SmartCEM

Continuous Emissions Monitoring System

Model D-CEM2100
Dust Monitor

Installation, Commissioning,
Operation & Maintenance Manual

OPS.106
Issue : B
Revision : 2
Date : 28 September 2011
Doc i/d : 0106/6
090041

CODEL

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ISO 9001 CERT NO.232
022

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CODEL International Ltd is a UK company based in the heart of the Peak District National Park in Bakewell, Derbyshire. The company specialises in the design and manufacture of high-technology instrumentation for monitoring combustion processes and atmospheric pollutant emissions.

The constant search for new products and existing product improvement keeps CODEL one-step-ahead. With a simple strategy, to design well-engineered, rugged, reliable equipment, capable of continuous operation over long periods with minimal maintenance, CODEL has set standards both for itself and for the rest of the industry.

All development and design work is carried out 'in-house' by experienced engineers using state-of-the-art CAD and software development techniques, while stringent assembly and test procedures ensure that the highest standards of product quality, synonymous with the CODEL name, are maintained.

High priority is placed upon customer support. CODEL's dedicated team of field and service engineers will assist with any application problem to ensure that the best possible use is derived from investment in CODEL quality products.

If you require any further information about CODEL or its products, please contact us using one of the numbers below.

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Contents

Important

The warning signs (and meanings) shown below, are used throughout these instructions and are intended to ensure your safety while carrying out installation, operation and maintenance procedures. Please read these instructions fully before proceeding.

Caution, risk of electric shock.

Caution, risk of danger.

Caution, hot surface.

Earth (ground) terminal.

Protective conductor terminal

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1. CODEL D-CEM2100 Analyser

1.1. Introduction

The D-CEM2100 is a dual-pass transmissometer configured for the measurement of opacity and dust concentration within the flue gas. Its unique optical arrangement provides continuous measurements of transmissivity of visible light across the stack in opposite directions, providing not only an accurate average of the dust loading in the stack, but a dynamic assessment of any mis-alignment errors that may occur due to stack movement.

The analyser consists of a pair of stack-mounted transceivers designed to send and receive a visible light beam across the stack in order to obtain measurement of transmissivity of the stack gases, from which are calculated values of opacity and dust concentration.

The transceivers are controlled by a signal processor unit (SPU) that can be interfaced with a laptop computer via a serial RS232 link for commissioning and servicing.

A remote data display unit (DDU) is connected to the processor via a 4-wire data bus up to 1km in length. This module enables all output and diagnostic data to be accessed on a 2-line, 32-character alpha-numeric display and keypad. It also provides 2 x 4-20mA outputs and 2 x volt-free contact relays for alarms. These outputs are fully configurable from the keypad and display.

A second DDU can also be connected to the SPU if required – see Supplement 1 at the end of this document.

1.2. Overview

Dust and smoke emissions have for a long time been recognised as major atmosphere pollutants, particularly since such emissions from stacks are clearly visible to an observer. There has been a requirement for monitoring, and quantifying these emissions, for some time and a variety of instruments have been marketed throughout the world for this purpose.

Instruments in the past have, however, generally proved to be unreliable, falling rapidly into disuse or to be so expensive and complex as to be affordable only by the very large users, such as power stations. The CODEL D-CEM2100 seeks to overcome these problems by providing a reliable, simple to use instrument with low maintenance requirements.

The arrangement is illustrated in Figure 1.

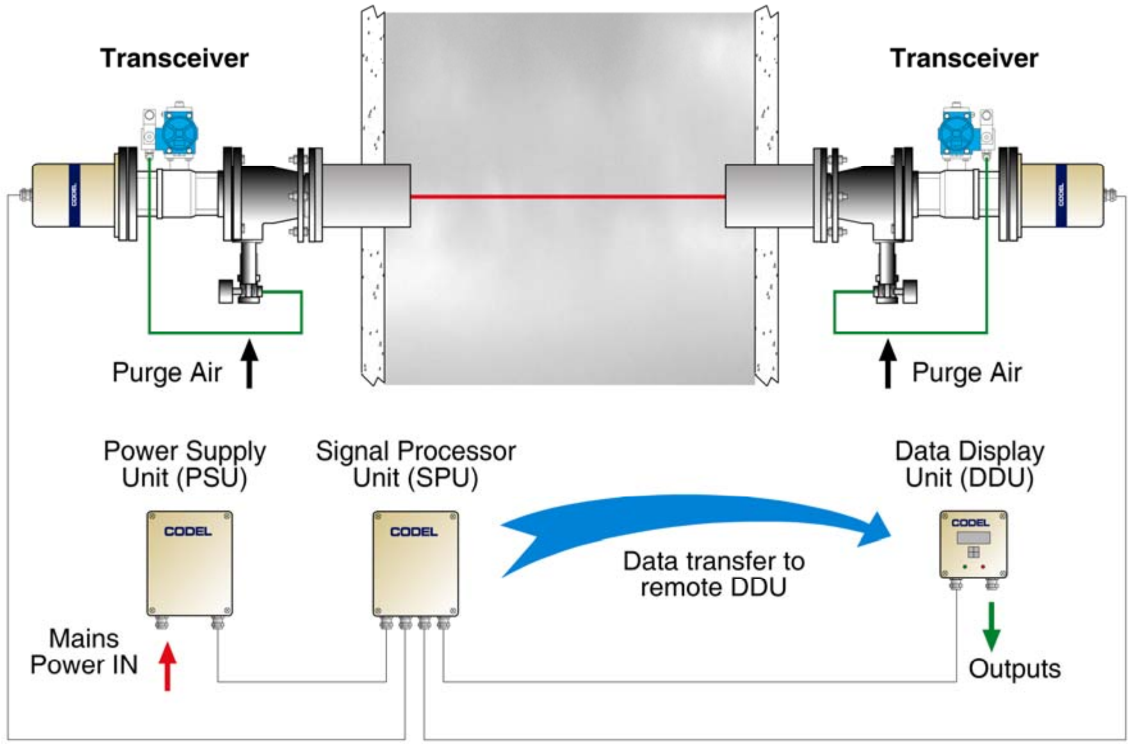


Figure 1 : Arrangement of D-CEM2100

2. Measurement Principle

Consider the two identical transceivers positioned at either side of the flue (or duct), unit 1 and unit 2. The transmissivity of light from unit 1 to unit 2 (unit 1 transmitting) can be represented by the equation:

τ_{12}	=	K_1 (Dr2/Dt1)	where:
K_1	=	gain constant to produce $\tau = 1$ (100% transmissivity, clean air condition)	
Dt1	=	transmitted light intensity at unit 1	
Dr2	=	received light intensity at unit 2	

The transmissivity of light from unit 2 to unit 1 (unit 2 transmitting) can also be represented by the equation:

τ_{21} = K_2 (Dr1/Dt2)

where:

K_2	=	gain constant to produce $\tau = 1$
Dr1	=	received light intensity at unit 1
Dt2	=	transmitted light intensity at unit 2

This is demonstrated schematically in Figure 2.

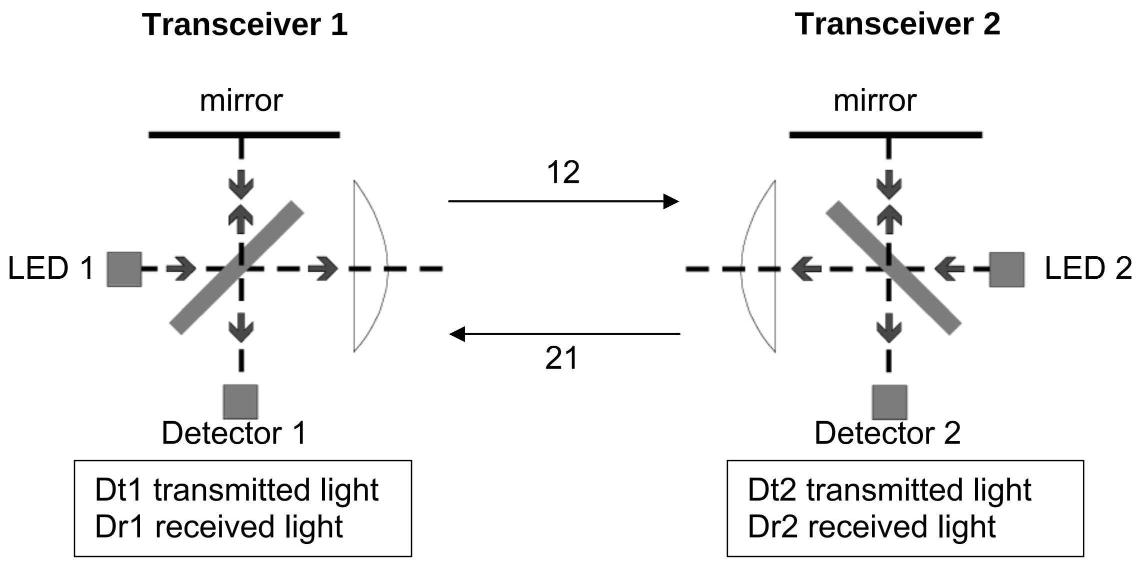


Figure 2 : Schematic of Principle of Transmissivity

Overall transmissivity of the system (τ) can, therefore, be represented as:

$$\tau = \sqrt{\tau_{12} \cdot \tau_{21}}$$

$$\tau = \sqrt{K_1 (Dr2/Dt1) \cdot K_2 (Dr1/Dt2)}$$

which can be rewritten as:

$$\tau = \sqrt{K_1 K_2 (Dr2/Dt2) \cdot (Dr1/Dt1)}$$

As the two bracketed terms above are each measured from only one of the transceivers, the output of the instrument is independent of drift of either detector.

2.1. Window Compensation

A reflector is mounted on the 'ball' of a compressed-air operated ball valve enabling it to be rotated in to and out of the optical path (see Figure 3). Window contamination levels are determined by monitoring the detector levels Dt at each transceiver with and without the reflector in place. From the data recorded the signal processor computes the window contamination for each transceiver. The ball valve is actuated by a compressed air supply that can be switched on and off by a solenoid valve controlled by the SPU.

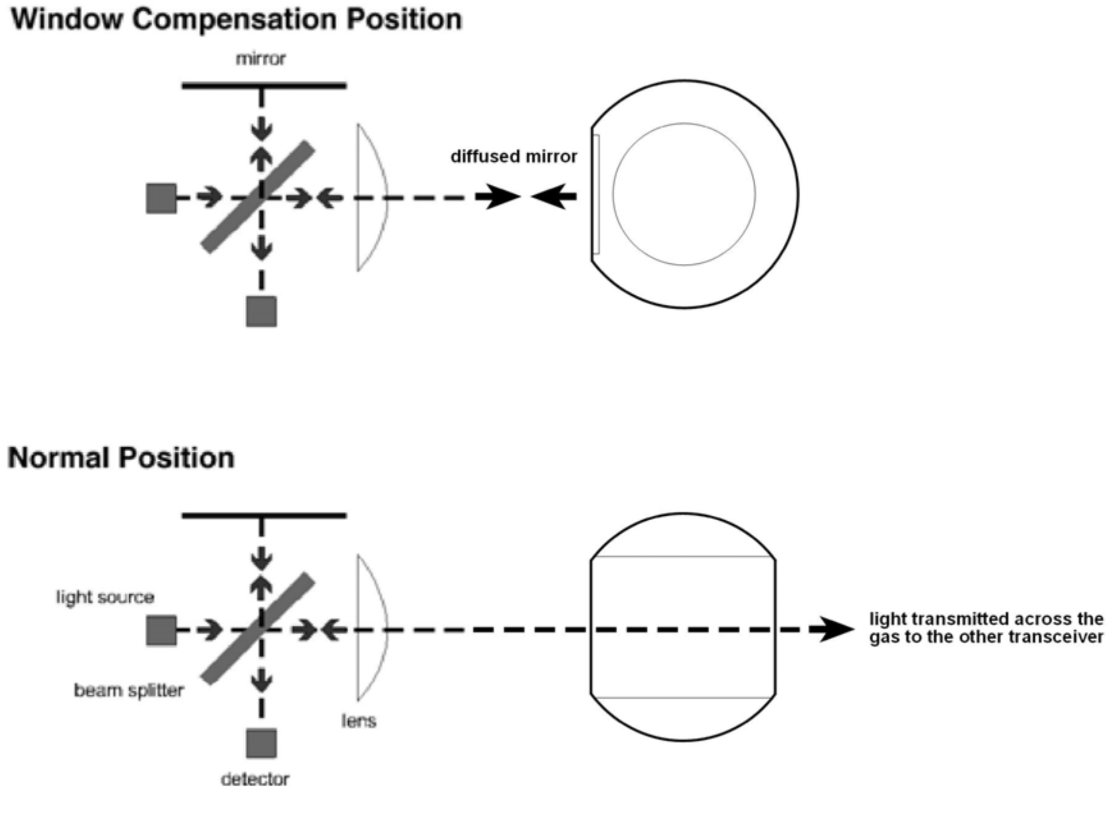


Figure 3 : Optical Arrangement of the D-CEM2100

When the ball valve is closed the transmitted light signal received by the internal detector is increased by light reflecting from the mirror on the ball valve, thus:

$$Dt_{mirror} = Dt + cDt.\ \tau_l^2$$

where Dt is the transmitted light signal with the ball valve open and 'c' is a constant representing the fraction of the light from the LED that reaches the detector via the ball valve mirror and 'τ_l' is the transmissivity of the transceiver lens. This term is 'squared' because the light passes through the lens twice en route to the detector.

The value of 'c' can be determined by making a measurement of Dt_{mirror} when the lens is known to be clean and 'τ_l' can be set to the value 1, thus:

$$(Dt_{mirror})\ cal = Dt + cDt$$

$$c = \frac{(Dt_{mirror})\ cal - Dt}{Dt} = kcal$$

and therefore, $c\tau_l^2 = \frac{Dt_{mirror} - Dt}{Dt} = k$

thus the transmissivity 'τ' at the lens van be determined as:

$$\tau_l^2 = \frac{k}{Kcal}$$

and lens contamination is simply $1-\tau_l$

3. Specification

Span		fully selectable in terms of dust, opacity or extinction
Response Time		selectable from 10-seconds to 30-days rolling average
Maximum Path Length		15m
Serial Data Port		to communicate with a central processor as part of an integrated monitoring system.
Dust Calibration		by independent analysis (by others) * see below
Accuracy		±0.2% Opacity
Power input	PSU	100-240V AC, 50/60Hz
	D-CEM	48V DC, 50VA (from PSU)
Air purge consumption		0.25 l/s @ 1.5bar
		Dry (to -20°C)
		Clean (better than 10μm)
Air driven ball valve		air pressure required 4bar (60psi)

* The dust calibration depends upon the size and nature of the dust particles. Only an accurate comparison of measured extinction values and dust concentration in mg/m3, determined by iso-kinetic gravimetric measurement, can produce a rigorous calibration.

4. Installation

4.1. Equipment List

The CODEL Model D-CEM2100 comprises the following:

- 2 x transceivers with 10m of cable (standard length)
- 2 x site mounting flanges
- 2 x air purges
- 2 x ball valves
- 1 x Power Supply Unit (PSU)
- 1 x Signal Processor Unit (SPU)
- 1 x Data Display Unit (DDU)

4.2. Positioning the Equipment

The equipment is designed for mounting on stacks in positions open to the weather. It is fully sealed to IP65 and requires no weather covers.

Consider the following:

- the site must be accessible at both sides of the duct for servicing the transceivers.
- the site should be as free as possible from extremes of temperatures and vibration. Permissible ambient temperature ranges are -20^{o}C to 80^{0}C for the transceivers and -20^{o}C to 50^{o}C for the SPU, PSU and DDU.

NB. At low temperatures, condensation might occur on the lens of the instrument causing an incorrect (high) opacity reading.

- there must be an uninterrupted sight path between each transceiver.
- the SPU should be mounted local to the transceivers, which are supplied with 10m of cable as standard.

4.3. Installation

The analysers and any other items are normally protected for transportation by an expanded foam packing material. When unpacking, please ensure that smaller items are not discarded with the packing material.

The analysers are supplied with standard 10m cables already connected.

If any items are missing please inform CODEL or your local CODEL supplier immediately.

The installation site should be free of all encumbrances and safety procedures should be observed at all times.

The recommended order, reflected in this manual, is:

- Installation of the stub-pipe and mounting flange
- Installation of air purges
- Fitting of ball valves and air supply
- Fitting of transceiver heads, PSU, SPU and DDU
- Installation and connection of cables

The transceivers should be mounted on diametrically opposite sides of the stack.

Construct the mounting assemblies by welding each site mounting flange to a suitable stub-pipe, nominal bore 75mm. The pipe should be long enough to keep the equipment clear of any duct lagging and it also helps to insulate the equipment from high duct temperatures. Suggested stub-pipe mounting arrangements are shown in Figure 4 for a metal stack and for a concrete stack. In the case of a metal stack it may be necessary to fit stiffening ribs for added rigidity.

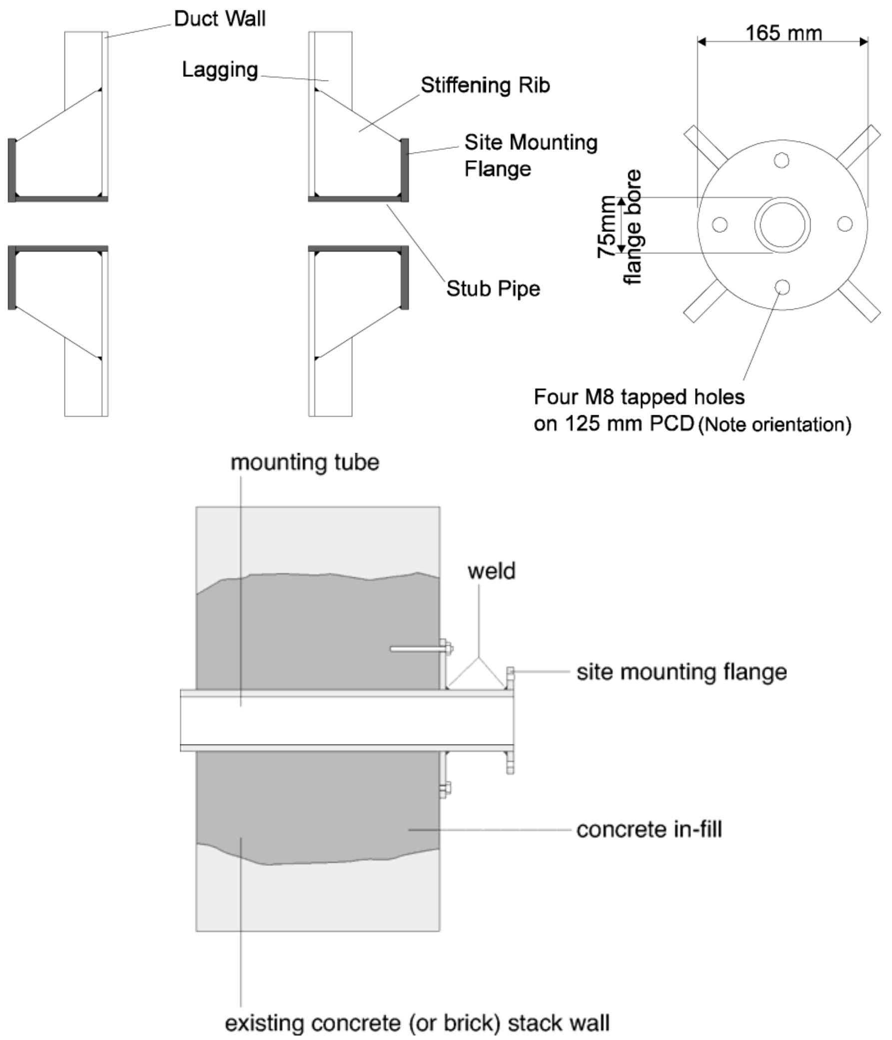


Figure 4 : Stub Pipe Arrangement

4.3.1. Air Purges

The purpose of the air purges is to keep the windows of the transceivers clean. The air purges mount directly onto the site mounting flanges. Separate the front flange from the air-purge by unscrewing the four retaining nuts. This should now be bolted to the site-mounting flange with a rigid gasket fitted between them, using the four countersunk screws provided.

The rear flange is then offered up to the front flange on to the protruding studs, taking care that the ‘O’ ring seal on the flange locates smoothly into the central aperture. This is then re-secured by the four nuts that screw down onto the adjustable flange. The arrangement should now appear as in Figure 5.

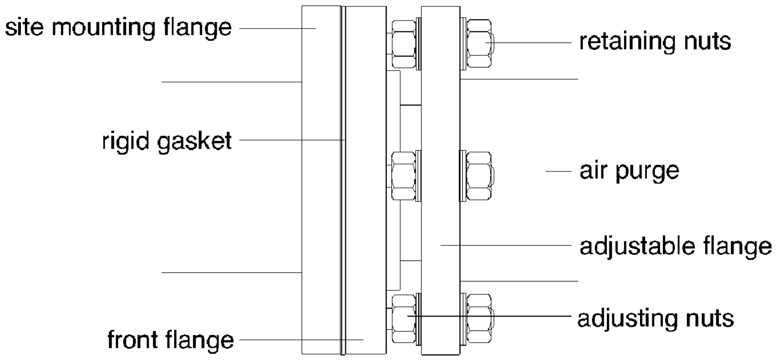


Figure 5 : Adjustable Mount Details

4.3.1. Ball Valves

The ball valves are mounted to the air purges using four M6 hexagon head screws. Note that these screws locate through the nylon insulating bushes in the air purge flange and screw into the valve flange. The nylon isolation bushes are essential to maintain electrical isolation of the transceivers from the duct.

Compressed air connections to the ball valve and air purge are as shown below. Failure of the compressed air supply will result in the ball valves closing and isolating the transceivers from the flue gas.

Do not insert fingers into the ball valve mechanism at any time while the compressed air is connected.

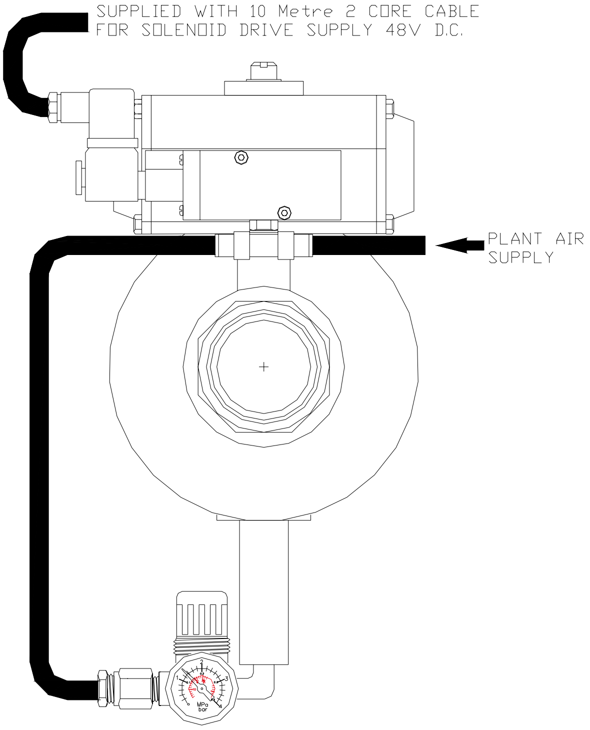


Figure 6 : Compressed Air Connections at the Ball Valve

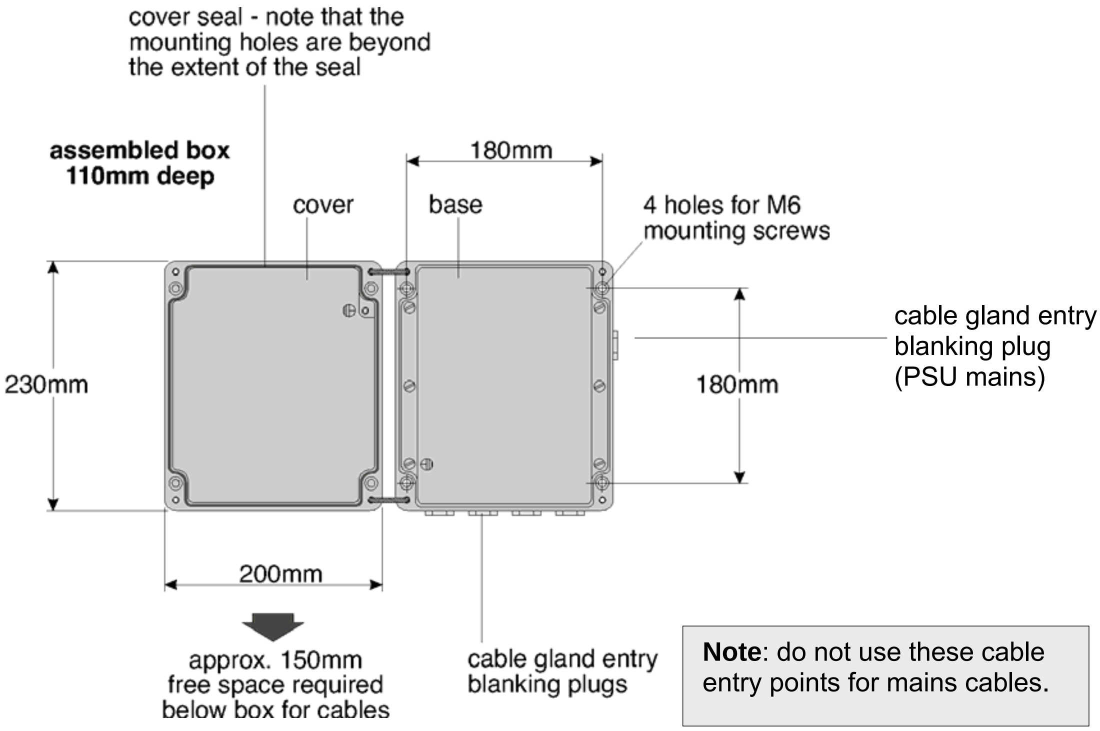
4.3.2. Transceivers

By means of four hexagon head screws, the transceiver head/ball valve assemblies may be attached to the air purges with the flexible gasket supplied, fitted between them. Take care to locate the dowel.

4.3.3. PSU & SPU

To mount the PSU & SPU, first remove the cover by loosening the four captive screws. The case is then secured to a firm support by use of the four mounting holes, one in each corner of the case, outside the sealing rim. Since the mounting holes are located outside the seal of the case, it is not necessary to seal the mounting holes after installation, nor is it necessary to remove the circuitry from the case for installation.

If commissioning is not to be carried out immediately, reattach the lid to the processor. Dimensions and mounting details are shown in Figure 7.



NB. When fitting the mains cable in the PSU secure an M20 banjo earth ring under the gland locknut in order to provide a good earth bond.

Figure 7 : PSU & SPU Mounting Details

4.3.4. DDU

To mount the DDU, first remove the cover by loosening the four captive screws and unplug the ribbon cable from at the lid connection. The case is then secured to a firm support by use of the four mounting holes, one in each corner of the case, outside the sealing rim. Since the mounting holes are located outside the seal of the case, it is not necessary to seal the mounting holes after installation, nor is it necessary to remove the circuitry from the case for installation.

If commissioning is not to be carried out immediately, reattach the lid to the processor. Dimensions and mounting details are shown in Figure 8.

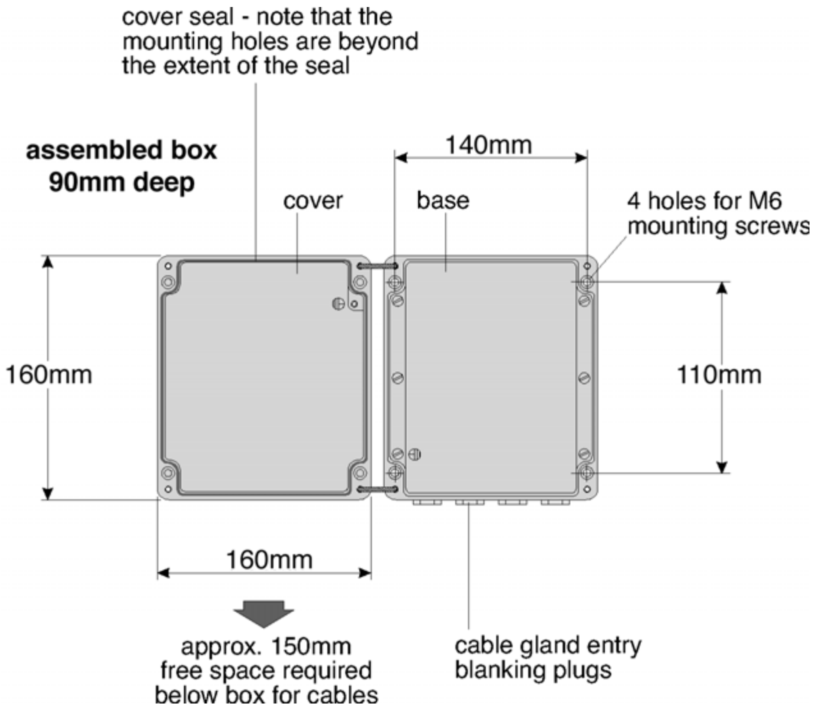


Figure 8 : DDU Mounting Details

5. Electrical Connections

WARNING! Wiring should only be undertaken by a qualified technician.

Ensure that the power supply is isolated.

DO NOT switch power on until all wiring work is complete.

5.1. Installation and Connection of Cables

Decide routing for all **non-power cables** (both those supplied by CODEL and those sourced locally). Use common routing wherever possible and install leaving sufficient free-end length to make final connections.

The maximum recommended length of the connecting cable between the SPU and the DDU (customer supply) is 100m – if a greater length is required please contact CODEL before installation.

Power cables (customer supply) should be installed separately, using different routes if possible to reduce the risk of cross interference. Leave sufficient free-end length to make final connections. The maximum recommended cable length is 5m – if a greater length is required please contact CODEL before installation.

CODEL supplied cables are provided with ferrite beads fitted to all cores to protect against interference and should not be modified without consulting CODEL.

WARNING! Mains connection must be via a fused isolating spur and should only be undertaken by a qualified technician.

See the electrical rating plate on the PSU.

5.2. Connection Schedule

The connection schedule for the D-CEM2100, PSU, SPU & DDU is shown in the following drawing.

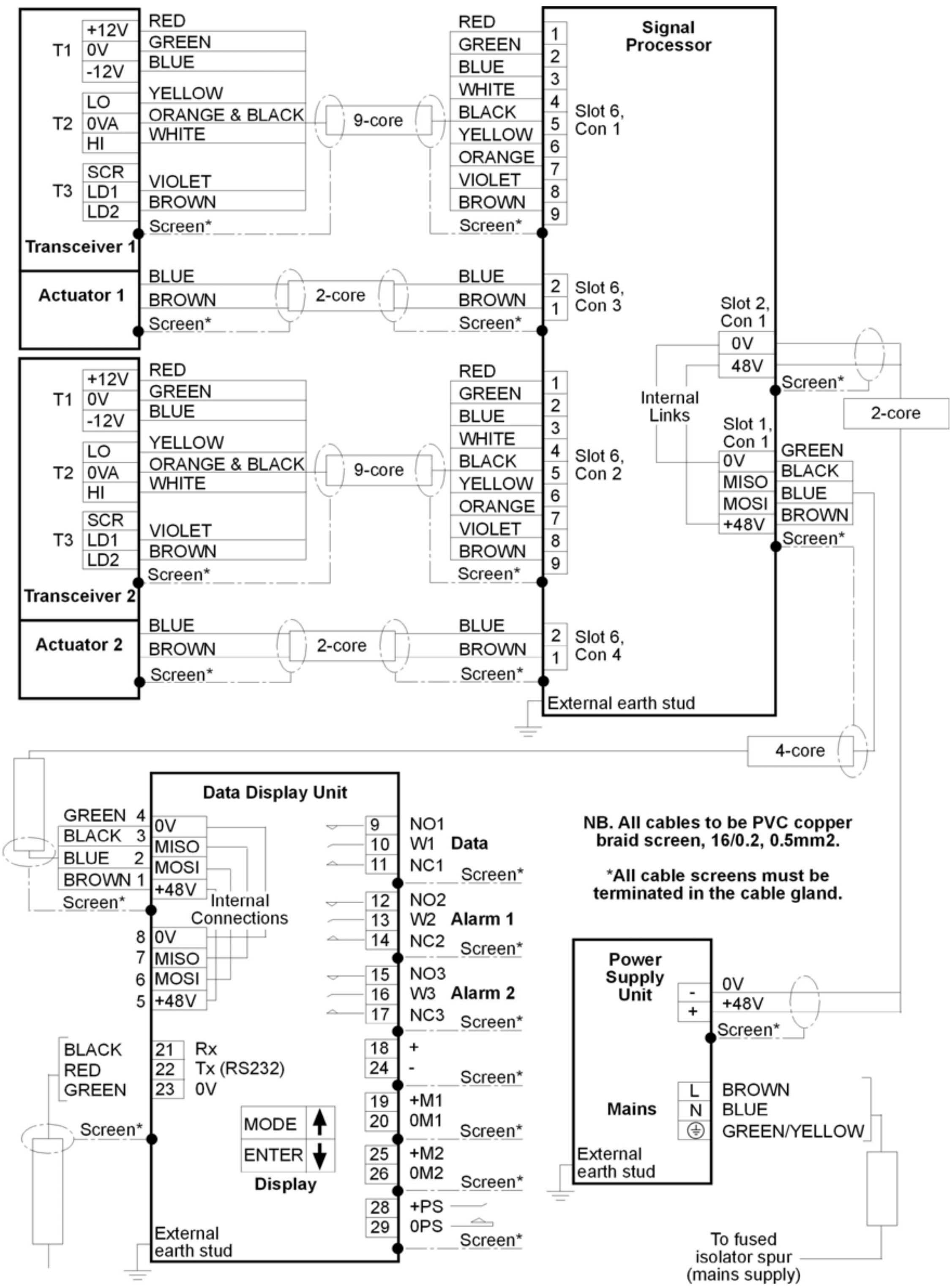


Figure 9 : Connection Schedule

6. D-CEM2100 Data Display Unit Operation

6.1. Introduction

After the instrument has been commissioned, it will measure the transmissivity between the transceivers, and produce an output proportional to either the opacity, dust or extinction level. An integral 32-character display also shows the calculated levels.

The instrument allows the operator to interrogate the micro-processor to observe the system parameters, and to change them if required.

A menu-based program is used and access is gained by four keys mounted on the lid of the DDU.

NB. Any data contained in the following display illustrations is intended to be representative only.

6.1.1. Measurement

Each transceiver, mounted on opposite sides of the duct, transmits modulated light to, and receives light from the other transceiver. The selector within each transmitter monitors both, the intensity of the received light (Dext). This enables the transmissivity from unit 1 to unit 2 (T12) and unit 2 to unit 1 (T21) to be measured simultaneously, from which the opacity is calculated.

6.1.2. Calibration

During the commissioning procedure, a calibration is conducted that sets the system gain to produce a zero or known opacity.

6.2. Operating Modes

The instrument has six modes of operation that are identified by a number in the top left-hand corner of the display:

- **Operating Mode** - display average opacity, extinction or dust density.
- **Parameter Mode** - display operating parameters.
- **Normalisation Data** - display normalisation data.
- **Diagnostic Mode** - investigate instrument operation.
- **Set-up Mode** - set operating parameters. The mode can only be accessed using a security code.
- **Maintenance Mode** - allows shut-off valve to be closed manually for sensor maintenance

NB. The outputs of the instrument are unaffected by key operation in all modes except the set-up and maintenance modes.

6.3. Key Operation

Each mode is accessed sequentially by each push of the MODE key. Figure 10 illustrates the display and keys of the DDU. After a mode has been selected, the **ARROW** keys will select the various options within these modes. The **ENTER** key will input the displayed value, and may step the cursor to the next option, if this is applicable.

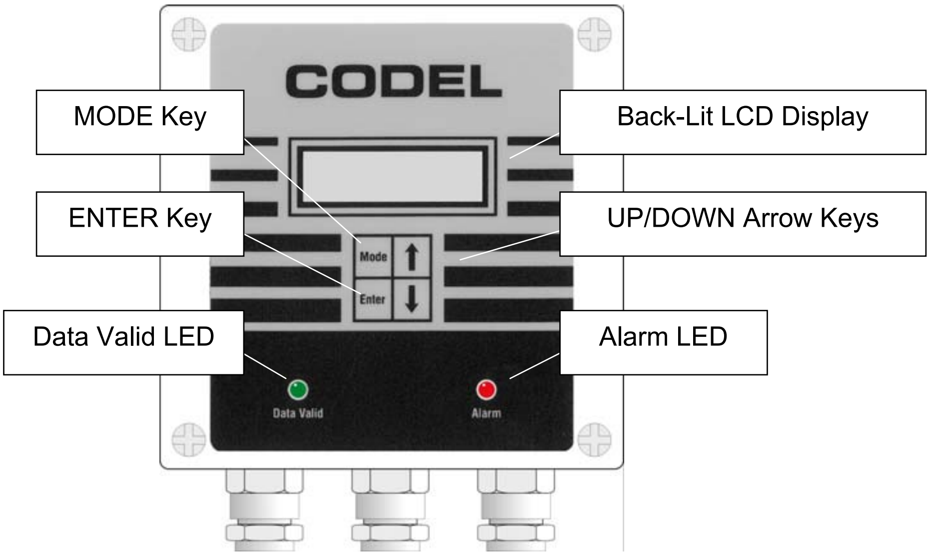


Figure 10 : Illustration of DDU and Keys

6.3.1. Mode Key

The **MODE** key will take the instrument to the next mode of operation, or take the instrument out of the current mode and back to mode 1.

6.3.2. Arrow Keys

Pressing the **ARROW** keys will do one of two things, depending on the position in the program:

- it will increase (⇑) or decrease (⇓) the displayed value. If the key is held down it will scroll quickly to the desired value, ***or***
- it will step through the available options within a mode or sub mode.

6.3.3. Enter Key

Pressing the **ENTER** key will do one of two things depending on the position in the program:

- it will input the displayed parameter value, **or**
- it will select the displayed mode or option from within a mode or sub mode.

NB. Allow time for the instrument to respond to a key instruction, otherwise a double key entry may be recorded.

6.3.4. LED Indication

The two LEDs (Data Valid & Alarm) indicate correct instrument operation and a high dust or opacity level. They mirror the operation of the two contact relays.

6.4. Program Tree

Figure 11 illustrates the main program of the instrument. Where an operating mode is complex, an extra program tree is given in this section.

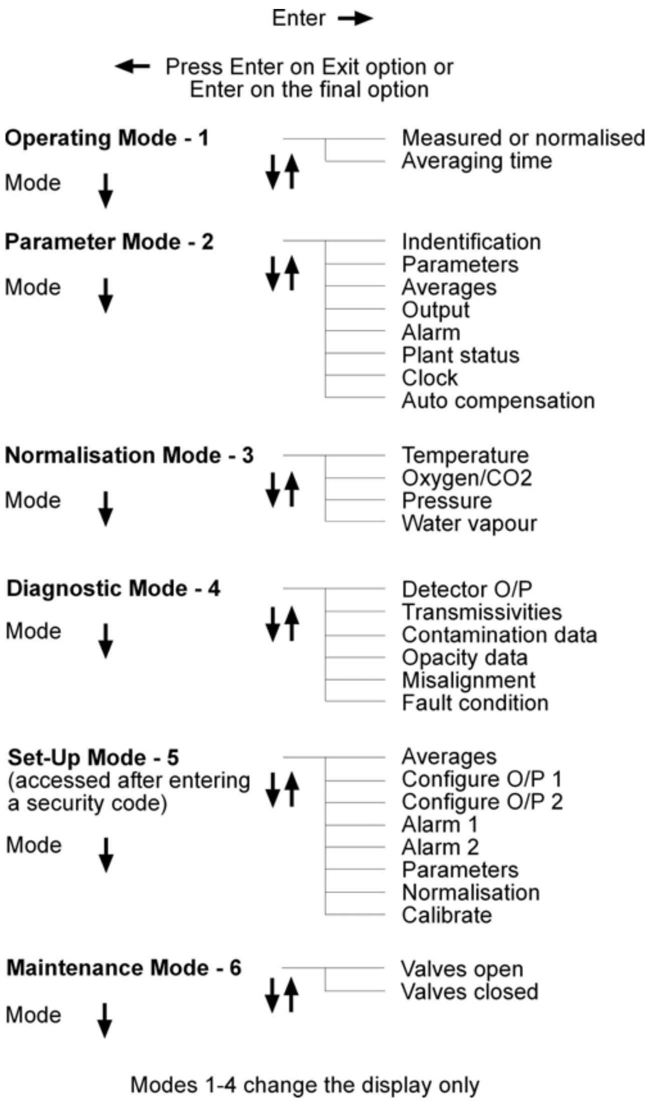


Figure 11 : Program Tree

6.5. Operating Mode

From this mode of operation the four averaging times, seconds, minutes, hours and days, may be displayed. The concentration units, opacity, extinction and dust density levels, may be altered and the measured/ normalised measurements for dust density observed.

When in this mode, the display will appear similar to that shown below. If the display is not similar, press the **MODE** key until number 1 appears in the top left corner of the display.

1	**OPACITY = 012.7%**
Normalised Av03	

To change the data displayed, press the **ENTER** key and a flashing cursor will appear at the beginning of each of the four concentration units. The **ARROW** keys will now change the highlighted parameter. Each push of the **ENTER** key will select another of the parameters, in the following order:

- **Concentration Units** - opacity, optical density, dust density (mg/m^3 or mg/Nm^3)
- **Averaging Time** - seconds, minutes, hours, or days.

Once the display configuration is as required, press the **ENTER** key when the cursor is flashing on the averaging time, and the cursor will disappear from the display. The **ENTER** key may be pressed again if required to bring the cursor back onto the display.

6.6. Parameter Mode

In this mode, the parameters set within the set-up mode may be examined, but not changed. Press the **MODE** key until the number 2 appears in the top left corner of the display, then press the **ENTER** key. The **ARROW** keys will now scroll through the available options. Press the **ENTER** key to display the selected option. Press the **ENTER** key again to exit from each option.

See 6.9. Set-Up Mode for further details of the display information and how to change the held parameters.

6.6.1. Identification

From this option, the analyser type, its program number, and the device identity of the instrument may be displayed.

- **Instrument type** - D-CEM
- **EPROM number** - will display the communications EPROM ID
- **Identity** - serial communications identity

6.6.2. Parameters

The following parameters are examined from this option, selected using the **ARROW** keys:

- **Measurement Path Length**

This is the path length between the transceivers. This value is not used within the current program.

- **Dust Factor**

A 'Dust Factor' is used to calculate the dust density - see 6.12. Calibration for Dust Measurement.

- **Output Fault 1**

Should a fault condition occur on output 1, the analogue output can be set from one of four options see the set-up mode. The selected option may be examined here.

- **Output Fault 2**

Should a fault condition occur on output 2, the analogue output can be set from one of four options see the set-up mode. The selected option may be examined here.

- **Protocol**

Displays the protocol selected for the serial communications output, either CODEL (for connection to CODEL's own software), or MODBUS (for connection to standard MODBUS system – see Supplement 3 at the end of this document).

- **Baud Rate**

Displays the baud rate selected for the serial communications - either 4800 or 9600 baud.

6.6.3. Averages

Selecting this option will display the times set for each of the four averaging stacks.

6.6.4. Outputs

- **Output 1**

The base, span and averaging of analogue output 1 are displayed from this option.

2 O/P1 (0Ma) Av60s
010 to 100%op

- **Output 2**

The base, span and averaging of analogue output 2 are displayed from this option.

2 O/P2 (4Ma) Av60s
1.0 to 5.0 Ringel

6.6.5. Alarms

- **Alarm 1**

A contact output is available within the processor to indicate high opacity, extinction and dust levels. The level at which this output (analogue o/p1) is operated, and the averaging stack from which the concentration value is obtained, may be examined from this display.

2 ALARM 1 Av 60s
Level 1.00Ext'n

- **Alarm 2**

A contact output is available within the processor to indicate high opacity, extinction and dust levels. The level at which this output (analogue output 2) is operated, and the averaging stack from which the concentration value is obtained, may be examined from this display.

2 ALARM 2 Av 60s
Level 9.0% Op

6.6.6. Plant Status

On entering this option the plant status condition is displayed, i.e. **ON** or **OFF**.

2 PARAMETERS
Plant Status OFF

To switch OFF Plant Status short together terminals 28(+PS) and 29(0PS) in the DDU.

Note that if Auto Compensation calibration is selected Logic Input YES (when Plant Status is switched OFF) then a 'Window Check' compensation will take place.

When Plant Status is OFF the current outputs will be set to the zero point (either 0 or 4mA), all alarms will be cleared and the rolling averages will stop updating.

6.6.7. Clock

Scroll down the options to view each setting in turn - year, month, day, hour, minute and second.

2 time 12 * 00 * 00
date 19/11/04

6.6.8. Auto Compensation

The parameters that control the operation of the automatic zero calibration system are displayed here:

- Interval - displays the interval in hours between auto calibrations.
- Logic - the plant status logic input can be reconfigured to act as an external calibration input. The display shows the status of the logic selection.
- Cal Alarm - alarm 1 can be configured to act as a Cal in Progress alarm. This display shows the status of that alarm.
- Next Cal - if the timer is being used to trigger the automatic calibrations the time that the next calibration is scheduled to occur is displayed here.

Using the down arrow set the auto calibration parameters.

- Auto Calibration Interval

Set the auto calibration interval; if the interval is set to zero then the display will show ‘timer inhibited’.

2 Auto Cal Interval
interval 002hrs

- Logic/Plant Status Input

2 Auto Cal Interval
Logic OFF

- Cal Alarm

2 Auto Cal Interval
Cal Alarm OFF

- Output Data

2 Auto Cal Interval
Output Data OFF

- Next Calibration

Set time and date of next calibration

2 Next Cal 0300h
on 20/11/04

6.7. Normalisation

From this mode, the normalisation parameters that are currently being used can be displayed. Press the **ENTER** key to enter the routine, and use the **ARROW** keys to select which of the normalising parameters to display.

Press the **MODE** key until the number 3 is seen in the top left corner of the display. When the required normalising parameter is displayed, press the **ENTER** key to display the normalisation data. Press the **ENTER** key again to exit the parameter. The available parameters are:

- **temperature**
- **oxygen/CO2**
- **pressure**
- **water vapour**

6.7.1. Display Format

For each of the normalising parameters the display will appear similar to that shown below in Figure 12.

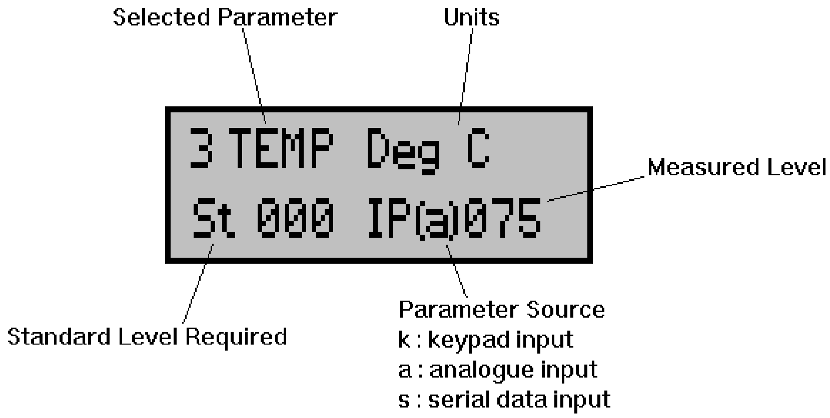


Figure 12 : Normalisation Parameters Display Format

After pressing the **ENTER** key to access the mode the **ARROW** keys can be used to scroll through the normalisation menu, Temperature, Oxygen/Carbon Dioxide, Pressure and Water Vapour.

3 NORMALISATION	
Temperature	

3 TEMP	**Deg C**
St 000 IP (k)	**127**

3 NORMALISATION	
Oxygen	

3 NORMALISATION	
Carbon Dioxide	

3 OXYGEN	**%DRY**
St 06 IP (k)	**06.8**

3 CO2	**%DRY**
St 09 IP (k)	**09.3**

3 NORMALISATION	
Pressure	

3 PRESSURE	**kPa**
St 101 IP (k)	**102**

3 NORMALISATION
Water vapour

3 WATER VAPOUR	**%**
St DRY IP (k)	**11.6**

3 NORMALISATION
EXIT

After selecting one of the four sections press ENTER to access the data. In each display the top line provides the units of measurement, while the bottom line gives the standard value for the normalisation, the measured value and method of measurement (m = measured by the analyser, a = analogue input, k = keypad input).

The standard or reference value is that value which is normally specified by the local Environmental Agency to which the gas channel output data should be normalised. For temperature this is usually zero Celcius, for pressure 101KPa and for water vapour 0%.

6.8. Diagnostic Mode

The detector levels, Analogue to Digital (A-D) levels, receiver gain, calibration and opacity data may be examined from this mode. Press the **MODE** key until number 4 appears in the top left corner of the display, and push the **ENTER** key to enter the mode.

The **ARROW** keys will now select from the following, press the **ENTER** key to select the displayed option. Figure 13 illustrates a program tree for this mode.

Enter →

← Press Enter on Exit option

Detector Outputs	Detector output levels within the transceivers
↓↑	
Transmissivities	Transmissivity & calibration constants
↓↑	
Contamination Data	Contamination levels for windows 1 & 2
↓↑	
Opacity Data	Raw & smooth opacity levels
↓↑	
Misalignment Data	Misalignment error as % opacity
↓↑	
Fault Condition	Fault status
↓↑	
Exit	

Figure 13 : Illustration of the Diagnostic Program

6.8.1. Detector Outputs

The output levels from the detector within the transceivers are displayed here. Dt is the detector level of the transmitting LED and Dr is the detector level for the received light.

4 Dr 1 = 18573
Dr 2 = 18211

4 Dt 1 = 11059
Dt 2 = 10748

6.8.2. Transmissivities

Transmissivities between each transceiver 1 to 2 & 2 to 1 are displayed with their relevant calibration factors K12 & K21

4 T12 = 09998
T21 = 09963

4	**K12 = 09998**
	K21 = 09963

6.8.3. Contamination Data

Contamination levels are expressed as % obscuration and are displayed to both windows 1 and 2.

4	**Window 1 0.06%**
	Window 2 0.10%

6.8.4. Opacity Data

This display indicates the raw (Op0) and the 60-second average (Op60) opacity values. The 60-second smoothed value is used to generate the minutes, hours and days rolling averages.

4	**Op(0) = 000.0%**
	Op(60) = 000.0%

6.8.5. Misalignment

The error between the two transmissions expressed as % opacity

4	**Misalignment**
0.35% Op	

6.8.6. Fault Condition

To display the current fault condition, press the **ENTER** key while this is displayed.

4	**Fault Status**
ALL CLEAR	

The instrument automatically selects this display mode should a fault condition occur. The following fault conditions are recognised by the instrument:

- **Dt** is less than 5242 (equivalent to 3.2V peak-to-peak).
- **Dt1 (Tx) saturated** - the detector level within the transmitter1 is too high for the current duct conditions. Dt is greater than or equal to 29,484 which approximates to 18V on the Tx wave shape on a storage oscilloscope.
- **Dt2 (Tx) saturated** – the detector level within the transmitter2 is too high for the current duct conditions. Dt is greater than or equal to 29,484 which approximates to 18V on the Tx wave shape on a storage oscilloscope.
- **Dr1 (Rx) saturated** - the detector level gain within the receiver 1 is too high for the current duct conditions. Dr > or equal to 29,484 as for transmitter.
- **Dr2 (Rx) saturated** - the detector level gain within the receiver 1 is too high for the current duct conditions. Dr > or equal to 29,484 as for transmitter.

- **Dt2 low** – the detector level for the internal signal from head 1 is too low <5000
- **Dt1 low** – the detector level for the internal signal from head 1 is too low <5000
- **Dirty optics** - the lens of the transceiver is contaminated. Kwkg is approximately equal to twice Kcal.
- **Misalignment** - misalignment has produced an error between the two transmissivities at >2 % opacity.
- **Cal. in Progress** – calibration has been requested either by serial comms. or a second DDU in the system.
- **Valve 1 closed** – the detector level Dt1 is above threshold 16128 indicating that the valve is closed and the mirror in position.
- **Valve 2 closed** – the detector level Dt2 is above threshold 16128 indicating that the valve is closed and the mirror in position.
- **All Clear** - no fault condition.

Also, the previous fault may be displayed by pressing the down arrow key.

6.9. Set-Up Mode

All system parameters can be changed and a basic calibration initiated from this mode. To prevent any unauthorised changes, the user must enter a four number security code before the mode can be accessed.

NB. After this mode has been selected, the instrument will suspend its operation. If no key is pressed within 5 seconds after selection of this mode, the instrument will revert to the normal operating mode.

Press the **MODE** key until the number 5 is displayed in the top left-hand corner. After the security code has been correctly entered there are 8 sub-modes of operation from which the set-up parameters may be changed (see Figure 14), these are:

- **Set Averages**

The four averaging stack times (seconds, minutes, hours & days) may be set as required. The averages may also be reset from this menu.

- **Configure O/P 1**

The first analogue output (O/P1) is configured from this sub mode.

- **Configure O/P 2**

The second analogue output (O/P2) is configured from this sub mode.

- **Alarm 1**

The source, units and level of the alarm for output 1 are set here.

- **Alarm 2**

The source, units and level of the alarm for output 2 are set here.

- **Parameters**

The following are set from this mode: security #, identity #, pathlength, dust factor and the real-time clock.

- **Normalisation**

All normalisation parameters may be set up from this mode.

- **Calibrate**

The outputs of the detectors and the basic calibration of the instrument can be set.

After the correct code has been entered, the user may access each of the eight sub-modes (listed above) by using the **ARROW** keys and pressing **ENTER** when the required option is displayed.

NB. When a parameter has been altered and ENTER has been pressed to exit the option, the changed parameter has been altered in the memory. There is no 'confirm' option for changed parameters.

6.9.1. Security Code Entry

Once this display is shown, to gain access to the set-up mode, press the **ENTER** key. The cursor will now flash over the first digit of the presented code number, select the required first digit with the arrow keys and press **ENTER**. Repeat this procedure for the remaining three numbers. If the code is correct after the **ENTER** key is pressed on the last digit, then the sequence will be continued, if it is not correct, the instrument will return to the operating mode.

5 SET UP MODE
Security # 0000

NB. The code number will be set to 0000 by CODEL at the factory. This should be changed by the user from within the set-up mode.

Enter →

← Press Enter on Exit option

Averages	Seconds	10 to 60s @ 10s intervals
	Minutes	01 to 60m @ 01m intervals
	Hours	01 to 24h @ 01h intervals
	Days	01 to 30d @ 01d intervals
	Reset	Reset stack averages
Configure O/P 1 & 2	Output	0 or 4-20mA
	Average	Take average from secs, mins, hours or days stack
	Units	Opacity, extinction or dust density
	Span	0 to 9999 span (units depend on above)
	Fault Condition	Measured, zero mA, FS (20mA) or hold last value
	Set mA O/P	Set up current output levels
Alarm 1 & 2	Source	Select averaging stack from alarm 1 & 2
	Units	Opacity, extinction or dust density
	Level	Set alarm level for 1 & 2 (units depend on above)
Parameters	Security No.	4-digit code
	Identity	Serial communication identity
	Pathlength	Gas pathlength in mm
	Dust Factor	Dust density calibration
	Protocol	CODEL's own or MODBUS
	Baud Rate	4800 or 9600
	Set Clock	Set year, month, day, hour, minute & second
Normalisation	Temperature	Set up normalisation I/P & std. levels for temp.
	Oxygen	Set up normalisation I/P & std. levels for O2/CO2
	Pressure	Set up normalisation I/P & std. levels for pressure
	Water Vapour	Set up normalisation I/P & std. levels for H2O
Calibrate	Set Cal Data	Set calibration target & number of cycles
	Calibrate	Conduct a basic calibration
	Window Compn.	Check window contamination levels
	Span Check	Span calibration check
	Auto Compn.	Configure auto calibration

Exit options not shown

Figure 14 : Program Tree for the Set-Up Mode

6.9.2. Averages

Four separate averages are calculated within the instrument. These are defined in units of seconds, minutes, hours and days. Any of these four averaging stacks can be used to provide the analogue output of the instrument.

Each averaging time is set within pre-defined limits.

5	**AVERAGES**

Press the **ENTER** key when this display is shown, the display will now show seconds. Use the **ARROW** keys to select the average time that requires changing, and press the **ENTER** key to access it. The value can now be changed using the **ARROW** keys and input by pressing the **ENTER** key.

5 AVERAGES
Seconds 60

Set the seconds averaging stack to the required value. This is limited from 10 to 60 seconds in 10-second intervals.

5 AVERAGES
Minutes 30

Set the minutes averaging stack to the required value. This is limited from 1 to 60 minutes in 1-minute intervals.

5 AVERAGES
Hours 4

Set the hours averaging stack to the required value. This is limited from 1 to 24 hours in 1-hour intervals.

5 AVERAGES
Days 1

Set the days averaging stack to the required value. This is limited from 1 to 30 days in 1-day intervals.

5 AVERAGES
Reset YES

The average values currently held in the four averaging stacks, may be reset using this option. This will erase the current averages that are held in all of the stacks.

Select either **YES** or **NO** using the arrow and enter keys. If **YES** is selected confirmation is requested before the averages are reset.

If this option is selected, all data in the averaging stacks is reset, and the data for as much as 30 days will be lost.

6.9.3. Configure O/P1

The analogue current loop output for output 1 is set up from this mode. Press the **ENTER** key while this display is shown, then press the **ARROW** keys to step through the available options. Press the **ENTER** key to enter each option; change the displayed parameter by using the arrow keys.

5 CONFIGURE O/P 1

6.9.3.1. Output

An origin of 0 or 4mA can be set for the current loop output. The **ARROW** keys will toggle between these two options. Press the **ENTER** key to enter the new value.

5 CONFIGURE O/P 1
OUTPUT = 4 to 20mA

6.9.3.2. Average

Any of the four averaging stacks (seconds, minutes, hours or days) may be used for the analogue output. They are selected by the **ARROW** keys and entered using the **ENTER** key.

5 CONFIGURE O/P 1
Average 01m

6.9.3.3. Units

The analogue output can represent either a measure of: opacity, extinction or dust. The **ARROW** keys will scroll through these options, press the **ENTER** key to chose the correct units. The dust is represented as either mg/m^3 or mg/Nm^3, the latter normalised to standard conditions.

5 CONFIGURE O/P 1
Units mg/m3

6.9.3.4. Span

NB. Both the zero and span values default to zero one second after being displayed - these must always be re-configured for the instrument to function properly.

Press the **ENTER** key and the **Zero** value will need to be entered. Select using the **ARROW** keys for each digit. The **ENTER** key is pressed to enter the value of each digit. The units displayed will depend on what has been selected above.

5 CONFIGURE O/P 1
Set Span

5 CONFIGURE O/P 1
Zero = 0000mg/m3

The current value will be displayed for 1 second then the value will clear to zero. **This must always be reset for the instrument to be configured correctly.**

When the zero value has been correctly selected press the **ENTER** key to access the next display which is **Span**.

The upper limit of the span is set here in a similar manner to the zero and its value will depend on the maximum emission of the process being monitored. Once again the current value will be displayed for 1 second and will clear to zero. **This must be reset for the instrument to be configured correctly.**

5 CONFIGURE O/P 1
Span = 0300mg/m3

6.9.3.5. Fault Condition

Should a fault condition occur the current output of the instrument may be set to any of the following options.

- Set the output at 0mA - **ZERO**.
- Adjust the output to the measured concentration even though a fault condition exists - **MEAS**
- Hold the last measurement - **HOLD**.
- Set the output to full scale (20mA) - F.S.

5	**CONFIGURE O/P 1**
Fault Cond ZERO	

One of these options can be selected by pressing the **ARROW** keys, when the desired option is displayed press the **ENTER** key.

6.9.3.6. Set mA Output

NB. This will already have been configured at the factory - do not alter unless the calibration is suspected to be wrong.

The current levels of the analogue output are set up in this option. Press the **ENTER** key to access the option and set the current levels at 0 and 20mA as prompted.

5	**CONFIGURE O/P 1**
Set Zero (0040)	

When this is displayed, the current output should be set to 0mA as measured with a calibrated current meter across the analogue current loop terminals (47 and 48). Nothing else should be connected to these terminals when the output is being set up. The **UP** and **DOWN** arrow keys will take the current up and down respectively. Press the **ENTER** key when the correct output current is displayed on the ammeter. The limits for the display value are 0-4095. A typical value will be 40.

NB. Zero mA should be set up, irrespective of the selection for the base of the current output.

In a similar manner as above, the current output level should now be set to 20mA using terminals 47(+mA) or 48(0V).

5	**CONFIGURE O/P 1**
Set Span (3726)	

The limits for the display are 0-4095. A typical value will be 3700.

6.9.4. Configure O/P2

This menu sets analogue output 2. Proceed as 6.9.3. Configure O/P1. For this output use terminals 23(+mA) and 24(0V) to set 0mA and 20mA outputs if necessary.

5	**CONFIGURE O/P 2**

6.9.5. Alarm 1

The alarm parameters for analogue output 1 are set in this sub menu.

5 Alarm 1

6.9.5.1. Source

Press **ENTER** and this option is displayed. Select the averaging source (averaging units) required for this source. These are selected in a similar manner as for Configure Outputs (6.9.3. Configure O/P1 and 6.9.4. Configure O/P2). When the source is selected press **ENTER** to access the next option.

5 Alarm 1
Source 60s

6.9.5.2. Units

This option is entered after Source has been completed. Select the units required for the alarm as in 6.9.3.3. Units. When these have been selected press **ENTER** and the Level option is accessed.

5 Alarm 1
Units %Op

6.9.5.3. Level

Select the required level for **ALARM 1**. Note that the current value is displayed for 1 second, but then it defaults to zero and so must be re-entered for the alarm level to be properly configured. Levels may be set in intervals of 1%.

5 Alarm 1
Levels 090%Op

6.9.5.4. Exit

After the alarm level has been set press **ENTER** to reach this display. Press **ENTER** and the display exits to the **ALARM 1** option.

5 Alarm 1
Exit

6.9.6. Alarm 2

Use the **DOWN** arrow key to select this after **ALARM** 1 has been completed. The parameters for the alarm for analogue output 2 are selected here in a similar manner as for **ALARM 1**.

5 Alarm 2

6.9.7. Parameters

Select this option by pressing the **ENTER** key. The **ARROW** keys will now display the available options from within this sub-mode, when the option that requires changing is displayed, press the **ENTER** key. When all required changes have been made, select the **EXIT** option and press **ENTER**.

5 PARAMETERS

6.9.7.1. Security Number

To prevent any unauthorised tampering with the set up information, it is important that the security code is changed from the factory setting. Each digit is selected with the **ENTER** key and changed with the **ARROW** keys.

5 PARAMETERS
Security # 0000

NB. It is important to make a note of this number, otherwise it will not be possible to change the instrument set up.

6.9.7.2. Identity

The communication address for the serial communication output is set up here. Each device on the serial communications highway should have a unique communications address identity number.

5 PARAMETERS
Identity # 05

6.9.7.3. Measurement Path Length

NB. When this option is accessed the value defaults to zero after 1 second - this must be reset for the instrument to operate correctly.

The path length entered must represent the length of the actual gas pass, not the flange to flange dimension between the source and receiver. The current value is displayed for 1 second and then defaults to zero, this must be re-entered for the instrument to be correctly configured.

5 PARAMETERS
Pathlength 3000mm

6.9.7.4. Dust Factor

If the instrument is being used as a fine dust monitor, a dust factor is required to convert the opacity level to a measure of dust. A value up to 9999 may be selected.

5 Dust Factor
Input Value 3000

6.9.7.5. Protocol

Select here the required serial communication protocol:

- MODBUS for standard MODBUS
- Codel for CODEL's own diagnostic software.

5 PARAMETERS	
Protocol	**ModBus**

6.9.7.6. Baud Rate

Select here the speed of the communications, either 4800 or 9600 baud:

5 PARAMETERS	
Baud Rate	**9600**

6.9.7.7. Set Clock

The DDU processor contains a real time clock used for initiating automatic calibrations. The clock time and date are set here:

- Year - adjust the year by scrolling up or down using the **ARROW** keys and entering with the **ENTER** key.
- Month - adjust the month by scrolling up or down using the **ARROW** keys and entering with the **ENTER** key.
- Days - adjust the day by scrolling up or down using the **ARROW** keys and entering with the **ENTER** key.
- Hours - adjust the hour by scrolling up or down using the **ARROW** keys and entering with the **ENTER** key.
- Minutes - adjust the minutes by scrolling up or down using the **ARROW** keys and entering with the **ENTER** key.
- Seconds - adjust the seconds by scrolling up or down using the **ARROW** keys and entering with the **ENTER** key.

Exit - press the **ENTER** key to revert to the MODE 5 menu.

5 PARAMETERS
Set Clock

5 Set Clock	
Year	**2009**

5 Set Clock	
Month	04

5 Set Clock	
Days	30

5 Set Clock	
Hours	09

5 Set Clock	
Minutes	27

5 Set Clock	
Seconds	42

5 PARAMETERS
EXIT

6.9.8. Normalisation

All of the normalisation inputs and parameters are set up from this mode. Press **ENTER** to access the mode and the **ARROW** keys will select which of the normalising inputs are to be changed, they are:

- **Temperature**
- **Oxygen/CO2**
- **Pressure**
- **Water Vapour**

5	NORMALISATION

NB. Normalising parameters are only required for the calculation of the dust density.

After selecting the normalising parameter, the user may set the standard levels to which the measurement is to be normalised and how the instrument reads the value, i.e., fixed keypad input or 4-20mA input via an optional mA input card – see Supplement 2 at the end of this document. Figure 15 illustrates the program tree for entering the normalisation parameters.

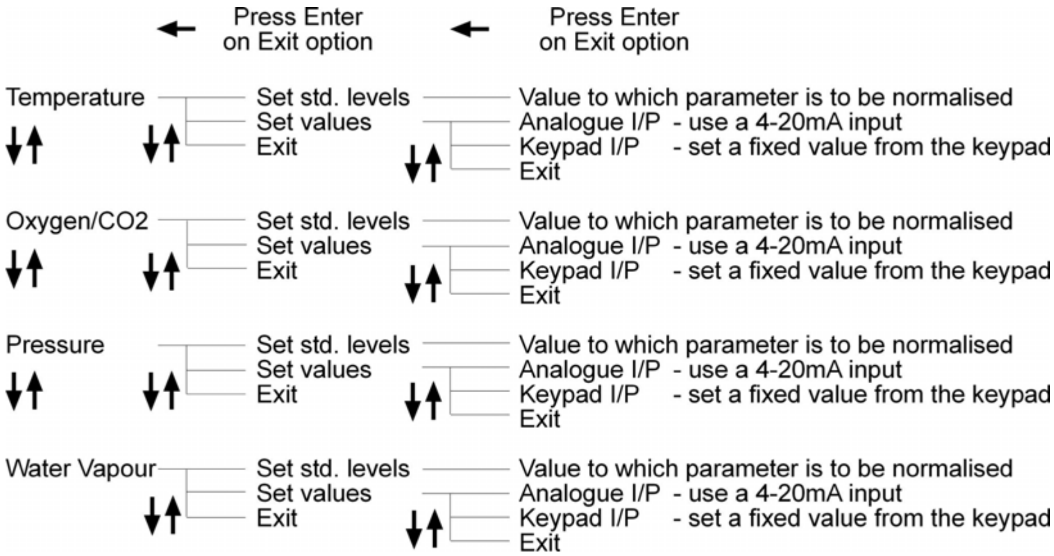


Figure 15 : Normalising Set-Up Program Tree

6.9.8.1. Setting the Normalising Parameters

After selecting the parameter to be set up, the **ARROW** keys will select between entering the standard levels, and how the normalisation data is to be brought into the instrument.

- **Set Standard Levels**

Each normalising parameter normalises the measured dust concentration to standard conditions of temperature, oxygen, pressure and water vapour. These levels are set from within this option and are typically: 0^{0}C, 3% Oxygen, 101kPa pressure, dry water vapour. Use the **ARROW** keys to change each displayed normalising standard value. Refer to the process guidance notes for the application in which this unit is being used, to determine the best normalisation values.

5 TEMP °C
std level = 000

- **Set Values**

The normalising data can be brought into the instrument in one of 3 ways:

* by entering a fixed value via the keypad. This is suitable where the value is stable to about ±5%,

5 TEMP °C
Keypad input

* using the 4-20mA inputs within the processor to receive measurement transducer data. The values at 4mA and at 20mA will be requested should this option be selected.

5 TEMP °C
Analogue input

6.9.8.2. Temperature

Enter the temperature of the flue gas at the point of the across the duct measurement. This value is used to normalise the dust measurement.

6.9.8.3. Oxygen/CO2

To correct the data to standard levels of oxygen or CO2 an estimate of the oxygen at the point of measurement is required. If no normalisation for oxygen or CO2 is required, then a fixed value should be used and the standard level brought to the same value.

If the oxygen or CO2 level is being continuously measured connect the analogue output of the oxygen analyser into the CODEL analyser and select the analogue input. Note that the O2 standard must be less than 20.9% and the CO2 standard must be greater than 0%.

6.9.8.4. Pressure

To correct the data to a standard pressure, normally 101kPa, the pressure at the point of measurement needs to be determined. If the flue pressure is relatively constant through all firing conditions, then a fixed input should be used. If the pressure is not constant, it should be measured and bought into the instrument via the 4-20mA input within the processor.

If no normalisation for pressure is required, then a fixed value should be used and the standard level brought to the same value.

6.9.8.5. Water Vapour

The standard level is set to wet or dry. For the set values option the percentage water vapour in the flue gas needs to be determined and entered. This has a range of 0.0 to 30.0%. If the vapour concentration is relatively constant a fixed input should be used. If it is not it should be measured and brought into the instrument via the 4-20mA input in the processor.

6.10. Calibrate

From this option the levels of the detector within the transceivers may be displayed. The basic calibration of the instrument is set by a 'Gain Factor' which can be calculated during a calibration routine.

5 CALIBRATE

Press the **ENTER** key while this is displayed and the following options are available:

6.10.1. Calibrate

The basic calibration of the instrument can be calculated from this routine. It is preferable to conduct this operation with the plant shut down to ensure zero opacity within the duct. If this is not possible, however, the instrument can calibrate to an estimate of the opacity.

Set the calibration target either to an estimate of the opacity or to zero, and set the desired number of cycles over which the calibration factor is determined (a minimum of 30 is recommended). The calibration should now be run and the display will show a count down during its execution. When the calibration is complete, the instrument will exit the calibration routine.

5 CALIBRATE
Calibrate

⇓

5 CALIBRATE
Target 00.0%

⇓

5 CALIBRATE
Set # cycles = 030

⇓

5 Cycle # 024
Cal in progress

⇓

5 Cycle complete
K21 14613

⇓

5 Cycle complete
K12 10814

On completion of the calibration cycle the instrument automatically proceeds with a window contamination check cycle to set the % window obscuration to zero.

5 Cycle 03-04
Window 1

⇓

5 Cycle 02-04
Window 1

⇓

5 Cal complete
% contamination 0.00

6.11. Window Compensation

This procedure enables the contamination at each transceiver to be determined so that the measured opacity can be determined so that the measured opacity can be accurately compensated for dust on the windows.

The procedure operates on each transceiver window in turn by a cycle of removing and replacing the window in the sight path, by means of a ball valve, and measuring the transmissivity with and without the window.

5 CALIBRATE **Window compens'n**

⇓

5 Cycle 03-04 **Window 1**

⇓

5 Cycle 05-04 **Window 1**

⇓

5 Cycle 01-06 **Window 2**

⇓

5 Cal complete **% contamination 0.06**

NB. The calibration routine must be run during commissioning otherwise the instrument will not be able to calculate the true level within the duct. DO NOT run the calibration routine unless reasonable conditions exist in the duct. If it is not the initial calibration, it is recommended that the Gain Factor is recorded from the parameters option, before the calibration is run.

Auto Cal - set up the method of initiating an automatic calibration routine. Press **ENTER** to access:

5 CALIBRATE **Auto Cal**

5 Auto Cal **Initiate**

5 Initiate **Cal timer**

5 Cal timer **Interval**

5 Cal timer **Interval 024 hrs**

5 Cal timer **Next Cal**

5 Cal timer **Next Cal 0300 hrs**

5 Cal timer **EXIT**

5 Initiate **Logic**

5 Initiate via **Logic Input NO**	**5 Initiate via** **Logic Input YES**

5 Initiate **EXIT**

Initiate	-	there are two methods of initiating an automatic zero calibration, by the on board clock or remotely via a logic input. Scroll and select using the **ARROW** and **ENTER** keys
Cal timer	-	having selected Cal timer first set the cal interval by scrolling the 3-digit number in the display using the **ARROW** keys to give an interval between calibrations measured in hours. Save the setting by pressing the **ENTER** key. Setting a value of 000 will inhibit the timed auto cal.
Next Cal	-	using the **ARROW** and **ENTER** keys enter the time in 24-hour clock format at which the next calibration is to be performed, e.g. 0300 is 3:00 am.
Exit	-	after entering the last data the display switches to EXIT. Press **ENTER** to revert to Mode 1 display and normal operation.
Logic	-	this enables the plant status logic input to be configured as an input for calibration initiation. Press **ENTER** to access. Select 'YES' using the **ARROW** keys and press **ENTER** to accept. This will overwrite any configurations previously made for Plant Status input.

6.12. Calibration for Dust Measurement

For Opacity Monitors to provide a measure of the dust density, the relationship between opacity and the dust density needs to be established. For a particular measurement point in a particular flue, duct, or chimney, this can only be accomplished accurately by iso-kinetic sampling over a defined period. Over the same period, the opacity monitor will calculate the corresponding average extinction, which is directly proportional to the dust density

The relationship between extinction and dust density may be described as the 'Dust Factor'.

Dust Density = Fine Dust Density/Extinction

where:

fine dust density = mg/m^3 of dust by iso-kinetic sampling

extinction = average extinction for the same period.

This Dust Factor is input and held within the instrument to convert extinction to fine dust density. Some important points to note when calibrating the analyser from iso-kinetic sampling results are given below.

- Take care to ensure that the normalisation parameters temperature, oxygen, pressure & water vapour) are set to sensible values, and establish to what standard conditions the sampling results will be normalised to. Iso-kinetic results are automatically brought to ambient temperature as the flue sample cools through the sample line, and in general these are then normalised to ^{0}C (273K). Normalisation to the other parameters is variable, and depends largely upon whether they are being measured at the same time as sampling.

- It is reasonable to start with an estimate of the dust factor (see below) and ensure that at least the correct temperature is held within the instrument, entered via the keypad. If it is uncertain whether the sampled data will be normalised to the other conditions, they may be taken out of operation, by bringing the measured values to the standard levels. e.g. O_2 standard level 3%, value fixed at 3 %, Pressure standard level 101kPa, value fixed at 101kPa and Water Vapour standard level DRY, value fixed at 0 %.

- While the sampling is being conducted, record the minutes average and normalised dust value mg/Nm^3 preferably from a chart recorder, if used, (making sure of course, that the current output has been correctly configured). If not available, however, the displayed normalised dust value should be recorded regularly for comparison.

After the sampling has been conducted, the two results may be compared, and the dust factor adjusted if necessary, to bring the model analysers' calibration to that measured by iso-kinetic sampling.

NB. Important, take care to compare only like with like with regard to the normalising data.

6.12.1. Estimate of a Dust Factor

For the analyser to calculate the dust density from the opacity data, the Dust Factor needs to be determined by iso-kinetic sampling. However, if there is a delay before sampling can be conducted, an estimate of the dust factor may be used.

Estimated Dust Factor = 2500/pathlength in metres

It must be emphasised that this approximation of the dust factor cannot be accurate and that it might be as much as a factor of 2 in error particularly if the particle size is large.

6.13. Maintenance Mode

This menu allows shutting-off the ball valves for isolation/lens cleaning.

Note that on positive pressure ducts, ensure that the ball valves are closed before removing the transceivers (for lens cleaning etc.) in order to avoid exposure to hot toxic gases. If in doubt concerning the valve position then de-energise the valves to ensure closure before removing the transceivers.

6	**MAINTENANCE**
No	

Press ‘Enter’ & scroll down.

6	**MAINTENANCE**
Yes	

Press ‘Enter’.

6	**MAINTENANCE**
Valves > Open	

Press ‘Enter’ & scroll down.

6	**MAINTENANCE**
Valves > Close	

Press ‘Enter’. The top line of the display now verifies the valve positions.

Valves 1&2 Closed
Valves > Close

Press ‘Enter’ & scroll down.

Valves 1&2 Open
Valves > Open

The valve position is determined by the Dt value increase exceeding the 16128 threshold. This is caused by the mirror being inserted when the valve is closed.

Other ‘top line’ indicators:

- Valve 1 closed – implying that valve 2 is still open.
- Valve 2 closed – implying that valve 2 is still open.
- Dt1/Dt2 low – levels too low – error.

7. Commissioning

The instrument should now be fully installed and ready to be commissioned. This involves the following basic procedures that can be carried out with the plant on or off and with occasional reference to Section 6. D-CEM2100 Data Display Unit Operation.

7.1. Pre-Commissioning Checks

Before proceeding the following checks should be carried out :

- If wiring has been installed and connected by others (and particularly if no certification of connection accuracy exists), check all wiring and connections for conformity with the information provided.

- Although the instrument is equipped with all practical safeguards against the consequences of incorrect wiring, it is not possible to provide total protection against all errors.

  Please be aware that damage arising from incorrect wiring will invalidate the warranty.

- Finally check that the air purge is functioning. If not, take corrective action.

7.2. Setting Instrument Gains

Having installed the D-CEM2100 in accordance with the installation manual, ensure that purge air is flowing to the purge units at about 7.5 l/sec. Check that the address in the D-CEM2100 control unit is set to 2.

7.2.1. Alignment

In order for the instrument to function correctly, the transceiver units should be in optical alignment. Some optical redundancy is present within the instrument and normal duct movements can be accommodated.

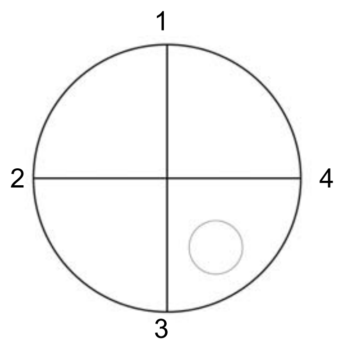
Each transceiver has an integral adjustable mount and air purge that are aligned using an optical telescope, as follows:

- After fitting the air purge and ball valve bolt the alignment telescope to the ball valve flange as shown below.

- Referring to the illustration below, at the adjustable mount, lock the nuts at positions 1 & 3.

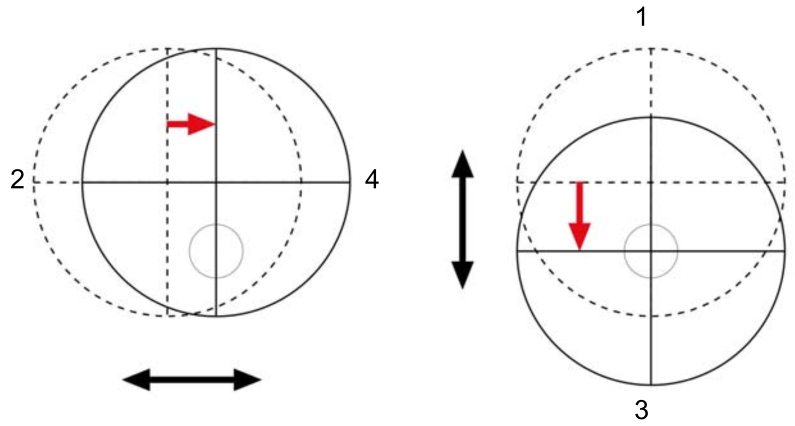
- By means of the adjusting nuts at positions 2 & 4, adjust the alignment of the transceiver (TRx1) until the cross-hairs (viewed through the telescope) coincide with the <u>vertical</u> centerline of the bore of the opposite ball valve; lock the nuts at positions 2 & 4.

- Now unlock the nuts at positions 1 & 3 and, by means of the adjusting nuts at these positions, adjust the alignment of the transceiver (TRx1) until the cross-hairs coincide with the <u>horizontal</u> centerline of the bore of the opposite ball valve; lock the nuts at positions 1 & 3.



With the nuts at positions 1 & 3 locked, adjustment at positions 2 & 4 will move the cross-hairs <u>horizontally</u>.

With the nuts at positions 2 & 4 locked, adjustment at positions 1 & 3 will move the cross-hairs <u>vertically</u>.

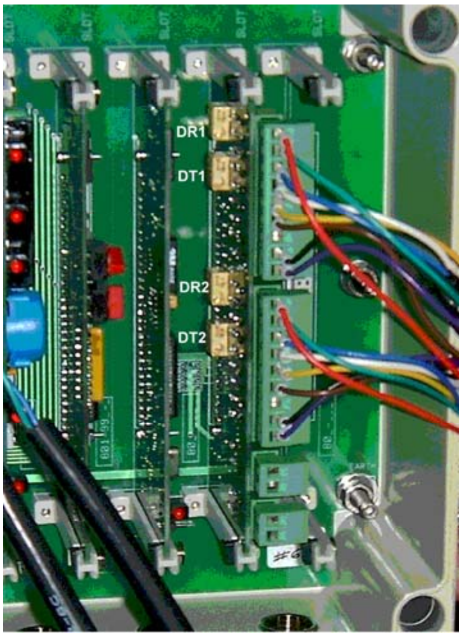


- With the four locking nuts tight check that the opposite transceiver (TRx2) is still in the centre of the cross-hairs – adjust again if necessary.

- Repeat the operation with the alignment telescope attached to the ball valve flange of the opposite transceiver (TRx2).

7.2.2. Detector levels

Next check the detector levels; the optimal values are: 20,000 ±1000 (Dr1 & Dr2) and 15,000 ±500 (Dt1 & Dt2) open path. To adjust these values the trim pots in the SPU must be adjusted with an insulated trim pot screwdriver (see below).



Pressing the ‘up’ and ‘down’ arrows will scroll the display between the current Dr & Dt values.

7.2.3. Transmissivities

At this point, check the transmissivities to ensure proper operation and also check for gross misalignment. Error between the two transmissions is expressed as % opacity - any value greater than 1% is too high and the transceivers should be immediately re-aligned in accordance with the instructions given earlier.

7.2.4. Zero and Span calibration

The final commissioning task is to initiate a zero and span calibration cycle. Referring to Section 6.10. Calibrate, enter Mode 5 on the DDU and scroll down to ‘Calibrate’; the current calibration parameters (stored in the SPU) will appear on the display.

The basic calibration on the instrument may be performed from here. It is preferable to conduct this operation with the plant off with the stack clear of dust. However, if this is not possible, the instrument can calibrate to an estimate of the opacity.

Set the calibration target value to 0% opacity (or to an estimated value), and set the desired number of calibration cycles – recommended 30 minimum.

On completion of the calibration cycle the instrument will automatically commence a window contamination check to set the % obscuration to zero.

The window compensation routine is also instigated from Mode 5 – refer to Section 6.11. Window Compensation. Set the number of window cycles – recommended 10 minimum.

NB. Remember - the calibration routine must be run during commissioning, otherwise the instrument will not be able to calculate the true level within the duct. DO NOT run the calibration routine unless reasonable conditions exist in the duct. If this is not the initial calibration, it is recommended that the Gain Factor is recorded from the parameters option, before the calibration is run.

8. Routine Maintenance

All CODEL equipment is designed for continuous and reliable operation and to keep the levels of maintenance to an absolute minimum. The electronics require no routine maintenance; they are all solid-state and undergo a rigorous factory burn-in procedure.

It is important that the optical windows of both the transceivers are kept reasonably clean and any mounting tubes free from build-up of dust and fly ash. This can be accomplished by removing the transceivers** and wiping their windows with a soft, dry cloth. If the windows are cleaned, a calibration is advised afterwards.

Should a clean flue condition become available and the instrument was commissioned with an opacity offset, it is recommended that a calibration be conducted to take advantage of this situation.

On positive pressure ducts ensure that the ball valves are closed prior to removal of the transceivers for lens cleaning – failure to do so could cause exposure to dangerous, hot, toxic gases.

9. Fault Finding

The analysers that make up this SmartCem system are sophisticated devices and any problems necessitating internal repair or adjustment should only be undertaken by fully trained technicians.

In the absence of any CODEL trained technicians on site, it is strongly recommended that, in the event of a fault, CODEL or its local service agent be contacted immediately with equivalent current information contained in the analyser records.

To obtain current values for data recorded in the analyser records follow the ‘Current Data’ procedure described in the SmartCom software manual (OPS.088).

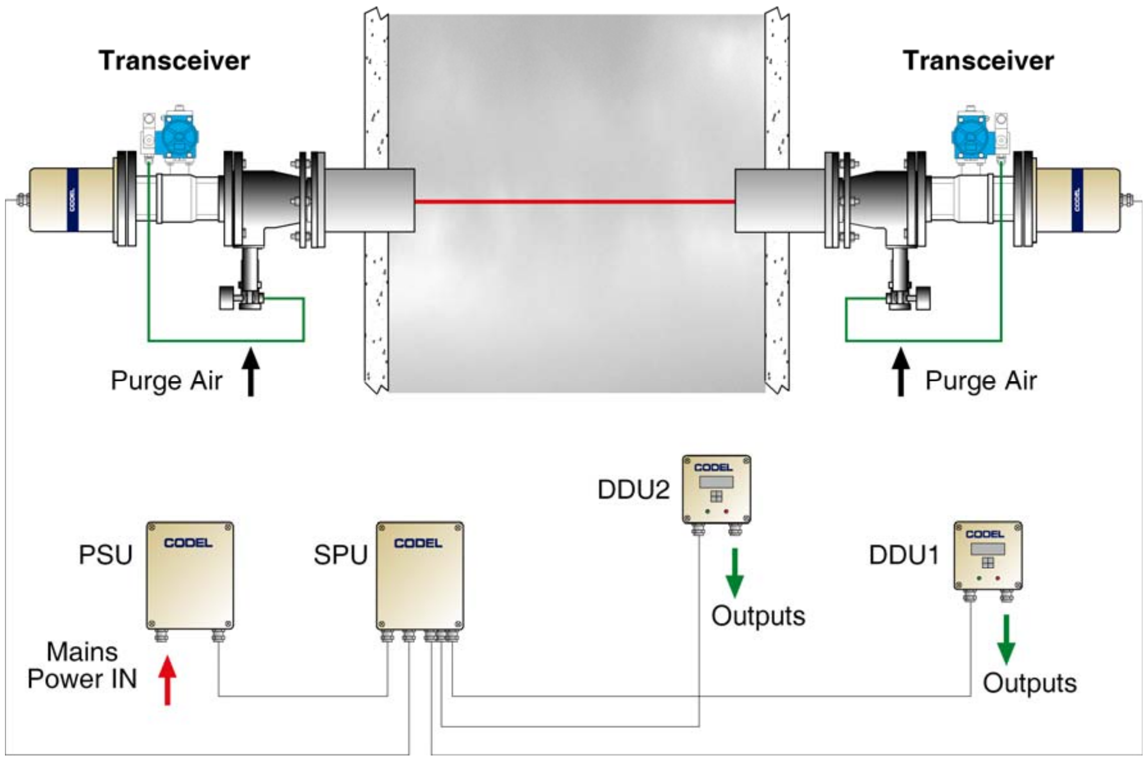
10. Table of Figures

Supplement 1 – Installation of a Second DDU to the D-CEM2100

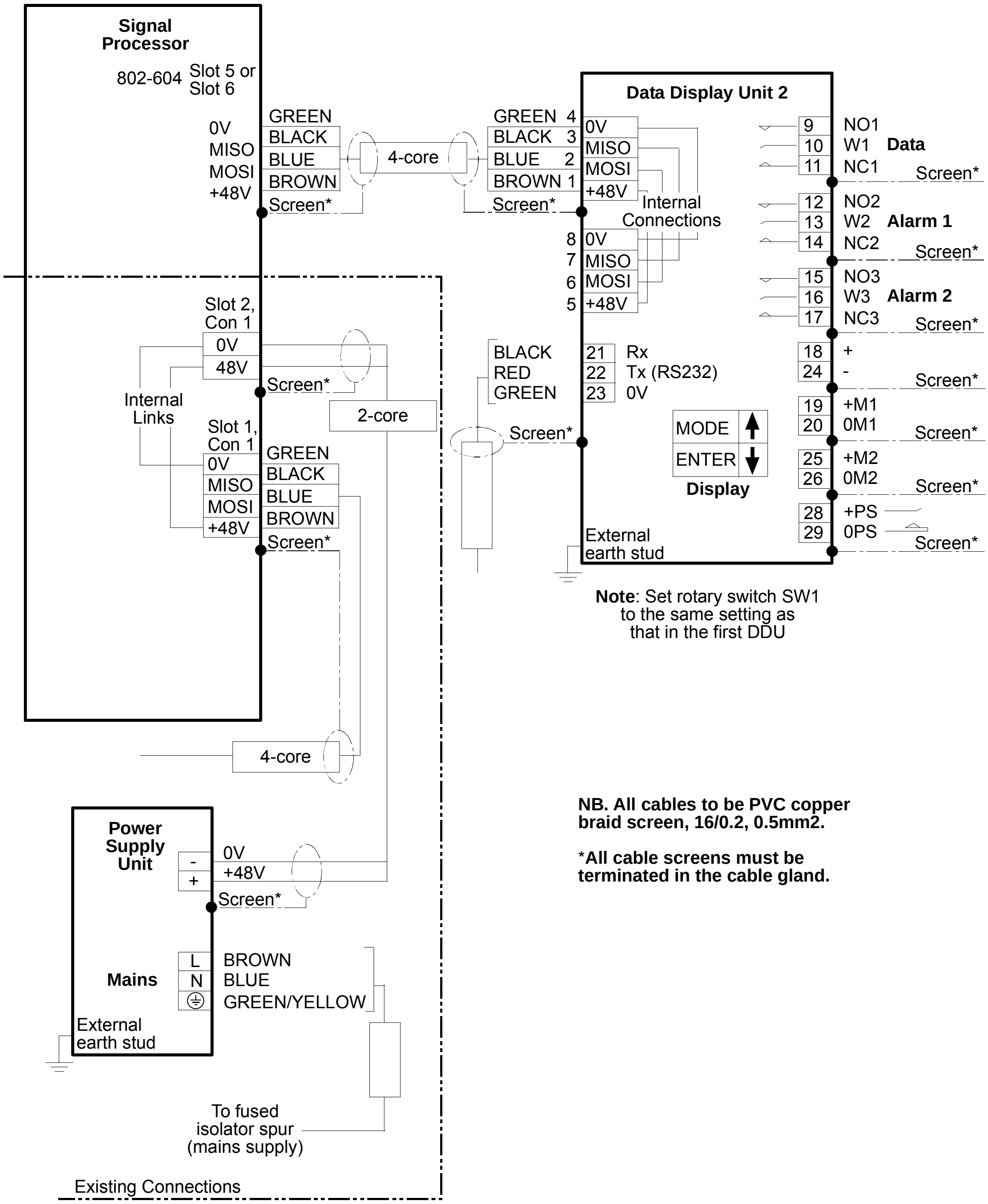
With the addition of a separate PCB in the SPU the D-CEM2100 can operate with a second DDU, as follows:

- Turn OFF the power to the SPU at the isolator unit.
- Install PCB 802-604 into either slot 5 or slot 6 of the SPU.
- Connect a cable as shown in the supplementary connection schedule (next page), between the second DDU and PCB 802-604 in the SPU.
- Set SW1 address switch (located on the micro-processor card) in the second DDU to the same value as that already set in the first DDU.
- At the isolator unit, turn ON the power to the SPU and set parameters in the second DDU as required.

The arrangement will now look like this:



Supplementary Connection Schedule for Second DDU



Note: Set rotary switch SW1 to the same setting as that in the first DDU

NB. All cables to be PVC copper braid screen, 16/0.2, 0.5mm2.

***All cable screens must be terminated in the cable gland.**

Supplement 2 – D-CEM2100 with Optional mA Card for Normalising Inputs (802.204)

The mA input card 802-204 can be installed in the D-CEM2100 SPU. Only 4 of the inputs on the card are used and are allocated as follows:

1 - not implemented
2 - not implemented
3 - not implemented
4 - not implemented
5 - H2O 4-20mA 0-30.0%
6 - Oxygen 4-20mA 0-25.0%
7 - Pressure 4-20mA 0-160kpa
8 - Temperature 4-20mA 0-300^{o}C

The card can be used to supply 24VDC to Temp & Pressure sensor.

Note LK1 & LK2 jumper links are fitted on card 802-204 to give the 24V DC outputs.

The optional mA input card is installed in slot 5, 6 or 7 of the SPU. The inputs will be 4-20mA with typical ranges:

H2O	0 - 30.0%
O2	0 - 25.0%
Pressure	0 - 160kpa
Temperature	0 - 300^{o}C

The ranges for the inputs will need to be set up in the DDU.

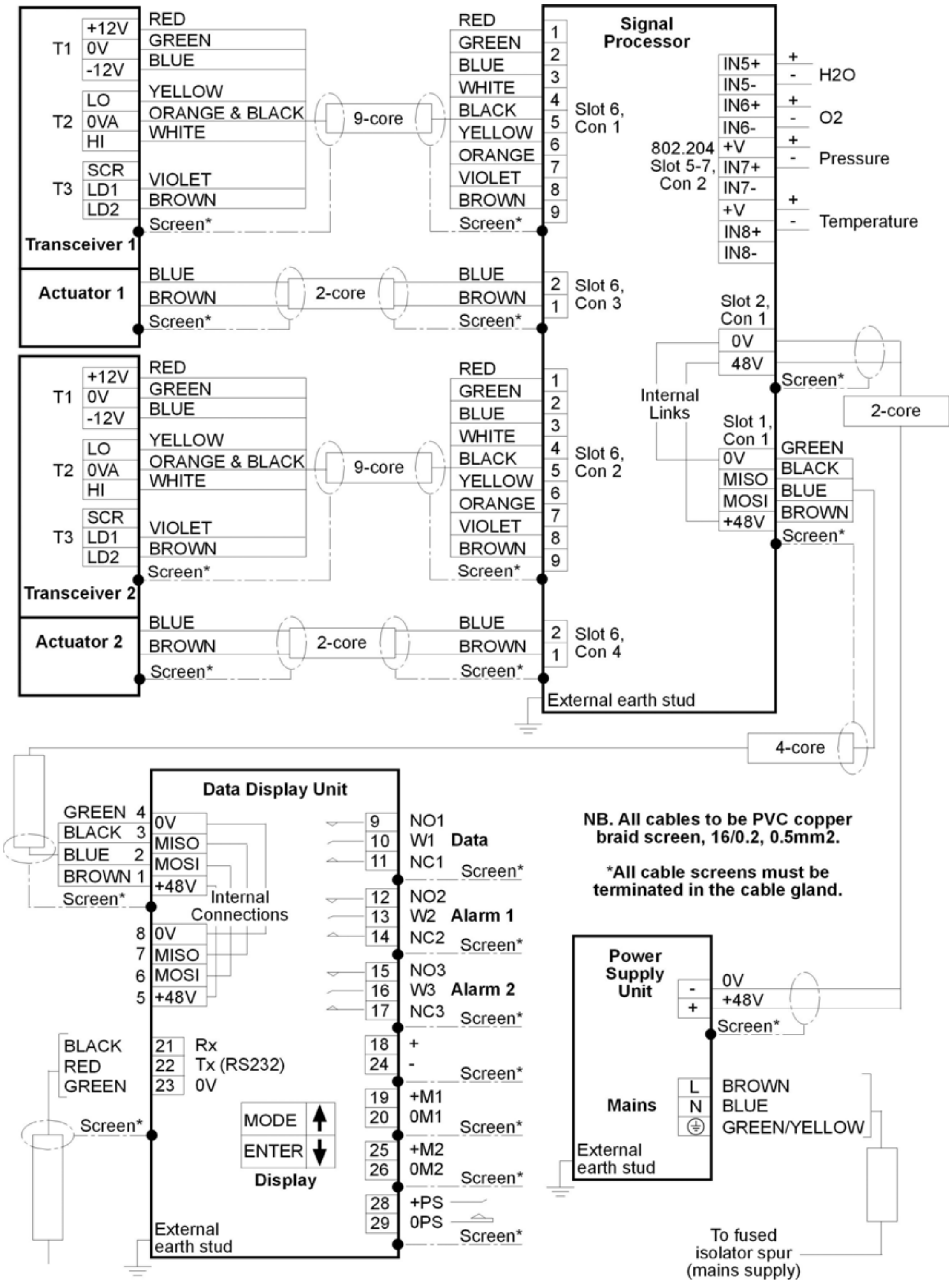
The pressure and temperature inputs can source 24V to feed the sensors:

Pressure	-	terminals +V, IN7+
Temperature	-	terminals +V, IN8+

Alternatively, the pressure and temperature inputs can be self-powered from the sensors:

Pressure	-	terminals IN7+, IN7-
Temperature	-	terminals IN8+, IN8-

Supplementary Connection Schedule for Optional mA Input Card for Normalising Inputs



Dust Density mg/Nm3 Conversion

The mg/m3 value is normalised for the effects of …….

- excess air
- temperature
- pressure
- water vapour

……. to give mg/Nm3 as follows.

mg/m3 = extinction x dust factor

Using O2:

mg/Nm3 = mg/m3 x $O2_{norm}$ x T_{norm} x P_{norm} x W_{norm}

Using CO2:

mg/Nm3 = mg/m3 x $CO2_{norm}$ x T_{norm} x P_{norm} x W_{norm}

Given:

$$O2_{norm} = \frac{20.9 - \text{O2 standard \%}}{20.9 - \text{O2 input \%}}$$

where …….

O2 input is expressed on a dry gas basis

O2 standard is typically
- 15% for a gas turbine
- 11% for an incinerator
- 6% for a large boiler
- 3% for a small boiler

O2 standard must be less than 20.9%.

$$CO2_{norm} = \frac{\text{CO2 standard \%}}{\text{CO2 input \%}}$$

where …….

CO2 input is expressed on a dry gas basis

CO2 standard must be greater than 0%.

$$T_{norm} = \frac{273 + T\ input}{273 + T\ standard}$$

where …….

T input is the temperature input in ^{o}C

T standard is typically $0^{o}C$ or $20^{o}C$.

$$P_{norm} = \frac{P\ standard}{P\ input}$$

where …….

P standard is 101kPa

P input is pressure input in kPa.

$$W_{norm} = \frac{100\%}{100\% - H2O\ input}$$

where …….

H2O input is the H2O concentration %.

Note: O2 or CO2 measured wet, but expressed on a dry gas basis, is given by:

$$O2\ or\ CO2\ dry = O2\ (or\ CO2)\ wet \times \frac{100\%}{100\% - H2O}$$

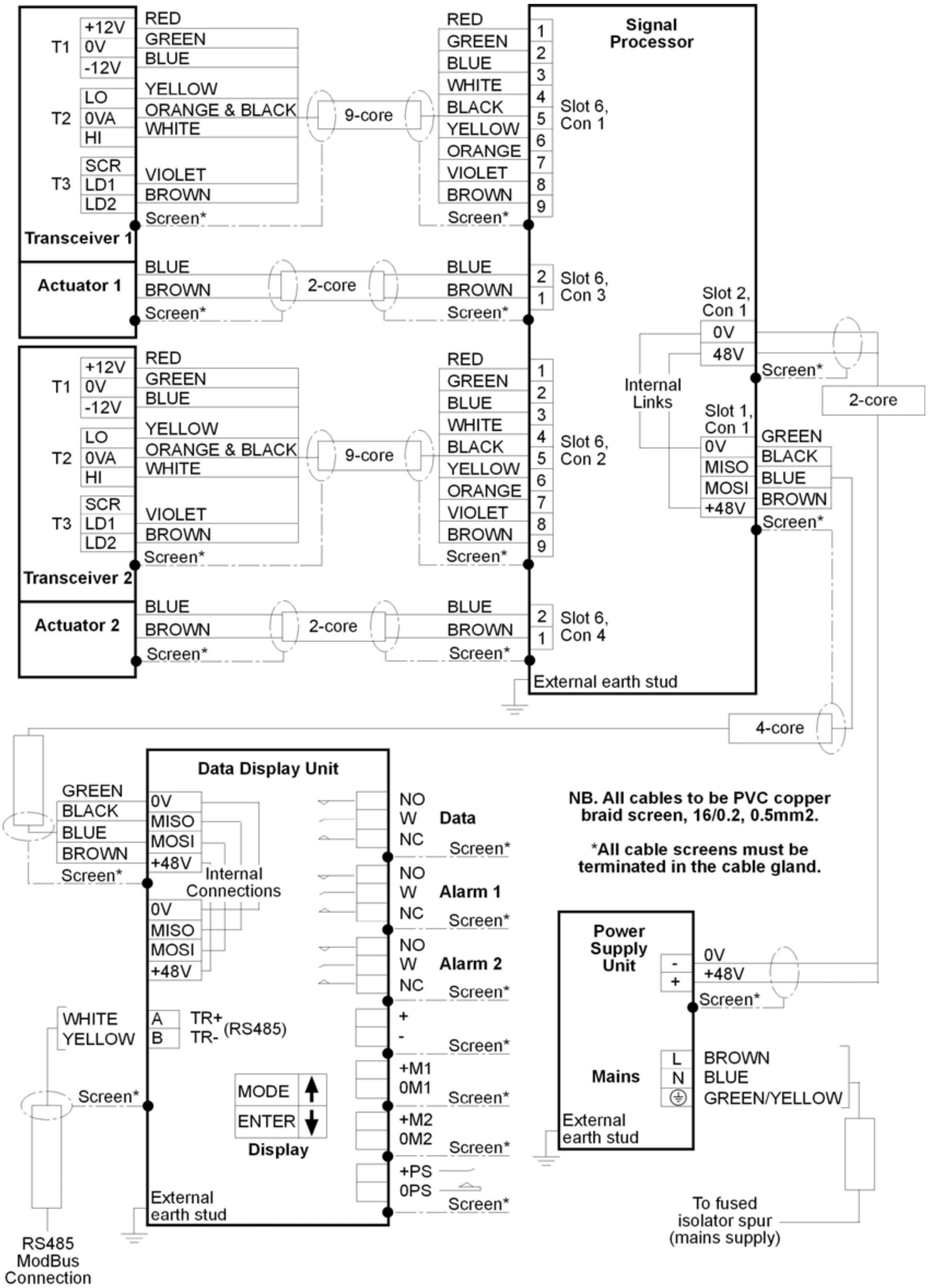
O2 or CO2 keypad inputs are assumed to be dry values only.

Supplement 3 – D-CEM2100 with Additional MODBUS RS485 Serial Communication Output

This supplement is for use where the DCEM2100 DDU is fitted with circuit card 802.836 with RS485 serial data output.

To implement the serial data output (after the physical connection for the RS485 has been completed), enter ‘Set-Up’ mode and select the serial communication identity as required; set up the protocol and then the baud rate.

Supplementary Connection Schedule for Optional Card 802.836 for RS485 Serial Data Output



Standard MODBUS Communication with CODEL DCEM2100

Summary

Using standard MODBUS protocol function 03 allows a host to obtain the contents of one or more holding registers in the CODEL DCEM2100.

The request frame from the host (typically a DCS or SCADA) defines the relative address of the first holding register followed by the total number of consecutive registers to be read.

The response frame from the CODEL DCEM2100 lists the contents of the requested registers, returning 2 bytes per register with the most significant byte first. A maximum of 125 registers can be accessed per request.

The formats of the request and response frames are detailed below, where 'X' and 'n' are hexadecimal variables.

An example of a MODBUS register map is shown below:

Host Request Frame

01	Address
03	Function code
XX XX	Address of starting register
00 XX	Number of consecutive registers
XX XX	CRC

Slave Response (from CODEL DCEM2100)

01	Address
03	Function code
XX	Byte count
XX XX	Date from starting register
…to…	…to…
XX XX	Date from nth register
XX XX	CRC

Standard baud rate - 4800 or 9600 (user selectable)

Bits per byte
- 1 start bit
- 8 data bits (least significant sent first)
- 1 stop bit
- no parity

The protocol used is standard MODBUS protocol with RTU framing and only function code 03 is supported.

The DCEM2100 will be a MODBUS slave device.

NB. Standard MODBUS protocol <u>not</u> MODBUS PLUS protocol.

Reference: AEG Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev. D.

Each register is defined to be 2 bytes wide.

Modbus Register Location

0070h	Opacity Data	0001h = 0.01%, 0064h = 1.00%
0404h	Dust mg/m3	0001h = 1m, 03E8h = 1000m

Data Register Locations at CODEL DCEM2100 DDU for Interrogation using Standard MODBUS are shown in the following table:

REGISTER FORMAT					CUSTOMER SPECIFIC DETAILS			
Location		Analyser Data	Data	Units	Typical Range	Tag	Value	Description
0070	Opacity	instantaneous	XXXX	0.01%	0-100.0		XXXX	DCEM2100 Opacity Instant
0071	Extinction	instantaneous	XXXX	0.0001	0-3.0000		XXXX	DCEM2100 Extinction Instant
0072	Opacity (+20.00 offset)	instantaneous	XXXX	0.01%	0-120.00		XXXX	
0073	Ch1 Analogue Input	mA input (if fitted)	XXXX	-	-		XXXX	
0074	Ch2 Analogue Input	mA input (if fitted)	XXXX	-	-		XXXX	
0075	Ch3 Analogue Input	mA input (if fitted)	XXXX	-	-		XXXX	
0076	Ch4 Analogue Input	mA input (if fitted)	XXXX	-	-		XXXX	
0077	Normalisation Source - Temperature	mA input (if fitted)	XXXX	1 degree C	0-300		XXXX	mA input Normalisation - Temperature
0078	Normalisation Source – Oxygen/CO2	mA input (if fitted)	XXXX	0.1%	0-25.0		XXXX	mA input Normalisation – O2/CO2
0079	Normalisation Source - Pressure	mA input (if fitted)	XXXX	1kPa	0-160		XXXX	mA input Normalisation - Pressure
007A	Normalisation Source - Water Vapour	mA input (if fitted)	XXXX	0.1%	0-50.0		XXXX	mA input Normalisation – H2O
007B	Not Used	-	XXXX	-	-		XXXX	
007C	Data Valid	instantaneous	XXXX	logic	XX00=valid, else=invalid		XXXX	
007D	Data Valid/Calibration Status	instantaneous	XXXX	logic	00XX=data valid, XX00=cal off		XXXX	
007E	Plant Status/Head Indentifier	instantaneous	XX05	logic	0005=plant on, else plant off		XX05	
007F	DCEM2100 DDU Comms validation	instantaneous	XXXX	logic	00XX=valid, FFXX=no reply		XXXX	

…………………………… continued

0400	Opacity	s sec	XXXX	0.01%	0-100.00		XXXX	DCEM2100 Opacity
0401	Opacity	m mins	XXXX	0.01%	0-100.00		XXXX	DCEM2100 Opacity
0402	Opacity	h hours	XXXX	0.01%	0-100.00		XXXX	DCEM2100 Opacity
0403	Opacity	d days	XXXX	0.01%	0-100.00		XXXX	DCEM2100 Opacity
0404	Dust mg/m3	s sec	XXXX	mg/m3	0-9999mg/m3		XXXX	DCEM2100 Dust mg/m3
0405	Dust mg/m4	m mins	XXXX	mg/m3	0-9999mg/m3		XXXX	DCEM2100 Dust mg/m3
0406	Dust mg/m5	h hours	XXXX	mg/m3	0-9999mg/m3		XXXX	DCEM2100 Dust mg/m3
0407	Dust mg/m6	d days	XXXX	mg/m3	0-9999mg/m3		XXXX	DCEM2100 Dust mg/m3
0408	Dust mg/Nm3	s sec	XXXX	mg/Nm3	0-9999mg/Nm3		XXXX	DCEM2100 Dust mg/Nm3
0409	Dust mg/Nm4	m mins	XXXX	mg/Nm3	0-9999mg/Nm3		XXXX	DCEM2100 Dust mg/Nm3
040A	Dust mg/Nm5	h hours	XXXX	mg/Nm3	0-9999mg/Nm3		XXXX	DCEM2100 Dust mg/Nm3
040B	Dust mg/Nm6	d days	XXXX	mg/Nm3	0-9999mg/Nm3		XXXX	DCEM2100 Dust mg/Nm3
040C	Normalisation Data - Temperature	Keypad Input	XXXX	1 degree C	0-300		XXXX	Keypad Input Normalisation - Temperature
040D	Normalisation Data - Oxygen/CO2 dry	Keypad Input	XXXX	0.1%	0-25.0		XXXX	Keypad Input Normalisation – O2/CO2
040E	Normalisation Data - Pressure	Keypad Input	XXXX	1kPa	0-160		XXXX	Keypad Input Normalisation - Pressure
040F	Normalisation Data - Water Vapour	Keypad Input	XXXX	0.1%	0-50.0		XXXX	Keypad Input Normalisation – H2O