuring pair through an internal reservoir of filling solution containing bicarbonate ions.

The filling solution is 0.05M sodium bicarbonate saturated with sodium chloride and is separated from the sample by a gas-permeable hydrophobic membrane fitted in the tip of the probe. Sample is caused to flow past the probe membrane, whereupon the partial pressures of carbon dioxide gas in the two solutions on either side of the membrane equilibrate, transferring gas across the membrane.

At equilibrium, the concentration of carbon dioxide in the thin film of filling solution between the probe membrane and the glass electrode membrane equals that in the sample. The resultant change in pH value of the thin film is measured by the pH electrode pair which thus develops an output potential related to the carbon dioxide concentration in the sample. Like most ion-selective electrodes, the 8237 Probe produces an output which is logarithmic with respect to concentration.

Under typical circumstances, with appropriate standard solutions and calibration frequencies, accuracies better than ±5% of reading or $0.1 mgl^{-1}$ whichever is the greater, can be achieved.

4.2 General Operation – Fig. 4.1

The sequence of events is:

a) The sample enters the constant head unit from below and any excess is allowed to overflow to drain.
The constant head unit is fitted with a float switch to signal an 'Out of Sample' condition. This switch is used by the monitor to initiate the 'Out of Sample' alarm.

b) From the bottom of the constant head unit the sample is drawn through the normally open ports of the solenoid valves SV1 and SV2 by one channel of the peristaltic pump.

c) The sulfuric acid reagent is drawn through another channel of the peristaltic pump, and is then mixed with the sample. The tube diameters are arranged so as to obtain the correct ratio of sample and reagent.

d) The acidified sample is allowed to react under constant temperature conditions to release free carbon dioxide gas.

e) The sample then enters a flow-through cap at the end of the gas sensing probe where the measurement takes place.

f) The sample then flows to waste via the contaminated drain connection.

g) During a calibration, the monitor introduces two calibration solutions sequentially in place of the sample by means of the solenoid valves SV1 and SV2.

To provide remote indication of a calibration in progress, the calibration relay is activated.

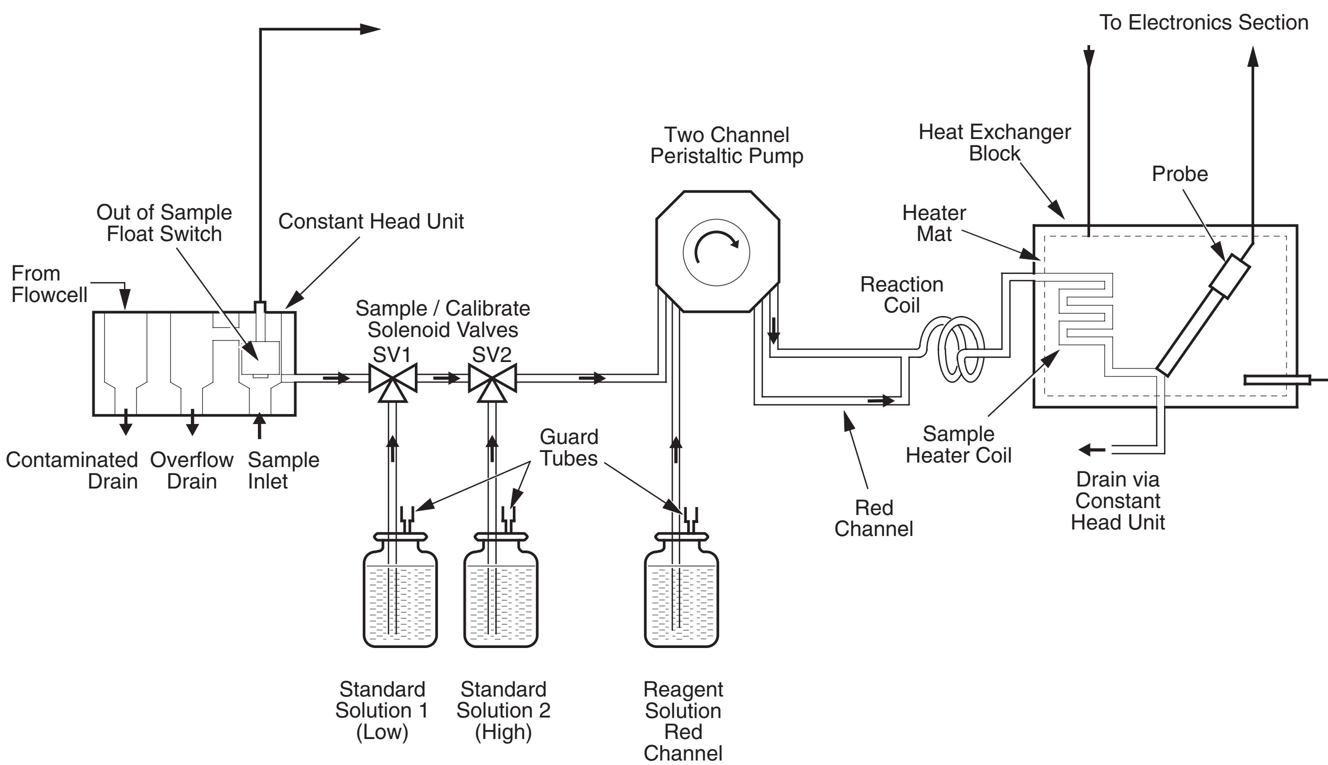


Fig. 4.1 Flow Schematic

5 ELECTRONICS SECTION

5.1 Electronic Layout – Fig. 5.1

The electronic section comprises two separate sections:

- The User Junction Box at the top right hand side.
- The Microprocessor Unit at the top left hand side.

5.2 User Junction Box

The User Junction Box contains the relays for the heater, solenoid valves and alarms, and all the user external connection terminals, with the exception of the serial interface (if fitted).

Once installed there should be no need to remove the junction box cover on a regular basis. However, to assist in any fault finding procedure, there are l.e.d.s on the p.c.b. to indicate if the relays and heater are being energised.

Switches for the mains and pump/heater are situated on the right hand side of the junction box, together with a mains indication lamp and mains fuse – see Fig. 2.3.

Two additional fuses (F2 and F3) are located within the junction box. These are connected in the 24V AC circuits.

5.3 Microprocessor Unit

The Microprocessor Unit contains the analogue input processing, microprocessor, alarm and current output generation, and (if fitted) the serial interface output.

The programme controls, digital and dot-matrix displays, alarm indication and status l.e.d.s are all mounted on the front panel of the microprocessor unit.

5.4 Front Panel Controls – Fig. 5.2

The programme controls comprise eight tactile membrane switches. These switches are situated behind a hinged door below the display, access is via a screwdriver-operated catch. In normal operation the switches are used to view the measured ion concentration value, initiate a manual calibration, or to activate the 'alarm hold' facility.

When programming, the switches are used to sequence through a programming procedure as detailed. The procedure is set out in programming pages for Input, Current Output, Alarms, Real Time Clock and Monitor Calibration. Each programme page contains the programme functions, the values or parameters of which are programmable.

Switch functions are as follows:

Mode Used for viewing the CO2-concentration, electrode mV output, block control temperature, sensor slope, date, time, the day of the next calibration and the date of the last calibration.

Cal Used to enable or disable the automatic calibrations, enter the standard solution values and manually initiate a calibration sequence. Operating 'Cal' during a calibration aborts the sequence and returns to normal operation.

Hold Used to inhibit any change in the alarm relay/l.e.d. status and the start of any auto calibration. The feature is used during maintenance ('Hold' l.e.d. illuminated).

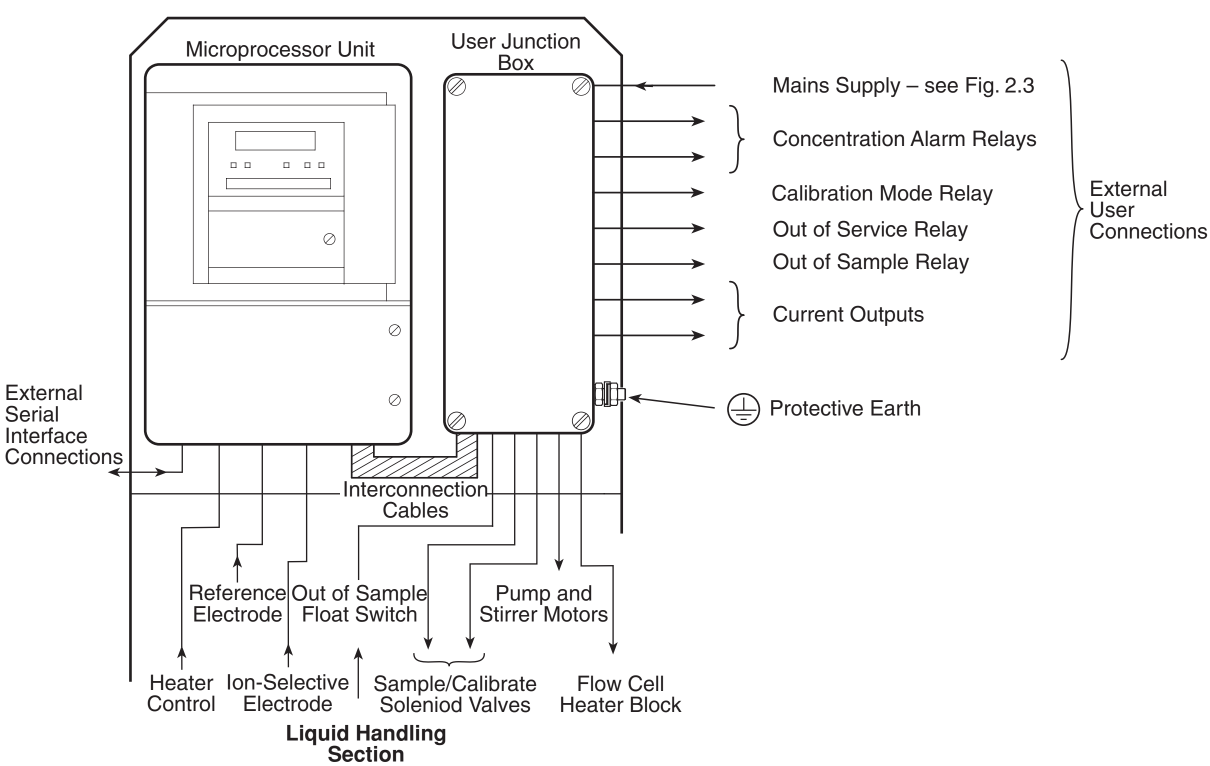


Fig. 5.1 Electrical Connections Layout

> **Note.** If the 'Hold' facility is inadvertently left switched-in, it is automatically cancelled after a period of approximately 3 hours has elapsed.

Enter Used for storing the programmed function parameters and values in the instrument's nonvolatile memory.

> **Note.** The instrument responds instantly to any programme change but the new value is lost in the event of a power interruption if it has not been 'Entered'.

Parameter Advance – used for selecting a particular parameter from a programme page.

▲ ▼ Used for increasing or decreasing a parameter value or stepping up or down through a selection of parameters applicable to a particular function.

> **Note.** Continued pressure on the 'Raise' or 'Lower' switches causes the rate of change of the displayed value to increase. To make small adjustments, operate the switches momentarily.

Page Advance – used, via the security code, for selection of individual programme pages.

5.5 Displays – Fig. 5.2

Two blue vacuum fluorescent displays are provided:

a) The upper is a 5-digit 7-segment type display which indicates the measured variable.

b) The lower is a 20-character dot matrix type which provides user information during setting up and in normal operation.

5.6 L.E.D. Indication – Fig. 5.2

There are 5 l.e.d.s (indicators situated between the two displays) which provide information on the current status of the monitor. From left to right the indicators are as follows:

A1 or **A2** Used to indicate a concentration alarm state (either high or low). This indicator is used in association with an external alarm relay output.

Hold Used to indicate that the 'Hold' button has been operated.

Cal Indicates when a calibration sequence is taking place.

Fail Indicates that the monitor was unable to carry out a successful calibration.

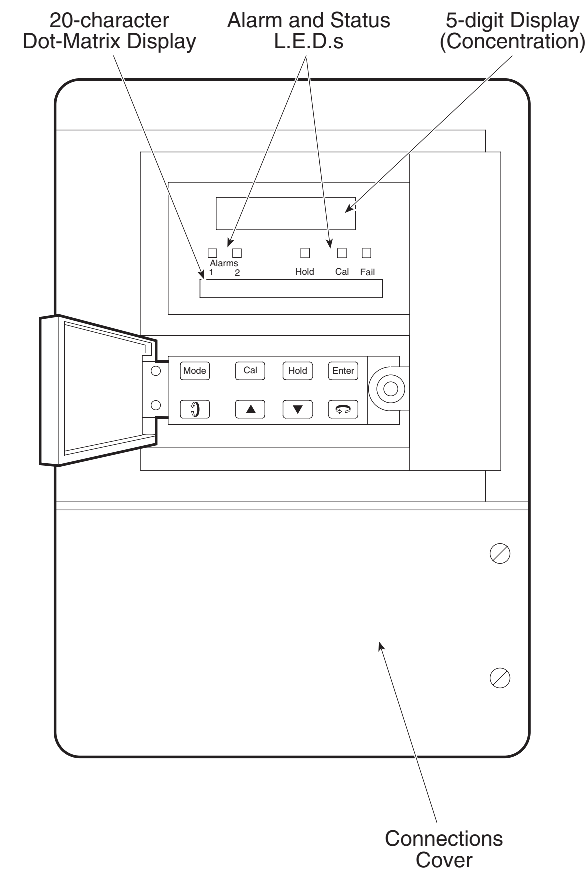
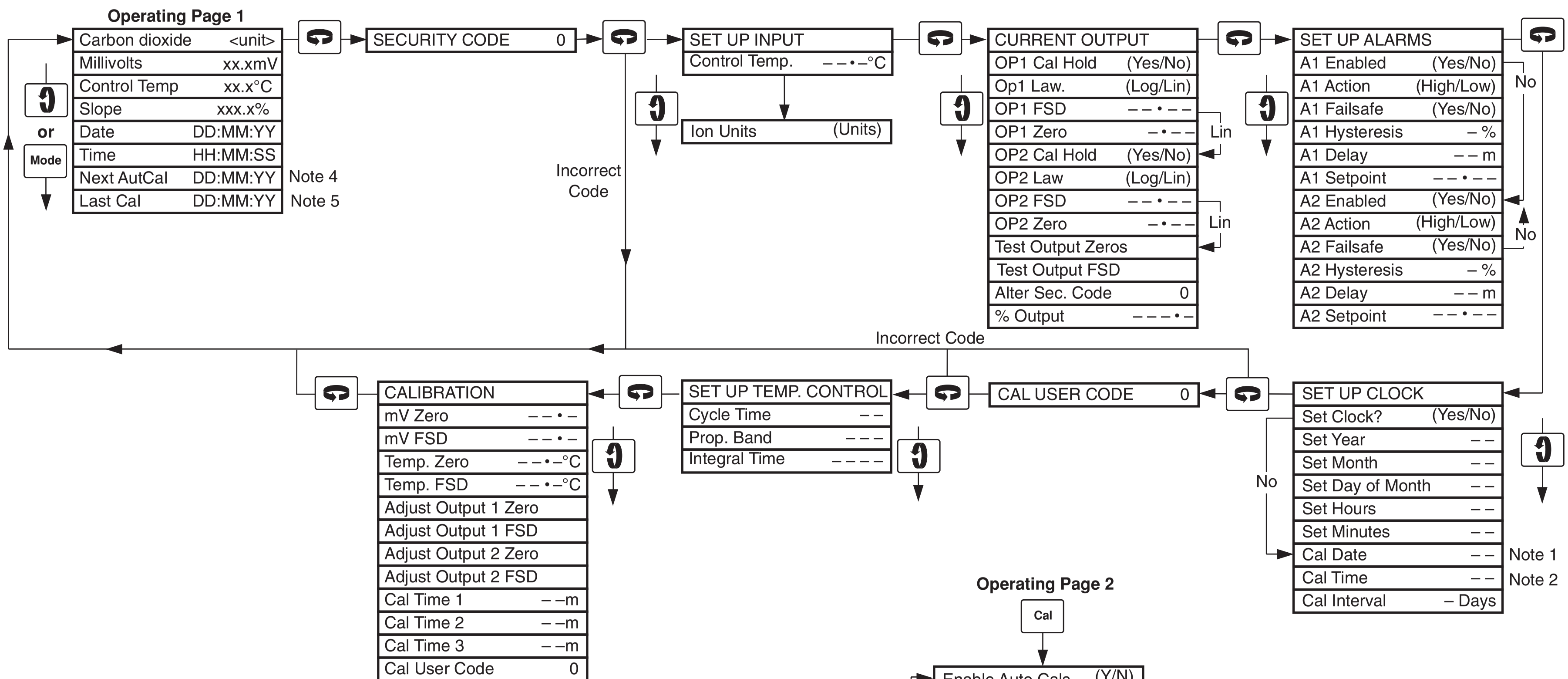
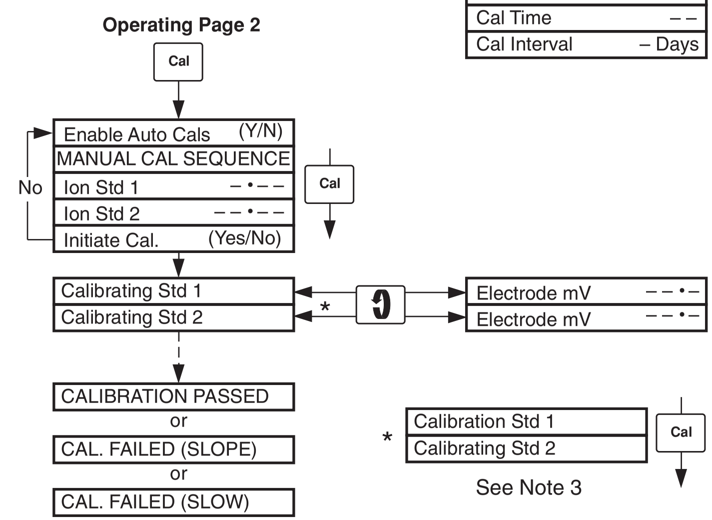


Fig. 5.2 Location of Controls, Displays and L.E.D.s





Note 1.
'Cal Date' is the date when the first calibration is due and is updated every time an automatic calibration is carried out, i.e 'Cal Date' = autocal date + 'Cal Interval'

Note 2.
'Cal Time' is the time of the day when the autocalibration is required.

Note 3.
Operating [Cal] during a calibration aborts the sequence and returns the system to normal operation.

Note 4.
'Next AutCal' is the date of the last automatic calibration + the calibration interval 'Cal interval'. If the instrument has been switched off, the next 'AutCal' is the present date + the 'Cal interval'. If the 'AutCal' is switched off, 'OFF' is displayed on the 20-character display.

Note 5.
'Last Cal' is the date of the last automatic or manual calibration.

Fig. 6.1 Overall Programming Chart

6.1 Normal Operation

In normal operation (Operating Page 1) the lower, dot matrix, display gives indication of the units of measurement, millivolt value, sensor slope and time. Selection is made using the [⟳] switch. Operation of the [Cal] switch gives access to a second Operating Page (Operating Page 2) in which the standard solution values can be set and a manual calibration can be initiated. Either page can be selected at any time by using the [Mode] or [Cal] switches.

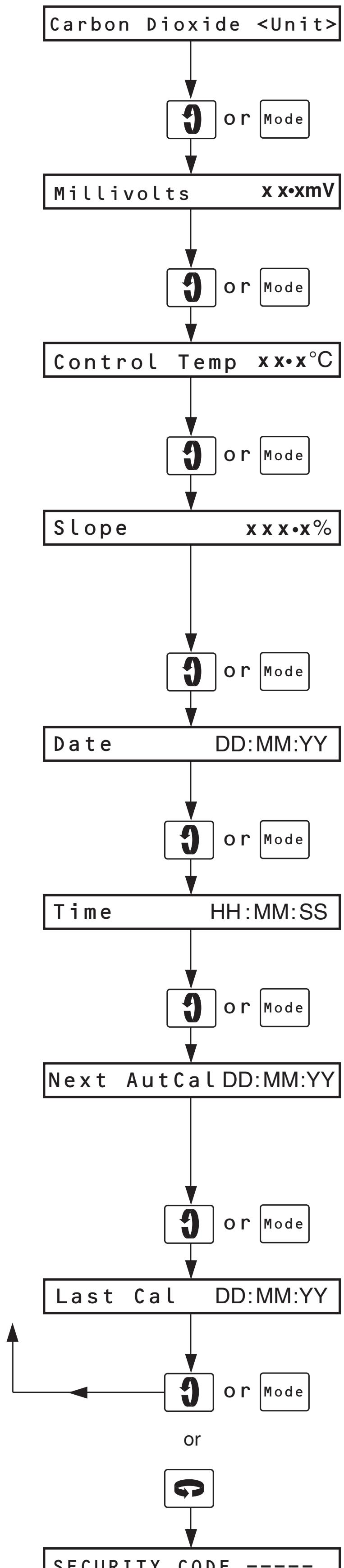
6.2 Programming Pages

Operation of the [⟲] switch enables a series of 'programming' pages to be displayed. Unauthorised entries to this page are inhibited by a 5-digit security code which is displayed immediately after the page header.

In the programming pages, displayed values indicated 'xxxxx' are for viewing only and cannot be altered by the operator. Displayed values indicated '– – –' can be altered using the [▲] and [▼] switches. When the desired reading is displayed, operate the [Enter] switch. The l.e.d.s flash momentarily, to indicate that the value has been stored in the nonvolatile memory. Although the instrument operates satisfactorily if the [Enter] switch is not operated, in the event of power interruption, the new values are lost. When power is reapplied, the previously 'entered' values are restored. If previously programmed values are to be viewed only, it is unnecessary to operate the [Enter] switch.

6.2.1 Operating Page 1

The values displayed in Operating Page 1 are for viewing only and cannot be altered in this page.



Measurement Units
The measurement units are displayed, e.g. Carbon dioxide mg l[-1].

Advance to next parameter.

Sensor Output
The sensor output is displayed in millivolts.

Advance to next parameter.

Control Temperature
The heater block control temperature is displayed in degrees Celsius.

Advance to next parameter.

Slope Check Value
The slope value should be between 70 and 110%. If the value is outside these limits check the electrode.

Advance to next parameter.

Date
The date is displayed.

Advance to next parameter.

Time
The time is displayed.

Advance to next parameter.

Next Calibration Date
The date when the next automatic calibration is to be carried out is displayed. If the automatic calibration is disabled, 'OFF' is displayed in place of the date.

Advance to next parameter.

Last Calibration Date
The date of the last automatic or manual calibration is displayed.

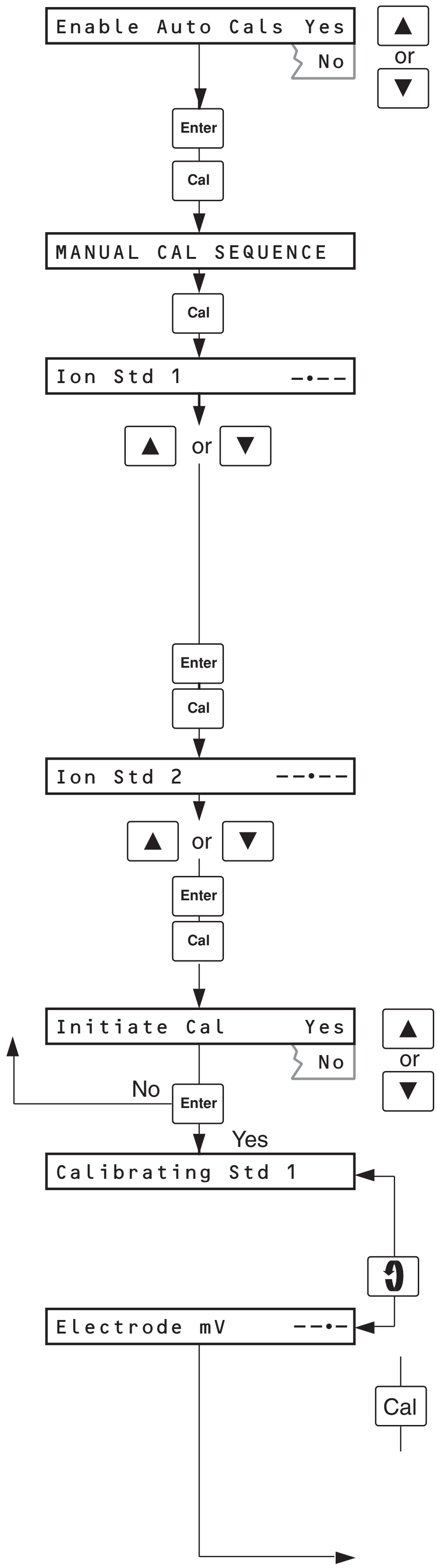
Return to top of **Operating Page.**

or

Advance to **Security Page** (Section 6.2.3).

6.2.2 Operating Page 2

To gain access to the Calibration Page (Operating Page 2), operate the Cal switch.



Enable Automatic Calibrations
Select 'Yes' to enable or 'No' to disable the automatic calibrations.

Store.

Advance to next parameter.

Page header.

Advance to next parameter.

Ion Standard 1
Set the value of the 'Low' standard solution (Std 1).
Because of the instability of such solutions, low value carbon dioxide standard solutions should be avoided. It is not possible to programme a carbon dioxide standard solution of lower concentration than 4mg l^{-1} CO_2 on the Model 8237 monitor. Lower concentrations of CO_2 solutions can be prepared with care, but are of uncertain stability when stored in plastic bottles even with guard tube protection from atmospheric CO_2, making them unsuitable for long term use with the monitor.

Store.

Advance to next parameter.

Ion Standard 2

Set the value of the 'High' standard solution (Std 2). The concentrations of the two standard solutions must differ from each other by a factor of at least four.

Store.

Advance to next parameter.

Initiate Calibration (manual)
Select 'Yes' to carry out a manual calibration or 'No' to return to the top of the page.

Enter must be pressed to initiate a manual calibration.

Calibrating Standard 1
The upper display shows the CO_2 concentration value. The display remains until a stable output is obtained from the sensor.

Toggle between the two displays.

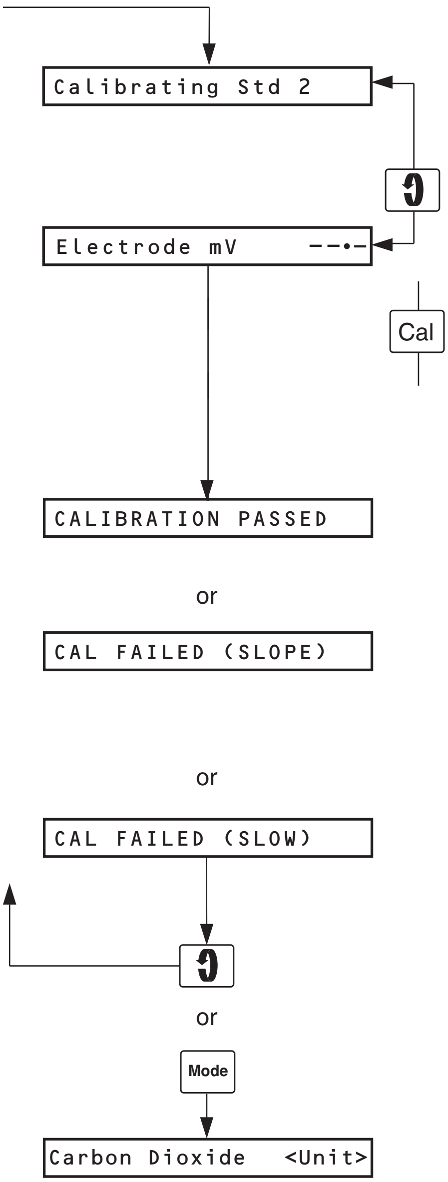
Electrode Millivolts
The sensor output can also be displayed during calibration

Note. Pressing Cal during a calibration aborts the sequence and returns to normal operation.

When a stable sensor output is detected the display automatically advances to the next parameter.

Continued on next page.

…6.2.2 Operating Page 2



Calibrating Standard 2
The upper display shows the CO_2 concentration value. The display remains until a stable output is obtained from the sensor.

Toggle between the two displays.

Electrode Millivolts
The sensor output can also be displayed during calibration

Note. Pressing Cal during a calibration aborts the sequence and returns to normal operation.

When a stable sensor output is detected the display automatically advances to the next parameter.

Calibration Passed
A satisfactory calibration has been carried out.

or

Calibration Failed (slope)
The monitor was unable to obtain an adequate slope value during calibration. The slope value required is 70 to 110%.

or

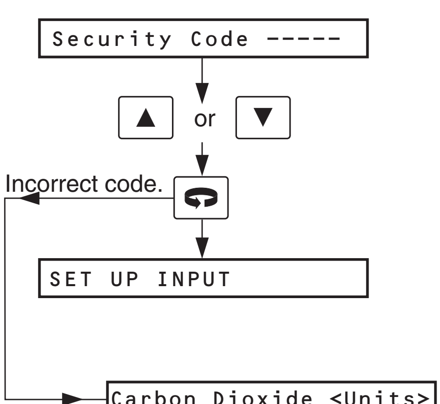
Calibration Failed (slow)
The monitor was unable to obtain a stable output from the sensor during calibration.

Return to top of **Operating Page 2.**

Return to **Operating Page 1.**

6.2.3 Security Code Page

A security code is required to gain access to all subsequent programming pages. The code is preset at the factory to '0' but can be changed if required in the Current Output Page – see Section 6.2.5.



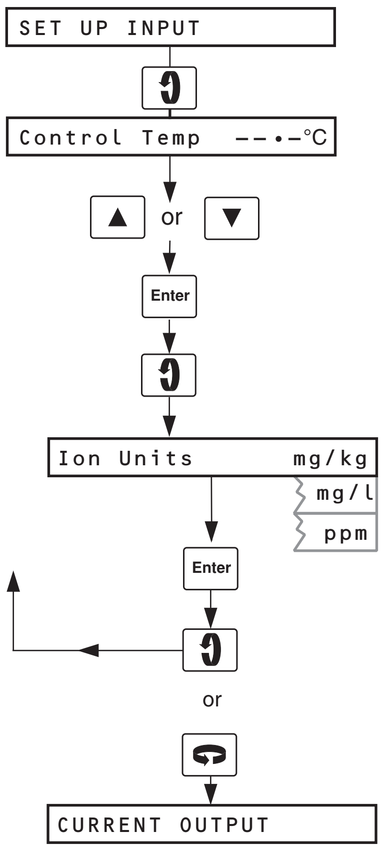
Security Code

Set the correct security code.

Advance to the first of the programming pages – **Set Up Input Page.**

Return to **Operating Page 1.**

6.2.4 Set Up Input Page



Page header.

Advance to next parameter.

Control Temperature

Set the required block control temperature within the range 30 to 45°C in 0.1°C increments

Store.

Advance to next parameter.

▲ or ▼ **Ion Units**
Select the required display units for CO_2 concentration.

Store.

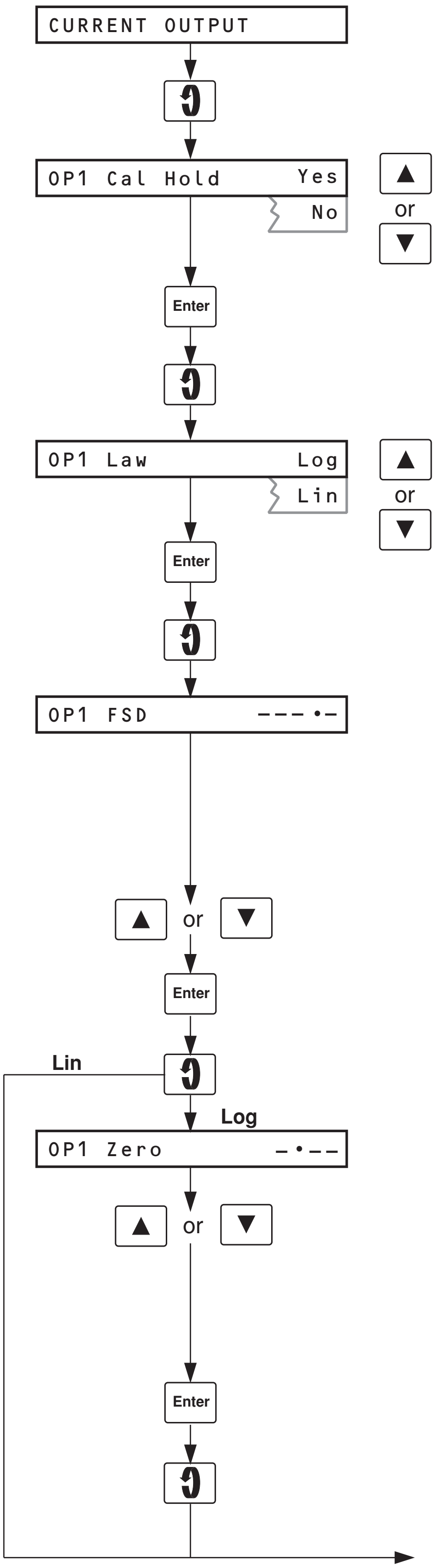
Return to top of **Set Up Input Page.**

or

Advance to **Current Output Page.**

6.2.5 Current Output Page

The current output is assigned to the CO_2 concentration but is only operative if the relevant output modules are fitted – see Fig. 2.4.



Page header.

Advance to next parameter.

Output 1 Calibration Hold
Current Output 1 can be held during calibration, if required. Select 'YES' or 'NO'.

Store.

Advance to next parameter.

Output 1 Law
Current Output 1 can be either logarithmic or linear. Select 'Log' or 'Lin'.

Store.

Advance to next parameter.

Output 1 Full Scale
Current Output 1 full scale range: 1 to 1000mgl^{-1} CO_2, i.e. minimum span 1 decade.

Set the required concentration value for Current Output 1 full scale.

Store.

Advance to next parameter.

Output 1 Zero

Set the required concentration value for Current Output 1 zero. Default is $^{1}/_{10}$ of FSD.

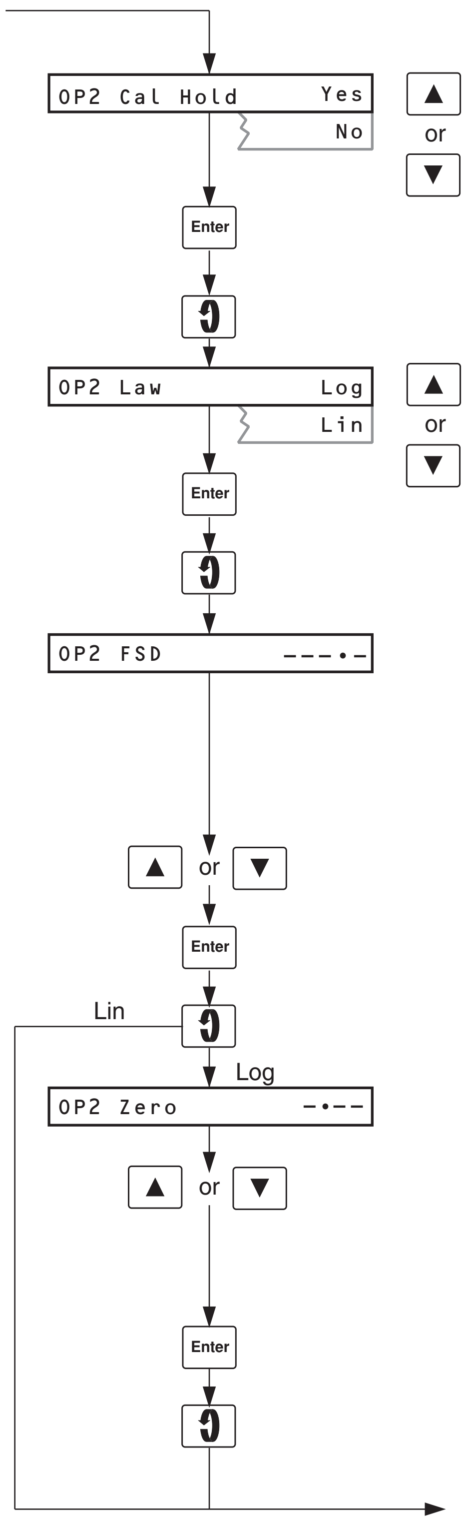
Note. If the output 1 Law is linear (Lin), this parameter is omitted and the zero current output is automatically set to '0'.

Store.

Advance to next parameter.

Continued on next page.

6.2.5 Current Output Page



Continued from previous page.

Output 2 Calibration Hold
Current Output 2 can be held during calibration, if required. Select 'YES' or 'NO'.

Store.

Advance to next parameter.

Output 2 Law
Current Output 2 can be either logarithmic or linear. Select 'Log' or 'Lin'.

Store.

Advance to next parameter.

Output 2 Full Scale
Current Output 2 full scale range: 1 to 1000mgl^{-1} CO_2, i.e. minimum span 1 decade.

Set the required concentration value for Current Output 2 full scale.

Store.

Advance to next parameter.

Output 2 Zero

Set the required concentration value for Current Output 2 zero. Default is $^1/_{10}$ of FSD.

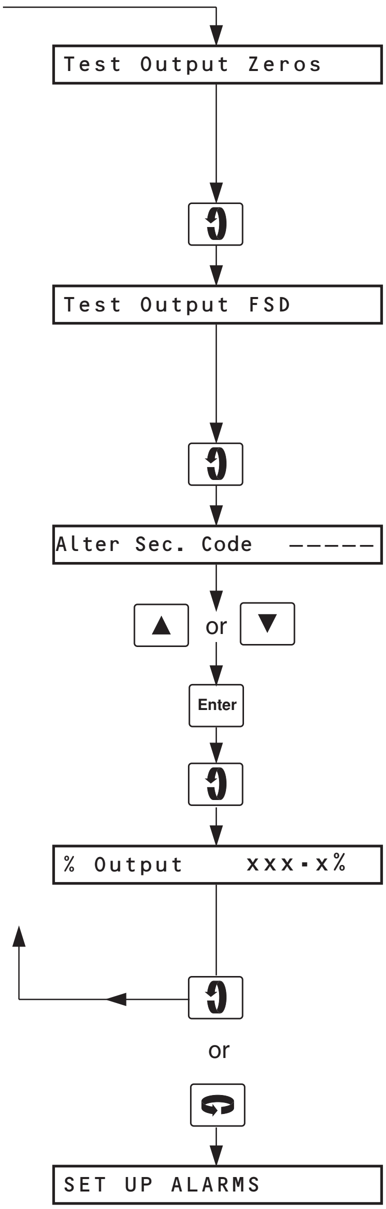
Note. If the Output 2 Law is linear (Lin), this parameter is omitted and the zero current output is automatically set to '0'.

Store.

Advance to next parameter.

Continued on next page.

…6.2.5 Current Output Page



Test Current Output Zeros
The instrument automatically transmits a current output zero test signal on both outputs.

Example – For a 4 to 20mA current output range, 4mA is transmitted.

Advance to next parameter.

Test Current Output Full Scale
The instrument automatically transmits a current output full scale test signal on both outputs.

Example – For a 4 to 20mA current output range, 20mA is transmitted.

Advance to next parameter.

Alter Security Code

Set the Security Code required, between 0 and 19999. This value must then be entered again to access the secure parameters from Operating Page 1.

Store.

Advance to next parameter.

Proportional Output Percentage (to heater)
Used as a diagnostic check to indicate the proportionally controlled current output (%) to the heater.

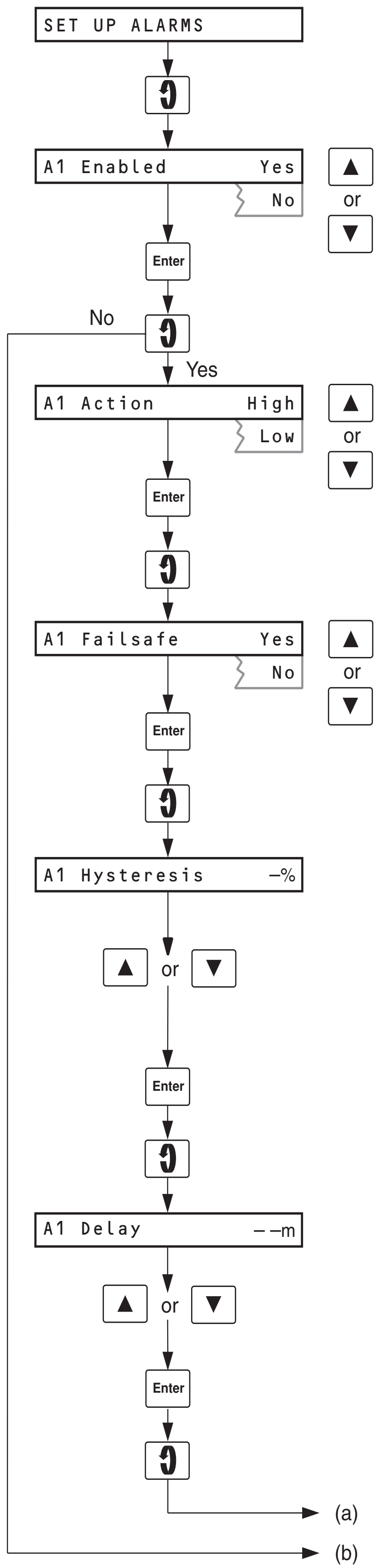
Return to top of **Current Output Page.**

or

Advance to **Set Up Alarms Page.**

6.2.6 Set Up Alarms Page

Alarm l.e.d. indication and relay output can be assigned either to the CO_2 concentration or switched off.



Page header.

Advance to next parameter.

Alarm A1 Enable
Select 'YES' to enable or 'NO' to disable.

Store.

Advance to next parameter.

Alarm A1 Action
Select the alarm action required, 'High' or 'Low' – see Table 6.1.

Store.

Advance to next parameter.

Alarm A1 Failsafe
If failsafe action is required select 'Yes', otherwise select 'No' – see Table 6.1.

Store.

Advance to next parameter.

Alarm A1 Hysteresis
A differential set point can be set as a percentage of the set point value. The differential setting operates about the set point.

Example – A 5% differential setting operates 2.5% above and below the setpoint.

Select the differential required, between 0 and 5% in 1 % increments.

Store.

Advance to next parameter.

Alarm A1 Delay
If required, relay actuation and alarm l.e.d. indication can be delayed in the event of an alarm condition. If the alarm condition clears within the programmed delay time, the alarm function is not activated and the delay time is reset.

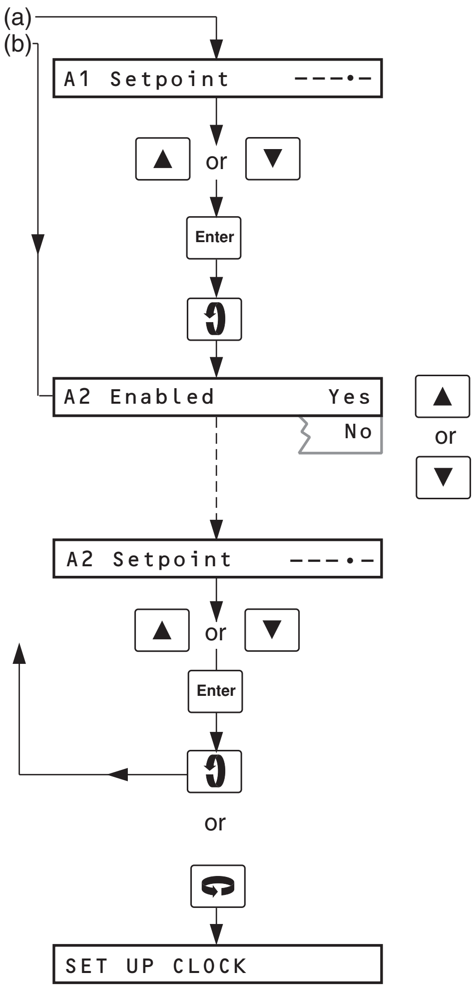
Set the required delay time between 0 and 60 minutes in 1 minute increments.

Store.

Advance to next parameter.

Continued on next page.

…6.2.6 Set Up Alarms Page



A1 Setpoint

Set the required setpoint value.

Store.

Advance to next parameter.

A2 Enabled
Repeat the programming procedures as for Alarm Relay 1.

A2 Setpoint

Set the required set point value.

Store

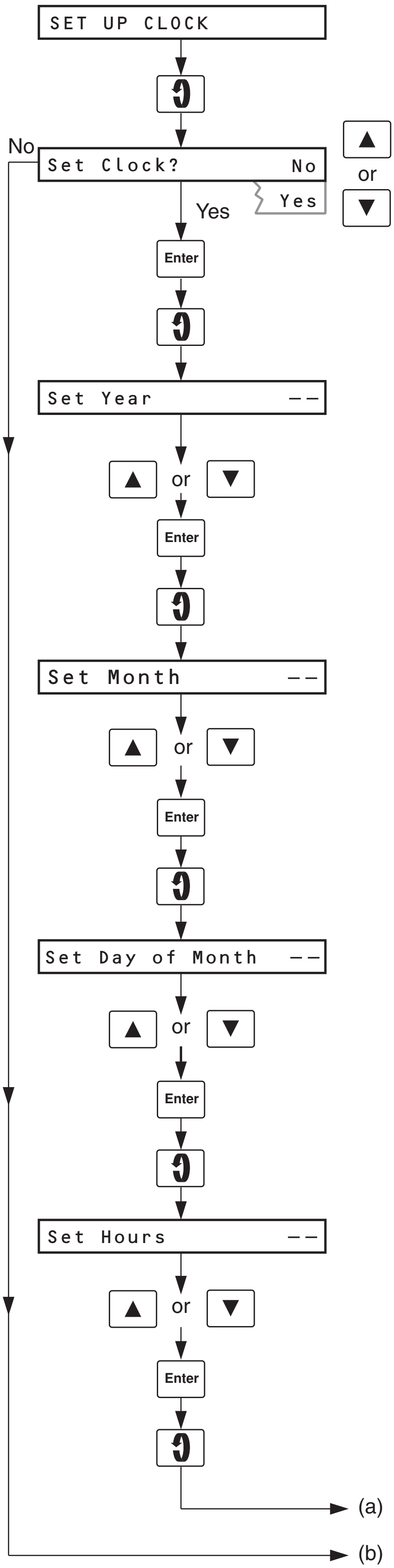
Return to top of **Set Up Alarms Page**.

or

Advance to **Set Up Clock Page**.

Action	Failsafe	Measured Value	Relay Status	L.E.D. Indication
High	YES	Above Setpoint	De-energised	Flashing
		Below Setpoint	Energised	Off
High	NO	Above Setpoint	Energised	Flashing
		Below Setpoint	De-energised	Off
Low	YES	Above Setpoint	Energised	Off
		Below Setpoint	De-energised	Flashing
Low	NO	Above Setpoint	De-energised	Off
		Below Setpoint	Energised	Flashing

6.2.7 Set Up Clock Page



Page header.

Advance to next parameter.

Set Up Real Time Clock
Select 'Yes' to set up the clock, otherwise select 'No'.

Store.

Advance to next parameter.

Set Year

Set the appropriate year.

Store.

Advance to next parameter.

Set Month

Set the appropriate month.

Store.

Advance to next parameter.

Set Day

Set the appropriate day of the month.

Store.

Advance to next parameter.

Set Hours

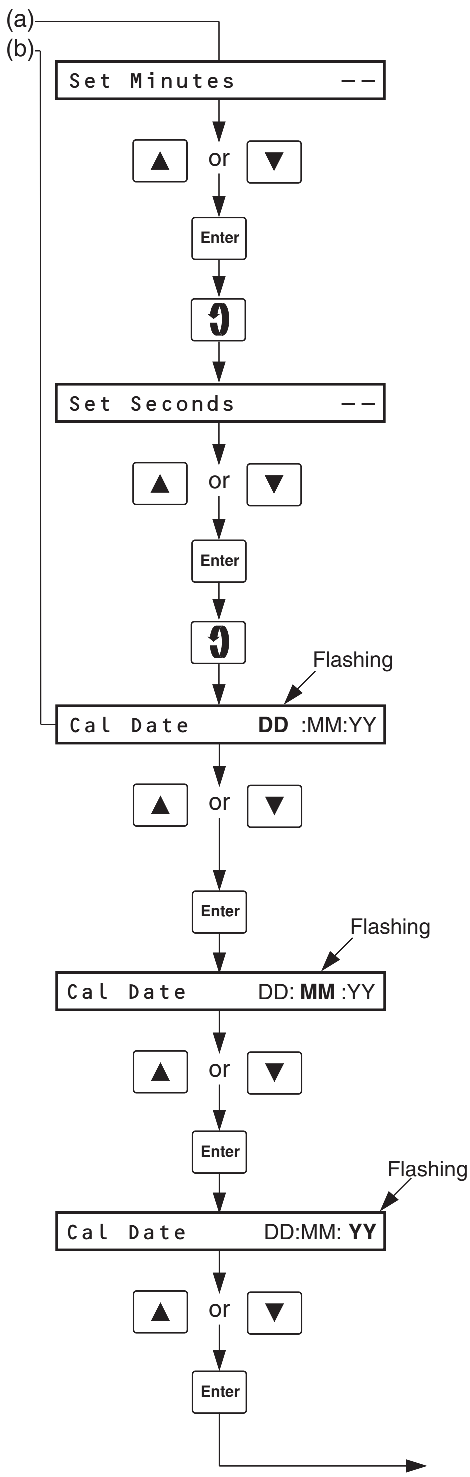
Set the appropriate hour – (24 hour clock).

Store.

Advance to next parameter.

Continued on next page.

…6.2.7 Set Up Clock Page



Set Minutes

Set the appropriate minutes.

Store.

Advance to next parameter.

Set Seconds

Set the appropriate seconds.

Store.

Advance to next parameter.

Calibration Date (day of the month)

Set the day of the month when the first automatic calibration is to be carried out.

Store and advance to next parameter.

Calibration Date (month)

Set the month when the first automatic calibration is to be carried out.

Store and advance to next parameter.

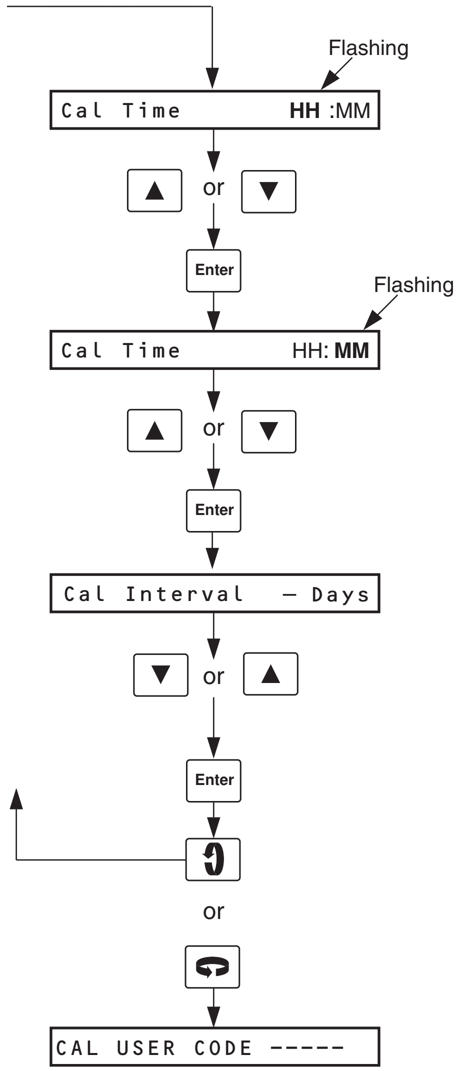
Calibration Date (year)

Set the year when the first automatic calibration is to be carried out.

Store and advance to next parameter.

Continued on next page.

6.2.7 Set Up Clock Page



Continued from previous page.

Calibration Time (hour – 24 hour clock)

Set the hour of the day when the first automatic calibration is to be carried out.

Store and advance to next parameter.

Calibration Time (minutes)

Set the minute of the hour when the first automatic calibration is to be carried out.

Store and advance to next parameter.

Calibration Interval

Set the calibration interval required between automatic calibrations, starting from the calibration date (6 hours, 12 hours or 1 to 7 days in 1 day increments).

Store.

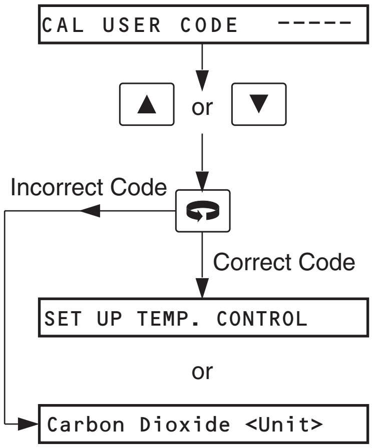
Return to top of **Set Up Clock Page**.

or

Advance to **Calibration User Code Page**.

6.2.8 Calibration User Code Page

The calibration user code is required to gain access to the Set Up Temperature Control and Calibration Pages. The access code can be altered in the Calibration Page, if required – see Section 6.2.11.



Calibration User Code

Set the correct user code.

Advance to next programming page.

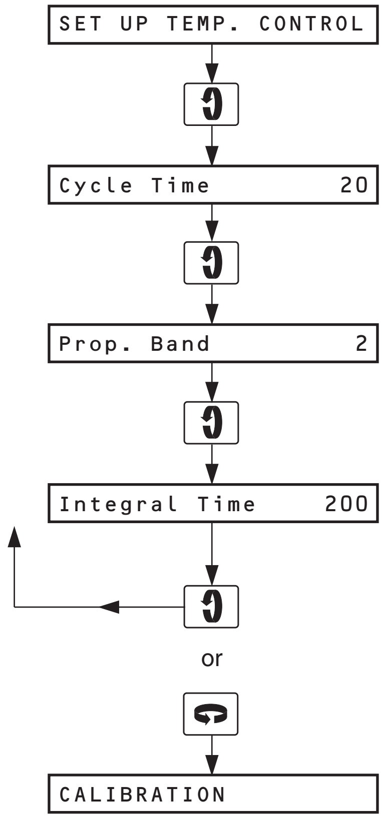
Set Up Temperature Control Page.

or

Return to **Operating Page 1.**

6.2.9 Set Up Temperature Control Page

The parameters within this page are factory preset and should not require any adjustment.



Page header.

Advance to next parameter.

Cycle Time
The cycle time is adjustable between 5 and 60 seconds in 1 second increments.

Advance to next parameter.

Proportional Band
The proportional band is adjustable between 1 and 500% in 1% increments.

Advance to next parameter.

Integral Action Time
The integral action time is adjustable between 1 and 1800 seconds in 1 second increments (1801 = 'OFF').

Return to top of **Set Up Temperature Control Page**.

or

Advance to **Calibration Page**.

6.2.10 Electrical Calibration

Electrical calibration is carried out prior to despatch and should require no subsequent adjustment. However, if measurements become suspect or if the contents of the 'CALIBRATION' page are inadvertently altered, recalibrate as detailed in the following sections.

> **Note.**
> The calibration procedure involves modifying part of the original programme but, **provided that changed values are not stored using the 'Enter' switch**, the original programme, which was stored in the nonvolatile memory, can easily be reinstated at the end of calibration by switching off the instrument and switch on again.

If there is thought to be any risk that the original programme could be lost, it is advisable to make a note of the normal parameter settings. If the changed programme values are inadvertently 'Entered', the instrument can be reprogrammed on completion of the calibration procedure.

Equipment Required

Millivolt source, range –400 to +400mV.

Electrode coaxial plug/lead assembly – supplied with monitor

Decade resistance box*, 0 to 1kΩ in 0.01Ω increments.

Digital milliammeter, 0 to 20mA – refer to Fig. 2.4 to identify the output range.

* Resistance boxes have an inherent residual resistance which may range from a few milliohms to one ohm. This value must be taken into account when simulating input levels, as must the overall tolerances of the resistors within the box.

Preparation

a) Switch off the supply and disconnect the temperature sensor leads from terminals 1, 2 and 3 in the Microprocessor Unit. Make the following connections:

   1 & 3 (temperature sensor) } decade box
   2 (temperature sensor) }

b) Insert the coaxial plug into the ISE socket above the flowcell and connect the millivolt source (inner +ve, outer –ve).

c) Connect the milliammeter in place of the appropriate current output connections in the junction box – see Section 2.6.

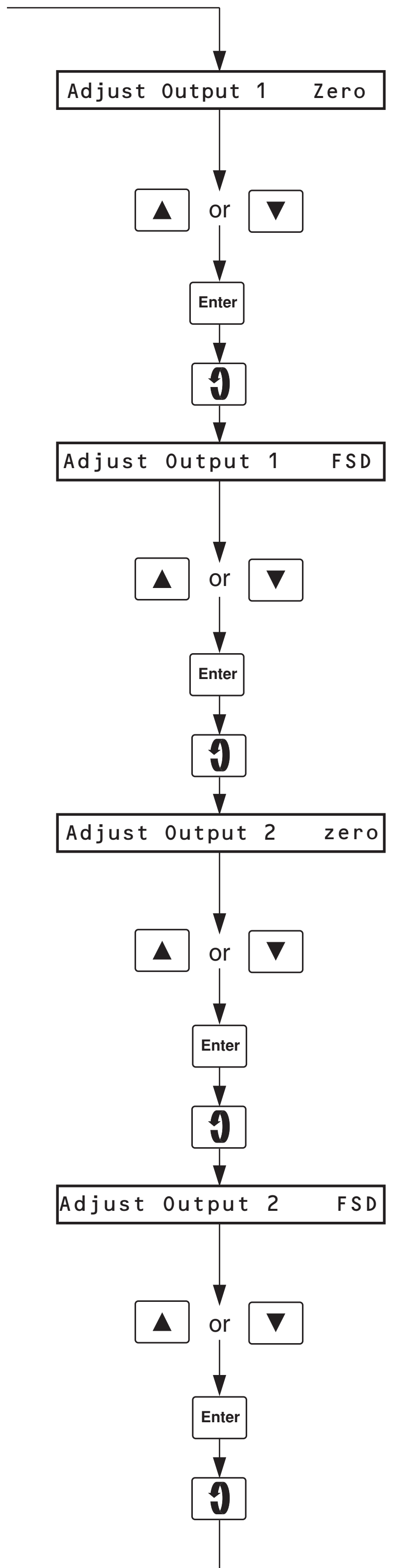
d) Switch on the supply and allow two minutes (30 minutes from cold) for the circuits to stabilise.

e) Select the appropriate **Cal User Code** to gain access to the programming pages – see Section 6.2.8

6.2.11 Electrical Calibration Page

CALIBRATION	Page header.
(advance key)	Advance to next parameter.
mV Zero ----	**Millivolt Input Zero** Set the millivolt source to –400mV.
▲ or ▼	Set the display to '–400'mV.
Enter	Store. New value is accepted only when input is stable.
(advance key)	Advance to next parameter.
mV FSD ---•-	**Millivolt Input Full Scale** Set the millivolt source to +400mV.
▲ or ▼	Set the display to '+400'mV.
Enter	Store. New value is accepted only when input is stable.
(advance key)	Advance to next parameter.
Temp. Zero ---•-°C	**Temperature Zero** Set the resistance box to 96.09Ω (resistive equivalent of –10°C).
▲ or ▼	Set the display to '–10°C'.
Enter	Store. New value is accepted only when input is stable.
(advance key)	Advance to next parameter.
Temp. FSD ---•-°C	**Temperature Full Scale** Set the resistance box to 142.29Ω (resistive equivalent of 110°C).
▲ or ▼	Set the display to '110°C'.
Enter	Store. New value is accepted only when input is stable.
(advance key)	Advance to next parameter.
→	Continued on next page.

6.2.11 Electrical Calibration Page



Continued from previous page.

Adjust Current Output 1 Zero
The monitor transmits a zero signal, e.g. for a 4 to 20mA output range, 4mA is transmitted.

Set the milliammeter reading to the current output 1 zero level, i.e. 0mA (zero-based ranges) or 4mA (4 to 20mA range).

Store.

Advance to next parameter.

Adjust Current Output 1 Full Scale
The monitor transmits a span signal, e.g. for a 4 to 20mA output range, 20mA is transmitted.

Set the milliammeter reading to the current output 1 full scale level, i.e. 1mA, 10mA or 20mA as applicable.

Store.

Advance to next parameter.

Adjust Current Output 2 Zero
The monitor transmits a zero signal, e.g. for a 4 to 20mA output range, 4mA is transmitted.

Set the milliammeter reading to the current output 2 zero level, i.e. 0mA (zero-based ranges) or 4mA (4 to 20mA range).

Store.

Advance to next parameter.

Adjust Current Output 2 Full Scale
The monitor transmits a span signal, e.g. for a 4 to 20mA output range, 20mA is transmitted.

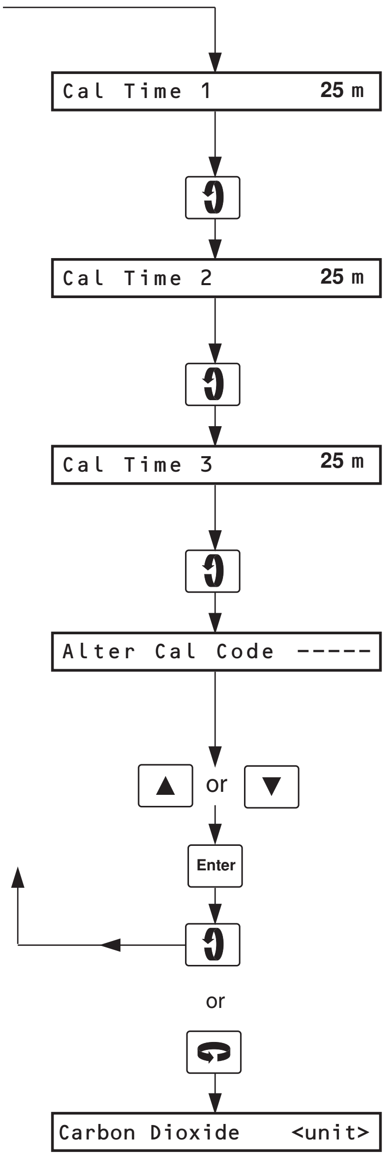
Set the milliammeter reading to the current output 2 full scale level, i.e. 1mA, 10mA or 20mA as applicable.

Store.

Advance to next parameter.

Continued on next page.

…6.2.11 Electrical Calibration Page



Continued from previous page.

Calibration Time 1
The displayed value is preset at the factory and must not be altered. See Table 7.1.

Advance to next parameter.

Calibration Time 2
The displayed value is preset at the factory and must not be altered. See Table 7.1.

Advance to next parameter.

Calibration Time 3
The displayed value is preset at the factory and must not be altered. See Table 7.1.

Advance to next parameter.

Alter Calibration Code
The calibration user code inhibits access to the **Set Up Temperature Control Page** and the **Calibration Page** – see Section 6.2.8.

Set a suitable user code, between 0 and 19999.

Store.

Return to top of **Electrical Calibration Page.**

or

Return to **Operating Page 1**.

7 CALIBRATION

7.1 Calibration Sequence

Calibration of the monitor is carried out by replacing the sample solution sequentially with two standard solutions of known concentration. This calibration sequence (see Table 7.1) can be initiated automatically at preset times, or manually on demand.

The sensor outputs obtained during calibration are used to calculate the calibration graph for the monitor and the accuracy of the standard solutions will, therefore, have a direct effect upon the overall accuracy of the monitor. Given accurate standards, it is clear that the best accuracy would be expected at the two calibration points. Ideally, the concentrations of the two standards should bracket the expected sample concentration closely, but the latter often varies quite widely. In practice, as when the long term stability of lower concentration standard solutions is uncertain, this ideal is not always achievable. For CO_2 monitoring, standards of 5 and 50ppm are recommended.

Note. The concentrations of the two standard solutions must differ from each other by a factor of at least four.

On initiation of the calibration sequence, either manual or automatic, the 'Cal' l.e.d. is illuminated and the Calibration Mode relay is energised. Two solenoid valves, SV1 and SV2 operate sequentially to shut off the sample and admit standard solutions of known concentration, one low and one high (STD1 and STD2), to the sample path.

Once a valve is energised, sufficient time (preset to suit the sensor response time) is allowed for the previous solution to be displaced, and for the sensor to respond to the new solution, before the sensor output is evaluated for stability by the microprocessor. When a stable output is achieved the next stage in the sequence is initiated.

After calibration the sensor outputs corresponding to the two standard solutions are used to calculate a new calibration graph for the monitor, thus compensating for any drift in sensor or liquid handling performance characteristics since the last calibration, and the new slope value can be displayed in Operating Page 1 (100% slope is the theoretical value).

If the values are within limits, 'CALIBRATION PASSED' is displayed.

'CAL FAILED (SLOPE)' is displayed if the slope value is outside acceptable limits and 'CAL FAILED (SLOW)' is displayed if the sensor output failed to stabilise within 15 minutes after the end of Cal Time 1 or Cal Time 2.

Activity	**Introduce STD1**	**Sensor Stabilises**	**Introduce STD2**	**Sensor Stabilises**	**Introduce Sample**	**Normal Operation**
Valve Open	SV1	SV1	SV2	SV2	None	None
Timing	Preset (Cal Time 1)	Variable *	Preset (Cal Time 2)	Variable *	Preset (Cal Time 3)	None

*15 min. max.

Table 6.1 Alarm Actions

8 MAINTENANCE

8.1 Chemical Solutions

The reagent and standard solutions described below are required to maintain the monitor in operation. Where possible, they should be freshly made and stored in plastic (e.g. polythene) bottles. Typical reagent solution consumption for a continuously operating monitor is approximately ten litres per month. The monitor uses 50 to 80ml of each standard solution each calibration cycle. Consumption of the standard solution also depends on the frequency with which this cycle is carried out.

8.1.1 Reagent Solution 0.75M Sulphuric Acid

> **Warning.** Concentrated sulphuric acid must be handled with great care at all times - in particular, ensure that when diluting concentrated acid, it is added to water and **not** water to acid. Wear appropriate protective clothing i.e. rubber gloves and full face protection.

To prepare from concentrated acid:

a) **Slowly and carefully** add 420 (±2)ml of concentrated sulphuric acid (S.G. 1.84) to approximately four litres of de-ionised water in a 10 litre volumetric flask, swirling the contents continuously and cooling under running water if necessary.

b) Allow this to cool to room temperature, and then make up to the mark with further de-ionised water, to produce a 0.75M solution.

c) Fill the reagent bottle with this solution, and remove any carbon dioxide present by bubbling nitrogen gas through it, using a sintered glass diffuser, for approximately 30 minutes.

d) Fit a guard tube to the reagent bottle cap assembly and then fill the bottom 15mm of the guard-tube with loosely-packed glass wool. Fill the tube to within 15mm of the top with soda-lime crystals, and seal off the top with a plug of cotton wool.

e) Fit this assembly immediately to the reagent bottle.

8.1.2 Standard Solutions

> **Note.** Because carbon dioxide is present in the atmosphere, and is easily absorbed by de-ionised water, it is necessary to take extra care to avoid errors in preparing standard solutions.
>
> For low-level standards (less than 10ppm CO2) it is good practice to carry out the whole of the preparation under a blanket of flowing nitrogen gas, and if necessary, to purge the water with nitrogen gas from a sintered glass diffuser before use. Once made, the standard solution bottles should be immediately fitted with guard tubes (i.e. carbon dioxide traps). Guard tubes are made up by placing glass wool at the bottom of the tube, filling to within 10 to 15mm of the top with soda-lime granule (1.0 to 2.5mm grain size, self indicating) and fitting a small retaining plug of glass wool in the top.

The two standard solutions are stored in plastic bottles (packed separately). Freshly made up solutions should be made up using carbon dioxide-free water taken **directly** from the outlet of a mixed bed de-ionizer, and should not be exposed unnecessarily to the atmosphere.

A – Stock Solution 10,000ppm (mg l^{-1}) CO_2

a) Weigh out 9.550 (±0.005)g of sodium bicarbonate and 12.050 (±0.005)g sodium carbonate (both anhydrous analytical reagent grade) and dissolve in approximately 600ml of carbon dioxide-free water in a one litre flask.

b) Make up to the mark with more carbon dioxide-free water.

B – Primary Calibration Solution 5ppm (mg l^{-1}) CO_2

a) Pipette 5.0 ml of the 10,000 ppm solution into a 10 litre volumetric flask.

b) Make up to the mark with carbon dioxide-free water, to give a 5 ppm standard solution.

C – Secondary Calibration Solution 50ppm (mg l^{-1}) CO_2

a) Pipette 50 ml of the 10,000 ppm solution into a 10 litre volumetric flask.

b) Make up to the mark with carbon dioxide-free water, to give a 50 ppm standard solution.

8.1.3 Probe Filling Solution

The filling solution used in the 8237 probe is made up as follows:

a) Weigh out 0.042 (±0.001)g sodium bicarbonate and 0.42(±0.01)g sodium chloride (both anhydrous analytical reagent grade) into a 100ml volumetric flask containing approximately 80 ml of de-ionized water.

b) Add, by drops, 0.1M silver nitrate solution until a white precipitate of silver chloride persists after mixing; make up to the 100ml mark with more de-ionized water, and mix. Allow the precipitate to settle before using.

c) Add approximately 1ml of 0.1% bromothymol blue indicator to the solution. The filling solution has a characteristic blue colour - when it is exhausted, it turns yellow.

8.2 Scheduled Servicing

The following servicing schedule has been produced as a general guide only. Because the monitor has been designed for a very wide range of applications, where the nature of the sample can vary considerably, it may be necessary to amend the schedule to suit the particular installation and sample conditions.

8.2.1 Regular Visual Checks

It is recommended that the monitor and the sampling system is visually inspected on a regular basis to check the correct functioning of the system and to assure the integrity of the readings.

a) Check for leaks, particularly around the sample and drain pipework connections.

b) Confirm sample flow by checking delivery to the constant head unit and effluent from the drain.

c) Check liquid flow through sensor flow through cap.

d) Check for build-up of air in the flow through cap.

e) Check liquid levels in the reagent and standard solution containers.

f) Check the soda lime guard tubes and replace the soda lime if any of it has changed color, indicating exhaustion.

g) Check for malfunction indications on the instrument display.

Note. The mains and pump/heater switches are situated on the right hand side of the User Junction Box.

8.2.2 Four Weekly

a) Inspect all tubing and connections for leaks and deterioration.

b) Examine all tubing for signs of accumulation of solid deposits. Clean as required with high purity water.

c) Check the filling solution in the probe, and top-up if necessary. Ensure that there is a 50 to 60mm depth of solution inside the probe so that the reference element is immersed.

d) Discard old reagent and standard solutions. Clean containers thoroughly before refilling with fresh solutions – see Section 8.1.

Note. It is vital that the containers are not topped up.

e) Examine the sample input pipe for leaks and deterioration.

f) Ensure the drain is in good order and free from obstruction.

8.2.3 Twelve Monthly

a) Service pump, tubing and capstans – see Section 8.2.7.

b) Replace all internal plumbing tubing – see Section 8.2.8.

c) Carry out the normal 4 weekly schedule not already covered above.

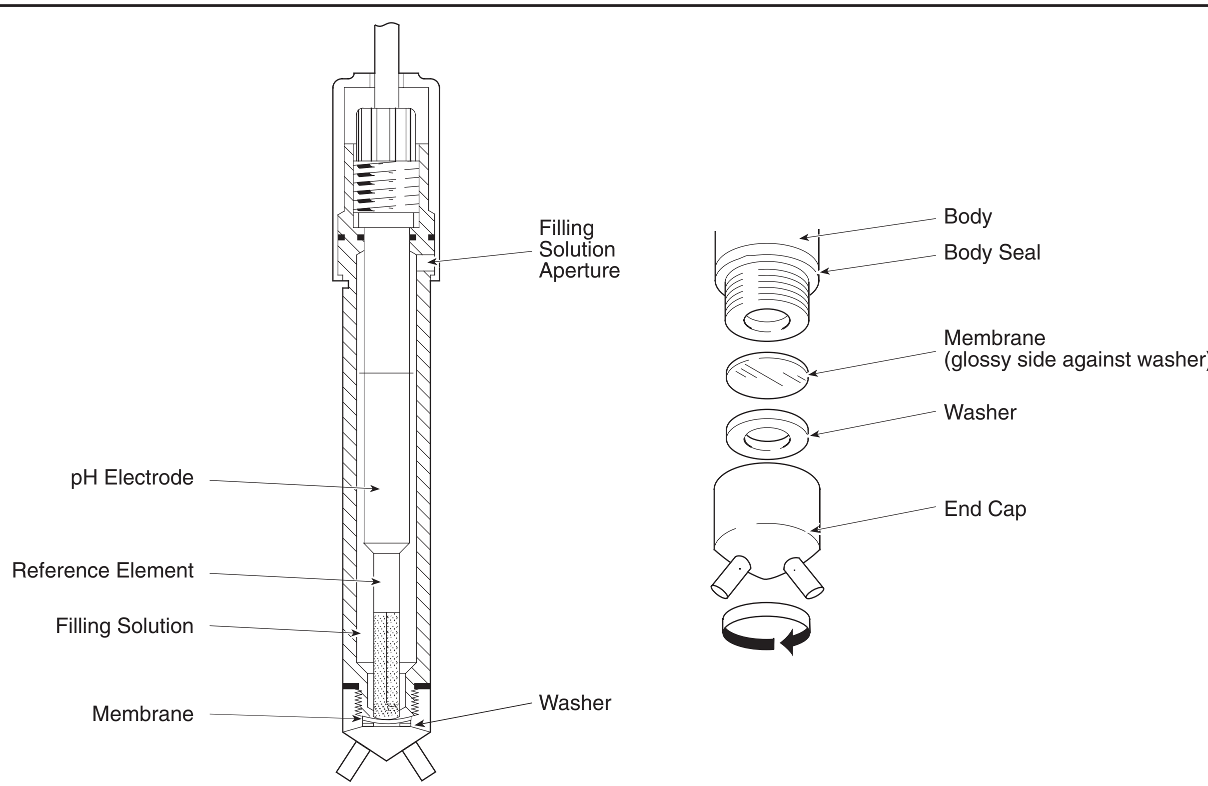


Table 7.1 Calibration Sequence Summary

8.2.4 Consumables Spares Kit

The monitor is supplied with a consumable spares kit (see Section 10). This consumable spares kit includes all the components which are recommended for replacement annually (refer to the details in the spares kit). This annual refurbishment ensures a high level of reliability from the monitor over a period of many years. The kit should be reordered when used so that all the items are available throughout the following year's operation. The consumable spares kit is in addition to the electrode spares kits for the 8237 probe.

The kit contains the following:

a) one set of pump tubing

b) one set of pump capstans

c) a complete set of plumbing tubing

d) sundry items – 'O' rings, tube connectors, pump tube bungs and fuses.

e) plastic syringe and bottle brush – for cleaning pipework, valves, flowcell and constant-head unit.

8.2.5 Probe Assembly – Fig. 8.1

The 8237 probe is a gas sensing combination electrode assembly. It is supplied as a kit and must be assembled and prepared for use as follows:

> **Note.** It is essential that the coaxial connection of the probe is kept free of any moisture, due to the very high sensor source impedance (up to 5000 MΩ).

> **Caution.** Do **NOT** touch the delicate membrane – see below – with any hard or sharp objects.

a) Unscrew the end cap from the probe body. Rinse the probe body with distilled or de-ionised water. Allow to drain.

b) Remove the teat from the glass electrode. Rinse the electrode with distilled or de-ionised water. Dry with a paper tissue.

c) Screw the glass electrode into the body until the tip of the electrode is flush with the end face of the probe. Note the number on the electrode cap in line with the mark on the body. Unscrew the electrode cap four full turns.

d) Remove the flow-through cap and place the white washer in the bottom of the recess of the cap.

e) Take one of the white plastic membranes from the spares kit and place it onto the washer with the glossy surface of the membrane against the washer.

f) Screw the flow-through cap firmly onto the body, taking care not to wrinkle the membrane. Ensure that the body seal and the membrane sealing washer are both under compression.

g) Holding the probe upright, inject the filling solution provided through the filling hole until there is a 50 to 60mm depth of solution inside so that the reference element is immersed in the solution. Wipe any excess filling solution from the body.

h) Tap the end of the probe with the finger to dislodge any air bubbles which have been trapped between the end of the glass electrode and the membrane. Screw the glass electrode down four turns to the flush position again and then a further 0.2 to 0.3 turn. The tip of the electrode should now be pressing against the membrane. In some circumstances, particularly if the electrode response is sluggish, the screw may be given a further 0.1 to 0.2 turn. Beware of overtightening, which can puncture the membrane.

i) Push the probe cap onto the top of the probe body so that it covers the filling hole.

> **Note.** A newly assembled probe should be run on sample for two to four hours before a calibration is attempted.

8.2.6 Fitting the Probe – Fig. 8.2

When the 8237 probe has been prepared for use in accordance with Section 8.2.5 above, proceed as follows:

a) Hinge down the flowcell block cover to gain access to the block. Fit the assembled probe into the recess in the temperature–controlled block, ensuring that the probe sits at the bottom of the recess. Rotate the retaining clip to hold the probe in position.

b) With sample and reagents flowing, ensure that liquid is delivered to the flow-through cap, and that there are no air bubbles trapped in the cap.

c) Replace the cover on the temperature-controlled block.

Note. It is essential that the coaxial connection is kept free of any moisture, due to the very high probe source impedance.

d) Connect the probe lead to the coaxial socket above the flowcell.

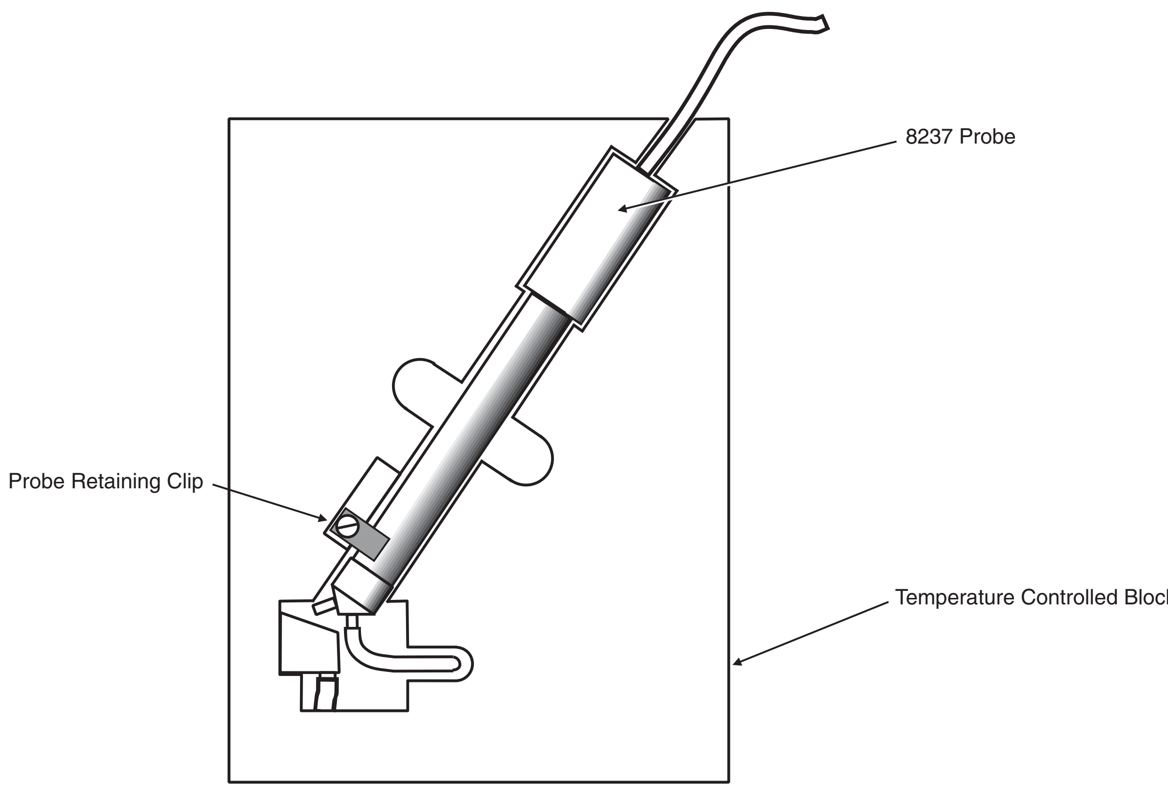


Fig. 8.1 CO_2 Probe Details

8.2.7 Peristaltic Pump – Fig. 8.3

It is recommended that the pump tubing and pump capstans, supplied in the Consumable Spares Kit, are replaced after one year of operation. Carry out the following procedure ① to ⑧:

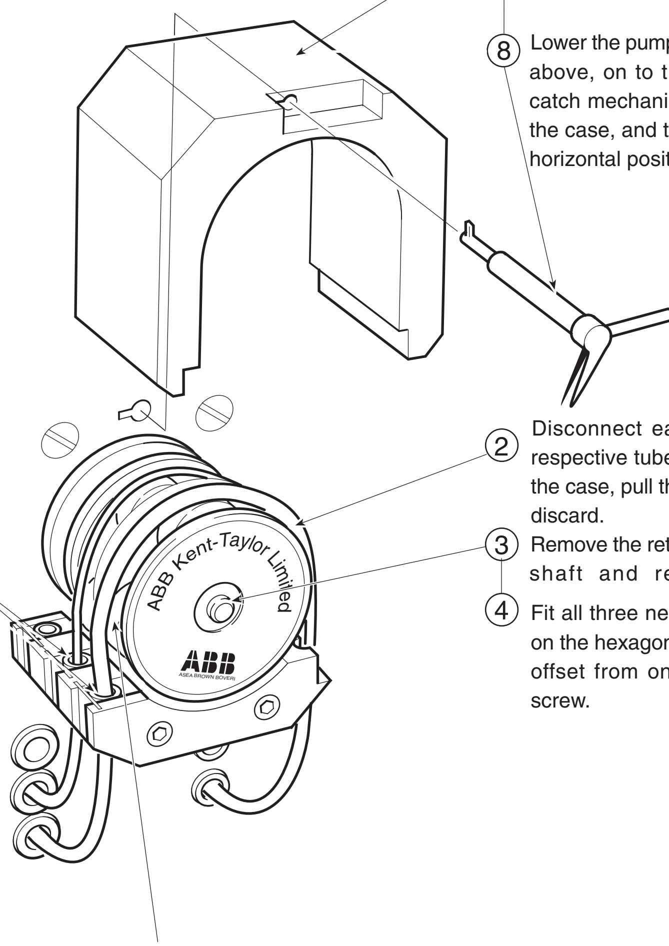


Fig. 8.2 Fitting the Probe

8.2.8 Replacement of Plumbing Tubing

All the following items are included in the Consumable Spares Kit.

a) Remove sensor for short term storage.

b) Remove each section of the sample and reagent plumbing tubing in turn and replace with new tubing of the same length.

c) Remove drain tubing and replace with new tubing of the same length.

d) Using a syringe, clean constant head unit, solenoids and sample heating coil in flowcell with sodium hypochlorite solution.

e) It is recommended that the sample and drain tubing to and from the monitor is inspected and replaced if the tubing is in poor condition or shows evidence of any build-up of solids.

8.3 Shutdown Procedure

8.3.1 Short Term

The monitor can be left with the power switched off for up to 24 hours without any detrimental effects. When returned to normal monitoring mode, the monitor should be run on sample for 30 minutes, followed by a calibration – see Section 7.

If the probe is left in the monitor with no liquid flowing, the internal filling solution becomes more concentrated by evaporation of water through the membrane. The probe output drifts when normal operation is resumed and many hours may be required to re-establish stability. In such cases normal performance can sometimes be restored by unscrewing the glass electrode two to three turns and then returning it to its original position, thus allowing fresh filling solution to flow between the electrode and the membrane. If this procedure is not successful replace the membrane and filling solution.

If the probe is likely to be out of use for more than one day, remove the probe from the monitor and store it with the lower part of the body immersed in a small quantity of liquid in a beaker or other suitable vessel. Probe filling solution is the best storage solution. It is essential that all traces of the storage solution are rinsed away with clean water before use.

8.3.2 Long Term

When the monitor is required to be shut down for more than 24 hours, proceed as follows:

a) Switch off the monitor.

b) Close the sample valve upstream of the monitor.

c) Remove and dismantle the probe, and return it to its box. To dismantle the probe, unscrew the glass electrode and empty the rest of the probe. Rinse with clean water and drain. Store the glass electrode with its end in a teat containing a neutral buffer solution, taking care not to cover the reference element.

d) Clean sample pipework both inside and outside the monitor, constant head unit, and filtration system (if used).

e) Remove pressure plate from peristaltic pump.

8.4 Unscheduled Servicing

The monitor indicates abnormal operation by means of signals on the 20 character dot matrix display and the l.e.d.s The indications are listed in Table 8.1.

8.4.1 Malfunction of the Monitor

It should always be remembered that any unpredictable problems may be due to the standard or reagent solutions, or their flow through the flowcell. If any doubts exist regarding the integrity of the solutions, they should be replaced with freshly prepared solutions in the early stages of the fault finding investigations.

> **Note.**
> The accuracy of the monitor is governed by the condition of these solutions which may be incorrectly made or contaminated.

In general, any problems are likely to be due to the probe, which may require refurbishment (see Section 8.4.3), but may be due to other parts of the liquid handling section of the monitor.

Mechanical components which are involved with the liquid handling, for example, pumps, valves, tubing and tubing connections etc., should be systematically checked for correct operation, and for leaks or blockages which change the chemical conditions around the probe. The majority of all problems are found to be associated with the chemistry and the liquid handling section.

8.4.2 Monitor Diagnostic Information

Out of Service Alarm

This alarm relay output is a normally energised relay which de-energises in the following circumstances:

a) Loss of mains supply.

b) Calibration Failed – the calculated electrode slope value is outside the acceptable limits or the response of the electrode is too slow. The 'CAL FAIL' l.e.d. on the front panel is illuminated with the appropriate text on the 20-character display.

c) Block temperature out of limits – the measured temperature of the block is not within 5°C of the Control Temperature. 'TEMP. CONTROL ERROR' is indicated on the 20-character display.

d) 'OUT OF SAMPLE' alarm – a float switch in the constant head unit detects the loss of sample. 'OUT OF SAMPLE' is indicated on the 20-character display.

e) 'OUT OF SERVICE' alarm – displayed when the pump is switched off.

> **Note.** The heater is switched off by the software when an 'OUT OF SAMPLE' condition is detected.

Calibration Fail Alarm

A calibration failed condition occurs after a two point calibration if the calculated slope value is less than 70% or if the sensor output is unstable. The failure could be caused by a number of factors which should be investigated.

In the 'CAL. FAILED (SLOPE)' case some indication of the problem may be obtained from the slope value.

Slope value just below 70%

a) Clean the membrane by flushing the flow-through cap with clean water from a wash-bottle or syringe.

b) Disassemble probe and reassemble – see Section 8.2.5.

c) Check glass electrode – see Section 8.4.3.

Slope value grossly abnormal

a) Check, and top up as necessary, the filling solution in the probe. There should be a 50 to 60mm depth of solution inside the probe.

b) Disassemble probe and reassemble – see Section 8.2.5.

c) Check glass electrode – see Section 8.4.3.

d) Check reference element – see Section 8.4.3.

Noisy, unstable response or slow response

a) Clean membrane by flushing the flow-through cap with clean water from a wash–bottle or syringe.

b) Check, and top up as necessary, the filling solution in the probe. There should be a 50 to 60mm depth inside the probe so that the reference element is immersed in the solution.

c) Osmotic effects, i.e. total concentration of dissolved species in samples too high.

d) Puncture of the membrane (usually visible), disassemble sensor and reassemble – see Section 8.2.5.

e) Interference (from for example high concentrations of anionic detergents).

f) Check glass electrode – see Section 8.4.3.

g) Check reference element – see Section 8.4.3.

8.4.3 Malfunction of the Probe

Internal Filling Solution

The internal filling solution incorporates a coloured indicator which is normally blue. The indicator changes to yellow if the probe membrane, or membrane seal, allows acid reagent to leak into the probe. If this occurs the membrane should be replaced, and care taken to tighten the end cap sufficiently to provide a good seal. The solution keeps indefinitely.

Ageing of the glass electrode

After the probe has been in use for some months, the performance of the glass electrode may eventually deteriorate due to its continued use in weakly buffered solutions at near neutral pH. The response of the probe becomes sluggish and the response slope drops. The electrode may frequently be restored to its initial condition by soaking for 12 hours in 0.1M hydrochloric acid. The performance of the electrode may be checked as described below.

Checking the performance of the glass electrode

The glass electrode may be checked independently of the probe with a laboratory calomel reference electrode by testing the pair in pH buffer solutions.

Immerse the glass electrode in a buffer solution to a depth of 5 to 10mm. There must be no liquid contact with the reference element.

Connect the electrodes to a pH meter and calibrate with pH buffers in the usual way. The glass electrode may be found to be somewhat slower in response than a conventional bulb-type electrode, but adequate scale length should be obtained, typically better than 98% of the theoretical slope value.

Reference Element

During the lifetime of the probe, the internal reference element may show signs of deterioration, indicated by the removal of the grey/brown silver chloride coating, exposing the buff/light grey silver element beneath. This is a normal process, the rate of removal depending on probe operating conditions and maintenance.

When new, and in good condition, this element is completely and evenly coated. Loss of a large part of this coating causes probe drift, but can be restored by re-chloridising the element, using the procedure in Section 8.6.

Display	Possible Cause
'CALIBRATING Std 1 (or 2)' Cal L.E.D. flashing	Normal when calibration is taking place. 'Std 1' or 'Std 2' refers to the standard solution being admitted at the time.
'CALIBRATION PASSED'	A recent two point calibration has been successfully carried out.
'CAL. FAILED (SLOPE)' Fail L.E.D. flashing	The outputs from the sensors did not reach adequate stability during calibration.
'CAL. FAILED (SLOW)' Fail L.E.D. flashing	The monitor was unable to achieve a stable output from the sensors.
'TEMP. CONTROL ERROR'	The sensor flowcell temperature is significantly different from the Control Temperature.
'OUT OF SAMPLE'	Indicates loss of sample.
Hold L.E.D. 'ON'	This indicates the Hold button has been pressed to freeze the concentration alarm states and to activate the Out of Service alarm relay. Pressing the button again returns the monitor to normal operation after a period of 3 hours.

Fig. 8.3 Peristaltic Pump

8.5 Microprocessor Unit Error Messages

The instrument incorporates an automatic self-diagnostic checking facility for detection of input and output errors. If such a fault occurs, one of the error messages detailed below is shown on the dot matrix display.

'CHAN 1 INPUT ERROR'

This error message is usually caused by an open circuit sensor input allowing the input to drift outside the range of ±400mV. This may be due to any of the following:

a) Low level of internal filling solution in the probe.

b) Open circuit electrode internally, e.g. broken connection, blocked liquid junction in reference electrode etc.

c) Broken electrical connections between the sensor and the Microprocessor Unit sensor input.

d) Sensor coaxial plugs not correctly inserted.

'TEMP INPUT ERROR'
'PRT OUT OF LIMITS'
'TEMP REF. ERROR'
'THIRD LEAD ERROR'

The above four error messages refer to electrical problems with the temperature sensor input, – usually an open or short-circuit connection.

8.6 Procedure for Chloridising the Reference Element

Requirements

a) Plating solution – hydrochloric acid (HCl) 0.1M, 500ml.

> **Note.**
> Do not use acid preserved with mercuric ions.

b) Cleaning solutions – Ammonia solution (NH_3) 50% vol./vol., 200ml.

To prepare, dilute 100ml analytical reagent grade concentrated ammonia solution, s.g. 0.88, with 100ml distilled water and stir.

c) Nitric acid (HNO_3), 25% vol./vol. 200ml.

To prepare; cautiously pour 50ml analytical reagent grade, concentrated nitric acid, s.g. 1.42, into 150ml distilled water, stirring continuously. Allow to cool before use.

> **Warning.**
> STRONG AMMONIA SOLUTIONS AND CONCENTRATED NITRIC AND HYDROCHLORIC ACIDS ARE IRRITANTS AND VERY CORROSIVE. TAKE CARE NOT TO INHALE ANY OF THE FUMES OR TO GET ANY SOLUTION ON SKIN OR CLOTHING. ANY SLIGHT SPILLAGE ON SKIN, CLOTHING OR WORKING SURFACE MUST BE WASHED AWAY WITH PLENTY OF WATER.

d) Constant current supply, 2mA d.c.

e) Silver wire (counter electrode).

f) 1 beaker.

Cleaning –

a) Immerse the lower 5cm of the combination electrode (i.e. so that the silver reference element is covered) in the ammonia solution for about one minute. Remove and rinse with distilled water.

b) Immerse the electrode to the same depth in the 25% nitric acid until the silver element is a uniform creamy white. This process usually takes about one minute, but the element must be inspected frequently as prolonged immersion is detrimental.

c) If the element is not uniform in colour repeat the ammonia/ nitric acid process.

d) When clean, rinse with distilled water and immediately transfer to the plating solution such that the reference element is completely immersed.

Chloridisation

a) Attach the screen of the combination electrode cable to the negative terminal of the constant current supply and immerse the lower 5cm of the electrode in the plating solution so that the reference element is covered. Immerse a silver counter electrode in the plating solution and connect to the positive terminal of the supply.

b) Pass a current of 2mA for approximately 30 seconds. Carefully tap the electrode to remove all bubbles and then reverse the connections to the supply (i.e. the electrode to be plated is connected to the positive terminal).

c) Pass a current of 2mA for 30 minutes after which time the electrode will be a dark brown or grey colour. A more uniform coating may be obtained by employing moderate stirring during the process.

d) Remove the electrode from the plating solution, rinse with distilled water and dry with a tissue.

9 SPECIFICATION

Range: Carbon Dioxide 0.1 to 1000mg l–1.

Repeatability: ±2% of reading.

Reproducibility: ±3% of reading.

Response Time: Less than 10 minutes for 90% step change.

Millivolt Range: –400 to +400mV.

Millivolt Resolution: ±0.1mV.

Control Temperature Range: 30 to 45°C

Temperature Resolution: ±0.1°C

Displays:
- Concentration: 5 digit blue fluorescent.
- Information: 20 character dot matrix blue fluorescent.
- Status indication: Two flashing l.e.d.s in alarm state.
  - Single l.e.d. lit when 'Hold' switch operated.
  - Single l.e.d. lit when calibration is in progress.
  - Single l.e.d. lit when the monitor is 'Out of Service'

Current Outputs: As standard one isolated current output 0 to 1, 0 to 10, 0 to 20 or 4 to 20mA, selectable via plug in links. Maximum voltage load 15V.

Current Output Span: Minimum of 1 decade of display range, logarithmic or linear.

Computer Interface: Optional second current output or RS422/RS423 serial interface.

Alarms: Two high or low concentration alarms.
- Remote calibration mode indication.
- Remote monitor 'OUT OF SERVICE' indication.
- Remote 'OUT OF SAMPLE' indication.
- All voltage free 250V, 5A noninductive changeover relay contacts.

Concentration Alarm Setpoint: Programmable over range.

Concentration Alarm Differential: 0 to 5%.

Concentration Alarm Delay: 0 to 60 minutes.

Programmable Data Retention: 3 years.

Calibration: Fully automatic two point, plus manual initiation on demand.

Routine Maintenance:
- Four weekly: Replenish reagents, clean flow system.
- Twelve monthly: Replace plumbing and pump tubing, and pump capstans. Refurbish sensors depending on application.

Power Supply: 115 or 230V, 50/60Hz, 100VA.

Power Supply Tolerance: +6% to –20%.

Isolation Voltage: Input, Output and power supply 1.5kV.

Dimensions:
- Height: 890mm (35.04in).
- Width: 542mm (21.34in).
- Depth: 220mm (8.68in).

Weight: 30kg

Degree of Protection:
- Electronic Section: IP65
- Liquid Handling: Case IP31, critical internal components IP65.

10 SPARES

Consumable Spares

Part No.	Description	Qty
8237 020	Consumable spares kit comprising pump tubes,pump capstans, plumbing tubing, tube connectors and 'O' rings etc.	1

Consumables not included in the above

8237 248	8237 Probe – Internal filling solution.	1
8237 250	8237 Probe spares kit (membranes and 'O' rings etc.).	1

Refurbishment Spares

Part No.	Description	Qty.
8237 240	8237 Probe kit (includes bottle of filling solution, spares kit, combination electrode and body assembly).	1
8237 260	8237 Probe combination electrode – boxed	1
8237 242	8237 Probe body assembly	1
8002 830	8237 Probe flow through cap	1
8237 271	Sample heating path	1
8237 230	Reagent bottle assembly	1
8232 269	Mixer coil	1
8237 220	Standard solution bottle assembly – 'Low'	1
8237 221	Standard solution bottle assembly – 'High'	1
8063 710	Container tube sinker	3
0214 514	Hose connector – sample inlet 6mm i.d.	1
0214 526	Hose connector – monitor drain 9mm i.d.	2
8230 240	Temperature sensor assembly	1
0234 019	Solenoid valve	2

Strategic Spares

Part No.	Description	Qty
8237 269	Drain receptacle	1
8237 270	Drain receptacle mounting plate	1
8232 280	Inlet manifold and drain	1
8061 864	Float switch – 'Out of Sample'	1
0232 069	Pump motor	1
8035 870	Pump motor coupling assembly	1
8232 254	Heater mat	1
0234 712	Heater thermal cut-out	1
8237 265	Heater plate assembly	1
0232 325	Mains transformer – user junction box	1
0234 726	Toggle switch – mains and pump	2
0234 714	Toggle switch boot	2
8230 130	PCB assembly – user junction box	1
0239 117	Electrode coaxial plug	1
0239 118	Electrode coaxial socket	1

4500 0845	Processor board (without PSD)	1
4500 0817	Power supply board assembly	1
4500 0140	Display board pack assembly	1
4500 0255	Current O/P board	1
4500 0855	Serial Modbus PCB assembly	1

…Strategic Spares

Part No.	Description	Qty.
4500 0265	Temperature Input Board	1
4500 0805	Input Board	1
4500 0285	Power supply board	1
4500 0275	5-Digit, 7-segment display board	1
4500 0443	5-Digit display flexi-circuit	1
4500 0603	Display flexi-circuit	1
4500 0395	Membrane switch	1
8237 070	Programmable system device (PSD)	1

Fuses (Junction Box)

Part No.	Description	Qty.
0231 558	F1 – 1A 20 x 5mm Anti-surge 250V AC	1
B10208	F2 – 5A 20 x 5mm Quick Blow 250V AC	1
0231 596	F3 – 0.5A 20 x 5mm Anti-surge 250V AC	1

Fuse (Transmitter Power Supply Board 4500/0817)

Description	Qty.
F1 – Not a site-serviceable fuse, contact the company	1

APPENDIX A – REPLACING SOFTWARE EPROM

Warning. Switch off the monitor and electrically isolate it before carrying out the following steps.

A.1 Access the Transmitter Unit – Fig. A.1

Caution. Employ normal antistatic precautions while handling chips and PCBs.

Caution. To avoid damaging EPROM, base or PCB, it is essential that you use an approved IC extractor in this procedure.
For example, a PLCC Extractor, RS Stock Number: 404-727

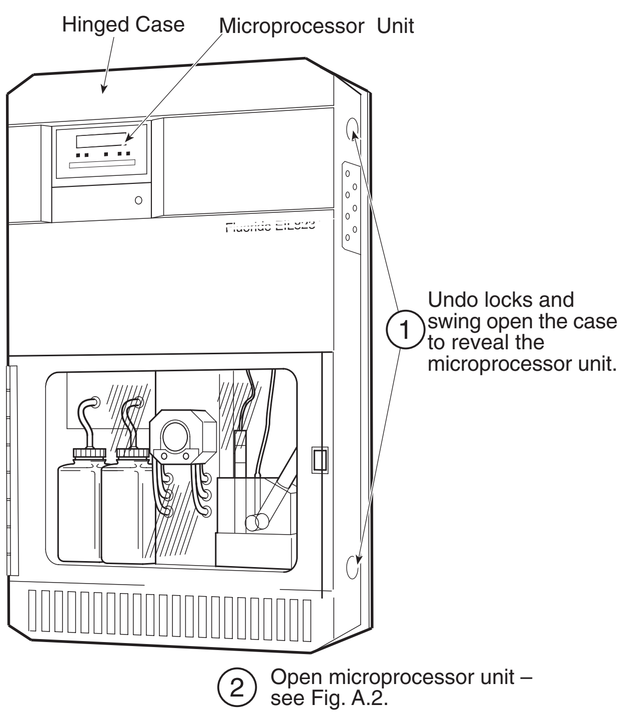


Table 8.1 Unscheduled Servicing Messages

A.2 Access the PCB – Fig. A.2

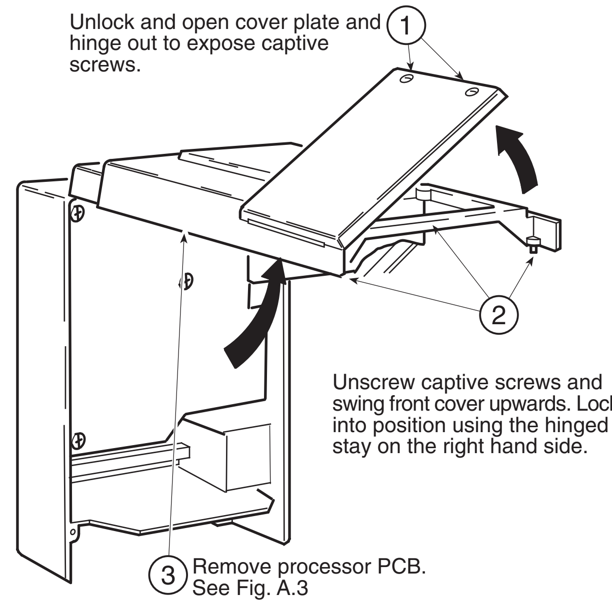


Fig. A.1 Procedure to Open the Enclosure

A.3 Removing the PCB – Fig. A.3

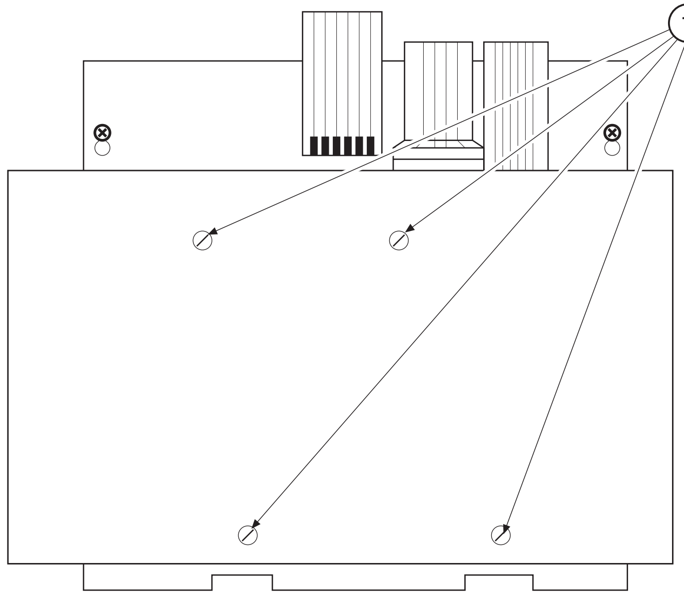


Fig. A.2 Procedure to Access the Processor PCB

A.4 Changing the EPROM – Fig. A.4

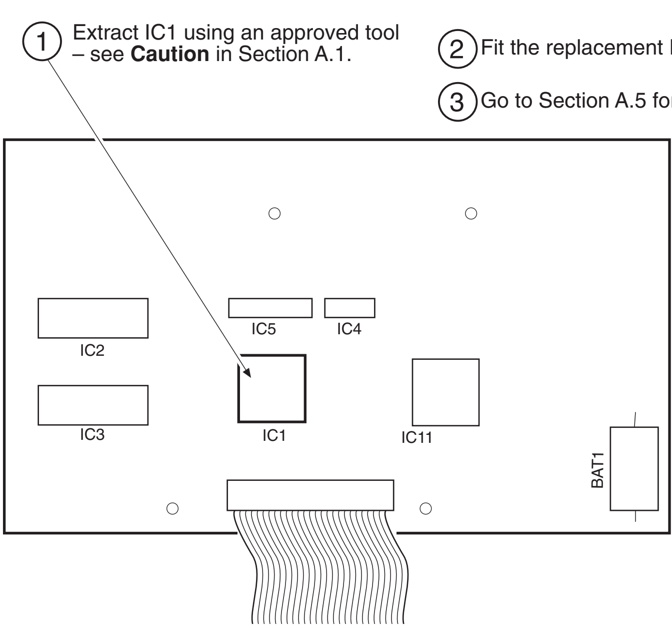


Fig. A.3 Procedure to Remove the PCB

A.5 Completing the Procedure

1) Fit the PCB using the reverse procedure in Fig. A.3.

> **Important Note.** Ensure that the washers are fitted between the PCB cover and the PCB.

2) Close the microprocessor section using the reverse procedure in Fig. A.2.
3) Close and lock the hinged cover – Fig. A.1.
4) The monitor may now be put into service.
5) Check program parameters – see Section 6.
6) Carry out a routine 2-point calibration.

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Client Warranty

Prior to installation, the equipment referred to in this manual must be stored in a clean, dry environment, in accordance with the Company's published specification.

Periodic checks must be made on the equipment's condition. In the event of a failure under warranty, the following documentation must be provided as substantiation:

1. A listing evidencing process operation and alarm logs at time of failure.
2. Copies of all storage, installation, operating and maintenance records relating to the alleged faulty unit.

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