Big system

Continuous Loss-in-Weight Dosing System

USER'S MANUAL

Sysmetric Ltd
P.O.B. 1122 Afula Illit 18550
Israel
Tel: +972-4-6405857
Fax: +972-4-6405911
Email: info@sysmetric-ltd.com

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1. Introduction

The Graviman Continuous-Dosing Unit is used to keep track of raw-material flow using a loss-in-weight method. With this method, the rate of weight reduction in the weighing-bucket is consistently monitored.
It is possible to integrate a number of weigh modules with an 'Additive feeder gravimetric control' in order to realize a mixing / blending facility.

The weighing-bucket is filled automatically.

System Control is based on an OMRON CQM1H CPU51 industrial programmable logic controller and an OMRON NT11S user interface console.

An advanced method of controlling named '***Control Modeling Method'*** (as opposed to regular methods such as PID etc.) is employed by the Graviman in order to control the speed of each screw feeder in the system.

The '***Control Modeling Method'*** boasts many advantages: high accuracy, immunity to many kinds of disturbance, non-linear control and very good stability.

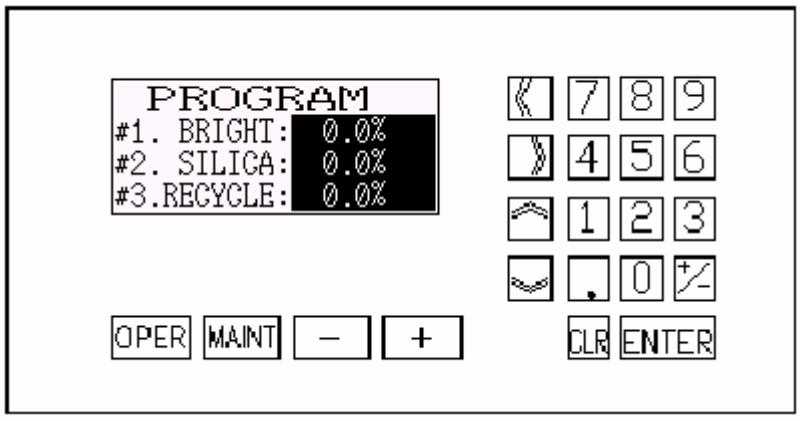
2. Console Description

Consists of a numpad, 4 directional arrow keys, 4 function keys and a 4X20 LCD display.

2.1 Description of the Function Keypad

LCD pages are selected using the 4 function keys:

- **OPER** key: For choosing between operating screens.
- **MAINT** key: Entering the maintenance mode and screens
- '+', '-' Keys: Scrolling between maintenance screens.



2.2 Typing in Data

In the various screens that will be explained later in the text, parameters have to be changed from time to time by the operating and maintenance personnel (i.e. Data such as dosage and throughput have to be changed according to the product). Data input is accomplished as follows:

i) The appropriate screen is called up using the function keys.

ii) The data to be changed is brought into focus using the arrow keys.

iii) New data is typed in using the numpad.

iv) Clicking <**ENTER>** accepts the changes.

Incorrect typing can be fixed using the <**CLR**> key. Data is not accepted until the <**ENTER**> key has been pressed. If the <**ENTER**> key is not pressed within 10 seconds of a data change, the editing action will be canceled and the data will revert to its old value.

3. Graviman Structure and Operation

3.1 Structure of the Continuous weigh-unit.

The Graviman Continuous weigh-unit constitutes the heart of the system It provides precise loss-in-weight information from the weighing-bucket to the PLC controller. The unit has been designed to protect the bucket from all kinds of disturbances.

The weigh-unit is made up of three main components:

1. Outer housing.
2. Pneumatic shutter.
3. Weighing-bucket with Load Cell.

- The housing protects the weighing process from being disturbed in any way. Two service hatches in the housing facilitate periodic checking and cleaning of the bucket.
- The shutter controls weighing-bucket filling.
- The unit continuously tracks the material flowing through the system.

3.2 Principals of operation.

At startup, the system controller (PLC) checks the amount of material in the weighing-bucket and fills it up as needed by opening the pneumatic shutter.
The weigh-unit provides the PLC with continuous weight readout.
During work, when the material weight in the weighing-bucket is reduced to a predetermined minimum level, the pneumatic shutter is opened and the bucket is refilled.
The PLC calculates throughput by using weight data and screw-feeder-RPM from the production machine.

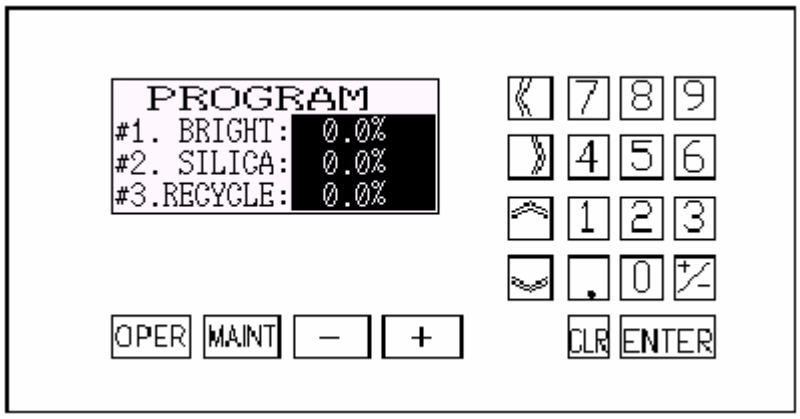
3.3 Principal of Operation.

The explanation in this manual and the screen illustrations accompanying it, refer to a continuous weigh system consisting of three combined Graviman units, channels 1-3. Screen attributes may change a little from system to system.

The **<OPER>** key selects the four operator screens:

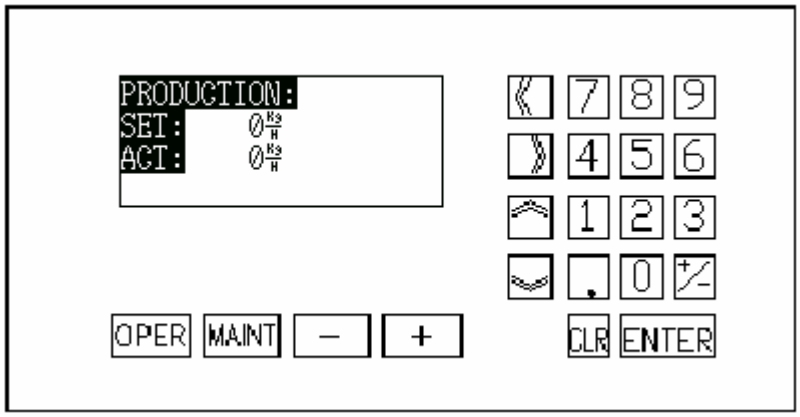
1. "PROGRAM" screen - changing material percentage.
2. "PRODUCTION" screen - Set the production rate.
3. "TOTAL" screen - Keeps track of material consumption in each channel
4. "SCRWES SPEED" screen - Display a percentage screw speed in each channel.

Press **<OPER>** once to display the PROGRAM screen:



Enter the desired percentage of the SILICA channel material (SCREW#2) and RECYCLE channel material (SCREW #3). The percentage of the BRIGHT material (SCREW#1) will adjust itself automatically to complement to 100.0%.

Press **<OPER>** again to display the PRODUCTION screen:

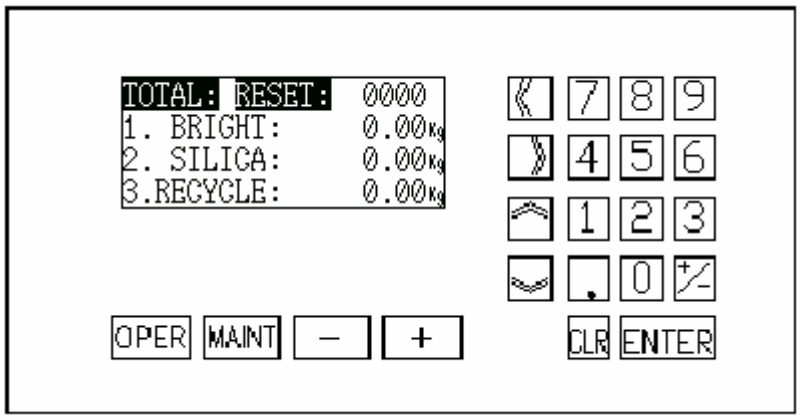


Enter here the desired production rate of the system. The ACT shows the actual capacity. Design the rate according to the lines needs to prevent too many starts and stops from the system. If for example the capacity of the line is 1000 Kg per hour, it is best to set the system to 1100 to 1200 Kg per hour. Now when the system will turn on, as the material level drops below the lower proximity switch, the system will work for a long period, reducing the inaccuracy caused by many starts and stops.

Please note that the actual capacity may vary from the SET value in two cases:

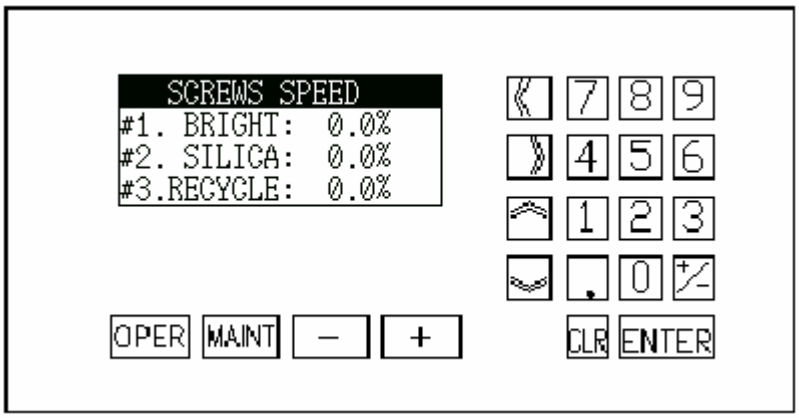
1. If one of the screws reaches the maximum limit, the whole system capacity will be reduced automatically so that the correct percentage of the materials will be maintained.
2. If the set capacity is too low for one of the screws, the whole system capacity will be increased automatically so that the slow screw will operate at its minimal speed maintaining a good bland.

Press **<OPER>** again to display the TOTAL screen:



Null the accumulated values by entering the RESET code 1234 <ENTER>.

Press **<OPER>** again to display the SCREWS SPEED screen:



Use this screen to check the limits of capacity for the system. Each screw can operate at the speed range of 2.0-100.0%. If a screw is operated close to the lower limit, it may be replaced by a smaller one and vice versa.

4. Maintenance and Servicing

The maintenance screen index numbers (at the top left hand corner) may differ from system to system. Take care to choose the appropriate screen when servicing each system in your plant.

4.1 Tuning the hopper sensors.

The sensors stop and start the feeder system in accordance with material level in the hopper.

These capacitive level sensors are connected to the PLC by their Normally Closed contact. This means that they activate the input to the PLC when the sensor isn't sensing material. The LED on the sensor's rear goes ON whenever the sensor detects material.

Sensor sensitivity is calibrated using the small screw on the rear. The screw is covered by a plastic cap, which should be removed first. Turn the screw clockwise to increase sensor sensitivity, and counter-clockwise to decrease sensitivity.

Note:

It is a common error to turn the cap instead of turning the calibration screw. This is because the cap has the shape of a screw itself. Be sure to remove the cap first.

4.1.1 Tuning procedure:

1. Make certain that the <MAIN> switch is on and the <SYSTEM> run\stop p.b lamp is off.
2. Make sure the sensor doesn't have any raw material in its vicinity.
3. Increase sensor sensitivity until the LED lights up and then slowly decrease sensitivity until it goes out again.
4. Decrease sensitivity by another half a turn.
5. Check the sensor, a light touch on the front should turn the LED on, remove your hand and the LED must go out.

4.2 Load-Cell calibration.

Load-cell calibration is performed in order to verify that the load-cell is operating properly and to make the weight reported by the unit identical to the actual weight of raw material in the bucket.

Calibration should be checked after replacement of a scale (weigh-unit) related component: - Load-cell, pneumatic pistons, pipes, amplifier ,PLC analog card or installation

It is recommended that a calibration be performed on a regular basis as scheduled by the customer. Calibration should be performed any time a weight reading is suspect.

Each weigh-unit must be calibrated separately.

During the calibration procedure, three tests are performed:

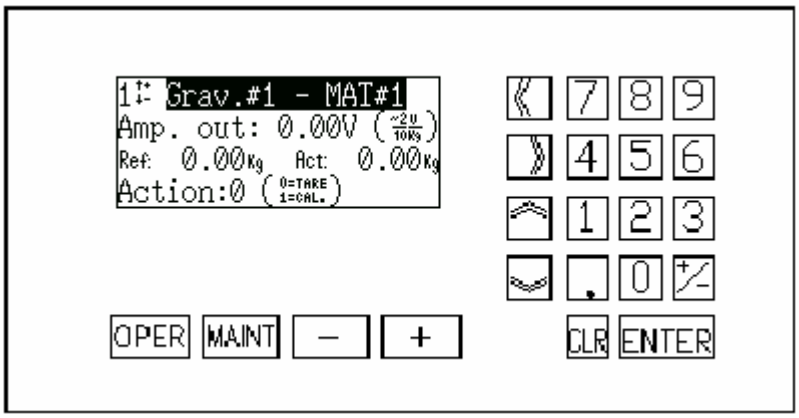
- Hysterasis Test: Ensures that there's no friction in the load-cell and weighing-bucket.
- Calibration Test: Ensures the correct ratio used by the unit to convert from the load-cell voltage output to the actual displayed weight.
- Linearity Test: Ensures the linearity of the load-cell.

There are two important considerations to be taken into account:

1. Each of these tests must be performed in order to ensure proper functioning of the unit.
2. There's no point in performing a test if the unit failed a previous test. For example, if the unit fails the hysterasis test then there's no point in performing the calibration test, because there's some friction (mechanical or otherwise) that is preventing the load-cell from working properly.

4.2.1 Calibration procedure.

1. Stop material loading to the channel #x, by the graviman selector switch to close.
2. Open the material drain slide gage to drain material from the bucket.
3. Click <**MAINT>** and enter the service code 4321<ENTER> the display switches over to the maintenance screens. Bring up the relevant channel screen by pressing the [+] or [-] keys.



- Voltage display - **Amp. Out: 0.00V** - displays the output voltage of the amplifier.
- "**Ref**" field – For entering the reference weight used in the calibration procedure.
- "**Act**" display - Shows the actual net weight.
- "**Action**" field - used to perform action-calibration and tare-compensation actions (see below).

4. When there's no load on the bucket, the voltage displayed should be 0.00±00.1V. If the display exceeds this tolerance, make sure the weighing-bucket is empty and has no forces exerted on it. When the bucket is free and empty perform the calibration procedure.
5. Hysterasis test: Gently press the weighing-bucket and release it. The value in "Act" should increase and then drop back to its original value. Allow a tolerance of 0.01 Kg. Gently pull the bucket up and let go of it, the value should drop momentarily below its original value, and then return (±0.01Kg).
6. A failure in the hysterasis test means the weighing-bucket is being obstructed in some way. Find and fix the problem.
7. Wait 10 seconds for the bucket to stabilize. Enter "0" in the "**Action:**" field and press **ENTER** so the unit can "learn" the weight of an empty bucket (Tare compensation). The "**Act:**" field should now display 0 (zero).
8. Calibration test: Enter "0" in the "**Action:**" field and press **ENTER** to counter any residual effects from the hysterasis check. Open the service door and place a reference weight inside on the special tray. The weight of the reference weight should be at least 4.00Kg . Make sure the "**Ref**:" value matches that of the reference weight or change the "Ref" value accordingly. The "Act" value should match that of the "Ref" value when the load-cell is calibrated (allow a tolerance of 0.01Kg). If the weight reported doesn't match that of the calibration weight, recalibrate.
9. Calibration: After performing steps 1 through 9, while the reference weight is on the tray, Enter "1" into the "ACTION" field and Press **ENTER**. The unit calibrates itself, and the "Act" value matches that of the "Ref" value within ±1g.
10. Linearity test: Place a weight of 4.00-10.00Kg on the tray. Make sure that the "Act" value matches that of the new weight. This can be repeated with additional reference weights to verify the whole range. If the range is not linear, the weigh-unit (bucket, load-cell or amplifier) must be checked and fixed.
11. Remove the calibration weight and special tray if used, Enter "0" in the "**Action:**" field and press **ENTER** .close the service door. Turn the selector switch back to Auto' position, start the <*SYSTEM*>.

Amplifying Card Adjustment

The amplifying card is factory-set to work with the system's load-cell. In the following cases the amplifying card should be adjusted in the field:

- Replacement of load-cell.
- Replacement of amplifying card (the new card should be adjusted).
- Difficulties in load-cell calibration.

The amplifying card is located inside the control cabinet.

The following procedure describes how to adjust the amplifying card to work with the load-cell:

1. Perform steps 5-9 of the calibration procedure (See 4.2.1, "calibration procedur"). The display should be in the calibration screen, and the bucket empty and closed.
2. The voltage display should be in the range of 0.00-0.02V. Adjust the voltage to 0.00-0.02V using the "Zero" potentiometer.
3. Open the service door and install calibration tray.
4. Put a weight of 4.00kg on the tray.
5. Using the "CAL" potentiometer, adjust the voltage in the voltage display to 0.8±0.01V. It shouldn't matter if the weight reported in the "Act" field differs from that of the weight on the tray - that will be fixed in the calibration procedure.
6. Perform the standard calibration procedure (See 4.2.1).

Note:

Amplifying card adjustment is no substitute for calibration. Always perform calibration after amplifying card adjustment, even if exact calibration is not needed.

4.3 Graviman, 'Modeling' method of control.

An advanced method of controlling named '***Control Modeling Method'*** (as opposed to regular methods such as PID etc.) is employed by the Graviman in order to control the speed of each screw feeder in the system.

The '***Control Modeling Method'*** boasts many advantages: high accuracy, immunity to many kinds of disturbance, non-linear control and very good stability.

During normal operation, the Graviman samples and 'learns' the angular throughput (throughput per rotation) for each screw feeder in the system. It uses this information to calculate the screw speeds needed to yield appropriate proportional throughputs.

The learning process is gradual. Relevant data is processed and selected using statistical algorithms.

Dedicated service screens allow adjustments and calibrations to be performed. Each channel has a number of maintenance and monitoring screens. 'Grav. #X' is the depiction of channel 'X' in the screens (replace 'X' with the true channel number).

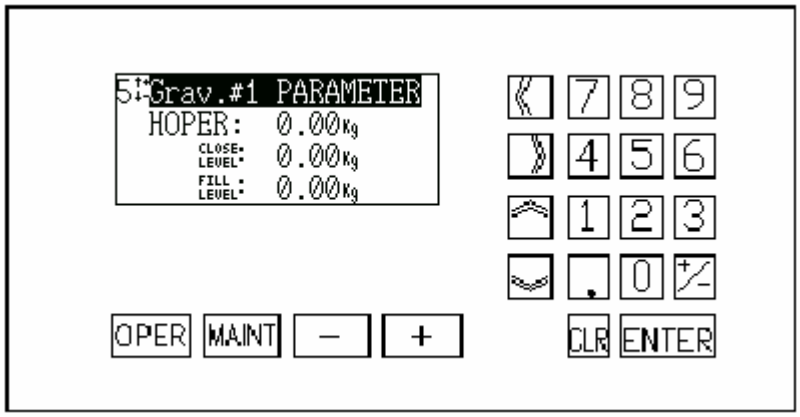
4.3.1 Filling the Graviman.

Material in the weighing-bucket is constantly decreased in relation to screw feeder throughput. The pneumatic shutter is automatically opened in order to refill the bucket every time material dwindles (10.00Kg). All calculations are suspended during the fill cycle because the measured weight doesn't reflect screw throughput.

During the critical fill cycle, the system controls the screw speed using previously accumulated data.

The data from the beginning of a fill cycle and the data from the end of a fill cycle should allow at least 30 seconds of uninterrupted operation between one fill cycle to the next.

Click <**MAINT>** and enter the service code 4321<ENTER> the display switches over to the maintenance screens. Press [+] and [-] to scroll to the relevant 'PARAMETER' screen:



HOPER: 0.00Kg - Continuous hopper (bucket) weight display (resolution = 10g).

CLOSE LEVEL - End of weighing-bucket fill cycle. Recommended value: 20.00-30.00Kg.

OPEN LEVEL - Start of fill cycle. Recommended value: 10.00Kg.

4.3.2 Calculation Thresholds.

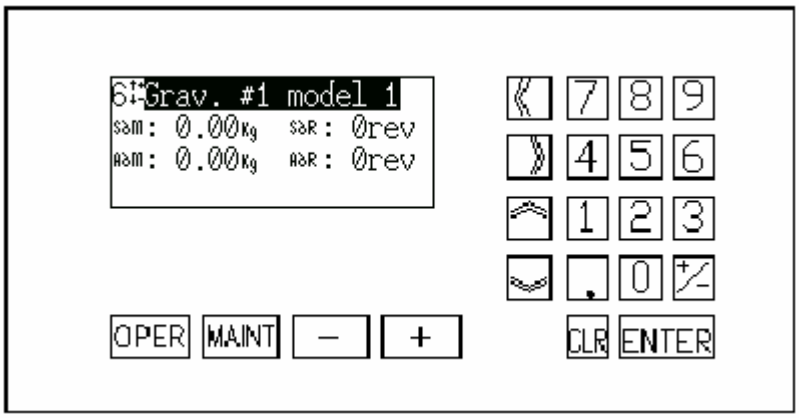
Screw throughput is not calculated continuously. A number of statistical tools assist in determining the 'sampling timing and rate' of material weight and screw revolutions needed to perform the calculation and build the control 'model'.

The machine operator can determine basic values that affect the timing of throughput calculation.

A fast rate of calculation will result in rapid assessments, but the outcome will be erratic owing to the nature of the process.
A slow rate of calculation will result in good average accuracy but will fall short on the learning rate of the system.

Correct tuning of the parameters will result in a calculation being performed every 3 to 10 seconds with a standard-deviation of about 2% (Standard-deviation results are displayed).

Click <**MAINT>** and enter the service code: 4321<ENTER> the display switches over to the maintenance screens. Press [+] and [-] to scroll to the 'MODEL 1' screen:



SdM: **S**et partial derivative of **M**ass, (loss in weight). Minimum-mass factor for calculations. Recommended value 1.00Kg.

SdR: **S**et partial **d**erivative of **R**evolutions, (a constant times screw revolutions). Sets minimum screw revolutions threshold for calculation. Recommended value 4 rev.

AdM; AdR: Actual derivative values calculated by the system.

The correct ratio of the two parameters (SdM; SdR) should result in actual values (AdM; AdR) just above the derived 'calculation' threshold. Adjust accordingly.

4.3.3 Control Modeling results.

1. General

Each calculation produces a result of dosing screw throughput (grams) per revolution.
The result is converted to a normalized percentage scale (Act) based on full-scale screw ratings.

2. Erroneous result:

Result (Act) is compared to minimum, maximum values (min, max).
This check allows disqualification of samples that occurred during disturbances. If the deviation continues for 3 consecutive samplings, a warning is issued: **Low/High throughput!**

3. Normal control output signal (c.e.) calculation:

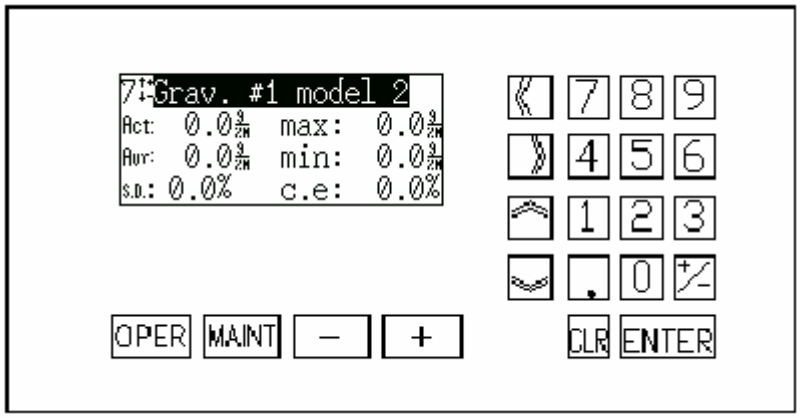
Good samples are analyzed statistically.

Average (Avr) and standard deviation (s.d.) results are used in further analysis.

The results are passed through a high order digital filter that screens out high frequencies and allows the system to adjust itself to rapidly fluctuating material flow conditions.

The digital filter is the final stage. The difference between filter output and the average of the last 10 results is the control output signal (known as the 'control error': c.e.).

Click <**MAINT>** and enter the service code: 4321<ENTER> the display switches over to the maintenance screens. Press [+] and [-] to scroll to the 'MODEL 2' screen:



Act: Last result screw throughput, in: Grams per 'percentage of full-scale screw speed'.

Avr: Average screw throughput of the last ten legitimate results, in: Grams per 'percentage of full-scale screw speed'.

s.d.%: Standard deviation of the last ten legitimate results.

c.e.: Control signal, should not exceed one standard deviation. Should the system digress occasionally, please consult 'Sysmetric'.

max: Typical maximum for a given screw and material. This value has to be learned: – Run the screw without interruption and collect some typical results, multiply by 2 and type onto the screen. Recommended value 800.0g/m.

min: Typical minimum for a given screw and material. This value has to be learned: – Run the screw without interruption and collect some typical results, multiply by 0.5 and type onto the screen. Recommended value 200.0g/m.

5. Troubleshooting

During alarm conditions suitable messages will pop-up on the screen and the illuminated alarm-cancel/reset button will blink.

Customer provided warning apparatus can be operated using the potential free relay contact provided.

Multiple alarms can be displayed one after the other by pressing the alarm-cancel/reset button repetitively.

The illuminated button will blink as long as any alarm is active.

The last alarm condition can be viewed for up to half an hour after it has been inactivated, to bring it up, press (the now extinguished) alarm-cancel/reset button. After half an hour the message, '**No alarms for the past 30 minutes**' will be displayed.

The following is a list of alarm conditions. It shows which message is displayed, what the possible causes may be and what actions to take:

5.1 Alarms

5.1.1 HOPPER is empty

Signal:

"CHANNEL**#X – EMPTY HOPPER** " is displayed.

Meaning:

Material level in the hopper is underneath the sensor (X represents the channel No.).

Possible causes:

1. Hopper loader malfunction.
2. Source silo is empty.
3. Hopper sensor faulty.

Action:

1. Check loader and pipes. Is the loader switched on? Is there a blockage or leakage?
2. Check vacuum motor. Isolating switch off? Tripped overload?
3. Check source silo for lack of material or blockage. Is the material moist?
4. Make sure the air pressure is within 6-8bars.
5. Check and tune the hopper sensor (see section 4.1).

5.1.2 Graviman is empty

Signal:

"CHANNEL**#X – Graviman empty**" is displayed.

Meaning:

No material in the weighing-bucket (X represents the channel No.).

Possible causes:

1. Hopper loader malfunction.
2. Source silo is empty.
3. Hopper sensor faulty.
4. Valve or piston faulty.
5. Gravimen sw is close.

Action:

1. Check loader and pipes. Is the loader switched on? Is there a blockage or a leak?
2. Check vacuum motor. Pump switch off? Tripped overload?
3. Check source silo for lack of material or blockage. Is the material moist?
4. Check compressed air pressure, should be 6-8bars.
5. Check and tune the hopper sensor.
6. Check valve and piston.
7. Check the gravimen sw.

5.1.3 Screw throughput is too high.

Signal:

"**CHANNEL#X – PRODACTION RATE TOO HIGH**!" is displayed.

Meaning:

Channel 'X' Screw-feeder output is too high.

Possible causes:

1. Weight per volume of a new material is high compared to the previous material.
2. Screw feeder is the wrong size.
3. Malfunction in the screw-feeder speed controller.

Action:

1. Tune the 'modeling control'.
2. Replace the screw. Retune the 'modeling control'.
3. Call a qualified technician.

5.1.4 Screw throughput is too Low.

Signal:

"**CHANNEL#X – PRODACTION RATE TOO LOW**!" is displayed.

Meaning:

Channel 'X' Screw-feeder output is too low.

Possible causes:

1. Weight per volume of a new material is low compared to the previous material.
2. Screw feeder is the wrong size.
3. Malfunction in the screw-feeder speed controller.
4. Dirty or worn components in the motor, screw or shaft.

Action:

1. Tune the 'modeling control'.
2. Replace the screw. Retune the 'modeling control'.
3. Call a qualified technician.
4. Check the overload lamp on the speed controller. Reset by disconnecting the power for 5 seconds.
5. Clean the screw and screw motor. Check the bearings and other parts for excessive wear.

5.1.5 Weighing alarm.

Signal:

"**CHANNEL#X – WEIGHING ERROR!**" is displayed.

Meaning:

Channel 'X' Fault weight in the weighing bucket.

Possible causes:

1. Material overflow in the weighing bucket.
2. Load cell dirty or out of calibration.

Action:

1. Check compressed air pressure, should be 6-8bars.
2. Clean the load cell as needed.
3. Calibrate the load cell.

5.1.6 Speed controller Alarm

Signal:

"**INVERTERS FAILS**" is displayed.

Meaning:

Common reporting screw-feeder speed controller malfunction.

Possible causes:

1. The motor faulty.
2. The inverters faulty

Action:

1. Check the motor and inverters.
2. Call a qualified technician.

5.1.7 PLC Battery alert.

Signal:

"**PLC BATTARY LOW – REPLACE SOON**" is displayed.

Meaning:

PLC memory backup battery is low on charge. If it is not replaced in time, the PLC could lose its program and memory contents.

Action:

1. Replace the PLC memory backup battery soon is possible.