

Section 3

Operating the Fre-energy Anaerobic Digester

3.1 Fre-energy Interface Control Panel (ICP)

The Fre-energy Interface Control Panel (ICP) is a user-friendly state-of-the-art operating system, enabling efficient on-site and remote management of the Fre-energy anaerobic digester to achieve maximum output; biogas and high-quality bio-fertiliser.

Operational feeding and emptying parameters (loading rates and frequency) are site/plant specific and are advised by Fre-energy. During the post-commissioning period, as the colonies of anaerobic organisms become established the ICP parameters are adjusted to optimise conditions for bacterial activity in order to maximise gas yield. This requires close communication between the operator and Fre-energy. The Operator(s) responsible for the daily management of the AD should be trained in the operations and management of the ICP control panel (see 4.2) functions as applicable.

Training is provided by Fre-energy Ltd. For more detailed information on how to operate the ICP to feed and empty the digester, refer to Section 5.

Note! Remote management of the ICP is included within Fre-energy Technical Support Service option.

3.2 Feeding the digester

The basic and first step in the successful management of any anaerobic digester is to ensure the digester is fed correctly. This digester has two feeding routes:

- Liquid feeding, this is via the Site sump / mixing pit. The pit is filled and then periodically fed into the digester via the 'MIXING PIT LOADIND' function. This is configured within the control system to load a predefined volume at each loading cycle. There is a further function that enables this pit to be topped up from a remote location – The control system provides a signal for a remote transfer pump to be started at defined periods of the day, this will then allow the pit to be filled to the set Fill level – The auto control cycle will then load that material into the digester. The Pit also acts as a sump for the de-gritting system as well as collecting any spillages from the loading area. In this instance when the mixing pit exceeds a pre-set level the control system will load a pre-set quantity on the next load cycle.
- Solids feeding, this is via the Vogelsang pre-mix unit. This has a front-end reception hopper that can be loaded with solid feed. The unit mixes a proportion of the solids with live digestate from the digester once per mixing cycle. The weight per load and the timing of the cycles are set within the control system. There is also a facility to vary the time between loads on time of day so the material can be loaded more rapidly during the day and then at a slower rate during the night, effectively spreading the load through the night.

The digester should be loaded with the correct quantity of feedstock as advised by Fre-energy. Infrequent loading of the digester will lead to spikes in biogas output; therefore, it is recommended that the digester is fed at least twice a day, preferably more frequently. This will lead to more efficient use of the biogas and prevent less flaring of excess biogas caused from spikes in production.

Should there be a problem with the Vogelsang unit it is possible to load some dry matter through the mixing pit. In this case the pit can be filled to a pre-set level, solid material is then added and mixed in the pit can then be topped up further and mixed again. This is practical when there is a high proportion of liquid feed to be mixed with a relatively small quantity of solid feed, for systems that are fed predominantly by Solid material it becomes extremely labour intensive.

HINT! If the DM level becomes too high the loading flow meter will show low and even negative flow rates while loading.

[Note: Irrespective of feedstock loading method, overloading will reduce the efficiency of the digester. Severe overloading can result in the bacteria colonies reaching critical levels causing the anaerobic process to be compromised, and a crust to form, this must be prevented]

3.3 Feedstock consistency

To feed via the mixing pit the material needs to be at a dry matter level of less than 12% If you are using the solid feeder the feedstock needs to have a dry matter > 24% i.e. it is 'stackable'

3.4 Procedure: Feedstock Loading via the mixing pit

Liquid feedstock: fully automated from the mixing pit.

Slurries and liquids can be directly loaded into the mixing pit, this can either be via channels, tanker or via pump. The control of pumps can be via the main control system. If pre-store pumps are used, either the pump can pump until the flow reduces to a negligible level, (indicated by the mixing pit level not rising) or the pit filled to a pre-set level, or under manual control. Any pre-store transfer pump operation is stopped by the control system if the mixing pit level reaches its maximum level.

Dry Feedstock: - NOT APPLICABLE IN THIS SYSTEM – Unless there has been a major problem.

Loading solids via the pit mixing

- Starting with the pit level Low / Empty.
- Fill the pit to the initial loading level this is done by either pressing the pit load button at the mixing pit (if this option is fitted) or selecting mixing pit re fill from the control screen this will pre-fill the mixing pit to the initial loading level (Set within the control settings screen). This will either top the pit up from the digester, the pre-determined pre-store or from a combination of the two.
- When this is completed the initial solids to be added this can then be mixed in.
- Fill the pit to the middle level, by pressing the pit load button (if fitted) or from the control screen. This will then continue to top the pit to the middle level
- Further solids can now be added and mixed in
- The pit can then be filled to the full level in the same manner and the final solids added.
- There is a limit to the quantity of solids you can mix into the system by this method; the limiting factor being what the centrifugal chopper pump can lift into the pipe work for the main pump to then load into the digester, if the material gets too thick the main pump will not be able to empty the pit and will trip out on 'LOW FLOW' faults, if this occurs it is recommended that the amount of dry material being loaded into the pit is reduced. It may be possible to recover the situation by topping up the pit with slurry or digestate to make the product thinner so the centrifugal pump can deal with the pit material. This is a feature of the system. The fixed displacement pump and the pipe work can handle thicker material than the centrifugal pump in the mixing pit can feed to it. This feature greatly reduces the susceptibility of the system to blocked pipes. The chopping nature of the pump also helps to reduce large contaminants that could cause blockages getting into the system as well as giving a degree of maceration to the loaded material.
- The mixing pit is designed with a void area beneath the chopper pump, this should accumulate any large stones, or pieces of metal that end up either in the slurry or in the materials being mixed.
- It will be necessary to periodically clear these out. Great care should be taken in doing this. THIS IS A CONFINED SPACE AND COULD CONTAIN TOXIC GASSES.

SAFETY NOTE: The mixing pit is a confined space; it is not ventilated it is possible for toxic gasses to build up in this area. See section on confined spaces.

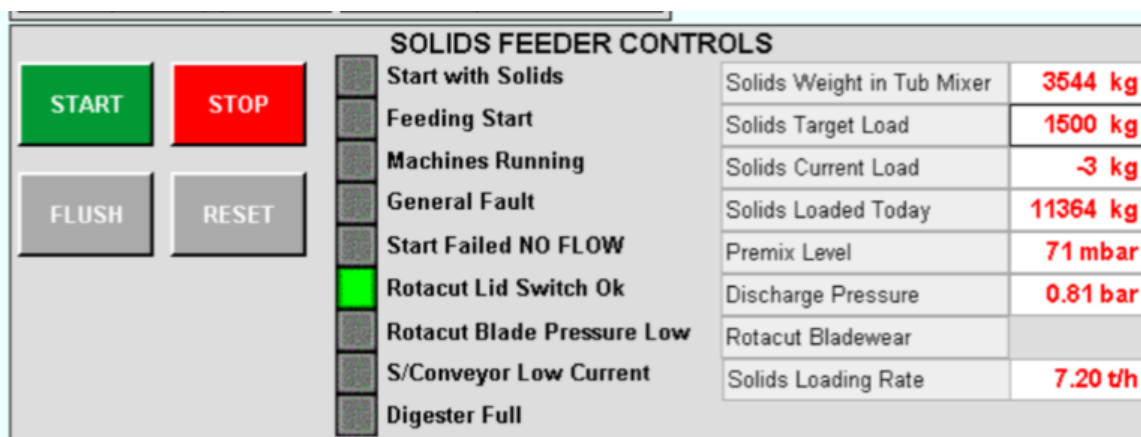
Loading feedstock into the digester

Solid Loading using the Vogelsang Premix

Periodically fill the load hopper, try not to do this during an active loading sequence as this will confuse the load weighing system and may cause the system to do a double load. When you tip material into the Hopper the Load Weighing system will detect an increase in weight, this will start the tub mixer. While the tub mixer is running during topping up the unit is locked out from loading – the time of this is settable within the control system. (currently set at 3 mins) – If you tip more material into the hopper in this time window the Mixing is continued for a further 3 mins.

When the hopper is full or has not had any further material added in the last 3 mins the unit will be re-enabled for loading – on the next loading sequence the pre-set quantity of feed will be fed into the digester. No further loading is allowed after the minimum hopper weight is reached or the current in the transfer auger falls below the pre-set minimum level – (this is to protect against the feed auger running dry and can happen when you have a dense product with significant weights sitting on the mixer head.)

Tipping more material into the hopper will re-commence the solid loading sequence. (i.e. on re-filling the Solids Hopper, the system will re-commence loading). This also means that the Hopper can be topped up at any time – try to avoid topping up the hopper while feeding is in progress, if this happens the calculation for material loaded is corrupted.



While loading, the current load sequence can be stopped by:

Pressing the **STOP** button in the Solid Feeder Controls section of the Operations page

Or changing the operation mode (Manual to Auto or Auto to Manual)

Pressing the **START** button in the Solid feeder controls starts a feed cycle if the unit is not running or clears the Solids Current Load back to zero if the premix is running.

The solids feeder system can under manual operation set to just flush liquid around itself by selecting

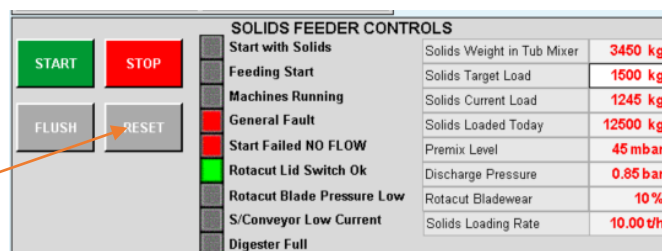


Should a fault occur in the Premix Loading Functions They will be indicated as:

General Fault – Fault detected by the premix.

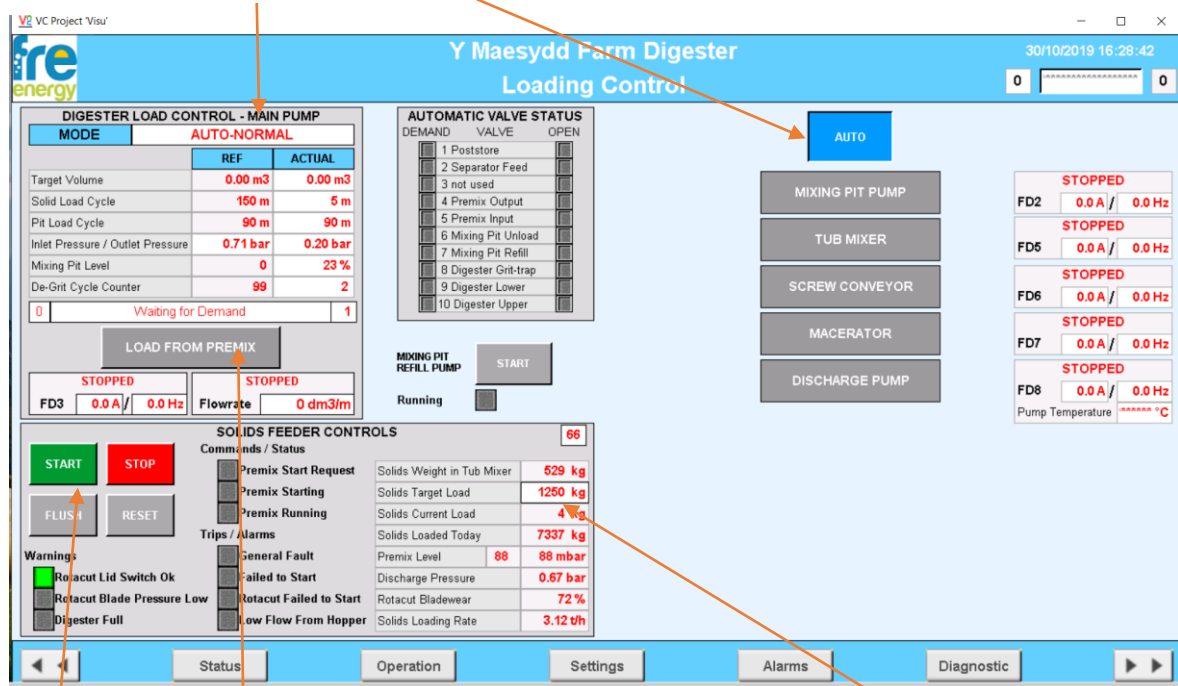
Start Fault – Main Control has been unable to start the Premix.

Faults can be cleared by the **RESET** button.



Manual Loading using the solids feeder

From the Operation screen select Manual Control



Then select **LOAD FROM PREMIX** as the main pump operation

The **START** button will call for the premix to load the amount set in

Solids Target Load **1500 kg**

From the Control Screen loading, can be performed under manual control. To do this the system must be:

- Set to manual control via the main pump Mixer control tab set the function required.
- An amount to Manually load must be set (on Settings – page 1)
- There must be room in the destination (Check on the Status page)
- Start the operation by pressing the START button alongside the main pump control.

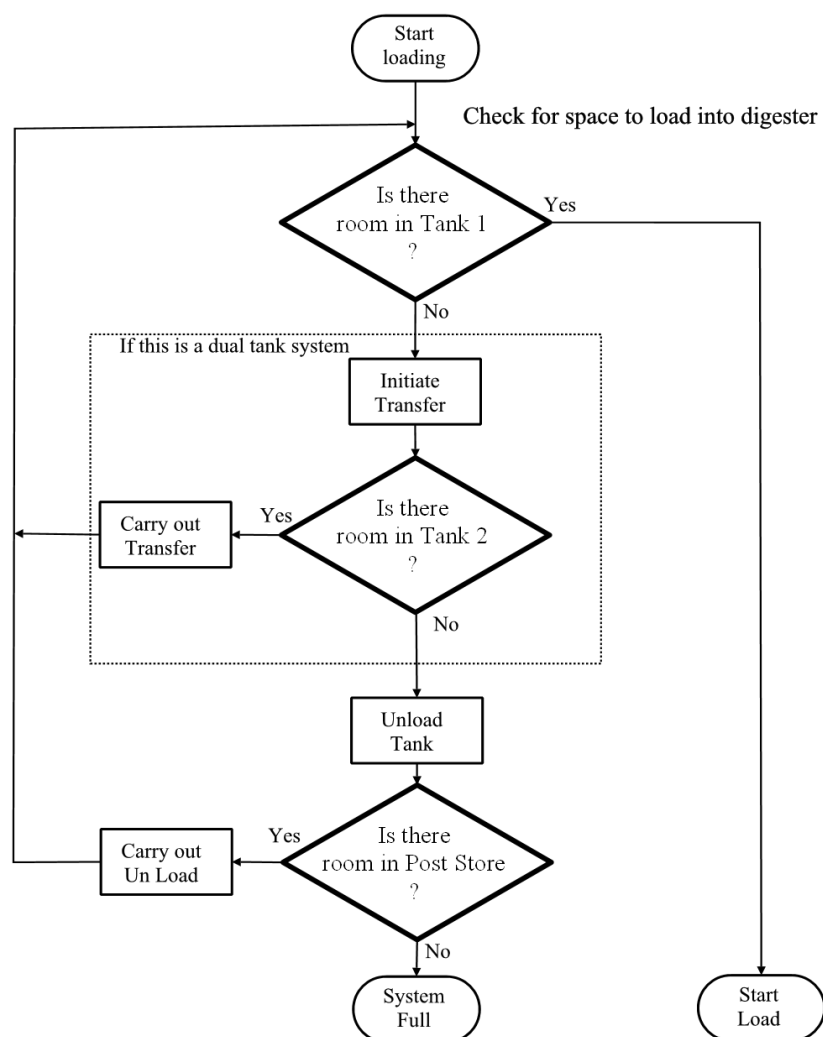
To carry out the operation from the CONTROL screen the top Tab needs to be pressed to select the desired operation and then the START button pressed, if a mixing or pre-feed pump is required then this will also need to be selected. The exception is Unloading to a Separator, in this case the other elements are automatically started. The other motors can be started or stopped by pressing their respective Start / Stop buttons.

Details of the control screens can be found in this manual.

Automatic Loading

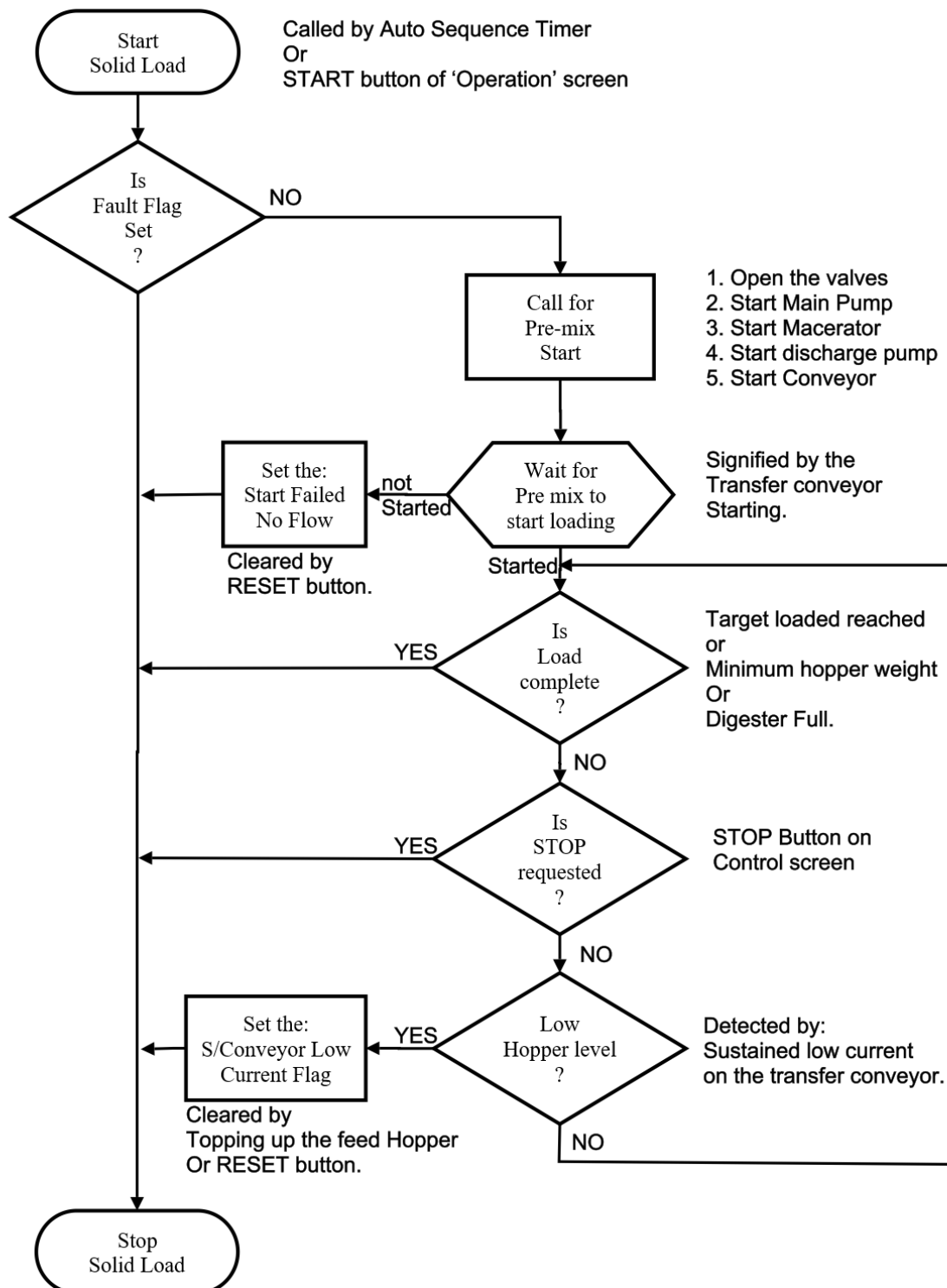
The control system runs around a time sequence, it attempts to load an amount set in the control systems SETTINGS pages, at the start of a sequence the system looks to see if there is space to accept the next load; before a solid or a liquid load is initiated this test is carried out, it checks there is room for the proposed loaded material in the tank.

Phase 1. Prepare to load the system.

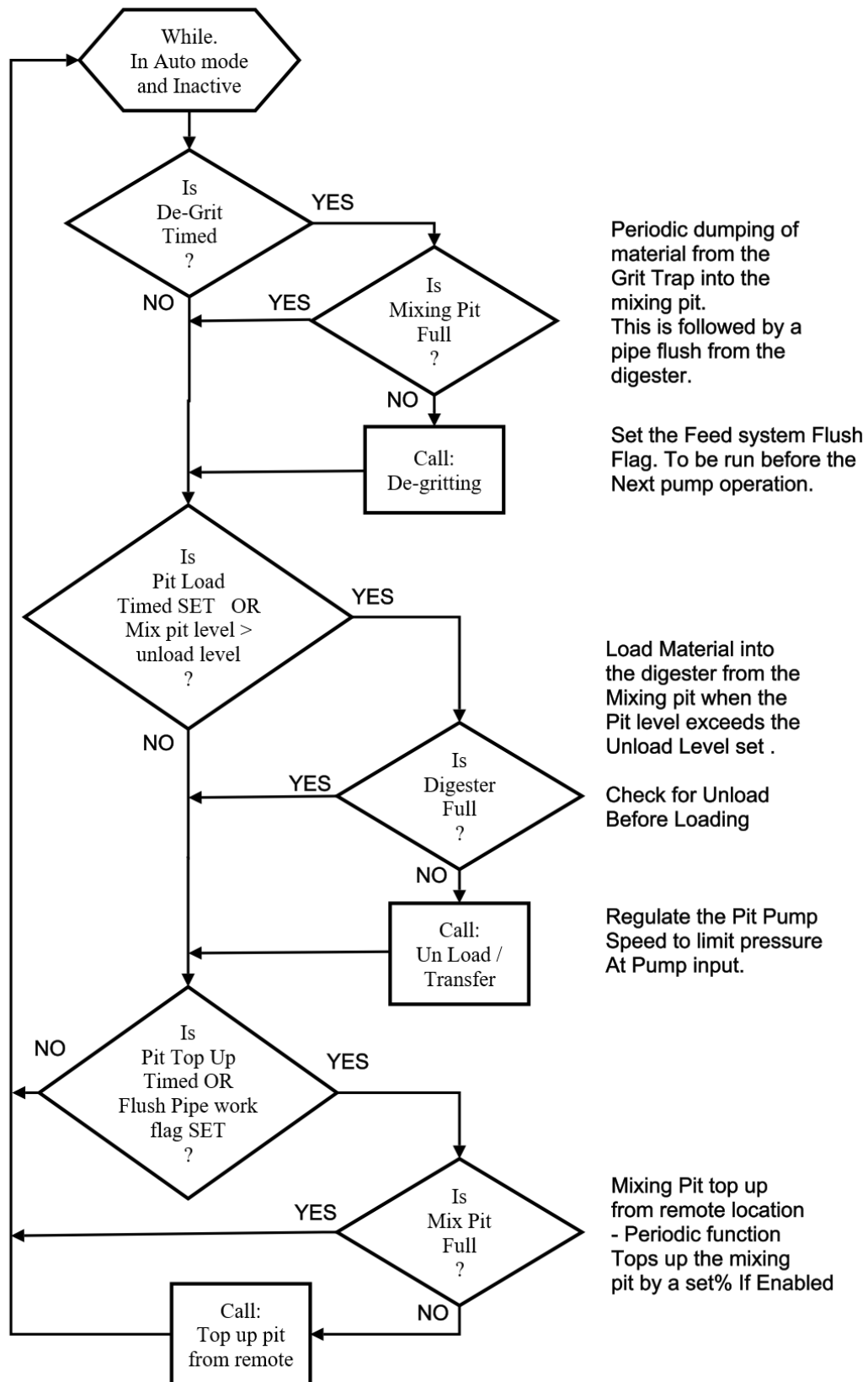


Having established that there is (or carried out an unload to create enough space) for a load, the system selects the loading to be carried out.

Phase 2. Solids Loading Function



Phase 3. Background Tasks

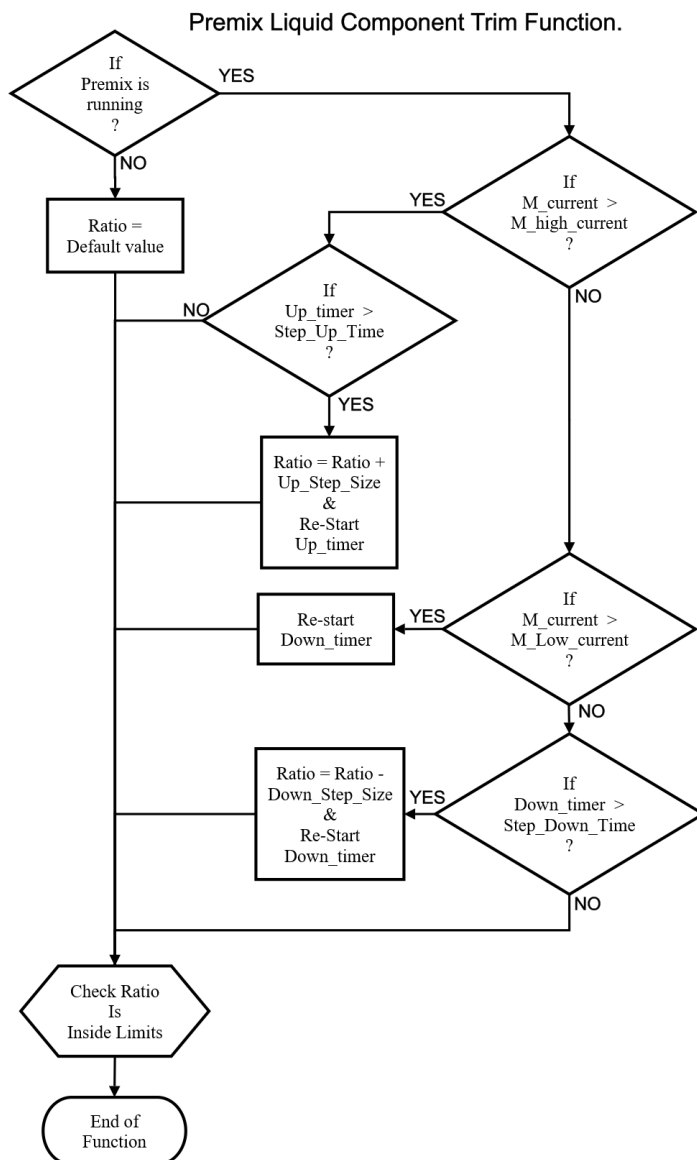


Function to intelligently modify the Premix mixture flow rate.

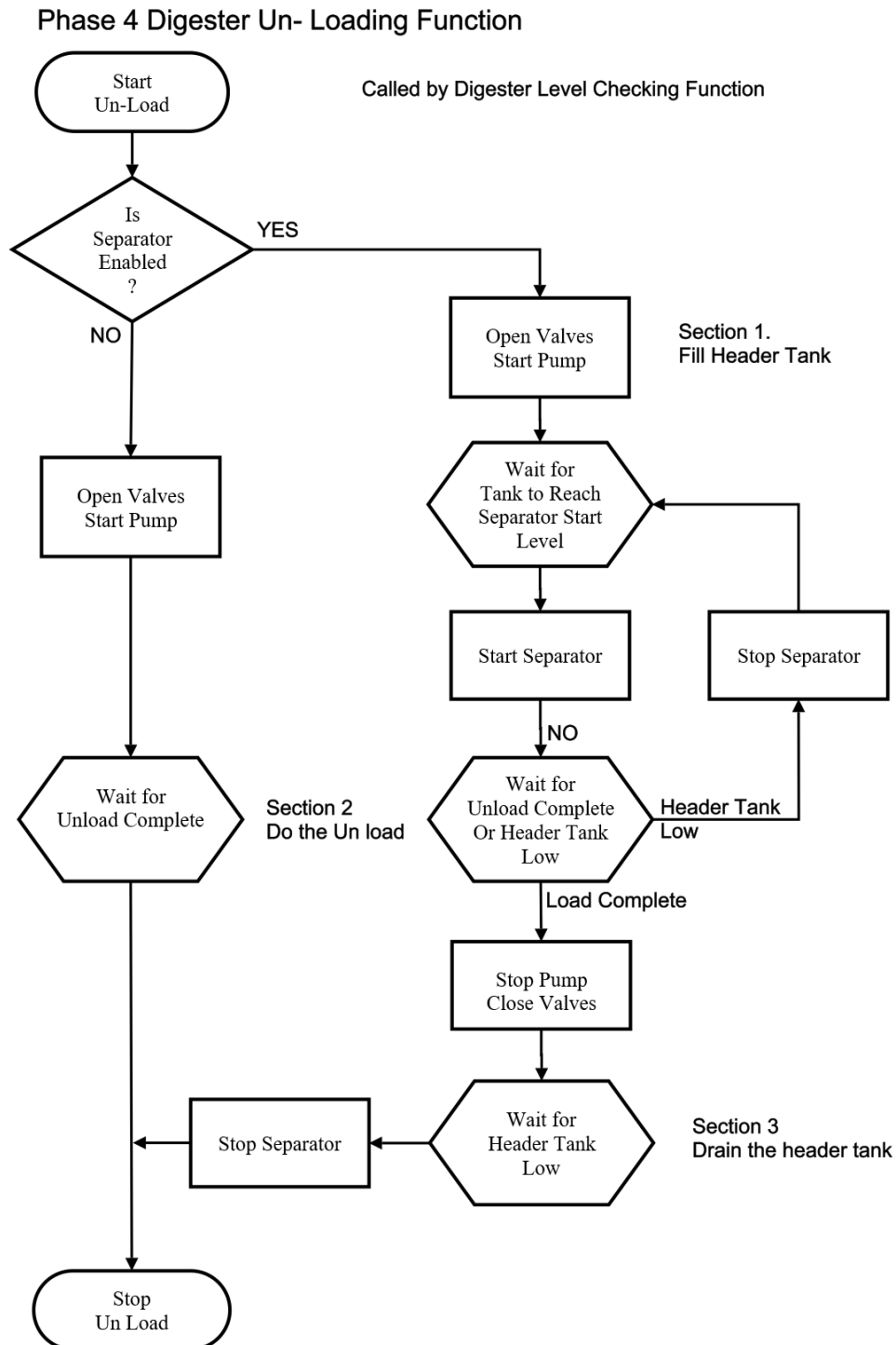
The ratio of liquid to solids processed through the Pre-mix is set as a variable. Using a fixed value with a static / fixed consistency of feedstock is acceptable, however, in Fre-energy plants it is preferred to minimise the customer intervention required for varying consistencies of feedstock

- Higher liquid feed and lower solids feed rate, longer feeding time, more parasitic energy used. There can also be an issue with liquid working its way back up the feed auger into the hopper.
- Lower liquid feed rate and higher solids feed rate, problems with blocking of the feeding system when there is too much load applied to the macerator.

To adapt to this, the current applied to the Macerator is monitored. If it rises above a threshold, the ratio of liquid to solids is increased. If it remains below a low threshold for an extended period, the ratio of liquid to solids is reduced.



Digester Un-Loading / Separator Control Function

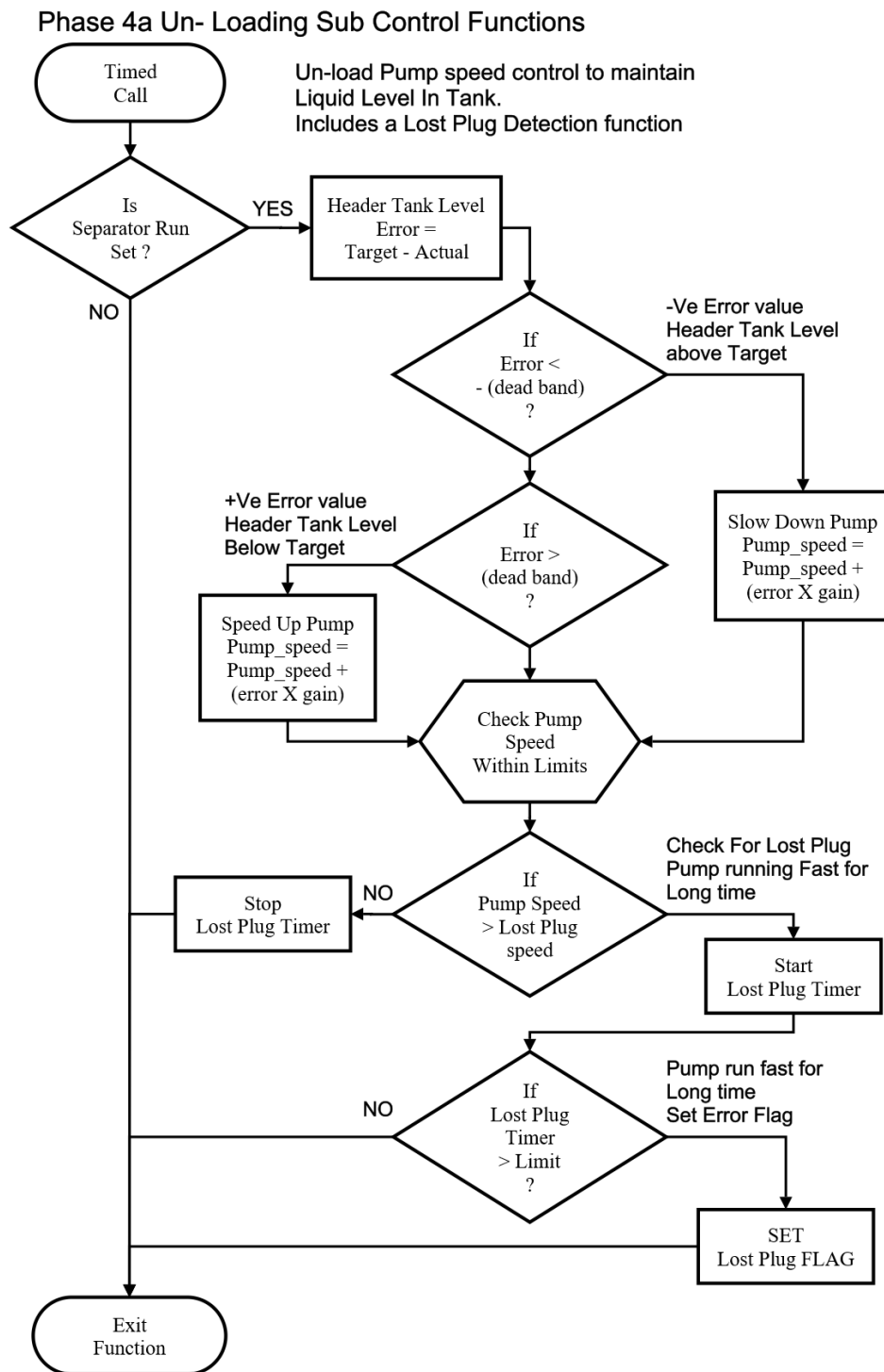


There is also a function that periodically reverses the direction of rotation of the separator; this can be programmed to include a reversal at the start and or end of the operation. For some systems this can be vital to scrape clean some of the meshes within the unit.

Note! Some separators should not be reversed. It is important to confirm with the separator supplier.

Separator sub-functions:

Maintenance of header tank level by adapting the feed pump speed and detection of lost plug.



Mixing Pit loading: Under Automatic control.

If the mixing pit level exceeds the 'Mixing Pit Unload Threshold' (Settings page 2), and as long as there is space in the digester and the system is not active on another function, then the mixing pit load function is activated.

The system is set to load the amount in 'Slurry Loading Volume' (Settings page 2); during loading, the pit mixing pump is run. The speed is regulated to limit the pressure at the main pump input to that specified in the Loading settings. This is necessary to prevent the pressure from the mixing pump triggering an over-pressure event at the input of the load pump.

For systems with mixing pit loading where solids are to be mixed in, there is the facility for a mixing propeller to enable the mixing pit pump to be run to mix up the contents of the pit prior to a load function. However, for systems where the pit primarily acts as a collection / de-gritting sump, this feature is disabled. Only a small amount of agitation is required to facilitate the liquid to be pumped into the digester and for the grit and silt to remain in the pit.

Note! If the mixing pit is below the level set within the control settings, the propeller mixer will be clear of the level in the pit. In this instance the mixer is not run.

3.5 Removing Digestate from the Digester

Removing digestate from the AD is a fully automated process

The separator automatically switches on as digestate leaves the digester. The working program for this is on the ICP **if installed**.

If the separation option is selected (picture of separator in the daily check list). The digestate (digested feedstock) which is of a slurry consistency is pumped from the digester to the 'High Output Separator' which separates the digested material into liquid and solid fractions. The solid fraction is deposited at the base of the separator, and the liquid fraction is directed to post-storage facility. Ideally the liquid storage should be covered to prevent the volatilisation of gasses from the digestate to retain the highest amounts of nitrogen possible in the liquid. The rate at which the feedstock is pumped into the digester is controlled by the red and the green buttons located on the front door of the separator. The green button increases the pump speed and the red button reduces it. The speed of the transfer pump from the separator to the post-store is locked to the loading pump. When stopping the High Output Separator, the liquor transfer pump continues to run for the time set on the UNLOADING CONTROL SCREEN; this is to allow the belt to clear.

The decision to unload the digester is made from within the control programme. When the digester is about to perform a load operation the control system checks to establish if there is enough space in the digester to accept the next load. If there is not an adequate amount of space available, enough is unloaded to enable the loading to occur. It is possible to override this and initiate further unloading under manual control.

If there is no separator installed or should it be linked out of the system, activating the BY-PASS feature on the UNLOADING SETTINGS page will run the Un-Loading and Transfer pumps without running the Separator.

Note! If this flag is set and the pipe connection has not been amended to by-pass the separator, it will be prone to dump digestate on the floor.

3.6 Rotating arm and gas indexing on top of the digester

Rotating Arm: The rotating arm and gas mixing pump feed inlet can be seen in picture 6.1.8. The rotating arm is controlled by the four rams on the top of the digester. At any one time two rams will be pushing the rotating arm forward, while two will be retracting, getting ready to push forward on the next move. These rams must be inspected daily to make sure they are working and moving the cogs on the rotating cog wheel. As grit builds up the lifting rams will retract lifting the rotating arm up over the grit. The lifting rams must not be allowed to retract fully, as this will put undue pressure on the drive rams and lead to mechanical breakdown. The lifting rams must be checked daily to ascertain the level of grit build up in the digester. For best practice, de-gritting should take place every two weeks and more often depending on the grit content of the feedstock. This will be at the operator's discretion. Mechanical breakdown due to lack of de-gritting, is not under warranty. If one or more of the drive or lift rams is not working, check that the solenoid valves are not sticking on the plate on the front of the top drive.

Gas mixing: The indexer must be checked to make sure that it is moving the agitation from one pipe to the next and that the pipes are not blocked; the gas pump will make a different noise when it is trying to blow down a blocked pipe. If the gas pump is constantly straining check the non-return valves in the gas mixing pipes (5.9). Gas pipes should be checked for leakage; the operator should be able to hear gas leaking. If a gas leak is suspected perform a soap test to confirm leakage and take appropriate action. Ensuring the recommended daily checks are performed is essential.

3.7 Procedure: Emptying the Grit Trap

While the digester is running, the organic matter is digested by the bacteria, leaving the inorganic material, generically referred to as 'Grit', which as it is no longer embedded in the organic dry matter, to sink to the bottom of the digester, where it accumulates. The Fre-energy patented combined gas-agitation with auto de-gritting technology sweeps this grit to the outside rim of the digester where it can then be removed via the grit trap.

The level of grit in the digester can be checked by looking at the level of the rotation drive system on top of the digester. The rotating arm is driven by the two pairs of hydraulic rams working on the 'escarpment' cog on the top of the drive shaft. The Fre-energy control system monitors the pressure needed to rotate this shaft and as this builds up it lifts the rotation drive using the four lifting rams located in the corners of the top-drive assembly. De-gritting should be carried out when the rotation drive system has lifted by more than 25 mm. If the system is not lifting, it is recommended to routinely perform a de-gritting cycle every month. If the feedstock includes high grit inputs like Chicken layer manure or Slurry where sand is included, as a minimum, one (1) de-grit cycle per day is recommended.

Procedure:

Select the UNLOAD control page on the ICP.

- 1 Turn the de-gritting pump that feeds away from the grit trap to ON
- 2 OPEN the valve on the de-gritter and CLOSE the valve on the NORMAL EMPTYING.
- 3 Some digestate will be pumped into the grit trap sump to balance the pressure, when this has finished OPEN the grit trap sliding door manually by pulling the handle OUT.
- 4 If the unloading pump does not start pumping the grit straight away, it may be necessary to switch it OFF, CLOSE the sliding door on the grit trap and OPEN the front plate (undo the four retaining bolts) to manually remove solid grit.
- 5 Grit emptying time will depend on the quantity of grit present in the digester.
- 6 It will be obvious to the operator when all the grit has been emptied, as the physical character and smell of the material coming off the separator will change and the lift rams will have returned to their fully extended position. At this stage turn the unloading pump OFF, CLOSE the grit trap door and SHUT the de gritting valve.

3.8 Foam Alleviation System

The foam alleviation system (see 6.2.5) is self-managing; if a foam build-up occurs in the digester, the foam will breach the water-trap in the foam alleviation unit, thus venting the methane gas and shutting down the CHP engine (avoiding damage to the engine caused by foam in the gas). Any foam exiting the digester through the foam alleviation unit is returned to the mixing pit, to be mixed with the feedstock.

3.9 Gas holder and pipes

It is of the utmost importance that the air blower for the gas holder is running. If the outer dome is not fully inflated the roof could be damaged in windy weather.

IMPORTANT ROUTINE MAINTENANCE TO BE CARRIED OUT BY THE OPERATOR:

Daily checks MUST be carried out on the gas pumps to make sure they are working properly. If any of the pumps stop working the operator must contact Fre-energy immediately, as a prolonged absence of agitation may result in a crust forming and a subsequent system failure. Oil levels must be maintained at the correct level as indicated on the oil storage box.

3.10 Crust Busting

If a crust is forming, the rotating arm control can be stopped to allow the mixing sequence to operate for a set period of time to initiate selective intensive localised mixing within the tank. The arm movement is frozen for the 'ON' time and then allowed to move for the 'OFF' time. This is carried out for a set number of cycles (as observed on the auto-counter). When this sequence has been completed normal operation is re-activated. See the comments on the Gas Pump Mode control above. A crust will be dry and uneven. If this occurs, it is important to consider what might have caused it. For example, analysis of the feedstock will identify the percentage dry matter and other feedstock quality parameters and elements of the input.