

# Facility Inspection Report

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## PET Facility



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# PET Facility

## Executive Summary

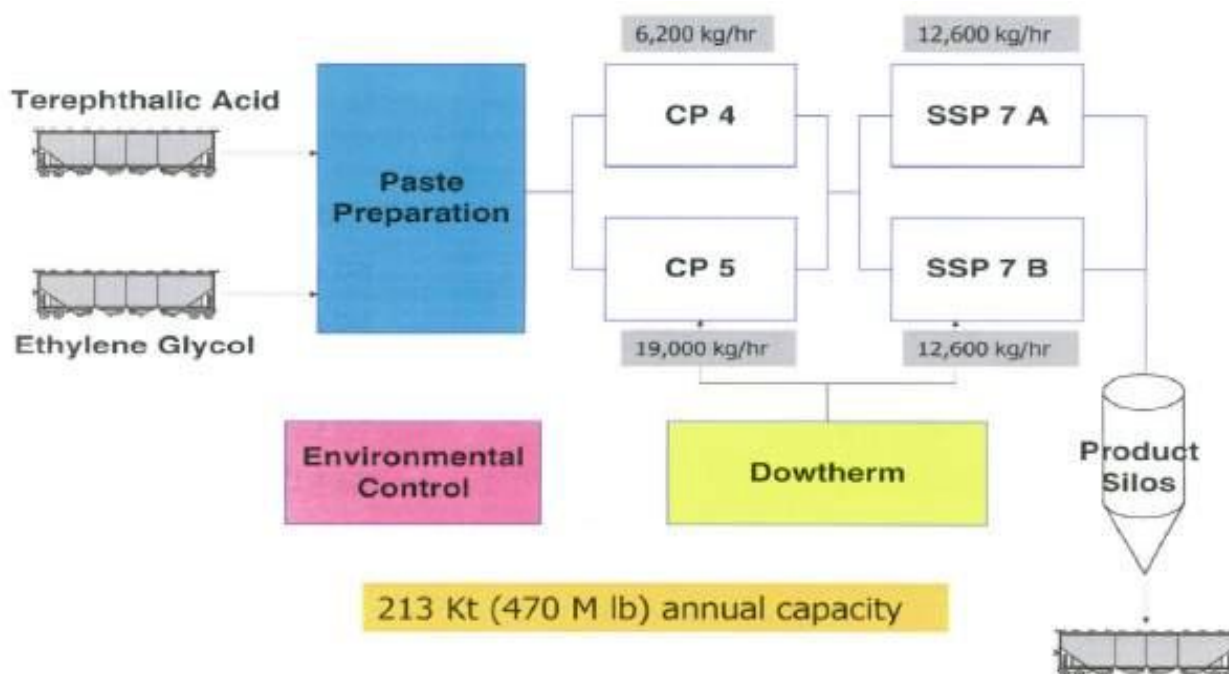
- 213 kmta PET resin capacity, start up in 1996 and shut down in December, 2008. Fiber capacity was shut down in 2000.
- The site has good rail and truck access. Ocean access through is also available from a nearby pier.
- The esterification and melt polymerization technologies are all ICI based or a derivative of the ICI designs. The solid state polymerization technology on the resin lines is Bepex.
- The 1996 PET facility is in very good condition and can be relocated. In fact, a sister facility has already been successfully relocated. All of the equipment in this process is constructed of 304L or 316L stainless steel. There are no clad vessels.
- There is no asbestos in the 1996 PET facility.
- Process control is performed with a Moore Products DCS which is compatible with Siemens. Nothing has been removed from this system and it can be restarted or reused in a short period of time.
- Documentation is excellent, in both electronic and paper form. Process flow diagrams with mass flow balances, general arrangement drawings, and major equipment drawings are immediately available.
- Some spare parts are available.

## PET Plant Process Description



Aerial View of Entire Facility

The plant consists of two continuous polymerization (CP) lines based on ICI technology. One line has an instantaneous capacity of 6,200 kg/hr (13,700 lb/hr), and the second line has an instantaneous capacity of 19,000 kg/hr (41,900 lb/hr). Both continuous polymerization trains feed two Bepex-design solid state polymerization (SSP) lines rated at 12,600 kg/hr (27,800 lb/hr) each.

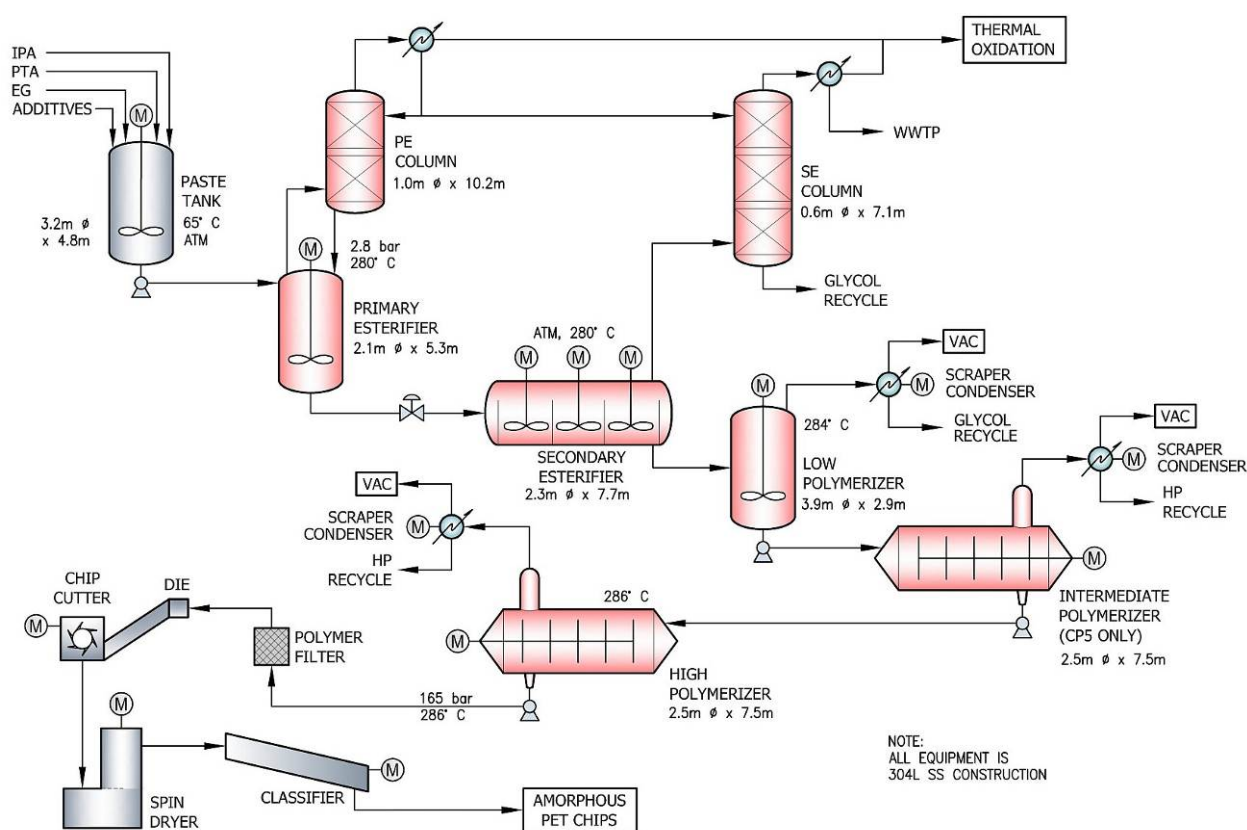


PET Plant Process Flow Diagram



Loading/Unloading Area

The primary raw materials, PTA (purified terephthalic acid), and EG (ethylene glycol) are supplied by rail. PTA powder is unloaded by a Waeschle dense-phase conveying system into dedicated 304 stainless steel storage silos. EG is pumped from railcars into aluminum and stainless steel storage tanks in the tank farm.



CP Process Flow Diagram

The CP process starts with the main raw materials PTA and EG being metered into the “paste” tank. The 304L stainless steel tank is agitated and has 44 m<sup>3</sup> capacity. The additive systems are all 304L and 316L stainless steel construction. The mixing tanks are approximately eight feet diameter by ten feet tall with Chemineer agitators. Cobalt acetate, along with some glycol related additives such as DEG, is added to the front end of the process in the paste tank.



CP4 Primary Esterifier

The paste is then gear-pumped into a 304L stainless steel vertical *primary esterification* vessel. This vessel is agitated with a 30 hp unit and is heated with Dowtherm-A vapor on the 316L stainless steel internal coils. The primary esterifier runs at 2.8 bar and 280°C. The vapor from the vessel goes to a 304L stainless steel, trayed distillation column. This *PE column* has two packed sections with 316L stainless steel packing. This column returns the EG to the process and sends the remaining water with volatile organic compounds (VOCs) to a thermal oxidizer for destruction. It operates at 2.4 bar pressure and 265°C.

The monomer from the *primary esterifier* is then fed into a three-stage, 304L stainless steel horizontal *secondary esterifier* vessel. Each stage is agitated and heated with 316L stainless steel internal coils using Dowtherm vapor. This vessel operates at atmospheric pressure and at 280°C. The vapor from the *secondary esterifier* goes to a 304L stainless steel, trayed distillation column with the EG being returned to the process and the remaining water with VOCs being sent to a thermal oxidizer for destruction. This *SE column* has three packed sections with 304L stainless steel packing and operates at atmospheric pressure.

The monomer from the *secondary esterifier* is then fed into the polymerization process. The *low polymerizer* (LP) is a 304L stainless steel, vertical agitated vessel with 316L stainless steel internal coils and a carbon steel jacket. This vessel is heated by a combination of liquid and vapor Dowtherm, and operates under a slight vacuum generated by glycol-vapor based ejectors.

The CP-5 line has an *intermediate polymerizer* which is very similar to the LP vessel. It operates under a slight vacuum and 284°C. The final vessel in the polymerization train is the *high polymerizer* (HP). This is a 304L stainless steel horizontal vessel with a wiped wall agitator the length of the vessel and a carbon steel jacket. This vessel operates at 286°C and at a higher vacuum generated by glycol vapor based ejectors.



CP5 Intermediate Polymerizer



CP4 High Polymerizer



CP4 HP Scraper Condenser

Each of the polymerizers has a unique scraper condenser on the overheads line. The upper section of the condenser has seven spray nozzles for knocking down the heavies and the lower section has one internal scraper similar to a wiped-film mixer.

Polymer is pumped with Maag gear pumps through a *Maag 100 micron candle filter* assembly with a filter life of four to six months. These units are constructed of 304L stainless steel with 316L stainless steel filter elements. Design is for 206 bar at 343°C and operation is at 165 bar at 286°C. These units weigh 9 mt each, and fit into a carbon steel shell in the process area. There are two filters in operation and two spares in the warehouse.

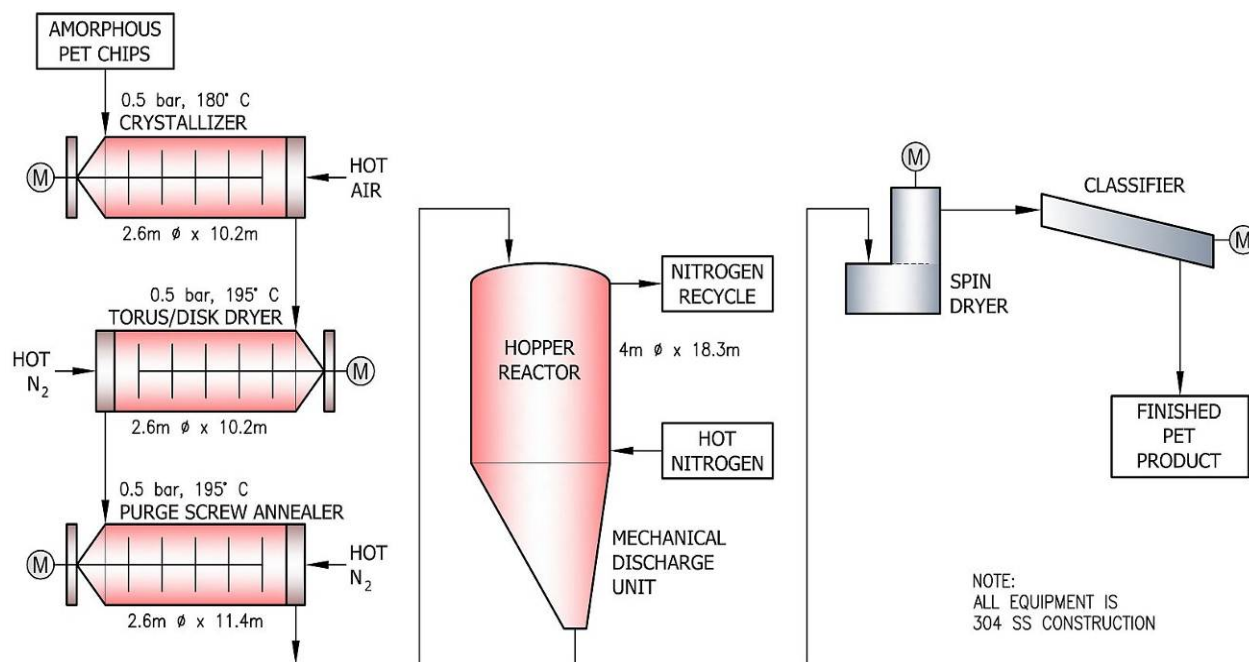


Spare Polymer Filter



Conair Cutter

After filtration the polymer is fed through die heads to three *Conair horizontal cutters* (model 9024) with two spares. The Conair units are constructed of 304 stainless steel and are rated for 10.5 mt/hr each. Finally, the product is dried with *Gala spin dryers* and is then sent to intermediate storage silos. The Gala dryers are constructed of 304 stainless steel and are rated for 10 mt/hr each.



SSP Plant Process Flow Diagram

The Solid State Polymerization plant (SSP) is a Bepex process, with some modifications to the finishing lines. The process starts with the amorphous chip being fed into two 50,000 kg day-hoppers, which feed both polymerization lines.

The chip is fed into a 304L stainless steel *Bepex Solidaire®* crystallizer heated with a once-through hot air system running at approximately 180°C and 0.5 bar. This raises the crystallinity to about 40%. This vessel is agitated with a 200 hp unit which turns the crystallizer internals at about 10-12 rpm. The exhaust air is fed to a thermal oxidizer to destroy any VOCs.



Bepex Crystallizer – Drive End

The chip is then fed into a 304L stainless steel *Bepex Torusdisk®* rotor dryer which has Dowtherm heated jackets, shafts, and paddles. The rotor turns at about 10-12 rpm and is driven with a 150 hp motor. This step raises the temperature to approximately 195°C and further increases the crystallinity. The process vessel in this unit operation is also fed with hot nitrogen at about 0.5 bar, which is recycled in the process.

The next step in the process is a 304L stainless steel *Bepex Thermascrew® jacketed purge screw-annealer*, which is also fed with hot nitrogen. This unit has a 150 hp drive which turns the rotor at 10-12 rpm. The annealer operates at 0.5 bar and 195°C. It forwards product to the vertical *hopper reactor* vessel.

The 304L stainless steel vertical plug-flow *hopper reactor* vessel is Dowtherm heated with 304L stainless steel coils wrapped around the outside of the vessel to maintain a chip temperature of about 200°C for approximately 15 hrs. This builds the IV properties to the final desired level of 0.80 to 0.84. The *SSP hopper reactor* technology is proprietary, but the license to operate will be included in the sale of the plant at no additional charge.

It is at this point in the process where the existing design differs from the Bepex design. The Bepex design would then take the product to a fluid-bed dryer followed by a cooler and deduster system. The existing modifications replace all of this equipment with a water-slurry system feeding a conventional spin dryer and classifier system. There are operational advantages to this water quench process as compared to the Bepex fluid bed cooling; specifically energy savings and a completely dust free final product.

The chip is then discharged into a water tank and mixed into a slurry with a *Waeschle Conticon* system. Finally, it is pumped to *Gala spin dryers*, *Rotex classifiers*, and then is dense-phase conveyed to the 304 stainless steel storage/shipping silos. The slurry system is used as it helps wash the chip and minimize dust for the customers.



Nitrogen Blower

The nitrogen system used in the above mentioned process vessels is closed loop, with the nitrogen gas stream being cleaned by glycol scrubbers. Nitrogen is compressed with two Hoffman model 79105B3 5-stage blowers rated for 20,000 CFM each with 900 hp electric drives.

Quality control is assisted with two *Satake Color Sorters* (Scan Master II Color Sorter, Model # SMII-8401E). These high-tech units provide electronic optical sorting based on visible and infrared light to scan product and sort material by grades. It is also used to reject off-color chips.

## Utilities:

*Dowtherm-A* (heat-transfer fluid) is heated by three vertical gas-fired process heaters. The heaters are rated at 35 MM BTU/hr each and are manufactured by Born. The primary Dowtherm system is a liquid system and contains about 50,000 gallons. A fourth vertical process heater is available and is located on the neighboring utility owned co-generation plant site. The heat is transferred from the primary Dowtherm system to the vapor systems through “reboiler” exchangers located near the process.



Dowtherm Furnaces

The three forced-air Dowtherm furnaces use 4” carbon steel tubes in the firebox. The furnaces are approximately 20’ diameter by 45’ tall. The convection section sits on top of the furnace, with the stack on top of that. The furnaces weigh approximately 80 mt each (verified with vendor prints). There are five Dowtherm recirculation pumps feeding the central loop for the process areas. Each pump has a 250 hp drive motor.

Natural gas is supplied with a 10” pipeline which primarily feeds the Dowtherm furnaces used for heating the process.

There are two diesel fire pumps (V6 and V12) and a 500 kw diesel generator set.

There are four large air compressors; two IR reciprocating compressors rated for 2,200 cfm each at 125 psig, one IR Centac centrifugal compressor rated for 3,800 cfm at 125 psig, and one IR Centac centrifugal compressor rated for 2,800 cfm at 125 psig.



IR Centac Air Compressor



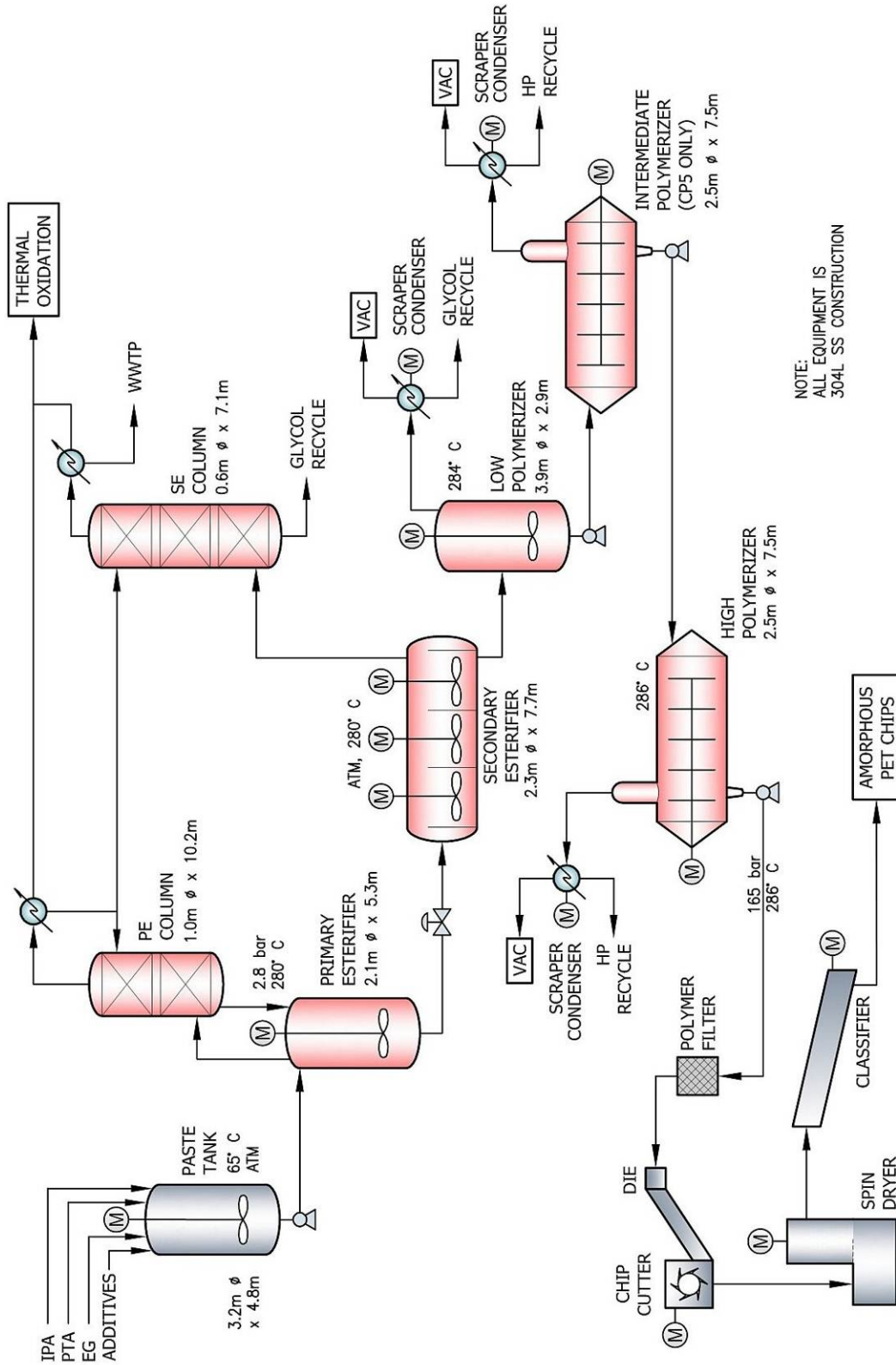
Incoming Electrical Station

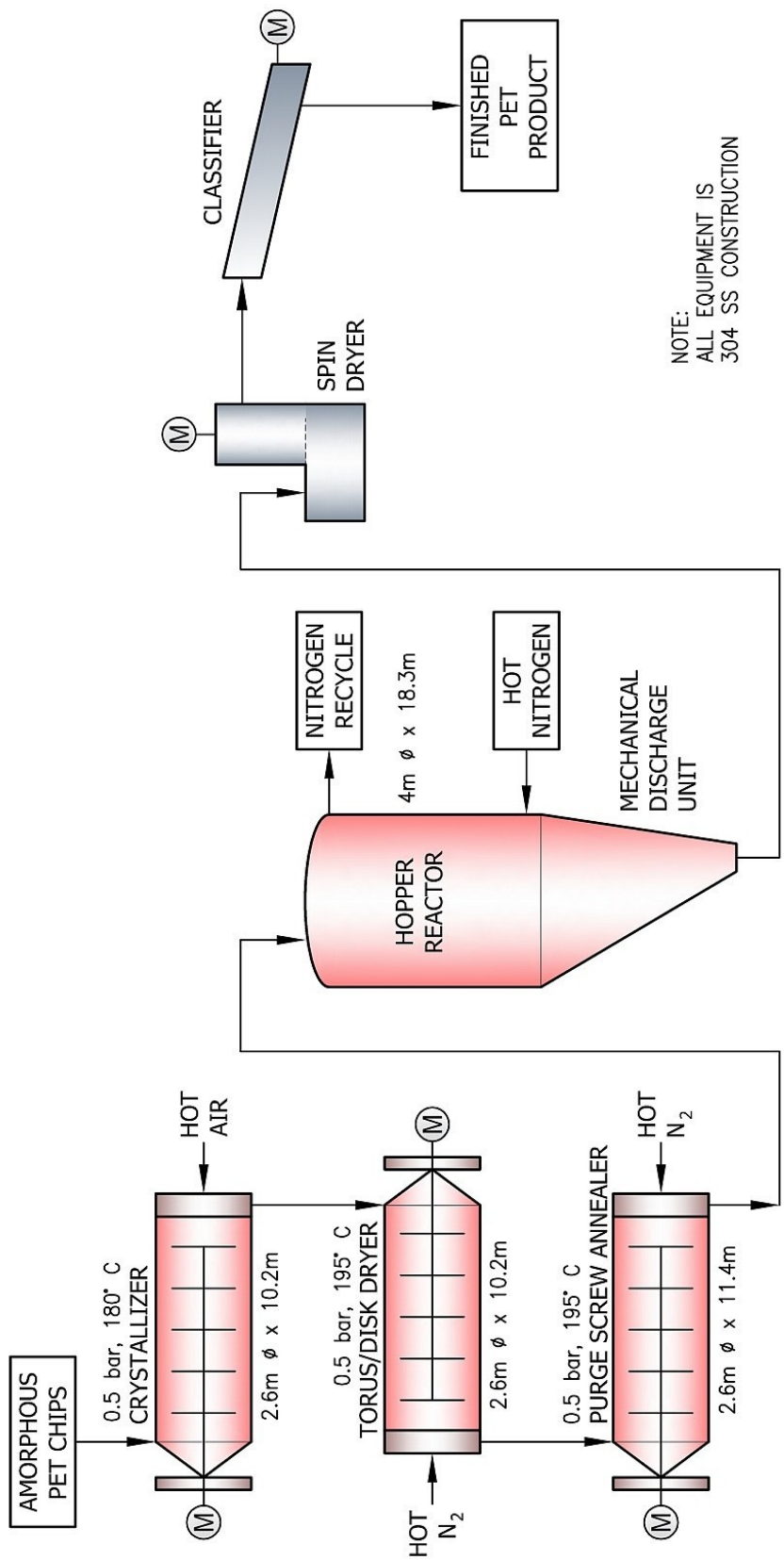
Most motors on site are 575 volts, except for some very large motors which are 2,400 or 4,160 volts.

There are three large (10+ MVA) oil-filled transformers stepping 115kv down to 13.8kv. All of the transformer details are shown in the following table:

<b>Electrical Transformers</b>		
<b>Transformer</b>	<b>Manufacturer</b>	<b>MVA</b>
Main 1	ABB	13.3
Main 2	Ohio	14.9
Main 3	Canadian	14.9
Main 4	English	2.5
Staples1	Hammond	2.0
Staples2	Hammond	2.0
Staples3	Hammond	2.0
D-Bldg1	Hammond	1.0
D-Bldg2	Hammond	2.0
F-bldg1	Hammond	1.0
F-bldg2	Hammond	1.0
CP4-1	Hammond	2.0
CP4-2	Hammond	2.0
CP4-3	Hammond	2.0
CP4-4	Hammond	2.0
Resins1	Rex	3.8
Resins2	Rex	3.8
Resins3	Hammond	2.5
Resins4	Rex	3.0
Resins5	Rex	3.0
Resins6	Hammond	2.0

### APPENDIX-A Process Flow Diagrams – CP & SSP





## APPENDIX-B Major Equipment Details

(All CP-4&5, SSP-7A&7B equipment manufactured in 1995/1996 unless otherwise noted.)

Equipment Description	Quantity	Diameter (ft)	Height (ft)	Thickness (in)	Material of Construction	Pressure (bar)	Temperature (°C)	Internals
<b>CP (2 lines)</b>								
Additive Tanks	11	8.0	10.0	0.250	304SS			
DEG Tanks	3	12.0	24.0	0.250	304SS			
Glycol Mix Tank	2	12.0	15.0	0.250	304SS			
PTA Feed Hoppers	2	15.0	30.0	0.125	304SS			
PTA Dust Filters	2	8.0	20.0	0.125	304SS			
Barometric Receivers	5	10.0	10.0	0.125	304SS			10x10x6 Rect
Glycol Tanks	2	6.0	24.0	0.125	304SS			
Check Silos	2	20.0	15.0	0.125	304SS			
Paste Tanks	2	10.5	15.7	0.250	304SS			
Armstrong Scrape Coolers	3	0.5	320.0	0.250	304SS/CS			
Primary Esterifiers	2	6.9	17.4		304SS/316SS	4.2/3.1	325/325	Coils
PE Columns	2	3.3	33.5		304SS/316SS	4	325	2 packing
Secondary Esterifiers	2	7.5	25.3		304SS/316SS	1.8/3.1	311/325	Jacket, Coils
SE Columns	2	2.0	23.3		304SS/304SS	2	325	3 packing
Low Polymerizers	2	12.8	9.5		CS/304SS/316SS	4.0/3.0	325/325	Jacket, Coils
Scraping Condensers	2	3.3			304SS/304SS			No tubes.
Intermediate Polymerizer	1	8.2	24.6		CS/304SS/304SS			Agitator
High Polymerizers	2	8.2	24.6		CS/304SS/304SS			Agitator
Polymer Filters	4				304SS/316SS	206	343	
Conair Chip Cutters	5				304SS			
Gala Spin Dryers	3	5.2	7.9		304SS			10 mt/hr
Rotex Classifiers	3							
Analysis Silos	4							
<b>SSP (2 lines)</b>								
Inlet Feed Hoppers	4	13.5	19.0		304SS			
Nitrogen Scrubbers	2	8.0	20.0		304SS			
Feed Hoppers	2	20.0	25.0	0.125	304SS			
Crystallizers	2	8.4	33.3		304SS			Agitator
Torus/Disk Heaters	2	8.6	33.3		304SS			Agitator
Purge Screw Feeders	2	8.6	37.5		304SS			Agitator
Hopper Reactors	2	13.0	60.0		304SS			Cone Bottom
Gala Spin Dryers	3	3.6	11.3		304SS			
Rotex Classifiers	2				304SS			

### CP-4&5 Units – additional details

**Paste Tanks (2):** 3.2m diameter and 4.8m tall with 44 m<sup>3</sup> capacity. Constructed of 304L SS. With agitator.

**Primary Esterifiers (2):** 2.1m diameter and 5.3m tall. Constructed of 304L SS with 316L SS internal coils. With 30 hp agitator. Shell is rated for 4.2 bar at 325°C, coils are rated for 3.1 bar at 325°C. Shell operates at 2.8 bar and 280°C.

**Primary Esterifier Columns (2):** 1.0m diameter and 10.2m tall. Constructed of 304L SS with 316L packing (2 sections). Column is rated for 4.2 bar at 325°C.

**Secondary Esterifiers (2):** 2.3m diameter and 7.7m long (horizontal vessel). Constructed of 304L SS with 316L SS internal coils (three sections). Has 3 agitators. Shell is rated for 1.8 bar at 311°C, coils are rated for 3.1 bar at 325°C. Operates at atmospheric pressure and at 280°C.

**Secondary Esterifier Columns (2):** 0.6m diameter and 7.1m tall. Constructed of 304L SS with 304L packing (3 sections). Column is rated for 1.7 bar at 325°C.

**Low Polymerizers (2):** 3.9m diameter and 2.9m tall (“fat boy”) with 44 m<sup>3</sup> capacity. Constructed of 304L SS with a CS jacket and 316L SS internal coils. Shell is rated for 4.0 bar at 325°C, the jacket is rated for 3.0 bar at 325°C, and the coils are rated for 3.1 bar at 325°C.

**Low Polymerizer Scraping Condensers (2):** 1.0m diameter with 5.6 m<sup>3</sup> capacity. Constructed of 304L SS (shell and jacket) – no tubes. Operates under vacuum.

**Intermediate Polymerizer (1):** 2.5m diameter and 7.5m long (horizontal). Constructed of 304L SS shell and jacket. Operates under vacuum and 284°C. Agitator turns at 11 rpm.

**High Polymerizers (2):** 2.5m diameter and 7.5m long (horizontal). Constructed of 304L SS shell and jacket. Combination of Vapor and Liquid Dowtherm heating on jacket. Operates under vacuum and 286°C. Agitator turns at 8.5 rpm.

**Polymer Filters (4):** Constructed of 304L SS with 316L SS filter elements. Design is for 206 bar at 343°C and operation is at 165 bar at 286°C.

**Conair Chip Cutters (5):** Horizontal model 9024, constructed of 304L SS. Rated for 10.5 mt/hr.

**Gala Spin Driers (3):** 1.6m diameter and 2.4m tall. Constructed of 304 SS shell and internals. 68 mt/hr water flow and 10 mt/hr chip capacity each. Aluminum air ducts.

### SSP-7A&7B Units – additional details

**Crystallizers (2):** 8'-5" diameter and 33'-4" long (horizontal). Constructed of 304 SS shell and internals. 200 hp agitator turns at 10-12 rpm. Operates at 0.5 bar and 180°C with heated dry air.

**Torusdisk® Heaters (2):** 8'-7" diameter and 33'-4" long (horizontal). Constructed of 304 SS shell and internals. 150 hp agitator turns at 10-12 rpm. Operates at 0.5 bar and 195°C with hot nitrogen.

**Purge Screw Heaters (2):** 8'-7" diameter and 37'-6" long (horizontal). Constructed of 304 SS shell and internals. 150 hp agitator turns at 10-12 rpm. Operates at 0.5 bar and 195°C with hot nitrogen.

**Hopper Reactors (2):** 13' diameter and 60' tall. Constructed of 304 SS shell and internals. Temperature profile is 205°C top, 210°C middle, and 205°C bottom. Total weight per spec sheet is 42 mt each. It appears that a thin carbon steel jacket was added to these reactors after installation.

**Gala Spin Driers (3):** 43" diameter and 136" tall. Constructed of 304 SS shell and internals.

**Hoffman Nitrogen Blowers (2):** 20,000 CFM, 5-stage centrifugal blower Model # 79105B3. Casing rated for 25 psi. 24" inlet, 19" outlet. Driven by a 900 HP, Siemens AC motor. Rated for 3542 rpm, 4160 volt. Overall dimensions 15' long x 70" wide x 88" high. Direct coupled and skid mounted.

**Satake Color Sorters (2):** Scan Master II Color Sorter, Model # SMII-8401E. Electronic optical sorting based on visible and infrared light to scan product and sort material by grades. Used in this application to reject off-color chips.

### Other Units

**Dowtherm Furnaces (3):** The three forced-air Dowtherm furnaces put out 35 MM BTU/hr each with 4" tubes in the firebox. The furnaces are approximately 20' diameter by 45' tall. The convection section sits on top of the furnace, with the stack on top of that. The furnaces weigh approximately 80 mt each. There are five Dowtherm recirculation pumps feeding the central loop for the process areas. Each pump has a 250 hp drive motor.

**DEDO Column (1):** 1.0m diameter and 25m tall. Constructed of 304L SS. Column has 43 trays and operates under a vacuum.

**DEDO Water Tanks (2):** 37' diameter and constructed of 304L SS. Atmospheric tanks.

**Silos:**

Equipment Description	Quantity	Capacity (mt PET)	Diameter (ft)	Height (ft)	Thickness (in)	Material of Construction	Bottom
PTA Silos	1	20	13.0	7.0		304L SS	45-60° cone
	2	300	20.0	34.0	0.236	304L SS	45-60° cone
Amorphous PET Silos	1	10	9.0	4.0		304L SS	45-60° cone
	1	20	13.0	7.0		304L SS	45-60° cone
	1	70	13.0	19.0		304L SS	45-60° cone
	1	100	15.0	25.0		304L SS	45-60° cone
	3	200	16.5	42.0	0.236	304L SS	45-60° cone
SSP PET Silos	4	25	13.0	9.0		304L SS	45-60° cone
	5	100	15.0	25.0		304L SS	45-60° cone
	3	125				304L SS	45-60° cone
	2	200	16.5	42		304L SS	45-60° cone

**Transformers:**

Electrical Transformers		
Transformer	Manufacturer	MVA
Main 1	ABB	13.3
Main 2	Ohio	14.9
Main 3	Canadian	14.9
Main 4	English	2.5
Staples1	Hammond	2.0
Staples2	Hammond	2.0
Staples3	Hammond	2.0
D-Bldg1	Hammond	1.0
D-Bldg2	Hammond	2.0
F-bldg1	Hammond	1.0
F-bldg2	Hammond	1.0
CP4-1	Hammond	2.0
CP4-2	Hammond	2.0
CP4-3	Hammond	2.0
CP4-4	Hammond	2.0
Resins1	Rex	3.8
Resins2	Rex	3.8
Resins3	Hammond	2.5
Resins4	Rex	3.0
Resins5	Rex	3.0
Resins6	Hammond	2.0