

Digital Density Gauge

Model SS200

Instruction Manual

Version 2.7

SIStec

Specialised Industrial Systems

Preface

What this manual contains

The first chapters of this manual contain information on how to use the SS200 Digital Density Gauge. Later Chapters give information on the theory of operation and the calculations used by the microprocessor.

Conventions

This manual uses the following symbols and conventions:

- ④ a list item
- an action to take
- 1. a step in a procedure
- ✓ a checklist
- FN** a key to press
- (XXX)** a variable sequence of keys
- Calibrate**
a message on the control unit screen

Version 2.4

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Chapter One

Safety Matters

Safety precautions

The SS200 density gauge is not a major radiation hazard, since the radioactive source is relatively small. However, all radioactive materials should always be treated with caution, and the following practices are recommended:

- Lock the control lever in the BEAM OFF position when transporting or handling the source housing
- Locate the source housing away from areas where workers spend long periods of time
- Bolt the source housing securely to the pipe, and check the bolts regularly
- Do not tamper or interfere with the source housing

If the source housing is damaged...

If this happens:

- Isolate the density gauge and prevent access to the area
- Report to your Radiation Safety Officer, who should then report to the supplier and the health authorities in your state *immediately*

Radiation specifications

A stainless steel plate attached to the source housing gives:

- ④ The name of the radioisotope used
- ④ The serial number of the source capsule
- ④ Radioisotope source activity, and the date on which it was measured
- ④ Dose rate of radiation that would be encountered by a person standing one metre from the source housing. This is expressed in $\mu\text{sv/hr}$ (microsieverts/hour)

Safe levels

The safe level recommended by health authorities for the general public is $2.5 \mu\text{sv/hr}$, for a 40 hour working week, for 50 weeks in a year.

The SS200 gauge gives $1.4 \mu\text{sv/hr}$ at one metre for a 100mCi Cs137 source.

Chapter Two

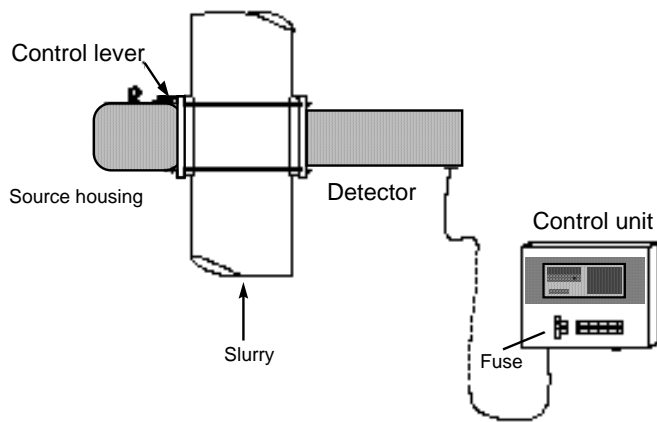
Introduction and Components

Introducing the density gauge

The SS200 Density Gauge has three major components:

- ④ *Source housing* — containing radiation source
- ④ *Detector* — containing scintillation detector
- ④ *Control unit* — with keypad for user interaction

The components are described in more detail later in this chapter. They are illustrated in the following sketch:



What it does

The SS200 Digital Density Gauge gives accurate, trouble-free measurements of SG or percent solids in slurries, oils, food products or other process fluids.

Note: *This manual refers only to slurries, but is equally applicable to all process fluids.*

The gauge measures radiation passing through a slurry. The control unit then converts the radiation counts to:

- ④ Density reported as specific gravity (the ratio of the slurry density to the density of water)
- ④ Percentage of solids within the slurry

With input from a temperature gauge it can convert the results to:

- ④ Temperature corrected specific gravity

With an input from a flow gauge it can convert the results to:

- ④ Solid mass flow rate

The gauge can also operate as a Digital Rate meter, reporting the radiation counts as they are received. This is useful during calibration.

How it works

The radiation source emits gamma rays into the pipe containing the slurry. Some of the gamma rays are absorbed, and some pass through to the detector.

The degree of absorption of the radiation is a measure of the density.

The detected radiation information is transmitted to the control unit, where it is converted to the required units.

Results are transmitted to recorders, controllers or computers by 4-20 mA current loop outputs or various communication protocols.

Controls and compensations...

- ④ Outputs can be smoothed over time, so that trends in readings are readily visible
- ④ You can set high and low values for the ranges of each variable
- ④ You can set a number of counts to be accumulated before each calculation of SG, OR:
- ④ a time to elapse before each calculation of SG

Automatic corrections

The control unit's microprocessor automatically corrects for:

- ④ Dead time in the detection system
- ④ Source decay

Source housing components

The source housing is a lead-filled cast steel container, enclosing and shielding the radioactive source.

Radioactive source

The radioisotope normally used is Caesium 137. The radioisotope is enclosed in a double thickness stainless steel capsule and mounted in a source holder within the housing.

The beam of radiation emerges along the source holder axis and passes through the pipe to a detector mounted on the other side.

Radioisotope activity

The activity of a radioisotope source is a measure of the number of nuclei that decay per second. The radiation output of the source is proportional to its activity.

The radioisotope activity required depends on the slurry density and pipe thickness. The *minimum* strength is always selected.

Control lever and source shutter

A control lever mounted on the top of the source housing controls a source shutter. The lever has three positions, which are clearly marked. They are:

- ④ BEAM OFF — the shutter completely shields the radioisotope and reduces the radiation to safe levels. The lever can be locked in this position.
- ④ STANDARDISE — a standard absorber is placed in the beam to reduce its strength. This is not used in most applications.
- ④ BEAM ON — the shutter is moved out of the path of the radiation beam.

Warning: *Do not select BEAM ON unless the source housing is securely mounted on the pipe. Radiation levels in the direct beam, close to the source housing, may exceed safe limits laid down by the health authorities.*

Design standards

The source housing meets standards laid down by the International Atomic Energy Authority, Australian National Health and Medical Research Council, and State Health Authorities.

Pipe clamp

This clamps the source housing and detector to the pipe and ensures the beam is aligned precisely on to the detector.

Radiation detector components

This unit comprises:

- ④ a scintillation detector, which detects the gamma rays.
- ④ a photo-multiplier tube (PMT) which converts them into electrical pulses
- ④ an electronics board, which gain stabilises the detector and transmits count rate information to the control unit

How the detector works

The scintillation type detector is highly efficient, and allows the gauge to use a much lower activity radioisotope source than other density gauges (using ionisation chambers). It consists of a sodium iodide (NaI) crystal doped with thallium.

When a gamma ray is absorbed in the scintillation detector crystal, its energy is converted to a pulse of light lasting less than a microsecond. The photons of this light pulse hit the photocathode of the photomultiplier tube and cause a burst of electrons to be emitted.

The burst of electrons is then amplified considerably (up to a million times). The amplified signal emerges from the anode of the photo-multiplier as a fast signal pulse.

Control unit components

The control unit is wall mounted up to 1000 metres from the gauge, in a clean, dry area, such as a control room.

The control unit comprises:

- ④ a CPU board (microprocessor)— which continuously monitors the detector, calculates results, and outputs them on the current loops.
- ④ a keypad — through which the user communicates with the microprocessor. The keypad includes a liquid crystal digital display
- ④ power supply
- ④ connection points for current loop outputs
- ④ power cord to the detector

Operating program

The microprocessor (or CPU) executes the operating program, which is stored in its permanent Read Only Memory (ROM).

The program is fixed, and cannot be changed. It is not affected by power failures.

Operating constants

Operating constants are stored in the microprocessor's non-volatile memory — the Random Access Memory (RAM).

The RAM is backed up by a long life lithium-iodine dry cell, which maintains the constants without external power for up to ten years.

Chapter Three

Installation

Mechanical installation

Check the delivery

Check that you have received the following components, in the configuration specified at the time of ordering:

- ✓ Control unit
- ✓ Detector
- ✓ Source housing

Warning: *Do not open or dismantle the source housing — the radioisotope is already installed*

- ✓ Pipe clamp

Selecting the location

- Select a location at least 10 metres from other radiation sources
- Make sure the pipe is vertical with upward flow of slurry
- The gauge should be at least 1 metre (or 10 x the pipe diameter) from any bends in the pipe
- Select a pipe size which allows a smaller radiation source to be used (10cm is typical)
- Make sure the slurry is well mixed and free of air bubbles
- There should be no build up of material on the pipe walls

Installing the gauge

- Assemble the pipe clamp to the pipe, making sure the clamp faces are parallel
- Bolt the source housing and detector unit to the mounting faces of the pipe clamp, with the bolts provided
- Adjust the pipe clamp bolt tensions until the mounting faces of the pipe clamp are exactly parallel
- The control unit can be up to 1000 m from the gauge. The unit is wall mounted, preferably with the liquid crystal display at eye level

Note: *Although the control unit is sealed to IP65, it is best located in a clean area, out of direct sunlight, and preferably in a control room, or similar.*

Electrical installation

- Refer to the *Wiring and Cabling* diagram, at the rear of this manual. Make sure that cabling used is as specified in this drawing
- Make sure that cabling to the detector unit is well screened, since it carries DC supplies
- Make sure that wiring used is at least of the minimum size specified

Installation notes

- ④ The control unit can run on 88 to 264 VAC and 50 or 60 Hz or 24Vdc.
- ④ The control unit is 370 mm wide x 300 mm high x 180 mm diameter. Cable entry is from the bottom
- ④ Current loop input is passive and must be driven externally. It is not an isolated input.
- ④ The 0V on the power supply is earthed and should not be used as a return for the current loops which are isolated.

Setting the current loop parameters

Using the following commands, current loop signals can be generated for test purposes.

To test outputs...

- Press **9,0, FN, EXAM**
- The display will indicate “Loop 1 4 ma” and 4ma will be generated in loop 1.
- Press **CAL**
- The display will indicate “ Loop 1 20 ma” and 20 ma will be generated in loop 1.
- Press **CAL**
- The display will indicate “ Loop 1 12 ma” and 12ma will be generated on loop 1.
- Further pressing of **CAL** will advance to loop2 in the same sequence.
- When completed testing, continue pressing **CAL** until the display is “ **CALIBRATE**”.

To test inputs...

- Set up parameters 23 and 24 to 4 and 20 respectively
- Connect the input from the external flow meter.
- Press **CAL, 4, 1, FN, EXAM**

This displays the input current.

<p>Note: <i>You can set parameters 23 and 24 at other values, but parameter 41 then displays a scaled value for the input.</i></p>
--

What next?

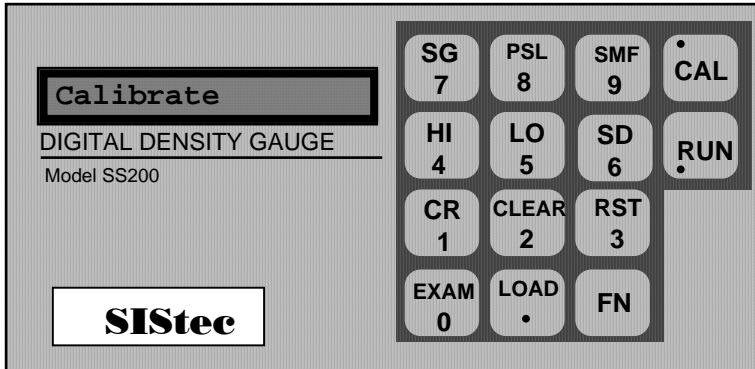
After the gauge is installed, check the parameters stored in the microprocessor, and perform the first calibration. These procedures are described in Chapter Five. Read Chapter Four first, however, to learn how to use the keypad and for other background information you'll need to set up the gauge properly.

Chapter Four

Operation

Using the keypad

The control unit keypad is the means of communicating with the density gauge. It has a liquid crystal display and pressure keys, as shown below:



Using the keys

The 'keys' have pressure sensitive contacts which are activated by pressing firmly in the key area.

Most keys have two functions, indicated by an upper and lower symbol.

- To use the lower function simply press the key. In this manual, this is shown as keys written in bold text, like: **7**, **RUN**, **FN**.
- To use the upper function press the **FN** key first.

If you make a mistake...

- Press **FN**, **CLEAR** to clear numbers entered.
- Press **FN**, **CAL** to abort the changes and return to calibrate command entry mode.

In order to enter a negative value...

To enter a negative number (-X):

- Press **FN**, **RUN** (which enters the – sign)
- Enter the number (X)
- Press **FN**, **LOAD**

Viewing and setting parameters

Parameters used in the calculations are stored in *locations* in the microprocessor memory.

You can view a parameter by entering the location number then pressing **FN**, **EXAM**.

Note: *The gauge must be in CALIBRATE mode to examine locations.*

For example, to view location 13 (today's date):

- Press **1**, **3**, **FN**, **EXAM**

The mnemonic for the location (in this case JDI) displays, along with the parameter — today's date (for this location). To enter a new date while the current entry is displayed, type in the new date, then press **FN**, **LOAD**.

To view all stored parameters...

- ❑ Press **FN, CAL, 9, 9, FN, EXAM**.

This displays parameters 1-29 in order. Press any key to display the next parameter.

The parameters are listed in the Appendix to this manual.

Fixed parameters

You can change only parameters 1 - 30; the remainder are fixed and you can view them but not change them.

Effect of changing parameters

Whenever a parameter is changed, this affects the gauge on all future results calculated. The latest set of results are recalculated and the outputs are adjusted immediately.

RUN and CAL mode

The control unit operates in one of two modes: CALIBRATE or RUN. It can freely be switched from one mode to the other.

The current mode is indicated by small lights in these two keys.

RUN mode

This is the normal mode of operation, and the gauge starts up in RUN mode, unless it has not yet been set up.

- ❑ Press **RUN** to enter RUN mode if the CAL light is on.

In RUN mode, providing the source beam is turned ON, the gauge is operating normally, and the microprocessor continuously monitors the detector and calculates results.

Unless instructed otherwise, the microprocessor reads counts rates and displays the calculated SG. At the same time it outputs the chosen results on the current loops, within the High-Low limits set.

The value displayed on the control unit is independent of the values output on the current loops.

CALIBRATE mode

- ❑ Press **CAL** to enter CALIBRATE mode if the RUN light is on.

In CALIBRATE mode, the microprocessor continues to monitor the detector and output the results on the current loops, but the results are not displayed unless selected. (To select the SG results for example, press **FN, SG**. Do not press **RUN** first. See the section below (Viewing the results) for instructions on selecting other results to display)

CALIBRATE mode is used to set up the parameters and constants used in the calculations. This is explained in Chapter 6.

Starting up the gauge

- ❑ To start the gauge, connect power to the control unit

The gauge starts up in RUN mode, and the RUN key light comes on. The message: *Running* displays*.

- ❑ To begin monitoring the slurry, turn the source housing control lever to BEAM ON

Viewing the results

The results displayed at the control unit are normally the calculated SG results.

* If the display shows anything other than *Running*, the gauge is probably not set up correctly. Refer to Chapter 5.

- ❑ Press **RUN** to display the results.

To read count rates...

- ❑ Press **FN, CR**

To read specific gravity...

- ❑ Press **FN, SG**

To read temperature adjusted SG...

You must have a 4-20 mA input from an external gauge to read temperature adjusted SG.

- ❑ Press **FN, SMF**

Both input and output units are °C.

To read %solids...

- ❑ Press **FN, PSL**

To read solid mass flow rate...

You must have a 4-20 mA input from an external gauge to read solid mass flow rate.

- ❑ Press **FN, SMF**

Input units are m³/hr. Output units are tonnes/hr.

Customizing the gauge

To calculate results over counts or time...

The SS200 Digital Density Gauge normally makes its calculations after 2^N counts (see Chapter Nine, page 9-10). You can set it to calculate after a fixed period of time instead:

- ❑ Press **1, FN, EXAM, 1, FN, LOAD**

To set the time between calculations, enter the number of seconds (T) in location 2:

- ❑ Press **2, FN, EXAM, (T), FN, LOAD**

To return to calculating after 2^N counts, enter the value zero in location 1.

To smooth current loop outputs ...

The values output on the current loops can be smoothed over time. The time constant parameter is stored in location 29.

Enter zero for no smoothing, or the time constant in seconds (T) over which outputs are to be smoothed:

- ❑ Press **2, 9, FN, EXAM, (T), FN, LOAD**

Smoothing is applied to both current loops when this feature is enabled.

This function should only be used when the gauge is configured to calculate results after a fixed period of time (ie. when location 1 = 1).

Setting the outputs

The control unit displays the results of SG and % solids, but outputs only one or the other. Refer to the next Chapter for details.

Chapter Five

Initial Set Up

What is required?

When the SS200 Digital Density Gauge is set up for the first time, three types of settings need to be entered or checked:

- ④ Calibration constants
- ④ Standard values
- ④ High and low limits for the 4-20 mA inputs and outputs

These parameters are entered into various *locations* in the control unit microprocessor, as described in this Chapter. All locations are listed in the Appendix.

First start up

At the first start up, if the parameters have not been set, the mnemonic (shown in the Appendix) referring to each parameter is displayed in turn when the control unit is powered up. You must enter an appropriate value before proceeding. Refer to this Chapter and the Appendix for details.

Entering dummy values

If some of the facilities provided by the gauge are not required, enter dummy values into the parameter location. A value of 2.0 is recommended for unused parameters.

Calibration constants

Calibration constants define the gauge and its operation. They are described in the parameter listing in the Appendix, in locations 1 to 9 for all gauges, and locations 25 to 28 for temperature corrected SG outputs.

The calibration constants should be entered into their correct locations before the outputs are set or the gauge is calibrated for the first time.

To set the constants, enter the required value into the calibration constant's location. See page 4-2 for instructions on how to enter a value into a location.

Standard values

The values of the calibration standards are entered by performing the initial calibration. Refer to the next chapter for details.

The calibration can be done before or after setting the outputs and limits, as described below.

Setting outputs

The control unit displays results of SG and % solids, but only one or the other is output through current loop 1.

- To output SG, press **1, 5, FN, EXAM, 0, FN, LOAD**
- To output % solids, press **1, 5, FN, EXAM, 1, FN, LOAD**

The other output depends on inputs (see opposite).

Setting limits

Set up limits for the required 4-20 mA inputs and outputs to the low and high limit required (X and Y respectively), as follows:

- Press **CAL** to enter calibrate mode first.

To set SG limits...

Low limit (X):

- Press **16, FN, EXAM, (X), FN, LOAD**

High limit (Y):

- Press **17, FN, EXAM, (Y), FN, LOAD**

To set % solids limits...

Low limit (X):

- Press **18, FN, EXAM, (X), FN, LOAD**

High limit (Y):

- Press **19, FN, EXAM, (Y), FN, LOAD**

To set up temperature adjusted SG or solid mass flow...

A 4-20 mA input is required from an external temperature gauge or flow meter, as applicable. The temperature should be in °C. Flow should be in m³/hour for calculation of solids mass flow rate in tonnes/hour.

See Chapter 9 for solids mass flow calculation using other units.

Solid mass flow:

- Set location 20 to one, by pressing **2, 0, FN, EXAM, 1, FN, LOAD**
- Set 4-20 mA low *input* limit to (X) by pressing: **2, 1, FN, EXAM, (X), FN, LOAD**
(X = flow rate at 4mA)
- Set 4-20 mA high *input* limit to (Y) by pressing: **2, 2, FN, EXAM, (Y), FN, LOAD**
(Y = flow rate at 20mA)
- Set 4-20 mA low *output* limit to (X) by pressing: **23, FN, EXAM, (X), FN, LOAD**
(X = solids mass flow rate at 4mA)
- Set 4-20 mA high *input* limit to (Y) by pressing: **24, FN, EXAM, (Y), FN, LOAD**
(Y = solids mass flow rate at 20mA)

Temperature adjusted SG:

- Set location 20 to zero, by pressing **2, 0, FN, EXAM, 0, FN, LOAD**
- Set 4-20 mA low *input* limit to (X) by pressing: **2, 1, FN, EXAM, (X), FN, LOAD**
(X = temperature at 4mA)
- Set 4-20 mA high *input* limit to (Y) by pressing: **2, 2, FN, EXAM, (Y), FN, LOAD**
(Y = temperature at 20mA)
- Set 4-20 mA low *output* limit to (X) by pressing: **2,3, FN, EXAM, (X), FN, LOAD**
(X = temperature corrected SG at 4mA)
- Set 4-20 mA high *input* limit to (Y) by pressing: **24, FN, EXAM, (Y), FN, LOAD**
(Y = temperature corrected SG at 20mA)

Note: See page 9-7 for discussions of SMF calculation and the units used.

Entering SG for % solids reading

For the % solids readings to be accurate, you must set an accurate SG of the dry solids in location 8, as follows:

- Press **8, FN, EXAM, (Z.ZZ), FN, LOAD**

where (Z.ZZ) is the S.G. of the dry solids, obtained by laboratory analysis of the slurry.

Chapter Six

Calibration

Why is calibration necessary?

Calibrating the SS200 Digital Density Gauge is essential to correct for pipe wear and long term drift in detector efficiency.

When should it be calibrated?

The gauge must be calibrated when it is first installed, to set up initial calibration standards.

After installation and initial set up, it should be calibrated every twelve months, or whenever the gauge is moved.

How is calibration done?

By measuring the count rate with the pipe empty, full of pure water, or full of slurry.

<p>Note: <i>Calibrating with pure water is the most accurate method. Whichever calibration method you choose, use the same method each time, or reset the standards.</i></p>
--

Should it be standardised as well?

No. For the SS200 Digital Density Gauge, calibration and standardisation are essentially the same thing. Only calibration is necessary, as described in the following sections.

Which calibration medium?

You can calibrate the gauge with pure water, the slurry, another transport medium, or with an empty pipe. Calibration with pure water is usually the most accurate method. Calibration with an empty pipe is less accurate. If you calibrate with slurry, accurate sampling is necessary to determine its true SG.

Preparing for calibration

To prepare the gauge for calibration:

1. Turn the source housing control lever to BEAM ON.
2. Set up parameters, as explained in the following section.
3. Leave the gauge to warm up. The beam must be on for at least one hour before you begin the calibration.

Setting parameters

The following parameters must be set before you begin the calibration:

1. Set the *dead time* to 4.5 by pressing **5, FN, EXAM, 4, •, 5, FN, LOAD**.
2. Enter the internal diameter of the pipe (in cm) in location 6.

<p>Note: <i>You must use the internal diameter. If the pipe is lined, use the internal diameter of the lining.</i></p>
--

3. Enter the water density (1.0) in location 7 (or enter the density of the transport medium, if not water).
4. Enter the slurry constant, U, in location 9. This is usually 0.074. (You can enter the location as 9, or as 09).

5. Enter today's date in location 14, by pressing **1, 4, FN, EXAM**, (date), **FN, LOAD**

Note: *This ensures that the real time clock is set to the correct date.*

Enter the date in the format ddmmyy or dmmyy. If the date in location 14 is already correct, press **FN, LOAD** without entering the date.

6. Set STD2 (mnemonic S2) to 10,000 by pressing **FN, STD, 2, 1, 0, 0, 0, 0, FN, LOAD**.

You can now begin the calibration, which involves recording the count rate with a fluid of known SG in the pipe. Refer to the section appropriate to the fluid you are using.

Calibration on water (or other transport medium)

This is the preferred method of calibration. If the transport medium is not water, you can use the pure transport medium provided its SG is accurately known.

1. Completely fill the pipe with pure, bubble free water (or pure transport medium). The water may be stationary or flowing.
2. Set the gauge to measure count rates over a given period by pressing **CAL, 1, FN, EXAM, 1, FN, LOAD**

The word **Calibrate** displays.

3. Enter the count period (300 seconds), into location 2, by pressing **2, FN, EXAM, 3, 0, 0, FN, LOAD**.

The word **Calibrate** displays again when the period is correctly loaded.

4. Press **FN, CR** to view the count rate. The screen displays the message:

CR = : ----_

5. After 300 seconds, a count rate (in counts per second) is displayed. Write this value down.
6. Wait a further 300 seconds and write down the next count rate. This should be similar to the first. (If it isn't, repeat the readings at 300 second intervals until the system has stabilized and two similar readings are obtained).
7. Calculate the average of the two count rates.
8. Enter the average count rate into location 56, and the SG of the fluid in the pipe (1.0 in the case of water) into location 57.

Warning: *You must load the SG value into location 57 even if the previous value in location 57 is correct. If you don't, the automatic calibration will not proceed.*

Loading the SG into location 57 triggers the automatic calibration of the gauge. The gauge automatically calculates new values for STD1, STD3 and JDI (the date of calibration).

You should inspect Location 13 (JDI) to ensure that it has been changed automatically to today's date.

Calibration on air (with pipe empty)

This is less accurate than calibration on water, but may be the only option available if the pipe cannot be filled with pure water and it is not possible to sample the actual slurry.

1. Empty the pipe, then flush with clean water to remove any solid material adhering to the inside of the pipe. Allow the pipe to drain to remove most of the water.

Note: *If pools of water form in the radiation beam, this method of calibration cannot be used.*

2. Set the gauge to measure count rates over a given period by pressing **CAL, 1, FN, EXAM, 1, FN, LOAD.**

The word `Calibrate` displays.

3. Enter the count period (300 seconds), into location 2, by pressing **2, FN, EXAM, 3, 0, 0, FN, LOAD.**

The word `Calibrate` displays again when the period is correctly loaded.

4. Press **FN, CR** to view the count rate. The screen displays the message:

CR = : ----_

5. After 300 seconds, a count rate (in counts per second) is displayed. Write this value down.
6. Wait a further 300 seconds and write down the next count rate. This should be similar to the first. (If it isn't, repeat the readings at 300 second intervals until the system has stabilized and two similar readings are obtained).
7. Calculate the average of the two count rates.
8. Enter the count rate in location 56 and the SG of the fluid in the pipe (0.0 in the case of air) into location 57.

Warning: *You must load the SG value into location 57 even if the previous value in location 57 is correct. If you don't, the automatic calibration will not proceed.*

Loading the SG into location 57 triggers the automatic calibration of the gauge. The gauge automatically calculates new values for STD1, STD3 and JDI (the date of calibration).

You should inspect Location 13 (JDI) to ensure that it has been changed automatically to today's date.

Calibration on slurry

This method of calibration is more difficult than calibration on water, but it is the preferred option if the pipe cannot be filled with water.

A sample of slurry must be taken over a sampling period which exactly coincides with the recording of count rate. The sample consists of many increments (usually at least 30) taken at regular intervals during the sampling period. Sufficient increments must be taken to ensure that the sample is representative of the slurry 'seen' by the gauge.

1. Fill the pipe with slurry.
2. Set the gauge to measure count rates over a given period by pressing **CAL, 1, FN, EXAM, 1, FN, LOAD.**

The word `Calibrate` displays.

3. Enter the count period (300 seconds), into location 2, by pressing **2, FN, EXAM, 3, 0, 0, FN, LOAD.**

The word `Calibrate` displays again when the period is correctly loaded.

4. Press **FN, CR** to view the results as count rates. The screen displays the message:

CR = : ----_

5. After 300 seconds, a count rate (in counts per second) is displayed. At this point sampling of the slurry should begin.
6. Continue to sample the slurry for 300 seconds and write down the next count rate when it appears.
7. If a sampling period of greater than 300 seconds is required, continue to sample and write down each new count rate as it appears. Sampling should stop at the precise moment a new count rate appears. The sampling period will therefore be a multiple of count periods.

8. Calculate the average count rate for the sampling period. Note that the count rate at the start of the sampling period (step 5 above) must NOT be included in the average, since it relates to the counting period before sampling began.
9. Take the slurry sample to the laboratory and determine the SG using the most accurate method available. *The ultimate accuracy of the SS200 will depend on this.*
10. Enter the average count rate into location 56, and the SG of the slurry into location 57.

Warning: *You must load the SG value into location 57 even if the previous value in location 57 is correct. If you don't, the automatic calibration will not proceed.*

Loading the SG into location 57 triggers the automatic calibration of the gauge. The gauge automatically calculates new values for STD1, STD3 and JDI (the date of calibration).

You should inspect Location 13 (JDI) to ensure that it has been changed automatically to today's date.

Checking the calibration

Press **RUN** to switch back to analyse mode, and press **FN, SG** to select display of SG.

Compare the SG reading with the SG of material in the pipe. The SG should read 0 for an empty pipe or 1 for a water filled pipe. If calibration was done by sampling slurry, another sample of slurry could be taken as a check.

Adjusting the calibration

After setting the Count Rate for water one should then check the SS200 displayed value of SG compared to a check of the slurry with a Marcy gauge or lab analysis. A good method is to take 10 corresponding samples of slurry and SS200 gauge readings using a 300 second update time. Then calculate the average of each.

The theoretical value of U may differ with pipe sizes >200mm and higher SG values. An incorrect inside pipe diameter will also cause an error. However by adjusting the Slurry Constant U, these errors can be reduced.

Using the slurry SG as determined from samples and the SS200 gauge reading SG_e , calculate the new value of U (U_e is the value in location 9).

Calculate a new value for U from the equation:

$$U = \frac{U_e(SG_e - \rho_w)}{(SG - \rho_w)}$$

Where ρ_w = transport medium density (=1 for water)

Returning to normal operation

When calibration is completed, press **RUN** to enter run mode and resume normal operation.

Chapter Seven

Maintenance

Maintenance requirements

The SS200 Digital Density Gauge is virtually maintenance free, other than keeping the unit clean, and calibrating it regularly, as explained in Chapter Six.

Source housing and detector

The source housing and detector do not require routine maintenance.

Warning: *Do not dismantle the source housing for any reason. Special tools are required to remove the radioisotope.*

Refer to the supplier if you experience any problems.

Replacing the radioactive source

The half life for Caesium¹³⁷ is 30.17 years, and for Cobalt⁶⁰ 5.27 years, but the working life of the source encapsulation is 15 years. The source should be replaced at the end of this period. The manufacturer of the source will generally accept sources for disposal no later than one year after the end of the working life.

Contact the gauge supplier for replacement.

Warning: *Do not attempt to replace the source yourself.*

Chapter Eight

Fault Finding

Gauge not working

If the control unit is not working, make the following checks:

1. Check the incoming power is at the correct voltage (either 88 to 264 Vac, 50 or 60 Hz)
2. Check the fuse, located in the control unit on the Din rail. The fuse used is a 20 x 5mm, 1A fuse
3. Check DC voltages at the power supply. See the wiring diagram

Note: <i>The +5v should be >+4.8v</i> <i>The +15v should be > +14.75</i> <i>The -15v should be < -14.50</i>
--

If these voltages are not correct, refer to the following section.

4. Check all wiring, both at the terminal strip in the control unit, and the terminal strip in the detector unit.
5. Check that connectors on the EB210 PCB (located in the control unit) are mating correctly and that any socketed integrated circuit chips on the EB210 are securely in their sockets.

DC voltages incorrect

If the voltages are not correct, the cause may be one of the following:

- Faulty power supply
- The plant connection to the circuit loop inputs or outputs is causing the power supply to operate incorrectly
- The detector unit or wiring to the detector unit is faulty or incorrect
- The CPU board (EB210) is faulty

The cause can be identified by turning the power to the unit off, then disconnecting the appropriate item from the power supply. Disconnect the following in turn:

- The plant connections from the control unit terminal strip
- The detector unit from the control unit terminal strip
- PL2 on the EB210 printed circuit board

If the disconnection of one of these items restores the DC voltages, then further investigation will be needed to locate the exact problem. Contact the supplier for further information.

If the disconnections do not correct the DC voltage it is likely that the power supply is faulty. Contact the supplier for further information.

Gauge working but results suspicious

If you suspect the results are inaccurate, re-calibrate the gauge and check all the parameters (see the parameter listing in the Appendix).

Parameters lost on power up

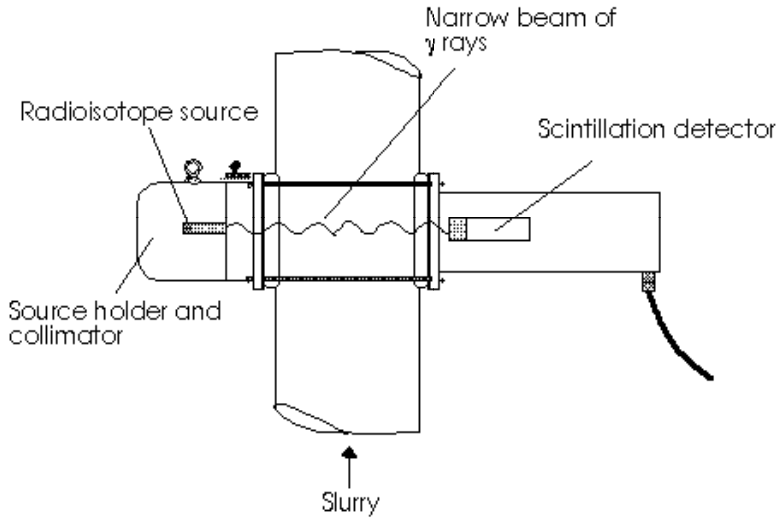
If any parameters are missing or lost, the mnemonic (shown in the Appendix) referring to each parameter is displayed when the control unit is powered up. You must enter an appropriate value before proceeding. Refer to Chapter Five, and the Appendix for further details.

Chapter Nine

Principles of Operation

Basic principles

The density gauge operates on the principle of gamma ray absorption. This is illustrated below:



Gamma rays from the source are partly absorbed by the slurry, and the remainder pass through to the detector. The degree of absorption is a measure of the density — high density slurries absorb more strongly than low density slurries.

The density is reported as specific gravity, which has no units, since it is the ratio of the density of the slurry to the density of water.

Absorption equation for fluids

The basic equation for a normal fluid, with no suspended solids is:

$$C = C_0 \exp(-\mu_m \rho L)$$

where:

- C = count rate of radiation beam emerging from the pipe *filled with fluid* (counts/sec)
 C₀ = count rate of radiation beam emerging from the *empty pipe* (counts/sec)
 μ_m = mass absorption coefficient for radiation for the fluid (cm²/g)
 ρ = density of the fluid (g/cm³) (minus density of air (assumed zero))
 L = path length of the gamma rays (cm) through the fluid
 (= internal diameter of the pipe or pipe lining, in cm)

Equation for calculating the slurry SG

The equation for pure fluid:

$$C = C_0 \exp(-\mu_m \rho L)$$

can be rearranged to give:

$$\frac{C}{C_0} = \exp(-\mu_m \rho L)$$

thus:

$$\ln \left(\frac{C}{C_0} \right) = -(\mu_m \rho L)$$

and:

$$\ln \left(\frac{C_0}{C} \right) = (\mu_m \rho L)$$

therefore:

$$\frac{(\ln C_0 - \ln C)}{\mu_m L} = \rho$$

It is more convenient to use the count rate for a water filled pipe than for an empty pipe to calculate the slurry SG. In this case:

- CO' = count rate obtained for water *at the present time* (calculated by the microprocessor, taking source decay into account — see page 9-5)
 CR = count rate obtained for the slurry
 U = slurry constant (calculated from the mass absorption coefficient of the slurry components — see page 9-11). This is usually 0.074
 ρ_w = density of water
 ρ_s = density of the slurry

Then, substituting these values in the equation gives:

$$\frac{(\ln \text{CO}' - \ln \text{CR})}{\text{UL}} = \rho_s - \rho_w$$

Therefore:

$$\rho_s = \frac{(\ln \text{CO}' - \ln \text{CR})}{\text{UL}} + \rho_w$$

This is the equation used by the control unit's microprocessor. Transport media other than water may be used by entering the correct density in place of ρ_w .

Decay correction

The microprocessor makes a daily correction for decay of the radiation source.

Daily decay constant

The decay correction is obtained from the half life of the radiation source:

$$\text{DDC} = \frac{\ln(0.5)}{(365.25 \times \text{HL})}$$

where:

- DDC = daily decay constant
 HL = half-life of the source, in years

Today's count rate

Today's count rate for pure water is estimated as follows:

$$\ln \text{CO}' = \ln \text{CO} + \text{DD}$$

where:

- CO' = estimate of today's count rate for pure water
 CO = corrected count rate for pure water obtained at the last calibration
 DD = DDC x (number of days since the last calibration)

Note: *It is obviously essential that the correct date is set in the microprocessor — see page 6-3 (step 5) for details.*

Dead time correction

Pulses produced by the photo-multiplier are analysed by the electronics in the density gauge. All of the electronics components have a finite response time, during which no further pulses can be analysed. This period is the *dead time* (DEAD).

Count rates are corrected to compensate for pulses missed during the dead time, using the formula:

$$\text{CR}_{\text{correct}} = \frac{\text{CR}}{1 - (\text{CR} \times \text{DEAD})}$$

A typical dead time is 4.5 microseconds, and the gauge maintains the dead time very precisely (important for the correction calculations).

Calculation of percent solids

The microprocessor calculates the percent solids in the slurry from the equation:

$$\text{PSL} = 100 \times \frac{\text{SS}(\text{SG} - \rho_w)}{\text{SG}(\text{SS} - \rho_w)}$$

where:

- PSL = percent solids by weight
- SS = specific gravity of dry solids in the slurry
- SG = specific gravity of the slurry
- ρ_w = density of the transport medium (usually pure water)

Solids mass flow calculation

The microprocessor can accept a 4-20 mA input from an external flow meter. It calculates the solids mass flow from the flow information and known SG, as follows:

$$\begin{aligned} \text{SF} &= F \times \text{SG} \times \frac{\text{PSL}}{100} \\ &= F \times \frac{\text{SS}(\text{SG} - \rho_w)}{(\text{SS} - \rho_w)} \end{aligned}$$

where:

- SF = solids mass flow (see below for units)
- SG = specific gravity of the slurry
- SS = specific gravity of dry solids
- F = slurry flow rate (m³/hour)
- ρ_w = density of transport medium (usually pure water — $\rho_w = 1.0$)

Units

Various units can be used for flow input — these units determine the units of the calculated solids mass flow (SF):

<i>Units of F</i>	<i>Units of SF</i>
m ³ /hour	tonnes/hour
m ³ /minute	tonnes/minute
litres/minute	kg/minute
litres/second	kg/second

Units other than these may be used by correct scaling of the flow input.

Example:

4-20 mA flow input corresponds to 0-20 cubic feet per minute. Solids mass flow is required in tons per hour.

Flow input must be converted to tons per hour of pure transport medium (water)

1 cu ft of water weighs 62.43 lbs

1 US ton = 2000 lbs

20 cu feet/minute of water = 20 x 60 x 62.43/2000 = 37.46 tons/hour.

Therefore set current loop input limits as follows:

- ❑ set location 21 (LO input) to 0
- ❑ set location 22 (HI) input) to 37.46

Temperature corrected SG

The microprocessor can accept a 4-20 mA input from an external temperature gauge. It corrects the SG back to a reference temperature, as follows:

$$St = SG(C_0 + C_1(T - T_0) + C_2(T-T_0)^2)$$

where:

- St = slurry SG at the reference temperature
- SG = slurry SG
- C₀, C₁ and C₂ are constants
- T₀ = reference temperature
- T = measured temperature (from external temperature gauge) (°C)

This correction is used in applications such as the petroleum industry, where the SG is required at standard temperature and pressure (STP).

Smoothing of current loop outputs

The microprocessor can smooth the current loop outputs to compensate for fluctuations in values over a time period. Two methods are available, namely exponential averaging and rolling average buffer.

Exponential Averaging

A smoothing *time constant* is used to reduce the effect of counting statistics, and short term fluctuations in slurry SG on the current loop outputs. An excessively large time constant will slow the response of the gauge to genuine density changes. The time constant you choose will therefore be influenced by the function of the current loop outputs at your site.

Smoothing should only be used when the gauge is configured to calculate results after a fixed period of time (location 1 = 1).

The calculation the microprocessor uses is:

$$NEW = VAL \times EAF + OLD \times (1 - EAF)$$

where:

- NEW = new value to be output on the current loop
- OLD = previous value on the current loop
- VAL = latest reading taken by the gauge
- EAF = Exponential averaging factor
- = $\exp\left(-\frac{T}{TC}\right)$
- T = period over which latest readings were taken (set in location 2)
- TC = time constant (set in location 29)

Rolling Average Buffer

The Rolling Average Buffer becomes functional when a “0” is entered in the Time Constant parameter location 29. It is then possible to select from 1 to 8 buffers by loading the a digit between 1 and 8 in parameter location 26 .

e.g. to load 6 buffer stages,

key in as follows

26 FN, EXAM, 6 FN, LOAD

Each time an update occurs (as determined by the Update Time in location2), a buffer pointer is incremented and succeeding update count rates are loaded into successive buffers. When the buffer is full (in this case 6 x count rate values) the first entered count rate is dropped and a new value entered. The count rate used in determining the SG is then the average count rate of the selected buffers.

Calculation of minimum counts for density measurement

Radiation from a radioisotope source does not emerge in a steady stream, but in erratic bursts. Therefore, repeated measurement of counts over a short time interval can show different results, and for high precision, long counting times should be used so that a large number of counts is collected.

When location 1 is set to 0, the parameter N (location 3) is the *minimum number of counts* per conversion. No calculation of SG is made until 2^N counts have been received. The time between calculations depends on the *count rate*.

When location 1 is set to 1, the SG is calculated after a fixed *counting time* (set in location 2). The total count in this case is equal to the count rate multiplied by the counting time.

Calculation of N or counting time

If many SG measurements are made on a liquid (such as pure water) of constant SG, the measurements will show a random (normal) distribution about the true value. The standard deviation of this distribution $\Delta\rho$ must be less than the tolerable error in SG measurement.

$\Delta\rho$ is calculated as follows:

$$\Delta\rho = \frac{1}{UL\sqrt{C}}$$

where:

- $\Delta\rho$ = SG error
- U = slurry constant — see below
- L = path length (cm) through the fluid (the internal diameter of pipe or pipe lining)
- C = total number of counts collected during the measurement
= 2^N or time x count rate

N should be at least 14, and preferably 20, but can be lower if a more rapid response is necessary.

The counting time should be selected to give an acceptable compromise between accuracy and time of measurement.

Slurry constant

The slurry constant, U, contains information that distinguishes one mineral slurry from another.

It can be calculated from the equation:

$$U = \frac{\mu_s \rho_s - \mu_w \rho_w}{\rho_s - \rho_w}$$

where:

- μ_s = weighted average mass absorption coefficient for the dry solids components of the slurry
- μ_w = mass absorption coefficient of the transport medium (= 0.08520 for water)
- ρ_s = SG of dry solids
- ρ_w = SG of the transport medium (1.0 for water)

Values for the mass absorption coefficients for the individual elements are tabulated in the scientific literature, and can be obtained for the supplier on request.

Alternatively, the supplier will calculate a value for U if provided with a detailed and accurate assay for the dry solids, and the dry solids specific gravity.

Large pipe or high SG?

The theoretical value of U may not apply if the pipe is large (>20 cm) or the SG is high (since the value strictly applies only to “narrow beam geometry” situations).

The variation between theoretical and actual values of U may be as high as 10%. Under these circumstances the gauge must be calibrated empirically.

Calibration method 1

- Calculate the best estimate for U, using the equation above. Call this estimate U_e , and enter it into the microprocessor memory in location 9.
- Operate the gauge with slurry, and record the gauge estimate of specific gravity, SG_e .
- Take samples of the slurry and measure the specific gravity by accurate laboratory methods, to find the true value for SG.
- Calculate a new value for U from the equation:

$$U = \frac{U_e(SG_e - \rho_w)}{(SG - \rho_w)}$$

Where ρ_w = transport medium density (=1 for water)

- Enter this new U into the microprocessor, and repeat the process until the gauge-indicated SG coincides with the measured SG.

Note: *Take more than one measurement of SG, since a single measurement is unreliable. SG measurements should be made by the most accurate method available.*

Calibration method 2

- ❑ Take a sample of slurry and have the SG measured independently. During the sampling, measure the count rate.

Note: Counting time should be long enough to accumulate at least 40,000 counts.

- ❑ Calculate U from the single count measurement:

$$U = \frac{\ln CO' - \ln CR}{L(SG - \rho_w)}$$

where:

- CO' = count rate for water, at the present time
- CR = count rate for the slurry
- L = path length in cm
- ρ_w = density of transport medium (=1 for water)

In practice a number of measurements should be made, and the average U found, OR, plot $\ln CR$ (y-axis) versus SG, and draw the line of best fit. The slope of this is UL.

Gain stabilisation

What is gain?

The photo-multiplier receives photons from the scintillation detector and converts them, at the photo cathode, to a burst of electrons.

The electrons then pass through the photo-multiplier tube, along a series of *dynodes* at successively higher voltages. As each electron hits a dynode several electrons are dislodged and pass to the next dynode, where each dislodges several more. This 'cascade' effect produces an amplification of up to a million fold.

The amplification of the pulse is called the *gain*. Gain is controlled by changing the high voltage on the photo-multiplier tube.

Why control the gain?

The size of the pulse leaving the photo-multiplier anode is proportional to the energy of the gamma ray impinging on the detector crystal.

The source produces gamma rays with a spectrum of energies, with one large peak. If the detector detects a low count rate, the slurry density could be high, or the detector may be detecting gamma ray energies away from the peak. It is therefore essential to make sure the detector is detecting energies at the peak. It does this by *gain stabilisation* — which ensures that the height of pulses corresponding to the main gamma ray remains the same.

How is the gain controlled?

The gauge uses two *discriminator levels* to control the gain. These are set at the factory, and the gauge maintains a constant count rate ratio from each discriminator. This ensures the gauge accuracy remains stable with time.

Source size calculation

A source is selected to give approximately 10,000 counts per second, using the formula:

$$\text{Source size} = \frac{4.9}{A \times B} \text{ mCi}$$

A and B are determined from the pipe size using the table below:

<i>Pipe OD (mm)</i>	<i>A</i>	<i>Pipe ID x SG (mm x SG)</i>	<i>B</i>
0	1.5	10	0.93
25	1.45	20	0.86
50	1.4	50	0.69
75	1.3	100	0.47
100	1.2	200	0.22
125	1.1	300	0.11
150	1	400	0.05
200	0.9	500	0.024
250	0.7	600	0.011
300	0.6	700	0.0052
350	0.5	800	0.0025
400	0.4	900	0.0012
450	0.33	1000	0.00055
500	0.3	1100	0.00026
600	0.25	1200	0.00012
800	0.15		

If the exact figure is not in the left column, interpolation should be used.

Calculate the source required to give 10,000cps, using the table and formula.* The following source sizes are available:

1, 3, 5, 10, 20, 30, 50 mCi

Choose the source as calculated, or the one immediately below the calculated requirement.

If a source of X mCi is calculated, and Y mCi is used, the expected count rate is given by:

$$\frac{Y \times 10000}{X}$$

<p>Note: <i>The calculations give a reasonable accuracy within a given time. If a lower source size is selected, a longer count period is necessary — twice as long for a source half the size.</i></p>
--

* For pipes larger than 300mm in diameter it may not be possible to achieve a count rate of 10,000cps, even with a 50 mCi source. The lower count rate is acceptable for larger pipes, however, and does not create problems.

Chapter Ten

Specifications and
Parts List

Specifications

<i>Component</i>	<i>Description</i>
Source holder	<input type="checkbox"/> Lead filled sealed mild steel, to IAEA specifications.
Radioisotope	<input type="checkbox"/> Doubly encapsulated Cs ¹³⁷ or Co ⁶⁰
Detector module	<input type="checkbox"/> Rugged mild steel enclosure, protection to IP67. Connects to control unit via instrumentation cable.
Scintillation detector	<input type="checkbox"/> Sodium iodide with integral photo-multiplier
SS200 control unit	<input type="checkbox"/> Switch mode power supply <input type="checkbox"/> Decay clock continues with power off <input type="checkbox"/> RS422 link to detector module <input type="checkbox"/> No loss of data when power is removed <input type="checkbox"/> 88 to 264 Vac 50Hz or 60Hz operation or other supply voltages as ordered. <input type="checkbox"/> 40 watts power consumption <input type="checkbox"/> IP65 protection standard <input type="checkbox"/> Up to 1000 metres from detector <input type="checkbox"/> Isolated 4 - 20 mA current output loops (1.5kV) <input type="checkbox"/> 0.1% resolution on current loops
<i>Operation</i>	<i>Description</i>
Temperature drift	<input type="checkbox"/> ± 0.00003 SG units per degree Celsius
Sensitivity	<input type="checkbox"/> ± 0.00003 SG units
Repeatability	<input type="checkbox"/> ± 0.0001 SG units
Operating Temperature	<input type="checkbox"/> 0 to 45 °C
Vibration	<input type="checkbox"/> 2 g at 100 Hz
Humidity	<input type="checkbox"/> 5 - 95% RH, non-condensing
Inputs	<input type="checkbox"/> 4 - 20 mA from mass flow gauge or temperature sensor operators keyboard <input type="checkbox"/> power supply
Outputs	<input type="checkbox"/> 16 character LCD display <input type="checkbox"/> two 4 - 20 mA current loops for SG, percent solids, solids mass flow, or temperature corrected SG <input type="checkbox"/> DC supplies to detector <input type="checkbox"/> Mass Flow Rate Integrator one pulse per tonne relay contacts.

Parts List

The following table includes the *major* parts and sub-assemblies of the SS200 Digital Density Gauge.

<i>Component No.</i>	<i>Description</i>
6210-00-0002	Clamp, universal, DDG
8010-90-0005	Cabinet, control, DDG SS200
1230-90-1660	PCB1660 16 char. disp.
1230-90-2100	PCB210 DDG Receiver SS2000
4470-90-0003	Keypad, SS200, DDG assembly
0150-00-0112	Fuse, 20 x 5mm, fast blow, 2 amp
3200-90-0010	Power supply assembly. $\pm 15V$ & $5V$, 30W
5050-00-0002	Bracket, support, SS200
5005-00-0002	Panel, SS200, density gauge
8020-90-0002	Housing, source assembly DDG
6867-00-0002	Padlock, unison brass 40mm
0260-00-0014	'O' Rings, .5 x .625 x .07
7055-00-0005	Sign, caution
4060-90-0007	Detector assembly, SS200 DDG
8020-00-0003	Housing detector, mild steel
4060-00-0008	Detector assembly, 2" x 2" (NaI (TL))
1230-90-2000	PCB200 DDG AGS

Appendix

Parameters list

Refer to Chapter Five for instructions on setting these parameters.

You can view all the parameters by pressing **FN, CAL, 9, 9, FN, EXAM**. This displays parameters 1-29 in order. Press any key to display the next parameter.

To enter a negative number, press **FN, RUN** to enter the negative sign (see page 4-2).

<i>Loc- ation</i>	<i>Alt keys</i>	<i>Mne- monic</i>	<i>Description</i>	<i>Typi-cal</i>
0			Version number	
1		MODE	Set to 1 to calculate results after a fixed time. Set to 0 to calculate after fixed number of counts	1
2		T	Time in seconds between calculation of SG. (Applies only if location 1 is set to 1)	10
3		N	2 ^N is the minimum number of counts to be used in calculating SG. (Applies only if location 1 is set to 0)	13.3
4		HL	Half-life in years of source used. For Cs ¹³⁷ , use 30.17. For Co ⁶⁰ , use 5.27.	30.17
5		DEAD	Dead-time in microseconds. This is the spacing below which two gamma rays striking the photo-multiplier cannot be discriminated.	4.5
6		L	Path length through the fluid, in centimetres. Normally the internal pipe diameter.	17.5
7		d	Density of transport medium. (1.0 (gcm ⁻³) for water)	1.0
8		SS	Density of dry solids in the slurry	4.0
9		U	Slurry constant	0.074
10	STD, 1	S1	Standard count rate 1.	10000
11	STD, 2	S2	Standard count rate 2.	10000
12	STD, 3	S3	Standard count rate 3 — determined during calibration.	8120.00
13		JDI	Date on which S3 was most recently measured. In format ddmmyy or dmmyy. d or dd = day (1-31). mm = month (01-12) yy = year (00-99)	31190

Appendix

14		JD	Today's date, in same format as above.	270191
15		PSSW	Set to 1 to output percent solids on loop 1. Set to 0 to output SG on loop 1.	0
16	SG,LO	SL	SG corresponding to 4 mA output	1.0
17	SG, HI	SH	SG corresponding to 20 mA output.	2.0
18	PSL,L O	PL	PSL corresponding to 4 mA output	0
19	PSL, HI	PH	PSL corresponding to 20 mA output.	66.67
20		SFSW	Set to 1 to input flow, calculate solids mass flow and output this on loop 2. Set to 0 to input temperature, calculate temperature corrected SG and output this on loop 2.	1
21		FL	Volume flow rate/temperature input corresponding to 4 mA	0
22		FH	Volume flow rate/temperature input corresponding to 20 mA	720
23	SMF, LO	RL	Solids mass flow/temperature corrected SG corresponding to 4 mA output	0
24	SMF, HI	RH	Solids mass flow/temperature corrected SG corresponding to 20 mA output	900
25		T0	Reference temperature (in °C) to which SG is to be corrected. (Applies only if SFSW (location 20) is set to 0)	20
26		C0	Number of buffers in Rolling Average Buffer	6
27		C1	Constant 1 for temperature adjustment. (Applies only if SFSW is set to 0).	0.07
28		C2	Constant 2 for temperature adjustment. (Applies only if SFSW is set to 0).	-0.12
29		TC	Time constant (in seconds) for smoothing of current loop outputs. Use 0 if no smoothing is desired.	60
30		A	Not used.	12
31		A4	Not used	4
32		A20	Not used	20

Note:

The following values may be examined but not set by the user.

33		AP25	Output to current loops value for on board calibration of the loops. This value is used by the manufacturer in the initial adjustment of the loops, and may result in an output current exceeding 20mA (typically 24mA)	0.25
34		FREQ	Number of accumulations of results made by the microprocessor per second.	10
35		MINR	Minimum number of accumulations before calculation of results (ie. T * FREQ).	100
36		MINN	Minimum number of counts before calculation of results (ie. 2 ^N).	131072
37		DDC	Daily decay constant: $\frac{\ln(0.5)}{(365.25 \times HL)}$	-6.29E-5
38		SSS	$\frac{SS}{(SS - d)}$	1.33
39		CO	Corrected water count rate: $\frac{S1 \times S3}{S2}$	10335
40		DD	Decay correction (DDC x (day(JD) - day(JDI)))	-270
41		F	Volume flow/temperature input from current loop input	300
42		NR	Number of accumulation of results to compute latest results.	12
43		RC	Number of counts recorded from the gauge circuitry. This is the number of events occurring in the photomultiplier tube, less those lost due to dead time, and divided by 2, owing to the detector circuitry employed.	4860
44	CR	CR=	Dead time corrected count rate.	10162
45		EAF	Exponential averaging factor	0.9
46	SG	SG=	Specific gravity (instantaneous)	1.5
47		SSG	Specific gravity (smoothed)	1.47

Appendix

48		SGI	Output current for SG in mA	12
49	PSL	PSL	Percentage solids (instantaneous)	44.4
50		SPSL	Percentage solids (smoothed)	43.8
51		PSI	Output current for PS in mA	14.67
52		FTOT	Totalised flow input from the external flow meter. This is an internal format, and the actual current is calculated as: $4 + 16 \times \frac{(FTOT / NR)}{1023}$	256

53	SMF	SMF=	Solids mass flow/temperature corrected SG (instantaneous)	200
54		SSMF	Solids mass flow/temperature corrected SG (smoothed)	200
55		SFI	Output current for solids mass flow, in mA	7.55

User-set calibration parameters

The following parameters are entered by the user and used for calibration. Entering a value into SC will recalculate values for S1, S2, S3 and JDI, and therefore should not be done except during a calibration.

56		CC	Calibration count rate (set by user)	81.20
57		SC	Calibration SG (set by user)	1

SS200 Density Gauge PROFIBUS DP Option

The PROFIBUS DP option provides the capability of reading from and writing to up to eight four byte registers of the Control Unit. Each four byte register provides the precision of 32 bit IEEE 754 format floating point numbers. The standard Control Unit read registers are SG, Per Cent Solids, Solids Mass Flow and Count Rate SG.

The Updating of the registers occurs at each Up Date Time as selected from the Control Unit keypad or by writing to the PROFIBUS slave from the Master.

The PROFIBUS interface plugs into the Control Unit motherboard.

INSTALLATION

Incoming and Outgoing PROFIBUS cables are terminated as shown in Fig.1

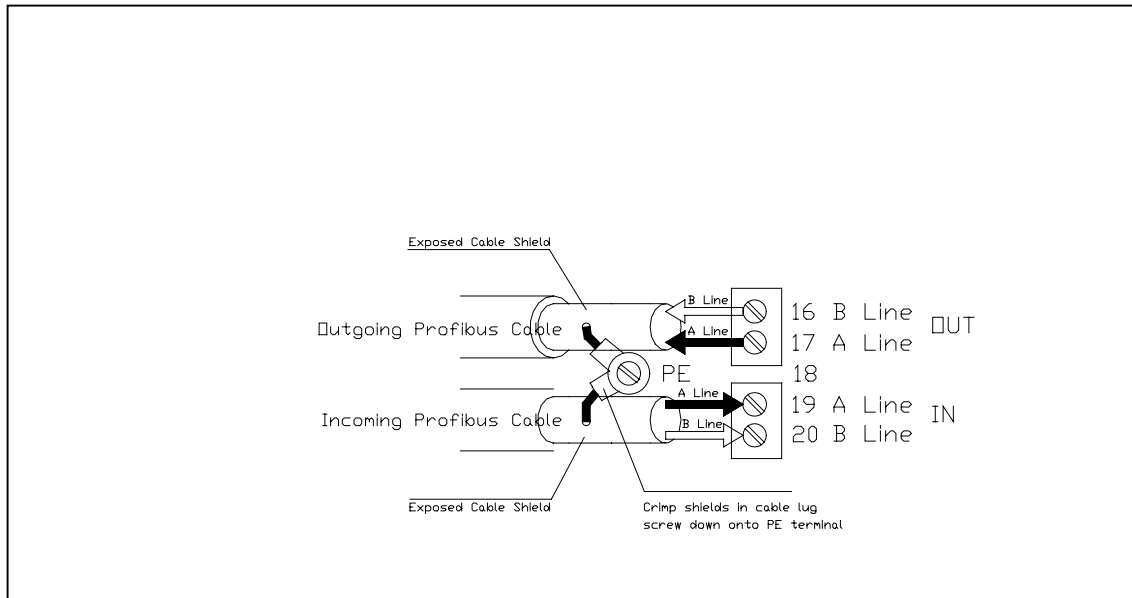


Fig.1

SLAVE ADDRESS

The PROFIBUS slave address can be selected either via the Control Unit Keypad or PROFIBUS Master. Using the relevant Control Unit access location 66, the current address will be displayed on the Control Unit LCD. It can be changed by loading in the new slave address. When using the Control Unit, it has to be in CALIBRATE mode to access and change the slave address. When using the PROFIBUS Master it is done on line in the RUN mode.

SS200 DENSITY GAUGE HART OPTION

Four Process Variables are available via the HART option, SG, Per Cent Solids, Solids Mass Flow and Count Rate. The Device Variable Codes are as follows.

Device Variable	Classification Code	Code	Units
Density	73	96	Kilograms per litre
Per Cent Solids	81	57	Percent
Solids Mass Flow	72	78	Tonnes per hour
Count Rate	80	38	Hz

This option provides the facility to write range limits for Density, Per Cent Solids and Solids Mass Flow to the Control Unit Registers.

The HART modem is available directly on terminals 18 and 20.

It is internally connected to current Loop 1.

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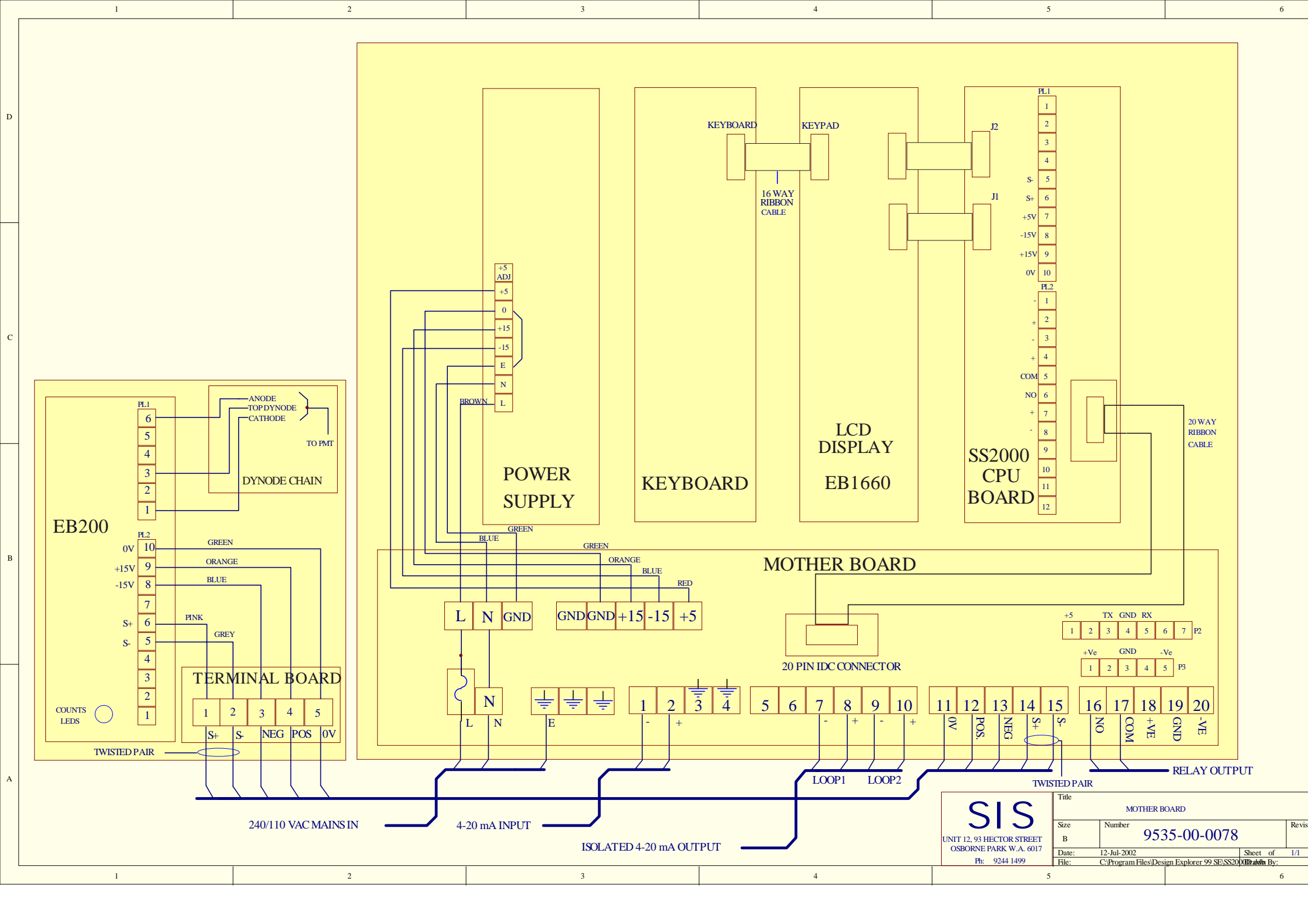
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Drawings

Drawings

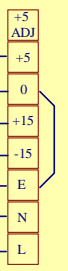
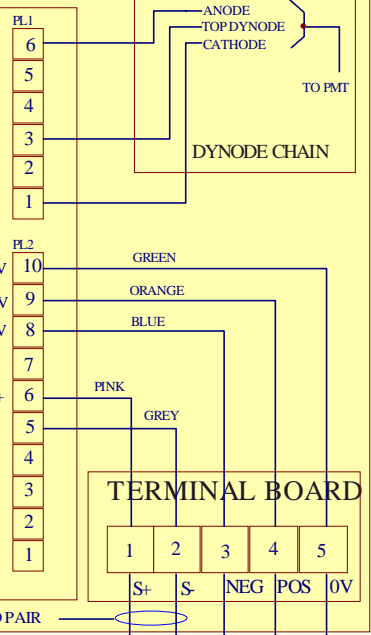
Drawing list

<i>Drawing number</i>	<i>Title</i>
9535-00-0078	SS200 density gauge wiring and cabling diagram
9535-00-178	SS200 density gauge 24Vdc with Profibus wiring and cabling diagram
9535-00-0378	SS200 density gauge HART wiring and cabling diagram



EB200

COUNTS
LEDS



POWER
SUPPLY

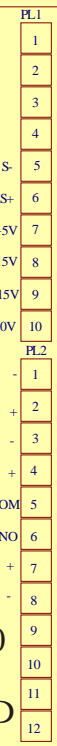
KEYBOARD

KEYPAD

16 WAY
RIBBON
CABLE

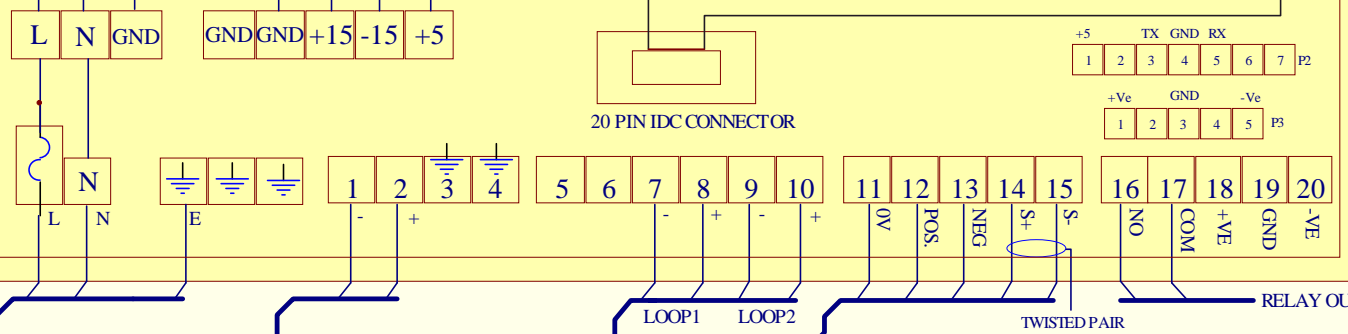
LCD
DISPLAY
EB1660

SS2000
CPU
BOARD



20 WAY
RIBBON
CABLE

MOTHER BOARD



240/110 VAC MAINS IN

4-20 mA INPUT

ISOLATED 4-20 mA OUTPUT

LOOP1 LOOP2

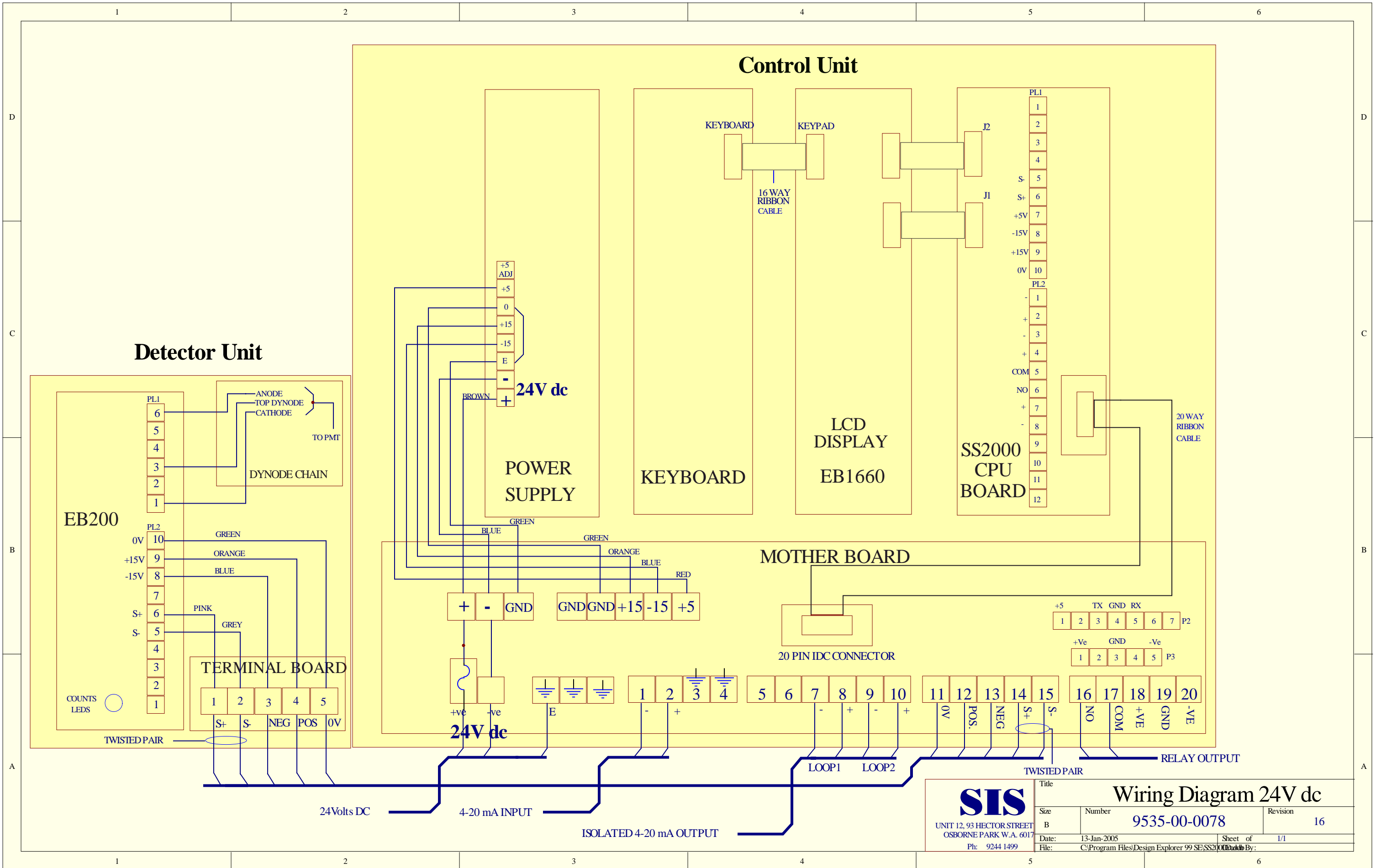
SIS

UNIT 12, 93 HECTOR STREET
OSBORNE PARK W.A. 6017
Ph: 9244 1499

Title: MOTHER BOARD

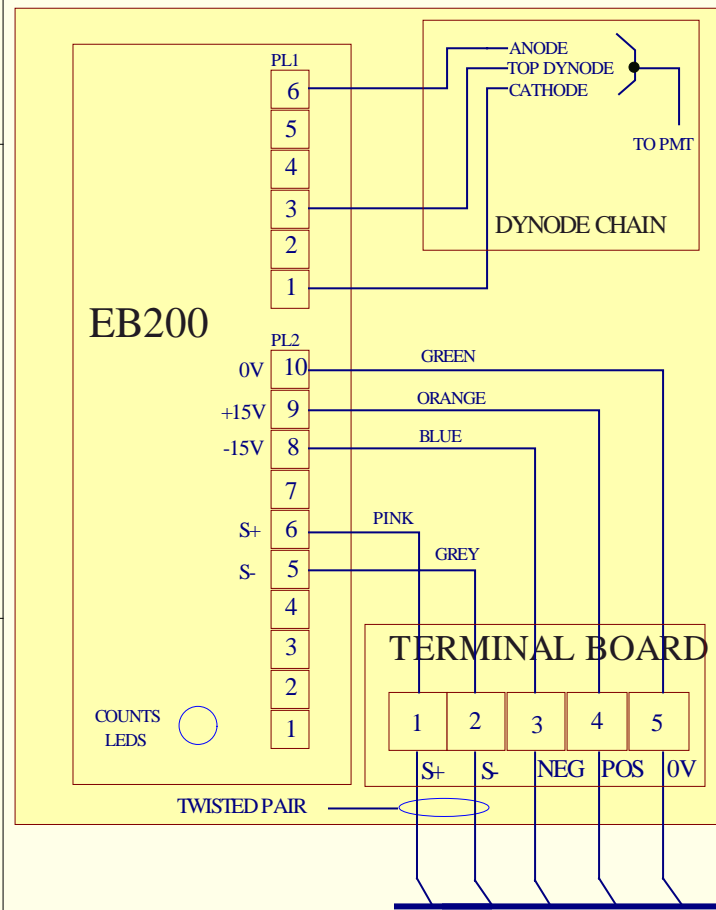
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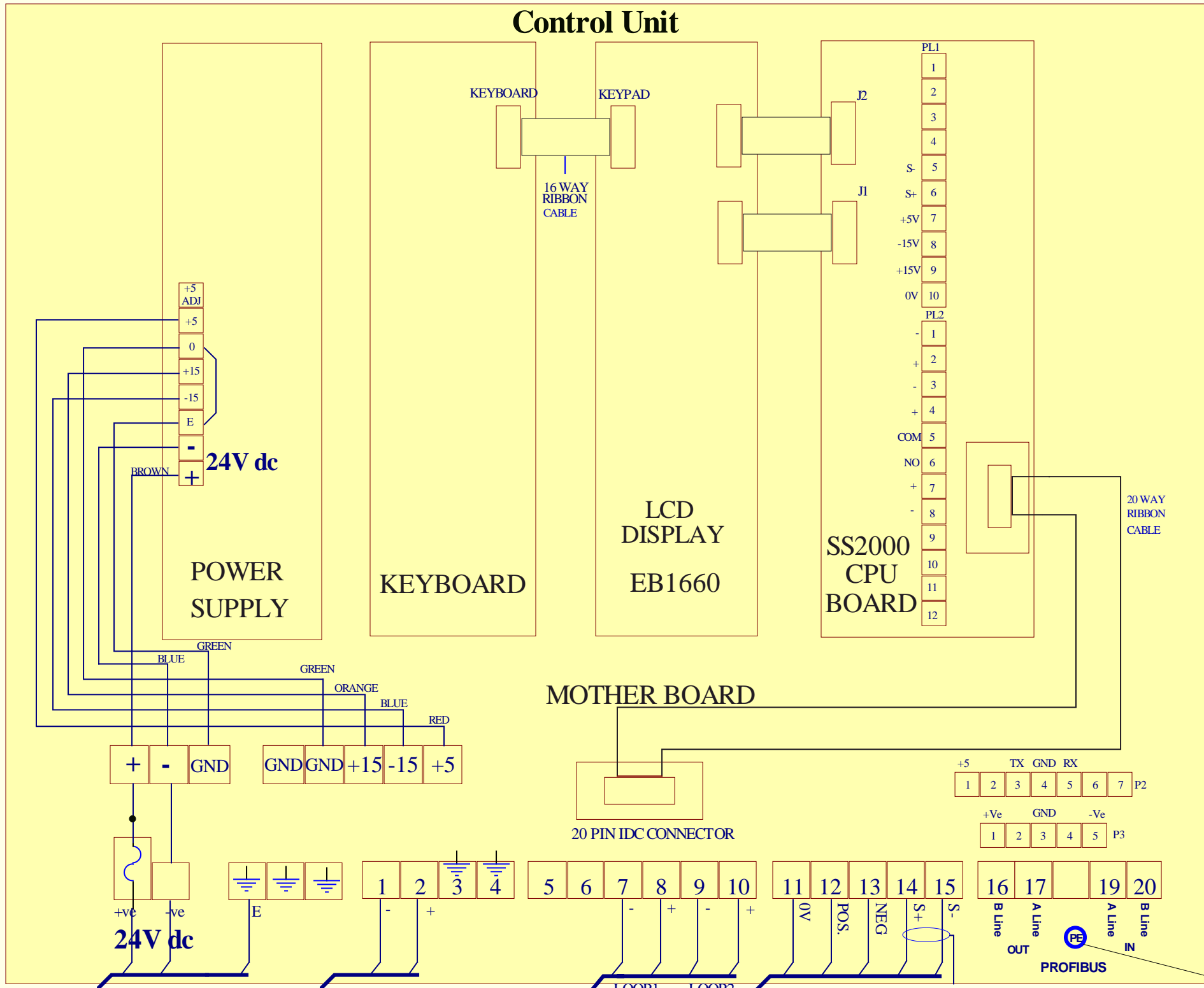


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	Date:	13-Jan-2005	Sheet of	1/1
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Detector Unit



Control Unit



EB200

TERMINAL BOARD

MOTHER BOARD

Roche Drg. No.
PC13-E02-I-133314

Profibus Cable Shield Clamp

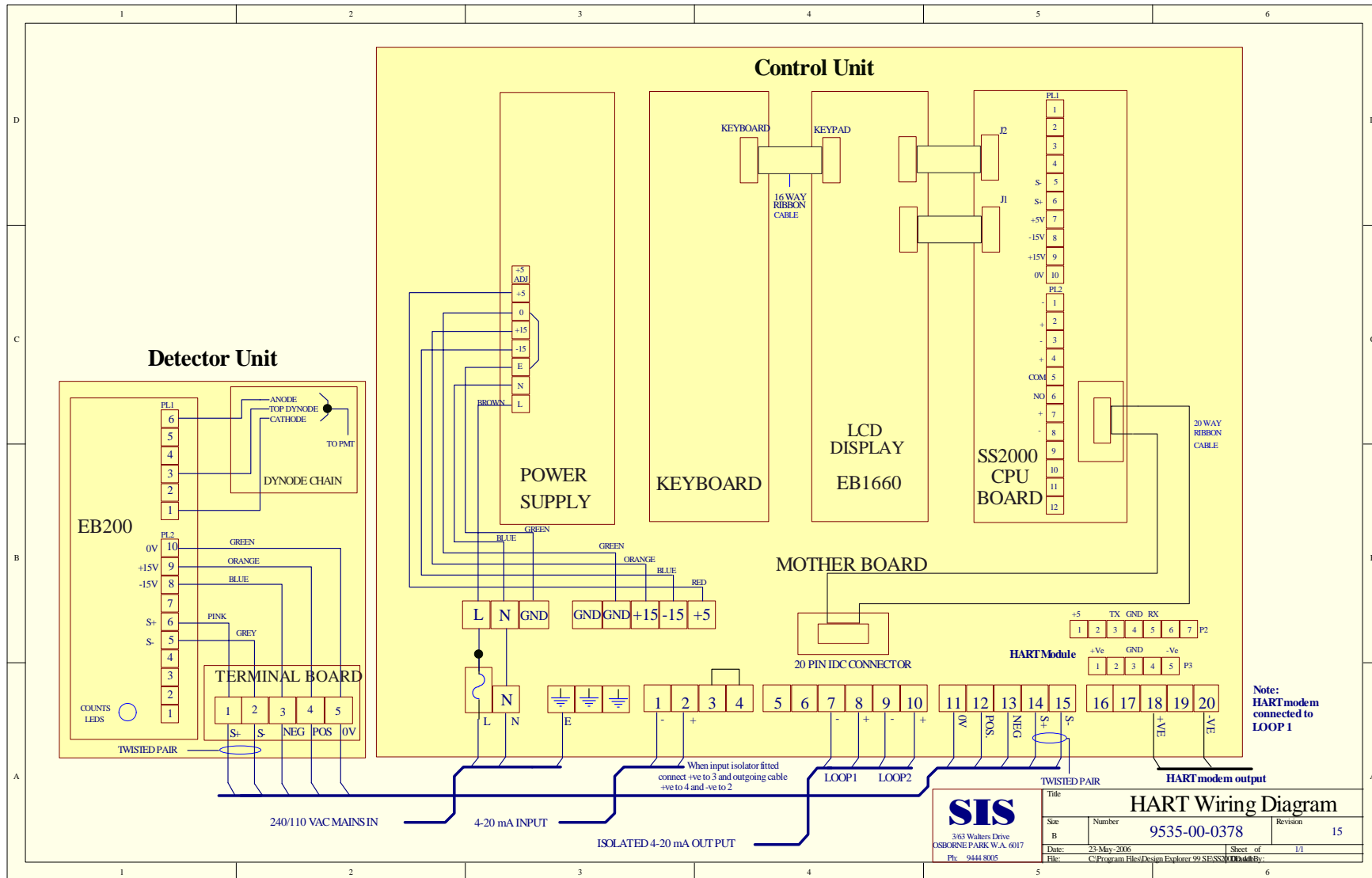
24Volts DC

4-20 mA INPUT

ISOLATED 4-20 mA OUTPUT

SIS
UNIT 12, 93 HECTOR STREET
OSBORNE PARK W.A. 6017
Ph: 9244 1499

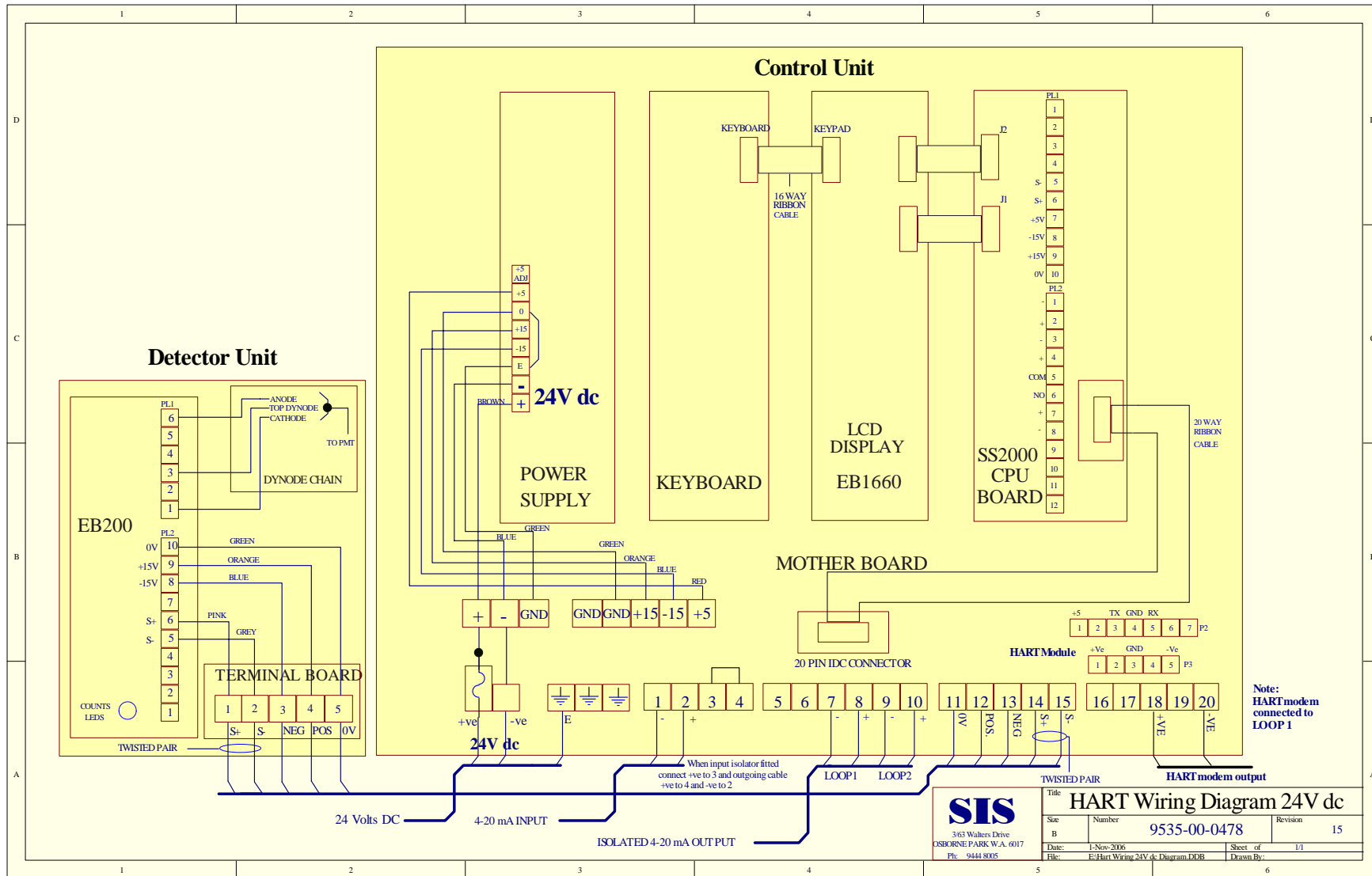
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 OSBORNE PARK W.A. 6017
 Ph: 9444 8005

Title			Revision		
HART Wiring Diagram			15		
Size	Number	9535-00-0378		Revision	
B					
Date:	23-May-2006	Sheet of	1/1		
File:	C:\Program Files\Design Explorer 99\SESS\10000000.dwg				

Note:
 HART modem
 connected to
 LOOP 1



SIS
 363 Walkers Drive
 OSDORNE PARK W.A. 6017
 Ph: 9444 9005

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Size: B	Number: 9535-00-0478	Revision: 15
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Note:
 HART modem
 connected to
 LOOP 1