4500 Series
Microprocessor Based
pH/Redox Transmitters

# Operating Instructions

Models 4535 and 4545

P.I. Controller Supplement

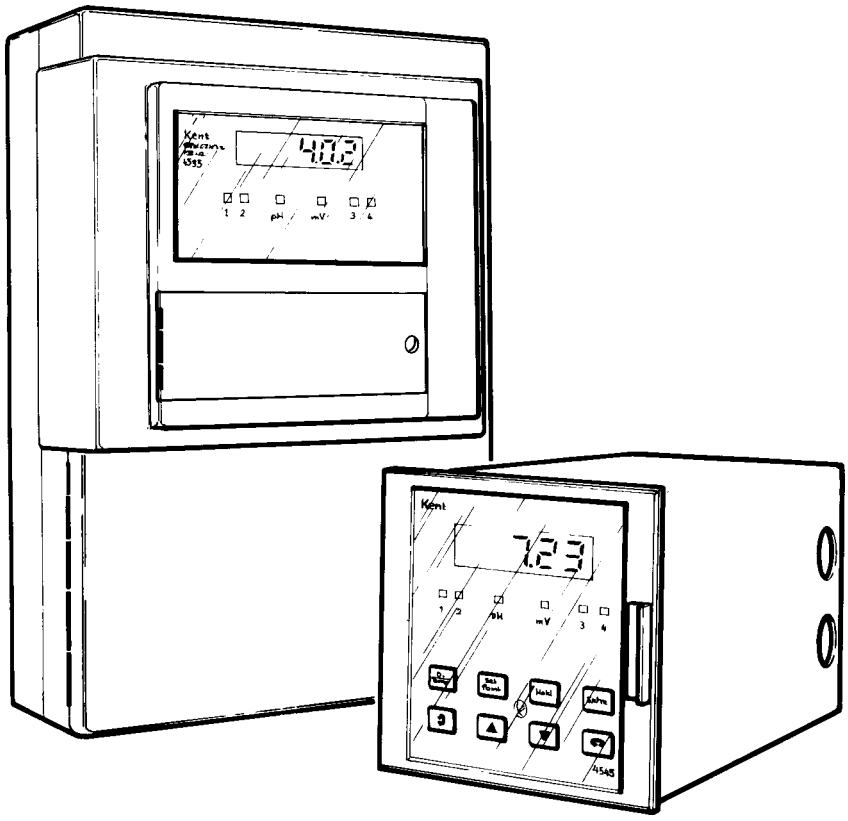


ABB Instrumentation

# ABB INSTRUMENTATION

## The Company

ABB Instrumentation is 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 NAMAS Calibration Laboratory No. 0255(B) is just one of the ten flow calibration plants operated by the Company, and is indicative of ABB Instrumentation's dedication to quality and accuracy.

**BS EN ISO 9001**

St Neots, U.K. – Cert. No. Q5907
Stonehouse, U.K. – Cert. No. FM 21106

**EN 29001 (ISO 9001)**

Lenno, Italy – Cert. No. 9/90A

Stonehouse, U.K. – Cert. No. 0255

## Use of Instructions

**Warning.**
An instruction that draws attention to the risk of injury or death.

**Note.**
Clarification of an instruction or additional information.

**Caution.**
An instruction that draws attention to the risk of damage to the product, process or surroundings.

**Information.**
Further reference for more detailed information or technical details.

Although **Warning** hazards are related to personal injury, and **Caution** hazards are associated with equipment or property damage, it must be understood that operation of damaged equipment could, under certain operational conditions, result in degraded process system performance leading to personal injury or death. Therefore, comply fully with all **Warning** and **Caution** notices.



**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.

**CONTENT** **Page**



## INTRODUCTION

The Models 4535 and 4545 microprocessor based pH/Redox transmitters have been enhanced with the addition of P.I. control in the pH mode.

P.I. control can be either relay output (time proportioning or pulse frequency) or analogue output.

With relay control there are 2 alarm setpoints which can be independently assigned to either the pH/Redox input or the temperature input. Each setpoint utilises a flashing l.e.d. for visual alarm indication. The remaining 2 relays can be set for time proportioning or pulse frequency operation with the appropriate l.e.d.s giving indication of when relays are energised. The current retransmission is not effected by the control and can be set to record the pH/Redox or temperature input.

With analogue control, either one or two retransmission outputs are required for control. In the single analogue control mode, Retransmission 1 can be assigned to record either the pH/Redox or temperature input.

This supplement provides additional information relevant to the P.I. control features and must be read in conjunction with the Operating Instructions 4500/0012 Issue 4 onwards.

## PREPARATION

As detailed in Operating Instructions 4500/0012.

## SITING

As detailed in Operating Instructions 4500/0012.

## MOUNTING

As detailed in Operating Instructions 4500/0012.

## ELECTRICAL CONNECTIONS

As detailed in Operating Instructions 4500/0012 but with the following changes to Tables 3 and 4:

**Table 3 Wall-Mounted Instrument Connections**

| Terminal Number | Connections | |
|---|---|---|
| | **Relays** | |
| 17 | Normally closed | Relay 3 (Type 5 or 6) or control relay (Type 1, 2, 3 or 4) |
| 18 | Normally open | |
| 19 | Common | |
| 20 | Normally closed | Relay 4 (Type 5 or 6) or control relay (Type 3 or 4) (not used if Type 1 or 2) |
| 21 | Normally open | |
| 22 | Common | |
| | **Output 1** | |
| 31 | + | Retransmission output 1 (Type 1, 2, 3, 4 or 5) or control output (Type 6) |
| 32 | – | |
| | **Output 2** | |
| 5 | + | Retransmission output 2 (Type 1, 2, 3 or 4) or control output (Type 5 or 6) |
| 6 | – | |

**Table 4 Panel-Mounted Instrument Connections**

| Terminal Number | Connections | |
|---|---|---|
| | **Relays** | |
| 12 | Common | Relay 3 (Type 5 or 6) or control relay (Type 1, 2, 3 or 4) |
| 13 | Normally open | |
| 14 | Normally closed | |
| 15 | Common | Relay 4 (Type 5 or 6) or control relay (Type 3 or 4) (not used if Type 1 or 2) |
| 16 | Normally open | |
| 17 | Normally closed | |
| | **Output 1** | |
| 33 | + | Retransmission output 1 (Type 1, 2, 3, 4 or 5) or control output (Type 6) |
| 34 | – | |
| | **Output 2** | |
| 37 | + | Retransmission output 2 (Type 1, 2, 3 or 4) or control output (Type 5 or 6) |
| 38 | – | |

**Note**. Control types 1 to 6 are selected at **Control Type** in the **Control Page** (page 7). Their functions are:

- Type 1 – Single time proportioning (relay 3)
- Type 2 – Single pulse frequency (relay 3)
- Type 3 – Double time proportioning
  - relay 3 – direct acting
  - relay 4 – reverse acting
- Type 4 – Double pulse frequency
  - relay 3 – direct acting
  - relay 4 – reverse acting
- Type 5 – Single analogue output (output 2)
- Type 6 – Double analogue output
  - output 1 – direct acting
  - output 2 – reverse acting

## SETTING UP

As detailed in Operating Instructions 4500/0012.

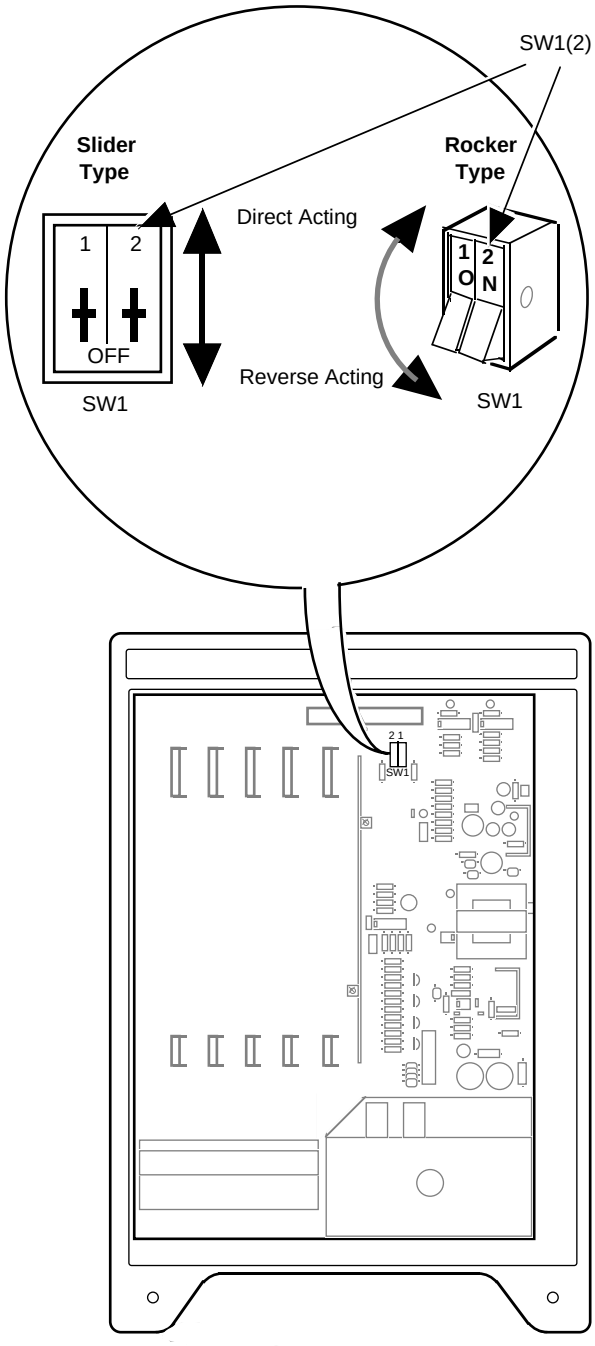
Control action (direct or reverse) is selected using a switch on the motherboard:

SW1(2) on Wall/Pipe-mounted – see Fig. 1
SW1(1) on Panel-mounted – see Fig. 2.

On early models of the wall/pipe-mounted instruments SW1 is a rocker switch and on later models a slide switch – see Fig. 1.

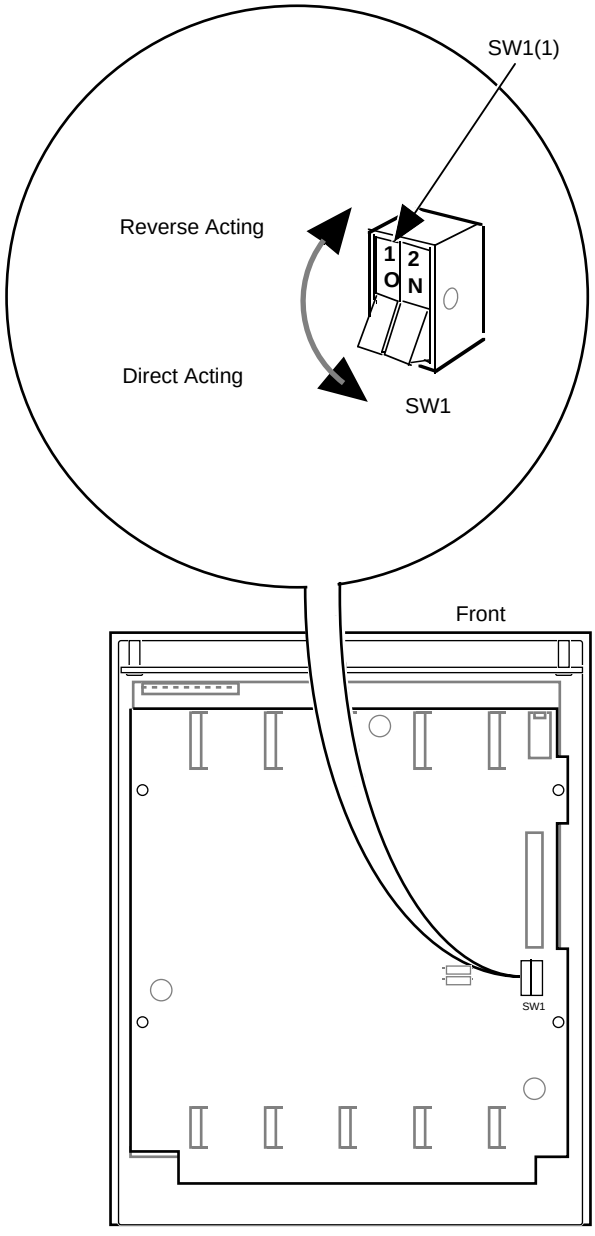
## FAMILIARISATION WITH CONTROLS, DISPLAY AND L.E.D. INDICATION

As detailed in Operating Instructions 4500/0012, however for pulse frequency and time proportioning control, l.e.d.s 3 and 4 remain on when relays 3 and 4 respectively are energised .




Instrument shown open with protective cover removed

**Fig. 1 Wall/Pipe-Mounted Instrument, Location of Switch SW1**




Instrument out of its case and viewed from above

**Fig. 2 Panel-Mounted Instrument, Location of Switch SW1**

## PROGRAMMING

### Introduction

As detailed in Operating Instructions 4500/0012, but with the following additions:

Three parameters in **Operating Page 1** – **Control Automatic/Manual Selection**
**Setpoint 1**
**Setpoint 2**
Refer to page 5

One programming page – **Control Page**, refer to page 7.

Fig. 3 is an abbreviated version of the overall programme chart with sufficient detail to show the location of the additional parameters and new Control Page.

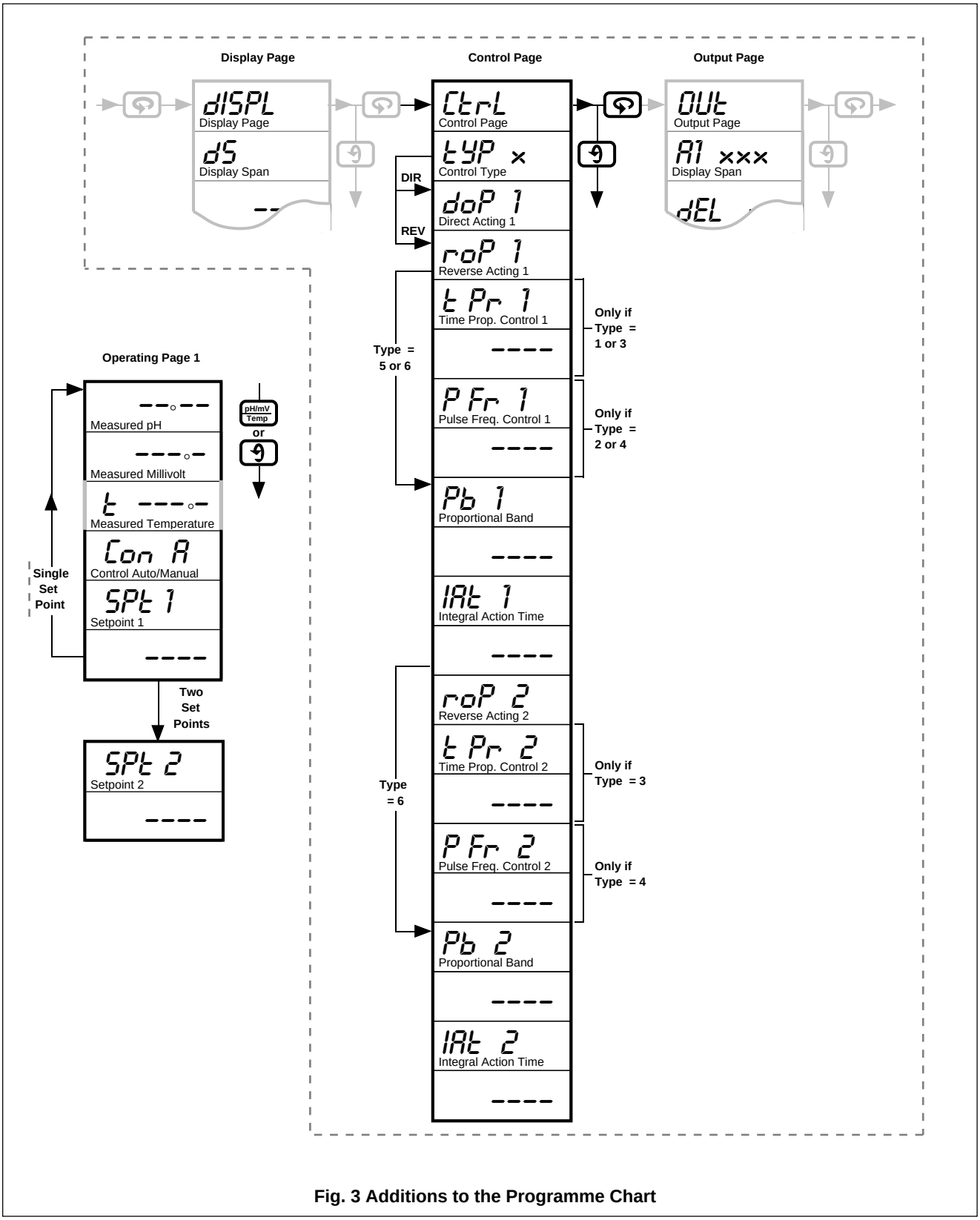
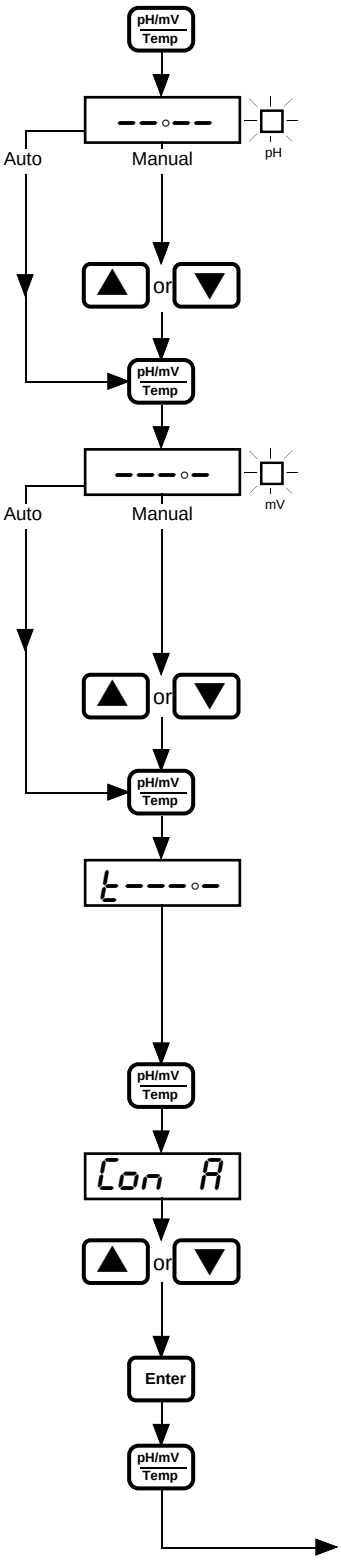



**Fig. 3 Additions to the Programme Chart**

**Operating Page 1**

The automatic or manual control mode selection is made in this programming page – see **Con A** below.

Either the pH/mV Temp or switch can be used to advance through this page; the pH/mV Temp switch has been shown for example only.




Select **Operating Page 1**.

**Measured pH**

The measured pH is displayed ('pH' l.e.d. illuminated) when 'pH' is selected at **Input Type Selection** in the **Input Page –** see page 20 in the Operating Instructions 4500/0012.

Adjust the displayed value to the required pH level.

Advance to display measured Redox or millivoltage.

**Measured Redox or Millivoltage**

The 'mV' l.e.d. is illuminated when 'mV' is selected at **Input Type Selection** in the **Input Page**. The displayed value may be either of the following, depending on the electrode system used:

Measured Redox (if using Redox electrode system)
System output in millivolts (if using pH electrode system).

Adjust the displayed value to the required Redox or millivoltage.

Advance to display the sample temperature.

**Sample Temperature**

The sample temperature is displayed in °C. The displayed value is either that of the manual temperature setting (manual temperature compensation) or temperature compensator measurement (automatic temperature compensation); selection being made in the **Input Page** – see page 20 in Operating instructions 4500/0012.

Advance to next programme function.

**Control Automatic/Manual**

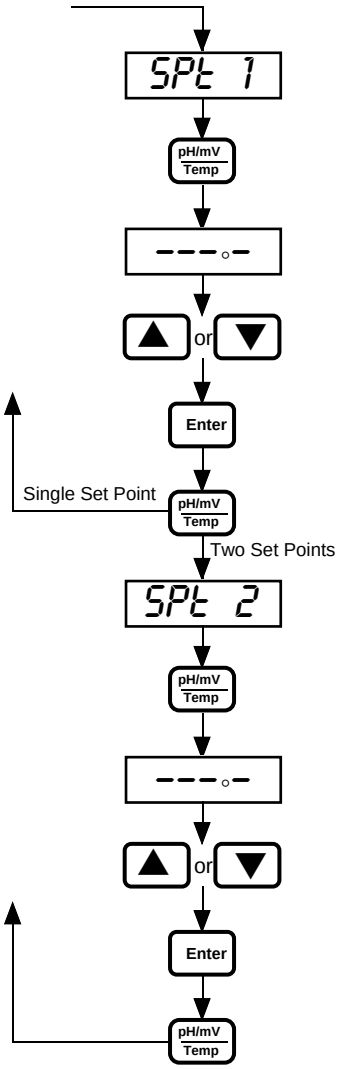
Select Automatic or Manual control, the display is:

**Con A** – Automatic mode
**Con** – Manual mode

Store

Advance to next programme function.

Continued on the next page.




Continued from the previous page.

**Setpoint 1**

Advance to next programme function.

Setpoint value display, the decimal point position is set automatically.

Set the required setpoint value, between display span and display zero.

Store

Advance to next programme function.

**Setpoint 2**

Advance to next programme function.

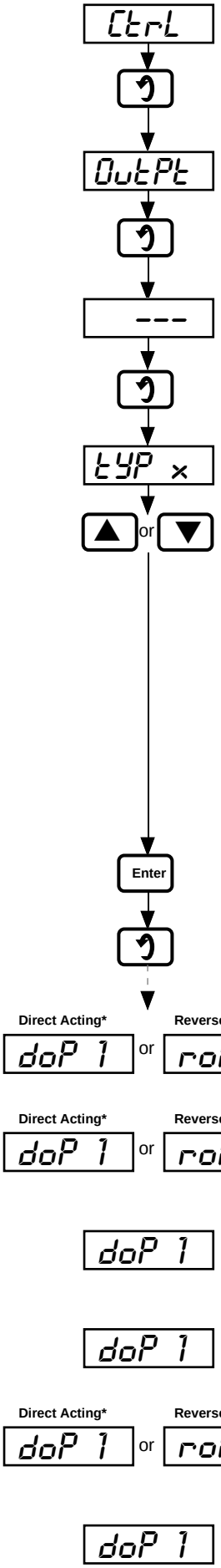
Setpoint value display, the decimal point is position is set automatically.

Set the required setpoint value, between display span and display zero.

Store

Return to top of **Operating Page 1**.

**Control Page**




Page Header – **Control Page**

Advance to next programme function.

**Controller Output**

Advance to next programme function.

Displays the instrument controller output (–100% to +100%) – display only.

Advance to next programme function.

**Control Type**

Select the control type number (x), between 1 and 6:

x = 1 – Single time proportioning (relay 3)
2 – Single pulse frequency (relay 3)
3 – Double time proportioning
relay 3 – direct acting
relay 4 – reverse acting
4 – Double pulse frequency
relay 3 – direct acting
relay 4 – reverse acting
5 – Single analogue output (output 2)
6 – Double analogue output
output 1 – direct acting
output 2 – reverse acting

Store

Advance to next programme function depending on the the selection made at **Control Type**:

**tYP 1** – see page 8.

**tYP 2** – see page 10.

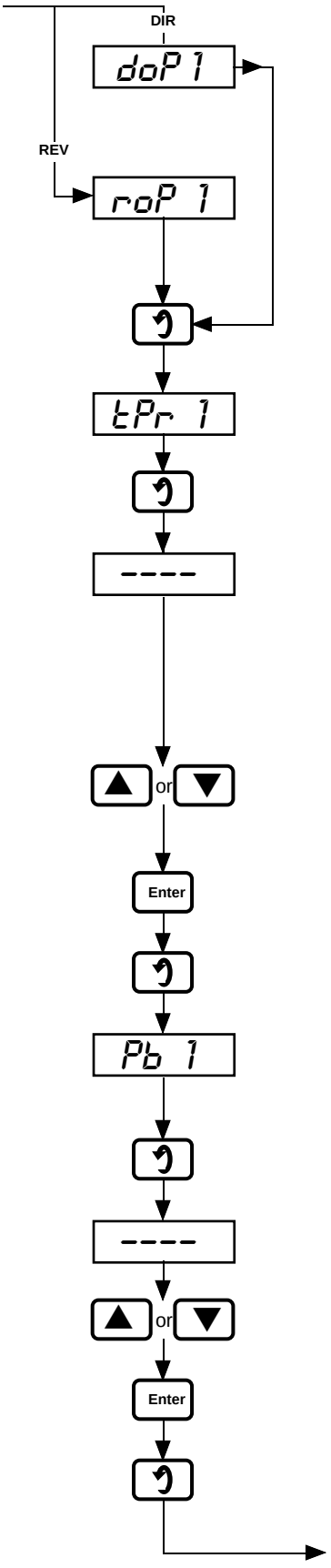
**tYP 3** – see page 12.

**tYP 4** – see page 14.

**tYP 5** – see page 16.

**tYP 6** – see page 17.

* The control action (direct or reverse) is selected using a switch on the motherboard – see page 3.




Continued from page 7 ( tYP 1 ).

**Direct Acting Output 1**
The output is direct acting when the witch SW1 on the motherboard is set for direct acting output – see Fig. 1 or Fig. 2 on page 3.

**Reverse Acting Output 1**
The output is reverse acting when the switch SW1 on the motherboard is set for reverse acting output – see Fig. 1 or Fig. 2 on page 3.

Advance to next programme function.

**Time Proportioning Control 1**

Advance to next programme function.

The time proportioning control is adjustable from 5 to 60 seconds. Adjust to a value in the range 0 to 4 for ON/OFF control:

0 – deadband = 0%
1 – deadband = 0.25%
2 – deadband = 0.5%
3 – deadband = 1.0%
4 – deadband = 2.0%

see Appendix A2.3 on page 22

Set the value required, between 5 and 60 seconds, in 1 second increments or 0 and 4 for On/Off control.

Store

Advance to next programme function.

**Proportional Band 1**
Refer to Appendix A1.1 on page 20.

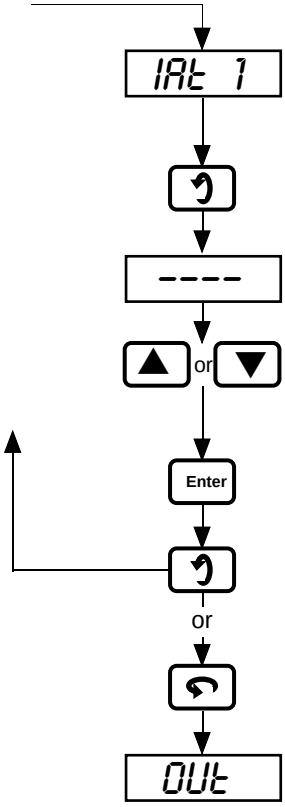
Advance to next programme function.

Set the proportional band value required, between 1 and 1000% in 1% increments.

Store

Advance to next programme function.

Continued on the next page.




Continued from previous page.

**Integral Action Time 1**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

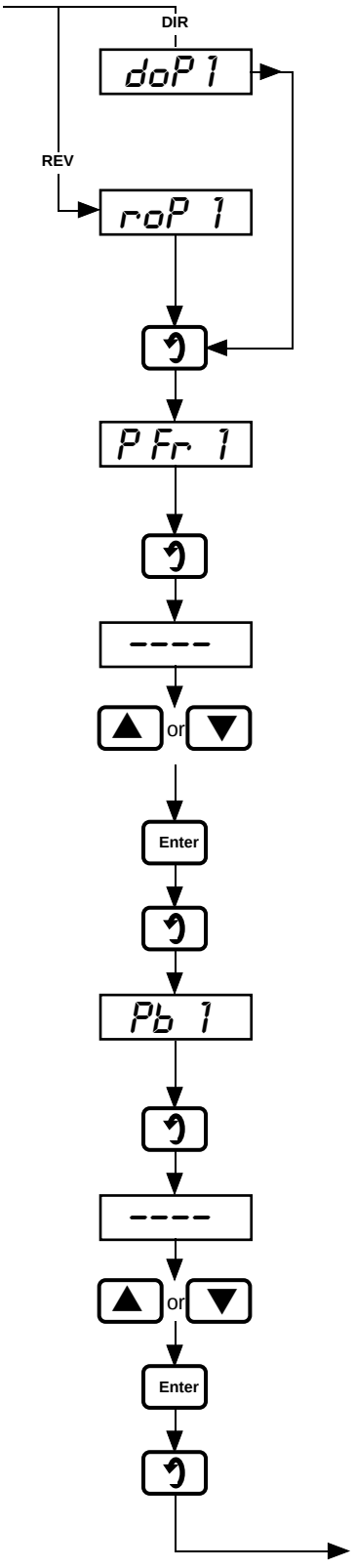
Set the required time, between 1 and 1800 seconds in 1 second increments. (1801 = OFF).

Store

Return to the top of the **Control Page**.

**or**

Advance to the **Output Page** – see page 23 in the Operating Instructions 4500/0012.




Continued from page 7 ( tYP 2 ).

**Direct Acting Output 1**
The output is direct acting when the switch SW1 on the motherboard is set for direct acting output – see Fig. 1 or Fig. 2 on page 3.

**Reverse Acting Output 1**
The output is reverse acting when the switch SW1 on the motherboard is set for reverse acting output – see Fig. 1 or Fig. 2 on page 3.

Advance to next programme function.

**Pulse Frequency Control 1**
Refer to Appendix A2.4 on page 22.

Advance to next programme function.

Set the pulse frequency required, between 40 to 120 pulses per minute in 1 pulse increments.

Store

Advance to next programme function.

**Proportional Band 1**
Refer to Appendix A1.1 on page 20.

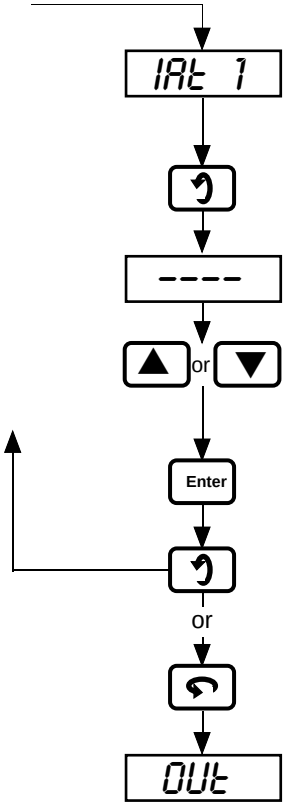
Advance to next programme function.

Set the proportional band value required, between 1 and 1000% in 1% increments.

Store

Advance to next programme function.

Continued on the next page.

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**Integral Action Time 1**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

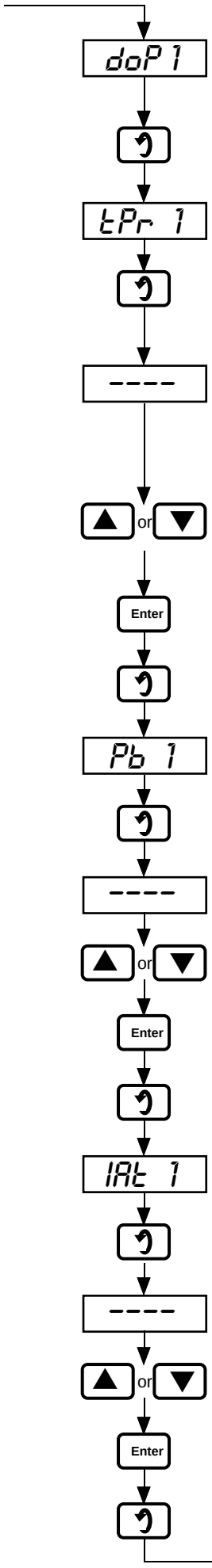
Set the required time, between 1 and 1800 seconds in 1 second increments. (1801 = OFF).

Store

Return to the top of the **Control Page**.

**or**

Advance to the **Output Page** – see page 23 in the Operating Instructions 4500/0012.




Continued from page 7 ( tYP 3 ).

**Direct Acting Output 1**
The output is always direct acting, regardless of the setting of SW1 – see page 3.

Advance to next programme function.

**Time Proportioning Control 1**

Advance to next programme function.

The time proportioning control is adjustable from 5 to 60 seconds. Adjust to a value in the range 0 to 4 for ON/OFF control:

0 – deadband = 0%
1 – deadband = 0.25%
2 – deadband = 0.5%
3 – deadband = 1.0%
4 – deadband = 2.0%

see Appendix A2.3 on page 22.

Set the value required, between 5 and 60 seconds, in 1 second increments or 0 and 4 for On/Off control.

Store

Advance to next programme function.

**Proportional Band 1**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the proportional band value required, between 1 and 1000% in 1% increments.

Store

Advance to next programme function.

**Integral Action Time 1**
Refer to Appendix A1.1 on page 20.

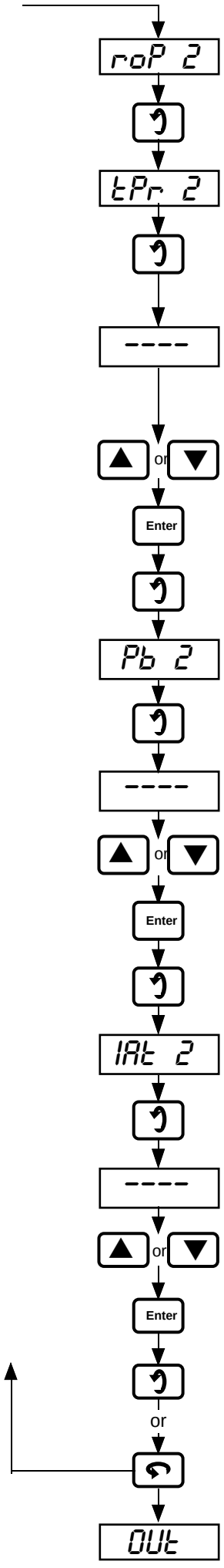
Advance to next programme function.

Set the required time, between 1 and 1800 seconds in 1 second increments. (1801 = OFF).

Store

Advance to next programme function.

Continued on the next page.




Continued from previous page.

**Reverse Acting Output 2**
The output is always reverse acting, regardless of the setting of SW1 – see page 3.

Advance to next programme function.

**Time Proportioning Control 2**

Advance to next programme function.

The time proportioning control is adjustable from 5 to 60 seconds. Adjust to a value in the range 0 to 4 for ON/OFF control:

0 – deadband = 0%
1 – deadband = 0.25%
2 – deadband = 0.5%
3 – deadband = 1.0%
4 – deadband = 2.0%

see Appendix A2.3 on page 22.

Set the value required, between 5 and 60 seconds, in 1 second increments or 0 and 4 for On/Off control.

Store

Advance to next programme function.

**Proportional Band 2**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the proportional band value required, between 1 and 1000% in 1% increments.

Store

Advance to next programme function.

**Integral Action Time 2**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the required time, between 1 and 1800 seconds in 1 second increments. (1801 = OFF).

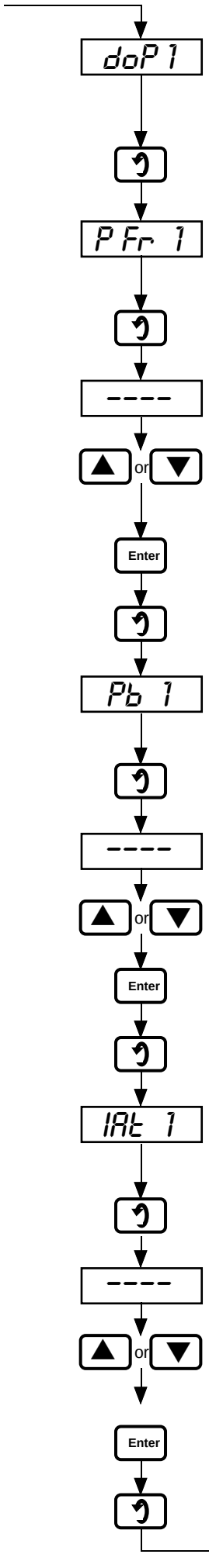
Store

Return to the top of the **Control Page**.

**or**

Advance to the **Output Page** – see page 23 in the Operating Instructions 4500/0012.

Continued from page 7 ( tYP 4 ).




**Direct Acting Output 1**
The output is always direct acting, regardless of the setting of SW1 – see page 3.

Advance to next programme function.

**Pulse Frequency Control 1**
Refer to Appendix A2.4 on page 22.

Advance to next programme function.

Set the pulse frequency required, between 40 and 120 pulses per minute, in 1 pulse increments.

Store

Advance to next programme function.

**Proportional Band 1**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the proportional band value required, between 1 and 1000% in 1% increments.

Store

Advance to next programme function.

**Integral Action Time 1**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

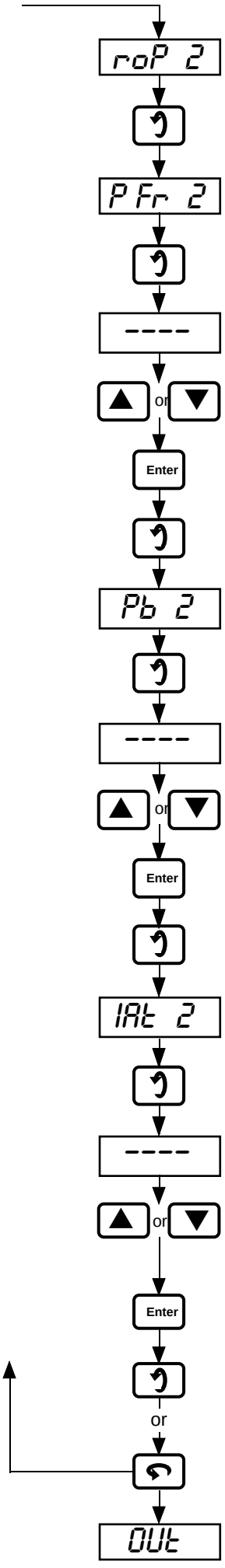
Set the required time, between 1 and 1800 seconds in 1 second increments. (1801 = OFF).

Store

Advance to next programme function.

Continued on the next page.

Continued from previous page.




**Reverse Acting Output 2**
The output is always reverse acting, regardless of the setting of SW1 – see page 3.

Advance to next programme function.

**Pulse Frequency Control 2**
See Appendix A2.4 on page 22.

Advance to next programme function.

Set the pulse frequency required, between 40 and 120 pulses per minute, in 1 pulse increments.

Store

Advance to next programme function.

**Proportional Band 2**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the proportional band value required, between 1 and 1000% in 1% increments.

Store

Advance to next programme function.

**Integral Action Time 2**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

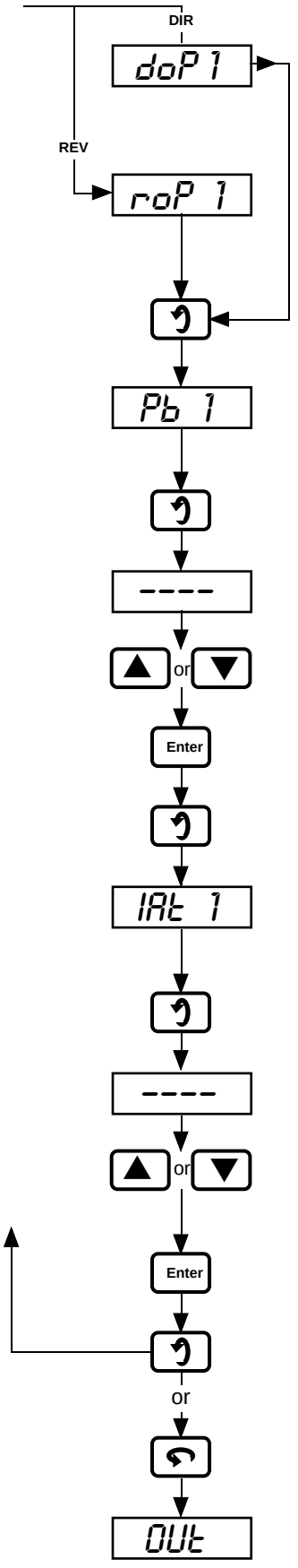
Set the required time, between 1 and 1800 seconds in 1 second increments. (1801 = OFF).

Store

Return to the top of the **Control Page**.

**or**

Advance to the **Output Page** – see page 23 in the Operating Instructions 4500/0012.




Continued from page 7 ( tYP 5 ).

**Direct Acting Output 1**
The output is direct acting when the switch SW1 on the motherboard is set for direct acting output – see Fig. 1 or Fig. 2 on page 3.

**Reverse Acting Output 1**
The output is reverse acting when the switch SW1 on the motherboard is set for reverse acting output – see Fig. 1 or Fig. 2 on page 3.

Advance to next programme function.

**Proportional Band 1**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the proportional band value required, between 1 and 1000% in 1% increments.

Store

Advance to next programme function.

**Integral Action Time 1**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the required time, between 1 and 1800 seconds in 1 second increments. (1801 = OFF).

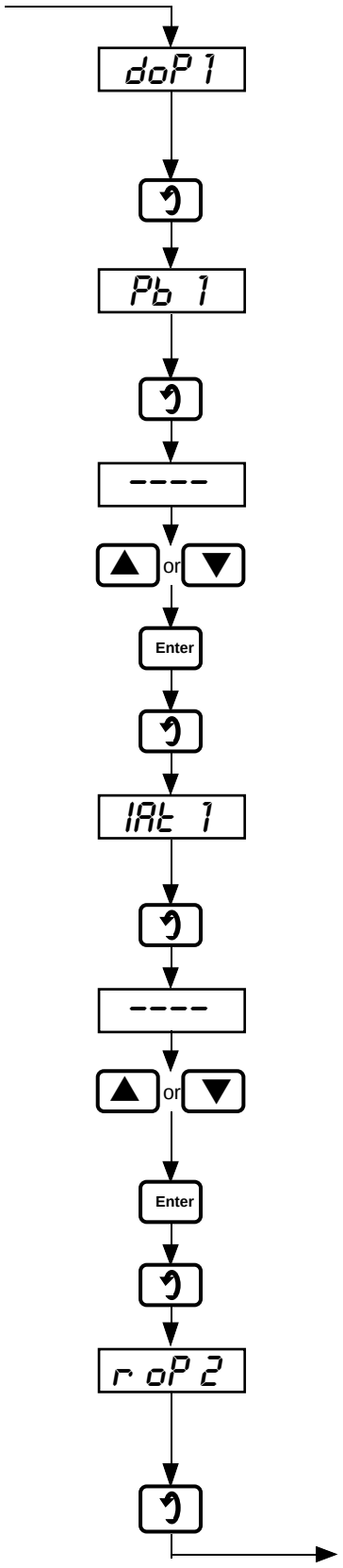
Store

Return to the top of the **Control Page**.

**or**

Advance to the **Output Page** – see page 23 in the Operating Instructions 4500/0012.

Continued from page 7 ( tYP 6 ).




**Direct Acting Output 1**
The output is always direct acting, regardless of the setting of SW1 – see page 3.

Advance to next programme function.

**Proportional Band 1**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the proportional band value required, between 1 and 1000% in 1% increments.

Store

Advance to next programme function.

**Integral Action Time 1**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the required time, between 1 and 1800 seconds in 1 second increments. (1801 = OFF).

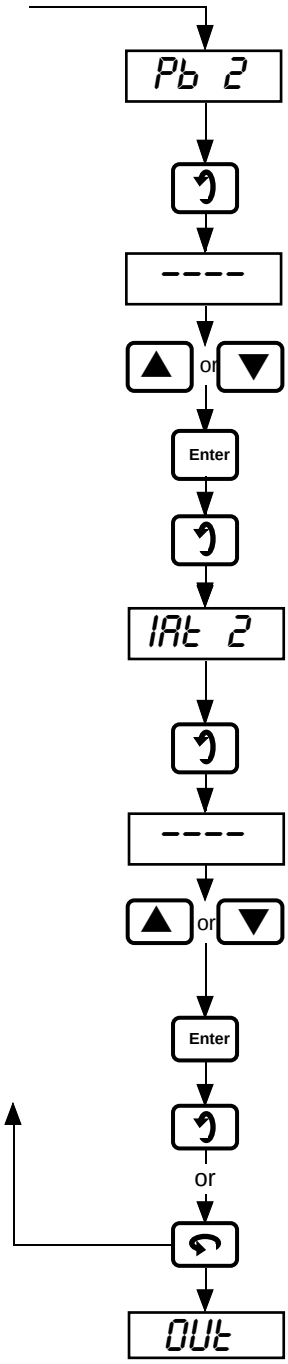
Store

Advance to next programme function.

**Reverse Acting Output 2**
The output is always reverse acting, regardless of the setting of SW1 – see page 3.

Advance to next programme function.

Continued on the next page.




Continued from previous page.

**Proportional Band 2**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the proportional band value required, between 1 and 1000% in 1% increments.

Store

Advance to next programme function.

**Integral Action Time 2**
Refer to Appendix A1.1 on page 20.

Advance to next programme function.

Set the required time, between 1 and 1800 seconds in 1 second increments. (1801 = OFF).

Store

Return to the top of the **Control Page**.

**or**

Advance to the **Output Page** – see page 23 in the Operating Instructions 4500/0012.

## SIMPLE FAULT FINDING

As detailed in Operating Instructions 4500/0012.

## ELECTRICAL CALIBRATION

As detailed in Operating Instructions 4500/0012.

## SPECIFICATION

As detailed in Operating Instructions 4500/0012 but with the following additions:

| | |
|---|---|
| **Control** | On/off or time proportioning. |
| On/off deadband | 0%, 0.25%, 0.5%, 1% or 2% programmable, displayed as doP (fail safe low, relay energised above setpoint) or roP (fail safe high, relay energised below setpoint). |
| Time proportioning cycle time | 5 to 60 seconds, programmable in 1 second steps displayed with doP or roP. |
| Pulse frequency | 40 to 120 pulses per minute. |
| Controller action | Reverse or direct, set by internal switch. |
| Controller function | P + I – available within P.I. limits. |
| Proportional band | 1 to 1000%, programmable in 1% steps. |
| Integral action time | 1 to 1800 seconds in 1 second steps, above 1800 = Off. |
| **Outputs and Setpoints** | |
| Number of setpoints | 2 if relay control, or 4 if analogue control. |
| Number of relays | 4 standard, 2 standard and 2 control. |
| Retransmission outputs | 2 maximum (1 standard, 1 optional) fully isolated (Note. If analogue control is required 2 retransmission outputs are needed). |

## IDENTIFICATION

| **Basic Type No.** | **Mounting** | **Temperature** | **No. of Alarm Relays/ Compensation** | **Power Supply** | **Retransmission** |
|---|---|---|---|---|---|
| **Code Digits 1,2** | **3,4/** | **6** | **7** | | **8** |
| | | | **110/230V A.C. Powered Instruments** | **10 to 30V D.C. Powered Instruments** | |
| 45<br><br>based analytical transmitter | 35 Wall-mounted Microprocessor<br><br>45 Panel-mounted transmitter | 1 Automatic + transmitter<br><br>7 Manual + P.I. control | 3 Three relays P.I. control<br><br>4 Four relays | D Three relays<br><br>E Four relays | 1 One (current)<br><br>2 Two (current) |

## APPENDICES

### A1 Setting Up a P+I System

Before a process can be satisfactorily controlled, the following conditions must apply:

a) the process should be capable of reaching a natural balance with a steady load

b) it must be possible to introduce small changes into the system without destroying either the process or the product.

The **Proportional Band** width determines the gain of the system. (The gain is the reciprocal of the proportional band percentage – e.g. a proportional band of 20% is equivalent to a gain of 5). If the proportional band is too narrow the control loop may become unstable and the system oscillate. With proportional band control only the system normally stabilises eventually, but at a point which is offset from the setpoint.

The addition of an **Integral Action Time** removes the offset. If the integral action time is too short the process goes into oscillation.

Integral action only operates when the measured variable is within the proportional band, thus avoiding integral saturation.

On start-up, if the process is changing rapidly there could be an unacceptable overshoot past the setpoint value.

The controller facilitates bumpless transfer from automatic to manual operation (and vice versa), providing the measured variable is within the proportional band and some integral action time has been programmed.

### A1.1 Setting for Optimum Performance

Check that the action is correct for the application. Select the **Control Page** and select **doP** or **roP.**

Direct output (doP) signifies that the output signal increases as the measured value increases.

Reverse output (roP) signifies that the output signal decreases as the measured value increases. If the action is incorrect, switch SW1(2) on the motherboard is in the incorrect position – see Fig. A2.2 or A2.3.

a) Before starting up a new process or changing an existing process, set **Proportional Band** to 100% and **Integral Action Time** to maximum (OFF).

b) Start up the process or change the load and note the response time (Fig A1.1). This gives an indication of the time to be allowed between successive adjustments of the controls.

**Note**. If the system goes into oscillation with increased amplitude (Mode B, Fig. A1.1) with the initial settings as specified at step a), set the **Proportional Band** to 200%.

If the system still oscillates as Mode B, increase the **Proportional Band** further until oscillation ceases.

If the system oscillates as Mode A or does not oscillate, proceed to step c).

c) Reduce the **Proportional band** by 20% steps and observe the response. Continue until the process cycles continuously without reaching a stable condition, i.e. it exhibits a sustained oscillation with constant amplitude (Mode C, Fig. A1.1). This is the critical point.

d) Note the cycle time 't' of the process at the critical point (Fig. A1.1) and the **Proportional Band** width (critical value).

e) Set the **Proportional Band** to:
2.2 times the critical value (for P+I control)
2 times the critical value (for P only control)

f) Set the **Integral Action Time** to:
$\frac{t}{1.2}$ (for P+I control)

The controller is now ready for fine tuning by small adjustments to the P and I terms, after the introduction of a small disturbance of the setpoint.

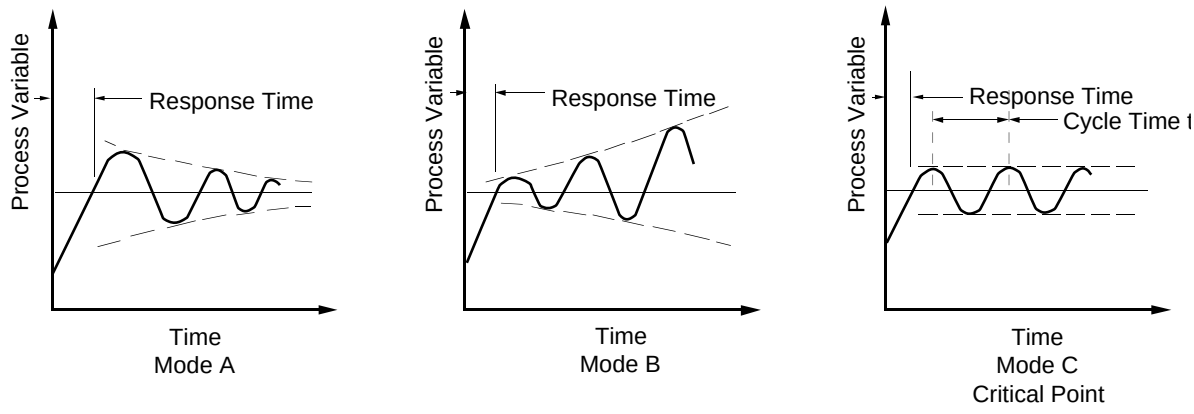



**Fig. A1.1 Control Conditions**

## A2 Control

### A2.1 Single Setpoint Operation – Fig. A2.1

Controller action (direct or reverse) is selected using a switch on the motherboard:

SW1(2) on Wall/Pipe-mounted – see Fig. 1 on page 3
SW1(1) on Panel-mounted – see Fig. 2 on page 3.

### A2.2 Two Setpoint Operation – Fig. A2.4

With a two setpoint system, the pH controller attempts to keep the measured variable at the artificial setpoint value (ASPT). This artificial setpoint is exactly midway between setpoint 1 (SPT 1) and setpoint 2 (SPT 2) when the proportional bands are equal. If the proportional bands for relays 3 and 4 are not equal the following equation can be used to calculate the artificial setpoint:

$$ASPT = \left[ \frac{PROP\ 2}{PROP\ 1 + PROP\ 2} \times SPT\ 1 - SPT\ 2 \right] + SPT\ 2$$

When the percentage output falls to the cut-off point, the pH controller ensures that both relay 3 and relay 4 remain switched off.

**Note**. Setpoint 1 **must** always be greater than setpoint 2.

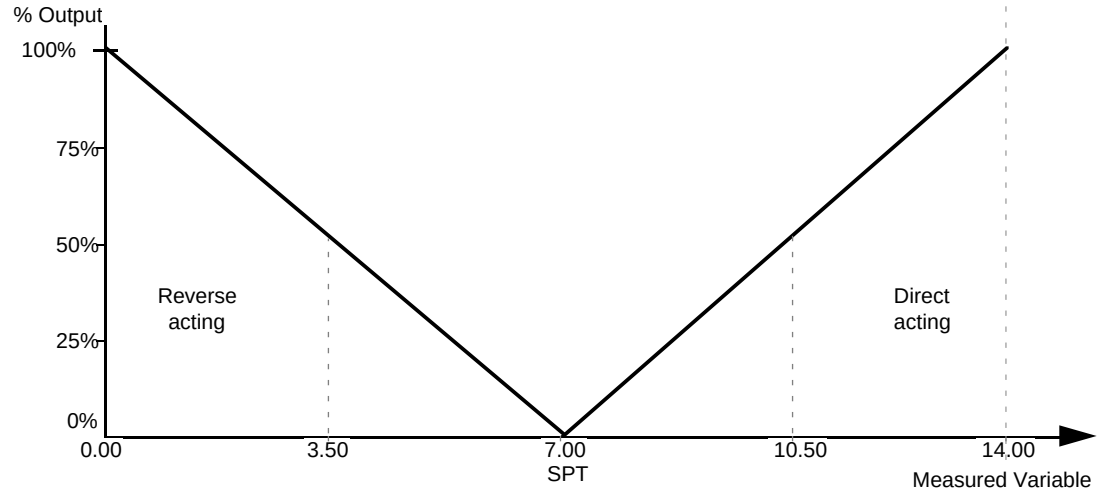



**Fig. A2.1 Single Setpoint – Direct and Reverse Acting**

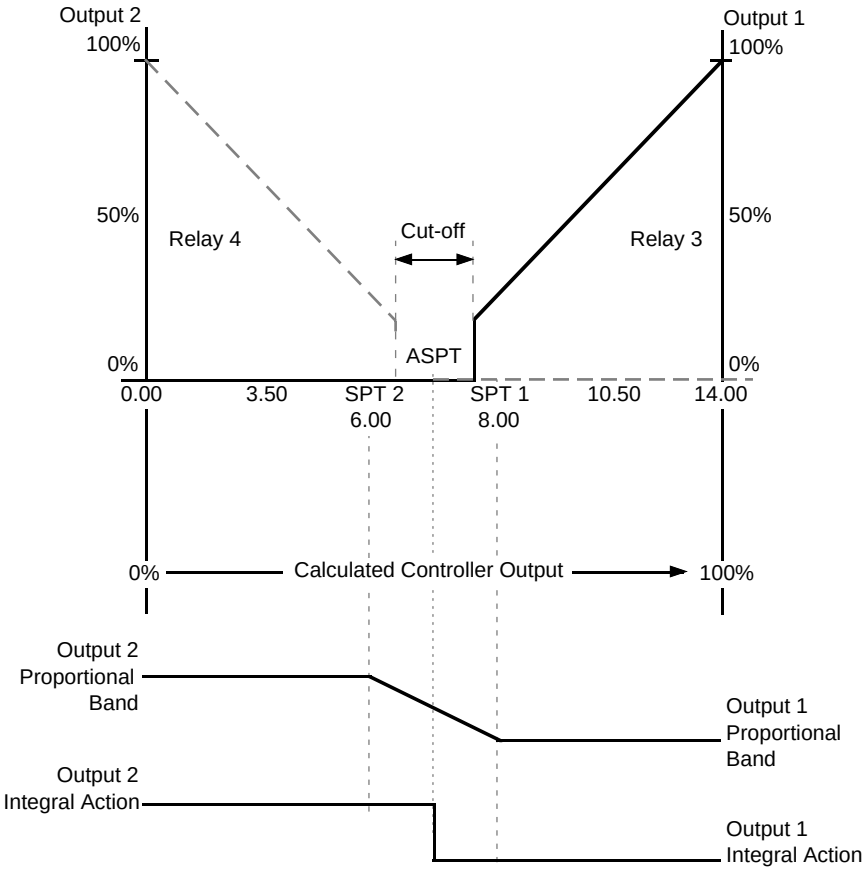



**Fig. A2.2 Two Setpoints – Outputs**

**A2.3 Time Proportioning Control – Fig. A2.3**
Time proportioning control operates by energising and de-energising relays for time periods depending on the difference between the setpoint and measured variable values (commonly known as mark/space control). The greater the difference the longer the relay remains energised.

**Example** –
Measured variable = setpoint, there is no output (0%).
Measured variable greater than setpoint the output is:
direct acting – output > 0%
reverse acting – no output (0%)
Measured variable less than setpoint the output is:
direct acting – no output (0%)
reverse acting – output > 0%

With no output the relay is permanently de-energised but with an output the relay is energised for a proportion of the cycle time equal to the percentage output.

**Example** (refer also to Fig. A2.3) –
If the cycle time (tPr) is set at 10 seconds and:
output is 0% – relay permanently de-energised
output is 50% – relay energised for 5 seconds and de-energised for 5 seconds
output is 100% – relay permanently energised (10 seconds).

The cycle time (tPr) can be set between 5 and 60 seconds. Values of 0 to 4 give ON/OFF control with deadband facility:

| Cycle Time | Deadband |
|---|---|
| 0 | 0% |
| 1 | 0.25% |
| 2 | 0.5% |
| 3 | 1.0% |
| 4 | 2.0% |

Deadband % = % of span value, i.e. for a span value of 14.00pH, a deadband of 1% and a setpoint of 7.00pH, the relay energises between 6.93 and 7.07pH.

**A2.4 Pulse Frequency Control – Fig. A2.4**
Pulse frequency control operates by pulsing a relay on for 300ms and off for a period of time determined by the pulse frequency. The pulse frequency (PFr) can be adjusted between 40 and 120 pulses per minute. The greater the difference between the measured variable and the setpoint the greater the pulse frequency.

**Example** – If the pulse frequency is set at 120 pulses per minute and the percentage output is 100% then the pulse rate is 2 pulses per second – see Fig. A2.4(a). Reduce the percentage output to 50% and the pulse rate is one pulse per second – see Fig. A2.4(b).

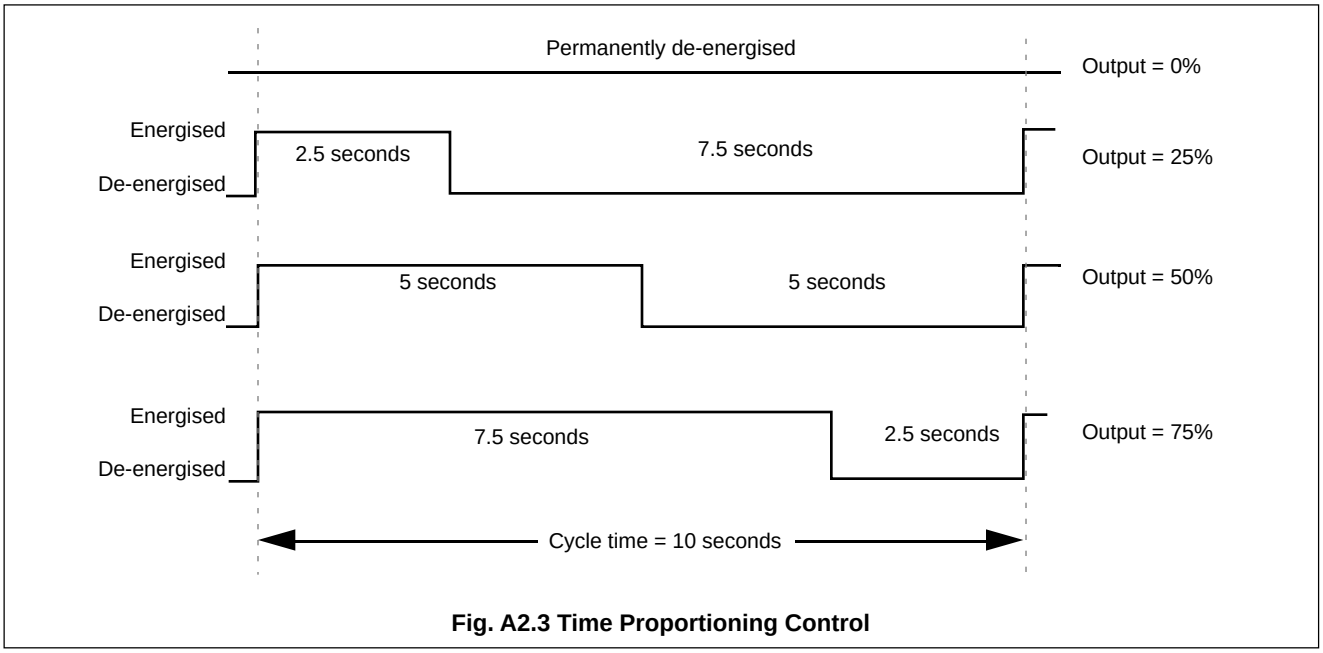



**Fig. A2.3 Time Proportioning Control**

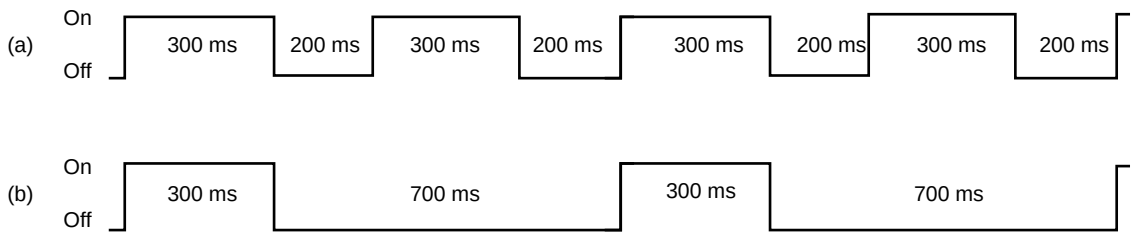



**Fig. A2.4 Pulse Frequency Control**

## NOTES

## NOTES

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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 operating and maintenance records relating to the alleged faulty unit.

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