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Greenbank Coal Flow Monitoring System (CFMS)

Operations & Maintenance Manual

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Version History

Operations & Maintenance Manual document is controlled by quality control systems to ISO 9001:2000.

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1.0	*N.Lad*	*28/01/2014*			*Document creation*
1.1	*S.Townsend*	*01/04/2014*			*Update*

The Company

Over many years Greenbank has developed a wide variety of specialised services for heavy industry.

Greenbank, in accordance with BS EN ISO 9001:2000, designs, manufactures supplies and installs their own specialised products together with all the associated equipment.

We also offer an ‘on site’ and 'in workshop' repair and maintenance service together with comprehensive range of replacement and spares.

The quality, accuracy and performance of the Company’s products result from over 50 years’ experience, combined with a continuous programme of innovative design and development to incorporate the latest technology.

Registered to: ISO 9001 and ISO 14001

RoSPA 2013 GOLD Award

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Health and Safety

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

1. The relevant sections of these instructions must be read carefully before proceeding.
2. Warning labels on containers and packages must be observed.
3. Installation, operation, maintenance and servicing must only be carried out by suitably trained personnel and in accordance with the information given.
4. Normal safety precautions must be taken to avoid the possibility of an accident.

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

Disclosure

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1 Introduction

The Coal Flow Measurement System (CFMS) is an on-line measuring system for use on pulverized coal feeds into power station boilers and plant such as blast furnaces. Up to 64 sensors can be linked together into a single system to provide continuous measurements of:

- Absolute velocity of the conveyed media
- Distribution or 'split' of conveyed media through bifurcators, trifurcators etc.
- Relative mass measurement

The measurement is derived from the electrostatic charge generated by passage of the pulverized coal particles through the pipelines and, being passive, eliminates the dangers associated with systems based on ionizing radiation.

The sensors are designed for use within harsh environments and the measuring system features advanced signal processing, resulting in fast and reliable measurements.

A basic system comprises three primary items: sensors, sensor electronics and a signal processing unit. The signal processing unit accepts the input from up to 64 sensors, each of which must have its own sensor electronics. Only Greenbank approved sensors and sensor electronics should be used.

Figure 1 – Typical CFMS installation (horizontal)

1.1 Conventions

The following conventions are used in this manual:

This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss or system crash. Please consult the documentation to minimise hazards where this symbol is present.

When symbol is marked on a product, it denotes a warning advising you to take precautions to avoid electrical shock.

This symbol denotes a terminal intended for connection to an external conductor for protection against electrical shock in case of a fault.

1.2 Sensor (Wafer-mount Type)

The sensor body is constructed from carbon steel and the sensor electrodes from stainless steel. The sensor uses a Wafer-mounting configuration. It is designed to be inserted in the fuel feed pipelines and ensures measurement across the total cross sectional area of the pipeline. Ideally, the chosen size should be identical to the internal diameter of the pipeline in which the sensor is to be installed. The CFMS is calibrated during manufacture negating the need for on-site calibration.

The wafer-mount sensors are optionally available with IEC Ex hazardous approval:

Ex ia IIB T4, Ex iaD A20 IP65 T135 °C (–20 °C Ta <125 °C).

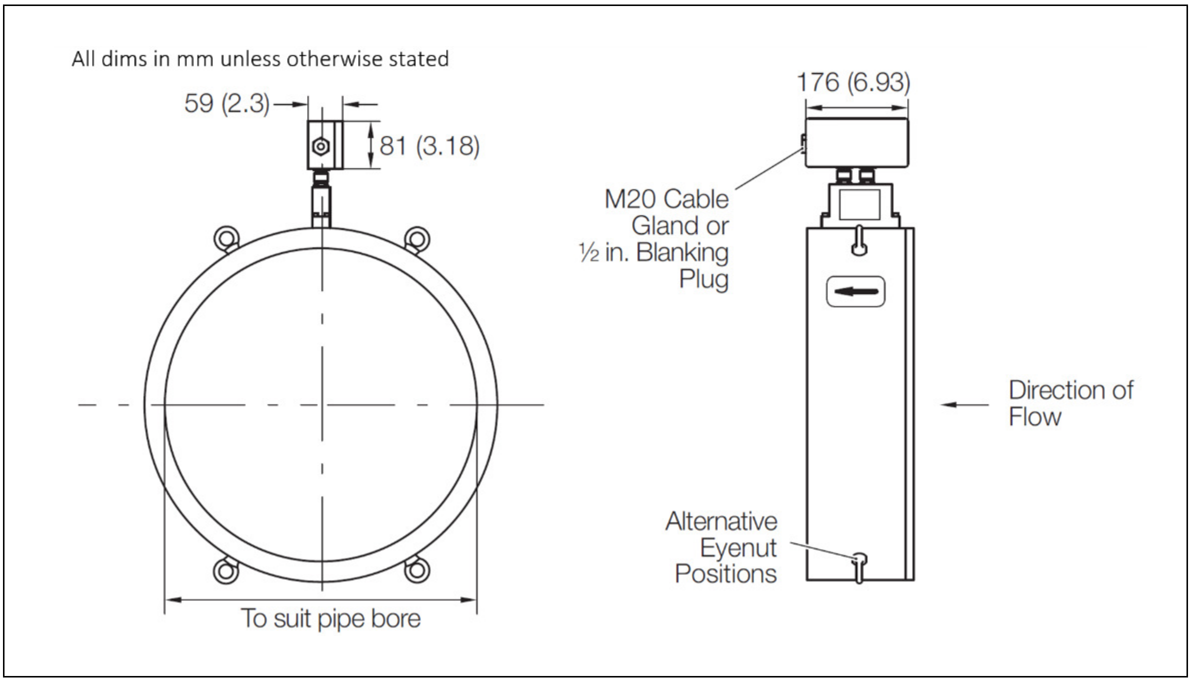


Figure 2- Typical dimensional information for sensor and sensor electronics

1.3 Sensor (Velocity Type)

The velocity sensor is designed to be installed on the outer edge of larger diameter pipes such as mill outlets. It is constructed from carbon steel with small strip electrodes located on its surface. The inner surface of the sensor is manufactured to have the same radius as the inside of the pipe. It is flange-mounted using a DN100 PN16 flange and is bolted from the outside onto a suitable pipe boss that facilitates installation and service.

As part of the CFMS, these sensors provide accurate velocity indication of the pulverized fuel flowing in proximity of the velocity sensor. This type of sensor is more sensitive to asymmetric flow profiles and roping than the wafer style of sensor and, as a consequence, this sensor is not suitable for accurate mass measurement.

- It is important that the sensing surface is flush with the inside of the pipe.
- It is important to align the sensing elements in the required direction of flow.

2 Sensor Electronics

Sensor electronics enclosure is designed to EEx ib e (CENELEC & FM) hazardous environment safety standards.

2.1 Integral Type

The sensor electronics are designed to be fitted to the sensor (see figure 12) or locally remote (see figure 13) and are powered from the signal processing unit. Power and signalling between sensor and sensor electronics is via two, 'N-type' connectors and a single, low-voltage multi-core cable to the signal processor. The sensor electronics enclosure is rated to IP65/NEMA 4, –20°C to 70°C (–4°F to 158°F).

2.2 Remote Type

Sensor electronics are designed to be fitted remote from the sensor and connected by a cable up to 3 m (10 ft) (supplied) to the sensor using a MIL-type connector. The sensor electronics enclosure is rated to IP65/NEMA 4, –20°C to 70°C (–4°F to 158°F).

3 Mechanical Installation

3.1 Packing

Packing case 1:	Internal sizes H2000mm x W1420mm x D650mm with removable front (2000mm x1420mm) and top.
Packing case 2:	Internal size, H700mm x W700mm x L6200mm with removable top (6200mm x 700mm) for packing Sensors, peripherals and sensor electronics.

Cases are fully lined and compliant to ISPM15 regulations.

3.2 Transportation

CFMS and peripherals are securely packed into the above crates and shipped via the appropriate land transport and sea freight.

3.3 Receiving

When receiving equipment, check crates for damage.

On site transportation, use the forks of a forklift in the middle of the 1420mm length for CFMS case and 6200mm length for the peripheral case.

Carefully match the actual quantities within each crate, with the amounts shown on the packing list.

It is important to see if there is any damage or shifting of the load. Make note of any discrepancies and / or damage on the truckers bill of lading or damage report form and immediately inform the manufacturer.

3.4 Unloading

The CFMS should be unloaded using a boom truck or crane with the lifting lugs provided.

Approximate weight of equipment:

Cabinent Case	150 Kg
Peripheral Case	Varies with pipe diameter, see contract specific documentation

3.5 Sensors

3.5.1 Location

Ideally, locate the sensor in a pipeline with a straight section of at least five times the pipeline diameter upstream of the sensor and one times the diameter downstream, see Figure 4. The upstream straight length must be increased if severe flow disturbances exist upstream of the sensor. Do not locate the sensor near to components that cause flow disturbances such as flow splitters and cones.

For correct indication of PF distribution, all sections of pipeline upstream of each sensor must be either unlined or lined and have the same hydraulic conditions. This ensures that, ideally, the PF sensors are located the same physical distance away from the hydraulic disturbances such as bends, bifurcators or trifurcators.

⚠ If an identical distance cannot be achieved, contact Greenbank for information

Due to gravitational effects on PF flow, that can lead to unstable PF flow in horizontal pipelines. Ideally, install the PF sensors in vertical pipelines.

This procedure should be applied on each mill independently, and all pipes of any particular mill must be considered.

3.5.2 Points for Consideration for all locations

Thoughtful consideration should be given to:

- Locations that would avoid direct impact of coal onto the rings of the CFMS sensor, which would adversely effects the measurement and degrades the life of the sensor. A venturi and intrusions into the pipe upstream of a sensor location can cause this effect and should be avoided also.
- Locations that allow steady state flow past the sensor location are important, as the velocity measured is the solids velocity in the direction of the sensor and local pipework (Given from time of flight of solids past two rings of exact known distance).
- The CFMS sensors for any particular mill should ALL be as close as possible in distance pneumatically from the previous upstream bend and all in the same orientation.
- Locations away from the mill should be selected, as installation near milling plant could possibly conflict with maintenance and access to milling plant and classifiers.

3.5.3 Operating Limitations

⚠ Do not exceed the following operating limits for the sensor:
Minimum process 0°C (32°F) temperature
Maximum process 150°C (302 °F) (Non Ex) temperature 125 °C (257 °F) (Ex)
Minimum process 0 bar gauge (0 psi) pressure

Maximum process 16 bar gauge (232 psi) pressure Maximum temperature 105 °C (221 °F) at sensor connector Maximum ambient 70 °C (158 °F) temperature

3.5.4 Installation Direction and Location

Install the sensor with the flow arrow on the sensor body pointing in the direction of the PF flow, see Figure 3.

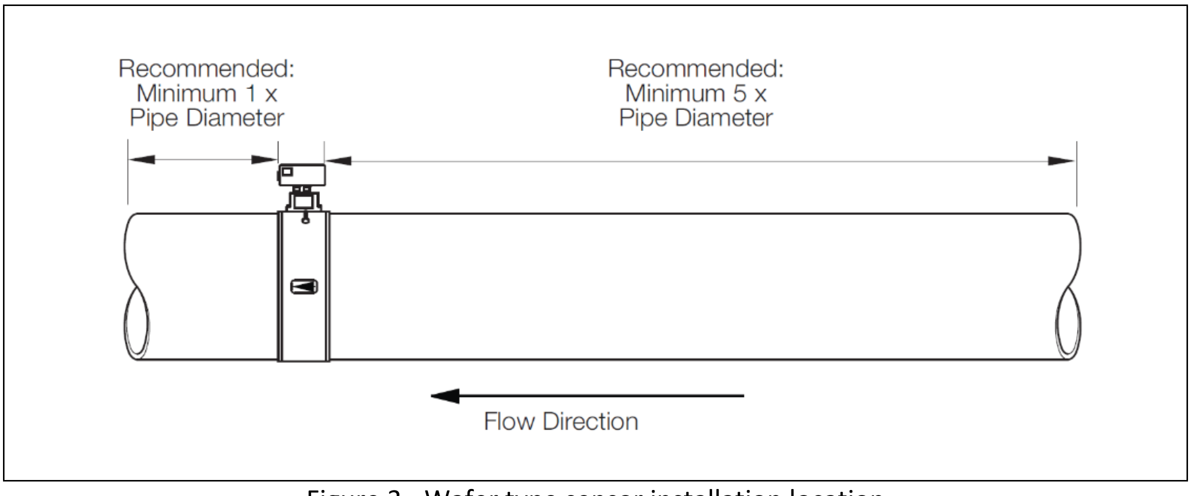


Figure 3 - Wafer type sensor installation location

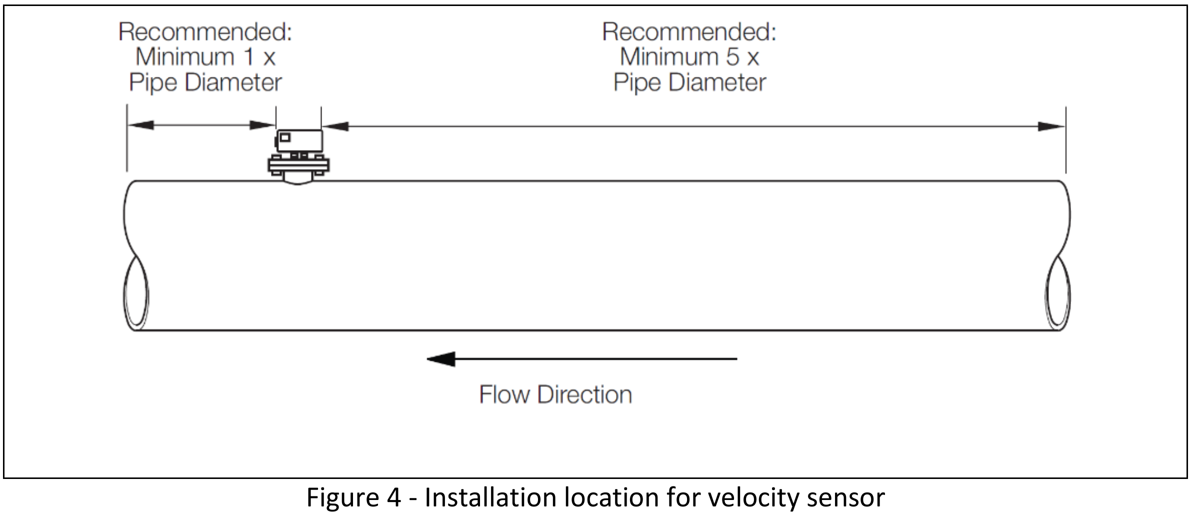


Figure 4 - Installation location for velocity sensor

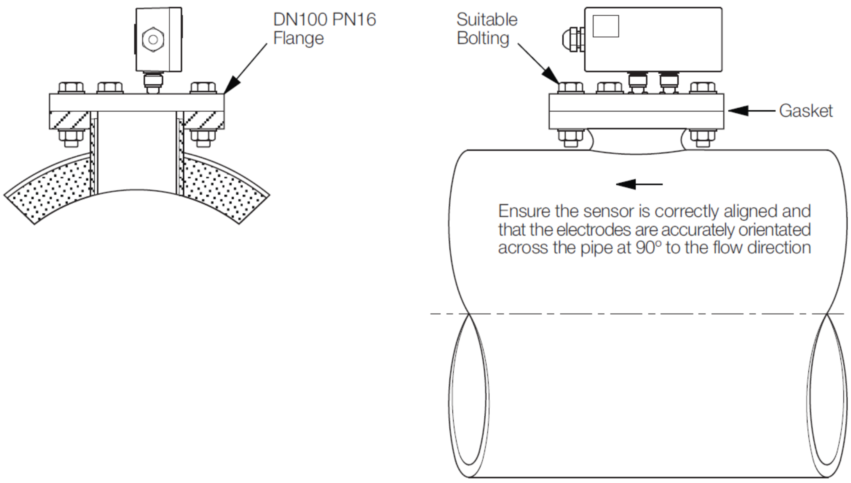


Figure 5- PF Velocity sensor installation configurations

3.6 Vertical installation

3.6.1 Procedure for sensor location selection

1. Preference should be given to location of all sensors in the vertical to avoid coal deposition.

2. All CFMS sensors should be installed preferentially in the vertical at the same pneumatic location from the upstream bend. This is more important than the requirement for continued access following commissioning, as sensors have demonstrated 7 years with no signs of wear and do not require routine access for maintenance. Sensor electronics can be supplied with a 2m push fit lead to the sensor to allow access to cabling, connections and electronics.

3. The distance should be known from the end of the upstream bend to the proposed sensor location using a common reference point, such as the closest flange.

4. The vertical pipes of the mill under survey should be studied to find common vertical sections with no intrusions between the upstream bend and the intended location such as a venturi, probe, non-return valve or other.

5. A manual PF sampling port that is flush with the inside of the pipe can be ignored as a permanent intrusion, although this may affect the meter for a short period when inserting a sampling device.

6. Intrusions or bends greater than 1 diameter downstream will have no impact on the CFMS relative mass, although consideration should be given to the laminar flow of the PF for the velocity measurement which will be the solids velocity in the direction of the sensor.

7. Given the above considerations, the shortest section of vertical pipe X suitable for the CFMS shall be used to determine the locations of all other sensors intended for that mill. The ideal location would be a common pneumatic distance from the end of the bend at typically 75 % of X for all sensors of that mill for X > 5 D (Diameters).

3.6.2 Table giving sensor locations

Shortest distance on vertical in diameters of pipework	Recommended distance for all sensors of that mill from end of upstream bend to nearest flange
< 3 D	In centre of pipe. Other sensors at same distance from end of bend.
~ 5D	3D all sensors
~ 7D	5D all sensors
> 9D	Common distance for all sensors > 5D from upstream bend.

3.6.3 Procedure for vertical installation with offset sensors

If the above procedure is not possible due to pipe clearances, with pipes being close together and/or flanges from neighbouring sensors fouling, then the sensors should be staggered by the height of the sensor body. Again keeping the pneumatic distance for all sensors as close as possible to the optimum locations advised in the table above.

3.6.4 Installation examples

Figure 5 – Examples of vertical installations, *left* Sensors at same pneumatic distance from upstream bends in vertical, *Right*, 3 way splits just before burners only allowing very short sections of pipework. *Right*, remote sensor electronics box used for ease of installation.

3.7 Horizontal Installation

3.7.1 Procedure for sensor location selection

Many stations have pipe work layout where there is no possibility of having PF sensors on the vertical pipework feeding the burners. In such applications, the sensors should all be installed 3 Diameters from the upstream bend. It is important to be close to the beginning of the horizontal stretch of pipework to ensure all PF transport is in air suspension.

> It is unacceptable to have sensors installed in the centre of long horizontal sections of pipework as this can result in PF fuel deposition which could increase wear of the sensor and also bias the result.

3.7.2 Application example

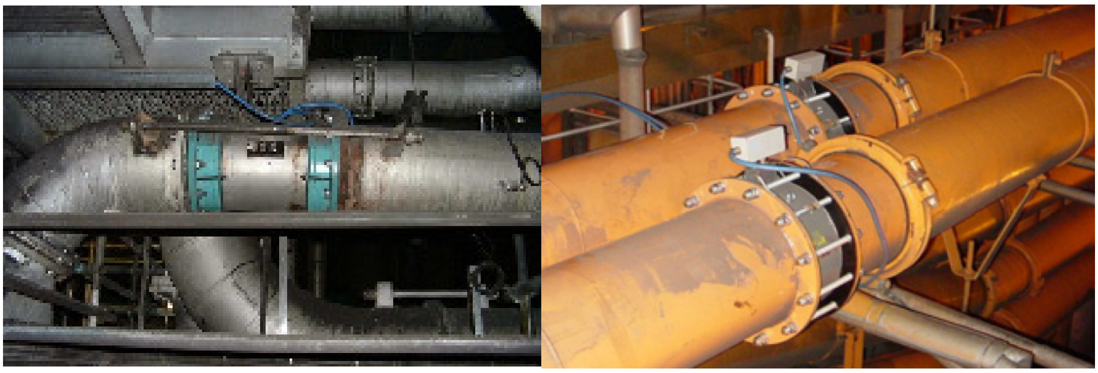


Figure 6 - Sensor for T-fired boiler at beginning of horizontal run to ensure minimal effects from coal deposition. No available horizontal sections of pipe on this boiler configuration.

3.7.3 Earthing Straps

Braided Steel Straps (two per sensor) are supplied with the Wafer Mounting sensor and must be used to bond each end of the sensor to the pipeline.

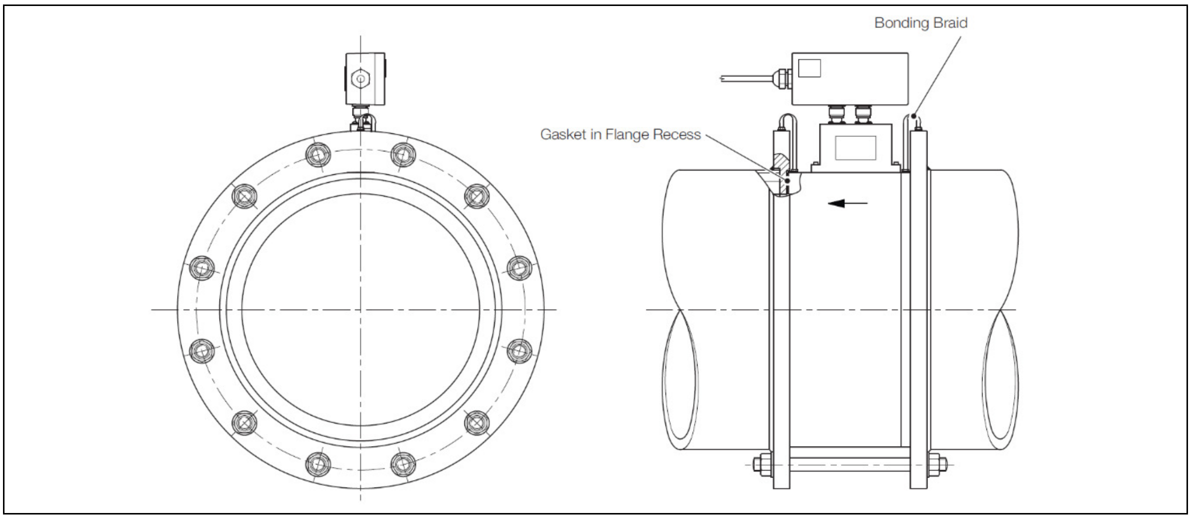


Figure 6- Position and installation of bonding braids.

4 Sensor Electronics

4.1 Environmental Limitations

Do not exceed the following operating limits for the sensor:
Minimum process 0°C (32°F) temperature
Maximum process 150°C (302 °F) (Non Ex) temperature 125 °C (257 °F) (Ex)
Minimum process 0 bar gauge (0 psi) pressure
Maximum process 16 bar gauge (232 psi) pressure
Maximum temperature 105 °C (221 °F) at sensor connector
Maximum ambient 70 °C (158 °F) temperature

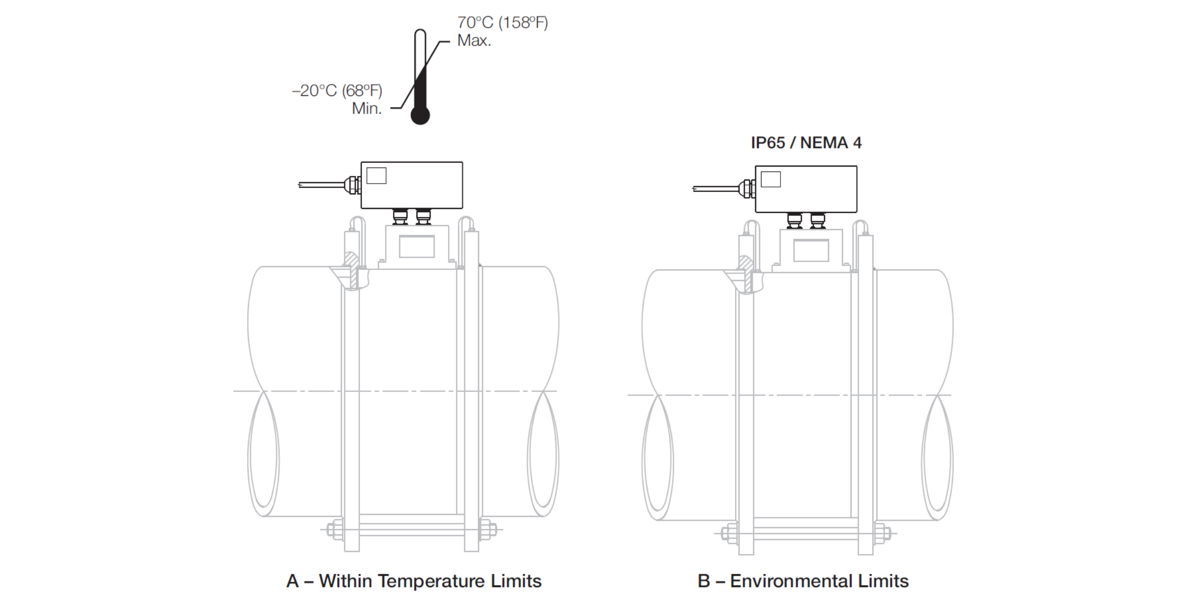


Figure 7 - Temperature and environmental limits of the sensor electronics

5 Enclosure mounting (up to 64 sensors)

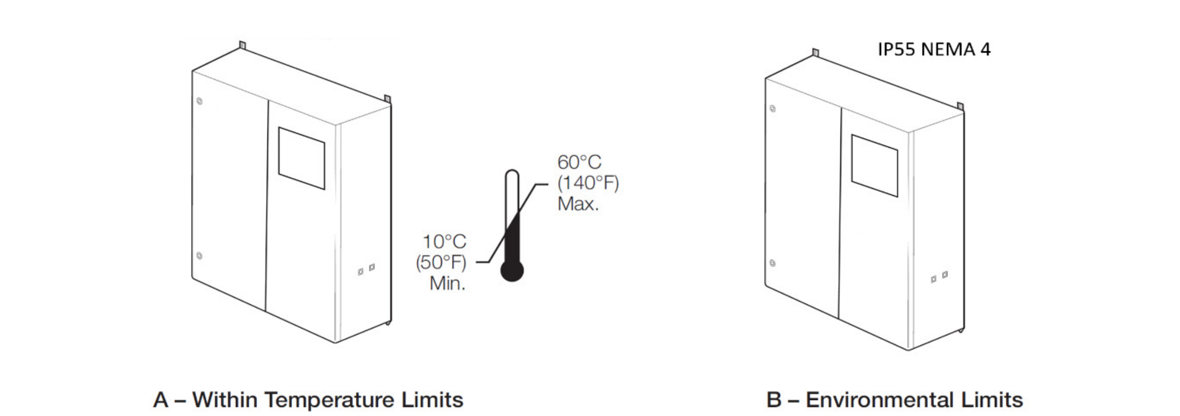


Figure 8 – Temperature and environment limits of the PF Signal processing enclosure

⚠ Failure to seal the USB and Ethernet connections with the covers supplied, invalidates the IP rating of the enclosure.

The Cabinet is floor mounted however, wall mounting brackets are an optional extra.

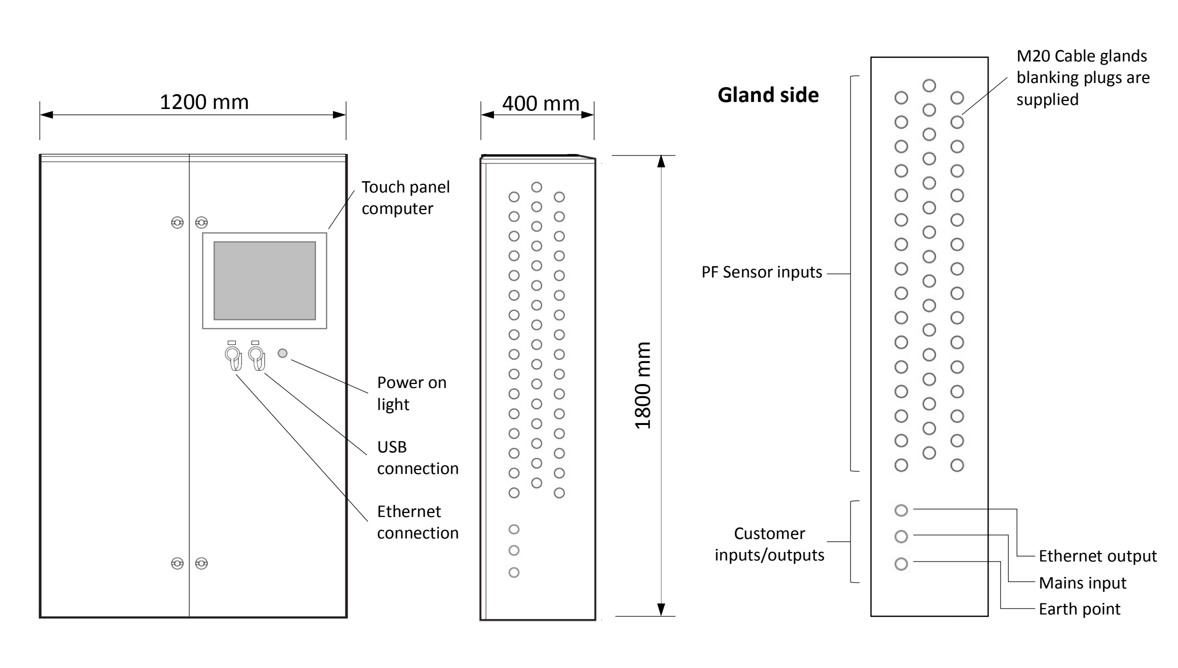


Figure 9- Enclosure unit dimensions and cable gland details.

If you need to clean the unit use a soft, non-metallic brush. The outside of the cabinet can be cleaned using a mild 10% soap and water mix. Ensure the unit is dry before returning to service.

6 Electrical Connections

6.1 Grounding

⚠ Failure to earth the unit can cause physical injury, death, increased electromagnetic interference and equipment malfunction.

- Ground the cabinet and sensor bodies to ensure personnel safety in all circumstances, and to reduce electromagnetic emission and interference.
- Details of sensor grounding can be found in section Earthing Straps.
- Make sure that grounding conductors are adequately sized as required by safety regulations and should never be below 1.5mm² CSA

6.2 Integral Mount Electronics Unit

⚠ Turn the connectors simultaneously and evenly to prevent damage to the sensor and electronics unit.

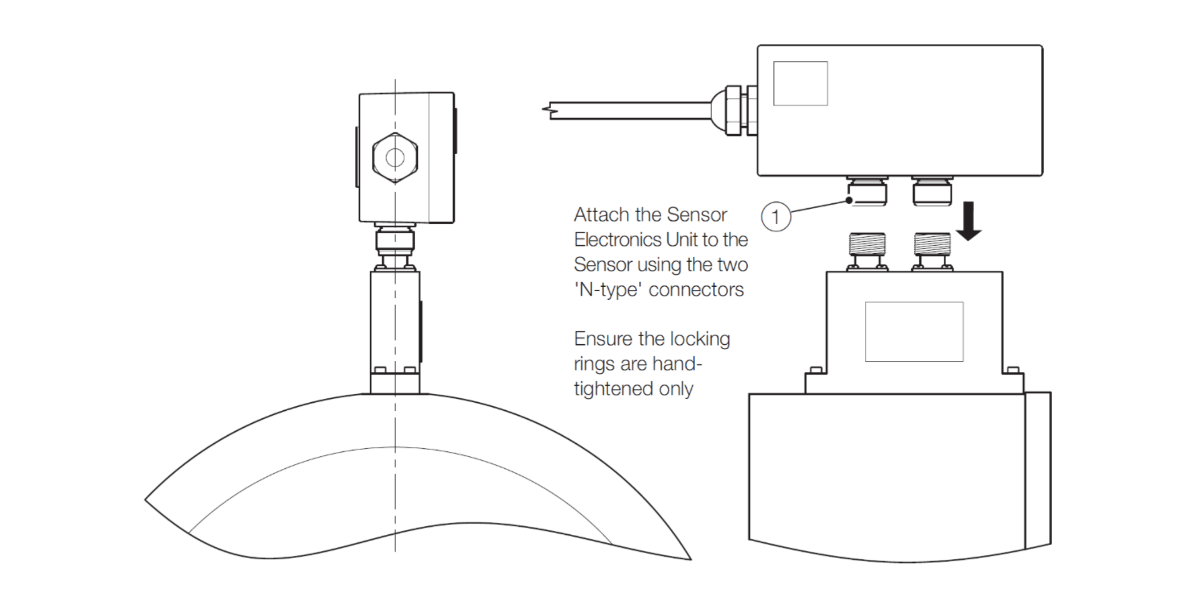


Figure 10- Integral Mount Electronics Box

6.3 Remote Mount Electronics Unit

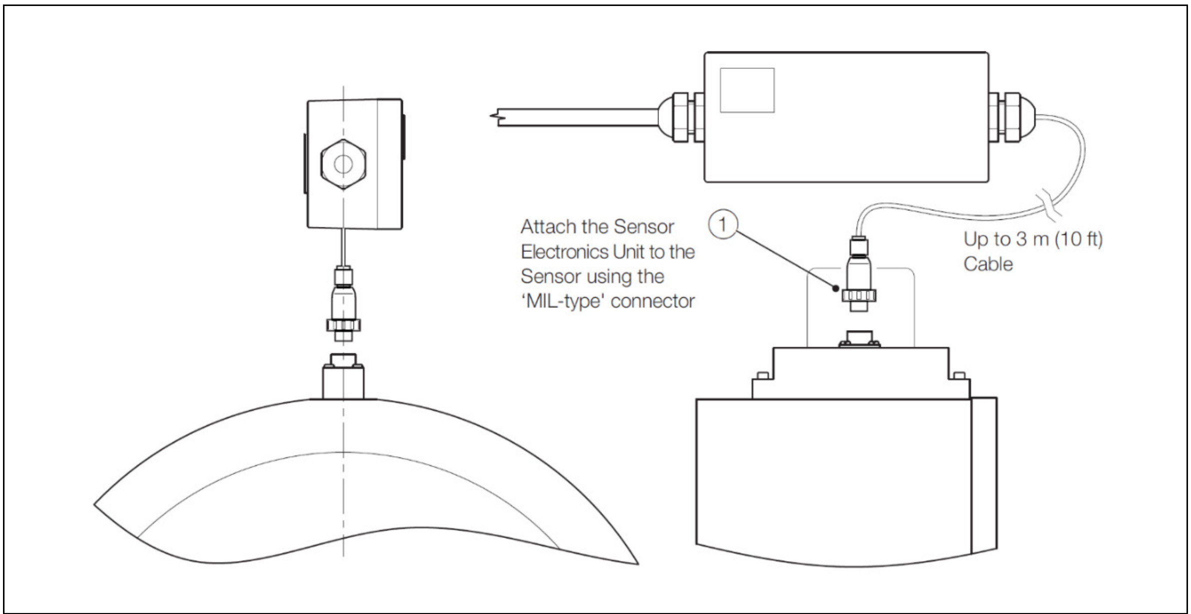


Figure 11- Remote mount Electronics Box

6.4 Sensor Electronics Unit and Signal Processing Unit connections

6.4.1 Cable Spec:

> ⚠ BS5308 0.75mm^2 , 5 Twisted Pair, Type 2 Part 1 CAM PVC, For cable between Sensors and Enclosure unit

Ideally screened cable direct between electronics boxes and CFMS cabinet will allow for best connections of the low voltage signals of the CFMS sensors.

The core CSA is sufficient to allow the 12V DC supply from the cabinet to reach all sensors allowing for voltage drop of no more than 3% across the circuit. Ideal to have a spare twisted pair in case of a fault with a core.

> ⚠ Maximum cable length is 50m
> Number of sensors to be evenly distributed over banks 1-8
> All junction box cable cores should be clearly tagged and labelled
> If a number of cores are found to be faulty then the multi-core cable should be replaced
> Point to point testing should be performed by the electrical contractor and all cores tested properly.

Additionally, the commissioning engineer can check the cabling integrity by following one of the procedures below at steady mill loading, although this requires the design and layout of the cabling to allow such tests to be performed. Best practice is to utilise the remote sensors with the 2m flying leads and position the electronics box such that the flying lead can stretch to the adjacent sensor.

- Adjacent sensor electronics should be cabled that facilitates swapping of sensors through adjacent cabling. For example sensor 1 input through cabling / electronics box 2 and sensor 2 input through cabling / electronics box 1.
- This swapping can easily done for testing on commissioning utilising the remote sensor electronics design with 2 metre flying lead and push fit connector to the sensor. The remote sensors should be positioned to allow the flying lead to stretch to the adjacent sensor if at all possible.
- The commissioning engineer can check the signals for each individual sensor or suspect low signals from certain sensors by removing each of the connections A+, A-, B+, B- in turn for that sensor and checking the signal level

Although this allows the commissioning engineer to view the trend and check signal integrity of meters with suspect signals, it is the responsibility of the electrical contractor to lay cabling professionally that is suitable for low voltage signals on a power station.

Connect a multi-core screened cable (obtainable from Greenbank Group UK) to the sensor electronics output terminals, see figure 12.

Connect the other end of the cable to the terminals of the appropriate sensor input module In the signal processing unit enclosure, see Figure 13.

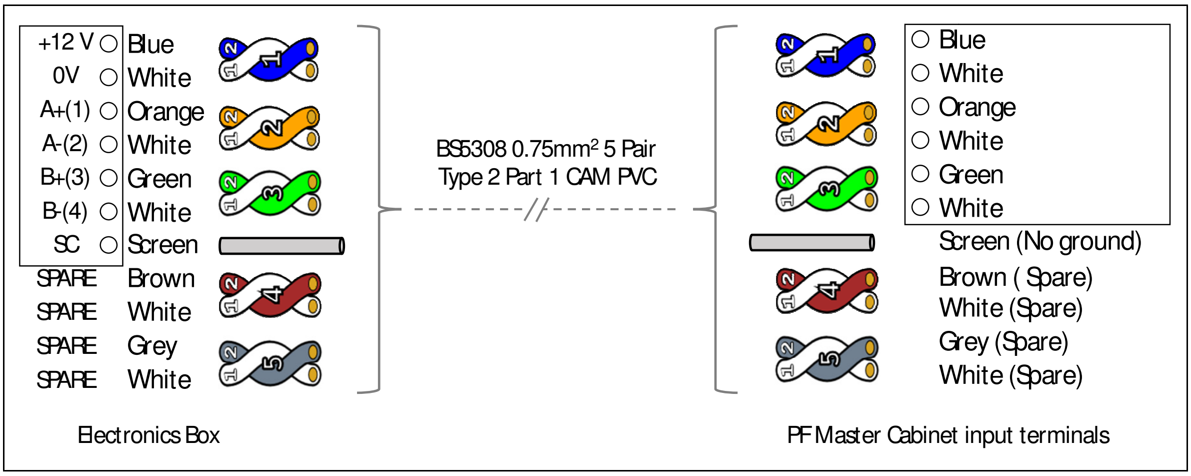


Figure 12- CFMS Sensor Connection to the Enclosure Unit.

⚠

Maintain each twisted pair of wires up to the terminal block.
Maintain shielding up to the terminal blocks
Ensure that the correct terminals are linked by the correct wires.
Ensure all cable gland seals re tightened correctly.
Ensure all unused cable entry glands are sealed.
Ensure all spare cabling is properly insulated.

6.5 Signal Enclosure Unit Layout

⚠ Number of sensors to be evenly distributed over banks 1-8

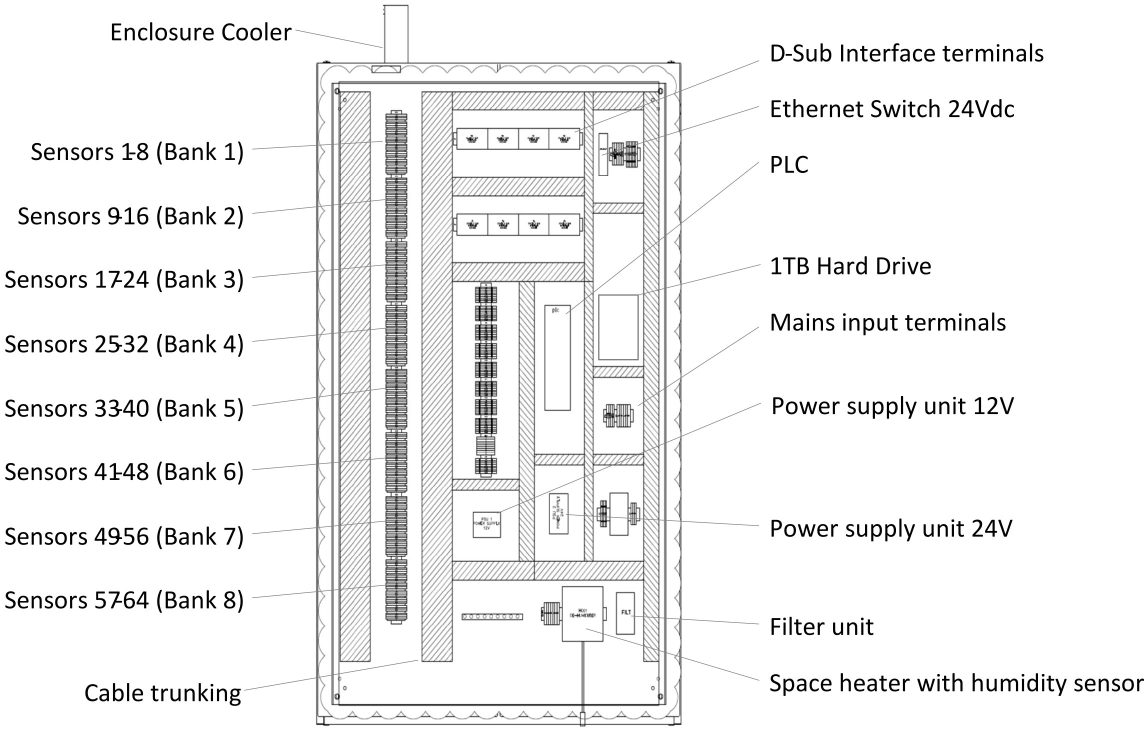


Figure 13 - Signal Enclosure Unit Panel Layout

Power supply requirements: 110 V AC 50-60 Hz 3 VA

Figure 14 – Mains input terminals.

Connect a power supply to the mains input terminals, see figure 13. Attach the earth (ground) cable to the mains earthing (grounding terminal).

6.6 System Outputs

The system can be supplied equipped with either a digital output connection in the form of an OPC Ethernet socket or a MODBUS TCP connection.

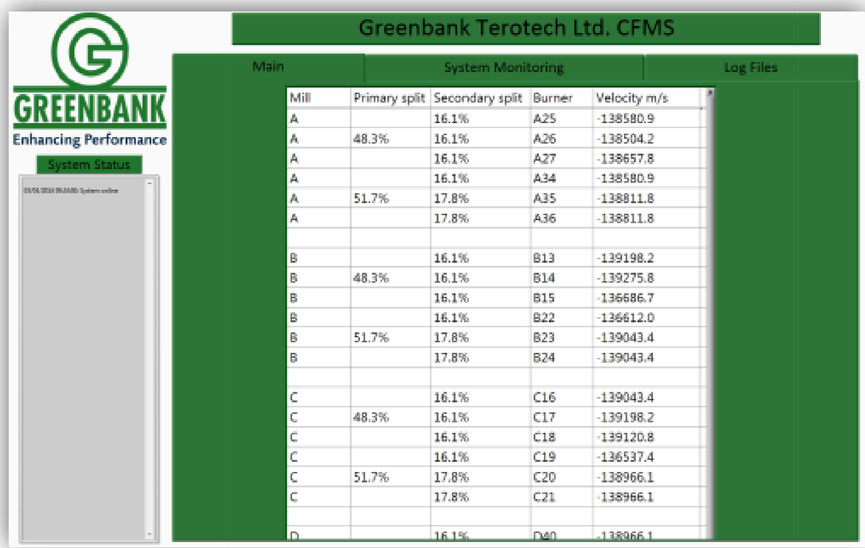
6.7 Fuse ratings

EQUIPMENT	TERMINAL REF	SIZE SELECTED In	FUSE TYPE
Spare	FT1-1	-	FA
Spare	FT1-2	-	FA
5v PSU	FT1-3	0.4	FA
24V PSU	FT1-4	1.6	FA
Sensor bank 1	FT2-1	0.125	FA
Sensor bank 2	FT2-2	0.125	FA
Sensor bank 3	FT2-3	0.125	FA
Sensor bank 4	FT2-4	0.125	FA
Sensor bank 5	FT2-5	0.125	FA
Sensor bank 6	FT2-6	0.125	FA
Sensor bank 7	FT2-7	0.125	FA
Sensor bank 8	FT2-8	0.125	FA
Lamp	FT3-1	0.4	FA
Switch	FT3-2	0.25	FA
HMI	FT3-3	2.5	FA
PLC	FT3-4	3.15	FA
Spare	FT3-5	-	FA
Spare	FT3-6	-	FA

7 Operation

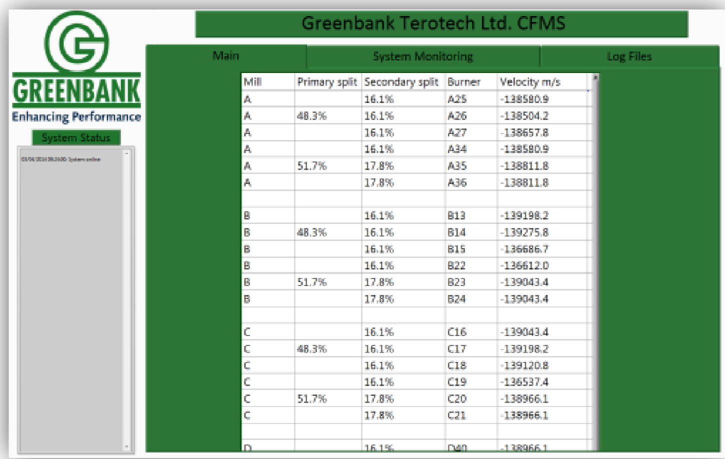
With power available the CFMS system should automatically activate. The unit can be controlled further using the touch screen. The following section describes the use of these screens.

7.1 System Status



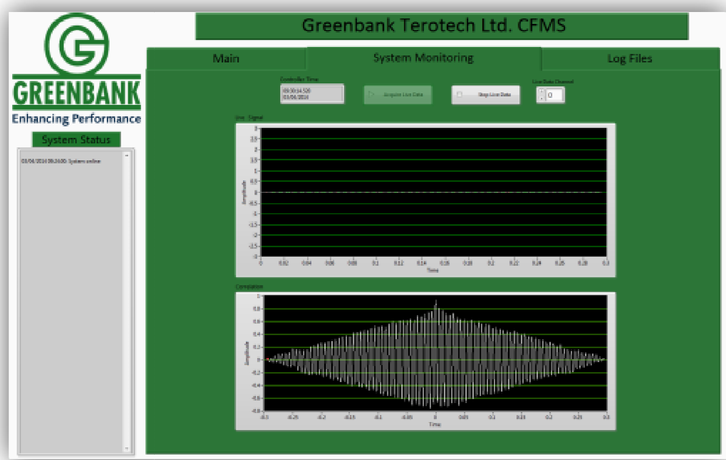
The status box can be seen on the left hand side of the screenshot above. It will display messages generated by the controller, these include system status updates, error codes and action confirmations.

7.2 Main



The Main display tab is the default page shown when the machine initialises. It displays primary and secondary splits as a percentage of total mass indexed by mill and burner designation. In Addition it displays the solids velocity in each line.

7.3 System monitoring



The system monitoring page is used to monitor the quality of the live data monitored by the system; it consists of the following components.

7.3.1 Controller Time

This displays the value of the UTC clock on the main controller.

7.3.2 Acquire live Data

This button activates a live data feed from the controller, this will display a live signal from the controller and is primarily used to verify correct connection of the sensor and sensor electronics. The channel displayed can be altered using the "live data channel" control and terminated using the "stop live Data" control.

7.3.3 Stop live Data

This key cancels the live data feed from the controller.

7.3.4 Live data channel

This control alters the channel the live signal and correlation displays are indicative of.

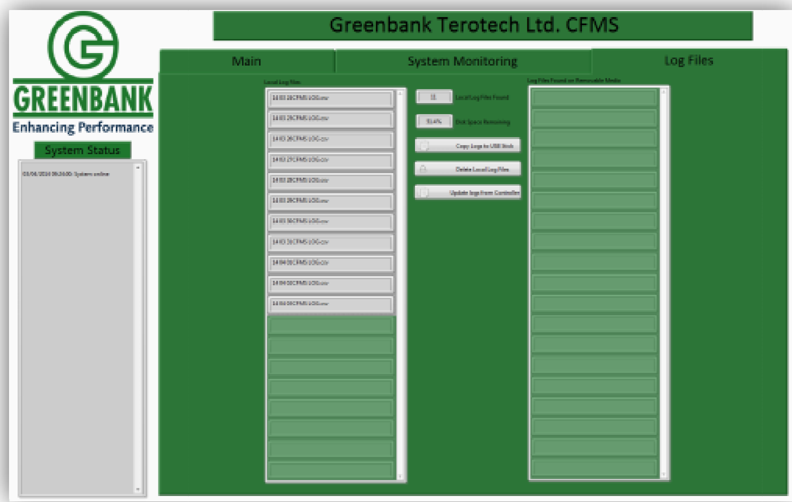
7.3.5 Live signal

This indicator displays the live signal from one of the data channels as it appears at the cabinet.

7.3.6 Correlation

This displays the cross correlation graph between the two inputs of a sensor.

7.4 Log files



7.4.1 Local log files

This Indicator displays the filenames of all log files present on the system storage drive.

7.4.2 Local log files found

This indicator displays the number of log files present on the system storage drive.

7.4.3 Disk space remaining

This indicator displays the % disk space remaining on the system storage drive.

7.4.4 Copy logs to USB stick

Activating this control will copy the files on the local storage drive to a USB stick connected to the USB port on the front of the cabinet. It does not automatically delete the files from the system storage drive after transfer.

7.4.5 Delete local Log files

Activating this control will delete the log files on the system storage drive. The present day's logs will still be retained on the controller.

7.4.6 Update logs from the controller

Activating this control will copy any log files including a current version of the current days file from the controller to the system storage device. This can be used to allow the current day's data to the transferred to the USB stick.

7.4.7 Log files found on removable media

This displays a list of the log files found on any inserted removable media.

8 Commissioning checks

Following wiring carried out by station (or station contractors), commissioning is carried out by Greenbank Engineers.

1) Sensors will be checked that all the signals are present and correct
2) All Modbus or OPC outputs are checked to see they can be read by the station
3) Software is tested to make sure all the functions work
4) Wiring integrity is checked
5) Sensors are verified to make sure they are correctly assigned.

9 System Data Sheet

Sensor

Size Range:
Variable ID. (Contact GBUK for Info.)
Weight (Contact GBUK for Info.)
Spool Piece:
Stainless steel, compact design
Epoxy coated carbon steel body
Stainless steel electrodes
Mounting:
Wafer Type—between adapter flanges
Process Temperature:
-20°C to 180°C (-4°F to 356°F)
Pressure Rating:
16 bar
Environmental:
IP65 / NEMA 4X
Measurements:
Burner PF split
Relative PF loading (concentration)
Accuracy:
Velocity and Concentration +/- 5 % upon calibration on OEM rig.

Sensor Electronics

Supply:
Up to 5V, powered from signal processor
Ambient:
-20°C to 70°C (-4°F to 158°F)
Environmental:
IP65 / NEMA 4X
Cabling:
Instrument Cable 5 pair 0.75mm^2 (20/0.2mm), BS5308 Type 2, Part 1 CAM PVC
Sensor distance <50m
Approvals:
Incorporates Zener barrier

Signal Processor

Display:
15" Touchscreen Computer
Sensor Input Channels:
1 to 64 channel processor
Velocity Range:
0.3 to 60 m/s
Outputs:
Output - OPC Server Client using Ethernet
or
MODBUS TCP
Alarms:
Programmable high/low points for velocity & split (on screen only).
System Response Time:
<1.5s – suitable for continuous on-line PF flow control
Logging:
Velocity, split, concentration with programmable logging intervals.
File format – Comma delimited (*.csv)
Temperature:
10°C to 60°C (50°F to 140°F)
Environmental:
Cabinet IP55 rated
Power:
110 V A.C 50 - 60Hz
Remote Support:
Modem supplied as standard. Requires an external direct dial telephone connection.
Cabinet Dimensions:
(H) 1800 mm x (W) 1200 mm x (D) 400 mm
Packing:
Packed and protected, suitable for shipment in wooden crates.
Desiccant will be used where necessary

10 Products and customer support

Materials: Cast Basalt, Alumina, Zalcon
Ni-Hard and High Chrome Steel- *Abrasion Resistant Lined Pipework Chutes and Hoppers*
Silicon Carbide - *Abrasion Resistant Lined Pipework*
Performance Steels- *Abrasion Resistant Lined Chutes and Hoppers*
HDPE and MDPE - *Pipework, Chutes and Hoppers*
Anti-Degradation Compounds – *for low to med wear resistance applications.*
Ceramite – *for medium wear resistance applications.*

Applications:

Acid Resistant Products and Cement
Pulverised fuel Pipework and Ancillary Equipment
Flow Dividing Riffles and Splitters
Ash Pipework and Ash Systems
Hoppers, Chutes and Fabrications
Automated Ashing and Handling Systems
Dense Phase Conveying Systems
Dampers and Valves
Mill Classifiers and Exhausters
Specialised Engineering and Lining Services
Heavy Industrial Fabrication

Equipment/Systems:

Material Handling Systems
G-CAM® – Lean Carbon-in-Ash Online Monitor
H-CAM® – Dense Carbon-in Ash Online Monitor
MillMaster® - Conveyed Particle Size Analysers
GA200™ – Acoustic Boiler Steam Leak Detection System

Customer Support

We provide a comprehensive after sales service.

Contact our office for details.

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Hartshorne Road, Derbyshire, UK,
DE11 7GT.
Tel: +44 (0)845 0707 097
Fax: +44 (0)870 0707 098
info@greenbankgroup.com

Client Warranty

Prior to installation, the equipment referred to in this manual must be stored in a clean, dry environment. Periodic checks must be made on the equipment's condition. In the event of a failure under warranty, the following documentation must be provided as substantiation:

1. A listing evidencing process operation and alarm logs at time of failure.

2. Copies of operating and maintenance records relating to the alleged faulty unit.

The Company’s policy is one of continuous product improvement and the right is reserved to modify the information contained herein without notice.