#785-847

GPC – STARCH COOKER

Operator's Manual

INTRODUCTION

The GPC Thermal Converter provides the user with a continuous automated system to prepare starch paste. Because of the properties of the starch being prepared, the basic unit consists of:

1. Slurry pump
2. Heating jet
3. Hold coil
4. ~~Chemical Addition System~~ — Delete.
5. Control instrumentation

With this equipment, the following functions can be performed:

A. Temperature Controlled High Shear Cooking

In the heating jet, steam enters the starch slurry flow to disperse the starch and elevate its temperature.

B. Thorough Starch Pasting and Necessary Chemical Reaction Time

The hold coil provides the necessary retention time to completely control the amount of starch modification. A back pressure valve prevents flashing in the coil and maintains the elevated product temperature. Usually set @ ~ 70 psi

C. Solids Control

Paste solids over a wide range are obtainable directly from the converter. This can be achieved by the controlled addition of pre-dilution water to the starch slurry so the pasting through the jet always takes place at the same flow rate, but the starch concentration can be varied. Solids also can be controlled by post-dilution water addition in the flash chamber for final solids and temperature control. Pre dilution alters solids coming into chamber

~~D. Automatic Chemical Addition System~~ Post Dilution changes exit solids

Delete

~~To modify the starch, ammonium persulfate is added to the starch slurry just prior to cooking in the jet. This chemical, also known as AP, is a soluble oxidant which reduces the viscosity of the cooked starch paste in direct proportion to the amount used. An automatic pressure tank system is used to pump and meter the AP solution into the slurry.~~

E. Control Instrumentation

Automatic controllers operate pneumatic control valves to regulate all flow rates and the cooking temperature. In addition, an electronic programmer is employed to allow proper sequencing of all the control components. This leads to complete automatic cycling from start to finish to heat the unit on water, switch to starch, produce starch paste, then flush the unit with water. Alarm instrumentation is also incorporated to shut the cooker down in case of a malfunction.

TYPICAL OPERATION

Basically, the unit has five steps to complete one cycle. These are: Start #1, Start #2, Run, Flush, and Standby. Each phase has a separate and specific role to play in the production of the starch adhesive. These phases are designed to warm the cooker on water, heat the starch slurry, divert the product to a storage tank when specified, then flush the system out when the demand is met, and stand by until more product is required.

To add versatility to the cooker, it can be operated manually or directly from a storage tank level on demand for product. A level sensing device (d/p cell) on the product tank will start the cooker up from the standby phase and when in the run cycle a high level will then advance the cooker to the flush cycle. This is called the "Auto" mode. Otherwise, in the "Hand" mode, an advance button is provided to initiate the cycle and shut down the cooker.

In order for each step of the cycle to sequence and function properly, a device called a "programmer" is used. This programmer controls electric switches and pneumatic solenoid valves located in the control panel. In addition, the length of time for the start #1, start #2, and flush phases is determined by a timer on the front of the control panel.

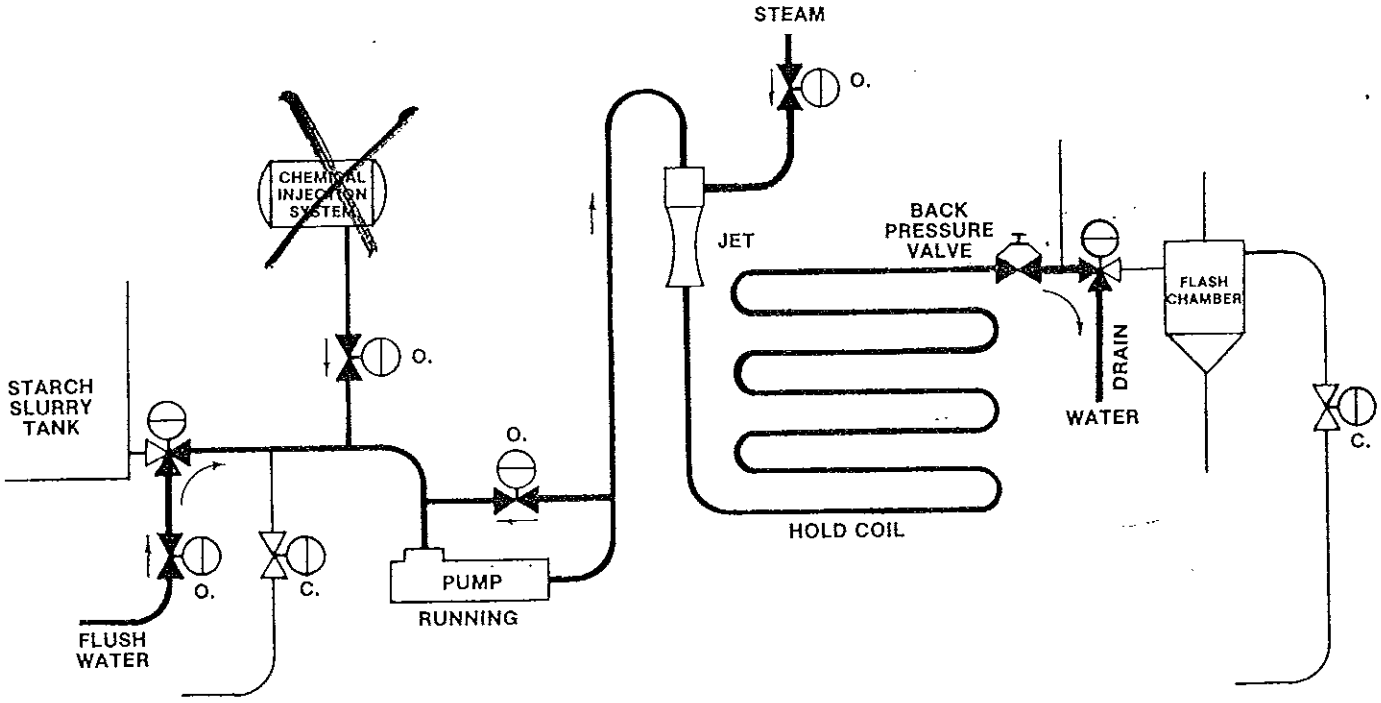
To better understand the cooker operation, each phase will be explained separately and accompanying sketches will visually show the different flow streams for each step. Following this section is a chart which summarizes the sequencing for all the flow control valves.

Start #1

The major objective of this phase is to warm up the hold coil, jet, and transfer lines with water so the starch slurry when cooked will not set up in the piping. Also, this time is used to level out the system for steam and water flow through the jet, ~~giving the chemical flow time to balance out~~. Water retained in the coil from the previous flush cycle is diverted to the sewer before it reaches the flash chamber. The length of this step is determined by the timer ~~on the front of the control panel~~.

The following equipment is involved:

ITEM	DESCRIPTION	FUNCTION
12C	Flush Water Block Valve	Open
10C	Slurry/Water 3-way Valve	Open to water
21	Slurry Pump Motor	On
24C	Slurry Flow Control Valve	Controlling
32C	Temperature Control Valve	Controlling
52C	Sewer/Process 3-way Valve	Open to sewer
54	Sewer Line Condensing Water	Open
~~64C~~	~~Chemical Flow Control Valve~~	~~Controlling~~
~~94~~	~~pH Control Pump~~	~~Off~~



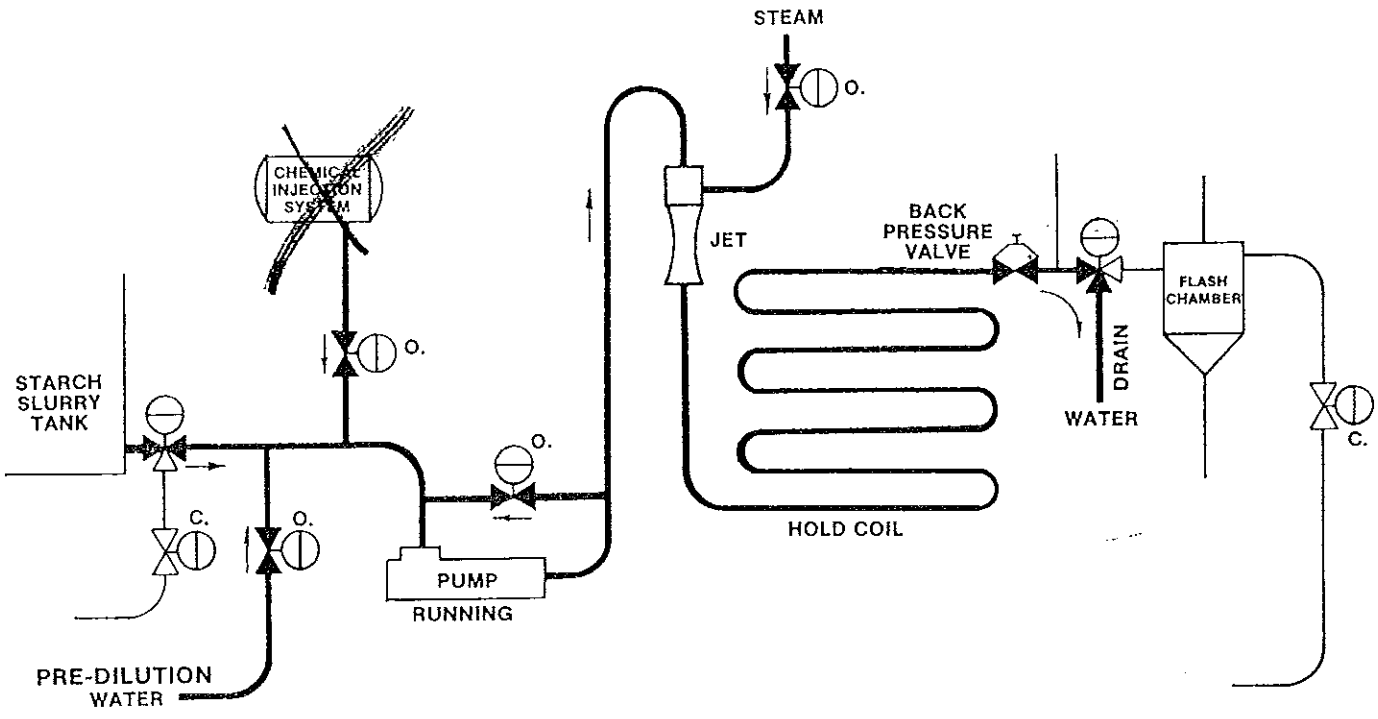
Flow of water in cooker during "Start 1"

Start #2

During start #2, starch slurry is introduced into the system and is diluted ahead of the jet with the desired amount of pre-dilution water. This diluted starch slurry is cooked in the jet and continues on into the coil. This flow displaces the hot water from the coil which is still being diverted to the sewer. The length of this step is determined also by the timer on the control panel.

The following equipment is involved:

ITEM	DESCRIPTION	FUNCTION
12C	Flush Water Block Valve	Closed
10C	Slurry/Water 3-way Valve	Open to slurry
13C	Pre-dilution Valve	Controlling
21	Slurry Pump Motor	On
24C	Slurry Flow Control Valve	Controlling
32C	Temperature Control Valve	Controlling
52C	Sewer/Process 3-way Valve	Open to sewer
54	Sewer Line Condensing Water	Open
~~84C~~	~~Chemical Flow Control Valve~~	~~Controlling~~
94	pH Control Pump	Off



Flow of starch and water in cooker during "Start 2"

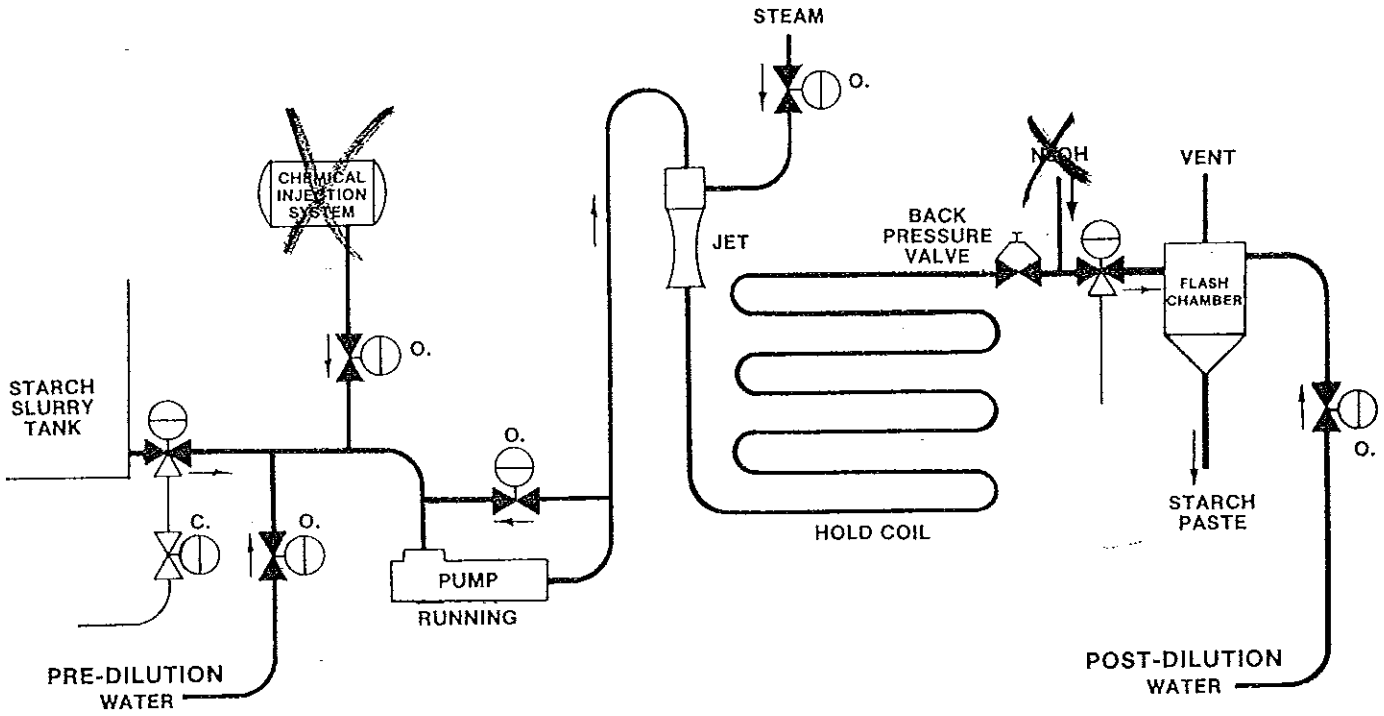
Run

As the timer times out in start #2, the starch paste has progressed through the coil to the end near the 3-way sewer-process valve. When the timer trips, this valve switches and diverts the starch paste to the flash tank. At this time, the post-dilution valve opens and lets water run into the flash tank to further dilute the products solids. ~~Additives such as caustic soda or soda ash are being added into the paste line after the back pressure valve at this time for pH control.~~ As stated before, the length of this step depends on the amount of product required.

The following equipment is involved:

ITEM	DESCRIPTION	FUNCTION
52C	Sewer/Process 3-way	Open to flash chamber
54	Sewer Line Condensing Water	Closed
61C	Post-dilution Control Valve	Controlling
~~64~~	~~pH Control Pump~~	~~On~~

All other items remain the same as start #2.



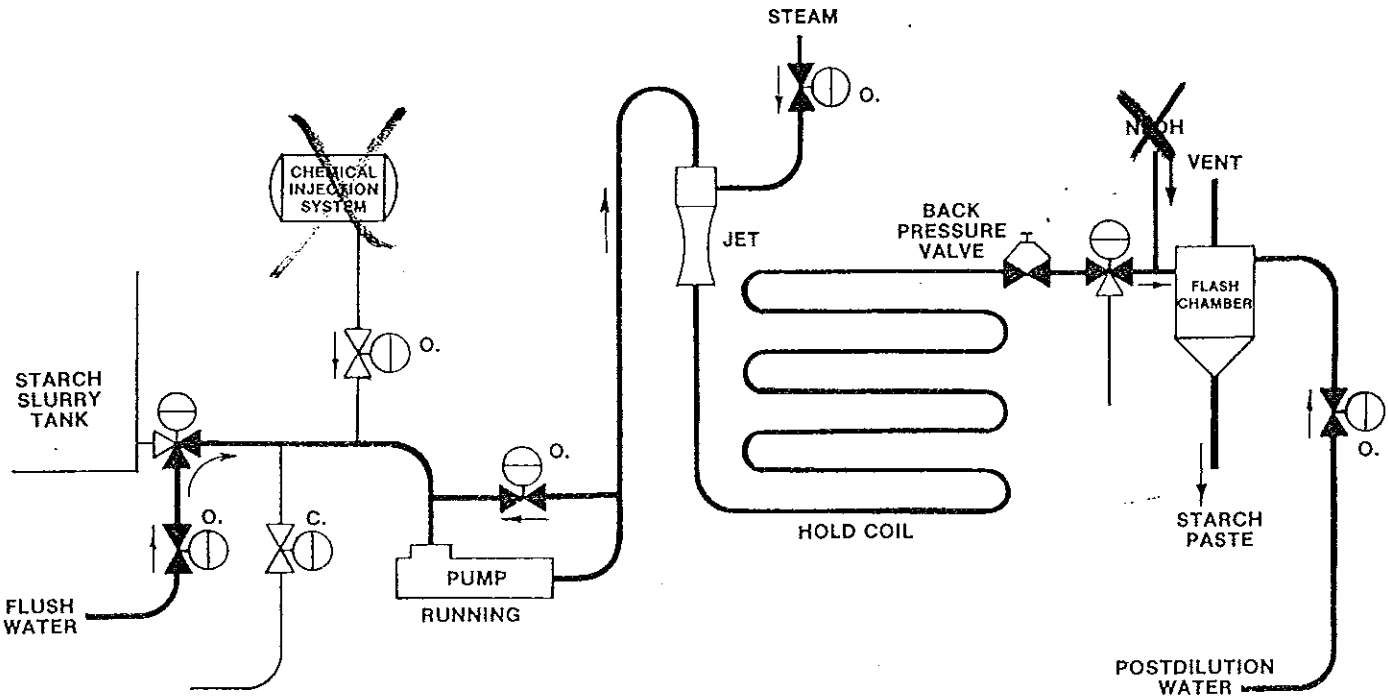
Flow of starch and water in cooker during "Run"

Flush

In the flush position, the objective is to remove all the starch paste from the coil and piping so it will not plug when the flow has stopped and the coil has cooled off. In addition, the pre-dilution water is shut off, but the post-dilution water, if being used, is still going into the flash tank as well as the starch paste from the coil. ~~and the caustic which is being added to the paste line after the back pressure valve~~. This is done so as not to run the product from the coil to the sewer and lose it. The timer is controlling the length of this flushing.

The following equipment is involved:

ITEM	DESCRIPTION	FUNCTION
12C	Flush Water Block Valve	Open
10C	Slurry/Water 3-way Valve	Open to water
21	Slurry Pump Motor	On
24C	Slurry Flow Control Valve	Controlling
32C	Temperature Control Valve	Controlling
52C	Sewer/Process 3-way Valve	Open to flash tank
61C	Post-dilution Control Valve	Controlling
~~64C~~	~~Chemical Flow Control Valve~~	~~Closed~~
~~64~~	~~pH Control Pump~~	~~On~~



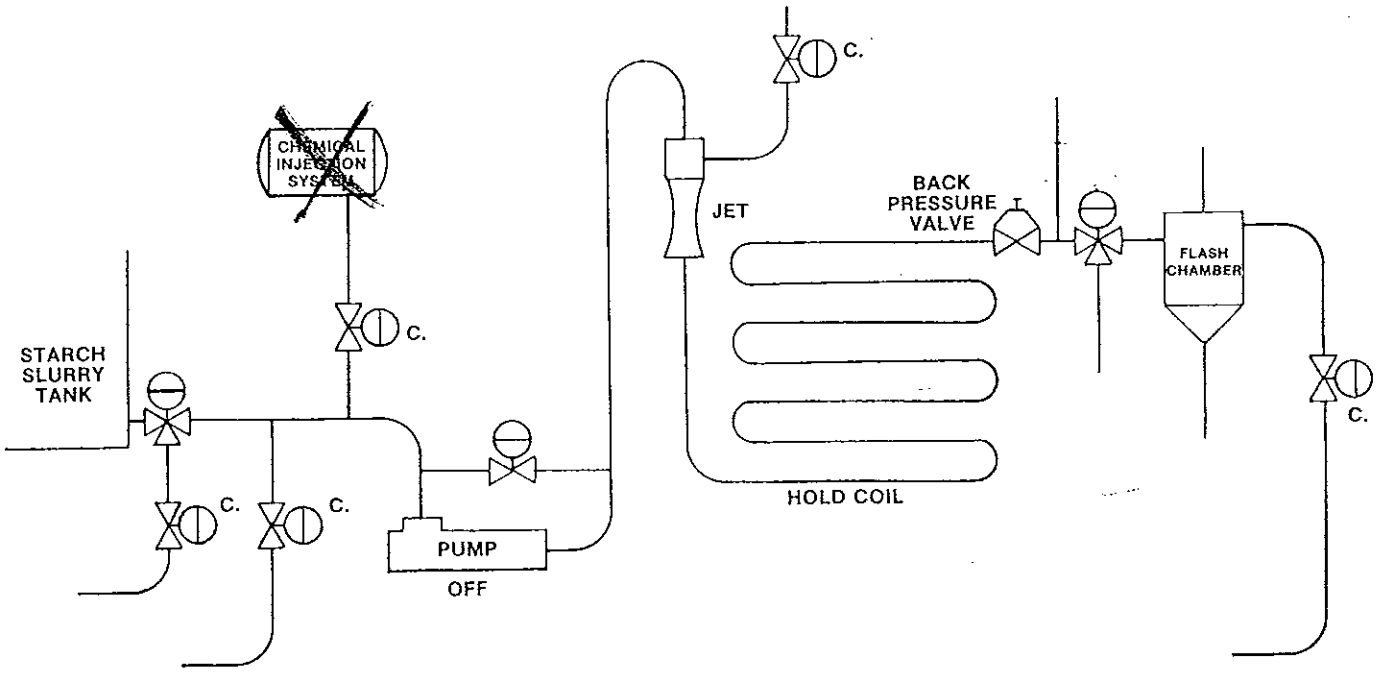
Flow of water and starch in cooker during "Flush"

Standby

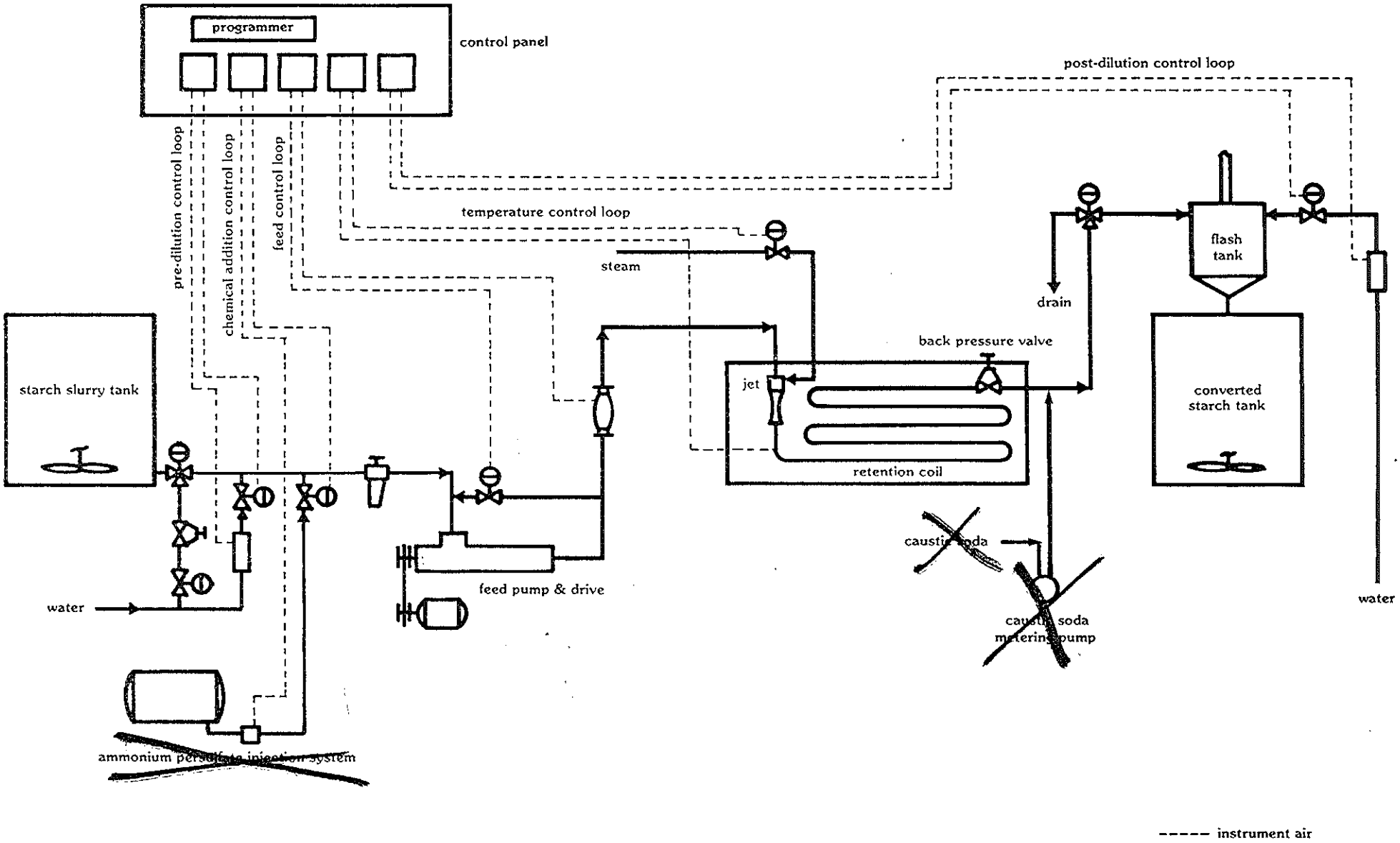
Essentially the standby phase involves shutting down the cooker in an orderly manner and then remaining in this position until a new complete cooking cycle is called for. During this shutting down period, the sewer/process 3-way valve opens to the sewer, the sewer line condensing water valve opens, quenches the hot water, and then closes. The steam valve closes, the pump shuts off, and the flush water block valve closes. The after-dilution water valve closes and the pH pump turns off as soon as the sewer/process valve switches to sewer.

The following equipment is involved in order of its functioning:

ITEM	DESCRIPTION	FUNCTION
61	Post-dilution Control Valve	Closed
52C	Sewer/Process 3-way Valve	Diverts to sewer
32C	Temperature Control Valve	Closed
54	Sewer Line Condensing Water	Closes after time delay
21	Slurry Pump Motor	Off
24C	Slurry Flow Control Valve	Open - Not Controlling
12C	Flush Water Block Valve	Closed
~~94~~	~~pH Control Pump~~	~~Off~~



Everything is shut down during "Standby"


programmer
control panel
post-dilution control loop
pre-dilution control loop
chemical addition control loop
feed control loop
temperature control loop
steam
drain
flash tank
back pressure valve
starch slurry tank
jet
converted starch tank
retention coil
caustic soda
water
feed pump & drive
caustic soda metering pump
water
ammonium persulfate injection system
instrument air

THERMAL-CHEMICAL CONVERTER
COMPONENT SEQUENCING CHART

Component	Standby	Start #1	Start #2	Run	Flush
Slurry Pump	Off	On	On	On	On
Alarm System					
Low AP Flow	Off	Off	On	On	Off
Low AP Level	Off	Off	On	On	Off
Low Cook Temperature	Off	Off	On	On	Off
High Coil Pressure	Off	On	On	On	On
10B	De-energized	De-energized	Energized	Energized	De-energized
10C Slurry/Flush	Flush water	Flush water	Slurry	Slurry	Flush water
12B	De-energized	Energized	De-energized	De-energized	Energized
12C Water Block	Closed	Open	Closed	Closed	Open
13B	De-energized	De-energized	Energized	Energized	De-energized
13C Predilution	Closed	Closed	Controlled	Controlled	Closed
24B	De-energized	Energized	Energized	Energized	Energized
24C Flow Recycle	Open	Controlled	Controlled	Controlled	Controlled
32B	De-energized	Energized	Energized	Energized	Energized
32C Steam	Closed	Controlled	Controlled	Controlled	Controlled
52B					
52C Sewer/Process	De-energized Sewer	De-energized Sewer	De-energized Sewer	Energized Process	Energized Process

THERMAL CHEMICAL CONVERTER
COMPONENT SEQUENCING CHART

Component	Standby	Start #1	Start #2	Run	Flush
53 Vapor Condensing	De-energized Closed	De-energized Closed	De-energized Closed	Energized Open	Energized Open
54 Sewer Condensing	De-energized Closed	Energized Open	Energized Open	De-energized Closed	De-energized Closed
61B 61C Post-dilution	De-energized Closed	De-energized Closed	De-energized Closed	Energized Controlled	Energized Controlled
84B 84C Chemical Flow	De-energized Closed	Energized Controlled	Energized Controlled	Energized Controlled	De-energized Closed
87B 87C AP Tank Fill	Energized Open	De-energized Closed	De-energized Closed	De-energized Closed	Energized Open
89B 89C AP Tank Vent	De-energized Open	Energized Closed	Energized Closed	Energized Closed	De-energized Open
88B 88C AP Tank Air	De-energized Closed	Energized Open	Energized Open	Energized Open	De-energized Closed
94 pH Control Pump	Off	Off	Off	On	On

STARTUP AND SHUTDOWN

Normal Operation

Depending on the "mode" switch, the cooker can be started in two ways. When in "Hand," the "Advance" button is pushed to initiate the cycle. In the "Auto" mode, a low level signal from the product receiving tank will initiate the operation sequence.

Likewise, the cooker is shut down in two manners. In the "Auto" mode, a high level in the product receiving tank will advance the cooker from the run phase to the flush phase and shut the cooker down. In the "Hand" mode, the "Advance" button must be pushed to advance the cooker to the flush cycle.

It should be noted that the Hand-Auto selector must be in the "Hand" mode to advance the cycle with the "Advance" button. Also, this push button overrides the cycle timer and will advance the programmer position at any one step. Use the "Advance" button to move from start #1, to start #2, to run, to flush, or to standby.

Extended Shutdowns

When a shutdown will be longer than 8 to 24 hours, use the following procedure:

1. Change the mode selector to "Hand".
2. Let the unit flush normally and cycle to standby.
3. Cut off the power switch on the front of the panel.
4. Block in steam line and other flow block valves as required.
5. Clean pump strainers.
6. For long extended shutdowns, the AP system should be drained and flushed and fresh AP made down when the unit is restarted.

Repair Shutdowns

The above procedure leaves the cooker hot and pressurized. If the cooker is to be repaired, such as inspecting the jet, the cooker should be cooled down and depressurized.

The following procedure should be used to obtain a repair shutdown:

1. Cycle the cooker normally to flush and standby.

2. Set the timer to 20 minutes and restart unit.

3. With the cooker in start #1, slowly decrease the temperature controller setpoint.

4. When the temperature reaches a low point, block in the steam control valve.

5. Run the cooker until the entire hold loop reaches cold water supply temperature. If 20 minutes is not enough time to cool the unit, flick the power switch to extend the time (to reset timer). Be sure to keep the unit in the start #1 phase.

6. Once the cooker is cooled completely, change the mode selector to "Hand." The programmer may now be cycled quickly through start I, starch II, run, flush, and into standby.

7. Once the unit is in standby, shut off the power switch and reset the timer to its normal time (approximately five minutes).

8. Cut off main power switch on side of panel and block in other lines as required.

9. Make sure the pressure is relieved from the coil before opening it.

CALCULATING APPROXIMATE COOKING CONDITIONS

Example:

It is desired to produce a paste at 9% solids. A 9% solids paste is normally stored at about 155°F. Calculate the pre-dilution and post-dilution flow rates required to give the desired solids and temperature.

Basis for Calculation:

For this example, an 18 GPM system is used.

The slurry solids concentration must be known. Assume for this example that slurry is made down at 3.5 lbs./gal.

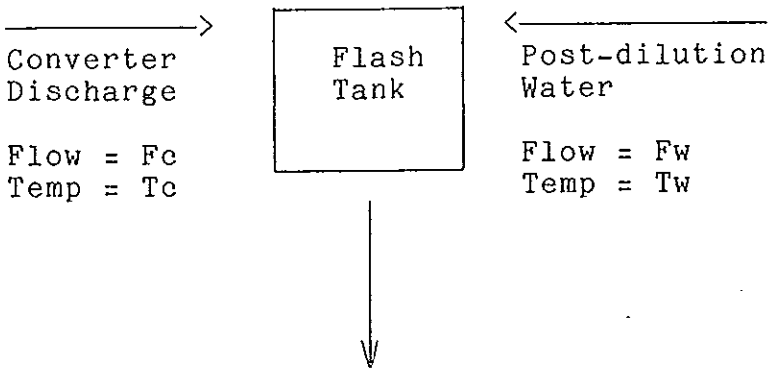
The post-dilution water temperature must be known. Assume 85°F. for this example.

Note:

There are two taps for introducing post-dilution water into the flash chamber. The upper tap is used whenever possible because it provides intimate mixing of the converter discharge stream (starch paste and flashed steam) with the post-dilution water stream. Because of the mixing, the relatively cool post-dilution water condenses most of the flashed steam, recovering the heat and providing greater energy efficiency. It also allows maximum use of post-dilution, thereby minimizing use of pre-dilution. Minimizing pre-dilution maximizes converter capacity. Therefore, the lower tap is used only when it is necessary to vent the flashed steam, in order to remove heat from the system in cases where the amount of post-dilution required to achieve a given temperature is more than required to yield the desired solids. The calculation is always made using the upper tap first.

Solution:

Step 1. Make a material and energy balance around the flash tank to determine post-dilution flow rate.



The following equation can be used:

$$Fc(Tc) + Fw(Tw) = Fs(Ts)$$

where:
- Fc = Flow rate from converter
- Fw = Flow rate of post-dilution water
- Fs = Flow rate to storage
- Tc = Temperature from converter
- Tw = Temperature of post-dilution water
- Ts = Temperature to storage

a. The converter discharge is a two-phase stream which includes pasted starch and flashed steam. The total equivalent liquid volume is 21.7 GPM (18 GPM from the converter feed and approximately 3.7 GPM of net condensate. Net condensate is the amount of steam condensed minus the vapor flashed off and vented from the top of the flash tank. If the upper tap of the flash tank is used for introduction of post-dilution water, the effective converter discharge stream temperature is 300°F.

so: Fc = 21.7
Tc = 300

b. The flow rate of diluted starch paste to storage is the sum of 21.7 plus the flow rate of post-dilution water. The paste temperature desired is 155°F.

so: Fs = 21.7 + Fw
Ts = 155

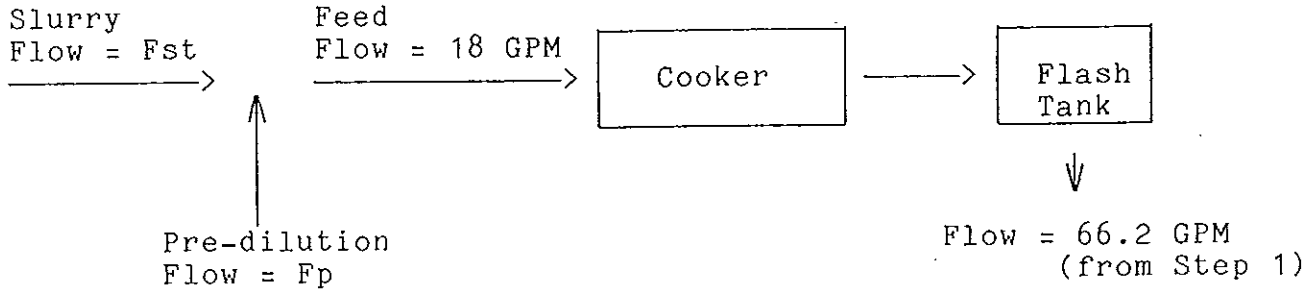
c. The post-dilution water temperature is assumed in this example to be 85°F.

so: Tw = 85

d. Now, substituting known variables in the equation, solve for Fw:

Fc(Tc) + Fw(Tw) = Fs(Ts)
21.7(300) + Fw(85) = (21.7 + Fw)(155)
solving, Fw = 44.5 GPM
and Fs = 21.7 + 44.5 = 66.2 GPM

Step 2. Make starch balance around entire converter to determine pre-dilution flow required.



a. Calculate starch flow out of system:
The flow rate, calculated in Step 1, is 66.2 GPM.
The desired solids are 9%--from the starch tables, 9% solids is 0.78 lb./gal.

so: starch out of system =
66.2 (0.78) = 51.6 lbs./min.

b. Calculate gal./min. starch slurry, F_{st}, which must be fed to converter:

F_{st} = 51.6 lbs./min. ÷ 3.5 lbs./gal. = 14.7 gal./min.

c. Calculate pre-dilution flow rate, Fp:

Fp = 18 - F_{st} = 18 - 14.7
= 3.3 gal./min.

So converter conditions required to yield 9% starch paste at 155°F, using 3.5 lbs./gal. slurry and 85°F. post-dilution water are:

a. Use top tap of flash tank
b. Use 44.5 GPM post-dilution
c. Use 3.3 GPM pre-dilution

Under certain conditions of desired solids and available water temperature, the amount of post-dilution water required in Step 1 to give the desired temperature to storage will be in excess of that acceptable to produce the desired solids to storage. This will be evidenced by a value of Fst, in Step 2(b), which is higher than the rated capacity of the converter.

Or, under certain conditions of desired solids and available water temperature, the amount of pre-dilution water calculated in Step 2(c) will be below the flow range of the pre-dilution rotameter.

If either of these occur, it becomes necessary to introduce the post-dilution water to the lower flash tank tap. Then, to make the Step 1 calculation, use a value of 240°F. for Tc.

In the case of high solids conversion, where very little post-dilution is required, the discharge temperature to storage will be up to 212°F. in the case of zero post-dilution.

AP Pressure Tank System (Continued)

Operation Notes

1. Since the pressure tank fills when the cooker is in the flush or standby cycles only, the concentration of chemical must be at a level to insure that no more than 40 gallons (about the size of the pressure tank) will be required during any one cook cycle to prevent running out of AP. Also, for best accuracy the flow rate should be kept between 5.5 and 8.0 gallons per hour.

2. When making down the AP solution, the valve under the mix tank should be closed so if the pressure tank fill valve would open, the new partially mixed AP solution would not run into the pressure tank.

3. When the chemical has mixed thoroughly, the agitator should be turned off. Continued aeration will cause the solution to lose strength.

4. On electrical power failure, the air valve closes, the fill valve closes, and the vent valve opens.

5. The vent line back to the mix tank should be piped in such a manner as to keep it from splashing chemical out of the tank. Also, it should be watched closely when making down new AP.

NORMAL INSTRUMENT SETTINGS, OPERATION CONDITIONS, and ADJUSTMENTS

ITEM	DESCRIPTION	NORMAL OPERATION
2	Air filter-regulators	Set @ 20 & 40 psig
11	Water pressure regulator	Equal to slurry head pressure
13A	Pre-dilution water flow controller	Based on solids desired
19	Water pressure gauge	5-15 psig (Equal to slurry head)
23	Pump pressure gauge	60-115 psig
24A	Slurry flow recording controller	Unit size
32A	Cook temperature recorder	305°F.
32-1	Low temperature switch	Set @ 265-270°F.
35	Safety relief valve	Preset @ 150 psig
36A	Slurry pressure gauge	60-115 psig
37A	Steam pressure gauge	90-125 psig
38A	Coil pressure gauge	66-72 psig
38-1	High pressure cutoff switch	Out @ 112 psig, In @ 75 psig
39	Steam pressure gauge Header pressure	150 psig, saturated
44	Coil temperature indicator	295-305°F.
45	Hold coil pressure gauge	68-72 psig
61A	Post-dilution water flow controller	Based on solids desired
63-1	Low storage level switch	Set to turn cooker on before tank runs dry. Note: 10 minutes to start
63-2	High storage level switch	Set to turn cooker off before tank runs over. Note: 5 minutes to stop
73	Chemical air filter-regulator	Set @ 60-80 psig
75	Chemical relief valve	Preset @ 125 psig
81	Chemical low level probe	On/off @ probe level
84A	Chemical flow controller	Not less than 1/3 scale
84-1	Chemical low flow alarm pressure switch	Set @ 4 psig

POWER FAILURE

If an electrical power failure occurs while the cooker is running, all valves will go to their normal failure position. All flows will stop while the power is off. The action required by the operator will depend on the power outage time and which step of the operating cycle the cooker was in when the power was lost.

Short-Term Outage

If the system is operating in "start 2" or "run" when the power failure occurs and power is restored immediately, advance the unit immediately through "flush," "standby," and directly back into "start 1." This will flush the cooker of any off-specification paste to the sewer and start a new cooking cycle.

Extended Power Outage

If the system is operating in "start 2" or "run" when the power failure occurs and power is not restored immediately, slurry may settle in the lines and there might be a danger of starch gelling in the hold coil (watch the hold coil outlet thermometer). This corrective procedure can be followed:

1. Shut off main power at control panel.

2. If the outage appears to be lengthy, to prevent the coil from plugging with gelled starch, manually open the steam valve slowly and carefully to blow the starch paste from the coil to the sewer.

3. When power is restored, turn on the control power and advance the unit to start 1. Any uncooked paste in the coil will be diverted to the sewer and a new cooking cycle will be started.

ALARM SYSTEM

Most cooker systems have four different alarms which will be activated by unusual operating conditions or a system malfunction, either of which will alert the operator. This alarm system prevents starch which has not been properly modified from reaching the product tank. Also, the alarm system prevents the unit from plugging with gelled starch.

The individual alarms are:

1. High coil pressure alarm
2. Low cook temperature alarm
3. ~~Low chemical flow alarm~~
4. ~~Low chemical level alarm~~

The high coil pressure alarm acts like a safety valve. On a high pressure signal from the coil, all power is cut off to the control panel and to the slurry pump. When the pressure in the coil lowers to a safe limit, the power will come back on and the cooker will continue to run in the same step as before.

The high pressure alarm is activated and ready during all steps of the cooking cycle except for the "Standby" step. Again, it should be noted that this alarm will not advance the cooker to the "flush" position.

Unlike the high pressure alarm, the low temperature, ~~low chemical level~~, ~~and low chemical flow~~ alarms are activated during just the "Start II" and "Run" steps. These are two steps when starch slurry is added to the system. These alarms will automatically advance the step programmer from either the "Start II" or the "Run" step to the "Flush" step.

Depending upon what step the cooker is in when the alarm happens, the cooker will go through either an emergency flush or a normal flush. If the cooker is in "Start II" when the alarm happens, a second timer, the emergency sewer delay timer, will keep the 3-way sewer/process valve diverted to the sewer, so no flush water reaches the starch paste storage tank. When the sewer delay timer times out, the 3-way sewer/process valve will divert from the sewer to the paste tank and will remain diverted so no starch paste reaches the sewer.

If the cooker is in "Run" when an alarm occurs, the cooker immediately goes to "Flush," and the 3-way sewer/process valve will stay diverted to the paste tank for the entire "Flush" step. When the cooker reaches the "Run" position, all flush water has been diverted to the sewer and the hold coils are full of starch paste.

When the situation arises for an operator to shut the cooker down manually because of some unusual condition, the mode switch must be in the hand position and the "Advance" push button used. To advance the cooker from "Start I" to "Start II," the "Advance" button is used. To advance the cooker further, the "Advance" button is used once again. This button drives the programmer directly and overrides the cycle timer.

TROUBLESHOOTING

This section consists of two parts. The first describes immediate actions to be taken by the operator to shut down the cooker. The second describes causes and remedies for the individual symptoms.

A. Cooker Shutdown for Each Step of the Cycle

1. Start #1

In this phase of the cycle, the only alarm is the high pressure shutdown. Since there is no starch in the system, the other three alarms are not activated. Because only water is in the system, the best and quickest thing to do is shut the power off if the high pressure alarm repeats itself. Quite often the high pressure alarm is caused by low flow or lack of flow and a large amount of steam then bumping the coil (water hammer) creating the high pressure. Check for proper flow and coil pressure.

Important Note: Do not run the Moyno slurry feed pump dry. Liquid flow through the pump is required for lubrication.

2. Start #2

At this point, the additional alarm circuit is activated. Therefore, if immediately on switch over to start #2, the alarm horn sounds, check the cook temperature, ~~AP of concentrate, and the AT supply. Any~~ one of these ~~three~~ alarms will advance the cooker to the flush step. If high pressure cuts the cooker out immediately after switch over, the most probable reason for the high pressure is a starch slurry flow problem. This should be investigated.

3. Run

All alarms are activated in this phase. Except for the high pressure alarm, the unit will be advanced to the flush cycle. If the unit keeps repeating itself on high pressure trips, advance the unit to flush.

4. Flush

For a high pressure alarm in this phase, the thing to remember is there is starch paste in the coil which must be removed. Normally, since the unit has switched to water for flushing, the coil will be cleaned by itself. If, after several cycles of the high pressure alarm, and the trouble cannot be found, the unit can be shut down and the steam control valve manually opened carefully to clear the paste from the coil. As in the power failure section of this manual, the unit must be started on water.

B. Troubleshooting Symptoms

1. High Pressure Trip

Note that a momentary loss of flow will cause the steam to bump the system and trip the high pressure switch.

Possible Cause	Remedy
No flow or loss of flow	(Check or adjust the following:) Plugged pump suction lines Pump belt tension Recycle flow control valve Control air pressure Low slurry tank level Pre-dilution flow uniformity Flush water valves and supply Pump operations Water pressure regulator settings All automatic valves for proper operation High agitation in a low slurry tank causing the pump to suck air
Continuous High Pressure	(Check and adjust as required the following:) Back pressure valve setting and operation Plugged piping to sewer or process Very high solids in system ~~AP in starch paste~~

Troubleshooting (Continued)

Possible Cause	Remedy
Unbalanced Jet	(Check or adjust as required the following:) Water or slurry feed flow incorrect Steam header pressure Superheated steam Condensate in steam Worn product jet nozzle Worn jet venturi Improper back pressure Cooking temperature too low Temperature or flow controller cycling too wide
Instrumentation	(Check and adjust the following:) Flow & temperature controller cycling too wide Air leak or failure to any part of system Faulty coil pressure transmitter

2. Low Temperature Trip

Possible Cause	Remedy
Steam Flow	(Check and adjust as required the following:) Poor or low steam supply Low steam pressure Condensate in steam Steam line restriction Malfunction of steam valve or controller
Water or Slurry Flow	Too fast a change in feed rate. No flow through cooker due to instrument air failure No flow due to high pressure cut out alarm

Troubleshooting (Continued)

Instrumentation	Steam valve controller Flow controllers Improper temperature pressure switch setting Temperature pressure switch malfunction

3. Low AP Flow Alarm

Possible Cause	Remedy
Equipment	(Check or adjust the following:) Air line supply pressure Air pressure regulator AP pressure & mix tank level Inspect fill, vent, & air valves Chemical line blockage Too low of a flow set on controller

Possible Cause	Remedy
Instrumentation	(Check and adjust the following:) Flow controller cycling Flow control valve Incorrect signal from flow transmitter Pressure switch PS84-1

4. Low AP Level Trip

Possible Cause	Remedy
Low Level	(Check or adjust as required:) AP mix tank level AP automatic fill valve AP fill block valve AP automatic vent valve Pressure tank drain open
Instrumentation	Faulty low level probe Probe sensitivity adjustment Dampening of sensor probe by piping

RECOMMENDED SPARE PARTS

The following list is a recommended minimum amount of spare parts that should be maintained in stock for a thermal-chemical converter system. Depending upon normal mill practice, other items may be stocked in the spare parts inventory to minimize downtime.

1. Item 31. Starch Cooking Jet

   Pardee D-10 line heater. Specify jet size. Order from Grain Processing Corporation.

2. Item 51. Coil Back Pressure Valve

   Fisher Series 98H back pressure valve, 2", stainless steel modified body and trim. Order from Grain Processing Corporation.

   The following spare parts should also be stocked:

   a. Part: diaphragm

3. Item 20. Slurry Pump

   When ordering spare parts, always specify the pump frame size, type designation, and serial number. The following spare parts should be stocked:

   a. Part: Rotor (standard size)

   b. Part: Stator

   c. Part: Connecting Rod Kit

   d. Part: Drive Belts (1 matched set)

4. Item 35. Safety Relief Valve

   Consolidated Model 2478-E-XDAI with bronze body and trim, Teflon™ soft seat, set to relieve at 175 psig, with relief handle.

PREVENTIVE MAINTENANCE

It is recommended that all variables from the panel instruments be logged hourly or bi-hourly. This information can be valuable in anticipating problems on the basis of trends in the logged data and can be of great help in correcting problems before they become serious. Also, in the event of instrument failure, the unit can be operated by inference from previously logged readings. Thus, if the temperature controller malfunctions, the unit can be operated on manual by setting up the steam pressure to the previously established value. Of course, this is recommended as a temporary expedient only while permanent repairs are being made.

Each mill will want to establish their own system to fit their overall maintenance program based on their experience. The following is intended as a guideline in the establishment of such a program.

Daily

1. Drain air separators on the air supply to the instrument panel and check the pressure supply to the controllers.

2. Check motor and pump bearings for overheating.

3. Review the log sheets for variations in the operating conditions and investigate unusual readings.

Every Three Months

1. Check operation of all transmitters, rotameters, recorders, valves, controllers, and pressure gauges. Clean, lubricate, and calibrate as required.

2. Check pump belts for tightness and wear.

3. Clean and inspect the interior of the control cabinet for dust. The presence of dust indicates poor door closure or inadequate pressurization. Dust and dirt are the biggest enemies of the electrical system.

Annually

1. Clean and repack Moyno pump bearings according to the manufacturer's recommendations.

2. Service pump motor according to standard mill practice.

3. Check for air tubing leaks with a sponge and soapy water. Also check each time the unit is moved or disturbed.

4. Dismantle steam jet and inspect for wear. Measure product nozzle and venturi and replace parts which exhibit signs of wear.

STARCH TABLE

Baume' at 60°F. Modulus 145 Specific Gravity at 60°/60°F.

Be at 60°F.	Specific Gravity in Air	% D.S. Starch	Weight in Pounds per Gallon	Grams D.S. Starch per 100 ml.	Pounds D.S. Starch per Gallon
0.0	1.0000	0.000	8.328	0.000	0.000
0.1	1.0007	0.178	8.334	0.178	0.015
0.2	1.0014	0.354	8.340	0.359	0.030
0.3	1.0021	0.531	8.346	0.527	0.044
0.4	1.0028	0.708	8.352	0.707	0.059
0.5	1.0035	0.885	8.357	0.887	0.074
0.6	1.0041	1.062	8.362	1.066	0.089
0.7	1.0048	1.239	8.368	1.246	0.104
0.8	1.0055	1.416	8.374	1.426	0.119
0.9	1.0062	1.593	8.380	1.594	0.133
1.0	1.0069	1.777	8.386	1.785	0.149
1.1	1.0076	1.955	8.392	1.965	0.164
1.2	1.0083	2.132	8.397	2.145	0.179
1.3	1.0090	2.310	8.403	2.325	0.194
1.4	1.0097	2.488	8.409	2.504	0.209
1.5	1.0105	2.666	8.416	2.684	0.224
1.6	1.0112	2.843	8.422	2.864	0.239
1.7	1.0119	3.021	8.427	3.044	0.254
1.8	1.0126	3.199	8.433	3.235	0.270
1.9	1.0133	3.376	8.439	3.415	0.285
2.0	1.0140	3.554	8.445	3.595	0.300
2.1	1.0147	3.732	8.451	3.775	0.315
2.2	1.0154	3.909	8.456	3.966	0.331
2.3	1.0161	4.087	8.462	4.146	0.346
2.4	1.0168	4.265	8.468	4.326	0.361
2.5	1.0176	4.443	8.475	4.518	0.377
2.6	1.0183	4.620	8.481	4.697	0.392
2.7	1.0190	4.798	8.486	4.877	0.407
2.8	1.0197	4.976	8.492	5.069	0.423
2.9	1.0204	5.153	8.498	5.249	0.438
3.0	1.0211	5.331	8.504	5.428	0.453
3.1	1.0218	5.509	8.510	5.620	0.469
3.2	1.0226	5.686	8.516	5.800	0.484
3.3	1.0233	5.864	8.522	5.991	0.500
3.4	1.0241	6.042	8.529	6.171	0.515
3.5	1.0248	6.220	8.535	6.363	0.531
3.6	1.0255	6.397	8.541	6.543	0.546
3.7	1.0263	6.575	8.547	6.734	0.562
3.8	1.0270	6.753	8.553	6.926	0.578
3.9	1.0278	6.930	8.560	7.106	0.593

STARCH TABLE

Baume' at 60°F. Modulus 145 Specific Gravity at 60°/60°F.

Be at 60°F.	Specific Gravity in Air	% D.S. Starch	Weight in Pounds per Gallon	Grams D.S. Starch per 100 ml.	Pounds D.S. Starch per Gallon
4.0	1.0285	7.108	8.566	7.298	0.609
4.1	1.0292	7.286	8.571	7.477	0.624
4.2	1.0300	7.463	8.578	7.669	0.640
4.3	1.0307	7.641	8.584	7.861	0.656
4.4	1.0314	7.819	8.590	8.053	0.672
4.5	1.0322	8.007	8.596	8.232	0.687
4.6	1.0329	8.174	8.602	8.424	0.703
4.7	1.0336	8.352	8.608	8.616	0.719
4.8	1.0343	8.530	8.614	8.807	0.735
4.9	1.0351	8.707	8.621	8.999	0.751
5.0	1.0358	8.885	8.626	9.179	0.766
5.1	1.0366	9.063	8.633	9.371	0.782
5.2	1.0373	9.240	8.639	9.562	0.798
5.3	1.0381	9.418	8.646	9.754	0.814
5.4	1.0388	9.596	8.651	9.946	0.830
5.5	1.0396	9.774	8.658	10.138	0.846
5.6	1.0403	9.951	8.664	10.329	0.862
5.7	1.0411	10.129	8.671	10.521	0.878
5.8	1.0418	10.307	8.676	10.713	0.894
5.9	1.0426	10.484	8.683	10.904	0.910
6.0	1.0433	10.662	8.689	11.096	0.926
6.1	1.0441	10.840	8.696	11.300	0.943
6.2	1.0448	11.017	8.701	11.492	0.959
6.3	1.0456	11.195	8.708	11.683	0.975
6.4	1.0463	11.373	8.714	11.875	0.991
6.5	1.0471	11.551	8.720	12.067	1.007
6.6	1.0478	11.728	8.726	12.259	1.023
6.7	1.0486	11.906	8.733	12.462	1.040
6.8	1.0494	12.084	8.739	12.654	1.056
6.9	1.0501	12.261	8.745	12.846	1.072
7.0	1.0508	12.439	8.751	13.049	1.089
7.1	1.0516	12.617	8.758	13.241	1.105
7.2	1.0523	12.794	8.764	13.433	1.121
7.3	1.0531	12.972	8.770	13.637	1.138
7.4	1.0539	13.150	8.777	13.828	1.154
7.5	1.0547	13.328	8.784	14.032	1.171
7.6	1.0554	13.505	8.790	14.224	1.187
7.7	1.0562	13.683	8.796	14.427	1.204
7.8	1.0570	13.861	8.803	14.619	1.220
7.9	1.0577	14.038	8.809	14.823	1.237

STARCH TABLE

Baume' at 60°F. Modulus 145 Specific Gravity at 60°/60°F.

Be at 60°F.	Specific Gravity in Air	% D.S. Starch	Weight in Pounds per Gallon	Grams D.S. Starch per 100 ml.	Pounds D.S. Starch per Gallon
8.0	1.0585	14.216	8.815	15.015	1.253
8.1	1.0593	14.394	8.822	15.218	1.270
8.2	1.0601	14.571	8.829	15.410	1.286
8.3	1.0608	14.794	8.835	15.614	1.303
8.4	1.0616	14.927	8.841	15.817	1.320
8.5	1.0624	15.105	8.848	16.009	1.336
8.6	1.0632	15.282	8.855	16.213	1.353
8.7	1.0640	15.460	8.861	16.417	1.370
8.8	1.0647	15.638	8.867	16.620	1.387
8.9	1.0655	15.815	8.874	16.812	1.403
9.0	1.0663	15.993	8.880	17.016	1.420
9.1	1.0671	16.171	8.887	17.219	1.437
9.2	1.0679	16.348	8.894	17.423	1.454
9.3	1.0687	16.526	8.900	17.627	1.471
9.4	1.0695	16.704	8.907	17.831	1.488
9.5	1.0703	16.882	8.914	18.034	1.505
9.6	1.0710	17.059	8.920	18.238	1.522
9.7	1.0718	17.237	8.926	18.442	1.539
9.8	1.0726	17.415	8.933	18.645	1.556
9.9	1.0734	17.592	8.940	18.849	1.573
10.0	1.0742	17.770	8.946	19.053	1.590
10.1	1.0750	17.948	8.953	19.257	1.607
10.2	1.0758	18.125	8.960	19.460	1.624
10.3	1.0766	18.303	8.966	19.664	1.641
10.4	1.0774	18.481	8.973	19.868	1.658
10.5	1.0782	18.659	8.979	20.071	1.675
10.6	1.0790	18.836	8.986	20.287	1.693
10.7	1.0798	19.014	8.993	20.491	1.710
10.8	1.0806	19.192	8.999	20.694	1.727
10.9	1.0814	19.369	9.006	20.898	1.744
11.0	1.0822	19.547	9.013	21.114	1.762
11.1	1.0830	19.725	9.019	21.318	1.779
11.2	1.0838	19.902	9.026	21.521	1.796
11.3	1.0846	20.080	9.033	21.737	1.814
11.4	1.0854	20.258	9.039	21.941	1.831
11.5	1.0863	20.436	9.047	22.156	1.849
11.6	1.0871	20.613	9.054	22.360	1.866
11.7	1.0879	20.791	9.060	22.576	1.884
11.8	1.0887	20.969	9.067	22.779	1.901
11.9	1.0895	21.146	9.074	22.995	1.919

STARCH TABLE

Baume' at 60°F. Modulus 145 Specific Gravity at 60°/60°F.

Be at 60°F.	Specific Gravity in Air	% D.S. Starch	Weight in Pounds per Gallon	Grams D.S. Starch per 100 ml.	Pounds D.S. Starch per Gallon
12.0	1.0903	21.324	9.080	23.199	1.936
12.1	1.0911	21.502	9.087	23.415	1.954
12.2	1.0920	21.679	9.094	23.618	1.972
12.3	1.0928	21.857	9.101	23.834	1.989
12.4	1.0936	22.035	9.108	24.050	2.007
12.5	1.0945	22.213	9.115	24.265	2.025
12.6	1.0953	22.390	9.122	24.469	2.042
12.7	1.0961	22.568	9.129	24.685	2.060
12.8	1.0969	22.746	9.135	24.900	2.078
12.9	1.0978	22.923	9.143	25.116	2.096
13.0	1.0986	23.101	9.149	25.332	2.114
13.1	1.0995	23.279	9.157	25.548	2.132
13.2	1.1003	23.459	9.164	25.763	2.150
13.3	1.1012	23.634	9.171	25.967	2.167
13.4	1.1020	23.812	9.178	26.183	2.185
13.5	1.1029	23.990	9.185	26.393	2.203
13.6	1.1037	24.167	9.192	26.614	2.221
13.7	1.1046	24.345	9.199	26.830	2.239
13.8	1.1054	24.523	9.206	27.057	2.258
13.9	1.1063	24.700	9.214	27.273	2.276
14.0	1.1071	24.878	9.220	27.489	2.294
14.1	1.1080	25.056	9.228	27.704	2.312
14.2	1.1088	25.233	9.234	27.920	2.330
14.3	1.1097	25.411	9.242	28.136	2.348
14.4	1.1105	25.589	9.248	28.352	2.366
14.5	1.1114	25.767	9.256	28.579	2.385
14.6	1.1122	25.944	9.263	28.795	2.403
14.7	1.1131	26.112	9.270	29.023	2.422
14.8	1.1139	26.300	9.277	29.238	2.440
14.9	1.1148	26.477	9.284	29.454	2.458
15.0	1.1156	26.655	9.291	29.682	2.477
15.1	1.1165	26.833	9.298	29.885	2.495
15.2	1.1173	27.010	9.305	30.113	2.513
15.3	1.1182	27.188	9.313	30.341	2.532
15.4	1.1190	27.366	9.319	30.556	2.550
15.5	1.1199	27.544	9.327	30.784	2.569
15.6	1.1208	27.721	9.334	31.000	2.587
15.7	1.1216	27.899	9.341	31.227	2.606
15.8	1.1225	28.077	9.348	31.455	2.625
15.9	1.1233	28.254	9.355	31.671	2.643

STARCH TABLE

Baume' at 60°F. Modulus 145 Specific Gravity at 60°/60°F.

Be at 60°F.	Specific Gravity in Air	% D.S. Starch	Weight in Pounds per Gallon	Grams D.S. Starch per 100 ml.	Pounds D.S. Starch per Gallon
16.0	1.1242	28.432	9.363	31.898	2.662
16.1	1.1251	28.610	9.370	32.126	2.681
16.2	1.1260	28.787	9.378	32.354	2.700
16.3	1.1268	28.965	9.384	32.570	2.718
16.4	1.1277	29.143	9.392	32.797	2.737
16.5	1.1286	29.321	9.399	33.025	2.756
16.6	1.1295	29.498	9.407	33.253	2.775
16.7	1.1304	29.675	9.414	33.480	2.794
16.8	1.1312	29.854	9.421	33.708	2.813
16.9	1.1321	30.031	9.428	33.924	2.831
17.0	1.1330	30.209	9.436	34.163	2.851
17.1	1.1339	30.387	9.443	34.379	2.869
17.2	1.1348	30.564	9.451	34.619	2.889
17.3	1.1357	30.742	9.458	34.846	2.908
17.4	1.1366	30.920	9.466	35.074	2.927
17.5	1.1375	31.098	9.473	35.302	2.946
17.6	1.1383	31.275	9.480	35.529	2.965
17.7	1.1392	31.453	9.488	35.757	2.984
17.8	1.1401	31.631	9.495	35.985	3.003
17.9	1.1410	31.808	9.503	36.224	3.023
18.0	1.1419	31.986	9.510	36.452	3.042
18.1	1.1428	32.164	9.518	36.680	3.061
18.2	1.1437	32.341	9.525	36.907	3.080
18.3	1.1446	32.519	9.532	37.147	3.100
18.4	1.1455	32.697	9.540	37.375	3.119
18.5	1.1465	32.875	9.548	37.614	3.139
18.6	1.1474	33.052	9.556	37.842	3.158
18.7	1.1483	33.230	9.563	38.082	3.178
18.8	1.1492	33.408	9.571	38.309	3.197
18.9	1.1501	33.585	9.578	38.549	3.217
19.0	1.1510	33.763	9.586	38.789	3.237
19.1	1.1519	33.941	9.593	39.016	3.256
19.2	1.1528	34.118	9.601	39.256	3.276
19.3	1.1538	34.296	9.609	39.496	3.296
19.4	1.1547	34.474	9.617	39.723	3.315
19.5	1.1556	34.652	9.624	39.963	3.335
19.6	1.1565	34.829	9.632	40.203	3.355
19.7	1.1574	35.007	9.639	40.430	3.374
19.8	1.1584	35.185	9.647	40.670	3.394
19.9	1.1593	35.362	9.655	40.910	3.414

STARCH TABLE

Baume' at 60°F. Modulus 145 Specific Gravity at 60°/60°F.

Be at 60°F.	Specific Gravity in Air	% D.S. Starch	Weight in Pounds per Gallon	Grams D.S. Starch per 100 ml.	Pounds D.S. Starch per Gallon
20.0	1.1602	35.540	9.662	41.149	3.434
20.1	1.1611	35.718	9.670	41.389	3.454
20.2	1.1621	35.895	9.678	41.629	3.474
20.3	1.1630	36.073	9.686	41.868	3.494
20.4	1.1640	36.251	9.694	42.108	3.514
20.5	1.1649	36.429	9.702	42.348	3.534
20.6	1.1658	36.606	9.709	42.587	3.554
20.7	1.1668	36.784	9.717	42.827	3.574
20.8	1.1677	36.962	9.725	43.079	3.595
20.9	1.1687	37.139	9.733	43.318	3.615
21.0	1.1696	37.317	9.741	43.558	3.635
21.1	1.1706	37.495	9.749	43.797	3.655
21.2	1.1715	37.672	9.757	44.049	3.676
21.3	1.1725	37.850	9.765	44.289	3.696
21.4	1.1734	38.028	9.772	44.528	3.716
21.5	1.1744	38.206	9.781	44.780	3.737
21.6	1.1753	38.383	9.788	45.020	3.757
21.7	1.1763	38.561	9.796	45.259	3.777
21.8	1.1772	38.739	9.804	45.511	3.798
21.9	1.1782	38.916	9.812	45.751	3.818
22.0	1.1791	39.094	9.820	46.002	3.839
22.1	1.1801	39.272	9.828	46.254	3.860
22.2	1.1810	39.449	9.836	46.494	3.880
22.3	1.1820	39.627	9.844	46.745	3.901
22.4	1.1830	39.805	9.852	46.997	3.922
22.5	1.1840	39.983	9.861	47.249	3.943
22.6	1.1849	40.160	9.868	47.488	3.963
22.7	1.1859	40.338	9.876	47.740	3.984
22.8	1.1869	40.516	9.885	47.992	4.005
22.9	1.1878	40.693	9.892	48.231	4.025
23.0	1.1888	40.871	9.901	48.495	4.047
23.1	1.1898	41.049	9.909	48.746	4.068
23.2	1.1908	41.226	9.917	48.986	4.088
23.3	1.1917	41.404	9.925	49.238	4.109
23.4	1.1927	41.582	9.933	49.489	4.130
23.5	1.1937	41.760	9.941	49.741	4.151
23.6	1.1947	41.937	9.950	50.005	4.173
23.7	1.1957	42.115	9.958	50.256	4.194
23.8	1.1966	42.293	9.966	50.508	4.215
23.9	1.1976	42.470	9.974	50.760	4.236

STARCH TABLE

Baume' at 60°F Modulus 145 Specific Gravity at 60°/60°F

Be at 60°F	Specific Gravity in Air	% D.S. Starch	Weight in Pounds per Gallon	Grams D.S. Starch per 100 ml	Pounds D.S. Starch per Gallon
24.0	1.1986	42.648	9.982	51.011	4.257
24.1	1.1996	42.826	9.991	51.275	4.279
24.2	1.2006	43.003	9.999	51.526	4.300
24.3	1.2016	43.181	10.007	51.778	4.321
24.4	1.2026	43.359	10.016	52.042	4.343
24.5	1.2036	43.537	10.024	52.293	4.364
24.6	1.2046	43.714	10.032	52.545	4.385
24.7	1.2056	43.892	10.041	52.809	4.407
24.8	1.2066	44.070	10.049	53.072	4.429
24.9	1.2076	44.247	10.057	53.324	4.450
25.0	1.2086	44.425	10.065	53.576	4.471

TEMPERATURE CORRECTIONS FOR STARCH SUSPENSION

Add to Observed Baume to reduce to Baume at 60°F

70°F	80°F	90°F	100°F	110°F	120°F	130°F	140°F	Baume
0.18	0.35	0.53	0.71	0.98	1.24	1.61	1.98	5
0.17	0.34	0.52	0.69	0.95	1.20	1.56	1.92	10
0.17	0.33	0.50	0.67	0.92	1.17	1.51	1.85	15
0.16	0.32	0.49	0.65	0.89	1.13	1.45	1.78	20
0.16	0.31	0.47	0.63	0.86	1.09	1.40	1.72	25
0.15	0.30	0.46	0.61	0.83	1.05	1.35	1.65	30

J. E. Cleland, E. E. Fauser and W. R. Fetzer, Anal. Ed. Ind. and Eng. Chem. Vol. 15, Page 334, May 15, 1943
Weight of One Gallon of Water at 60°F = 8.32323 Pounds.
11.982897 x Pounds D.S. Starch Per Gallon = Grams D.S. Starch per 100 ml.

In the above correction table, 70, 80, and 90°F values by extrapolation. 130°F value by interpolation. G.E.C.

RECOMMENDED SPARE PARTS

The following list is a recommended minimum amount of spare parts that should be maintained in stock for a thermal-chemical converter system. Depending upon normal mill practice, other items may be stocked in the spare parts inventory to minimize downtime.

1. Item 31. Starch Cooking Jet

   Pardee D-10 line heater. Specify size and capacity. Order from Grain Processing Corporation.

2. Item 20. Slurry Pump

   When ordering spare parts, always specify the pump frame size, type designation, and serial number. The following spare parts should be stocked:

   a. Part: Rotor (standard size)

   b. Part: Stator

   c. Part: Connecting Rod Kit

   d. Part: Drive Belts (1 matched set)

3. Item 35. Coil Safety Relief Valve

   Specify manufacturer, model, materials, size and pressure setting.