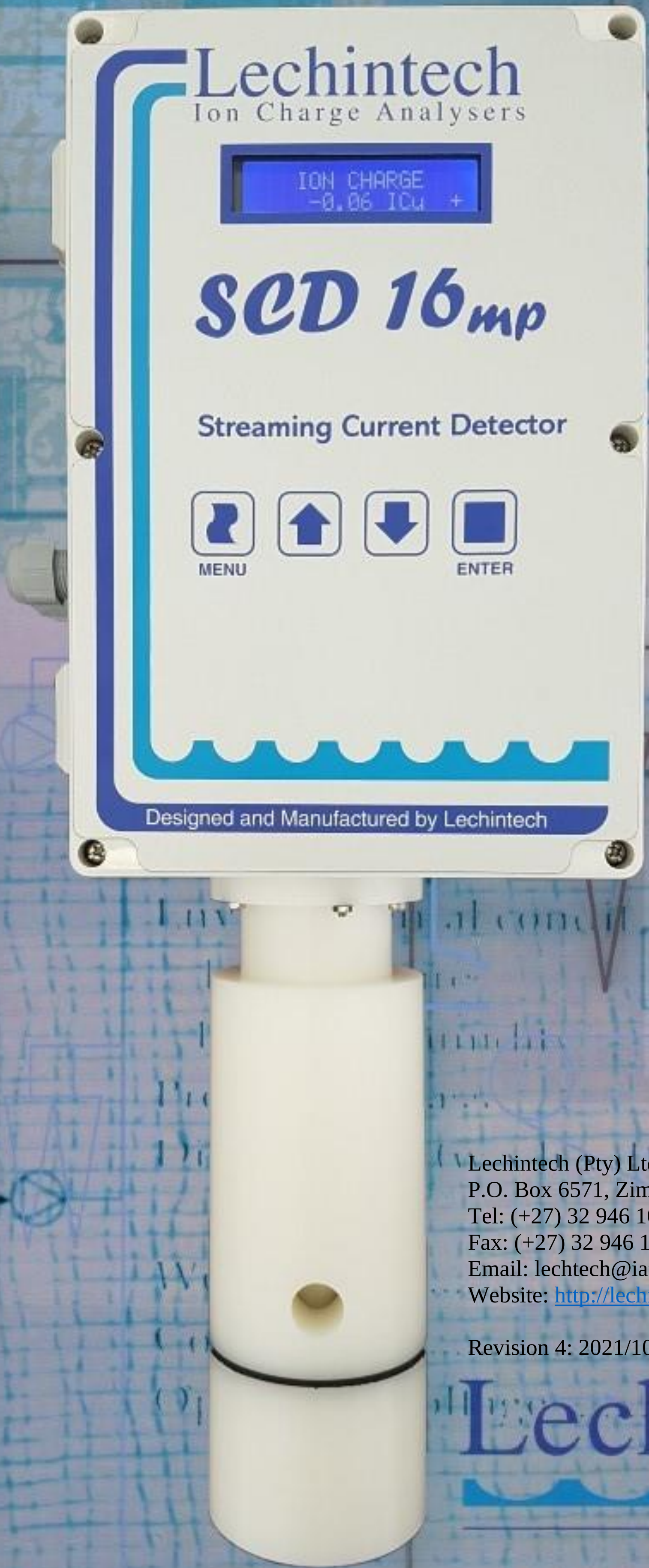
The Lechintech SCD 16mp



Your window on Colloidal Chemistry

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Lechintech

SCD 16mp ION CHARGE ANALYSER
OPERATING AND INSTRUCTION MANUAL

TABLE OF CONTENTS

1. INTRODUCTION

The Lechintech SCD 16mp is an instrument that has been developed to indicate the state of the chemistry in water particulate suspensions. The chemistry of these systems can be monitored by measuring the surface charge of the suspended particles in the fluid medium. The instrument determines the surface charge of the suspension by the streaming current technique, whereby; a current is developed due to the potential induced between two electrodes by the forced movement of the charged particles past the electrodes.

The probe has been designed for use as a laboratory instrument, or as a splash proof field instrument either for the on line measurement and control of a system, or just system monitoring. The ion charge is displayed on a two-line 16-digit liquid crystal display, with a two decimal accuracy.

The charge signal is available as a 4-20 mA output, allowing integration with most standard field instrumentation, for recording and control purposes.

The cost saving benefits of the ion charge analyzer are realized through its ability to be used to control the rate of addition of water treatment chemicals for clarification, filtration, retention, or drainage. This is generally done after the relevant trial work has been carried out to establish the optimum control criteria, viz. sampling point, charge control set point and tuning constants of controller. Once these have been established an automatic dosing control system can be implemented.

1.1 Symbols Used

⚠ Warning: Instructions must be followed for personal safety. Injury may result if instructions not followed.

Caution Caution: Instructions must be followed for correct equipment operation. Damage may result if instructions not followed.

Note Note: Important features for correct operating procedure regarding equipment or a process.

1.2 Acronyms and Definitions Used

ICA – ion charge analyzer
SCD – streaming current detector (also known as, SCM – streaming current monitor)

ICu – ion charge units (Lechintech units of measurement)

PLC/PAC – programmable logic controller, programmable automation controller
DCS – distributed control system
SCADA – supervisory control and data acquisition

PI controller – proportional integral controller

PV – process value
CV – control value
SP – setpoint value

NO – normally open (contact open when relay inactive)
NC – normally closed (contact closed when relay inactive)

H – height, W – width, D – depth

2. WHAT IS CHARGE ANALYSIS?

Charge analysis is the measurement of the electro kinetic charge of a solution due to the presence of charged particles. The electrokinetic charge can be measured by a number of different methods.

2.1 Applied Electric Field

Measure: The relative mobility of the solid or liquid phase, e.g. Electrophoresis

This is the first method developed for calculating the Zeta potential. The motion of charged particles under the influence of an electric field was observed and the potential required to achieve certain particle mobility was measured. A cell consisting of two flat plates separated by approximately 0.1 mm and having an electrode at each end of this cell, as shown in Figure 1, is filled with water containing suspended matter. When an electrical potential is applied to the electrodes, the particles can be observed to drift towards one of the electrodes. This is confirmed by reversing the polarity of the electrodes, and observing the reverse drift of the particles.

The speed of drift is measured, and from this, the Zeta potential can be calculated. It is effectively then, a measure of the charge on the particles observed.

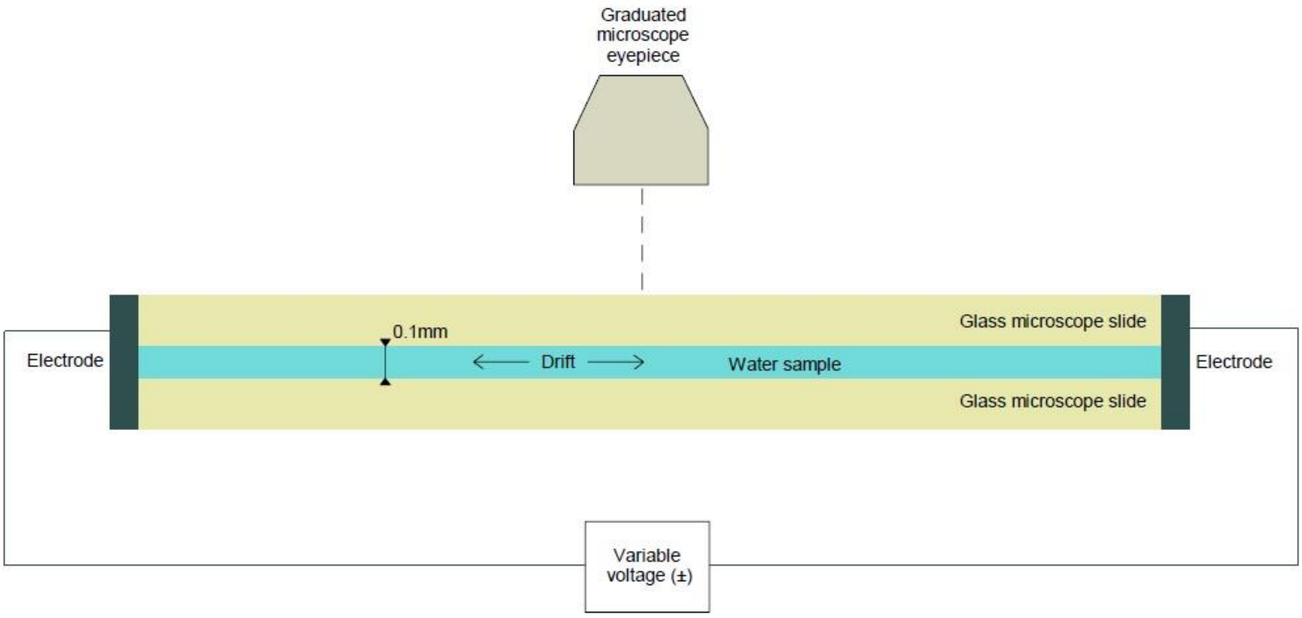


Figure 1: Measurement of Zeta potential using an applied electrical potential

2.2 Induced Electric Potential

Measure: The potential developed as a result of the forced movement of particles in the solution, e.g. Sedimentation potential or Streaming potential (used by Lechintech).

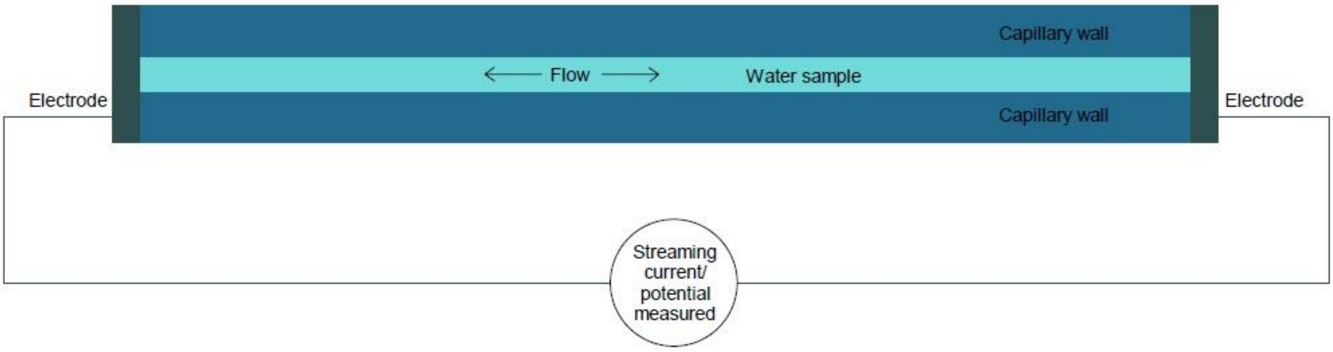


Figure 2: Measurement of Streaming current/potential using generated flow

3. THE LECHINTECH ION CHARGE ANALYSER

Just as a generator is to a motor, so the streaming current measurement is to the mobility of charged particles in the presence of an applied potential. The Lechintech streaming current detector works on the principle of generating a current by forcing a flow of charged particles between two electrodes.

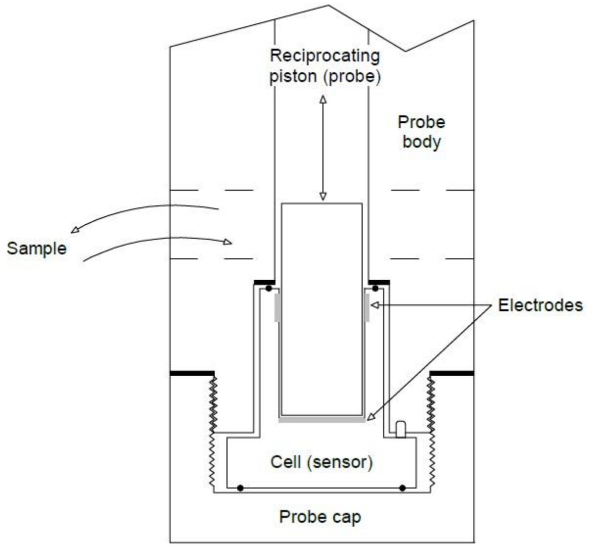
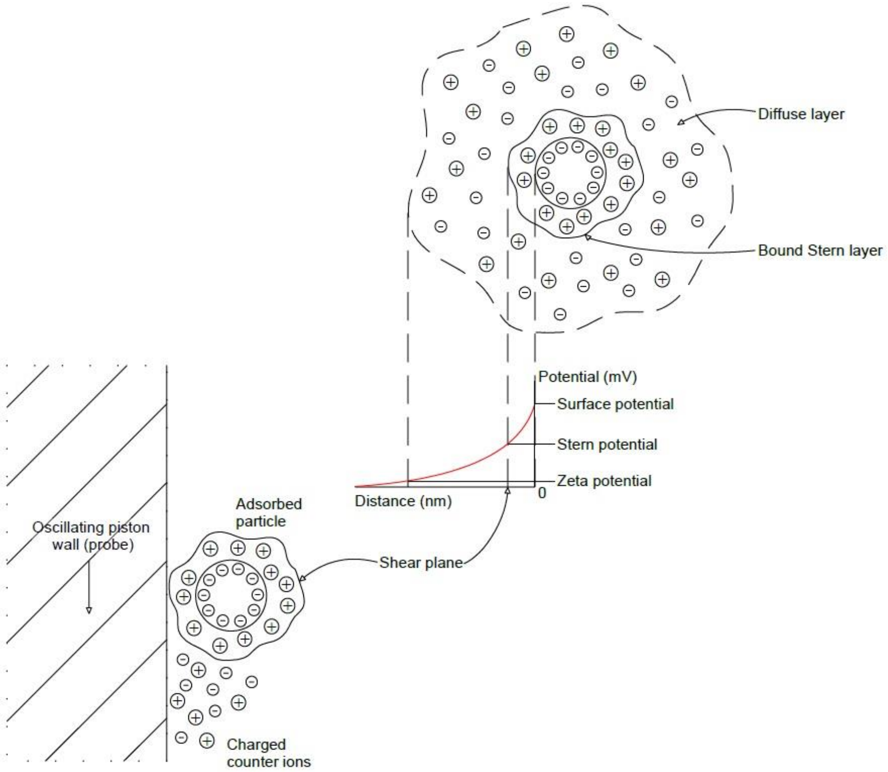


Figure 3 shows a schematic of the Lechintech streaming current detector. A continuous sample is directed into an annulus inside which a displacement piston, or probe, oscillates at a fixed frequency. The oscillating movement of the piston causes the liquid sample to flow along the wall of the cell.

Figure 3: The Lechintech Streaming Current Detector

Suspended particles are adsorbed onto the walls under the action of Van der Waal's and electrostatic forces, see Figure 4. As the sample is moved rapidly back and forth, mobile counter ions surrounding the charged particles, or colloids, are sheared near the surface of the particle and moved past the electrodes.



As potential difference is induced between two electrodes at the top and base of the cell. The resultant potential developed, proportional to charge is electronically processed to give a reading of the streaming current in ICu, ion charge units.

The streaming current detector has been calibrated so as to give a negative reading if the particles in suspension are negatively charged, and similarly a positive reading for a positively charged system. The greater the magnitude of the current, the higher the charge of the system being measured, and consequently the greater the mutual repulsion between the particles in the suspension.

Figure 4: Streaming Current Development

This fact is fundamental to the use of the instrument, as it allows the on-line measurement of the ionic charge of a water system, and decisions can be made as to the dosage required to maintain the best water quality.

4. DESCRIPTION OF THE SCD

The Lechintech Streaming Current Detector (SCD) has three distinct parts;

a. The body that houses the cell and probe
b. The mechanical drive
c. The electronic pack

4.1 The Body

Caution The body has a removable cap, two rubber gaskets, a set of O-rings, and a cell and probe set. The cell contains two electrodes between which a potential is developed due to the motion of the probe in the cell interacting with the water and suspended matter. The frequency of the alternating signal is ± 4 Hz, and the AC signal is sent via the signal cable to the electronics pack. To completely remove the cell from the body, the cable must be disconnected from the terminals on the PCB and the cable pulled through the length of the body. To replace the cell the reverse procedure must be followed. When replacing the cell after opening the end cap, care must be taken to ensure that the locating pin is seated correctly so as not to kink or damage the signal cable. A further consideration is the correct location of the three O-rings and two flat seals before securing the cell in place, and ensuring that there is no moisture on the cell base and in the body cap. Due to the fine tolerance to which the cell and probe are machined, it is important to ensure that grit particles do not enter the cell area as this will accelerate wear. See Section 11 for further detail.

Caution The probe tip is removed by loosening it with the PVC spanner supplied with the replacement kit. The cell and the probe tip should be replaced as a set. To replace the probe tip, insert the tip into the PVC spanner and screw it firmly onto the probe shaft, making sure that it is not over tight (do not use any other tools for this job). The probe setting has been done in the workshop prior to dispatch. If the probe shaft and connecting rod are removed from the SCD then set the depth of the probe to protrude past the end of the body, using a straight edge, to a distance of approximately 1 mm. Replace the cell and cap. Turn the cam by hand to ensure that the probe does not bottom on the cell electrode; this will cause the mechanism to jam. If the probe does bottom out, remove the cap and cell and adjust by turning the probe in one turn. Assemble and check for free operation. The overall length of the probe and adjustment shaft should measure 196 mm. This length is set at the factory but can be adjusted by loosening the nut and screwing the rod into, or out of, the plastic probe section. Ensure that new tab washers are used if adjustments are made and that the locking nut is tightened and secured if an adjustment is made. See Section 11 for further detail.

Replacement of the cell and probe is necessary when either one or both of these parts show extreme scoring, or when the span calculation fails when the unit is calibrated in standard positive calibration solution.

4.2 The Drive Mechanism

The drive mechanism includes a 12 VDC motor and gearbox combination, a mounting bracket and a cam and follower assembly. Mounted on a bracket are the motor and cam adjustment screws. On the sensor card (which is secured to the stainless steel device plate), is mounted a photo interrupter which is activated by the slotted wheel at the end of the cam.
The signal derived from this mechanism is used for:

a. The logic part of the instrument that actuates the motor trip relay when the signal is less than 2 Hz.
b. The sample trigger circuit used in the signal generation.

The motor speed is adjusted automatically by the microprocessor based speed control program. The motor direction of rotation must be anticlockwise for the equipment to function correctly. To change motor direction, reverse the polarity of the motor leads at the mascon plug on the motor board. The cam is pressed onto the gearbox drive shaft and located by means of a 4 mm grub screw. The slotted detector plate has been set at the factory and should not be moved under any circumstances. The probe connecting rod is screwed into the bottom of the cam follower and tightened into place by a lock nut and tab washer. A small amount of silicone grease can be used to lubricate the cam and follower and the lips of the probe connecting rod seal. See Section 11 for further detail.

4.3 The Electronics Pack

The electronics pack is made up of the motherboard and the display board. This, along with the mechanical drive section is mounted into an ABS enclosure, which is splash proof, with IP 53 rating. The digital display and function keys are mounted onto the hinged front cover of the instrument. The side of the box is provided with two cable glands, for the power and signal connections to the motherboard terminals via a Lechintech terminal box with IP68 cable connectors.

Electrical connections are shown in Section 6.4 of this manual.

4.4 Manufacturer and Distributors

Company:

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Fax: +603-9101 7569
GST No: 002041815040
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Sydney: Phone – (02) 9319 1808
Brisbane: Phone – (07) 3299 7881
Melbourne: Phone – (03) 9859 0157
Auckland: (09) 525 3425
Email: sales@pcspl.com.au
Website: http://www.pcspl.com.au

5. SPECIFICATIONS AND SAFETY NOTES

5.1 Technical and Material Specification

Power Supply:	85-264 VAC, 47-63 Hz at 12 VA, additional feature 24 VDC, fused 1 A. A solid earth connection is essential.
Signal Outputs:	SCD O/P – Ion Charge analogue 4-20 mA output, 12bit D/A resolution, scaled process value dependent on span setting, default setting -5.00 ICu to +5.00 ICu.
	TRIP – Trip relay output, normally open (NO) contact 250 VAC, 2 A rating, Contact - closed when SCD motor running, open when SCD motor stalled or fault.
Signal Input:	CAL – Calibrate digital input, 5 VDC sense voltage, requires potential free contact. Input – ON, perform automatic calibration. Requires automation of calibration procedure.
Indication and Controls:	LCD, 2-line, 16-digit, backlit.
	Keypad, 4 buttons, Menu, Increment, Decrement and Enter.
	Electronics, LCD and keypad ABS enclosure IP53 rated.
Probe:	Immersible to depth of 120 mm in sample.
	Material HDPE and POM.
	Wetted materials - HDPE, POM, Stainless Steel, Neoprene, ABS.
Dimensions:	SCD 16mp dimensions – 445 mm height x 160 mm width x 100 mm depth.
Weight:	SCD 16mp complete unit – 4.5 kg.

Standard Accessory: (Sold Separately)	For water treatment (potable water) applications – Cyclone sample pot, stainless steel material, 1” DN25 inlet and drain stainless steel ball valves, 1” BSP threaded female inlet and 1” BSP male threaded drain connection, 30-40 l/min sample flow rate required.
	Cyclone sample pot dimensions – 405 mm height x 160 mm diameter, volume 6.5 l. Cyclone sample pot assembly dimensions – 750 mm height x 460 mm width x 220 mm depth.
	Cyclone sample pot assembly weight – 9.0 kg.

Note All specifications subject to change without prior notice.

Note For small water treatment plants, the required sample rate is a substantial percentage of the throughput of the plant. A sample rate of 30-40 l/min equates to 1.8–2.4 m³/h, hence systems should be installed to recover the treated sample water.

5.2 Safety Schedule

⚠ Do not undertake any work or maintenance on this equipment if you are not qualified or trained to do so. Use only specified components to carry out repairs and maintenance.

1. The mains power point and possibly the alarm contact connector are supplied from voltage sources external to the instrument. Consider all terminals live until all sources of supply have been disconnected.
   a. Isolate the incoming power by switching the instrument off and removing the plug from the socket.
   b. With the SCD open check there is no external supply to the alarm contact connectors.

2. Before removing the securing screws and front covers from the SCD, ensure the supply has been isolated. This is necessary to ensure the rotating cam and follower is stationary and cannot start whilst working in the instrument. The rotating cam should be considered a hazard if operating without the front cover in place.

3. DO NOT allow the SCD to run in an upside-down position. Possible ingress of moisture into the electronics could cause a risk of electric shock as well as damage to the electronics.

4. Only remove the front cover from the SCD to carry out routine instrument calibration. (Removing the cover allows for access to output connections to facilitate measurement of the mA signals for calibration purposes). Replace the cover securely before placing the instrument into service.

5. When carrying out routine maintenance and cleaning of the SCD adhere to all safety rules and conditions applicable to the work being carried out. Use components for replacement supplied by Lechintech only. When cleaning scale from the instrument sensor and body using the mild HCI or NaOH (3 – 5 % concentration) solutions described in the manual, strict adherence to standard safety precautions is required.

5.3 Environmental Operating Limits

1. Ambient Temperature 0 °C to 40 °C
2. Sample Temperature 5 °C to 60 °C
3. Maximum Humidity 90 %
4. IP53 Rating

Note To ensure that no moisture enters the cell electrode connections, the O-rings and flat seals should be changed every six months or if they are deformed or damaged.

6. INSTALLATION

6.1 Mechanical Installation

The SCD 16mp is generally installed directly into a Cyclone sample pot lid. The probe body can be used for positioning with a custom mounting bracket in other installations such as channels or sample vessels. The rear of the SCD 16mp enclosure can be used for wall mounting if required.

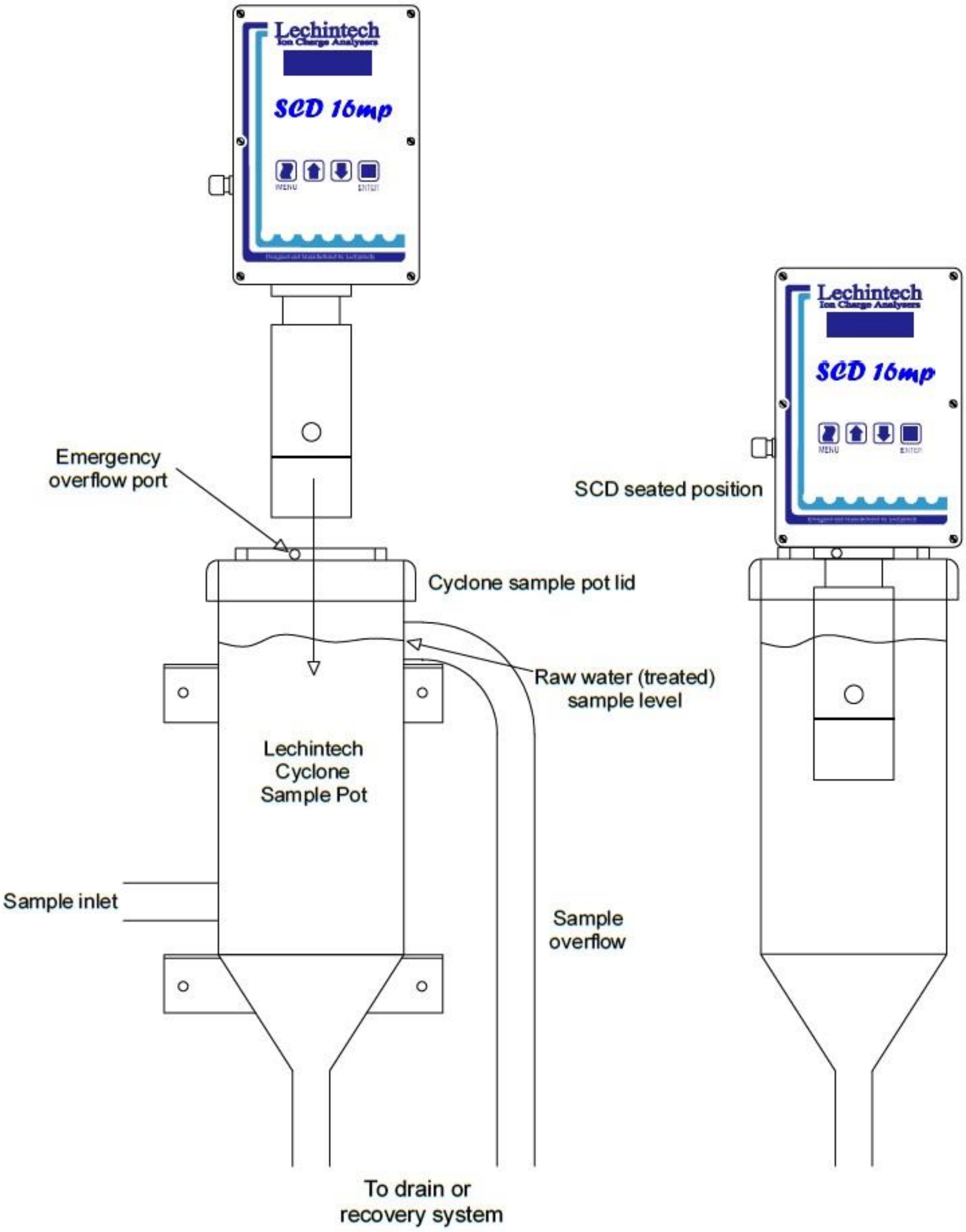


Figure 5: SCD 16mp standard installation

Note	For outdoor installations it is essential to have an enclosure protecting the SCD 16mp and Cyclone sample pot lid.
Note	For small water treatment plants, the required sample rate is a substantial percentage of the throughput of the plant. A sample rate of 30-40 l/min equates to 1.8–2.4 m³/h, hence systems should be installed to recover the treated sample water.

The SCD 16mp can be located directly in a flowing stream for entry into a clarifier, etc., provided the stream is not contaminated with particulate matter of a solid nature, greater than 0,1 mm particle size.

Note	Water with only flocculated particulate matter does not affect the probe adversely. Fibrous or sandy contaminants scratch the surface of the cell and probe, and the equipment will have to be tested first to establish reliability before using in a control loop.

The three scenarios shown in Figure 6, indicate a cross section of the incoming raw water pipe, and the sample point connections made directly onto it.

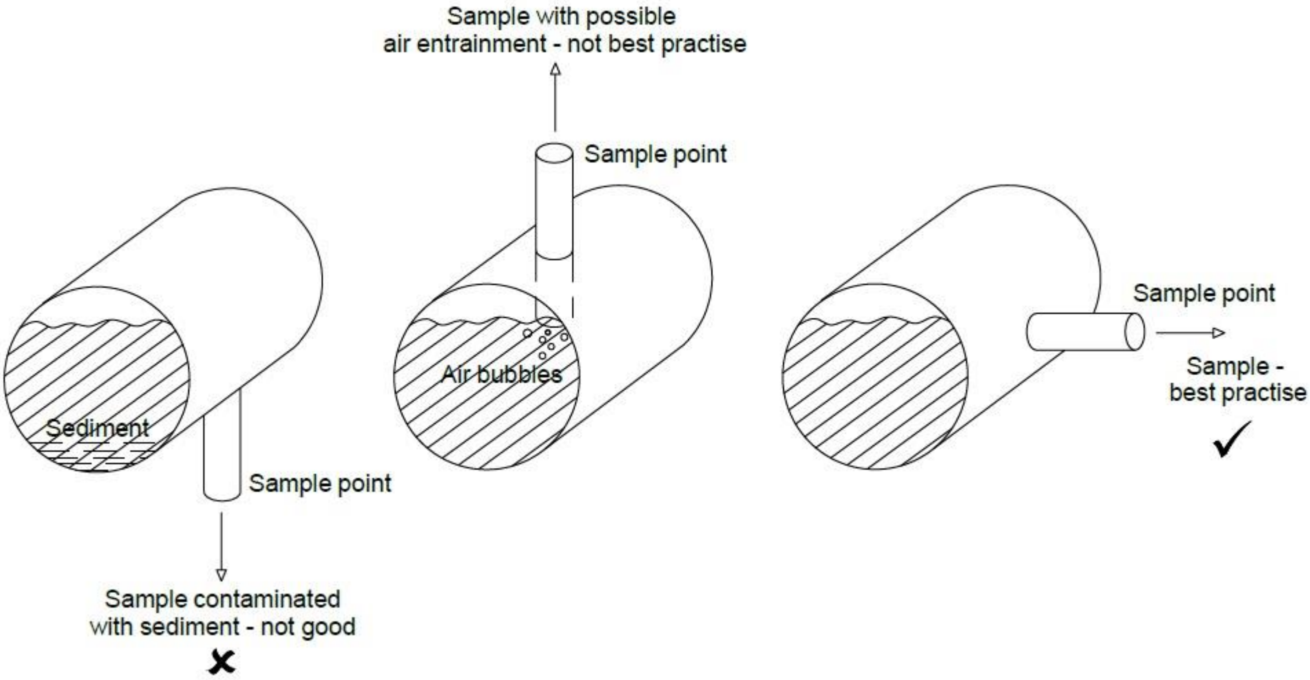


Figure 6: Sample point stream scenarios

The sampling point distance from the dosing point should be long enough to provide sufficient mixing time, but should not be less than 10 pipe diameters away from the dosing point, or 5 diameters after an elbow. The primary objective is to get the best possible mixing of the chemical with the raw water and the lowest possible lag time between the addition point and the measurement point.

For continuous sampling from the pipeline, it is recommended that a flow rate of between 30 and 40 l/min be drawn to a Cyclone sample pot, which overflows continually. The SCD 16mp probe should be immersed 80 mm below the sample surface. A bottom drain on the sample pot is an advantage, and should be open to ensure a continual purge of grit and heavy particles.

Should the sample be gravity fed from an open channel then the intake must have a filter to prevent debris from entering the sample line. The suction point must also be positioned far enough below the water surface to prevent the syphon flow from being interrupted when the plant is stopped. Allowance must be made to prime the sample line when utilizing this option.

Note	For small water treatment plants, the required sample rate is a substantial percentage of the throughput of the plant. A sample rate of 30-40 l/min equates to 1.8–2.4 m^3/h, hence systems should be installed to recover the treated sample water.

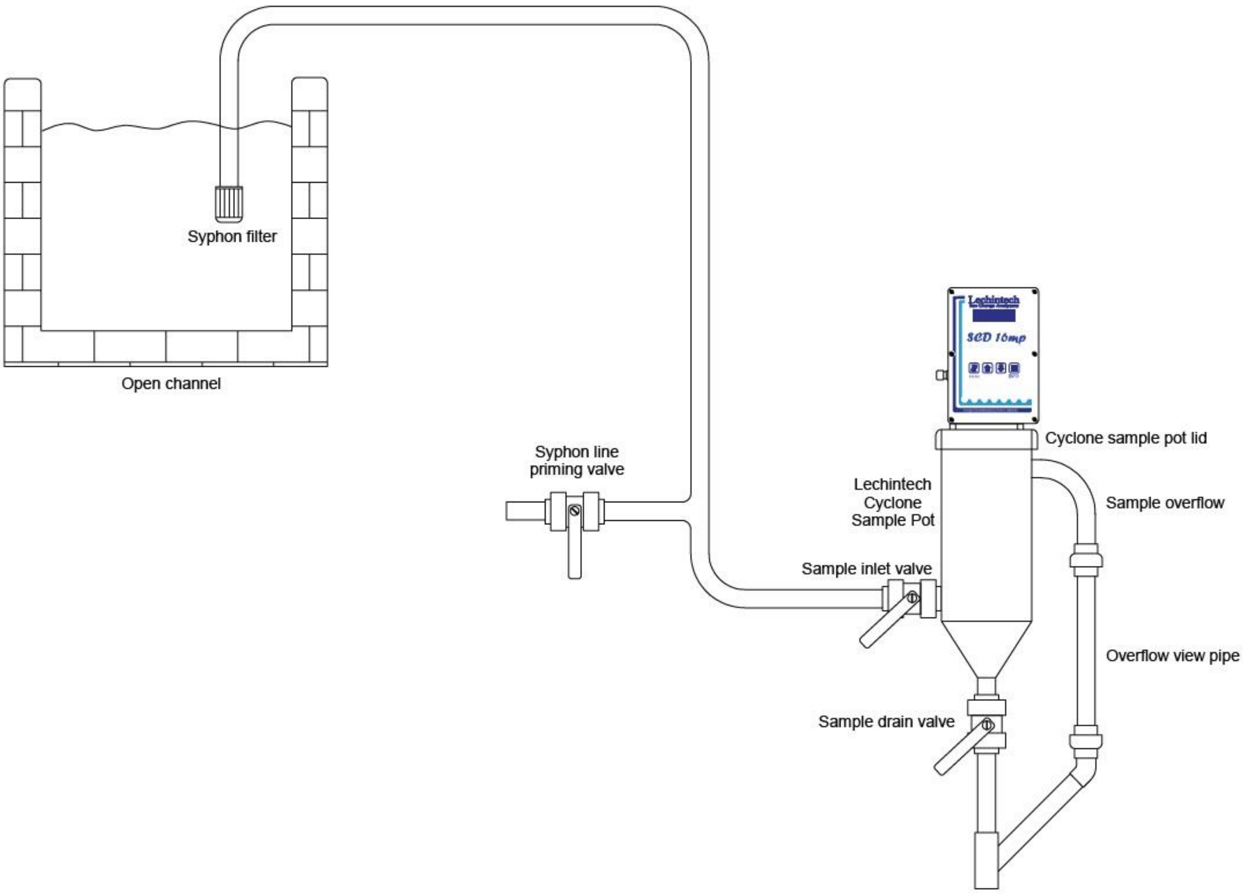
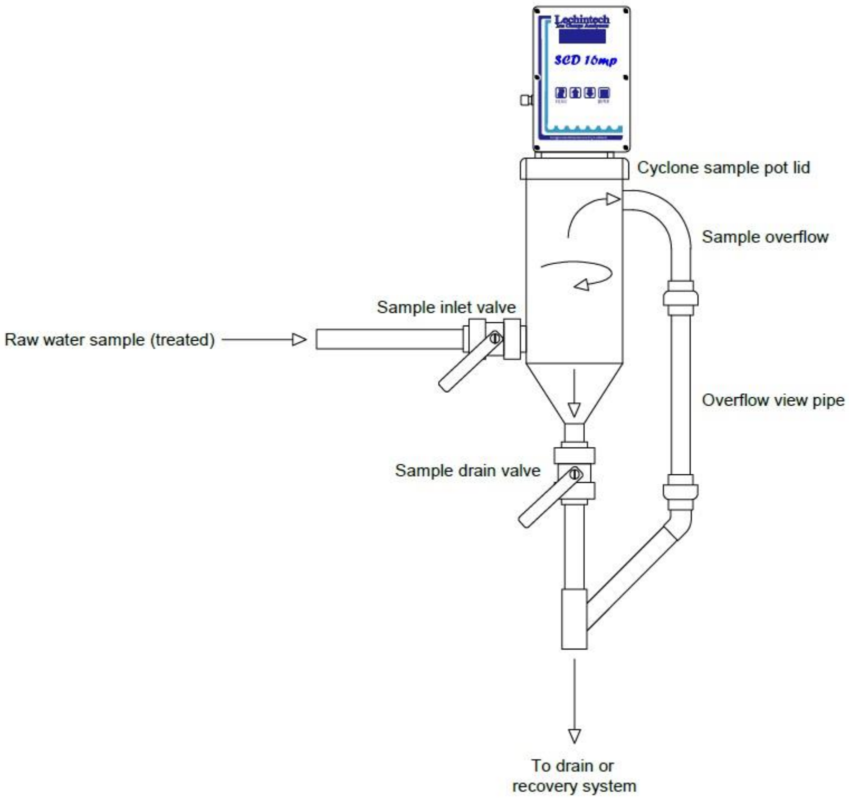


Figure 7: Gravity (syphon) feed sample example

6.2 Cyclone Sample Pot – Water Treatment



Cyclone type sample pot - for use in high turbidity and high grit loading applications. The water flow through this type of sample pot is in the region of 30-40 l/min. The inlet flow can be regulated on the inlet valve. It is preferable to have the drain valve open as widely as possible, but still maintaining the overflow pipe level at halfway mark.

The cyclone rotation action will allow for the heavy fraction of the sample to be forced outwards, down and eventually out of the drain valve.
The SCD 16mp is located in the center of the sample, thus limiting the amount of grit that will be introduced into the measuring sensor.

Figure 8: Cyclone sample pot and sample flow directions for water treatment works

Should the inlet flow not be adequate to maintain the overflow level, then, the drain valve must be throttled back to maintain the overflow level. If the underflow through the drain valve has to be stopped to maintain the water level in the sample pot, then the operator should purge the sample pot of the settled fraction at least once per shift, or whenever there is a build-up of grit in the bottom of the pot.

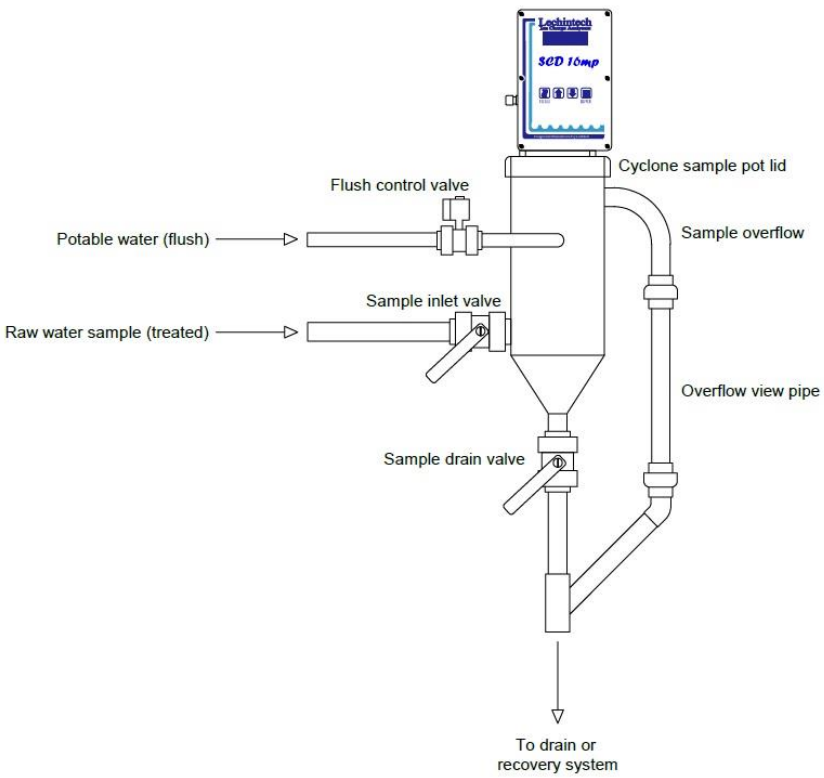
Note

In all instances, when making changes to the Cyclone sample pot flow or purging the drain during normal operation of the equipment, ensure that the control loop is selected to manual prior to making any changes. This will ensure that there is no plant upset due to spurious changes in dosage. Flow rate changes through the sample pot will be seen as variations in charge and the control loop will react accordingly. Once the purging has been completed and the flow and charge readings have settled, the control loop can then be set back to automatic mode.

In order to set up the Cyclone sample pot flow regulation, follow the steps below:

1. Start with the inlet valve closed, the sample pot empty and SCD 16mp extracted.
2. Set the drain valve half open.
3. Open the inlet valve and allow the sample pot to fill up to the overflow pipe halfway mark. The flow must not allow flooding over the Cyclone sample pot lid.
   One may have to also adjust the drain valve depending on the sample inlet flow available.
4. Install the SCD 16mp in position and check that the flow through the overflow pipe is maintained.
   Adjust inlet and drain valves if necessary.
5. If the sample supply is from a pump, switch off the pump and allow the Cyclone sample pot to empty.
6. Restart the sample supply pump and check that the overflow is maintained. This is to check the Cyclone sample pot flow in the event of a plant restart after a power failure (for example).

6.3 Cyclone Sample Pot – Waste (Effluent) Water Treatment



Cyclone type sample pot and flush control - The water flow through this type of sample pot is in the region of 25 l/min. The inlet flow can be regulated on the inlet valve. It is preferable to have the underflow valve open as widely as possible, but still maintaining the level at the overflow outlet halfway mark.

The heavy fraction will be forced to the outside of the flow, and down and out of the drain valve by the rotation of the fluid in the cyclone. The SCD is located in the centre of the sample, thus limiting the amount of grit that will be introduced into the measuring sensor.

A flush control valve and port are installed and controlled by a PLC to implement a flush cycle that can include a chemical additive to assist with the cleaning. The inlet and drain valves are usually also PLC controlled depending on the plant/process requirements.

Figure 9: Cyclone sample pot with flush port and valve for waste water treatment works

6.4 Electrical Installation

Power supply and signal connections to be made to terminals provided on the SCD motherboard or to Lechintech terminal box (if supplied) as in Figure 10 below.

Take care to provide a good earth connection to the unit to minimize the effect of 50 Hz interference. This is normally provided with the 220V/110V input, if fed off a mains three-pin connection. It is recommended to utilize a clean instrument power supply, UPS supply or the installation of an inline mains filter for the unit

If any external devices are connected to the 4-20 mA output from the unit, e.g. recorders, controllers, the total loop resistance should not exceed 500 Ohms. Also, the current input circuits of any externally connected devices must be floating with respect to that of the unit's earth. We would recommend the use of signal isolators between the instrument output and the plant DCS or recording device.

Cable entry glands are provided on the side of the box (size PG9).

Note	Unused glands must be plugged to maintain the splash proof rating of the box.

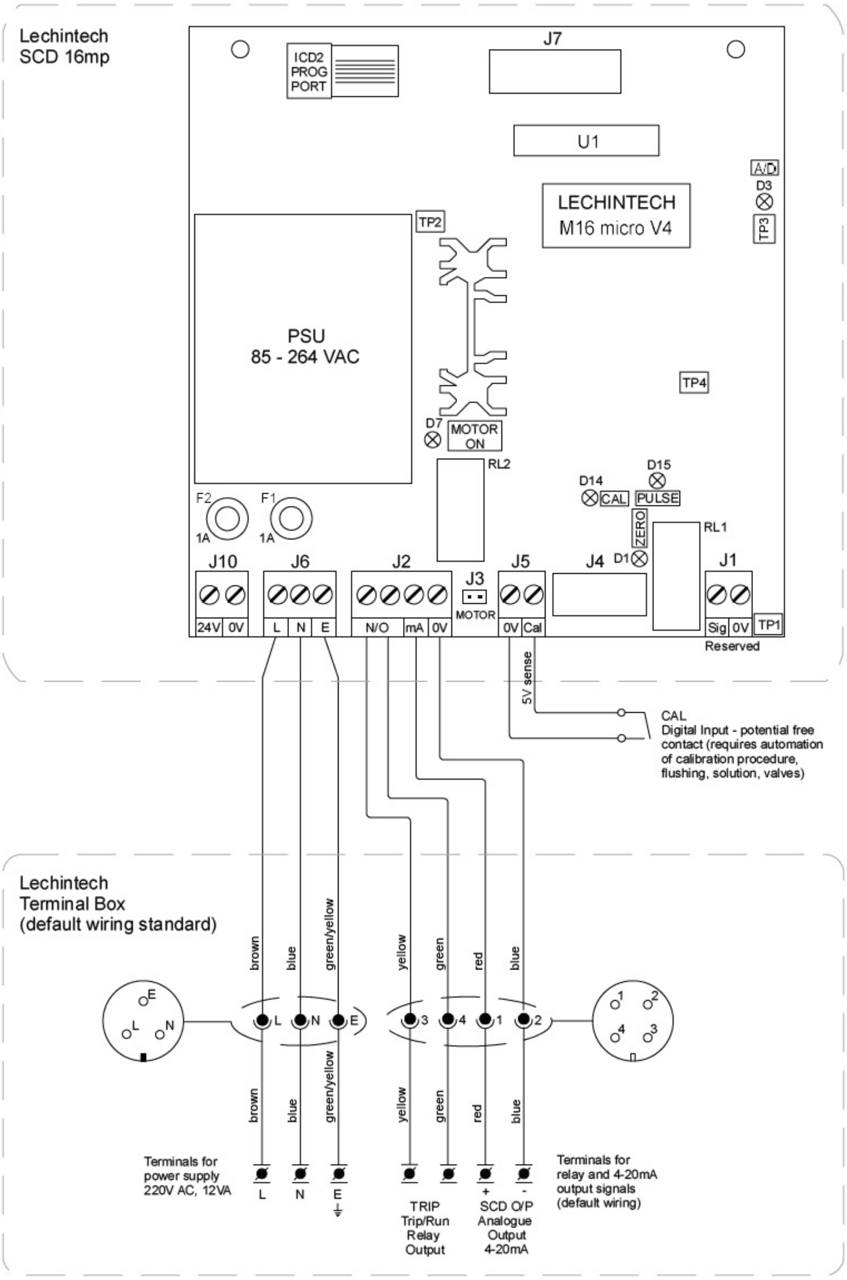


Figure 10: SCD 16mp PCB and Terminal Box electrical connections

6.5 Automation Options

For automating the flocculation dosing system with a SCD 16mp, various options are available.
In all cases a PI (proportional and integral) controller is required. Depending on the type of dosing pumps analogue input and pulse input models can be catered for. Duty/standby and lead/follower dosing pump arrangements can also be catered for either by using Lechintech SRC or Lechintech I to F converters or custom PLC/PAC/DCS configuration.

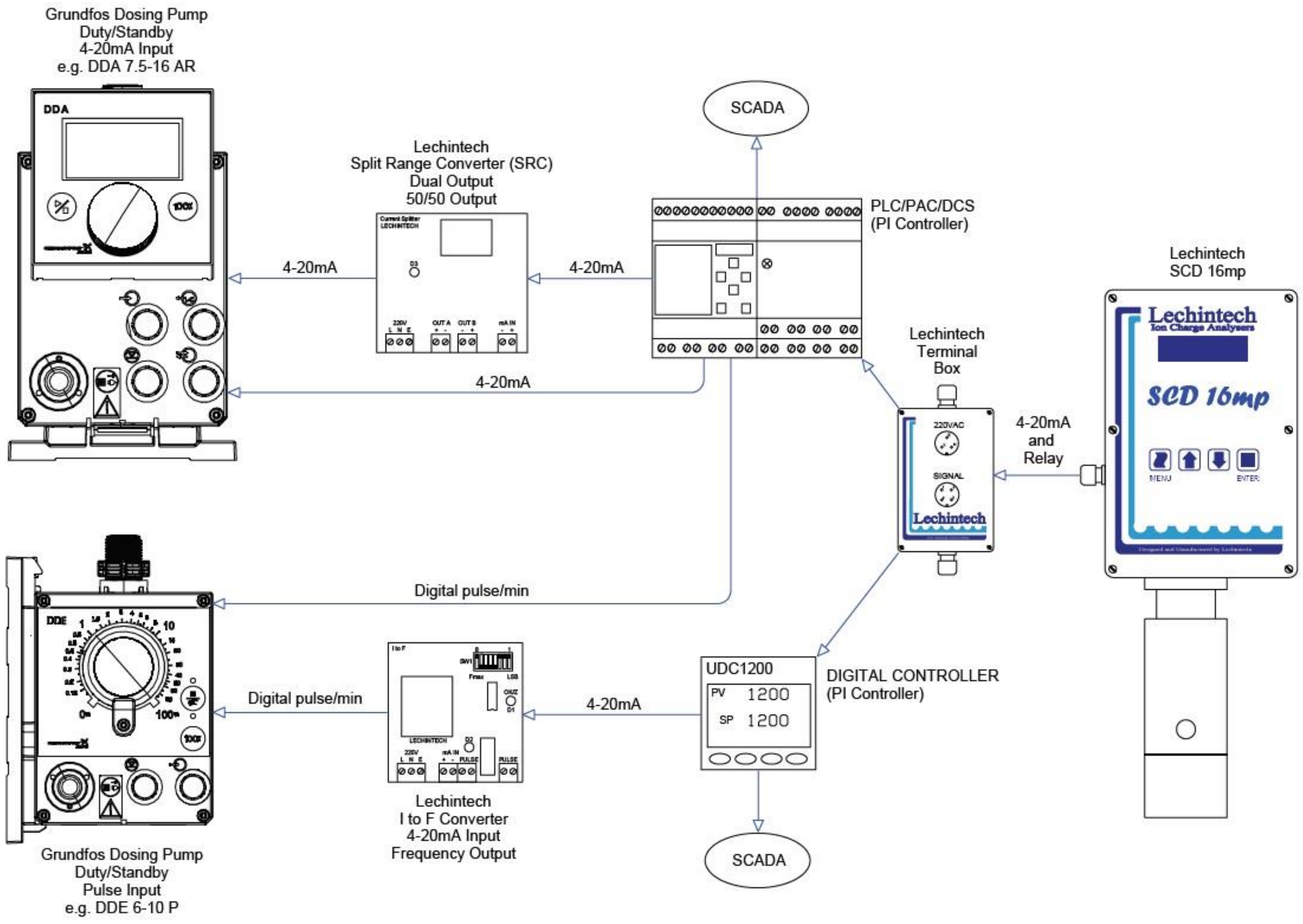


Figure 11: SCD 16mp automation example scenarios

External PI controllers supplied by Lechintech are configured with standard settings as outlined below:

1. PI controller setup for reverse-acting control.
2. SCD 16mp analogue signal (4-20 mA) scaled as -5.0 ICu to +5.0 ICu for process value (PV).
3. PI controller setpoint (SP) value limited between -4.0 ICu to +4.0 ICu.
4. PI controller control value (CV) limited between 5 % and 100 % of analogue signal (4-20 mA)
5. PI controller proportional band set to 200 %.
6. PI controller integral time set to 5 minutes.
7. PI controller derivative time set to 0 minutes (Disabled).

Each dosing system installation will require determination of the proportional band and integral time for control loop tuning.

External PI controllers with alarms supplied by Lechintech are configured with standard settings as outlined below:

1. PI controller SP versus PV deviation band alarm, ± 1.0 ICu.
2. PI controller CV limit alarm, < 10 % or > 90 %.

7 CALIBRATION AND TEST PROCEDURES

7.1 Chemical Calibration

Calibration should be carried out on a regular basis, depending upon the application, using a standard commercially available cationic polymer.

The initial laboratory calibration has been carried out before the unit has left our works, and therefore only a routine calibration check should be necessary. Every SCD 16mp leaving the Lechintech factory is calibrated to give a reading of + 5.30 ICu when placed in a 100 ppm (100 mg/litre) of a standard cationic polymer X.
A 100 ppm solution represents a saturated solution of the chemical as shown in Figure 12.
The charge curve flattens out as the concentration of polymer is increased and a charge reading of + 5.30 ICu is recorded.

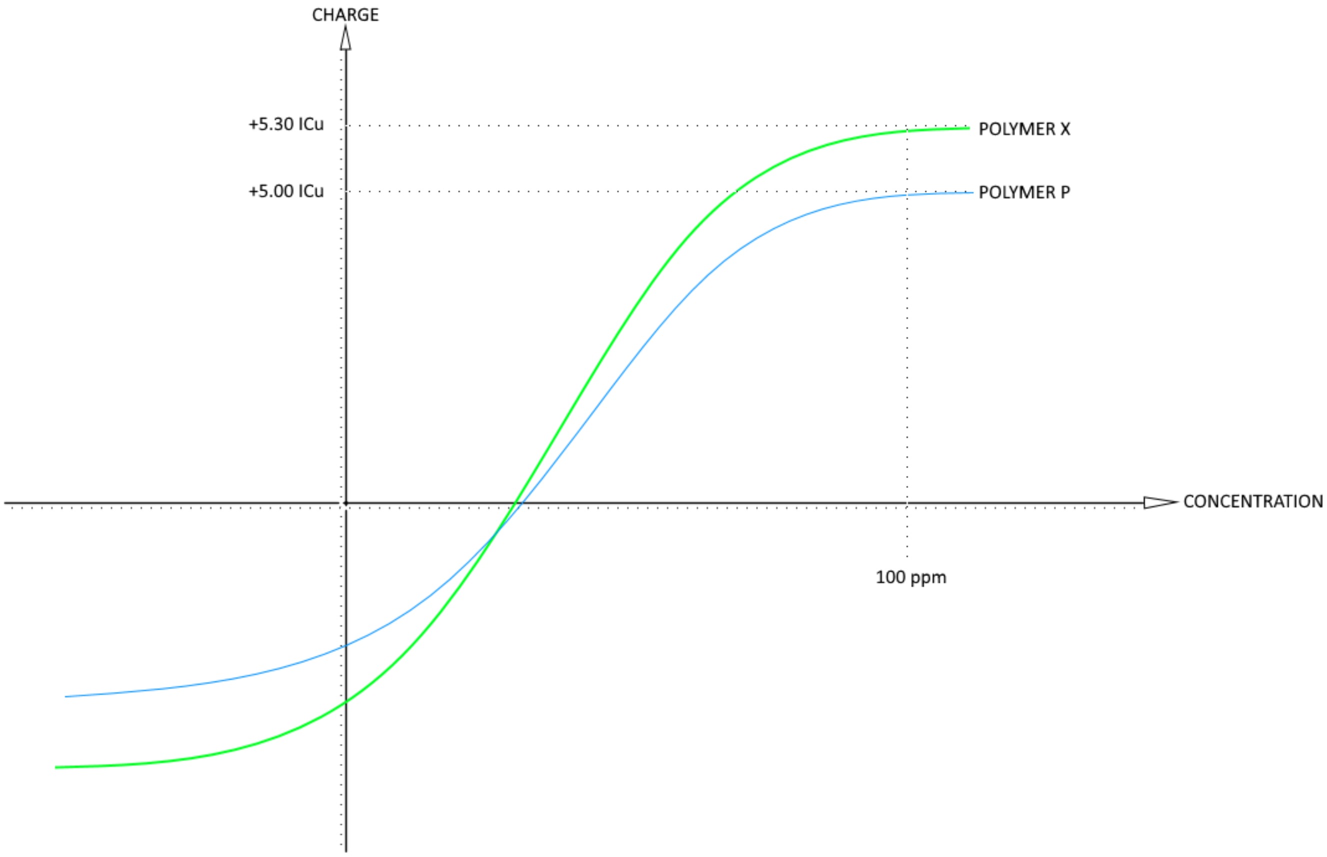


Figure 12: Characteristic charge vs chemical concentration curves for Polymer X and Polymer P

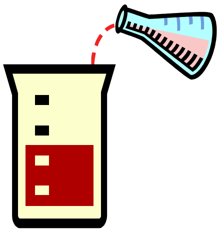
Any other cationic polymer may be used to calibrate the SCD, however its characteristic charge/chemical concentration curve will be different. It is necessary to standardize the polymer against Polymer X (used in the Lechintech laboratory) by determining the charge reading for a 100 ppm solution. This charge value can be established by comparison and the reading obtained can be used as the cationic standard for further calibrations, e.g. 100 ppm of Polymer P has a standard charge of + 5.00 ICu. Should the situation arise that there is no cationic standard of known strength available to standardize a given cationic chemical, an acceptable alternative would be to make up a 100 ppm solution of the chemical and calibrate the charge analyzer to read + 5.00 ICu. All readings after this will be relevant to this initial cationic standard used as the calibration agent.

Calibration Solution: This is a 100 ppm solution of the proposed cationic polymer, made up by placing 100 mg of chemical in 1 liter of tap water.

Note The solution should be allowed to stand for one hour after preparing before use, to allow the chemical to activate, otherwise unstable readings may result, due to a non-homogeneous mixture.

1. Add 1ml cationic standard to 1 litre of distilled/potable water and mix well for 2 to 3 minutes.

2. Now add 100 ml of the solution to 900 ml of distilled water and mix well.
Allow the solution to stand for one hour before calibrating the SCD.

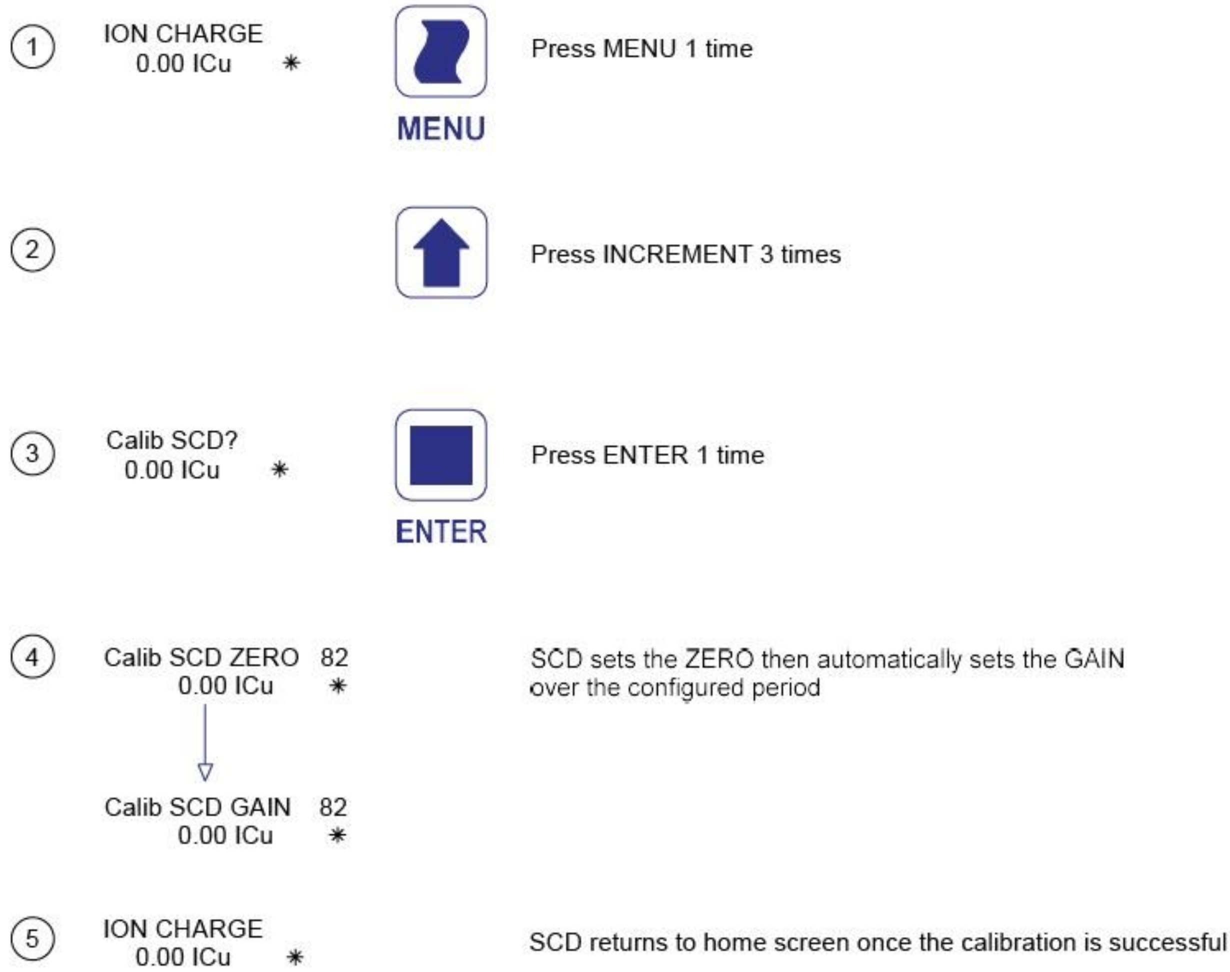


3. Rinse the SCD 16mp probe in tap water prior to immersing in the first beaker of calibration solution (500 ml).

4. Allow the ICu reading to stabilize in the calibration solution.
Replace the 500 ml of solution with a fresh 500 ml of 100 ppm cationic calibration solution.
Allow the ICu reading to stabilize, and using the menu prompts, calibrate the instrument.
Rinse the SCD 16mp probe in fresh water once the calibration routine has been completed and reinstate in plant operation.

7.2 Calibration Procedure

1. If the SCD 16mp is in operation switch the control loop to manual.
2. Rinse the SCD 16mp probe out with fresh water.
3. Run the SCD 16mp in a beaker of fresh water for a short period (two to three minutes).
4. Place the SCD 16mp in a beaker of calibration solution and allow to stand for one minute.
5. Place the SCD 16mp in a fresh calibration solution and allow the ICu reading to stabilize.
6. Using the menu prompts, initiate the calibration of the SCD 16mp from the keypad.



7. When the calibration is complete, rinse the probe in fresh water prior to placing the SCD 16mp back into the sample pot. Allow the SCD to run in the sample and allow the ICu readings to stabilize before switching the control loop to automatic.

7.3 SCD 16mp Calibration Details

An auto calibration facility is provided for on the SCD 16mp and may be initialized locally from the menu system via the keypad and LCD display or remotely by momentarily shorting J5 terminals, 0V and Cal as shown in Figure 10.
It is important to set the calibration reference equal to the calibration solution used (or the output value of the portable calibrator) prior to calibration. Once calibration has been initialized, the microcontroller will carry out the following calibration sequence:

1. Activate auto zero relay, RL1 (Figure 10). The LCD display will indicate Calib SCD Zero 80 on the top line. The value on the right is a countdown timer for the calibration time. This timer is required to allow for the response of the low pass signal filter. The calibration time is measurable but is limited to a minimum of the filter time constant (FTC) value x 8. The Calib Time and SCD FilterTC parameters are set in units of 250ms.
2. Once the timer has elapsed the micro controller will calculate the required zero offset value of the SCD 16mp input signal and save it in EEPROM as the parameter SCD Offset.
3. De-activate the zero relay and start the gain calibration. The LCD will indicate Calib SCD Gain 80 on the top line. The calibration timer will count down again after which the gain required to obtain a value equal to the calibration reference is calculated and saved in EEPROM as the parameter SCD Gain.
4. The LCD display top line will clear and display ION CHARGE if the calibration was successful. If the calibration failed due to excessive gain, the SCD motor will stop and the error message Calib FAILED will be displayed. If the calibration fails the gain will not be saved in EEPROM, which will allow the SCD unit to be restarted with the previously saved gain value.

Caution

The SCD Gain and SCD Offset parameters may be viewed and modified in the configuration mode. However, care should be exercised in modification of these parameters as they directly affect the calibration of the SCD!

Zero SCD: An auto zero facility is provided to zero the SCD 16mp ICu signal. This function is only available locally from the menu. The SCD 16mp will automatically zero the ICu signal on power restart or system reset.

7.4 Analogue Output Calibration

The analogue output signal may be calibrated by viewing and modifying the mA signal digital to analogue converter (DAC) values directly from the menu system via the LCD display and keypad. The parameters Calib 4mA and Calib 20mA are used for calibration of the output signal. The DAC has 12 bit resolution, where values are set between 0 and 4095.

When Calib 4mA is selected from the menu, its digital value may be increased or decreased using the INC and DEC buttons while the mA analogue output is measured across J2 terminals, mA and 0V (Figure 10) or in series with dosing control system connection, with a multimeter. Once the 4mA output has been calibrated, the keypad ENTER button is pressed to save the parameter in EEPROM.

The Calib 20mA parameter is calibrated/set similarly to the 4mA calibration.

Zeroing the SCD 16mp should give 12 mA across J2 terminals, mA and 0V (Figure 10) for confirmation of linearity.

7.5 SCD 16mp Configuration Mode

Configuration mode is activated by pressing the MENU keypad button while holding down/in the INC and DEC keypad buttons. A “C” will be displayed in the leftmost position of the bottom line of the LCD.

Table 1: Configuration mode allows the following parameters to be viewed and modified

Item	Parameter	Default	Unit	Range	Read/ Write	Description
1	Calib 4mA	39		0 to 4095	R/W	Ion charge measurement DAC value for 4mA output.
2	Calib 20mA	3708		0 to 4095	R/W	Ion charge measurement DAC value for 20mA output.
3	ZERO SCD					Auto Zero sequence.
4	Calib SCD					Auto Calibration sequence.
5	Calib Ref	+5.30	ICu	-10.00 to 10.00	R/W	Ion charge calibration reference for cationic 100mg/l solution.
6	SpdCon O/P	1035*		0 to 4095	R	Output of motor speed controller.
7	SpdCon SP	131		1 to 255	R/W	Motor speed controller setpoint.
8	SpdCon Gain	30		1 to 255	R/W	Motor speed controller gain.
9	SCD Offset	-16*		-10000 to 10000	R/W	SCD input signal offset.
10	SCD Gain	836*		0 to 10000	R/W	SCD input signal gain.
11	SCD Max Gain	10000		0 to 32767	R/W	Maximum allowed SCD gain.
12	SCD O/P Max	+5.00	ICu	0 to 10.00	R/W	SCD signal corresponding to 20mA.
13	SCD Filter TC (FTC)	10	250ms	0 to 255	R/W	Time constant of input low pass filter.
14	Calib Time	84	250ms	FTC x 8 to 255	R/W	Calibration timer.
15	Stall Time	12	250ms	1 to 255	R/W	Motor stall monitor time.
16	Set mA limit	0.20	mA	0 to 1	R/W	Analogue output mA over/under limit. e.g. analogue output mA limited at 20.2mA maximum and 3.8mA minimum for 0.20mA setting.

Note * These parameter values are determined by the SCD 16mp mechanical and electrical components.

Note In normal mode only the first 5 parameters are visible. Normal mode is entered by pushing the MENU button only. See Appendix F for further detail.

7.6 SCD 16mp Motor Speed Control

The microcontroller controls the measuring cell motor speed by adjusting the motor voltage via a 12 bit DAC and a LM317 voltage regulator. The motor speed is derived from the chopper plate pulses. The motor speed control setpoint is adjustable via the keypad and LCD display. The number displayed is a scaled number between 0 and 255. The factory default is 131, which equates to a motor speed of 240rpm.

To optimize motor load regulation a potentiometer P2 is provided between the DAC output and the adjust pin of the LM317. P2 is adjusted such that the DAC output is near its lower limit under no load conditions. A utility is provided on the LCD display to view the 12 bit DAC value, which is the speed controller output. The electrical output range of the DAC is between 0.6 and 4.4 V, which equates to a DAC value range of 0 to 4095. A typical value for P2 adjustment is 1035.

The microcontroller monitors the motor speed and provides a stall projection function.
There are two stall modes -

a. Sudden total stall i.e. motor or probe and cell jammed
b. Motor under speed i.e. electrical fault or mechanical wear/friction

A stall time parameter determines the time in 250 ms units to trip the motor control circuit.
Motor under speed is determined by accumulating the speed error and tripping the motor control circuit once this has exceeded a value equal to the stall time parameter x 250 ms.
The factory default for the stall time parameter is 12.

8. OPERATIONAL AND MAINTENANCE CHECKS

8.1 Daily Checks Include:

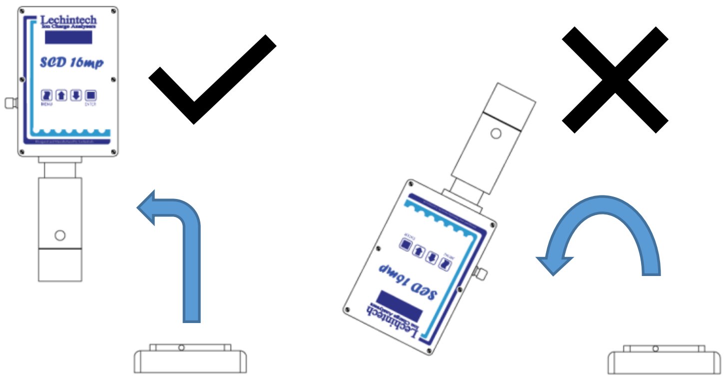
Purging and cleaning the sample pot.

1. Switch the control system to manual.
2. Remove the SCD 16mp from the sample pot and rinse the sample pot by opening the drain valve and cleaning with a brush or rag.
3. Return the system to normal operation and check and adjust the sample pot flow rate to between 30 and 40 l/min or by half filling the overflow pipe as described in Section 6 of this manual.
4. Replace the SCD 16mp in the sample pot and allow the ICu reading to settle.
5. Return the control system to automatic.

8.2 Weekly Checks Include:

1. Switch the control system to manual.
2. Remove the SCD 16mp from the sample pot and wipe down/rinse the probe body with tap water.
3. Replace the SCD 16mp in the sample pot and allow the ICu reading to settle.
4. Return the control system to automatic.
5. Check zero and perform chemical calibration if necessary as discussed under Section 7.2 and 7.3 of this manual.

Caution Do not invert the SCD 16mp during cleaning, water ingress may occur.



8.3 Monthly Checks Include:

1. Isolate the instrument and remove it to a stable work surface.
   Remove the instrument front cover and open the face (quarter turn screws).
2. Check for play on the gearbox output shaft by gently moving the cam and follower up and down.
   Maximum play should be movement of about 1 mm at the end of the cam. Replace the motor/gearbox combination should the wear be excessive.
3. Rotate the cam by turning on the slotted wheel, the probe shaft will oscillate up and down. The rotation should be smooth with no tight/friction spots. Uneven wear of the cam or follower will require replacing the cam and follower set.

8.4 Biannual Checks Include:

Six monthly maintenance includes a complete mechanical service and electronic and chemical calibration. All worn parts to be replaced as necessary. The servicing should only be carried out by trained technicians.

A service includes the following:
1. Strip and clean SCD 16mp probe body, probe and sensor cell – Section 11.
2. Replace O-rings and gaskets in probe body – Section 11.
3. Replace probe shaft seal and grease – Section 11.
4. Strip motor gearbox and oil – Section 11.
5. Reassemble SCD 16mp and perform chemical calibration – Section 7.
   The chemical calibration results can determine if the cell and probe require replacement.
6. Perform electronic calibration of analogue output (4-20 mA) – Section 7.

9. TROUBLESHOOTING

9.1 SCD 16mp

Table 2: Troubleshooting the SCD 16mp

Problem	**Cause**	**Solution**
"–" "+" "✳" symbols not changing on LCD display	Cell blocked Motor trip Motor burnt out Motor speed low Cam jammed Failed optic sensor card	Clean out cell. Press rear enclosure door reset button. Call instruments department. Factory inspection required. Call instruments department. Call instruments department.
LCD not working	Power off Unit trip Damaged (water?)	Switch power on. Power down, power up. Call instruments department.
Motor will not reset	Electronic card failure Motor burnt out Gearbox seized Relay stuck	Factory inspection required. Call instruments department. Call instruments department. Call instruments department.
Calibration failed	Calibration solution not prepared correctly or cationic polymer used has diminished strength Worn probe and/or cell sensor gain outside allowed limit values	Remake calibration solution. Replace probe and/or cell sensor.
SCD diminished sensitivity	Worn probe and/or cell sensor Motor speed low	Replace probe and/or cell sensor Call instruments department.

9.2 Sample Lines and Sample Pot

Table 3: Troubleshooting sample line and sample pot factors

Problem	**Cause**	**Solution**
SCD diminished sensitivity	Sample line or filter restricted No sample pot overflow, i.e. no upward flow of sample over probe port	Backwash and clean system lines. Set sample pot inlet and drain valves for correct overflow level.
Low flow through sample pot	Sample line or filter blocked	Backwash and clean system lines.
High wear on cell and probe	Sediment or grit entering probe port	Set inlet flow for cyclonic action of sample sediment and grit. Clear drain lines and set drain flow for sediment or grit removal.

10. BASIC OPERATION OF THE CONTROL LOOP

To be able to operate the system correctly, we need a suitable arrangement of variables. This includes the chemical and electronic calibration of the SCD 16mp, the correct tuning constants for the loop, and the correct stroke adjustment of the dosing pump. All these factors together combine to form a stable system for the control of chemical dosing.

The dosing pump stroke length/frequency or dose rate is adjusted to ensure an adequate delivery of chemical at both low and high flows into the plant, as well as catering for the average turbidity changes that can be expected from day to day. Some operator intervention is necessary if unexpectedly low or high flows or turbidity are experienced.

For determination of PI controller parameters, proportional band and integral time; the plant must be at a steady charge value with the controller in manual. Note this charge value. Make a 10 % increase in the output value. Start the stopwatch at this time. When the charge value stabilizes note the charge value and the time lapsed. From these values one will be able to calculate the proportional band and note the integral time settings for the PI controller parameters. An example follows for easy reference.

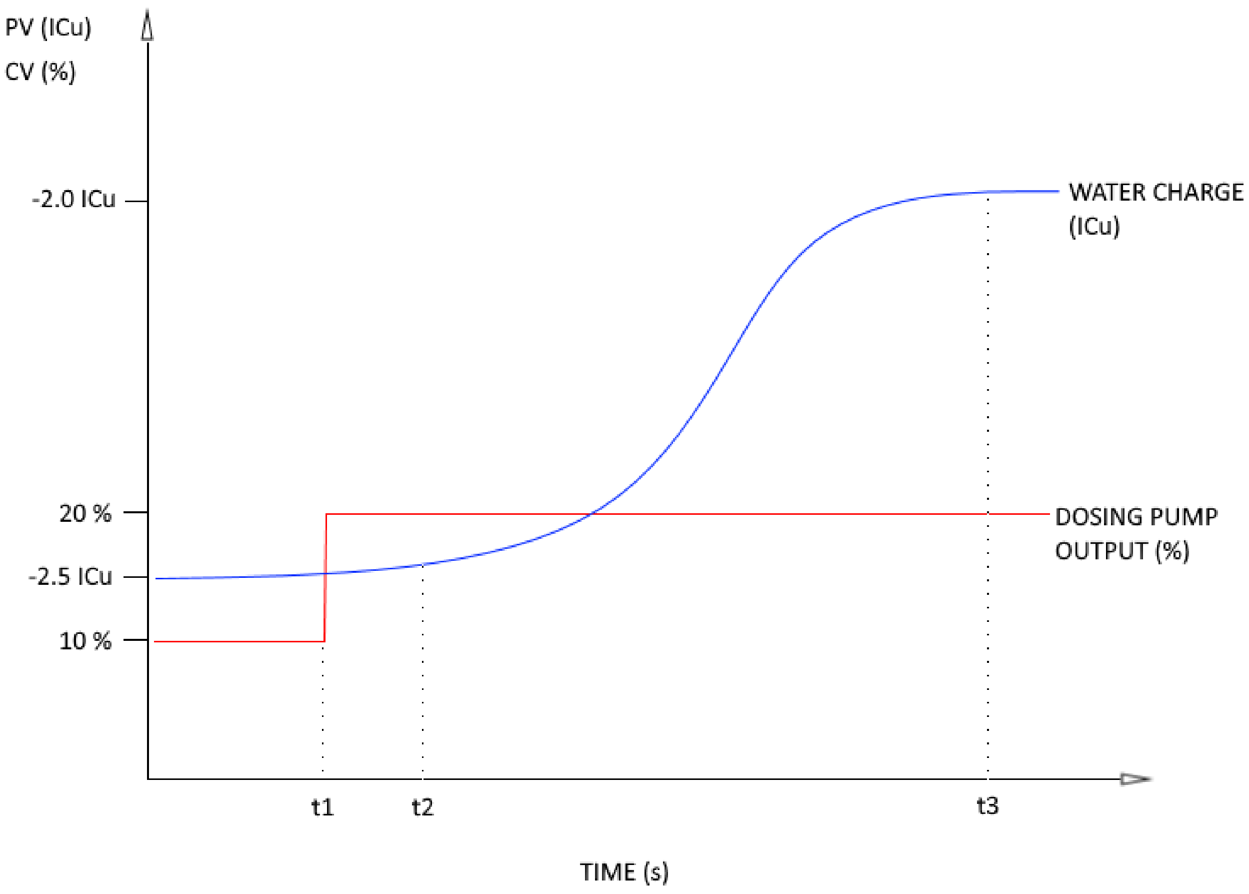


Figure 13: Dosage response curve to determine Proportional and Integral control constants.

The cause of the change in charge was a 10% increase in pump output i.e. 10 % more chemical was dosed into the water. Due to the delay time to mix the chemical with the carrier water and move it through the volume to the sample pot, we observe a time lag between the output change and the beginning of the charge curve, t_1 to t_2. We are interested in the time it takes to fully level out, i.e. t_1 to t_3, which we use as the integral time.

The proportional band (PB) is calculated as follows:

$$PB = \frac{\%\,Effect}{\%\,Cause} \times \frac{100\%}{1}$$

To calculate the effect, we see the difference between the start and the end charge is 0,5 ICu. On a scale of 10 ICu, i.e. -5 ICu to +5 ICu, 0,5 ICu represents a change of 5 %.

We can then calculate the proportional band:

$$PB = \frac{5\%}{10\%} \times \frac{100\%}{1} = 50\%$$

To slow the loop down slightly we multiply this value by 1,5 and obtain a setting of 50 % x 1,5 = 75 % which is used as the controller setting for PB.

Should it be required to use Gain in the calculation rather than PB.

$$GAIN = \frac{100\%}{PB}$$

Once the control parameters are set into the controller, and the dosing pump stroke has been set, the only operator action required is:

1. Change the setpoint (SP) as and when required (possible winter/summer change).
2. Ensure the sample is flowing.
3. The settling and sample pots are cleaned.
4. Ensure the dosing pumps are operating correctly.
5. Ensure the process value (PV) tracks the setpoint (SP).

Note

When the initial dosage is determined by tests, either jar test or historical dosing curve, the dosing pump stroke should be set at a value so that the controller output ranges from 20 % to 30 %. These are ideal parameters for average quality incoming raw water. This allows for really dirty water adjustment as well as trimming back dosage for cleaner water. This will be the initial setpoint (SP). Adjust this SP by -0,2 ICu each day until the water quality starts to deteriorate, once this happens adjust SP by +0,2 ICu to get the actual optimum dosage. Small SP changes can be made on a daily basis to trim the final water quality if necessary.

10.1 Setpoint (SP) Determination

The SCD 16mp is considered a robust and sensitive ion charge analyser for water treatment applications and the system as a whole (plant process) is fine-tuned according to jar tests. The SCD 16mp is accurate for measuring relative ion charge demand for optimum flocculation of the water being treated for a certain treatment plant.

The best ion charge setpoint is determined with jar tests. The setpoint is set in the controller and dosing control system keeps the ion charge constant for optimum flocculation. Setpoints are usually only altered during very high turbidity's or during season changes (temperature).

This procedure is to determine the cationic demand of the raw water for optimum flocculation.

1. At calculated dose rate or historical dose rate record the ion charge (ICu) with the SCD 16mp at a stable dose rate, e.g. coagulant dosing pumps set to manual control. This recorded ion charge value can be set as the initial setpoint in the PI controller.

2. Allow the PI controller to run in automatic, i.e. coagulant dosing pumps set to automatic control.

3. If water quality good, decrease setpoint e.g. by – 0.1 to – 0.2 ICu and check if quality still good, optimises flocculant usage. Continue process over a few days with jar tests to find optimum target ion charge setpoint.

4. If water quality bad, increase setpoint by reduction margins made above and check if quality better.

5. If one finds that increasing the ion charge setpoint causes worse flocculation, then the system is overdosing having a negative effect on flocculation. Therefore, one must reduce the target ion charge setpoint until water quality results are good. This takes time as the jar tests need to be done in between adjusting the target setpoint.

11. MODEL SCD 16mp SERVICE PROCEDURE

The requirements and procedure for a standard service is described here.

11.1 Requirements

1. Instrument screwdriver 3 mm flat
2. Instrument screwdriver 3 mm Philips
3. Lechintech PVC probe installation tool
4. Spanners 5.5 mm, 7 mm and 10 mm
5. Allen keys, 2 mm and 4 mm
6. Long nose pliers
7. Cell and probe set (new)
8. Shaft seal (new)
9. Set of three O-rings (new)
10. Set of two gaskets (new)
11. Cleaning brushes, cleaning agents (mild)
12. Hydraulic oil (for motor gearbox)

11.2 Disassembly

The SCD 16mp needs to be stripped before any servicing is conducted.

1. Disconnect the 220 VAC power and SIGNAL cables from the Terminal Box or remove the cables from the SCD 16mp enclosure if no Terminal Box installed.

2. Remove the instrument from the sample pot and conduct the rest of the procedure on a stable work surface.

3. Open the front cover of the unit by turning the six quarter-turn screws anti-clockwise.

4. Disconnect the cell sensor signal cable from the SCD 16mp PCB, J1 terminals, SIG (brown) and 0V (white), Figure 10.

6. Unplug the 10-way ribbon cable from the optic sensor board mounted on the vertical device plate.
   Loosen the 3 mm wing nut and remove the optic sensor board.

7. Unscrew the body cap from SCD 16mp probe body and pull out cell, completely removing the signal cable from the body.

8. Within the instrument casing, straighten the tab washer locking the M6 nut, which is located on the underside of the cam follower (the 6mm stainless steel shaft is connected to the cam follower).
   Loosen the M6 nut using a 10 mm spanner.

9. Fit the Lechintech supplied PVC probe tool over the probe tip and turn anti-clockwise to unscrew the probe shaft from the cam follower and remove the M6 nut.
   This will now allow the probe tip, together with the probe shaft, to be removed from the probe body.

10. There are six M3 screws holding the probe body to the ABS box. Four of these screws also hold the motor bracket in place. Remove these screws using a 5.5 mm spanner.

11. Disassembly now allows for the cleaning of the probe body, cell and probe, as well as access to the motor and gearbox for inspection and cleaning.

11.3 Motor and Gearbox

1. Check the drive chain and cam and follower for wear. Check for play on the gearbox output shaft by gently moving the cam up and down. Maximum play should be movement of about 1 mm at the end of the cam. Replace the motor/gearbox combination should the wear be excessive.

2. Rotate the cam by turning on the slotted wheel. The rotation should be smooth with no tight spots. The following reasons could be the cause of tight spots in the rotation:
   a. Motor or gearbox component wear or failure - Replace the motor/gearbox unit.
   b. Uneven wear of the cam or follower – Replace the cam and follower set.

3. If the motor and gearbox combination is in good condition, then only the gearbox needs servicing. To do this, remove the cam and follower by loosening the 4 mm grub screw holding the cam onto the motor shaft.

   Caution Do not loosen or unscrew the 4 mm Allen key bolt holding the chopper plate on the end of the cam. The position of the two parts are calibrated in the factory at synchronization of the sinusoidal measurement peak and the chopper plate trigger of the optic sensor.

   Remove the black gearbox cover by loosening the four M3 screws. Flush the gearbox with degreaser or thinners and dry with a lint free cloth or tissue paper. Once dry, recoat the surface of the gears with light general-purpose oil and ensure that the complete unit is running freely.

4. Reinstate the drive mechanism to normal state. Ensure that the cam adjustment screws are not binding on the follower. The adjustment of the runner's screws is made by loosening the M4 lock nut and adjusting the length of the screw, then retighten lock nut. The above can only be done when the SCD 16mp is completely reassembled.

11.4 Cell and Probe

1. Clean the probe body and cap with a suitable light abrasive cloth/pad and soap solution. Use a bottlebrush to clean the inside recesses of the probe body. In severe cases a mild acid solution is required (remember the necessary safety precautions when using chemical cleaners). The probe body should then be rinsed thoroughly in clean water and then dried.

2. Use the Lechintech PVC probe tool to unscrew the probe tip from the probe shaft. Clean the probe tip of any build up but do not use anything to scrape off any residue as this will damage it. Rinse the probe thoroughly after cleaning

3. The inside of the sensor cell can be cleaned using a thin bottlebrush. Pay careful attention to the stainless steel electrodes. These must be free of tarnish. Rinse the cell after cleaning.

Note During a service the sensor cell and probe tip may require replacement as determined by damage from wear and tear and/or by calibration failure.

4. Replace the two O-rings on the cell sensor, the two flat gaskets on the probe body and the single O-ring on the probe cap.

5. Replace the shaft seal located at the top of the probe body and add a light instrument grease to the inside of the shaft seal.

6. Use the Lechintech PVC probe tool to refit the probe tip onto the probe shaft. Finger tighten only.

11.5 Reassembly

1. Position the probe body onto the instrument casing by fitting only the two right hand M3 screws. Do not tighten them fully as you still need to line up the motor bracket.

2. Next fit the motor bracket using the four remaining M3 screws and tighten all six screws.

3. Insert the probe shaft from the bottom of the probe body through the top shaft seal carefully. As the tip of the stainless shaft passes through the seal, fit the M6 locking nut followed by the tab washer (the long tab is bent and should lie against the cam follower). Thereafter screw the shaft into the cam.

4. Push the cell sensor cable through the 4 mm hole in the body and install the cell sensor in position. Ensuring that the O-rings, gaskets and dowel pin locates correctly and that the cable is not kinked or pinched.

5. Reconnect the cell cable ensuring correct polarity to SCD 16mp PCB, J1 terminals, SIG (brown) and 0V (white), Figure 10.

6. Replace the probe body cap (hand tighten only).
   The length of the probe in the probe body cavity must be set as follows:
   a. Manually turn the cam using the chopper plate to check if the probe is touching the bottom of the cell sensor.
   b. If the above is true then use a long nose pliers to turn the stainless shaft into the cam to decrease the overall length. If not, then the shaft must be screwed out until the probe just bottoms in the cell.
   c. Repeat the above two steps until the probe just touches the bottom of the cell.
   d. Now turn the shaft a full turn into the cam watching the M6 nut turn one revolution.
   e. Lock the M6 nut against the cam and fold the tab washer down over the nut to keep it in place (note that the long side of the tab washer should be against the cam).
   f. Refit the optic sensor board with the 3 mm wing nut and check the chopper plate rotates centrally without touching the optic sensor channel sides.

7. Close the front cover of the unit by depressing (push down) and turning the six quarter-turn screws clockwise.

8. Reconnect the power and signal cables to the Terminal Box or PCB.

9. Calibration of the SCD 16mp <u>will be required</u>. After the SCD 16mp has been running in a tap water sample for about thirty minutes, perform the cationic standard calibration (Section 7).

APPENDIX A: SCD 16mp PARTS DETAIL

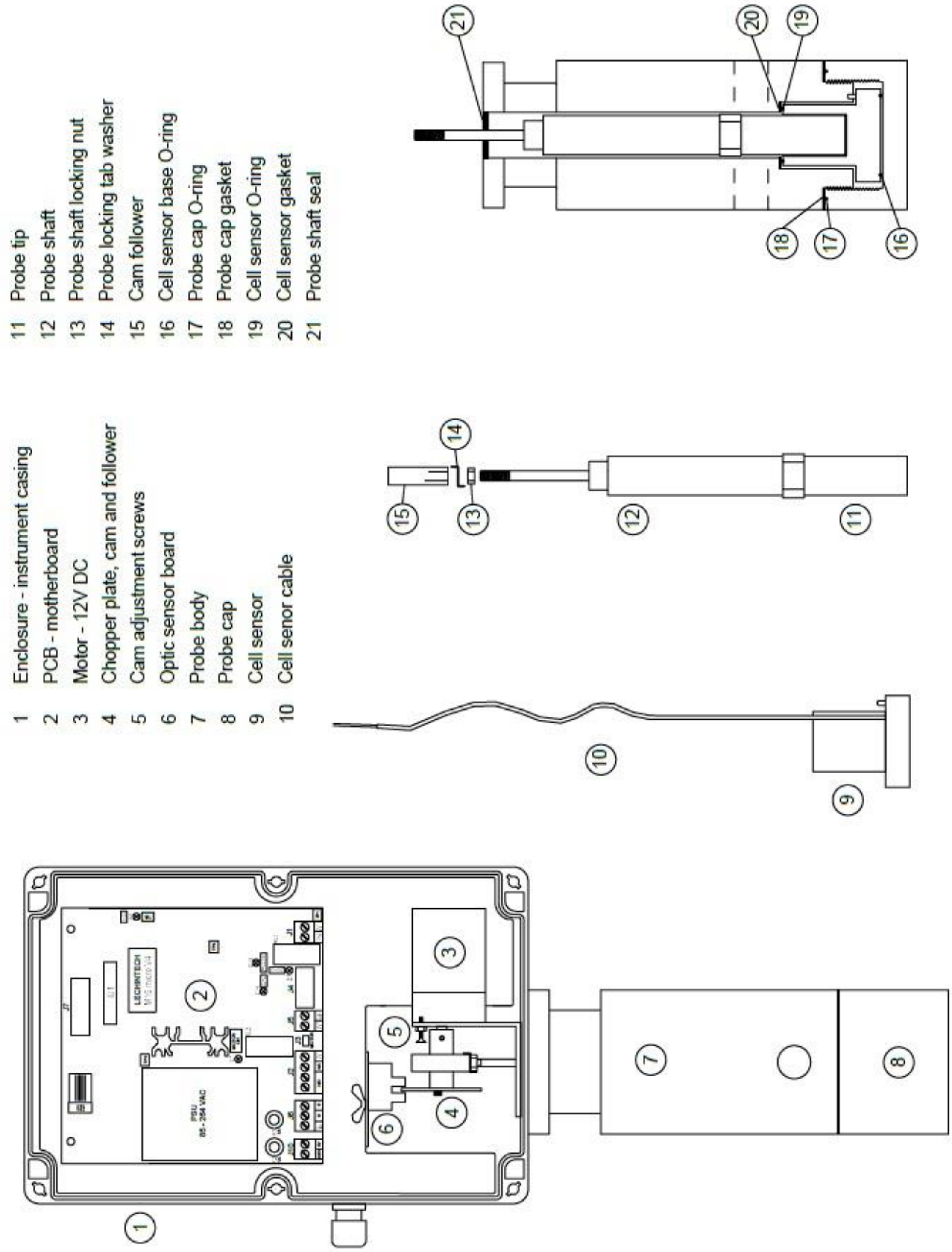


Figure 14: SCD 16mp part details

APPENDIX B: SCD 16mp SPARES

Part No.	**Description**
DM-12-10:1	SCD drive motor 12 VDC
DM-12-GB10	10:1 gearbox for SCD drive motor
05-001-CP	Cell and probe set
05-001-CPK	Cell and probe set with PVC probe tool and seal kit
05-001-SK	Seal kit - 3 O rings, 2 flat gaskets, 1 shaft seal
05-003-CF	Cam and follower with chopper plate
05-004-IH	SCD 16mp enclosure housing complete with enclosure face (door), hinges, glands, device plate and motor/gearbox bracket*
05-004-01	SCD 16mp enclosure face (door) with keypad
05-004-02	Enclosure door hinges set
05-004-03	PG9 glands and nuts each
05-004-04	Stainless steel back plate for SCD 16mp with screws
05-001-P	Probe body, stainless steel shaft, 2 locking nuts and tab washers
05-mp-RC01	Display ribbon cable for SCD 16mp
05-mp-RC02	Optic sensor board ribbon cable for SCD 16mp
05-mp-001	Complete SCD 16mp motherboard
05-mp-002	Complete SCD 16mp display board
05-mp-SB	Optic sensor board and rubber, with screw and wing nut

Note

* Depending on SCD 16mp versions (year of manufacture) the replacement housing may require measurements of older versions of the SCD 16mp for direct replacement.

APPENDIX C: SCD 16mp TYPICAL INSTALLATION A

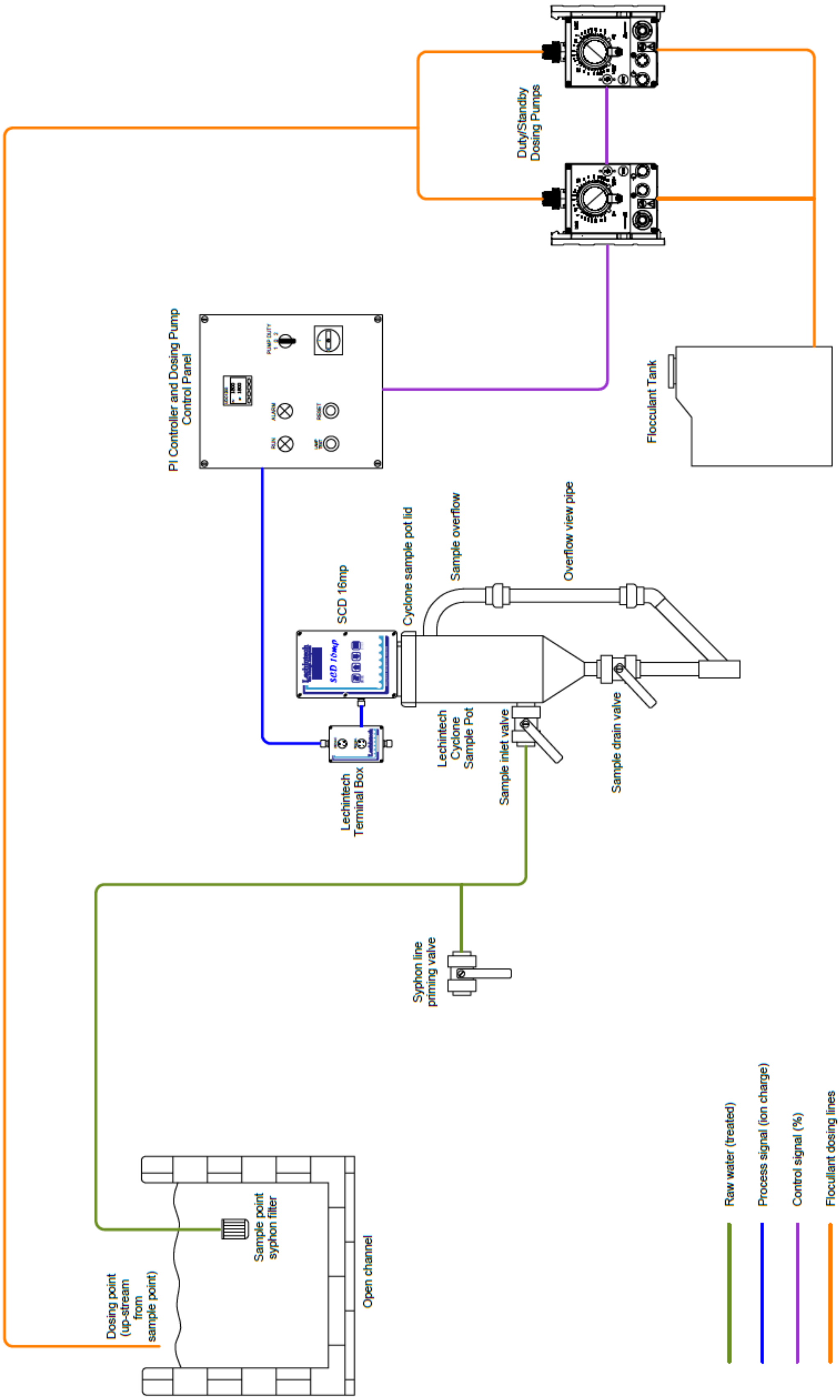


Figure 15: SCD 16mp typical installation example A

APPENDIX D: SCD 16mp TYPICAL INSTALLATION B

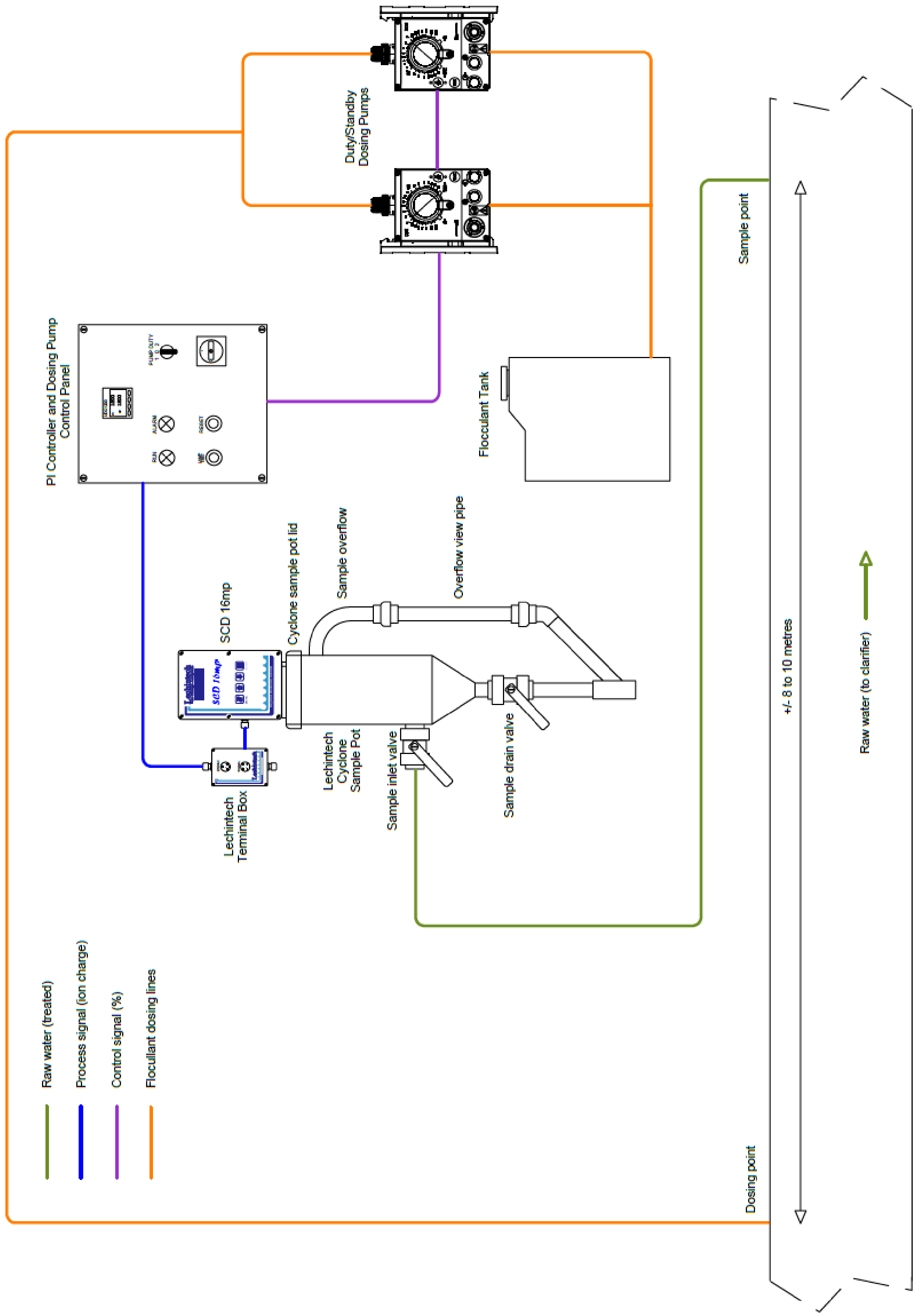


Figure 16: SCD 16mp typical installation example B

APPENDIX E: SCD 16mp MENU FLOWCHARTS

E1 – SCD 16mp Menu Navigation Flowchart

E2 – SCD 16mp Configuration Menu Navigation Flowchart

E3 – SCD 16mp 4-20mA Calibration Navigation Flowchart

E4 – SCD 16mp Calibration Navigation Flowchart

The following flowchart pages use the button descriptions below.

MENU button

INCREMENT button

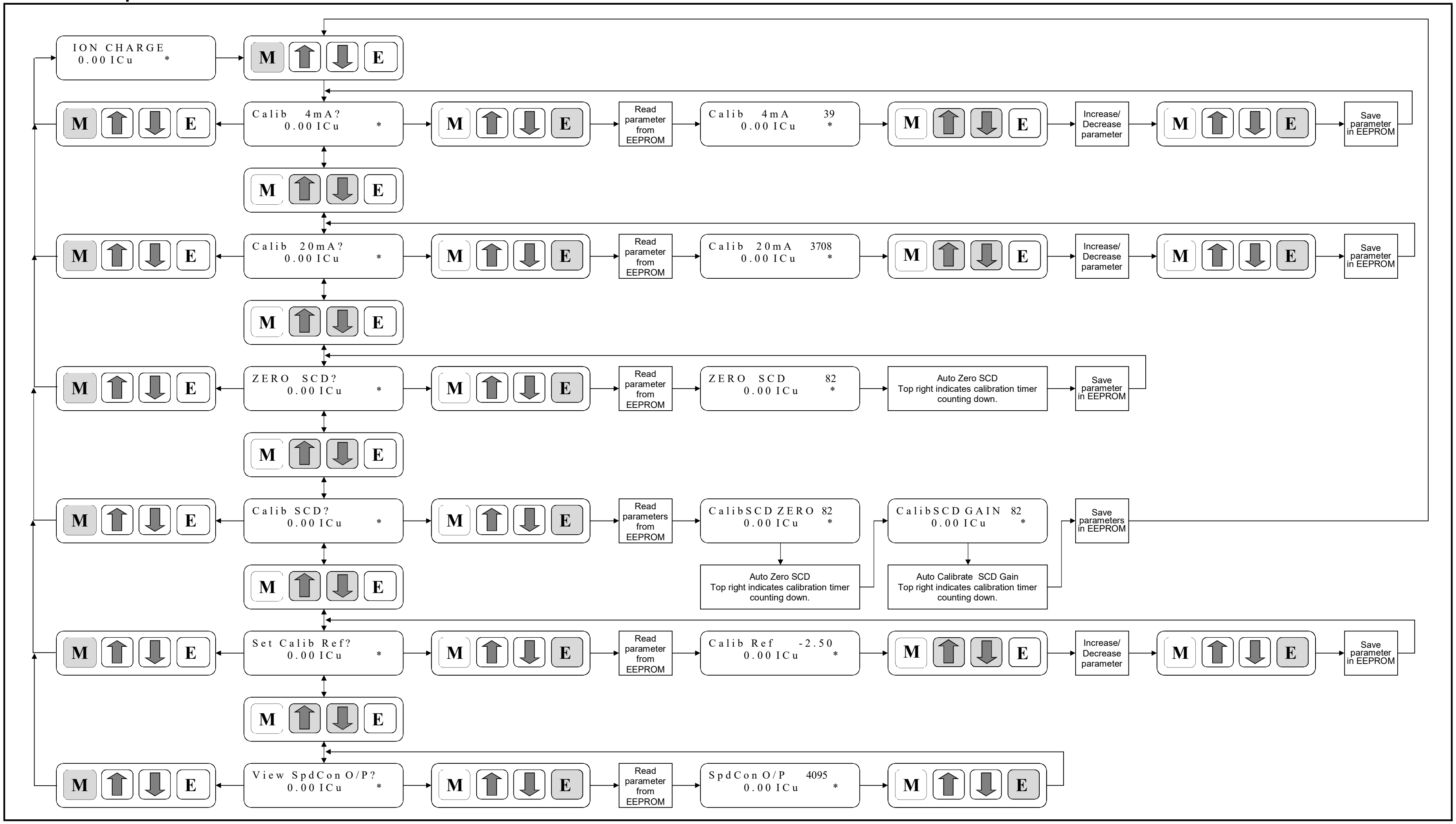
DECREMENT button

ENTER button

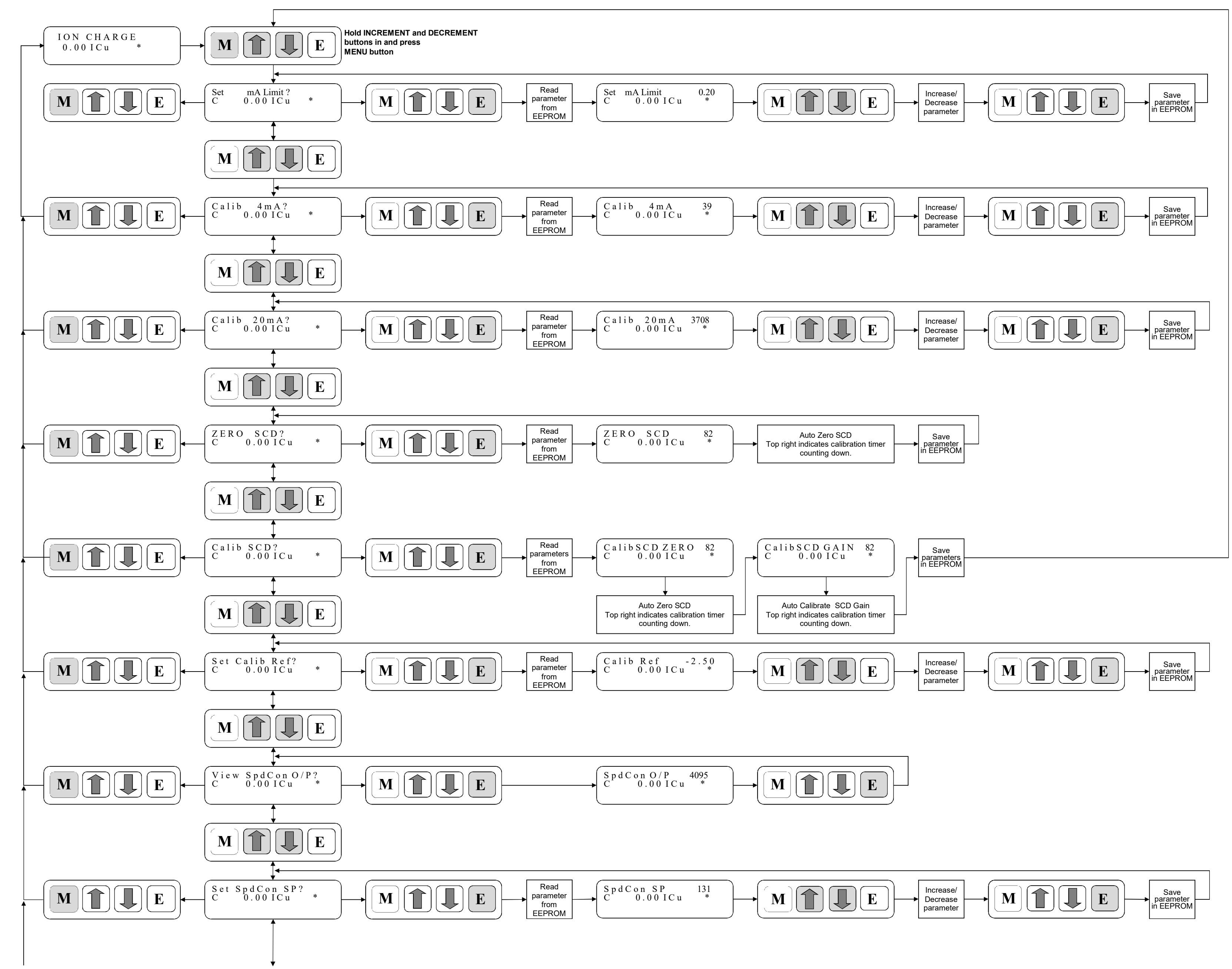
When the buttons are shown with a grey background, it means they are to be pressed for either navigation, a value change or accepting/saving a value.

The INCREMENT and DECREMENT buttons are both generally shown with grey backgrounds as shown below, a user can use the buttons to ascend/descend the menu navigation or change a value up/down.

E1 - SCD 16mp MENU NAVIGATION FLOWCHART



E2.1 - SCD 16mp CONFIGURATION MENU NAVIGATION FLOWCHART



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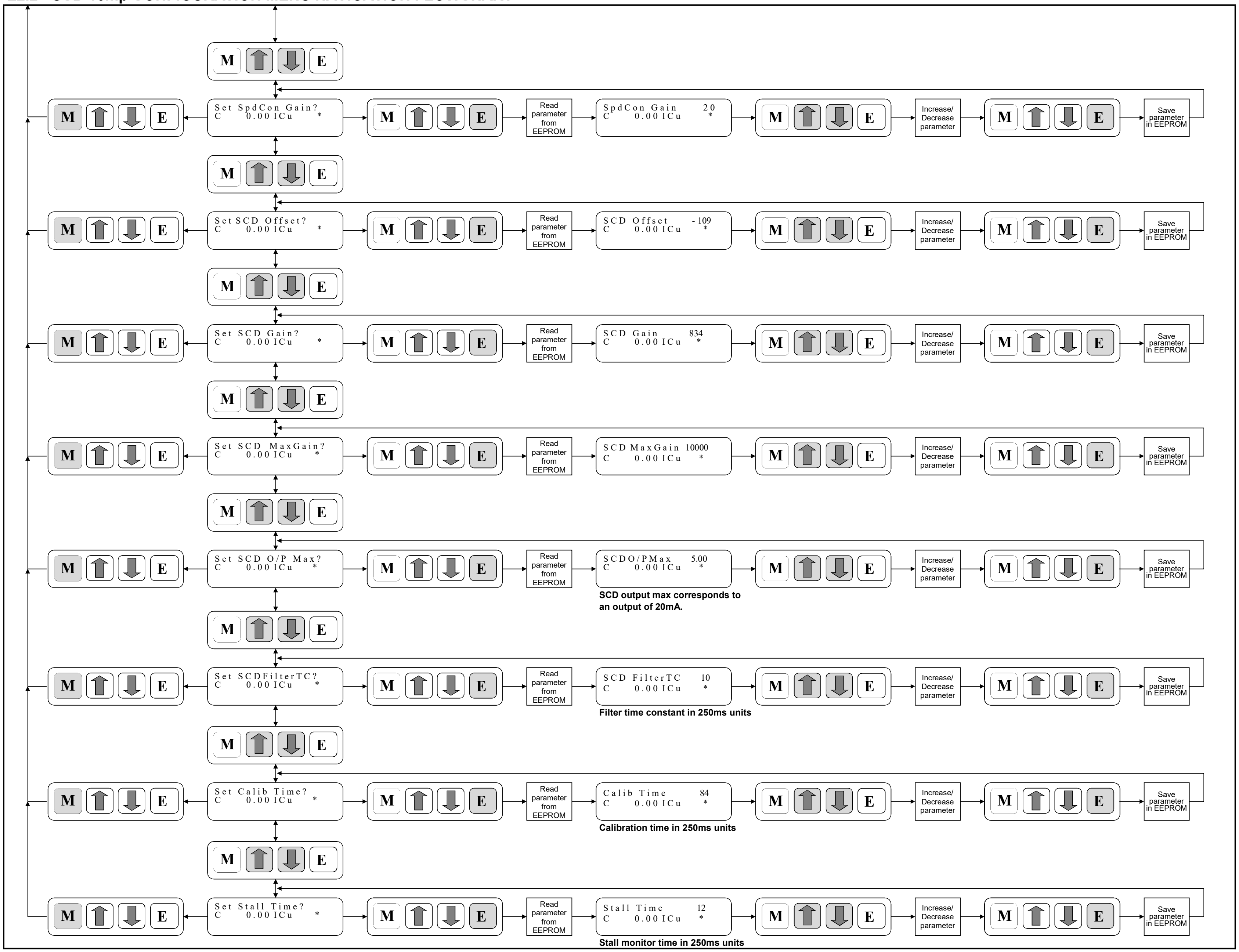
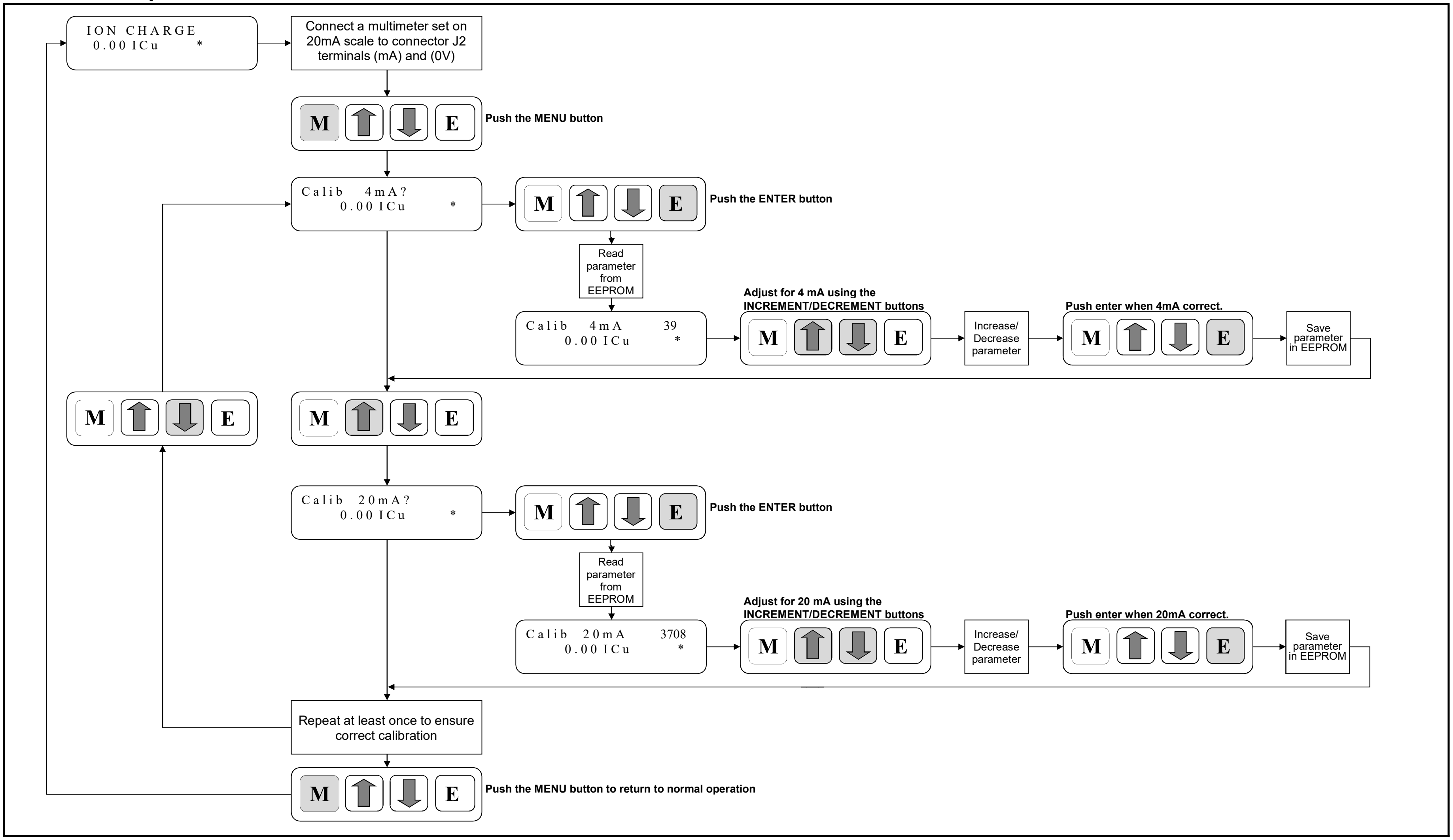
E2.2 - SCD 16mp CONFIGURATION MENU NAVIGATION FLOWCHART



E3 - SCD 16mp mA OUTPUT CALIBRATION FLOWCHART



E4 - SCD 16mp AUTO CALIBRATION FLOWCHART