An Advanced Alternative Environmentally Friendly Method for Organic Waste Processing

Bokashi (Acidic Anaerobic) Fermentation

On-site Manure Processing
AgroBio Products Production Plant

Instruction Manual

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Content

Introduction:

In order to efficiently ferment manure, the pH must be adjusted for optimal and effective fermenting conditions. In the schematic for manure processing shown below, the first stage in fermenting involves isolating the liquid fraction of manure and adjusting the pH for optimal fermenting in the range pH 3.5 to 6.

Manure is a complex substrate that rapidly changes in character depending on the temperature, moisture content, air exposure, and many other factors including how it is collected and how long it is allowed to stand before processing is initiated.

Typically manure is alkaline. The alkalinity is due to ammonia accumulating naturally due to the breakdown of urea frequently accompanying the manure. Microorganisms rapidly degrade urea into carbonic acid and ammonia. The ammonia and carbonic acid immediately form a weak acid base pair trapping nitrogen in the form of ammonium bicarbonate.

Ammonia is bound up as the ammonium ion in the manure and is in this form non-volatile. However carbonic acid is unstable and rapidly dissociates to carbon dioxide and water. The carbon dioxide escapes as a gas into the atmosphere leaving ever increasing amounts of ammonia and water.

Ammonia is strongly basic and the pH of manure shifts rapidly higher as ammonia accumulates. The pH of manure is commonly measured at about 8.9. Ammonia is also volatile and escapes into the atmosphere. Ammonia loss can be as high as 20% per day when manure is left to stand.

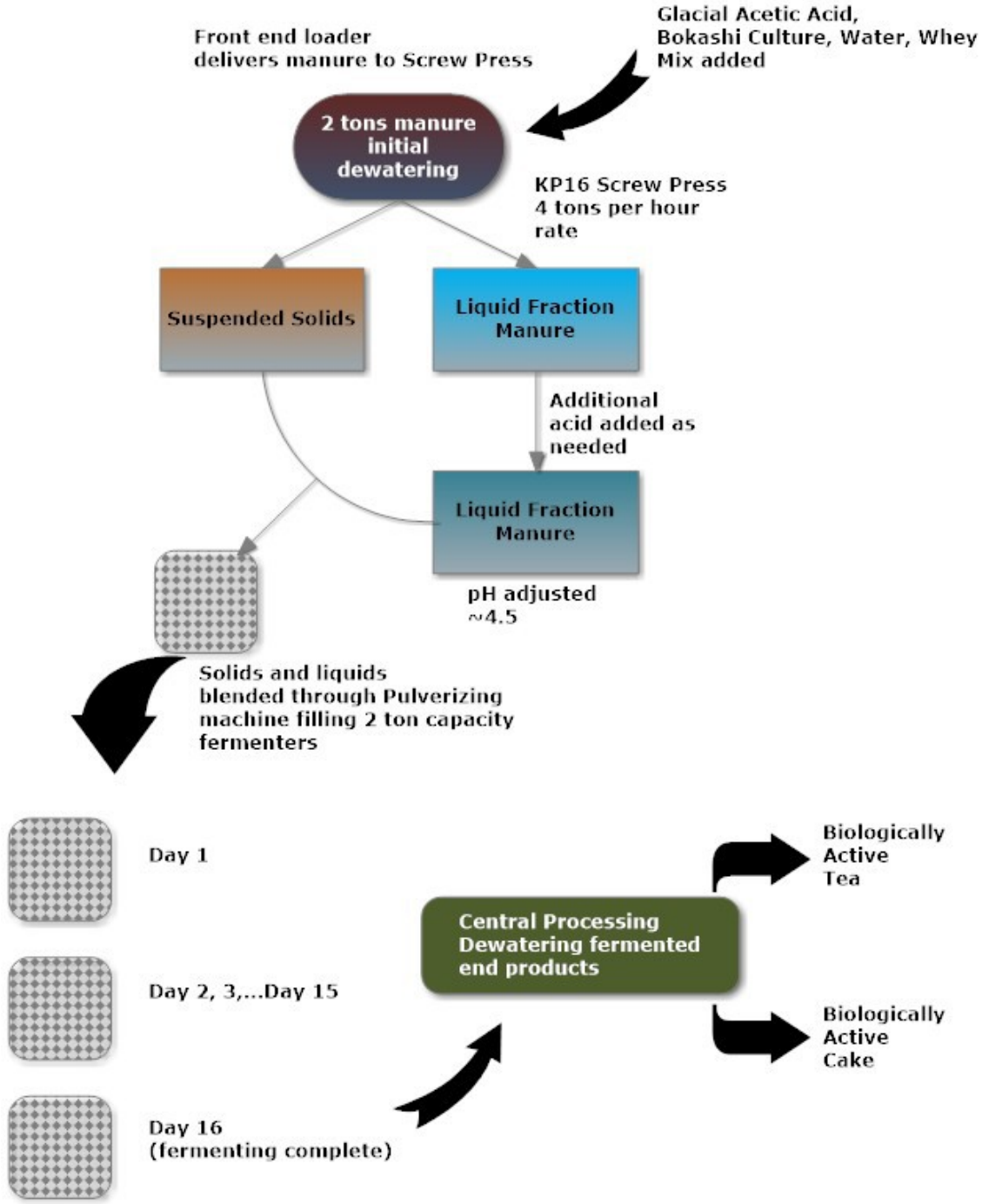
The alkalinity is ameliorated by the fact that ammonia is a volatile substance and it too dissipates into the atmosphere which accounts for the strong odor of ammonia wherever manure is allowed to accumulate.

Manure is heavy and difficult to mix generally and can not be easily pumped unless it is watered down. It may vary in consistency from self leveling to a relatively dense and firm form, especially if hay and straw or other absorbents are added to the manure during the collection process.

Manure is also heavily laden with a number of pathogens including potentially harmful coliforms. Although high ammonia concentrations can stress and suppress these organisms making it appear on initial testing that they are absent, they do survive and will show up in the soil and ground water if manure is improperly treated.

Bokashi (acidic anaerobic fermenting) destroys these pathogens within a few days once the fermenting process is initiated.

Schematic Protocol for Manure Processing:



Advantages of Low pH Manure Adjustment:

In addition to setting up the proper conditions for fermenting, adjusting the pH into the range 3.5 to 6 has numerous advantages over untreated manure.

The ideal pH for fermenting is between 4 and 5 because the enzymes (cellulases) that are most efficient in fermenting (metabolizing manure) are optimally active in this range.

Ammonium bicarbonate, ammonia and carbonic acid form a strong buffer and the amount of acid required to shift the pH below 7 can vary considerably depending on how fresh the manure is and how much ammonia and carbonic acid are present. The pH must be well below 7 and below 6 for efficient bokashi fermenting.

Manure held at or near pH 7 can form significant amounts of methane. This should be avoided.

Methanogens are the organisms involved in methane production but they are highly sensitive to pH shifts and are inhibited if the pH is to either side of pH 7. These organisms commonly found in nature are only active in the narrow range near pH 7 and will not produce methane when the pH is in the range 3.5 to 6.0.

Adding acid to drop the pH below 7 traps nitrogen in the form of ammonium ion which is non-volatile.

Since ammonia escapes rapidly when manure is allowed to stand without processing, much of the nitrogen value is lost if the pH is not adjusted to lower levels. For this reason we recommend processing manure as early as possible to maximize the fermentation end product value.

The advantages of adjusting the pH into the range 3.5 to 6.0 are;

- Optimal fermenting conditions are established
- Low pH is conducive to killing pathogens and prevents methane from forming
- Low pH traps nitrogen

Why Initially Dewater Manure?

Manure is heavy, abundant and difficult to handle. It is sufficiently viscous and hard to mix. Adding acid directly to the manure and mixing results in pockets of improperly acidified manure. There is no simple way to confirm that directly mixing acid with manure results in a uniformly mixed and adjusted pH. Because acidification can not be confirmed and failure to uniformly acidify manure is a problem, an efficient cost effective method of acidification and inoculation was developed.

Any insufficiently acidified regions of the manure will not ferment and insufficiently acidified regions will allow for pathogen survival.

Carbonic acid is a well known buffer. Ammonium bicarbonate, ammonia and carbonic acid are forming as acid is added to manure and the buffering capacity is highest around pH 7. Virtually all of the carbonic acid must be removed to obtain a pH less than 6.0.

Because the carbonic acid is unstable, dissociating spontaneously to carbon dioxide and water as it forms, its removal is assured with acidification. It is expelled by adding sufficient acid in excess to over come the buffering capacity of this weak (carbonic acid) that is an important transient buffer.

Bubbling and foaming may be observed as acid is added to the manure and liquids associated with the manure. The carbon dioxide escapes much more rapidly from the liquid fraction compared to an acidified viscous fraction of manure which traps and slows the movement of the gas dissipating into the atmosphere.

Glacial acetic acid is the recommended acid for pH adjustments because it forms a strong buffering capacity near pH 3.5. Using its buffering capacity at the lower end of the ideal range for fermenting makes it easier for operators to hit the target pH (between 4 and 5). Strong acids lacking adequate buffer capacity should not be used alone because it is too easy to inadvertently add too much acid.

Manure is separated into a liquid and solid component by dewatering. It is easy to acidify liquids and mix them adequately using pumps and valves so that the liquid is uniformly set to the proper pH.

It is faster, less costly, and more efficient to separate the manure into its solid and liquid components by dewatering and then recombining the components with a properly adjusted pH for fermenting than it is to try and mix raw manure with acid directly.

Acidifying the Manure:

We strongly recommend using 100% glacial acetic acid as the ideal acid for adjusting the pH. Because of the high buffering capacity of carbonic acid, ammonia, and ammonium bicarbonate it is difficult to predict how much acid will be required to set the pH to the proper range.

Collected manure may if highly desiccated require additional water content for appropriate conditioning to ferment and obtain valuable and useful fermented end products.

Adding straw and or wood chips to the manure will also change the quality and character of manure and may significantly change the pH.

It is advisable to run calibration curve studies on the manure to take into account the potential changing moisture content and to also account for other additives or changes in absorbents for optimal and consistent fermenting outputs in processing.

Glacial acetic acid is inexpensive and abundant. Muriatic acid, a far stronger acid is also abundant and inexpensive and may be used along with glacial acetic acid if the manure being processed has a very high buffering capacity near pH 7 that is not so easily overcome. High buffer capacity near pH 7 will require large volumes of acetic acid to reach the target pH ~4.5. A small amount of muriatic acid combined with glacial acetic acid will eliminate this problem with minimal amounts of acid in production.

By first adding the glacial acetic acid to the manure, the potential for dropping the pH too low with a strong acid like Muriatic acid is avoided. Acetic acid will establish a strong buffering capacity near 3.5. This also eliminates the need to precisely titrate to the proper pH.

Whey and other acidic liquids may be added to manure in processing at the initial step in processing as an easy way to dispose of whey by converting it to fermented end product in the manure.

These additions should be done in a manner that is consistent with established calibration curves used to define the end products in production.

As is evident in the schematic for manure processing above, manure is processed in 2 ton batches. We recommend adding the bokashi culture mix and glacial acetic acid to the manure at the point it is loaded into the auger hopper for dewatering.

The optimal amount of glacial acetic acid required to drop the pH into the proper fermenting range will be established in a short time of trial and error for any production site for each 2 ton batch of manure in process.

We recommend working out the calibration curves in small batch processing runs using a KP6 screw press or equivalent as it will be easier to handle in small batches as the curves are perfected for processing.

Fine tuning or adjustments may be made in the mixing reservoir where the liquid fraction is held while the pH is adjusted before sending it forward to fermenting bins. If the calibration curves have been well done there should be no need to add additional acids for pH control. However, it is a good practice to periodically quality control confirm that batches are being properly established to ferment as intended.

A 2 ton batch of manure may require 2 gallons of glacial acetic acid and 50 lbs of bokashi culture mix for proper fermenting. Muriatic acid may be used in addition to glacial acetic acid if the pH is too high after adding the glacial acetic acid.

Manure Dewatering with pH Adjustments:

As shown in the schematic on manure processing, the manure is loaded into the auger hopper in the first step initiating the process. Glacial acetic acid and bokashi culture mix are added to the manure and the dewatering is started.

The manure liquid component with suspended solids exiting the screw press is captured in a catch basin and directed to the **Mixing pH Reservoir** (see diagram Appendix A).

The solid component (dewatered manure) exiting the screw press is transported by a tube conveyor to a temporary holding bin.

Solids and liquids are recombined with mixing once the pH adjustment is complete. This is accomplished by transferring the pH adjusted liquid component to the pulverizing hopper where the solid and liquid components are blended.

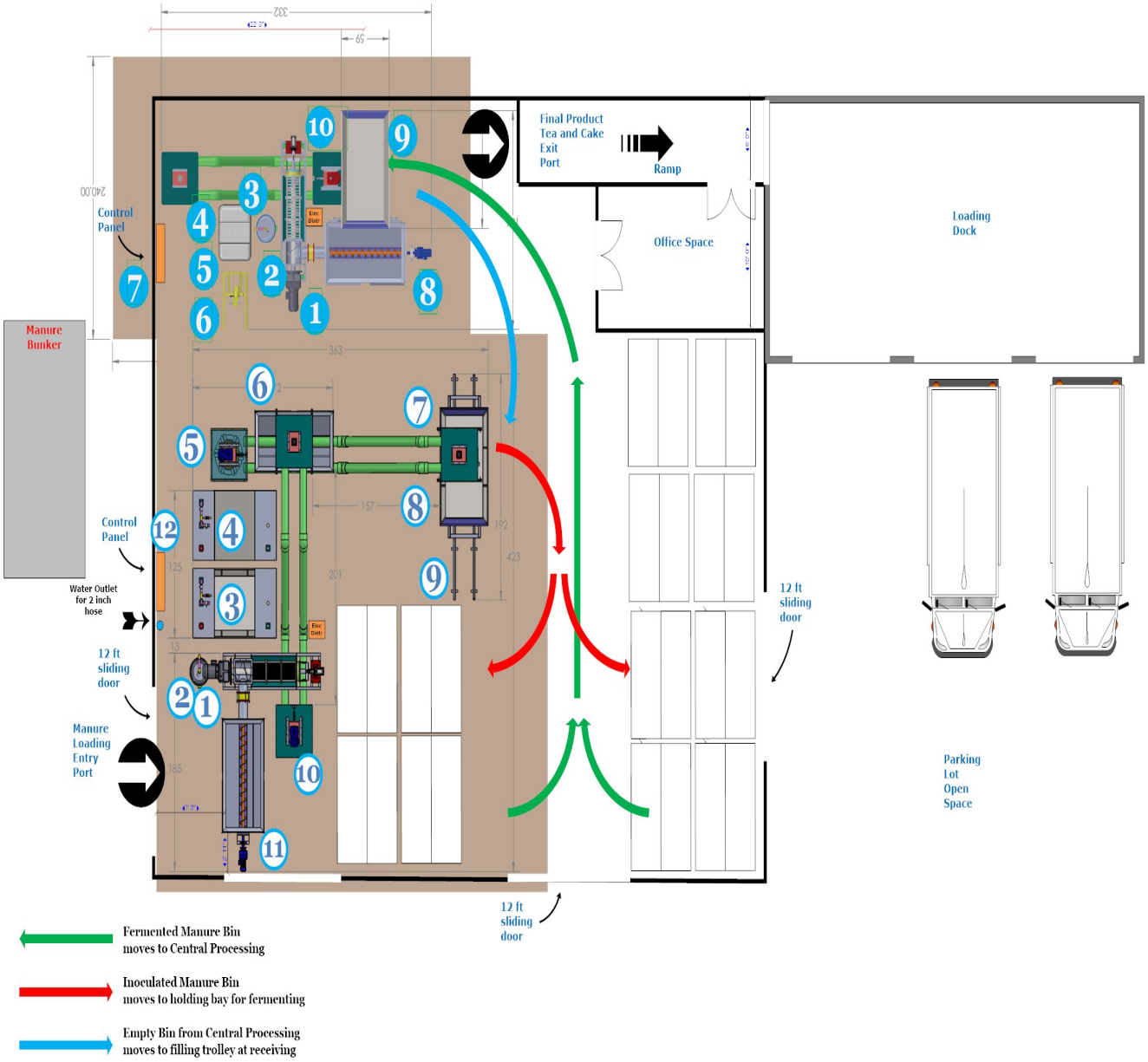
They are set aside in a fermenting bin for 16 days to complete the fermenting cycle. A bio pulp is formed by fermenting the manure.

At the end of the fermenting process, the pathogen free fermented bio pulp is directed to central processing and separated into a liquid component free of suspended particles greater than 200 microns, and a solid (cake) component.

Operators should become familiar with the equipment and steps to efficiently prepare manure for fermenting. A step by step protocol to accomplish this task is provided under **Appendix A**. This is the process taking place at the receiving station.

Receiving and Central Processing Stations:

The floor plan layout for the AgroBio Products Production Plant is as shown in the schematic top down floor plan shown below.



Receiving Processing Manure Plant – 460V Electrical:

Location	Item	Specification	AWG	Conduit	Breaker	Wire Input	Wire Output	Comment
1	Screw Press	KP16 15 HP, 3P 460V	10	0.75	3P 40 AMP	Control Panel	Distribution Box to KP16	VFD A510-4015-C3 on control panel
2	Catch Basin Pump	LE41AV 0.4HP, 1P 120V	12	0.75	1P 15 AMP	Distribution Box	Distribution Box to Quad receptacle	
	Hi Level Alarm Visual and Audible, 1P 120 VAC							
3	pH Mix Reservoir # 1	LE41AV 0.4HP, 1P 120V	12	0.75	1P 15 AMP	Distribution Box	Distribution Box to Quad receptacle	Quad Receptacle
	Hi Level Alarm Visual and Audible, 1P 120V							
4	pH Mix Reservoir # 2	LE41AV 0.4HP, 1P 120V	12	0.75	1P 15 AMP	Distribution Box	Distribution Box to Quad receptacle	Quad Receptacle
	Hi Level Alarm Visual and Audible, 1P 120V							
5	Tube Conveyor	1.5 HP Motor, 3P 460V	12	0.75	3P 15 AMP	Control Panel	Distribution Box to Hydraulic Motor	VFD A510-4002-C3 on control panel
6	Receiving Holding Cake Hopper							No Electrical devices at this location
7	Micro Switch for Mix/Blend	L510-403-H3-U 3P460v	12	0.75	3P 15 AMP	Distribution Box	Distribution Box to Micro Switch on Post	L510-403-H3-U 3P Micro Drive NEMA Enclosure
8	Mix/Blend Machine	3 HP Motor, 3P 460V						
9	Trolley with Empty Bin							No Electrical devices at this location
10	Tube Conveyor	1.5 HP Motor, 3P 460V	12	0.75	3P 15 AMP	Control Panel	Distribution Box to Hydraulic Motor	VFD A510-4002-C3 on control panel
11	Auger Hopper	1.5 HP Motor, 3P 460V	12	0.75	3P 15 AMP	Control Panel	Distribution Box to Auger Hopper	VFD A510-4002-C3 on control panel
12	Control Panel	Metal Base lug ground						Quad Receptacle LED Panel light

Central Processing Manure Plant – 460V Electrical:

Location	Item	Specification	AWG	Conduit	Breaker	Wire Input	Wire Output	Comment
1	Screw Press	KP16 15 HP, 3P 460V	10	0.75	3P 40 AMP	Control Panel	Distribution Box to KP16	VFD A510-4015-C3 on control panel
2	Catch Basin Pump	LE41AV 0.4HP, 1P 120V	12	0.75	1P 15 AMP	Distribution Box	Distribution Box to Quad receptacle	
	Hi Level Alarm Visual and Audible, 1P 120 VAC							
3	Hi-Lo Sensor	Model HC6000, 1P 120V	12	0.75	1P 15 AMP	Distribution Box	Distribution Box to Quad receptacle	Quad Receptacles on Spence Strainer Frame
4	Hi Level Alarm Visual and Audible, 1P 120V							
5	Cage Tote Pump	LE41AV 0.4HP, 1P 120V						
6	Spencer Strainer	GS-72-C, 1P 120V						
7	Control Panel	Metal Base lug ground						Quad Receptacle LED Panel light
8	Auger Hopper	1.5 HP Motor, 3P 460V	12	0.75	3P 15 AMP	Control Panel	Distribution Box to Auger Hopper	VFD A510-4002-C3 on control panel
9	Hydraulic Tilt Table	3 HP Motor, 3P 460V	12	0.75	3P 15 AMP	Control Panel	Distribution Box to Hydraulic Motor	L510-403-H3-U 3P Micro Drive Switch on CP
10	Tube Conveyor	1.5 HP Motor, 3P 460V	12	0.75	3P 15 AMP	Control Panel	Distribution Box to Hydraulic Motor	VFD A510-4002-C3 on control panel

Raw collected manure is loaded into the auger-hopper at the receiving station along with the determined amount of water/whey, acids and bokashi culture mix in 2 ton batch processing.

As can be seen, there are separate control panels in processing. One control panel is used at the Receiving Station. The manure is separated into the liquid and cake immediately. The liquid material is rapidly and uniformly mixed to allow rapid equilibration of acids and culture media (see Appendix A).

After mixing of the liquid fraction, both the cake and liquid are allowed to recombine at the blending machine at the end of the receiving station line. A bin placed on the trolley under the discharge end of the line is filled with fresh inoculated and acidified manure.

The bin is removed and covered with the seal to exclude oxygen and then transported to the floor and allowed to stand 16 days undisturbed as fermenting takes place.

Bin Identification Markings and Tracking:

All bins should be given an ID number by marking only the seal placed on the bin with its ID designation. Because the seal travels with the bin loaded with fermenting manure, a record of the day the bin was filled is established by recording the seal placed on the loaded bin.

Bins with seals that have been on the floor for at least 16 days may then be transported to central processing where they are placed on the hydraulic tilt table to empty contents into the screw press feed auger-hopper.

A daily record of seal ID bin loading must be established to properly manage this process. In so doing, the bins available for central processing are always easily identified.

We recommend using this data accumulating as a part of the quality control batch record file which could also be carried forward into labeling allowing for traking and tracing any product in production.

Control Panels - Receiving and Central Processing Stations:

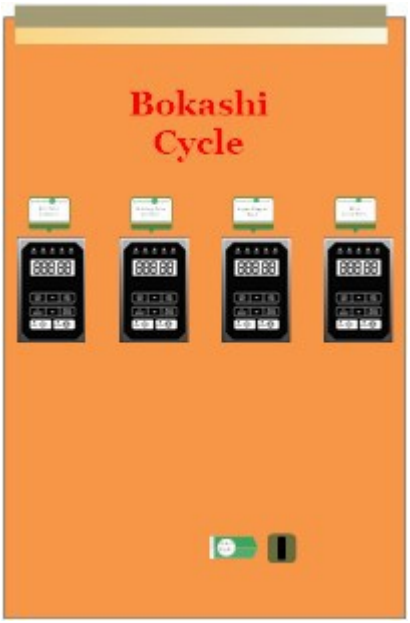
Wall mounted control panels are shown in the photo above. The panel doors are closed and should not be opened by any operator without an electrician's supervision. All of the controls are available on the surface.

The Receiving Station control panel is on the left and the more complicated Central Processing Station control panel is on the right.

All power directed to either panel is made available through a separate load center mounted on another wall equipped with circuit breakers. If power is unavailable at the control panel, the load center circuit breakers should first be checked to make sure the circuit breakers are properly set.

⚠ If the load center circuit breakers are properly set, and no power is available at the control panel, an electrician should be contacted and available before opening or entering either wall mounted control panel.

Receiving Station Control Panel:



There are 4 surface mounted key pads for power control at the Receiving Station control panel and a single LED panel light switch is used to illuminate the panel surface.

The motors in the receiving station area are all 3 phase 460V motors that are controlled by variable frequency devices (VFDs). A VFD is linked to each motor.

Each keypad is associated with a label identifying which motor and function is under that VFD control.

VFD Controls:

There are 4 VFD controller key pads that are illuminated when power is delivered to the control panel. In the order from left to right the VFD key pads are labeled as shown below;

1. **Bin-Tube Conveyor** - The key pad labeled "Bin – Tube Conveyor" is adjustable by changing the frequency in Hz and can run forward or backward. It is normally only run in forward mode. This conveyor transfers cake exiting the cone end of the KP16 screw press to a holding bin where material is kept as fluids are equilibrated in the pH mixing reservoir (Appendix A). Pressing "run" on the pad

activates the conveyor moving product forward. Pressing “stop” on the pad turns the conveyor off.

2. **Holding – Tube Conveyor** – The key pad labeled “Holding – Tube Conveyor” controls the movement of cake temporarily being held at the holding bin. When the operator is ready to discharge cake to blend with equilibrated liquids exiting the pH reservoir, this conveyor is turned on. It will dump cake into the blending machine where it mixes with liquid and is uniformly inoculated as it falls into a fermenting bin on the trolley track below the blending machine. Pressing “run” on the pad activates the conveyor moving product forward. Pressing “stop on the pad stops the movement. The rate of movement may be increased by turning the frequency up or down. Ideally the liquid and cake or run to mix and blend in a manner that allows a small amount of trailing fluid to clear material on the inner walls of the discharge chute above the bin.

3. **Auger – Hopper Feed** – The Key pad labeled “Auger – Hopper Feed” moves material that was dumped into the hopper to the KP16 screw press. Normally the rate of the auger turning is set and optimized to feed the KP16 material that is being dewatered. Pressing “run” on the pad activates the auger moving product forward. Pressing “stop on the pad stops the movement. The rate of movement may be increased by turning the frequency up or down.

4. **KP16 Screw Press** – The Key pad labeled “KP16 Screw Press” controls the screw turn rate and is normally set in forward motion. If at any time there is a need to reverse the screw turn, it can be set in reverse (see instructions Controlling the Screw Turn Rate). The degree of dewatering is dependent on both the turn rate and the pressure on the cone at the end of the screw press. A compressor is used to apply pressure at the cone end of the press. Generally higher screw turn rates and lower cone pressure results in a wetter cake discharge. Slow turn rates and higher cone pressure may result in very dry cake blocking the discharge end of the press and should be avoided. The KP16 Vincent Corporation operator's manual should be read and understood by operators using the screw press. Pressing “run” on the pad activates the KP16 screw press moving product forward. Pressing “stop on the pad stops the movement. The rate of movement may be increased by turning the frequency up or down.

Blending Machine Motor Control:

The blending machine and motor control are located above the trolley where a bin is filled at the end of the line for the Receiving Station.

Blending Machine VFD:

Power to the 3 phase 3 HP blending machine is delivered to the VFD mounted on the discharge end of the receiving station tube conveyor near the trolley where bins are loaded with inoculated feedstock.

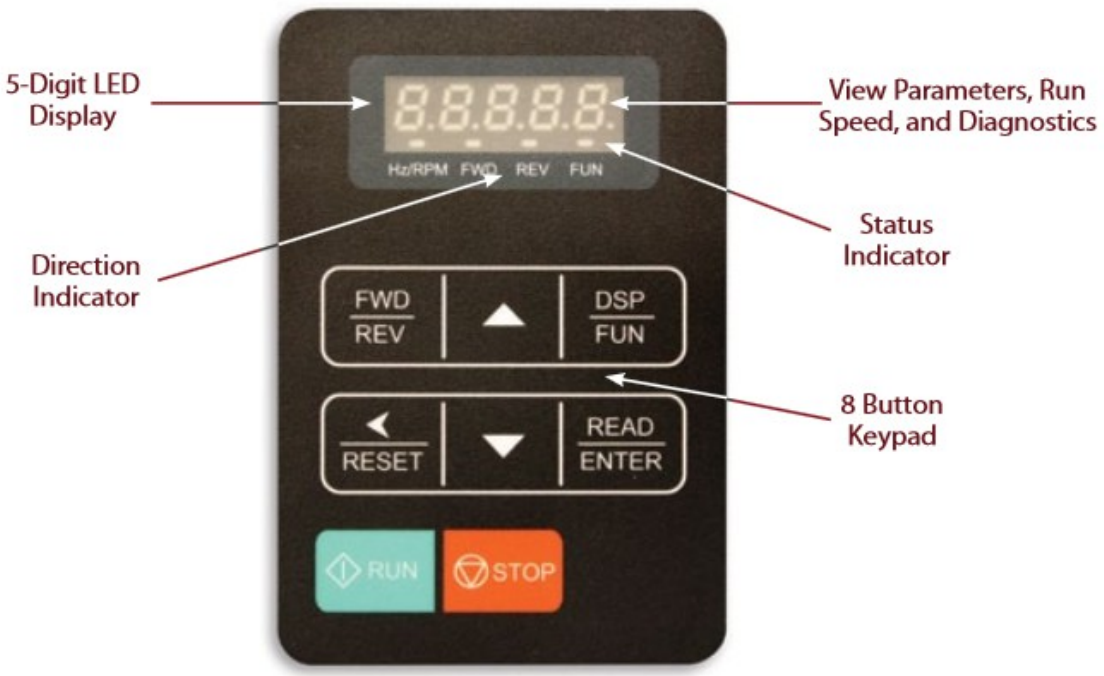
This is the only VFD on the production site floor available to an operator. ***It is set at 60 Hz in forward motion***. Do not change this setting. This VFD is NEMA rated IP66, water protected and can be operated in a designated wet area.

Input power may be cut immediately at any time by switching the power off (see diagram below).

With the power on position, the operator turns the motor on to blend and mix liquid and solids passing through the machine by hitting the (green) run button. The motor is turned off by hitting the (red) stop button.

* Available on models with suffix "FN4S-U"

As noted above, the frequency is set and remains at 60 Hz in forward motion. Key pad controls are identical to the Tecowestinghouse A510 controllers. The link to the operator's manual is as shown below.



On-Line E510 Teco Westinghouse Reference

https://www.tecowestinghouse.com/Manuals/E510_instruction_manual.pdf

Filling a Bin to Ferment at the Receiving Station Trolley End:

Bins are filled at a rate of 2 tons per bin at the terminal end of the Receiving Station. An empty bin on the trolley is placed under the discharge end of the blending machine and is then ready to fill.

The operator turns on the "Holding – Tube Conveyor" by pressing run at the control panel and then directs fluid from a pH mixing reservoir to discharge. The rate of fluid discharge can be controlled by opening more or closing down the valves at either the pH mixing reservoir or at the blending machine end to allow cake and fluid to uniformly mix as the bin is filled. Normally the "Holding – Tube Conveyor" rate is kept constant.

Once a bin is filled, it should be removed. Another bin should be place under the discharge chute in readiness for the next 2 ton batch of material in process.

VFD Settings and Adjustments:

Operators should become familiar with the VFD Keypad controls and appearance as shown below. The blending machine VFD and the Hydraulic Lift VFD are both 3 phase 3 HP controllers and they are set at 60 Hz frequency. These VFD's require no adjustments and are turned on by pressing “run” and off by pressing “stop”.

The other Keypad displays are as shown below. As noted, they are energized by pressing “run” and turned off by pressing “stop”.

The motor can be run in forward or reverse motion. The speed of the motor can be changed by increasing or decreasing the frequency Hz setting.

Keypad Display and Keys

On-Line A510 Teco Westinghouse Reference

https://www.tecowestinghouse.com/Manuals/A510_instruction_manual.pdf

LED Keypad Display and Keys

On-Line E510 Teco Westinghouse Reference

https://www.tecowestinghouse.com/Manuals/E510_instruction_manual.pdf

The E510 VFD's as noted above are set at 60 Hz forward motion and should not be changed. They are turned on or off by the operator using the “run” and “stop” buttons.

Controlling the Screw Turn Rate:

The screw turn rate either forward or reverse is controlled by the settings on the VFD. These operations are very straight forward. When the VFD is energized, the LCD panel is illuminated and the cursor will display blinking.

In the following example for a KP6 screw press we show how to calibrate turn rates with frequency settings. This exact same method applies to any machine or motor under control with a Tecowestinghouse VFD A510 controller.

The screw is only powered when the **"green" run key** is pressed. The screw is stopped when the **"red" stop key** is pressed. The factory default frequency reference is 5 HZ which is very low power delivered to the screw. At this frequency the turn rate is about 1.5 revolutions per minute.

You will first need to determine when the run key is depressed if the screw is turning in the direction to move product into the screw press (it may be turning in the wrong direction).

You can determine this by looking down the inlet hopper to observe the screw turning, or stand at the end opposite the motor (cone end) and note which direction the screw is rotating.

It should be turning clockwise to move material from the inlet down and out through the cone.

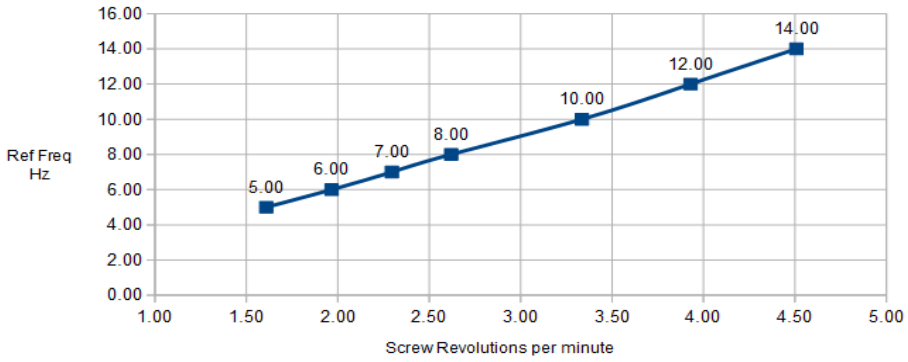
If the screw is moving in the wrong direction, you can change the direction by pressing the stop on the VFD. Then press the "REV" key. Hit run again and confirm it is now turning in the direction desired.

At any time you can forward or reverse the screw turn direction by stopping and pressing either "FWD" or "REV" keys on the VFD.

Turning Rate for the Screw Press:

How fast the screw turns over depends on the reference frequency. This is the only change you will generally have to adjust as operations proceed. Increasing the frequency (Hz) rate results in an increase in the speed of the screw turn.

As you can see below, the rate of turn is proportional to the frequency. The rate at 6 Hz is about half the rate at 12 Hz (2 versus 4 rpm).



Ref Freq Hz	Seconds 1 Rev	Rev per Minute
5.00	37.30	1.61
6.00	30.52	1.97
7.00	26.14	2.30
8.00	22.90	2.62
10.00	17.99	3.34
12.00	15.27	3.93
14.00	13.31	4.51

Changing the Turn Rate:

Changing the rate is straight forward. With the display set at "Freq Ref" and the cursor blinking, hit enter. Then move the cursor to shift left as needed from hundreds, to tenths, to unit frequency adjustments using the "RESET" key. Then press the up or down arrow key pad to either increase or decrease the frequency.

Hit "enter" on the key pad to set this new frequency reference setting. This will be the speed for all further operations whenever the VFD is energized unless another change is made and saved by "entering" a new reference frequency.

Central Processing Station Control Panel:

Central Processing – LED Indicators & VFD Controls:

There are 4 LED light indicators on the face of the Central Processing Control Panel that provide important information to the operator. Each LED when illuminated reports on an activity or function set or in process.

Sensing units and limit switches are located on the hydraulic tilt table to report these various activities resulting in the LED illumination.

In addition to the LED light indicators on the face of the panel there are 2 switches.

One switch is for the control panel lighting. Turning this switch on provides power to the sensing circuits at the hydraulic table and ***no power will be available at the tilt table for operations unless the panel light is turned ON.***

The second switch labeled "**Raise – Bin**" (upper location rocker forward) and "**Lower – Bin**" (lower location rocker down) is on the right side of the control panel and illuminates when the rocker is placed in the forward or down position. It is inactive and non-illuminated at the neutral center position. This rocker switch allows the operator to raise or lower a bin at the tilt table when a bin has been properly placed on the table with the security gate closed.

If a seal is inadvertently left on the bin, a sensing unit (red LED on the control panel) turns on and prevents power going to the hydraulic pump control valves. The tilt table will not function until the seal is removed from the bin.

If a bin is properly set on the table without a seal but the security gate is improperly closed or left open, no power will be delivered to the control valves on the hydraulic pump to lift the bin. When the gate is closed properly, the green LED indicating the gate is closed will illuminate and remain so as long as the gate is maintained in the closed position.

If at any time during operations the gate is opened, the tilt table power is taken away from the operator.

VFD Controls:

There are 4 VFD controller key pads that are illuminated when power is delivered to the control panel. In the order from left to right the VFD key pads are labeled as shown below;

5. **Hydraulic Lift** - The key pad labeled "hydraulic lift" is set at a frequency of 60 Hz in forward mode and provides power to the hydraulic pump. Do not change these settings which are required for proper operation of the hydraulic pump. Pressing "run" on the pad activates the pump. Pressing "stop" on the pad turns the pump off.
6. **Bin – Tube Conveyor** – The key pad labeled "Bin – Tube Conveyor" controls the movement of cake exiting the screw press from the end of the screw press to a point at the end of the line where product will be collected. Pressing "run" on the pad activates the conveyor moving product forward. Pressing "stop on the pad stops the movement. The rate of movement may be increased by turning the frequency up or down.
7. **Auger – Hopper Feed** – The Key pad labeled "Auger – Hopper Feed" moves material that was dumped into the hopper to the KP16 screw press. Normally the rate of the auger turning is set and optimized to feed the KP16 material that is being dewatered. Pressing "run" on the pad activates the conveyor moving product forward. Pressing "stop on the pad stops the movement. The rate of movement may be increased by turning the frequency up or down.
8. **KP16 Screw Press** – The Key pad labeled "KP16 Screw Press" controls the screw turn rate and is normally set in forward motion. If at any time there is a need to reverse the screw turn, it can be set in reverse (see instructions Controlling the Screw Turn Rate). The degree of dewatering is dependent on both the turn rate and the pressure on the cone at the end of the screw press. A compressor is used to apply pressure at the cone end of the press. Generally higher screw turn rates and lower cone pressure results in a wetter cake discharge. Slow turn rates and higher cone pressure may result in very dry cake blocking the discharge end of the press and should be avoided. The KP16 Vincent Corporation operator's manual should be read and understood by operators using the screw press. Pressing "run" on the pad activates the KP16 screw press moving product forward. Pressing "stop on the pad stops the movement. The rate of movement may be increased by turning the frequency up or down.

LED Light Indicators:

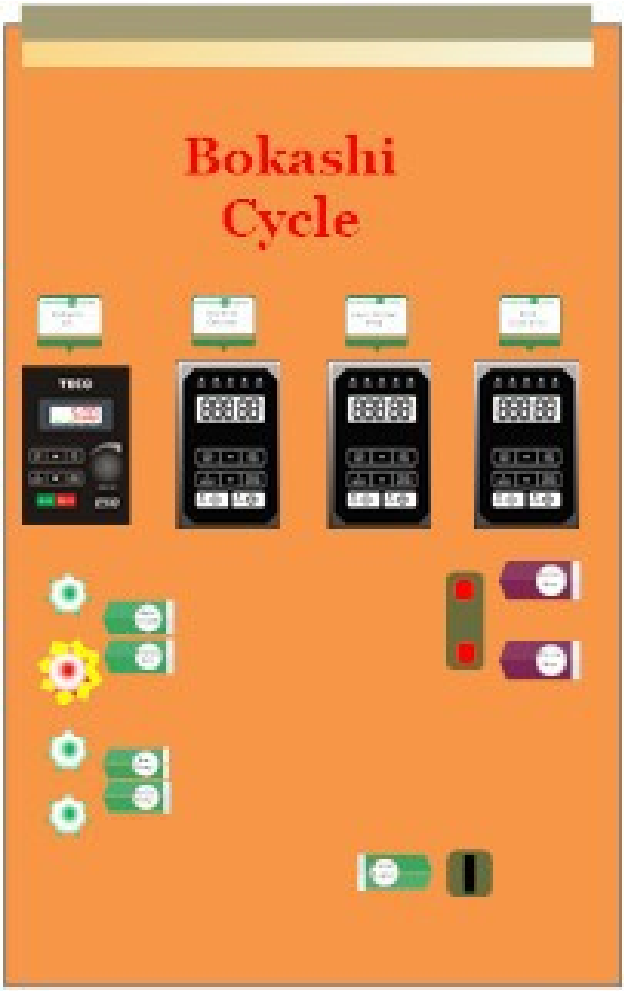
Operators should become familiar with these signal LED indicators as they are an important safety feature and guide to processing materials.

The LED illuminated lights are designed to reveal what is happening at the hydraulic tilt table to the operator at all times. Examples of the indicator lights are as shown below for several situations that may be encountered.Security Gate Open:

If the security gate is open, the red LED will display as long as 24 VDC is available at the control panel.

The control panel light must always be turned on at the Central Processing Station to have 24 VDC active. The hydraulic lift will not be energized and lift a bin even if the hydraulic pump is active without 24 VDC.

Even though the hydraulic pump is running, the tilt table will not activate to lift as no power is delivered to open or close control valves at the pump. LEDs are all dark as shown.



Security Gate Open
No Power to Lift

With or without a bin on the table all of the green LEDs are dark with the gate open and no power can be delivered to the control valves on the pump. The red LED will be illuminated if the gate is open if there is 24 VDC power.

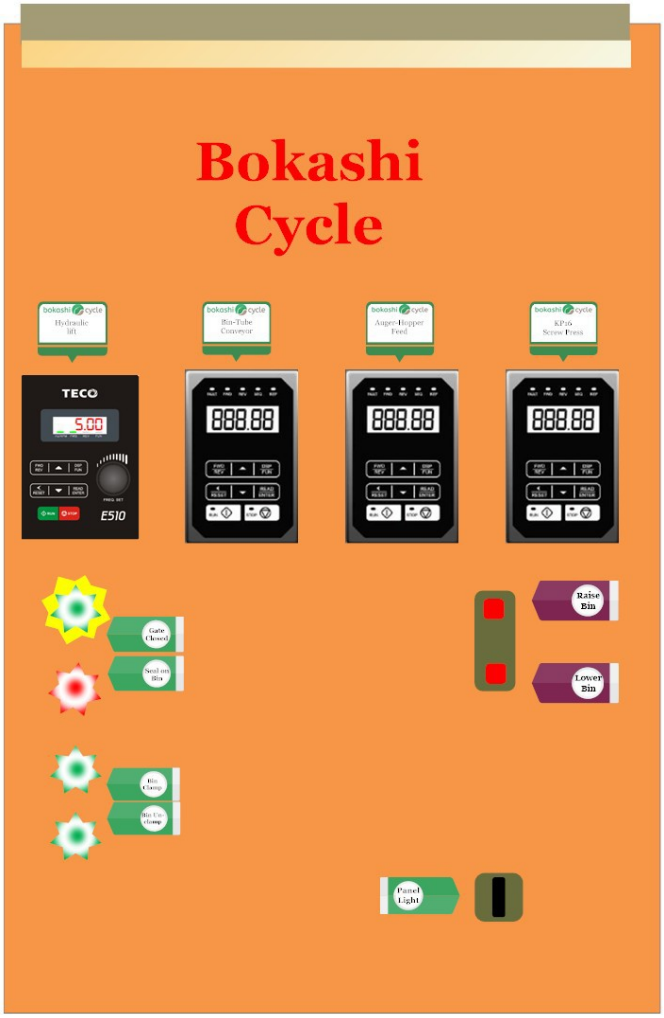
Security Gate Open Seal on Bin:

When the seal is left on the bin, the red LED will illuminate reminding the operator to remove the seal (or close the security gate). No power to lift the bin is available as long as a seal is in place regardless if the gate is closed or open.

Security Gate Open
Seal on Bin
No Power to Lift

Security Gate Closed No Seal on Bin:

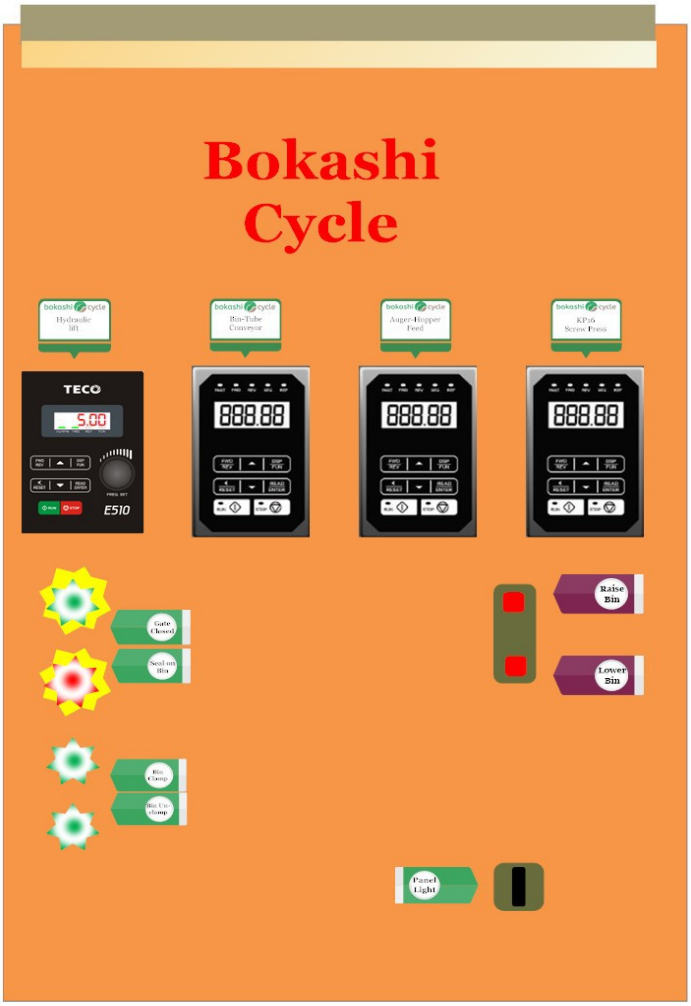
When the security gate is closed, the green LED for the closed gate is illuminated. Power to lift a bin is now available. If a seal is in place, no power will be available to lift the bin and the red LED will illuminate.



Security Gate Closed
Ready to Lift Bin

Security Gate Closed Seal on Bin:

Gate is closed but seal is still on bin. There is no power to lift the tilt table bin and the red LED is illuminated.



Security Gate Closed
Seal on Bin
No Power to Lift

Security Gate Closed Bin Table Lift:

When a bin is properly set on the tilt table without a seal in place, and the gate is closed, the operator can activate the bin lift to empty its contents into the auger-hopper feeding the KP16 screw press.

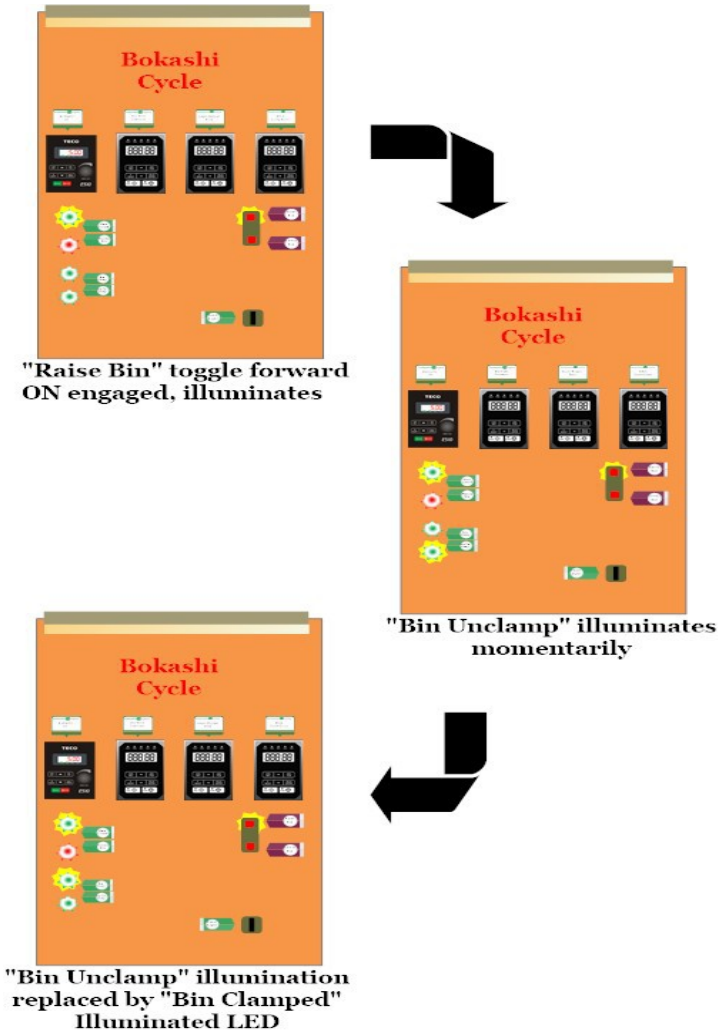
To raise the bin, the toggle switch is pushed forward and power is confirmed by the “Raise Bin” toggle light illuminating. The table will lift the bin to the full tilt position and remain at that position. When the bin reaches its full tilt position it will remain at that position if the lift rocker toggle is active or in the neutral position.

Initially, when the rocker switch is pushed to "Raise", the "Bin Unclamp" LED will be illuminated indicating that the bin is not yet clamped securely.

The raise sequence includes automatic clamping of the bin that is confirmed, and then switches over to raising the bin. After a few seconds when the bin is sensed to be properly secured, the "Bin Unclamp" LED will extinguish and the "Bin Clamped" LED will illuminate.

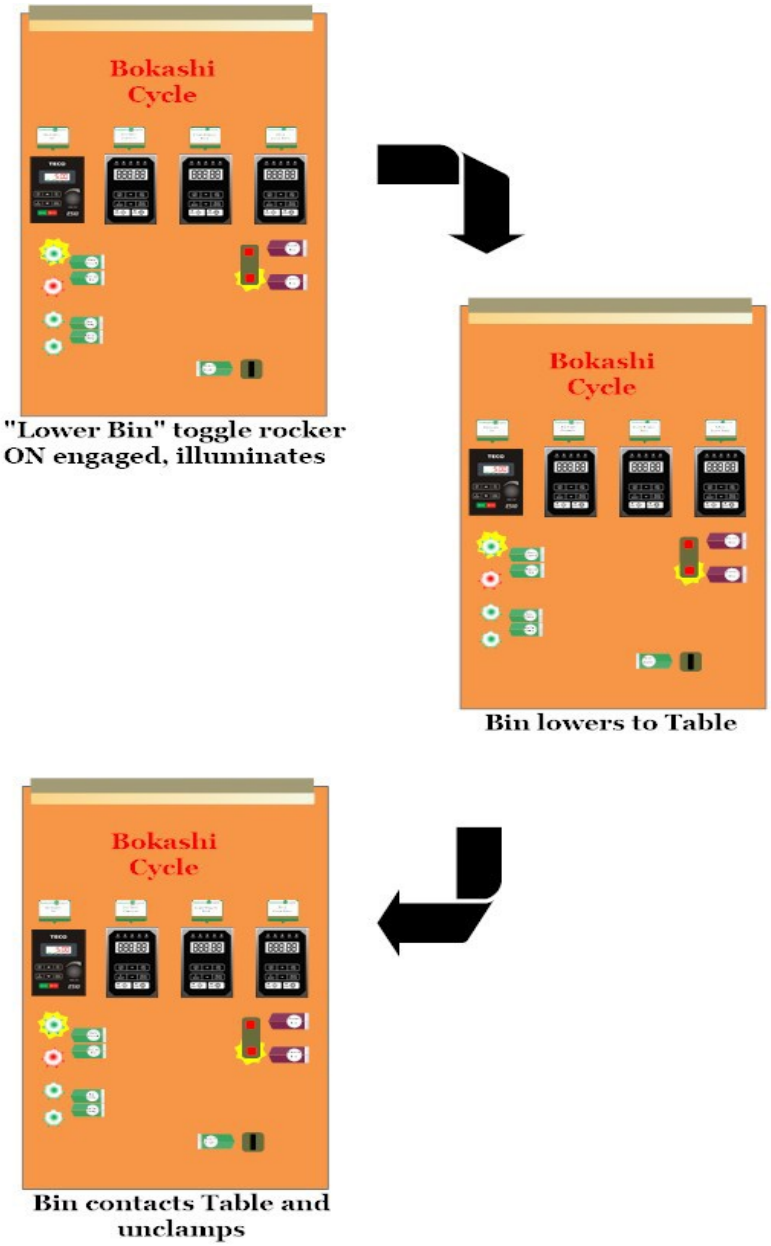
The “Bin Unclamp” light will illuminate confirming the clamp is properly positioned, and that LED will then extinguish as the “Bin Clamped” LED illuminates. The “Bin Clamped” LED will remain illuminated showing the bin is secure on the table locked in position as long as the rocker switch is pushed forward and illuminated.

The steps in confirming the bin is properly secured before lifting are verified as the “Bin Unclamp” LED is illuminated and then extinguished with the “Bin Clamped” LED illuminated at the time the bin is secured to the table.



Security Gate Closed Bin Table Lowering:

The bin in any position above the tilt table can be reversed and lowered to the table bed. This is accomplished by first moving the rocker switch momentarily to the center/neutral position, then to the Lower position. The “Lower Bin” power light will be illuminated and the table will lower to the table bed. ***Set rocker switch at neutral after landing the bin.***



A few seconds after the bin has landed, the lower sequence will move the bin off of the locking pins making it ready for removal. The locking pins securing the bin on the table have disengaged allowing an operator to open the gate and safely remove the empty bin. The LED indicators for this operation are as shown.

Loading and Unloading Bins on the Hydraulic Tilt Table:

Bins with fermented manure are moved from fermenting bays on to the hydraulic tilt table at the Central Processing Station. After 16 days the bio-active manure in a 3 cubic yard fermenting bin is taken to the tilt table using a fork lift capable of lifting 5,000 lbs.

Each bin holds approximately 2 tons of fermented manure. The seal should be removed and set aside before the bin is placed on the table.

Central Processing Bin Positioning Light Tower:

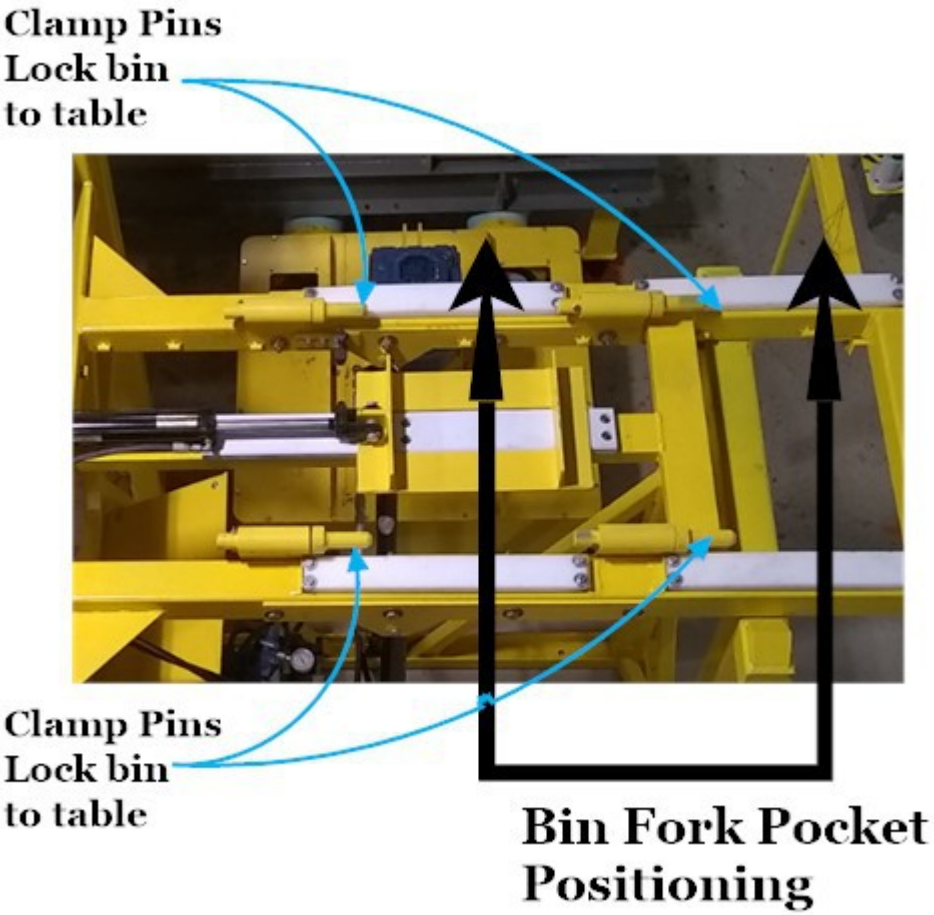
A light tower is mounted on the table bed frame and moves with the bin when it is raised or lowered. The tower lights when illuminated signals to the operator approaching the table how to place the bin in position so that the bin fork lift pockets are correctly located on the table for locking pins on the table to properly lock the bin on the table during a hydraulic lift.

If the pins do not lock properly ("Bin Clamped"), the operator will not be able to hydraulically lift the bin and dump its contents into the auger-hopper that feeds the screw press.

Fork lift pockets are designed to fit locking pins attached to the hydraulic tilt table to prevent movement or loss relative to the table frame as the bin is lifted and emptied.

The bin is always locked to the table at any position when raising or lowering the bin.

When a bin is positioned as shown below, with the fork pockets resting between the locking pins, it is properly loaded onto the table.



This proper position of the bin is confirmed when the security gate is closed and the "Raise Bin" rocker switch is powered on by rocking it forward at the Central Processing control panel.

The clamping cylinder retracts forcing the bin onto the locking pins. The green LED "Bin Clamped" illuminates as the table begins to lift.

The steps to properly position the bin on the table are as follows;

1. Open the security gate so that a fork lift can move with a bin to place it on the table.
2. With a fork lift, raise the bin high enough so that the bin pockets on the bottom of the fermenting bin will clear (left to right) the top of the table.
3. Align the fork pockets on the bottom of the bin with the table top openings so that the pockets will be just to the right of the locking pins.
4. As the forklift operator approaches with the bin and the bin crosses over the table top frame, a green LED light (positioning light) will illuminate signaling that the safe "set zone" for the bin has been entered. The locking pin slots in the pockets allow for approximately 6 inches forward and back movement for successful locking of the bin.
5. If in moving forward, when the fork lift has gone too deep, a red LED light will appear signaling to back away an inch or two cautiously.
6. The bin should then be set softly on the table.
7. The position indicating green LED light will remain illuminated as the fork lift operator disengages leaving the table loading area.
8. The security gate should then be closed.
9. At the control panel the “Gate Closed” LED light will then illuminate so that the operator can proceed raising the bin and dumping its contents into the auger-feed hopper.

Removing a Bin from the Hydraulic Tilt Table:

When a bin (loaded or unloaded) lands on the hydraulic tilt table, a limit switch is engaged that causes the locking pins to disengage from the bin fork pockets. The bin is then “Unclamped”.

Fork lift operators should always confirm that the bin is unclamped before attempting to lift the bin off of the table. If a bin has securely landed on the table and fails to unclamp, then the operator at the control panel should be advised of a problem and no further work should proceed at the table until the problem has been resolved and the bin on landing unclamps.

This event could be as simple as the limit switch has been damaged or displaced so no signal to unclamp the bin occurred. If the bin is not fully brought down to a landing position, it will remain clamped.

Generally, removing the bin is the reverse of loading. With the bin unclamped, the operator opens the gate, approaches the bin with a fork lift engaging with the pockets, and then lifts the bin off the table and backs away to clear the gate.

No operators or employees should ever be within the gate area under the hydraulic table when it is in operation and never close the gate while inside the area under the tilt table.

Dewatering Fermented Manure – End Product Production:

It is the operator's responsibility to define the level of dewatering and outputs that define and characterize AgroBio Products that are being produced.

The feed-auger hopper freshly loaded with fermented manure is normally set at a screw turn rate that slightly under feeds the capacity of the KP16 screw press. The optimal turn rate for both the KP16 and its cone pressure and the feed-auger hopper turn rate are arrived at empirically. Calibration curves should be constructed so that consistent outcomes in production are maintained.

The KP16 is rated at dewatering rates of 15,000 to 30,000 lbs per hour. Because of the normal time it takes to load and unload a 2 ton capacity bin on the hydraulic tilt table, these dewatering units have more than enough capacity to process what we believe is a high throughput process at 4 tons per hour (less than 50% capacity loading).

Distribution of Tea and Cake for Packaging:

Dewatered manure (cake) is transported by tube conveyor to the end of the Central Processing Station where it is collected in a bin for subsequent handling and packaging.

Both the “tea” and “cake” (dewatered fermented manure) should be package to exclude oxygen exposure as soon as possible. Prolonged air exposure will result in oxidation and the forming of many mycelia (white fungal growths) that can cause sprayers to clog.

Liquid leaving the KP16 is collected by gravity drainage through a 4 inch diameter pipe that is directed to a catch basin fitted with a pump capable of moving both suspended solids and liquid at up to 120 gallons per minute.

The pump in the catch basin (blue barrel in the image below) triggers a transfer of material to a 275 gallon cage tote reservoir in 15 to 20 gallon increments.

The cage tote reservoir is fitted with an equivalent 0.4 HP pump that will turn on to discharge approximately 225 gallons of filtered tea to a final product cage tote devoid of particles greater than 200 microns.

The cage tote reservoir is fitted with an immersion upper and lower sensing probe that turns the discharge pump on when the upper probe is in contact with fluid in the tote.

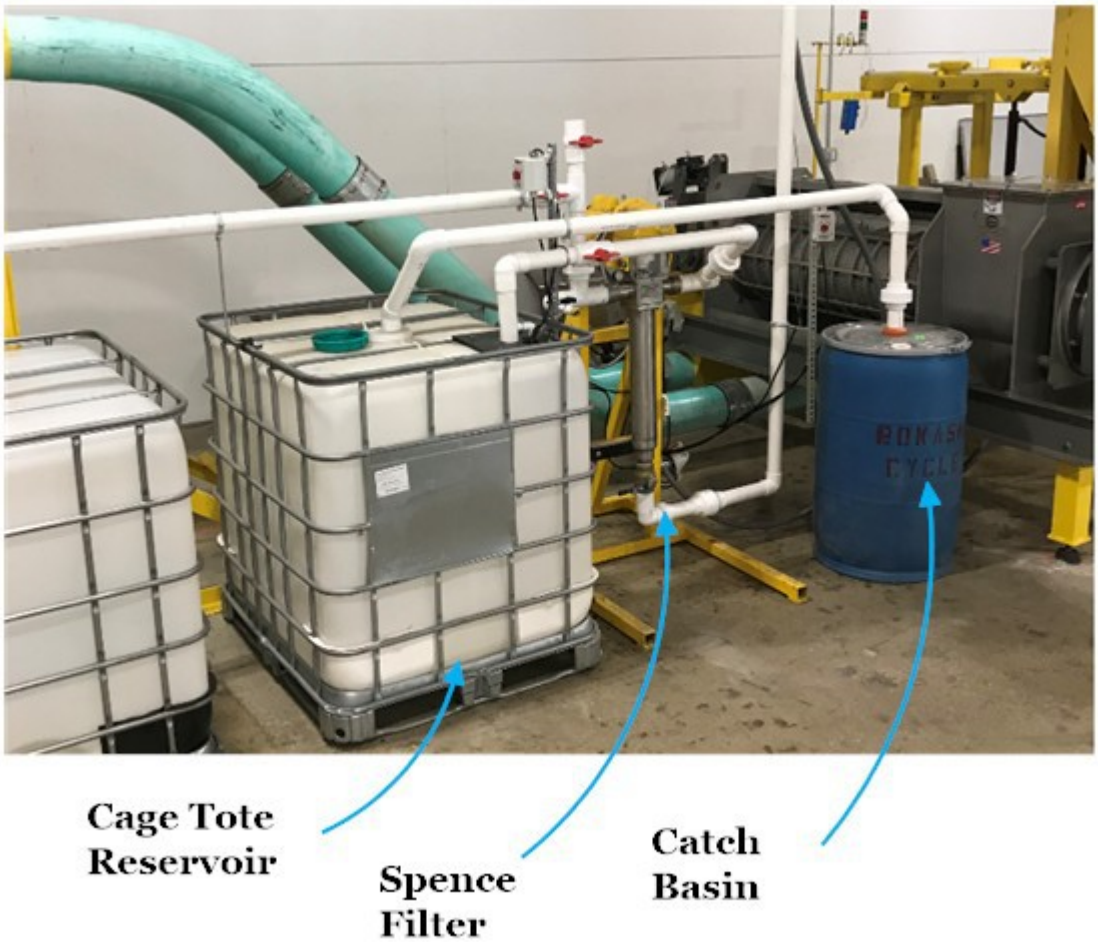
Since discharge is at a rate of about 100 gallons per minute it takes only a few moments to empty the cage tote reservoir. The pump is automatically turned off when the level of fluid drops again to the lower probe sensing unit and will not turn on again until fluid once again comes in contact with the upper probe.

The fluid transferring to the filtered product cage tote moves first through the Spence filter on its way to the filter product cage tote.

The Spence filter can be seen in the picture below. It is normally equipped with a filter to remove suspended particles greater than 200 microns which are periodically manually returned to the auger-hopper feeding the KP16 screw press.

More details on maintaining efficient filtering and back flushing to clean the Spence filter are provided with details below. The operator's manual on the Spence filter may also be consulted when replacing parts or changing to a different size filter.

Under optimal conditions of dewatering, the discharge rate of liquid at the KP16 can be as high as 60 gallons per minute.

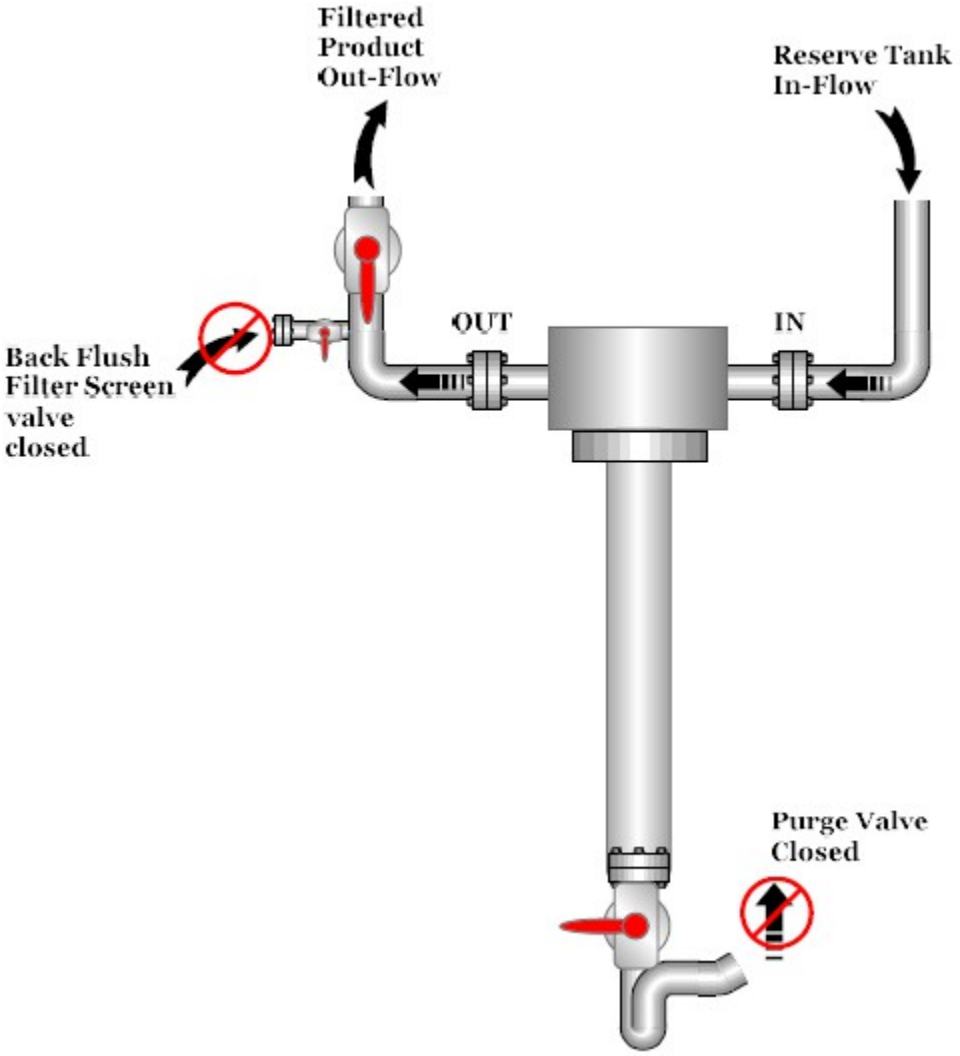


Spence Strainer – Filtering and Purging Operations

The Spence Strainer is used to remove suspended material at a size greater than 200 microns from the liquid obtained by dewatering the bio pulp. When the reserve tote cage fills to the trigger level, approximately 225 gallons of fluid is pumped through the strainer.

A check valve prevents fluid exiting the tote cage reservoir from back flowing and all fluid passes to an inlet port on the Spence Strainer. The unfiltered fluid may have numerous suspended particles which are removed and directed back through the screw press.

Normal Filter Valve Positions



The normal valve positions for efficient filtering are as shown in the diagram above. The 2 inch pipes on the Spence Filter are marked clearly designating the "IN" and "OUT" ports for proper filtering.

Fluid with particle size or suspensions less than 200 microns pass through a stainless steel screen and pass on to the exit ("OUT") port. The fluid passes to a cage tote and is ready for packaging or shipping to clients as a clean ready to use product.

The particles that do not pass through the screen are constantly being removed at the surface as the screen is swept with PEEK wiper blades and the heavier suspended particles accumulate within the cylinder. Most material will fall to the bottom where it is periodically removed.

The amount of material accumulating in the cylinder depends on the volume of suspended material in solution and experience will determine how often purging should take place.

Purging the cylinder is a normal procedure to remove accumulating materials too large to pass through the filtering screen. The purged material as noted is passed back through the screw press and ends up as either cake or is broken down to a size sufficiently small to pass the filtering process.

In addition to purging the system to remove accumulated particulate matter, the system is designed to allow the operator to back flow (reverse the flow of material through the screen) which has the advantage of removing material that may have lodged within the stainless steel screen. The wiper blades are also contributing to clearing of the screen and operators should be acquainted with proper care and maintenance for optimal machine performance.

There are 3 valves associated with the Spence Strainer and various operations are selected by how the valves are opened or closed.

1. Normal Operation –
    a. Back flush valve is closed,
    b. Exit valve for filtered product open
    c. Purge Valve is closed
2. Purging Operation -
    a. Purge valve is opened – purging can be done during back flushing or with normal operation opening the purge valve transiently to remove accumulated material at the bottom of the cylinder.
3. Back Flushing to Clean Trapped Screen Material –

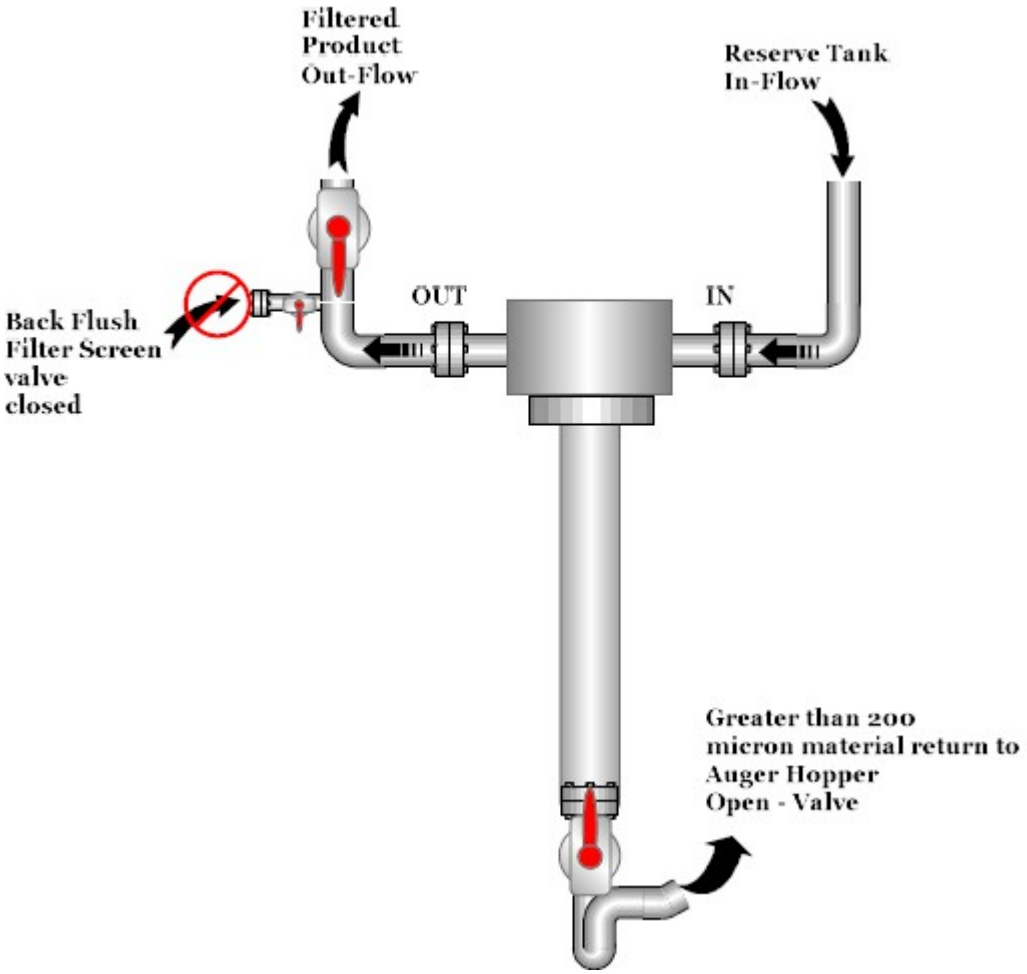
a. Exit valve is closed (to final product cage tote),

b. Back flush valve is open with an attached water hose connected and under pressure (water turned on).

c. Purge valve is open.

Purging Valve Positions

Purging will remove accumulating material at the bottom of the cylinder. This can be done during the normal filtering activity by intermittently opening the purge valve while fluid is passing through the system as shown below. It can also be done separately during the back flushing procedure (see below).

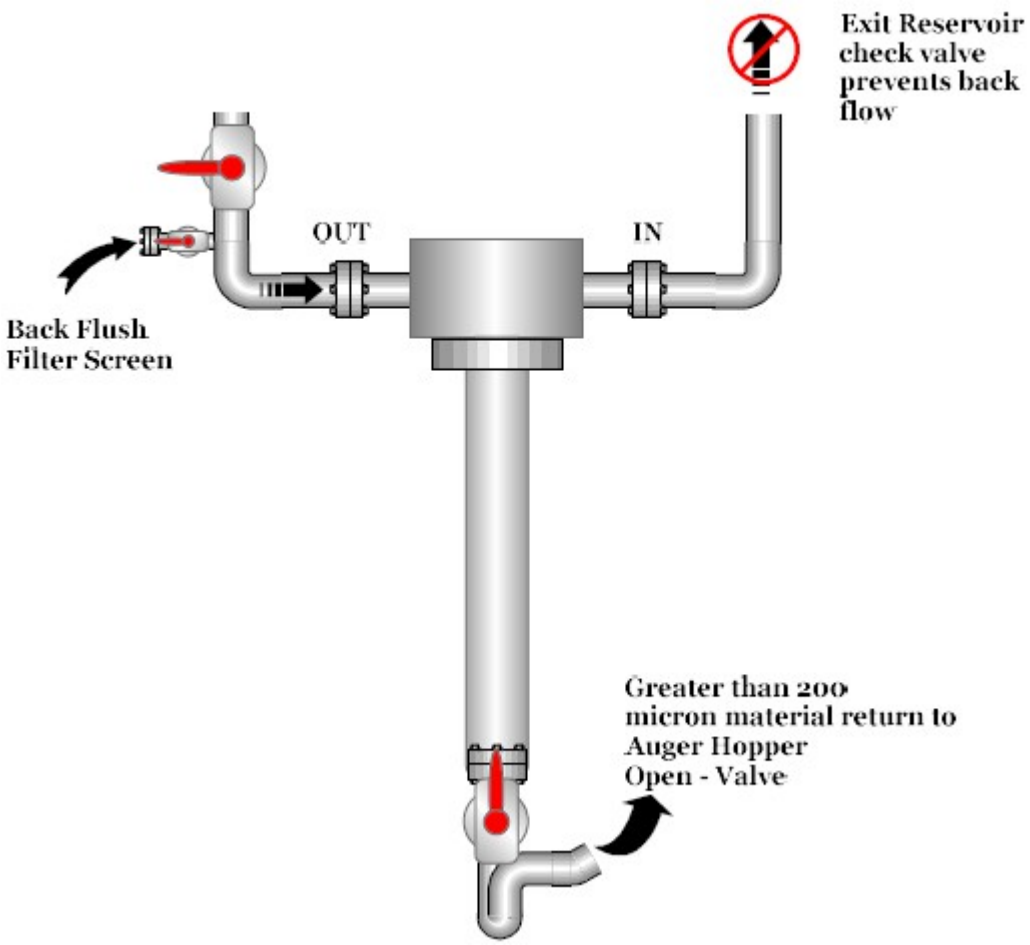


Back Flushing to Clean Trapped Screen Material

Back flushing the screen is highly recommended to preserve the screen integrity and for best filtering performance. We recommend back flushing at least once each day the unit is in use.

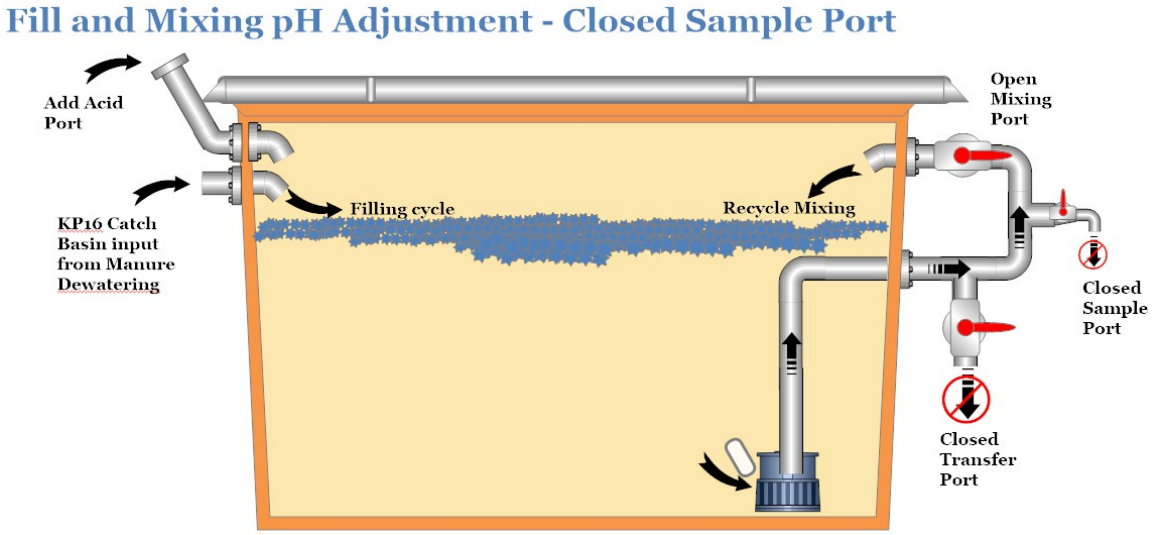
A water hose with the water turned on is attached to the back flushing port and the valve is opened. The purge valve is then opened as shown in the above diagram. High pressure is not required and water should flow freely through the purging port into the auger hopper.

When the water is flowing freely and clear through the purging port, the screen is clear of trapped material. Valves should then be placed back into the normal filtering mode.



Appendix A:

Mixing pH Reservoir:



There are 5 ports on the Mixing pH Reservoir.

1. **Catch basin fill port** – the entry port filling the reservoir. Fluid obtained in the dewatering of manure is pumped into the reservoir for pH adjustments.
2. **Add Acid port** – the port which allows for additional acid to be added if the pH is too high for optimal fermenting.
3. **Mixing port** – the valve controlled port that allows fluid to rapidly cycle to obtain a uniform pH in the fluid. Mixing of fluid is continuous when this valve is in the open position and stopped when the valve is in the closed position.
4. **Transfer port** – the valve controlled transfer port. When this valve is opened, fluid from the Mixing pH Reservoir is pumped out of the reservoir to recombine with manure solids in the step that initiates fermentation.
5. **Sample port** – the sampling port to allow sample collections from the reservoir as fluid circulates and mixes.

These ports are identified on the diagrams as shown and operators should be familiar with their proper use and function.

Also shown in this diagram is the Liberty 41A sewage pump which is located within the Mixing pH Reservoir. A float switch powers the pump on or off depending on the volume of liquid in the reservoir.

When the fluid level triggers the pump to switch on, fluid moves as shown in the diagram forming a continuous loop mixing at approximately 120 gallons per minute as the reservoir is being filled. Mixing will continue as long as the Mixing port valve is in the open position with a closed transfer (and sample) port valve.

The **normal valve position** is "**Open Mixing Port**", "**Closed Sample Port**" and "**Closed Transfer Port**". The sample and transfer ports are only opened when samples are collected and when the reservoir is being emptied and operators should **always return these valves to their closed position when those operations are completed.**

As shown above during the filling and mixing phase, the Mixing port is open and the Transfer port is closed. Fluid enters the reservoir and rises to a level triggering the pump to circulate fluid. Circulating fluid remains active as long as the fluid is in the reservoir.

The capacity of the reservoir is approximately 500 gallons and greatly exceeds the volume of liquid that can be obtained in dewatering 2 tons of manure.

The sample port is used to confirm the pH is within the range 3.5 to 6.0, and preferably between 4 and 5.

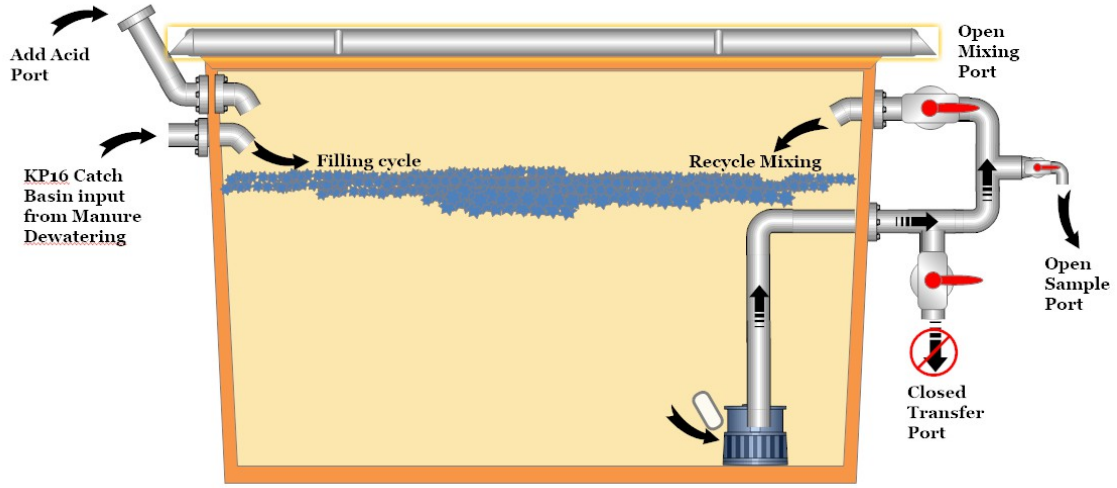
Additional acid may be added using the Add Acid port. A second sample can then be collected to confirm a proper pH has been obtained before transferring the fluid to the fermenting bins.

Sampling the Fluid for pH Adjustments:

A small amount of the fluid may be obtained while mixing is in progress by opening the Sample port. If the pH is too high and acid has been added, a second sample for checking the pH may be obtained but the operator should allow a few minutes circulating of fluid before obtaining another sample.

The sample port should be opened with care and closed immediately after a sample is obtained as the fluid circulating is under pressure. The valve position for sample collection is shown below (Open Sample Port).

Fill and Mixing pH Adjustment - Open Sample Port



All of the manure dewatering should be completed before any transfer of fluid is initiated from the Mixing reservoir to the fermenting bins.

Another batch of manure should not be started until the Mixing reservoir transfer is complete and the transfer valve is in the closed position for a reservoir in process.

Two Mixing pH Reservoirs for High Throughput Efficiency:

Having 2 identical Mixing pH Reservoirs working in the process is a great advantage and is highly recommended.

Operators can significantly speed up the manure processing if the auger hopper can be reloaded with manure when a manure batch previously loaded has passed completely into the screw press.

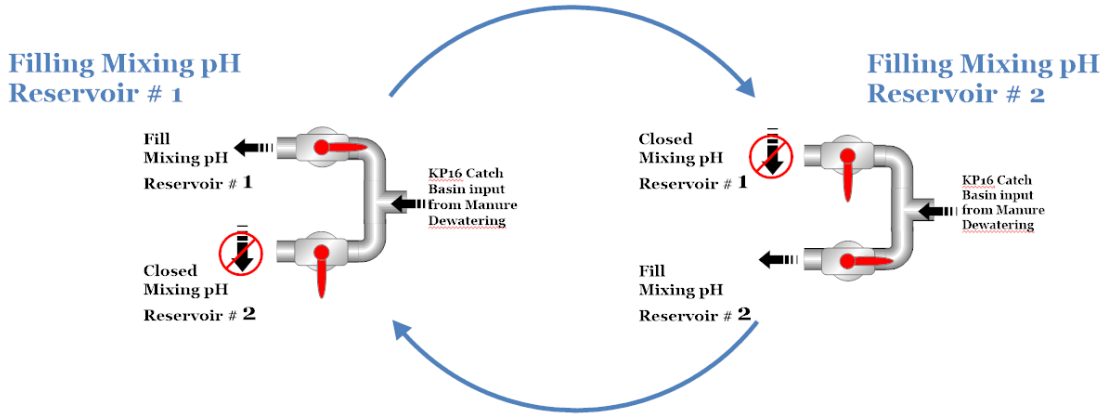
With a single Mixing pH Reservoir the next batch of manure can not be loaded for dewatering until all of the fluid in the Mixing pH Reservoir has been pH adjusted and transferred out of the reservoir.

It may take 5 to 10 minutes to empty the reservoir once the fluid is properly equilibrated and pH adjusted. With a single reservoir operators have to wait until the fluid in the reservoir is transferred to fermenting bins.

Continuous dewatering without delay is accomplished by switching back and forth between 2 reservoirs.

The fluid obtained by dewatering moves first to the catch basin and from there to the Mixing pH Reservoir. A wye junction is used to direct fluid for each batch in process to one or the other of 2 Mixing pH Reservoirs (diagram below).

Alternating Reservoirs in Batch Processing:



As shown above, the operator simply redirects fluid from the catch basin from one reservoir to the alternate reservoir at the end of each dewatering cycle.

This is accomplished by closing the valve for the reservoir currently being filled and opening the valve to the reservoir previously filled and emptied. In this way the dewatering step is nearly continuous without a waiting period as occurs with a single Mixing pH Reservoir.

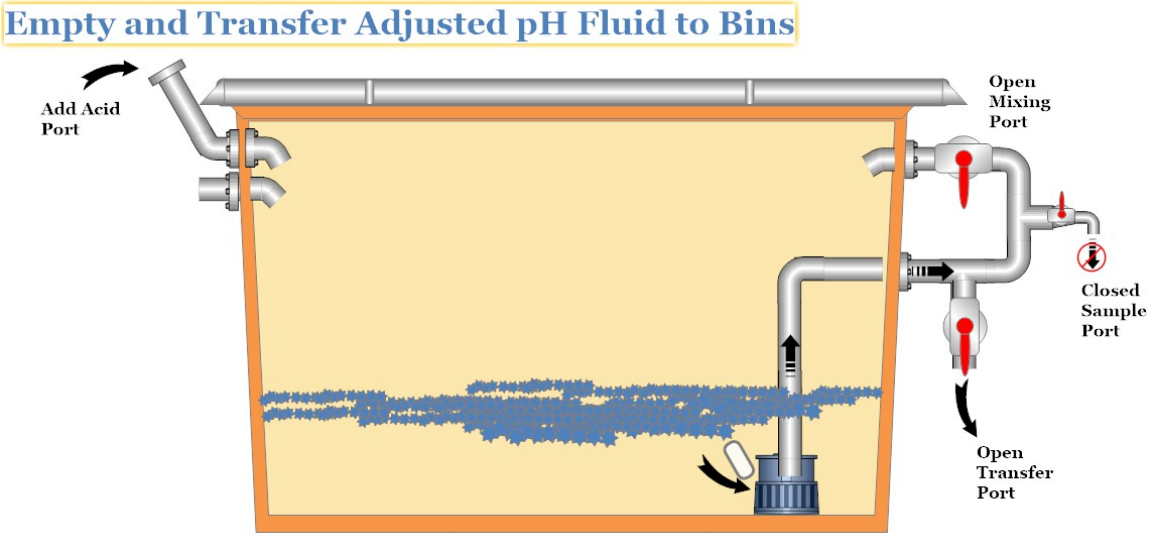
The time to equilibrate and pH adjust fluid and to transfer fluid from the Mixing pH Reservoir to the fermenting bin is short relative to the time to dewater 2 tons of manure.

A second Mixing pH Reservoir provides in addition to higher efficient processing rates, a redundant reservoir that is available for use in the event a problem results in a particular batch that takes time to resolve before fluid is transferred to the fermenting bin.

Transferring pH Adjusted Fluid to the Fermenting Bins:

Although it is not essential to close the Mixing port valve during the transfer phase, closing that valve will allow for a faster emptying of the reservoir.

As the fluid is transferred, the level of the fluid drops rapidly and the pump will normally stop running when the transfer is complete. The valve positions for transferring fluid to the fermenting bins is shown below.



The Transfer port valve should be closed and the Mixing port valve opened at the end of the transfer.

Appendix A: Step by Step Protocol – Manure Fermenting:

Activity	Comment
1. Locate and identify materials needed to ferment the manure.	Confirm that sufficient Glacial Acetic acid, Muriatic acid and bokashi culture mix are available to process the volume of manure to be fermented. Confirm a calibrated pH meter is available to verify pH readings on samples collected.
2. Verify the Mixing pH Reservoir valves are set properly.	Mixing port valve open, Sample port closed, Transfer port closed
3. Confirm power is available for the screw press, auger hopper, tube conveyor, pulverizing machine and pumps.	Power indicators on the VFD for the KP16 and auger hopper should be illuminated.
4. Confirm that a 2 ton capacity fermenting bin is available for filling.	Locate an available or empty fermenting bin taken from central processing.
5. Place the fermenting bin under the pulverizing machine.	Fermenting bins have ID labels located on the anaerobic seal.
6. Record the date and fermenting ID bin number for the batch of manure to be processed.	A record of each batch of manure processed must be established.
7. Identify the "bay" location where the fermenting bin will be placed once the batch is delivered to the bin.	Normally all bins collected on a particular day are placed together and allowed to age 16 days as fermenting progresses.
8. Select Mixing pH Reservoir to Use.	Open the valve for reservoir to be filled and close valve to just filled alternate reservoir.
9. Power on the KP16 screw press.	Optimal drive frequency is established by history and standardized.
10. Power up auger hopper.	
11. Load approximately 2 tons of manure into the auger hopper.	
12. Add ~2 gallon of glacial acetic acid and 50 lbs of Bokashi culture mix to the auger hopper.	Manure requires 25 lbs of Bokashi culture mix per ton to ferment. Glacial Acetic acid volumes for pH optimal adjustments are established by history.
13. Power on the KP16 tube conveyor for solid components.	Conveyor delivers "cake" to the temporary holding bin during which time the liquid fraction pH is adjusted to ~4.5.

Activity	Comment
14. Liquid moves from screw press to Mixing reservoir – check pH via sample port.	Confirm pump in Mixing reservoir is active as reservoir fills with fluid.
15. Obtain sample and check pH.	If pH is too high, add acid via the Add Acid port and allow a few minutes to equilibrate.
16. If pH is greater than 5, repeat steps 12 and 13.	Sampling is ideally done when the auger hopper has emptied and no more fluid is moving from the catch basin to the Mixing reservoir.
17. Transfer liquid and solid components to the fermenting bin.	
18. Power on the pulverizing machine.	Liquid and solid components are recombined as they pass through the machine resulting in a fully inoculated and mixed substrate for fermenting with an optimized pH.
19. Power on the Temporary Holding bin tube conveyor.	
20. Close the Mixing Port valve while opening the Transfer port valve.	Fluid moves from the Mixing reservoir to the pulverizing machine.
21. Complete the transfer to the fermenting bin.	
22. Close the Transfer port valve and open the Mixing port valve.	Sample port valve should remain closed.
23. Place the anaerobic seal over the fermenting bin with its ID and move the bin to its bay location.	Confirm date and ID are recorded in the record with the bay location.
24. Return to step 1 for processing the next 2 ton batch of manure.	