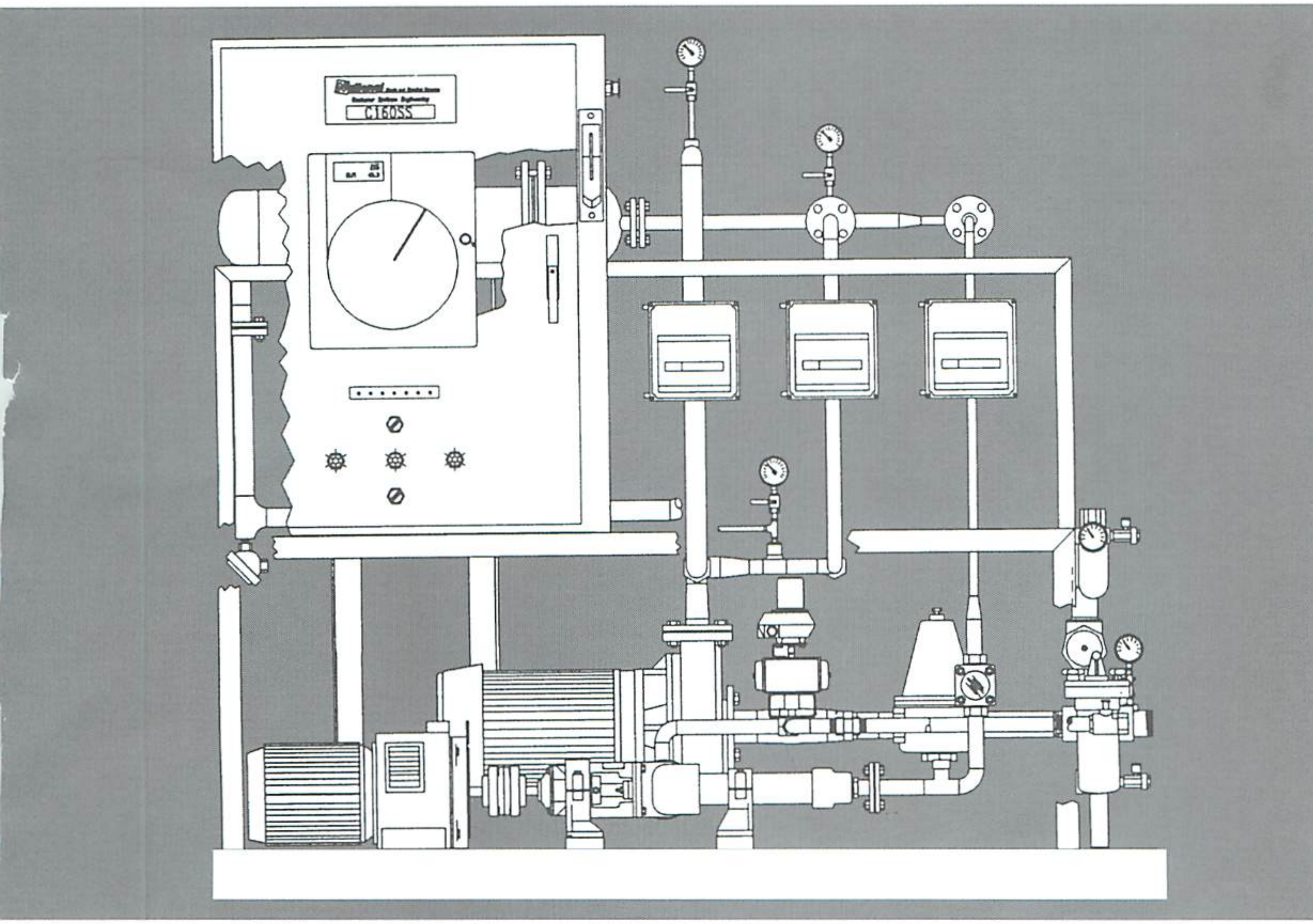
Starch Cooker Manual



National Starch and Chemical Company

CUSTOMER SYSTEMS ENGINEERING

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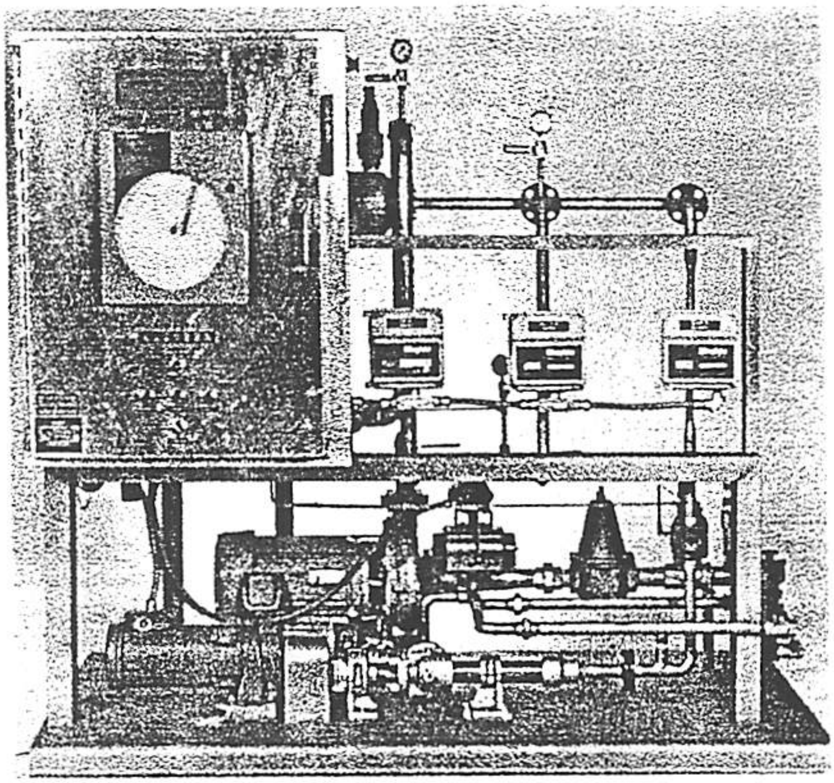
National Starch Cooker

Description and Specifications

Model C160SS



Applications

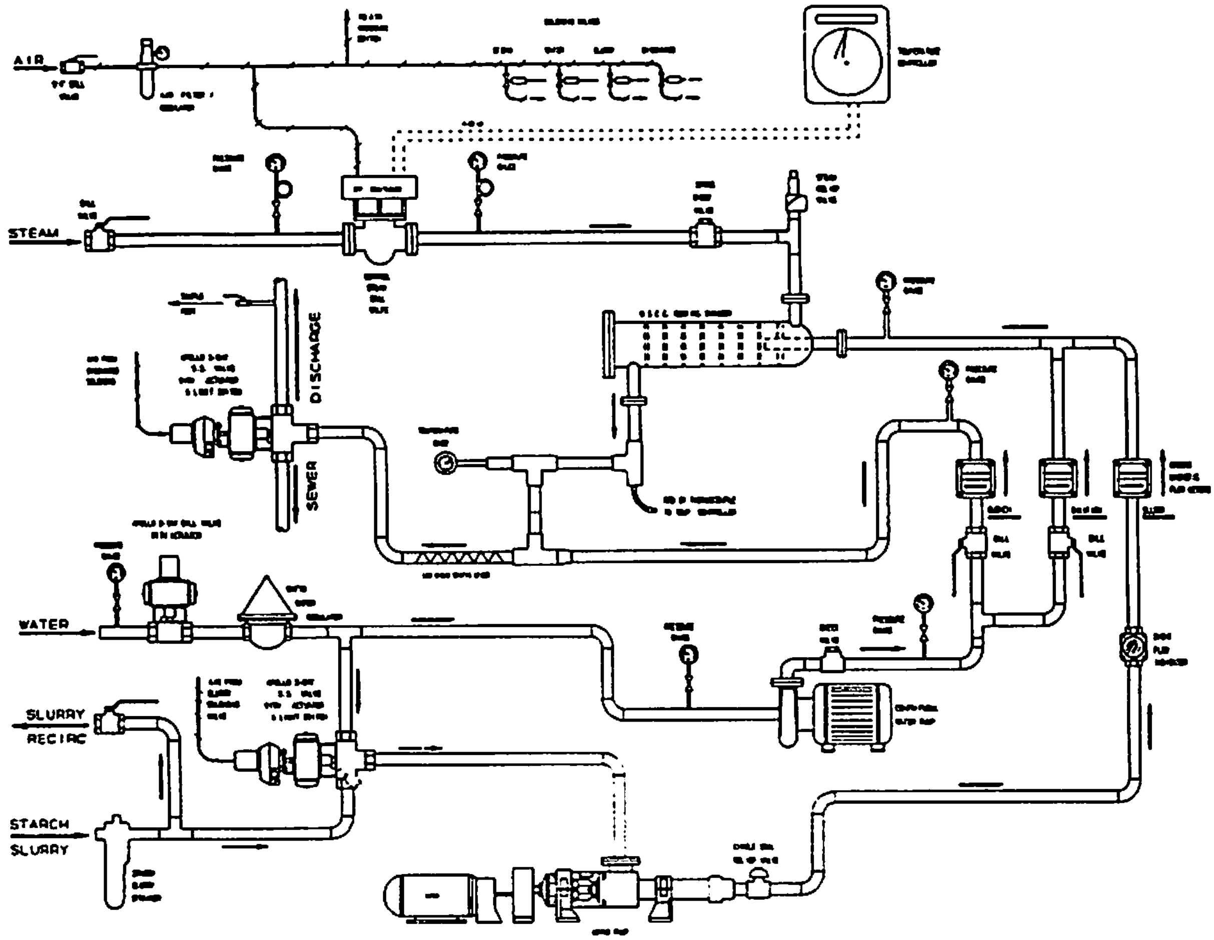
This cooker finds applications where raw starch requires processing (cooking) before use on a paper machine. It is designed to automatically maintain a supply of starch in a cooked starch storage tank at a nominal maximum cooking rate of 1000 dry lb/hr.

Specifications

Size - 80" x 48" x 73" high
Weight - 3,000 pounds
Flow rates:
- Starch slurry - 2 to 7 gpm
- Dilution water - up to 40 gpm
- Quench water - up to 100 gpm
- Cooking chamber - 15 to 40 gpm

Cooking temperature - up to 300°F
Slurry concentration - up to 32%

Description of Operation



Starch slurry of known concentration is metered to a cooking chamber by a positive displacement pump. The starch slurry may be diluted with predetermined amounts of water before or after cooking or both. As the starch slurry enters the chamber, it is immediately contacted by live steam in such a manner that intimate mixing occurs. The steam supplies both heat and turbulence to the system. As a result, the starch is instantly gelatinized.

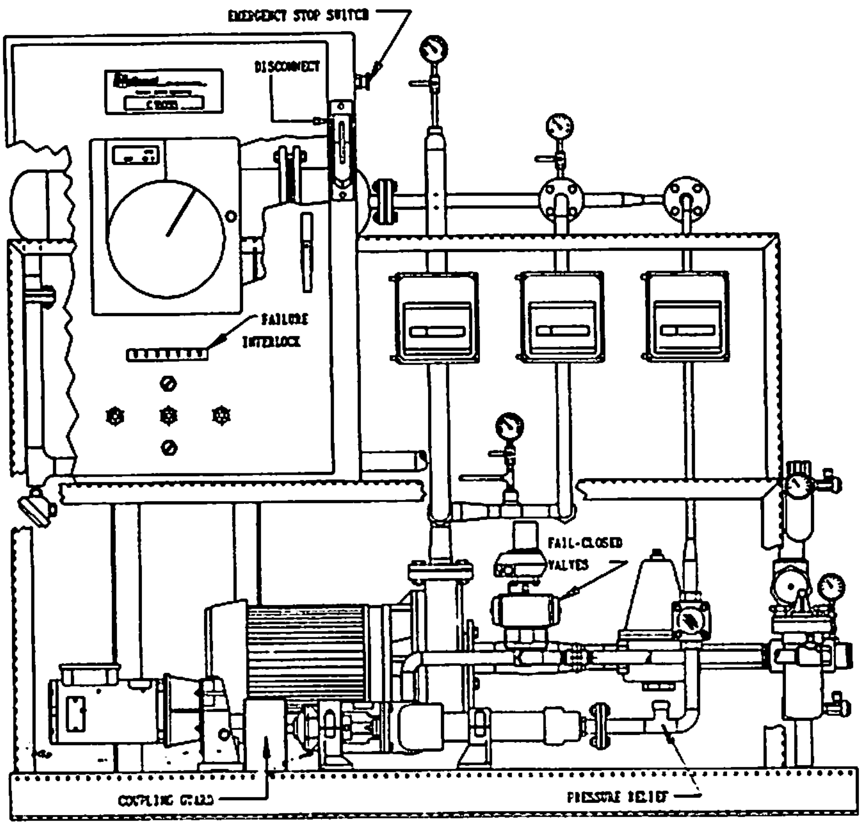
The actual amount of dilution water required is dependent upon final solids. With the dilution feature, it is possible to slurry high solids batches and control the dilution to suit the desired end product. On those starches where overcooking is undesirable,the quench water will rapidly cool the product.

The cooker is started by first turning on the utilities and then turning the Operating Switch on.

First, water is heated and discharged to the sewer for a predetermined period of time to allow the cooker to come to the operating temperature. Then the cooker automatically switches over to cooking starch and discharges to the cooked starch storage tank.

When the level in the storage tank reaches the high level setting, the cooker automatically switches back over to water and discharges to the sewer for a short period of time for flushing before shutting off. When the level in the cooked starch storage tank drops below the low level setting, the cooker automatically restarts.

Safety Features



Failure Interlock - The cooker's programmable logic controller continuously monitors seven systems for proper operation. These include motor overload, air pressure, water pressure, starch slurry flow, cooking temperature, and proper operation of the 3-way starch and discharge valves. Should any of these systems drop below their minimum safe operating thresholds, the cooker will "fail" and automatically shut down. Following a failure, the cooker will automatically reset and attempt to restart again. A remote alarm may be connected into the cooker's electrical control system to indicate a failure.

Starch Pump Relief Valve - A pressure relief valve set at 100 psi is provided on the discharge side of the positive displacement starch slurry pump.

Steam Pressure Relief Valve - A pressure relief valve set at 100 psi is mounted on the process steam line for relief of excessive pressure.

Local Disconnect - Interrupts all electrical power to cooker for servicing.

Emergency Stop Switch - A red mushroom push-pull maintained-contact switch interrupts all control power, which stops all motors and closes valves.

Fail-Closed Valves - All pneumatic valves are spring-loaded, fail-closed ball valves to ensure complete shut-off.

Coupling Guard - All cookers are provided with a guard covering the coupling between the starch slurry pump and motor.

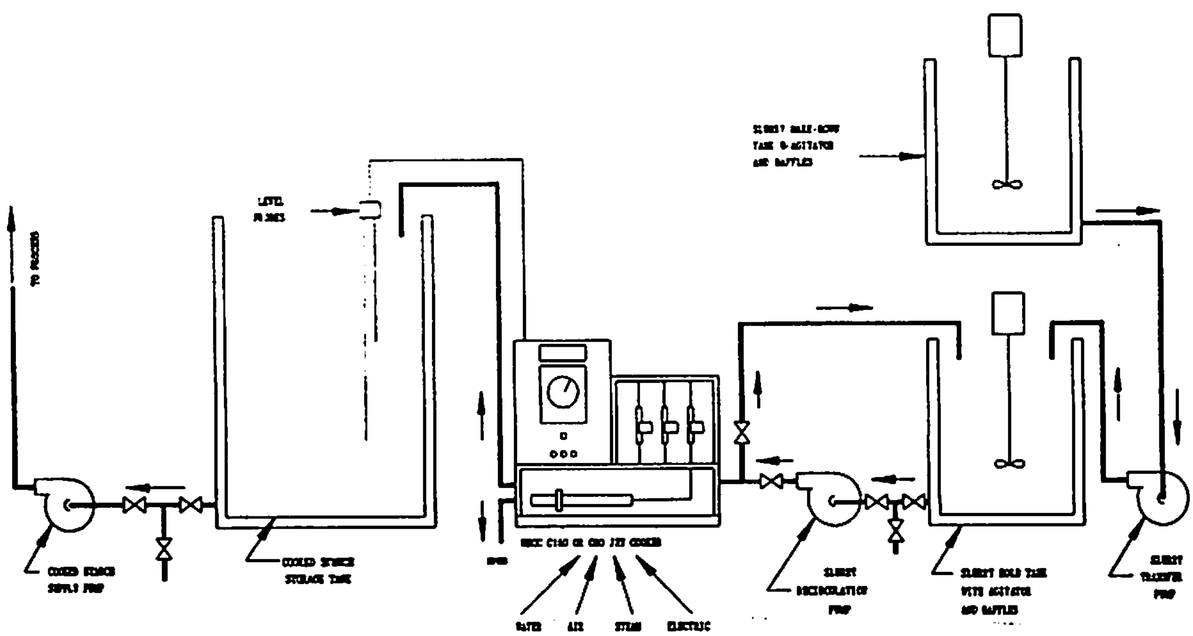
Cooker Location

The cooker is normally located in the mill area where starch is being used. The cooker and its associated equipment will require approximately 200-300 square feet of floor space and about 8 feet clear overhead space.

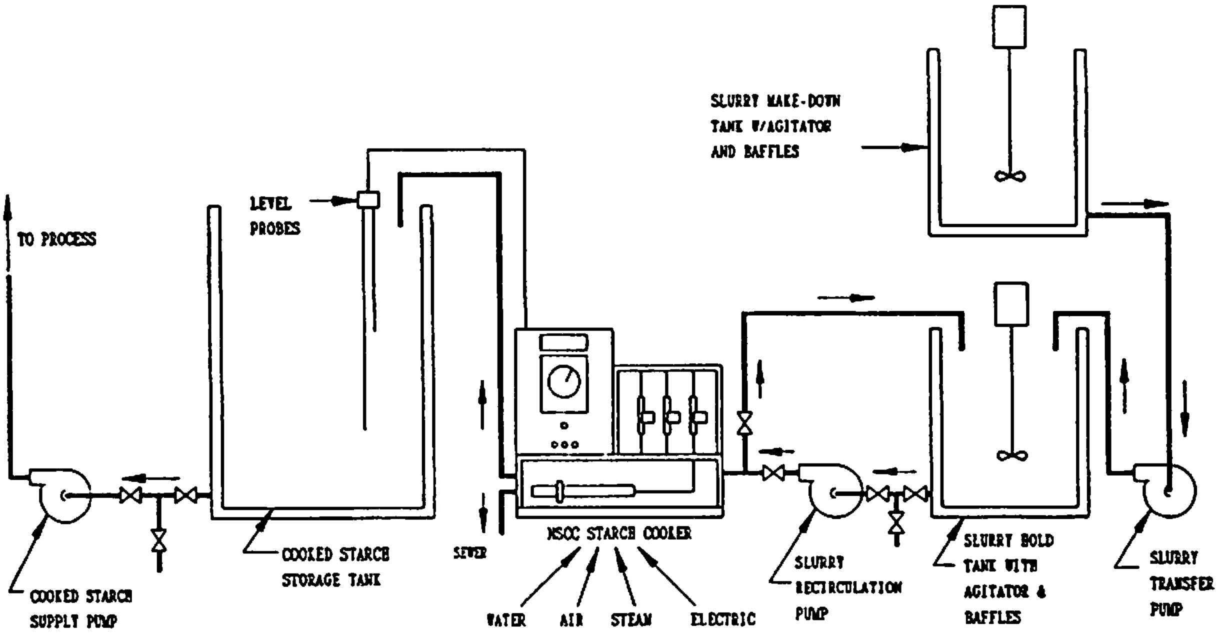
Utilities should be readily accessible to the cooker and meet the requirements outlined under Installation Requirements.

It would be best to have distances and fittings between equipment kept to a minimum, particularly between the cooker and cooked starch hold tank in order to minimize the back pressure on the cooker.

In selecting the installation location and layout of the various parts, consideration should be given to ease of maintenance.



Installation Requirements



UTILITIES	C80 MODEL	C160 MODEL
ELECTRIC	460 or 575 VAC/60 Hz 3 Phase/11 Horsepower	460 or 575 VAC/60 Hz 3 Phase/11 Horsepower
STEAM	1 1/2" Hard Piping 100-150 psig (sat.) Up to 2000 lb/hr	2" Hard Piping 100-150 psig (sat.) Up to 4000 lb/hr
AIR	1/4" O.D. Tubing 1-2 SCFM @ 70-150 psi Dry and Clean	1/4" O.D. Tubing 1-2 SCFM @ 70-150 psi Dry and Clean
WATER	80 gpm @ 20 psi min. 1 1/2" Line	160 gpm @ 20 psi min. 2" Line

ADDITIONAL PIPING

SLURRY	3/4" Feed and Recycle 6 gpm @ 5 ft/sec min. vel.	1" Feed and Recycle 15 gpm @ 5 ft/sec min. vel.
TO SEWER	1 1/2" Line	2" Line
TO PROCESS	1 1/2" Line Storage Tank with 1 Hour Capacity	2" Line Storage Tank with 1 Hour Capacity

Installation Requirements

Starch Storage Tanks

Slurry Makedown Tank

In order to make down dry starch powder into water, a tank must be provided for slurry preparation. This tank must be agitated to provide vigorous mixing to wet out the starch in water. A vortex in the tank will best wet out the starch. It is recommended that this tank be constructed of stainless steel, but fiberglass reinforced plastic (FRP) or high density polyethylene (HDPE) may be used if properly engineered for this service.

Tank size is often dictated by starch container or package size. For example, a 950-gallon tank might be used to prepare slurry at 32% or 25% solids from a 2,000-lb bulk bag. The "Starch Slurry Preparation" table in this manual is a useful tool to help determine tank size. Certainly floor space, headroom, floor loading and starch unloading requirements also affect tank size. To maximize cooker capacity and to minimize makedown water and preparation time, National recommends slurrying at 32% solids.

This tank may be used to supply the starch cooker directly. If this is the case, the cooker should be interlocked so that it does not start while slurry is being made down to prevent inconsistent solids. Also, enough cooked starch should be in storage to allow time for slurry batch preparation. Our recommendation is to install a slurry hold tank.

Slurry Hold Tank

This tank serves as a slurry tank to the starch cooker and should be sized to provide approximately eight hours of storage capacity based on starch usage on the paper machine. For example, a machine producing 25 tons per hour of paper using 20 lb of starch per ton of paper would require a hold tank with capacity to hold over 1,333 gallons of slurry at 32% solids (4,000 dry pounds). The tank should be large enough so that while the lower agitator blade is still covered, it can receive a full load from the slurry makedown tank.

The slurry hold tank should be agitated to keep the starch in suspension, but it does not have to be vigorous or create a vortex in the tank. Tank material should be stainless steel, but FRP or HDPE tanks may be considered.

Cooked Starch Hold Tank

This tank is supplied with cooked starch from the starch cooker. Cooked starch is *usually* stored at 1-4% solids for wet end products and 6-15% solids for surface or size press starches. Tank size should provide between 1-3 hours of capacity based on machine usage. Stainless steel is certainly adequate for use in this tank, but tank size may make this material selection expensive. FRP is usually a desirable material for construction because of its strength and relative cost. HDPE may be used, but the cooked starch must be held at or below 150°F. Tank manufacturers should be consulted during tank selection.

A 2" NPT coupling must be provided on top of the cooked starch hold tank for the level probes which operate the cooker. This tank should not be agitated as the mixing shears down the molecular integrity of the cooked starch granule.

Pump Recommendations

Slurry Transfer Pumps

Centrifugal pumps are best suited for transferring slurry from the slurry makedown tank to the slurry hold tank. Pump capacity should be such that it transfers the contents of the tank in less than 10 minutes with head requirements as dictated by the transfer piping. Transfer pumps should be constructed with a stainless steel casing and impeller with a stuffing box or mechanical seal. Open impellers are recommended, but not required. It is imperative to include a pump case drain to facilitate cleaning the system in the case of a power outage.

Slurry Recirculation Pumps

These pumps supply slurry continuously from the slurry hold tank to the starch cooker. The pump should circulate approximately 20-40 gpm of slurry through the cooker and back to the slurry hold tank. This allows the cooker to draw off from the slurry supply during the cook cycle with an adequate amount of circulation back to the tank to keep the starch in suspension.

Pump selection and construction closely follow those requirements of the slurry transfer pumps.

Cooked Starch Pumps

Cooked starch pumps deliver starch from the cooked starch hold tank to the paper machine. Centrifugal pumps are recommended for most applications based on reliability and economics. Centrifugal pumps also offer versatility as far as single or multiple addition points and hand or automatic flow control valves. To help minimize shear, centrifugal pumps should operate at 1800 rpm and not be oversized.

Where excessive pressure is required from the pump, positive displacement pumps are best suited. Diaphragm and piston pumps are usually not suited for starch addition because of the pulsation in flow. Gear pumps are only recommended where very viscous products are being used.

In all cases, stainless steel is the recommended construction for wetted pump parts. Because "all starches are not alike", it is best to consult National Starch to aid in the selection of the cooked starch pump for a product-specific application.

Piping

General Recommendations

Drains should be provided at low points in the piping for housekeeping and maintenance concerns. Water flush lines are also helpful in the slurry transfer lines when transferring a batch of slurry from the makedown tank to flush slurry through to the hold tank. This flush should be timed and metered to account for the additional dilution water added to the slurry.

Material

All piping in a permanent starch system should be stainless steel. For trial work, properly rated rubber hose is adequate for all connections, except for steam which should always be hard piped.

"Dead Space"

Starch slurry without agitation or flow will allow the starch to settle out of suspension. Because of this, it is very important to eliminate stagnant spaces in the piping where the slurry is not moving. This includes isolation valves, tees, vertical piping sections and any other portion in the system where slurry is allowed to settle. Vertical dead space is most critical because starch settling out will fill the lower half of the length of pipe totally blocking fluid passage. In horizontal dead space, starch settles out in the bottom of the horizontal run with water in the top half. To ensure that the starch does not settle out in the line, a minimum pipeline velocity of 5 ft/sec is recommended.

Tank Piping

The slurry transfer line from the slurry makedown tank and the recirculation line from the cooker should extend to the bottom of the slurry hold tank to prevent foaming and air entrainment. Be sure to locate these lines away from any agitation and pump suctions.

The cooked starch piping from the cooker into the cooked starch hold tank should extend below the low level control point of the cooker so that it enters the tank below the surface of the starch. This also prevents foaming and air entrainment.

Recirculation of cooked starch back to the cooked starch tank is not required or recommended.

Siphoning

If the slurry hold tank is located on a floor below the cooker, the recirculation piping after the cooker has a tendency to create a siphon, starving the suction of the Moyno slurry pump on the cooker. If this should happen, the ball valve on the slurry recirculation leg located near the front, right side of the cooker should be throttled to pressurize the Moyno pump suction.

Startup & Shutdown Procedures

Startup Procedure

1. Check that starch slurry duplex strainer baskets are clean.

2. Open service lines to cooker i.e. water, air, steam, and starch slurry supplies. Turn electric power on.

3. Adjust set point of the temperature controller to desired cooking temperature.

4. Put cooker into operation by turning the Operating Switch "On".

5. Set the desired dilution and quench water flow rates by adjusting the valves on the inlet lines to the mag flow meters.

6. Set the desired starch slurry flow rate using the speed pot on the panel box.

7. When cooker switches from sewer to process, check all flow rates and compensate for any changes that may have occurred due to pressure variations.

Operating Switch

The Operating Switch controls power to the level control system ONLY, which in turn affects the automatic operating sequence of the cooker.

The Operating Switch will NOT IMMEDIATELY STOP the cooker. Only the Emergency Stop switch located on the top right side of the panel box will stop ALL cooker functions.

When the Operating Switch is turned off, the pump motors remain energized until the cooker completes a shutdown (flush-out) cycle.

Shutdown Procedure

Since the automated cooker flushes itself on each shutdown, no special procedures are required for a shutdown. Simply turn the Operating Switch "Off".

If the shutdown is for an extended period of time, shut off the utilities once the cooker's shutdown is complete. Be sure that the starch slurry storage tank and lines are cleaned to prevent plugging of the lines by settling of the starch slurry.

Cooker Timing Sequence

Programmer keyswitch should be in the RUN position.

To monitor main timer: CLR SHF 6 0 0 MON

STARTUP CYCLE	TIME (sec)
Stand-By	0 - Holds @ 0 (Note 1)
Water valve opens	2
Water pump starts	4
Moyno pump starts	8
Steam valve starts to open	12 - Holds @ 12 (Note 2)
Slurry valve to slurry	42
Discharge valve to process	47
Start-Up complete/cooking	50 - Holds @ 50 (Note 3)

SHUT DOWN CYCLE	
Slurry valve to water	52
Discharge valve to sewer	62
Steam valve closes	72
Moyno pump off	92
Water pump off	94
Water valve closes	96
Shut down complete/reset to 0	98

NOTE 1: Timer holds @ 0 until:

1. Operating switch to on or
2. Low level signal

NOTE 2: Timer holds @ 12 until:

1. Cooker satisfied for temperature or
2. 180 seconds elapse

NOTE 3: Timer holds @ 50 until:

1. High level signal or
2. Operating switch to off

CATO®TABLE

(Starch Slurry & Cooked Starch)

% Dry Cato	Lb Dry CATO/Gal	Density, Lb/Gal
1	0.084	8.36
2	0.168	8.39
3	0.252	8.43
4	0.338	8.46
5	0.425	8.49
6	0.511	8.53
7	0.599	8.56
8	0.687	8.60
9	0.776	8.63
10	0.867	8.67
12	1.048	8.74
14	1.233	8.81
16	1.421	8.88
18	1.612	8.95
20	1.806	9.03
22	2.003	9.11
24	2.204	9.19
26	2.409	9.27
28	2.617	9.34
30	2.828	9.43
32	3.043	9.51

Above data at 60°F
Wt of 1 gal H_2O @ 60°F = 8.33 lb.

Starch Slurry Preparation

1 Lb Dry Starch per Gallon Slurry

(11.5%=6.45°Baume′=8.717 Lb/Gal)

Pounds Starch Added	Gallons Water Added	Total Gallons Slurry
50	41	45
100	82	90
200	164	180
300	246	270
400	328	359
500	410	449
600	492	539
700	574	629
800	656	719
900	738	808
1000	819	897
2000	1639	1796

2 Lb Dry Starch per Gallon Slurry

(21.9%=12.3°Baume′=9.105 Lb/Gal)

Pounds Starch Added	Gallons Water Added	Total Gallons Slurry
50	19	23
100	37	45
200	75	91
300	112	135
400	149	180
500	187	226
600	224	271
700	261	316
800	299	361
900	336	406
1000	373	451
2000	747	903

2.5 Lb Dry Starch per Gallon Slurry

(26.9%=15.1°Baume′=9.303 Lb/Gal)

Pounds Starch Added	Gallons Water Added	Total Gallons Slurry
50	13	17
100	27	35
200	54	70
300	81	105
400	108	140
500	134	174
600	161	209
700	188	244
800	215	279
900	242	314
1000	269	348
2000	538	697

3 Lb Dry Starch per Gallon Slurry

(31.6%=17.8°Baume′=9.494 Lb/Gal)

Pounds Starch Added	Gallons Water Added	Total Gallons Slurry
50	11	15
100	22	30
200	44	60
300	67	90
400	89	120
500	111	150
600	133	180
700	155	210
800	177	240
900	200	270
1000	222	300
2000	444	600

NOTE: Above tables assumes equilibrium moisture content of Cato® starch = 10%.

CATO® Starch Cooker Flow Settings

Cooking @ 4% Chamber Solids *1% and 2% Final Solids*

3 Lb/Gal Slurry (31.6% Solids)

Starch Thruput Lb/Hr	Slurry GPM	Dilution GPM	Quench GPM 1%	Quench GPM 2%
100	0.56	3.7	15.0	-
150	0.83	5.6	22.5	-
200	1.11	7.5	30.0	-
250	1.39	9.3	37.5	12.5
300	1.67	11.2	45.0	15.0
350	1.94	13.1	52.5	17.5
400	2.22	14.9	60.0	20.0
450	2.50	16.8	67.5	22.5
500	2.78	18.7	75.0	25.0
550	3.06	20.5	82.5	27.5
600	3.33	22.4	90.0	30.0
650	3.61	24.3	97.5	32.5
700	3.89	26.1	105.0	35.0
750	4.17	28.0	112.5	37.5
800	4.44	29.9	120.0	40.0
850	4.72	31.7		42.5
900	5.00	33.6		45.0

2 Lb/Gal Slurry (21.9% Solids)

Starch Thruput Lb/Hr	Slurry GPM	Dilution GPM	Quench GPM 1%	Quench GPM 2%
100	0.83	3.50	15.0	-
150	1.25	5.20	22.5	-
200	1.67	6.90	30.0	-
250	2.08	8.60	37.5	12.5
300	2.50	10.4	45.0	15.0
350	2.92	12.1	52.5	17.5
400	3.33	13.8	60.0	20.0
450	3.75	15.5	67.5	22.5
500	4.17	17.3	75.0	25.0
550	4.58	19.0	82.5	27.5
600	5.00	20.7	90.0	30.0
650	5.42	22.5	97.5	32.5
700	5.83	24.2	105.0	35.0
750	6.25	25.9	112.5	37.5
800	6.67	27.6	120.0	40.0
850	7.08	29.4		42.5
900	7.50	31.1		45.0

1 Lb/Gal Slurry (11.5% Solids)

Starch Thruput Lb/Hr	Slurry GPM	Dilution GPM	Quench GPM 1%	Quench GPM 2%
100	1.67	2.6	15.0	-
150	2.50	3.9	22.5	-
200	3.33	5.2	30.0	-
250	4.17	6.6	37.5	12.5
300	5.00	7.9	45.0	15.0
350	5.83	9.2	52.5	17.5
400	6.67	10.5	60.0	20.0
450	7.50	11.8	67.5	22.5

Basis of Calculations

1) Condensate estimated at 15% of slurry & dilution flows.

2) Pounds of dry starch per gallon (slurry or cooked starch):

1% = 0.0836 lb/gal
2% = 0.1678 lb/gal
3% = 0.2530 lb/gal
4% = 0.3380 lb/gal
5% = 0.4250 lb/gal
6% = 0.5120 lb/gal

DIRECTIONS:

1) Select appropriate table based on solids of slurry supply to cooker.
2) Select usage rate of starch greater than paper machine requirements. This is the cooker thruput.
3) Read flow settings horizontally across from thruput based on final solids requirements.
4) Refer to *Starch Cooker Flow Calculations* for flows with parameters other than shown in tables.

CATO® Starch Cooker Flow Settings

Cooking @ 5% Chamber Solids *1% and 2% Final Solids*

3 Lb/Gal Slurry (31.6% Solids)

Starch Thruput Lb/Hr	Slurry GPM	Dilution GPM	Quench GPM 1%	Quench GPM 2%
100	0.56	2.8	16	-
150	0.83	4.3	24	-
200	1.11	5.7	32	12
250	1.39	7.1	40	15
300	1.67	8.6	48	18
350	1.94	10.0	56	21
400	2.22	11.4	64	24
450	2.50	12.8	72	27
500	2.78	14.3	80	30
550	3.06	15.7	88	33
600	3.33	17.1	96	36
650	3.61	18.6	104	39
700	3.89	20.0	112	42
750	4.17	21.4	120	45
800	4.44	22.8		48
850	4.72	24.3		51
900	5.00	25.7		54
950	5.28	27.1		57
1000	5.56	28.5		60

2 Lb/Gal Slurry (21.9% Solids)

Starch Thruput Lb/Hr	Slurry GPM	Dilution GPM	Quench GPM 1%	Quench GPM 2%
100	0.83	2.6	16	-
150	1.25	3.9	24	-
200	1.67	5.2	32	12
250	2.08	6.4	40	15
300	2.50	7.7	48	18
350	2.92	9.0	56	21
400	3.33	10.3	64	24
450	3.75	11.6	72	27
500	4.17	12.9	80	30
550	4.58	14.2	88	33
600	5.00	15.5	96	36
650	5.42	16.8	104	39
700	5.83	18.0	112	42
750	6.25	19.3	120	45
800	6.67	20.6		48
850	7.08	21.9		51
900	7.50	23.2		54

1 Lb/Gal Slurry (11.5% Solids)

Starch Thruput Lb/Hr	Slurry GPM	Dilution GPM	Quench GPM 1%	Quench GPM 2%
100	1.67	1.7	16	-
150	2.50	2.6	24	-
200	3.33	3.5	32	12
250	4.17	4.4	40	15
300	5.00	5.2	48	18
350	5.83	6.1	56	21
400	6.67	7.0	64	24
450	7.50	7.8	72	27

Basis of Calculations

1) Condensate estimated at 15% of slurry & dilution flows.

2) Pounds of dry starch per gallon (slurry or cooked starch):

1% = 0.0836 lb/gal
2% = 0.1678 lb/gal
3% = 0.2530 lb/gal
4% = 0.3380 lb/gal
5% = 0.4250 lb/gal
6% = 0.5120 lb/gal

CATO® Starch Cooker Flow Settings

Cooking @ 6% Chamber Solids *2% and 4% Final Solids*

3 Lb/Gal Slurry (31.6% Solids)

Starch Thruput Lb/Hr	Slurry GPM	Dilution GPM	Quench GPM 2%	Quench GPM 4%
200	1.11	4.6	13.4	-
250	1.39	5.7	16.7	-
300	1.67	6.8	20.0	-
350	1.94	8.0	23.4	-
400	2.22	9.1	26.7	-
450	2.50	10.2	30.0	-
500	2.78	11.4	33.4	-
550	3.06	12.5	36.7	-
600	3.33	13.6	40.1	-
650	3.61	14.8	43.4	-
700	3.89	15.9	46.7	11.7
750	4.17	17.1	50.1	12.6
800	4.44	18.2	53.4	13.4
850	4.72	19.3	56.8	14.2
900	5.00	20.5	60.1	15.1
950	5.28	21.6	63.4	15.9
1000	5.56	22.8	66.8	16.8
1100	6.12	25.1	73.5	18.5
1200	6.67	27.4	80.2	20.2
1300	7.23	29.6	86.8	21.8

2 Lb/Gal Slurry (21.9% Solids)

Starch Thruput Lb/Hr	Slurry GPM	Dilution GPM	Quench GPM 2%	Quench GPM 4%
200	1.67	4.0	13.4	-
250	2.08	5.0	16.7	-
300	2.50	6.0	20.0	-
350	2.92	7.0	23.4	-
400	3.33	8.0	26.7	-
450	3.75	9.0	30.0	-
500	4.17	10.0	33.4	-
550	4.58	11.0	36.7	-
600	5.00	12.0	40.1	-
650	5.42	13.0	43.4	-
700	5.83	14.0	46.7	11.7
750	6.25	15.0	50.1	12.6
800	6.67	16.0	53.4	13.4
850	7.08	17.0	56.8	14.2
900	7.50	18.0	60.1	15.1

1 Lb/Gal Slurry (11.5% Solids)

Starch Thruput Lb/Hr	Slurry GPM	Dilution GPM	Quench GPM 2%	Quench GPM 4%
200	3.33	2.3	13.4	-
250	4.17	2.9	16.7	-
300	5.00	3.5	20.0	-
350	5.83	4.1	23.4	-
400	6.67	4.7	26.7	-
450	7.50	5.2	30.0	-

Basis of Calculations

1) Condensate estimated at 15% of slurry & dilution flows.

2) Pounds of dry starch per gallon (slurry or cooked starch):

1% = 0.0836 lb/gal
2% = 0.1678 lb/gal
3% = 0.2530 lb/gal
4% = 0.3380 lb/gal
5% = 0.4250 lb/gal
6% = 0.5120 lb/gal

Size Press Starch Cooker Flow Settings

3 Lb/Gal Slurry (31.6% Solids)

Shaded data indicate settings at optimum cooking chamber flows, approximately 20-25 gpm (excl. condensate).

Starch Thruput Lb/Hr	Slurry GPM	10% Cooking Chamber Solids			
		Dilution GPM	Quench GPM		
			6% Final	8% Final	10% Final
800	4.44	8.9	10.6	4.0	0
900	5.00	10.1	12.0	4.5	↓
1000	5.56	11.2	13.3	5.0	
1100	6.11	12.3	14.6	5.5	
1200	6.67	13.4	16.0	6.0	
1300	7.22	14.5	17.3	6.5	
1400	7.78	15.6	18.6	7.0	
1500	8.33	16.8	20.0	7.5	
1600	8.89	17.9	21.3	8.0	
1700	9.44	19.0	22.6	8.5	
1800	10.0	20.1	24.0	9.0	
1900	10.6	21.2	25.3	9.5	
2000	11.1	22.4	26.6	10.0	
2200	12.2	24.6	29.3	11.0	
2400	13.3	26.8	31.9	12.0	
2600	14.4	29.1	34.6	12.9	
2800	15.6	31.3	37.3	13.9	
3000	16.7	33.5	39.9	14.9	

Starch Thruput Lb/Hr	Slurry GPM	12% Cooking Chamber Solids			
		Dilution GPM	Quench GPM		
			6% Final	8% Final	10% Final
800	4.44	6.6	13.3	6.7	2.7
900	5.00	7.4	15.0	7.5	3.0
1000	5.56	8.3	16.6	8.3	3.3
1100	6.11	9.1	18.3	9.2	3.7
1200	6.67	9.9	20.0	10.0	4.0
1300	7.22	10.8	21.6	10.8	4.3
1400	7.78	11.6	23.3	11.7	4.7
1500	8.33	12.4	25.0	12.5	5.0
1600	8.89	13.2	26.6	13.3	5.3
1700	9.44	14.1	28.3	14.1	5.7
1800	10.0	14.9	30.0	15.0	6.0
1900	10.6	15.7	31.6	15.8	6.4
2000	11.1	16.6	33.3	16.6	6.7
2200	12.2	18.2	36.6	18.3	7.4
2400	13.3	19.9	40.0	20.0	8.0
2600	14.4	21.5	43.3	21.6	8.7
2800	15.6	23.2	46.6	23.3	9.4
3000	16.7	24.8	49.9	25.0	10.0

Size Press Starch Cooker Flow Settings

3 Lb/Gal Slurry (31.6% Solids)

Shaded data indicate settings at optimum cooking chamber flows, approximately 20-25 gpm (excl. condensate).

Starch Thruput Lb/Hr	Slurry GPM	14% Cooking Chamber Solids			
		Dilution GPM	Quench GPM		
			6% Final	8% Final	10% Final
800	4.44	5.0	15.2	8.2	4.6
900	5.00	5.6	17.1	9.6	5.2
1000	5.56	6.2	19.0	10.7	5.7
1100	6.11	6.8	20.9	11.8	6.3
1200	6.67	7.4	22.8	12.8	6.9
1300	7.22	8.1	24.7	13.9	7.4
1400	7.78	8.7	26.6	15.0	8.0
1500	8.33	9.3	28.6	16.1	8.6
1600	8.89	9.9	30.5	17.1	9.2
1700	9.44	10.5	32.4	18.2	9.7
1800	10.0	11.2	34.3	19.3	10.3
1900	10.6	11.8	36.2	20.3	10.9
2000	11.1	12.4	38.1	21.4	11.5
2200	12.2	13.6	41.9	23.6	12.6
2400	13.3	14.9	45.7	25.7	13.7
2600	14.4	16.1	49.5	27.8	14.9
2800	15.6	17.4	53.3	30.0	16.0
3000	16.7	18.6	58.1	32.1	17.2

Starch Thruput Lb/Hr	Slurry GPM	16% Cooking Chamber Solids			
		Dilution GPM	Quench GPM		
			6% Final	8% Final	10% Final
800	4.44	3.7	16.7	10.0	6.0
900	5.00	4.2	18.7	11.2	6.8
1000	5.56	4.6	20.8	12.5	7.5
1100	6.11	5.1	22.9	13.7	8.3
1200	6.67	5.6	25.0	15.0	9.0
1300	7.22	6.0	27.1	16.2	9.8
1400	7.78	6.5	29.2	17.5	10.5
1500	8.33	7.0	31.2	18.7	11.3
1600	8.89	7.4	33.3	20.0	12.0
1700	9.44	7.9	35.4	21.2	12.8
1800	10.0	8.4	37.5	22.5	13.5
1900	10.6	8.8	39.6	23.7	14.3
2000	11.1	9.3	41.6	25.0	15.0
2200	12.2	10.2	45.8	27.5	16.5
2400	13.3	11.1	50.0	30.0	18.0
2600	14.4	12.1	54.1	32.5	19.5
2800	15.6	13.0	58.3	35.0	21.0
3000	16.7	13.9	62.5	37.5	22.6

Size Press Starch Cooker Flow Settings

3 Lb/Gal Slurry (31.6% Solids)

Shaded data indicate settings at optimum cooking chamber flows, approximately 20-25 gpm (excl. condensate).

Starch Thruput Lb/Hr	Slurry GPM	18% Cooking Chamber Solids			
		Dilution GPM	Quench GPM		
			6% Final	8% Final	10% Final
800	4.44	2.7	17.8	11.1	7.1
900	5.00	3.1	20.0	12.5	8.0
1000	5.56	3.4	22.2	13.9	8.9
1100	6.11	3.8	24.4	15.3	9.8
1200	6.67	4.1	26.7	16.7	10.7
1300	7.22	4.5	28.9	18.1	11.6
1400	7.78	4.8	31.1	19.4	12.5
1500	8.33	5.2	33.3	20.8	13.4
1600	8.89	5.5	35.5	22.2	14.3
1700	9.44	5.8	37.8	23.6	15.1
1800	10.0	6.2	40.0	25.0	16.0
1900	10.6	6.5	42.2	26.4	16.9
2000	11.1	6.9	44.4	27.8	17.8
2200	12.2	7.6	48.9	30.5	19.6
2400	13.3	8.2	53.3	33.3	21.4
2600	14.4	8.9	57.8	36.1	23.2
2800	15.6	9.6	62.2	38.9	24.9
3000	16.7	10.3	66.6	41.7	26.7

Starch Thruput Lb/Hr	Slurry GPM	20% Cooking Chamber Solids			
		Dilution GPM	Quench GPM		
			6% Final	8% Final	10% Final
800	4.44	2.0	18.7	12.0	8.0
900	5.00	2.2	21.0	13.5	9.0
1000	5.56	2.5	23.3	15.0	10.0
1100	6.11	2.7	25.7	16.5	11.0
1200	6.67	3.0	28.0	18.0	12.0
1300	7.22	3.2	30.3	19.5	13.0
1400	7.78	3.5	32.7	21.0	14.0
1500	8.33	3.7	35.0	22.5	15.0
1600	8.89	4.0	37.3	24.0	16.0
1700	9.44	4.2	39.7	25.5	17.0
1800	10.0	4.4	42.0	27.0	18.0
1900	10.6	4.7	44.3	28.5	19.0
2000	11.1	4.9	46.6	30.0	20.0
2200	12.2	5.4	51.3	33.0	22.0
2400	13.3	5.9	56.0	36.0	24.0
2600	14.4	6.4	60.6	39.0	26.0
2800	15.6	6.9	65.3	42.0	28.0
3000	16.7	7.4	70.0	45.0	30.0

Starch Cooker Flow Calculations

(1) CALCULATION OF STARCH COOKER SLURRY FLOW

$$\textit{SLURRY FLOW (gpm)} = \frac{\textit{STARCH THRUPUT (lb/hr)}}{60 \times \textit{SLURRY CONCENTRATION (lb/gal)}}$$

(2) CALCULATION OF STARCH COOKER DILUTION WATER FLOW

$$\textit{DILUTION (gpm)} = \frac{\textit{STARCH THRUPUT (lb/hr)}}{60} \times \left[\frac{1}{1.15 \times \textit{CHAMBER CONC.(lb/gal)}} - \frac{1}{\textit{SLURRY CONC.(lb/gal)}}\right]$$

(3) CALCULATION OF STARCH COOKER QUENCH WATER FLOW

$$\textit{QUENCH (gpm)} = \frac{\textit{STARCH THRUPUT (lb/hr)}}{60} \times \left[\frac{1}{\textit{FINAL OUTPUT CONC. (lb/gal)}} - \frac{1}{\textit{CHAMBER CONC. (lb/gal)}}\right]$$

Basis for Calculations

1) Additional dilution due to steam condensation is estimated at 15% of the cooking chamber flow (slurry and dilution).

2) PERCENT STARCH vs POUNDS OF DRY STARCH/GALLON (SLURRY OR COOKED)

1% = 0.084 lb/gal	5% = 0.425 lb/gal
2% = 0.168 lb/gal	6% = 0.512 lb/gal
3% = 0.253 lb/gal	7% = 0.599 lb/gal
4% = 0.338 lb/gal	8% = 0.688 lb/gal

3) See starch tables for additional information.

Cooker Starch Solids Adjustment

When operating the cooker, it may become necessary to make adjustments to the flow rates through the cooker to increase or decrease the solids of the cooked starch exiting the cooker. It is important to consider the operating conditions and requirements of the starch before selecting the flow stream to adjust.

Quench (Post-Dilution) Water Flow Rate

The quench water has a two-fold purpose: it dilutes the cooked starch exiting the chamber to the desired final solids, and also cools the cooked starch to prevent overcooking or thermal degradation of the starch.

Increasing the quench water *decreases* the final solids and final starch temperature. *Decreasing* the quench water *increases* the final solids and final starch temperature.

Because the quench water does not affect temperature *control* or cooking chamber solids, it is the preferred flow stream to be used for making solids adjustment to the cooked starch.

Dilution (Pre-Dilution) Water Flow Rate

The dilution stream dilutes the concentrated slurry before it enters the cooking chamber and comes in contact with steam. Adjusting the dilution water flow rate will affect the temperature control momentarily while the cooker is processing starch. *Increasing* dilution water *decreases* final solids and *decreasing* dilution water *increases* final solids.

If the dilution water is increased too rapidly during cooking, the steam valve may not open fast enough to avoid dropping the cooking chamber temperature below the alarm limit. This may cause the cooker to shut down due to a temperature alarm condition.

Because the dilution water is heated in the cooking chamber, *increasing* dilution water will *increase* the temperature of the starch going to the hold tank (assuming the other flows and cooking temperature remain constant). Cooked starch should be held at 150°F or less in the tank.

It is important to keep these considerations in mind when adjusting the dilution water flow to compensate for final cooked starch solids.

Starch Slurry Flow Rate

The Moyno pump meters slurry through the cooker at a constant rate and, therefore, dictates the starch throughput or capacity of the cooker. Because of this, the slurry flow should be the last choice of flow rate adjustment when targeting a specific solids output. If, however, this is the only avenue for solids adjustment, *increasing* the slurry flow *increases* the starch solids exiting the cooker. Conversely, decreasing the flow rate *decreases* the final starch solids.

Also keep in mind that *increasing* slurry flow rate *increases* cooker throughput and *decreasing* slurry flow *decreases* cooker capacity. Be careful that when adjusting the slurry flow, the capacity of the cooker is not less than the required amount of starch being consumed at the machine.

Cooked Starch Storage Temperature

Most starches should not be stored in the cooked starch storage tank above 150°F. Application requirements on the paper machine may also dictate the storage temperature of the cooked starch. National Starch should be consulted for any product-specific storage and use requirements. This is especially important with surface starch applications. The storage temperature of the cooked starch may be estimated by the following formula:

$$(S + D)\,CT + Q\,(WT) = (S + D + Q)\,FT$$

Where:

S	=	Slurry flow rate in gallons per minute
D	=	Dilution water flow rate in gallons per minute
CT	=	Cooking temperature in °F
Q	=	Quench water flow rate in gallons per minute
WT	=	Ambient water temperature in °F entering cooker
FT	=	Final starch temperature in °F

Example:

A cooker with flow rates of 6 gpm slurry, 15 gpm dilution water and 40 gpm quench water uses water at 60°F and cooks at 225°F. What is the final starch temperature?

$$(6 + 15)\,225 + 40\,(60) = (6 + 15 + 40)\,FT$$
$$FT = 117°F$$

Pipe Losses for Viscous Liquids

The following equation can be used to estimate the amount of system back pressure on the discharge piping of a cooker or cooked starch pump. The viscosity of the fluid must be measured or converted to Centipoise and the flow of the fluid must be known. National Starch recommends that the cooker be operated at or below 40 psi in chamber back pressure to maintain accurate temperature and solids control.

CALCULATION OF PIPE FRICTION LOSS IN PIPING FOR VISCOUS LIQUIDS

PRESSURE LOSS (p.s.i. per 100 feet of pipe) = FLOW (gal/min) x VISCOSITY(Centipoise) x K Factor (see below)

Where "K" =	0.1824	for 1/2"	Schedule 40 Pipe
	0.0592	for 3/4"	Schedule 40 Pipe
	0.0225	for 1"	Schedule 40 Pipe
	0.00753	for 1¼"	Schedule 40 Pipe
	0.00406	for 1½"	Schedule 40 Pipe
	0.001496	for 2"	Schedule 40 Pipe
	0.000735	for 3"	Schedule 40 Pipe
	0.0001039	for 4"	Schedule 40 Pipe

NOTE: This equation calculates losses per 100 feet of pipe. If you have any multiple or part of 100 feet in length the resultant loss must be multiplied or divided accordingly.

EXAMPLE: A National C160 Starch Cooker is cooking 600 lb/hr using 2 lb/gal slurry of CATO® 232 at 4% chamber solids. The final cooked starch solids in the cooked starch tank are at 1%. The piping from the cooker to the tank is 200 feet long and is 3" schedule 40 pipe. CATO® 232 has a viscosity of 150 Centipoise at 1% solids at 140°F. Calculate the line loss to see if this will be excessive back pressure on the cooker.

SOLUTION Based on the 2 lb/gal slurry table on page 10 of the cooker manual, the cooker flow settings for 4% cooked solids and 1% final solids for 600 lb/hr cooker thruput are 5 gpm of slurry, 20.7 gpm of dilution, and 90 gpm of quench water. 15% of the chamber flow is added to the total flow due to condensate (3.87 gals). This is a total of 119.6 gallons of 1% cooked starch going to the tank. Using the above equation and inserting "K" as 0.000735 for 3" pipe we calculate:

psi/100 ft = (119.6 gpm) x (150 Centipoise) x (0.000735)

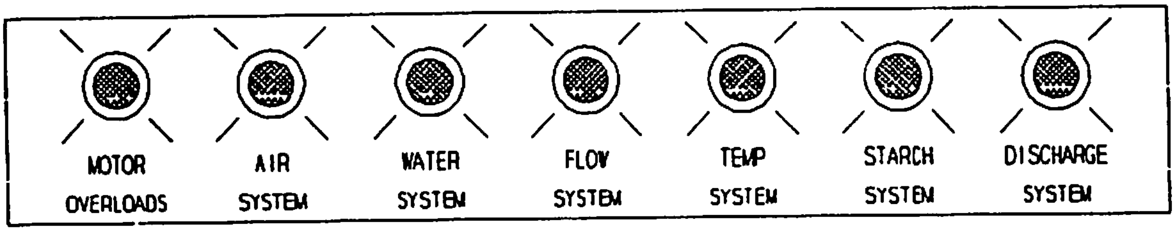
psi/100 ft = 13.19 psi

Since there is 200 feet of piping, the back pressure will be 2 x 13.19 or 26.38 psi which is acceptable for the cooker when added to the chamber back pressure shown when the cooker is running to the sewer.

Cooker Troubleshooting

Failsafe System

National's Starch Cooker is designed to cook starch under optimum conditions only. The



cooker's PLC (programmable logic controller) continually monitors seven systems for proper operation. The status of each of these systems is indicated by its neon light on the panel box. When the cooker is running, a system's neon light is on when the system is not satisfied and off when it is satisfied.

Should any of the failsafe systems drop below their minimum safe operating thresholds, the cooker will "fail" and shut down immediately. The fail cycle lasts for 30 seconds, during which time the large red "Master Failure Light" is on and the system which caused the failure is indicated by the appropriate blinking neon light.

Following a failure, the cooker attempts to restart. If the failure was caused by a momentary deficiency, the cooker should restart without difficulty. However, if the cooker repeatedly fails for one particular system, that system must be investigated for trouble.

It is important to understand what the seven failsafe systems are and how they are monitored:

- **Motor Overload** - Monitors motor amperage draw.
  The water pump motor starter is equipped with thermal overload devices (heaters). The slurry pump motor is protected in two ways; first, through the variable frequency drive's fault conditions and second, by a temperature switch mounted in the motor winding.

- **Air System** - Monitors regulated air pressure.
  Air from the cooker's air filter/regulator is fed to an adjustable pressure switch located inside the electrical panel box. The switch is typically set at 50 psi.

- **Water System** - Monitors pumped water pressure.
  A non-adjustable pressure switch set at 50 psi is mounted on the discharge side of the water booster pump.

- **Flow System** - Monitors starch slurry flow through the cooker. A 4-20 mA signal is generated by the mag flowmeter in the starch slurry line. This signal is looped through a signal conditioning relay equipped with a small potentiometer located inside the electrical panel box. The potentiometer provides a blind setting for the low mA alarm trip point (low starch slurry flow). A light inside the relay is green when the flow switch is satisfied and red when there is insufficient flow. Settings are approximately 1 gpm for C80 cookers and 2 gpm for C160 cookers.

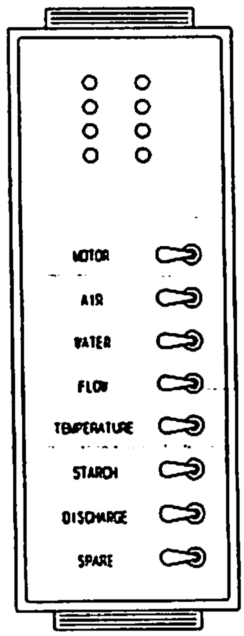
- **Temperature System** - Monitors cooking temperature. The cooking temperature is sensed using a "J" thermocouple and fed to an electronic temperature recorder/controller equipped with an internal alarm switch. The alarm set point is accessed through the controller's configuration and is typically set at 195°F.

- **Starch Slurry Valve** - Monitors 3-way starch slurry valve position. A position limit switch is mounted on top of the 3-way starch slurry valve's pneumatic actuator. When starch slurry is called for, this switch ensures the valve is in the proper position.

- **Discharge Valve** - Monitors 3-way discharge valve position. A position limit switch is mounted on top of the 3-way discharge valve's pneumatic actuator. When the cooker should be feeding the cooked starch storage tank, this switch ensures the valve is in the proper position.

I/O SIMULATOR

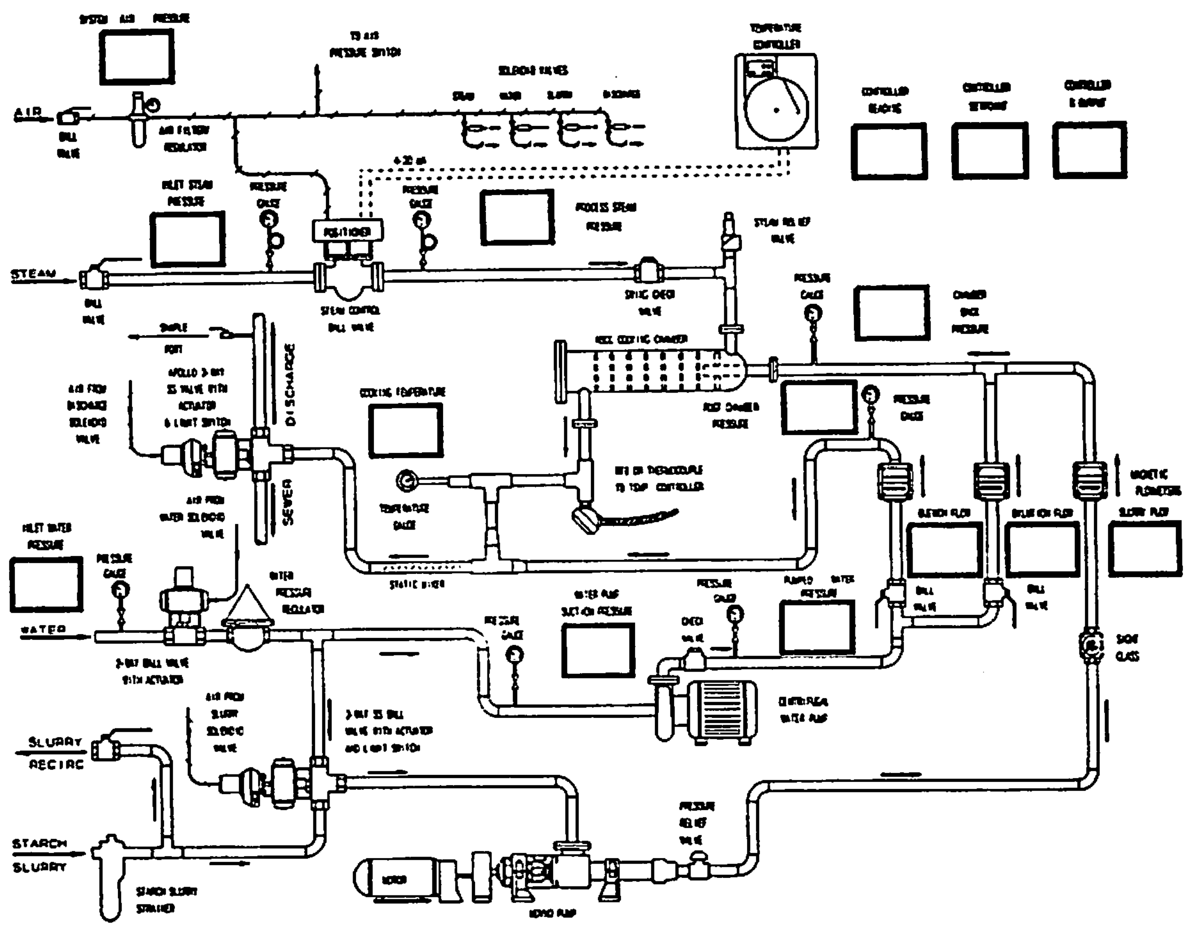
If a cooker failure is caused by faulty instrumentation rather then an actual system deficiency, an I/O Simulator Module in the cooker's PLC can be used to bypass the defective device. The I/O Simulator contains eight small toggle switches, seven of which are labeled and can be used to bypass each of the seven failure systems. Flipping one of these switches "On" will bypass its respective system.



If the instrumentation on one of the failsafe systems is giving a false fail condition, that system can be bypassed in order to cook starch until the unit can be repaired. While a system is bypassed, its neon light blinks slowly to serve as a reminder of the problem. The bypassing feature should not be used during normal cooker operation since off-quality product or equipment damage can result.

Cooking Conditions Data Sheet

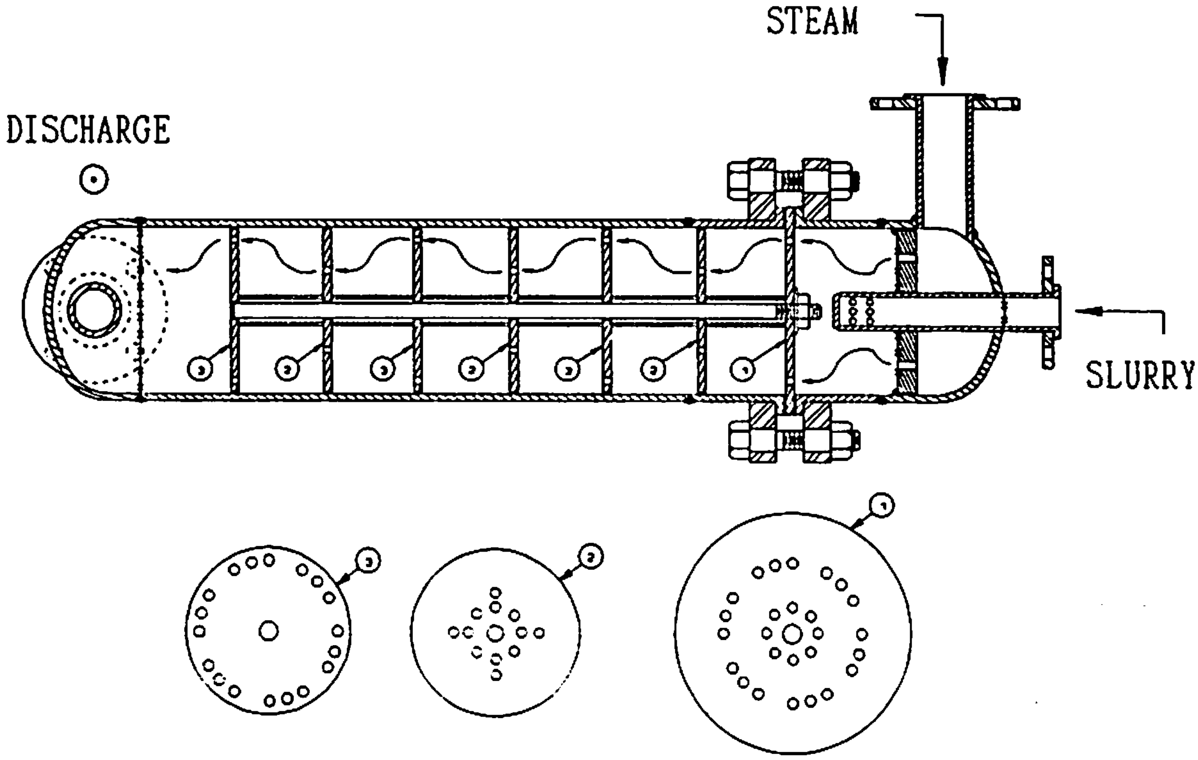
When troubleshooting problems with the starch cooker, fill out the boxes in the diagram below to indicate the operating conditions of the cooker. Before notifying National Starch of cooker difficulties, please have this form completed to speed up the troubleshooting process.



COMPANY/LOCATION	
COOKER SERIAL NUMBER	
SLURRY SOLIDS	
COOKING CHAMBER SOLIDS	
FINAL STARCH SOLIDS (TANK)	
FINAL STARCH TEMPERATURE (TANK)	
STARCH ADDITION RATE (GPM)	

Periodic Servicing

Strainers, Filters, and Cooking Chamber



Internal View of National Starch Cooking Chamber

Starch Slurry Strainer - Should be opened and cleaned at least once a shift. Unusual conditions may require cleaning the strainer more frequently.

Main Air Filter - The quality of the air supply will determine how often the air filter should be blown out. With a dry, clean air supply, once a week may be sufficient. A wet air supply may require blowing out the filter reservoir several times a day.

Cooking Chamber - There is a tendency for scale to build up in the cooking chamber. Scaling rate is usually a function of water hardness; the harder the water, the greater the tendency toward scaling. Inspect and clean chamber at least twice a year or if there is a noticeable increase in chamber backpressure.

Temperature Recorder/Controller - Replace charts daily and pen points as required.

Lubrication

1. Moyno Slurry Pump

A. Ball Bearings - Ball bearings in the Moyno pump are lubricated at the factory and do not require additional lubrication for the first 1500 hours of normal operation.

Any type of EP lithium soap grease is satisfactory for lubrication, however sodium or calcium base grease is not recommended.

The Robbins & Myers Moyno literature in the Appendix provides some specific bearing lubricants which are appropriate.

B. Packing Gland - When a gland is freshly packed, frequent adjustments of the packing nuts may be necessary to seat the packing. It is important to grease the packing often, but with limited quantities of grease until the packing gland is properly seated.

Any grease which is insoluble in water may be used to grease the packing gland.

2. Aurora 341A Water Pump

Internal pump bearings are lubricated by the pumped fluid. Therefore, no external lubrication is required.

3. Reliance Tigear C-Face Reducer

Proper oil level must be maintained to insure adequate lubrication of the gear reducer. For temperatures from 35-70°F, use SAE 20W grade oil, and for temperatures from 60-110°F, use SAE 30 grade oil.

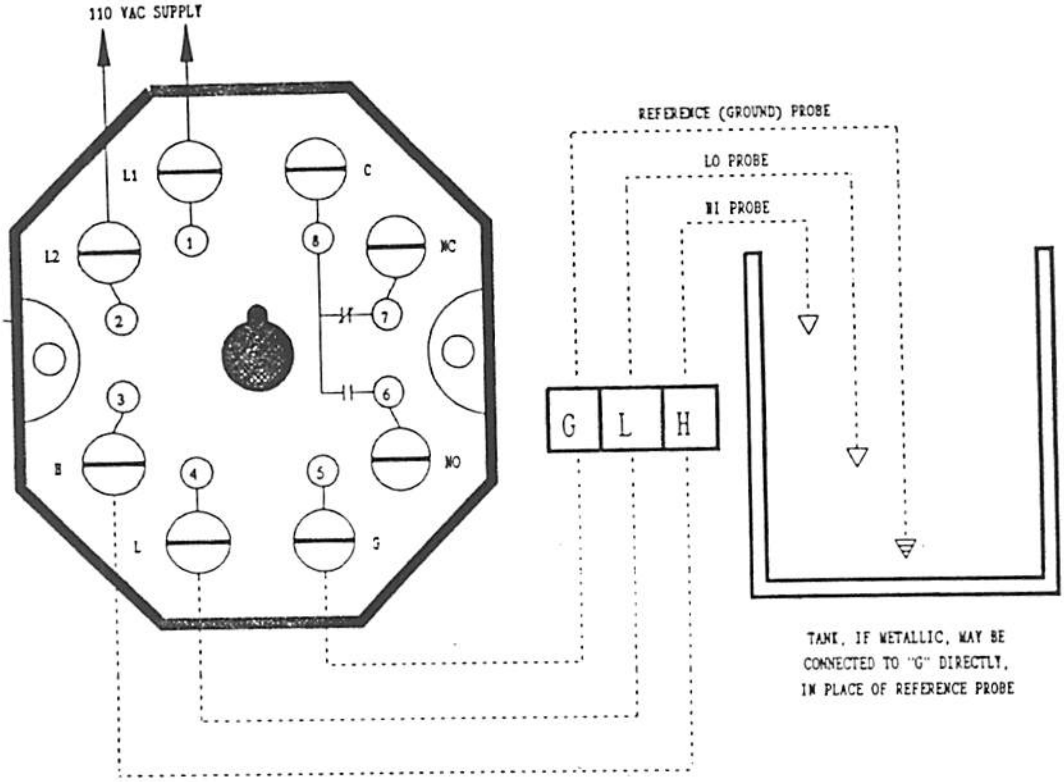
Fill the oil reservoir in the gear reducer by removing the red plug which indicates oil level and filling with oil until it begins to overflow. Reinstall this plug when finished.

4. Electric Motors

Bearings of both electric motors should be lubricated using E.P. lithium-base grease.

Refer to Reliance and U.S. Motors manufacturing literature in the Appendix of this manual.

Level Control Troubleshooting



Level Controller and Probes

Some symptoms which point to possible level control or probe problems are:

- tank overflow because cooker fails to shut off at upper level probe
- cooker fails to restart when level drops below lower level probe
- generally erratic level control

If a problem with the Warrick level controller or with the level control probes is suspected, the first thing to do is to determine whether the problem is *internal* to the cooker or *external* to the cooker (probes, probe head, or lead wires).

To Troubleshoot:

1. At the L-G-H terminal block in the cooker, disconnect the three wires coming from the level control probe head located on the cooked starch storage tank.

2. Turn the cooker Operating Switch "On". Cooker should start up normally, go thru a complete startup cycle, and continue to run. If the cooker does not start with the probe lead wires disconnected, try replacing the plug-in Warrick level controller. If the cooker still does not start, refer to the General Troubleshooting Procedure.

3. If the cooker starts and continues to run through the entire startup cycle with level probe wires disconnected, turn the Operating Switch "Off". The cooker should shut down and stay down.

4. If the cooker performs properly in steps 2 & 3 above, restart the cooker and allow it to start up completely.

5. Connect an electrical jumper wire between terminals G & L on the L-G-H terminal strip. Momentarily jump (a few seconds) terminals G & H with another jumper. The cooker should shut down and stay down.

6. If the cooker passes step 5, remove the jumper wire between G & L. The cooker should restart and continue running. (Steps 5 & 6 above simulate the effect of hi and lo liquid levels making and breaking contact with the probes.)

7. If the cooker performs properly thru step 6, the trouble is apparently not in the cooker itself but external to the cooker in the level probes, probe head, or lead wires back to the cooker L-G-H terminal strip.

8. A common cause for the cooker not shutting off at the upper level probe is a poor ground connection to the tank or to the reference probe. The wire from "G" on the cooker terminal strip must make a good electrical connection to the metal tank. (If a non-conductive tank is used, the "G" wire must be attached to a metal probe which extends well below the lower working level (lo level probe) or attached to a metal valve at the tank outlet which is in continuous, intimate contact with the liquid.

9. If the cooker performs as expected in steps 2 & 3 above, but not in steps 5 & 6, try replacing the plug-in Warrick level control relay.

10. Make sure that the probe lead wire to the "L" terminal (usually a black wire) is connected to the *lo level* probe in the probe head and that the wire to the "H" terminal (usually a white wire) is connected to the *upper* probe.

Note: The hi level probe is *always* the shortest probe. The lo level probe is *longer* than the hi level probe, but *shorter* than the reference ground probe (if used in a non-metallic tank).

Troubleshooting Hints

- Be sure the wire(s) entering panel box are not cut. This may create a control short.

- Condensation in cooked starch storage tank *may* cause false level signals–place probe *head* outside enclosed tank.

- Starch build-up may cause false level signals. Change uncoated probes to coated probes.

- Extremely long runs of control wiring (200 feet or more) from the cooker to the cooked starch storage tank *may* cause false level signals. Relocate level control relay near storage tank and run 110V circuitry from relay to cooker. Be sure to mount the relay in a suitable NEMA-rated enclosure.

- Be sure the probe head is not located near the starch inlet line to the tank. Splashing from the inlet line may cause a false hi level signal.

- Any foam in the cooked starch storage tank acts as a conductive fluid. This may cause false control signals. If this occurs, lower the starch inlet line below the low level probe to prevent freefall/foaming of the starch. Foam is particularly a problem when a stilling well is used around the probes. In this case, the stilling well holds the foam in place and does not allow it to dissipate.

Starch Table

Degrees Beaume´	Specific Gravity	Percent Starch	Density in Lb per Gal	Pounds Dry Starch per Gallon
0.0	1.0000	0.000	8.328	0.000
0.1	1.0007	0.178	8.334	0.015
0.2	1.0014	0.354	8.340	0.030
0.3	1.0021	0.531	8.346	0.044
0.4	1.0028	0.708	8.352	0.059
0.5	1.0035	0.885	8.357	0.074
0.6	1.0041	1.062	8.362	0.089
0.7	1.0048	1.239	8.368	0.104
0.8	1.0055	1.416	8.374	0.119
0.9	1.0062	1.593	8.380	0.133
1.0	1.0069	1.777	8.386	0.149
1.1	1.0076	1.955	8.392	0.164
1.2	1.0083	2.132	8.397	0.179
1.3	1.0090	2.310	8.403	0.194
1.4	1.0097	2.488	8.409	0.209
1.5	1.0105	2.666	8.416	0.224
1.6	1.0112	2.843	8.422	0.239
1.7	1.0119	3.021	8.427	0.254
1.8	1.0126	3.199	8.433	0.270
1.9	1.0133	3.376	8.439	0.285
2.0	1.0140	3.554	8.445	0.300
2.1	1.0147	3.732	8.451	0.315
2.2	1.0154	3.909	8.456	0.331
2.3	1.0161	4.087	4.462	0.346
2.4	1.0168	4.265	8.468	0.361
2.5	1.0176	4.443	8.475	0.377
2.6	1.0183	4.620	8.481	0.392
2.7	1.0190	4.798	8.486	0.407
2.8	1.0197	4.976	8.492	0.423
2.9	1.0204	5.153	8.498	0.438
3.0	1.0211	5.331	8.504	0.453
3.1	1.0218	5.509	8.510	0.469
3.2	1.0226	5.686	8.516	0.484
3.3	1.0233	5.864	8.522	0.500
3.4	1.0241	6.042	8.529	0.515
3.5	1.0248	6.220	8.535	0.531
3.6	1.0255	6.397	8.541	0.546
3.7	1.0263	6.575	8.547	0.562
3.8	1.0270	6.753	8.553	0.578
3.9	1.0278	6.930	8.560	0.593

Starch Table *continued*

Degrees Beaume´	Specific Gravity	Percent Starch	Density in Lb per Gal	Pounds Dry Starch per Gallon
4.0	1.0285	7.108	8.566	0.609
4.1	1.0292	7.286	8.571	0.624
4.2	1.0300	7.463	8.578	0.640
4.3	1.0307	7.641	8.584	0.656
4.4	1.0314	7.819	8.590	0.672
4.5	1.0322	7.997	8.596	0.687
4.6	1.0329	8.174	8.602	0.703
4.7	1.0336	8.352	8.608	0.719
4.8	1.0343	8.530	8.614	0.735
4.9	1.0351	8.707	8.621	0.751
5.0	1.0358	8.885	8.626	0.766
5.1	1.0366	9.063	8.633	0.782
5.2	1.0373	9.240	8.639	0.798
5.3	1.0381	9.418	8.646	0.814
5.4	1.0388	9.596	8.651	0.830
5.5	1.0396	9.774	8.658	0.846
5.6	1.0403	9.951	8.664	0.862
5.7	1.0411	10.129	8.671	0.878
5.8	1.0418	10.307	8.676	0.894
5.9	1.0426	10.484	8.683	0.910
6.0	1.0433	10.662	8.689	0.926
6.1	1.0441	10.840	8.696	0.943
6.2	1.0448	11.017	8.701	0.959
6.3	1.0456	11.195	8.708	0.975
6.4	1.0463	11.373	8.714	0.991
6.5	1.0471	11.551	8.720	1.007
6.6	1.0478	11.728	8.726	1.023
6.7	1.0486	11.906	8.733	1.040
6.8	1.0493	12.084	8.739	1.056
6.9	1.0501	12.261	8.745	1.072
7.0	1.0508	12.439	8.751	1.089
7.1	1.0516	12.617	8.758	1.105
7.2	1.0523	12.794	8.764	1.121
7.3	1.0531	12.972	8.770	1.138
7.4	1.0539	13.150	8.777	1.154
7.5	1.0547	13.328	8.784	1.171
7.6	1.0554	13.505	8.790	1.187
7.7	1.0562	13.683	8.796	1.204
7.8	1.0570	13.861	8.803	1.220
7.9	1.0577	14.038	8.809	1.237

Starch Table *continued*

Degrees Beaume´	Specific Gravity	Percent Starch	Density in Lb per Gal	Pounds Dry Starch per Gallon
8.0	1.0585	14.216	8.815	1.253
8.1	1.0593	14.394	8.822	1.270
8.2	1.0601	14.571	8.829	1.286
8.3	1.0608	14.749	8.835	1.303
8.4	1.0616	14.927	8.841	1.320
8.5	1.0624	15.105	8.848	1.336
8.6	1.0632	15.282	8.855	1.353
8.7	1.0640	15.460	8.861	1.370
8.8	1.0647	15.638	8.867	1.387
8.9	1.0655	15.815	8.874	1.403
9.0	1.0663	15.993	8.880	1.420
9.1	1.0671	16.171	8.887	1.437
9.2	1.0679	16.348	8.894	1.454
9.3	1.0687	16.526	8.900	1.471
9.4	1.0695	16.704	8.907	1.488
9.5	1.0703	16.882	8.914	1.505
9.6	1.0710	17.059	8.920	1.522
9.7	1.0718	17.237	8.926	1.539
9.8	1.0726	17.415	8.933	1.556
9.9	1.0734	17.592	8.940	1.573
10.0	1.0742	17.770	8.946	1.590
10.1	1.0750	17.948	8.953	1.607
10.2	1.0758	18.125	8.960	1.624
10.3	1.0766	18.303	8.966	1.641
10.4	1.0774	18.481	8.973	1.658
10.5	1.0782	18.659	8.979	1.675
10.6	1.0790	18.836	8.986	1.693
10.7	1.0798	19.014	8.993	1.710
10.8	1.0806	19.192	8.999	1.727
10.9	1.0814	19.369	9.006	1.744
11.0	1.0822	19.547	9.013	1.762
11.1	1.0830	19.725	9.019	1.779
11.2	1.0838	19.902	9.026	1.796
11.3	1.0846	20.080	9.033	1.814
11.4	1.0854	20.258	9.039	1.831
11.5	1.0863	20.436	9.047	1.849
11.6	1.0871	20.613	9.054	1.866
11.7	1.0879	20.791	9.060	1.884
11.8	1.0887	20.969	9.067	1.901
11.9	1.0895	21.146	9.074	1.919

Starch Table *continued*

Degrees Beaume´	Specific Gravity	Percent Starch	Density in Lb per Gal	Pounds Dry Starch per Gallon
12.0	1.0903	21.324	9.080	1.936
12.1	1.0911	21.502	9.087	1.954
12.2	1.0920	21.679	9.094	1.972
12.3	1.0928	21.857	9.101	1.989
12.4	1.0936	22.035	9.108	2.007
12.5	1.0945	22.213	9.115	2.025
12.6	1.0953	22.390	9.122	2.042
12.7	1.0961	22.568	9.129	2.060
12.8	1.0969	22.746	9.135	2.078
12.9	1.0978	22.923	9.143	2.096
13.0	1.0986	23.101	9.149	2.114
13.1	1.0995	23.279	9.157	2.132
13.2	1.1003	23.459	9.164	2.150
13.3	1.1012	23.634	9.171	2.167
13.4	1.1020	23.812	9.178	2.185
13.5	1.1029	23.990	9.185	2.203
13.6	1.1037	24.167	9.192	2.221
13.7	1.1046	24.345	9.199	2.239
13.8	1.1054	24.523	9.206	2.258
13.9	1.1063	24.700	9.214	2.276
14.0	1.1071	24.878	9.220	2.294
14.1	1.1080	25.056	9.228	2.312
14.2	1.1088	25.233	9.234	2.330
14.3	1.1097	25.411	9.242	2.348
14.4	1.1105	25.589	9.248	2.366
14.5	1.1114	25.767	9.256	2.385
14.6	1.1122	25.944	9.263	2.403
14.7	1.1131	26.122	9.270	2.422
14.8	1.1139	26.300	9.277	2.440
14.9	1.1148	26.477	9.284	2.458
15.0	1.1156	26.655	9.291	2.477
15.1	1.1165	26.833	9.298	2.495
15.2	1.1173	27.010	9.305	2.513
15.3	1.1182	27.188	9.313	2.532
15.4	1.1190	27.366	9.319	2.550
15.5	1.1199	27.544	9.327	2.569
15.6	1.1208	27.721	9.334	2.587
15.7	1.1216	27.899	9.341	2.606
15.8	1.1225	28.077	9.348	2.625
15.9	1.1233	28.254	9.355	2.643

Starch Table *continued*

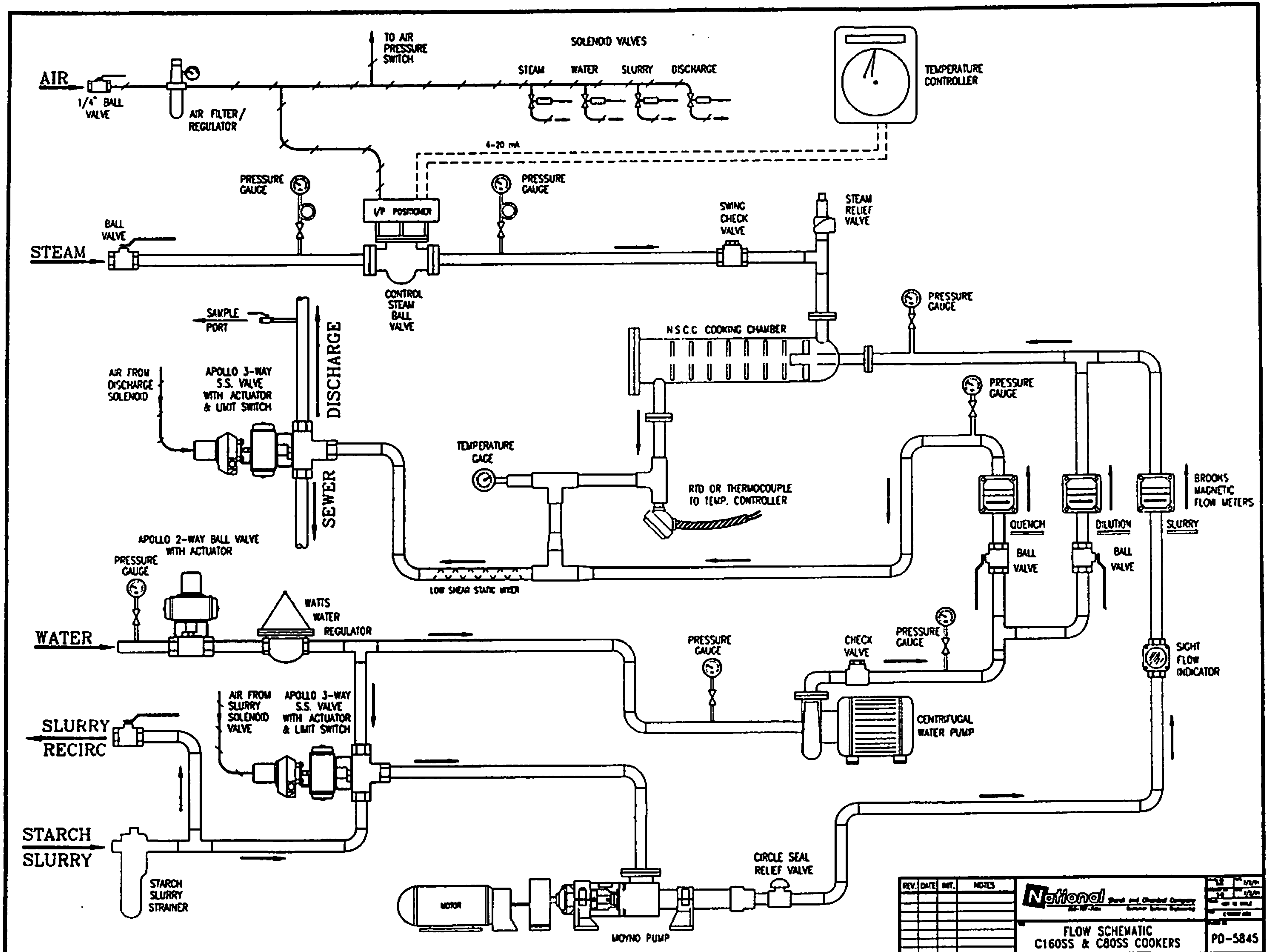
Degrees Beaume´	Specific Gravity	Percent Starch	Density in Lb per Gal	Pounds Dry Starch per Gallon
16.0	1.1242	28.432	9.363	2.662
16.1	1.1251	28.610	9.370	2.681
16.2	1.1260	28.787	9.378	2.700
16.3	1.1268	28.965	9.384	2.718
16.4	1.1277	29.143	9.392	2.737
16.5	1.1286	29.321	9.399	2.756
16.6	1.1295	29.498	9.407	2.775
16.7	1.1304	29.675	9.414	2.794
16.8	1.1312	29.854	9.421	2.813
16.9	1.1321	30.031	9.428	2.831
17.0	1.1330	30.209	9.436	2.851
17.1	1.1339	30.387	9.443	2.869
17.2	1.1348	30.564	9.451	2.889
17.3	1.1357	30.742	9.458	2.908
17.4	1.1366	30.920	9.466	2.927
17.5	1.1375	31.098	9.473	2.946
17.6	1.1383	31.275	9.480	2.965
17.7	1.1392	31.453	9.488	2.984
17.8	1.1401	31.631	9.495	3.003
17.9	1.1410	31.808	9.503	3.023
18.0	1.1419	31.986	9.510	3.042
18.1	1.1428	32.164	9.518	3.061
18.2	1.1437	32.341	9.525	3.080
18.3	1.1446	32.519	9.532	3.100
18.4	1.1455	32.697	9.540	3.119
18.5	1.1465	32.875	9.548	5.139
18.6	1.1474	33.052	9.556	3.158
18.7	1.1483	33.230	9.563	3.178
18.8	1.1492	33.408	9.571	3.197
18.9	1.1501	33.585	9.578	3.217
19.0	1.1510	33.763	9.586	3.237
19.1	1.1519	33.941	9.593	3.256
19.2	1.1528	34.118	9.601	3.276
19.3	1.1538	34.296	9.609	3.296
19.4	1.1547	34.474	9.617	3.315
19.5	1.1556	34.652	9.624	3.335
19.6	1.1565	34.829	9.632	3.355
19.7	1.1574	35.007	9.639	3.374
19.8	1.1584	35.185	9.647	3.394
19.9	1.1593	35.362	9.655	3.414

Starch Table *continued*

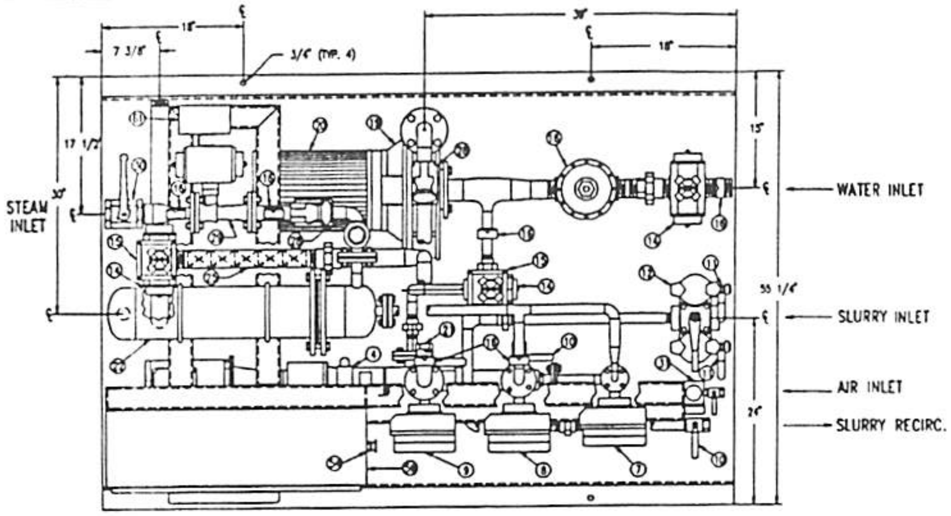
Degrees Beaume´	Specific Gravity	Percent Starch	Density in Lb per Gal	Pounds Dry Starch per Gallon
20.0	1.1602	35.540	9.662	3.434
20.1	1.1611	35.718	9.670	3.454
20.2	1.1621	35.895	9.678	3.474
20.3	1.1630	36.073	9.686	3.494
20.4	1.1640	36.251	9.694	3.514
20.5	1.1649	36.429	9.702	3.534
20.6	1.1658	36.606	9.709	3.554
20.7	1.1668	36.784	9.717	3.574
20.8	1.1677	36.962	9.725	3.595
20.9	1.1687	37.139	9.733	3.615
21.0	1.1696	37.317	9.741	3.635
21.1	1.1706	37.495	9.749	3.655
21.2	1.1715	37.672	9.757	3.676
21.3	1.1725	37.850	9.765	3.696
21.4	1.1734	38.028	9.772	3.716
21.5	1.1744	38.206	9.781	3.737
21.6	1.1753	38.383	9.788	3.757
21.7	1.1763	38.561	9.796	3.777
21.8	1.1772	38.739	9.804	3.798
21.9	1.1782	38.916	9.812	3.818
22.0	1.1791	39.094	9.820	3.839
22.1	1.1801	39.272	9.828	3.860
22.2	1.1810	39.449	9.836	3.880
22.3	1.1820	39.627	9.844	3.901
22.4	1.1830	39.805	9.852	3.922
22.5	1.1840	39.983	9.861	3.943
22.6	1.1849	40.160	9.868	3.963
22.7	1.1859	40.338	9.876	3.984
22.8	1.1869	40.516	9.885	4.005
22.9	1.1878	40.693	9.892	4.025
23.0	1.1888	40.871	9.901	4.047
23.1	1.1898	41.049	9.909	4.068
23.2	1.1908	41.226	9.917	4.088
23.3	1.1917	41.404	9.925	4.109
23.4	1.1927	41.582	9.933	4.130
23.5	1.1937	41.760	9.941	4.151
23.6	1.1947	41.937	9.950	4.173
23.7	1.1957	42.115	9.958	4.194
23.8	1.1966	42.293	9.966	4.215
23.9	1.1976	42.470	9.974	4.236

Starch Table *continued*

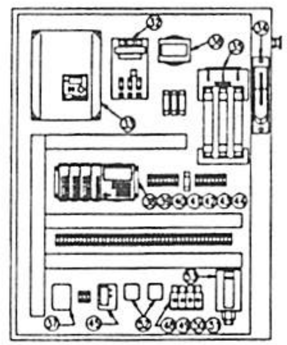
Degrees Beaume´	Specific Gravity	Percent Starch	Density in Lb per Gal	Pounds Dry Starch per Gallon
24.0	1.1986	42.648	9.982	4.257
24.1	1.1996	42.826	9.991	4.279
24.2	1.2006	43.003	9.999	4.300
24.3	1.2016	43.181	10.007	4.321
24.4	1.2026	43.359	10.016	4.343
24.5	1.2036	43.537	10.024	4.364
24.6	1.2046	43.714	10.032	4.385
24.7	1.2056	43.892	10.041	4.407
24.8	1.2066	44.070	10.049	4.429
24.9	1.2076	44.247	10.057	4.450
25.0	1.2086	44.425	10.065	4.471



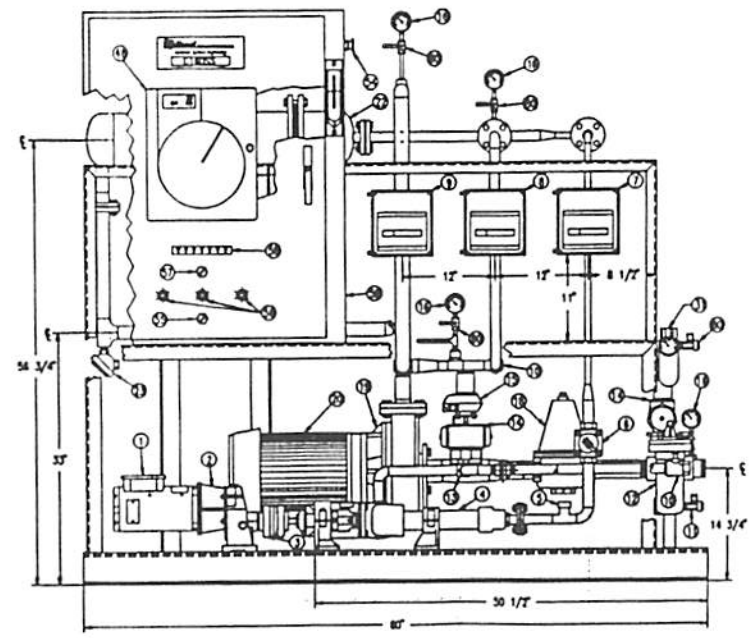
AIR
1/4" BALL VALVE
AIR FILTER/ REGULATOR
TO AIR PRESSURE SWITCH
SOLENOID VALVES
STEAM
WATER
SLURRY
DISCHARGE
TEMPERATURE CONTROLLER
4-20 mA
PRESSURE GAUGE
I/P POSITIONER
PRESSURE GAUGE
BALL VALVE
STEAM
CONTROL STEAM BALL VALVE
SWING CHECK VALVE
STEAM RELIEF VALVE
SAMPLE PORT
DISCHARGE
NSCC COOKING CHAMBER
PRESSURE GAUGE
AIR FROM DISCHARGE SOLENOID
APOLLO 3-WAY S.S. VALVE WITH ACTUATOR & LIMIT SWITCH
PRESSURE GAUGE
TEMPERATURE GAGE
RTD OR THERMOCOUPLE TO TEMP. CONTROLLER
SEWER
BROOKS MAGNETIC FLOW METERS
QUENCH
DILUTION
SLURRY
APOLLO 2-WAY BALL VALVE WITH ACTUATOR
PRESSURE GAUGE
BALL VALVE
BALL VALVE
LOW SHEAR STATIC MIXER
WATTS WATER REGULATOR
WATER
PRESSURE GAUGE
CHECK VALVE
PRESSURE GAUGE
SIGHT FLOW INDICATOR
AIR FROM SLURRY SOLENOID VALVE
APOLLO 3-WAY S.S. VALVE WITH ACTUATOR & LIMIT SWITCH
CENTRIFUGAL WATER PUMP
SLURRY RECIRC
STARCH SLURRY
STARCH SLURRY STRAINER
CIRCLE SEAL RELIEF VALVE
MOTOR
MOYNO PUMP
REV. DATE INT. NOTES
National
FLOW SCHEMATIC
C160SS & C80SS COOKERS
PD-5845



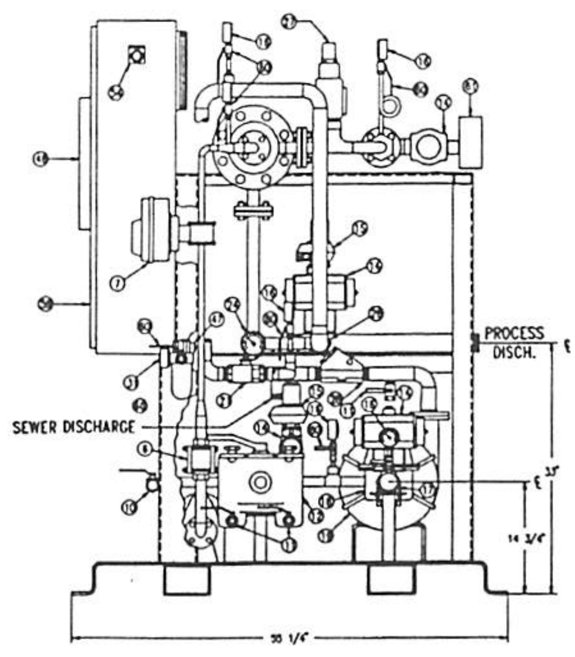
TOP VIEW



CONTROL PANEL



FRONT VIEW



RIGHT SIDE VIEW

NO.	DESCRIPTION	QTY	NSCC PART NO.
1	RELIANCE 2 HP MOTOR 1800 RPM 3/60/230-460 145TC	1	74-2110
2	RELIANCE GEAR REDUCER SMTSA [illegible] 25:1 RATIO	1	74-1215
3	WOODS SURE-FLEX COUPLING #6S 3/4 x 1/4	1	74-1174
4	ROBBINS & MEYERS MOYNO PUMP 2L3-SSQ-AAA	1	74-1154
5	CIRCLE SEAL RELIEF VALVE #5559T1-6M-100	1	74-3144
6	BROOKS SIGHT GLASS [illegible] 1" FPT	1	74-1117
7	BROOKS MAG-FLO [illegible] 1.0-10.0 GPM	1	74-3006
8	BROOKS MAG-FLO [illegible] 4.0-40.0 GPM	1	74-3008
9	BROOKS MAG-FLO [illegible] 10-100 GPM	1	74-3879
10	WATTS #S-8000 BALL VALVE 304 S.S. 1" NPT	2	74-4005
11	WATTS #S-8000 BALL VALVE 304 S.S. 1/2" NPT	3	74-4004
12	MUELLER DUPLEX STRAINER [illegible] 1-1/4" NPT 1/16" PERF.	1	74-2706
13	APOLLO #76-605-01 3-WAY BALL VALVE 304 S.S. 1" NPT	1	74-4822
14	GH BETTIS RP-1000-SR3 SPRING RETURN ACTUATOR-60 PSI SET	4	74-1015
15	WESTLOCK #2004-BY SPDT LIMIT SWITCH WITH DOME INDICATOR	2	74-2820
16	WIKA 0-160 PSIG PRESSURE GAUGE #233.50 1/4" NPT 316 S.S.	6	74-1833
17	APOLLO #76-105-01 2-WAY BALL VALVE 304 S.S. [illegible] NPT	1	74-4811
18	WATTS PRESSURE REGULATOR [illegible] 25 PSI [illegible] NPT	1	74-[illegible]
19	AURORA #341 CENT. PUMP [illegible] GPM @ 150 TDH	1	74-[illegible]
20	U.S. ELECTRIC 10 HP MOTOR 1750 RPM 3/60/230-460 215JM	1	74-2128
21	WATTS #S-8000 BALL VALVE 304 S.S. 1-1/2" NPT	1	74-4006
22	NSCC [illegible] STARCH COOKING CHAMBER PER DWG. PD-5894	1	74-[illegible]
23	BURNS ENGINEERING [illegible] THERMOCOUPLE [illegible]	1	74-[illegible]
24	TRERICE BI-METAL THERMOMETER [illegible] NPT	1	74-1[illegible]
25	[illegible] INDUSTRIES [illegible] STATIC MIXER [illegible] NPT [illegible] 316 S.S.	1	74-2[illegible]
26	APOLLO #76-606-01 3-WAY BALL VALVE 304 S.S. [illegible] NPT	1	74-4[illegible]
27	AQUATROL MODEL 178 RELIEF VALVE 1-1/2" NPT SET @ 100 PSI	1	74-3[illegible]
28	POWELL #-1444 SWING CHECK VALVE 304 S.S. 1-1/2" NPT	1	74-3[illegible]
29	MCCANNA #F151-[illegible] 1-1/2" 150# FL. BALL VALVE	2	74-4[illegible]
30	WATTS #S-8000 BALL VALVE 304 S.S. [illegible] NPT	1	74-4[illegible]
31	NORGREN FILTER/REGULATOR [illegible] 1/4" NPT	1	74-[illegible]
32	ALLEN-BRADLEY MOTOR STARTER #509-[illegible]	1	74-[illegible]
33	ALLEN-BRADLEY #1333-[illegible] VARIABLE FREQUENCY A.C. DRIVE	1	74-[illegible]
34	ALLEN-BRADLEY DISCONNECT #1494-[illegible]	1	74-[illegible]
35	ALLEN-BRADLEY FUSE KIT #1494F-[illegible]	1	74-[illegible]
36	[illegible] ELECTRIC [illegible] TRANSFORMER [illegible] KVA	1	74-[illegible]
37	WARRICK LEVEL CONTROL RELAY [illegible] 120VAC	1	74-1142
38	G.E. SERIES ONE PLC CPU #IC610CPU104	1	74-[illegible]
39	G.E. SERIES ONE PLC 16 INPUT MODULE #IC610MDL[illegible] 120VAC	1	74-[illegible]
40	G.E. SERIES ONE PLC 16 OUTPUT RELAY #IC610MDL[illegible] 120VAC	2	74-[illegible]
41	G.E. SERIES ONE PLC I/O SIMULATOR #IC610MDL124 120VAC	1	74-5530
42	G.E. SERIES ONE PLC PROGRAMMER #IC610PRG105	1	74-[illegible]
43	G.E. SERIES ONE PROM CHIP #IC610ACC155A	1	74-[illegible]
44	G.E. SERIES ONE PLC 5-SLOT RACK #IC610CHS110	1	74-[illegible]
45	API SIGNAL CONDITIONER #API-1000G 115VAC 4-20 mA INPUT	1	74-1999
46	HONEYWELL TEMP. CONTROLLER #DR4501-1500-10-001-0-00	1	74-4811
47	SOR PRESS. SW. [illegible] ACTUATES @ 50 PSI DECR.	1	74-[illegible]
48	HUMPHREY SOLENOID #M310-30 120VAC	4	74-[illegible]
49	HUMPHREY SUB-BASE #[illegible]	4	74-[illegible]
50	HUMPHREY END CAP ASSEMBLY #7-100A	1	74-[illegible]
51	HUMPHREY [illegible]	4	74-[illegible]
52	[illegible] RELAY [illegible] 1/3 HP @ 120VAC	2	74-[illegible]
53	ALLEN-BRADLEY PRESSURE SWITCH #836-C5A	1	74-[illegible]
54	SQUARE D EMERGENCY STOP SW. [illegible]	1	74-[illegible]
55	ALLEN-BRADLEY SELECTOR SWITCH #800T-[illegible] SERIES T	1	74-[illegible]
56	ALLEN-BRADLEY PILOT LIGHT #800T-P16 SERIES T	3	74-1960
57	ALLEN-BRADLEY POTENTIOMETER #800T-U70 SERIES P	1	74-1[illegible]
58	INDUSTRIAL DEVICES NEON LIGHT #2110A1 125VAC 1/2 WATT	2	74-1[illegible]
59	AUSTIN CUSTOM ALUMINUM ENCLOSURE NEMA [illegible]	1	74-[illegible]
60	WATTS #S-8000 BALL VALVE 304 S.S. 1/4" NPT	2	74-4[illegible]
61	ESPC PWI SERIES P-3000 I/P POSITIONER 4-20 mA INPUT	1	74-4110

NOTES:

1. ALL PIPING AND STRUCTURAL STEEL TO BE 304L STAINLESS STEEL.
2. ALL WELDS TO BE CONTINUOUS, AND BRUSHED FREE OF DEBRIS.
3. DIMENSIONAL TOLERANCE TO BE +/- 1/8".
4. ALL BURRS AND SHARP EDGES TO BE REMOVED.
5. ALL FASTENING BOLTS SHALL BE SECURED WITH NUTS AND LOCK WASHERS.

CAD:C160SSL.DWG

REV.	DATE	INT.	NOTES

National Starch and Chemical Company — Customer Systems Engineering

C160 STAINLESS STEEL STARCH COOKER MECHANICAL LAYOUT

1/2"=1'

C160SSL.DWG

PD-5850