

Pumps					
Identification: L-223AB			Date	4/2/99	
			by	Team 2	
Function: Recycle to Absorber					
Purchased Cost:	\$ 42,000	Cost Index	1 02 Base	382 Current	390
Installed Cost:	\$ 61,320				
Type:	Centrifugal				
Material of construction	Carbon Steel				
Volumetric flowrate	36 gpm				
Pressure					
Operating	10 psi				
Design	55 psi				
Temperature					
Operating	153 °F				
Design	198 °F				
Hydrostatic head	0 ft				
NPSH _A	13.7 ft				
NPSH _R	10 ft				
Impeller diameter	9 in				
Motor:					
Motor efficiency	0.45				
Brake horsepower	5.70 hp				
Power consumption	2.57 hp				
Utilities:	Electricity				
Controls:	NA				
Insulation:	NA				
Tolerances:	NA				
Comments:	None				

HEAT EXCHANGERS

Identification: E-232	Date	4/2/99
	by	Team 2

Function: Distillation condenser

Purchased Cost: \$ 839,000 **Cost Index** 1.02 **Base** 382 **Current** 390

Installed Cost: \$1,224,940

Type:

Heat exchanger type:	Shell and tube	Duty	1763200 Btu/min
Configuration:	6 Parallel cross flow horizontal	Surface area	7538.6 ft ² /shell
		Mean temperature diff.	12.6 °F

Tube side:		Tubes:	
Fluid handled	ammonia	Material of construction	Carbon steel
Flowrate	201656 lb/h	Outer diameter	0.75 in
Pressure		Thickness	0.083 in
Operating	128.495 psi	Length	16 ft
Design	158.8 psi	No. of tubes	2256
Temperature		Tube pattern	30°
Operating	69.8 °F to 69.8 °F	Pitch	0.95 in
Design	146.8 °F	Pressure drop	0.075 psi
No. of Passes	2	Fouling	0 Btu/min-ft ² -°F
Inlet nozzle ID	27 in	Corrosion allowance	0.125 in
Outlet nozzle ID	87 in		

Shell side:		Shell:	
Fluid handled	Distillate	Material of construction	Carbon steel
Flowrate	389418 lb/h	Inner diameter	60 in
Pressure		Thickness	0.4375 in
Operating	1.15 psi	Total weight	
Design	29.7 psi	Shell and Bundle	51746 lb
Temperature		Pressure drop	0.065 psi
Operating	85.7 °F to 79.1 °F	Fouling	0 Btu/min-ft ² -°F
Design	162.7 °F	Corrosion allowance	0.125 in
No. of passes	1		
Inlet nozzle ID	35 in		
Outlet nozzle ID	6.0 in		

Baffles:

Type	Full-support	Spacing	
Material of construction	Carbon steel	inner	70.4 in
Cut	0	center	48 in
		outer	66.2 in

Utilities: Ammonia Refrigerant – 201,200 lb/h

Controls: N/A

Insulation: None

Tolerances: N/A

Comments: None

Distillation Column			
Identification: D-230		Date	4/2/99
		by	Team 2
Function: Azeotropic distillation to separate acrylic acid			
Purchased Cost	\$ 1,117,000	Cost Index	1.02 Base 382 Current 390
Installed Cost: \$ 1,630,820			
Design: Column			
Material of construction	carbon steel	Functional Height	48 ft
Pressure		Inner diameter	18 ft
Operating	1.03 psia	Working stress	13700 psi
Design	29 psia	Joint efficiency	0.8
Temperature		Corrosion allowance	0.125 in
Operating	174 °F	Thickness of shell	1.4375 in
Design	219 °F	Weight of shell	1,058 lb
Head Information			
Material of construction	carbon steel	Joint efficiency	0.8
Head type	hemi-spherical	Corrosion allowance	0.125 in
Inner diameter	18 ft	Weight of head	29813 lb
Thickness	1.4375 in		
Working stress	13700 psi		
Height	48.39 ft		
Overall pressure drop	0.2702 psi		
Calculated maximum flooding	85.50%		
Pressure drop per length	0.0056 psi/ft		
Flooding gas velocity	17,660 USGPM/ft ²		
HETP	3.226 ft		
Utilities: NA			
Controls: NA			
Insulation: None			
Tolerances: NA			
Comments: None			

Pressure Vessels

Identification: F-233

Date 4/2/99
by Team 2

Function: Decanter for Distillation Condenser

Purchased Cost: \$ 155,000 Cost Index 1.02 Base 382 Current 390

Installed Cost: \$ 226,300

Design Data:

Vessel

Material of construction	Carbon Steel	Functional Length	51 ft
Shape	Cylindrical	Inner diameter	10 ft
Configuration	Horizontal	Thickness	1.125 in
Pressure		Hold-up time	0.57 hr
Operating	1.03 psia	Volume	31700 gal
Design	29 psia	% full (liquid)	95
Temperature		Corrosion allowance	0.125 in
Operating	75 °F		
Design	100 °F		

Head

Material of construction	Carbon Steel	Joint efficiency	0.8
Head type	Hemispherical	Corrosion allowance	0.125 in
Inner diameter	10 ft	Weight	7201 lb
Thickness	1.125 in		
Working stress	13700 psi		

Utilities: N/A

Controls: N/A

Insulation: N/A

Tolerances: N/A

Comments: None

Pressure Vessels

Date 4/2/99
by Team 2

Function: Acrylic Acid Storage Tank

Purchased Cost: \$ 242,000 Cost Index 1.02 Base 382 Current 390

Installed Cost: \$ 353,320

Design Data:

Vessel

Material of construction	Carbon Steel	Functional height	30 ft
Shape	Cylindrical	Inner diameter	10 ft
Configuration	Vertical	Thickness	0.375 in
Pressure		Hold-up time	1 week
Operating	14.7 psi	Volume	2356 ft ³
Design	60 psi	% full (liquid)	90
Temperature		Corrosion allowance	0.125 in
Operating	77 °F	Joint efficiency	0.8
Design	176 °F	Working Stress	13700 psi

Head

Material of construction		Joint efficiency	0.8
Head type	Hemispherical	Corrosion allowance	0.125 in
Inner diameter	10 ft	Weight	2400 lb
Thickness	0.375 in		
Working stress	13700 psi		

Auxiliaries

Platforms
Ladders
Inlet location
Outlet location
Mist separator

Utilities: None

Controls: NA

Insulation: NA

Tolerances: NA

Comments: Designed for the temperature of the product.

Reactor 1			
Identification:	R-110	Date	4/2/99
		by	Team 2
Function:	Conversion of Propylene to Acrolein		
Purchased Cost:	\$ 119,000	Cost Index	1.02 Base 382 Current 390
Installed Cost:	\$ 173,740		
Type:	<i>U ≈ 375 ← Pretty high.</i>		
Heat exchanger type:	Shell and Tube	Duty	2.38E+07 Btu/h
Configuration:	2 in Parallel	Surface area	1410 ft ²
		Mean temperature diff.	45 °F
Tube side:		Tubes:	
Fluid handled	Reactor Feed	Material of construction	Stainless Steel
Flowrate	5.77E+04 lb/h	Outer diameter	0.947 in
Pressure		Thickness	0.197 in
Operating	87.2 psi	Length	4 ft
Design	132.2 psi	No. of tubes	900 /shell
Temperature		Tube pattern	30 °
Operating	770 °F to 770 °F	Pitch	1 in
Design	815 °F	Pressure drop	14.66 psi
No. of Passes	1	Fouling	0 Btu/min-ft ² -°F
		Corrosion allowance	0.125 in
Shell side:		Shell:	
Fluid handled	Molten Salt	Material of construction	Stainless Steel
Flowrate	61000 /shell	Inner diameter	4 ft
Pressure		Thickness	0.25 in
Operating	14.7 psi	Total weight	
Design	59.7 psi	Shell	2.7 lb/shell
Temperature		Bundle	1231 lb/tube bundle
Operating	698 °F to 752 °F	Fouling	0 Btu/min-ft ² -°F
Design	797 °F	Corrosion allowance	0.125 in
No. of passes	1		
Utilities:	Molten Salt		
Controls:	NA		
Insulation:	1.5 in		
Tolerances:	NA		
Comments:	None		

Reactor 2			
Identification:	R-120	Date	4/2/99
		by	Team 2
Function:	Conversion of Acrolein to Acrylic Acid		
Purchased Cost:	\$ 931.000	Cost Index	1.02 Base 382 Current 390
Installed Cost:	\$ 1.359.260		
Type:		$U = 5, \dots$	
Heat exchanger type:	Shell and Tube	Duty	1.48E+07 Btu/h
Configuration:	3 Trains of 2 in Series	Surface area	52.775 ft ²
		Mean temperature diff.	54 °F
Tube side:		Tubes:	
Fluid handled		Material of construction	Carbon Steel
Flowrate	7.06E+04 lb/h	Outer diameter	2.197 in
Pressure		Thickness	0.197 in
Operating	72.5 psi	Length	12 ft
Design	117.5 psi	No. of tubes	1400 /shell
Temperature		Tube pattern	30 °
Operating	482 °F to 482 °F	Pitch	1 in
Design	532 °F	Pressure drop	0.4 psi
No. of Passes	1	Fouling	0 Btu/min-ft ² -°F
		Corrosion allowance	0.125 in
Shell side:		Shell:	
Fluid handled	Molten Salt	Material of construction	Stainless Steel
Flowrate	61000 /shell	Inner diameter	4 ft
Pressure		Thickness	0.25 in
Operating	14.7 psi	Total weight	
Design	59.7 psi	Shell	8 lb/shell
Temperature		Bundle	5743 lb/tube bundle
Operating	410 °F to 464 °F	Fouling	0 Btu/min-ft ² -°F
Design	509 °F	Corrosion allowance	0.125 in
No. of passes	1		
Utilities:	Molten Salt		
Controls:	NA		
Insulation:	1.5 in		
Tolerances:	NA		
Comments:	None		

Fired Heater			
Identification: E-113		Date	4/2/99
		by	Team 2
Function: To preheat the reactor feed.			
Purchased Cost:	\$ 687,000	Cost Index	1.02 Base 382 Current 390
Installed Cost:	\$ 1,003,020		
Type:	Direct fired heater		
Duty	1,500,000 Btu/hr		
Material of construction:	Stainless steel		
Flow rate	57,600 lb/hr		
Pressure			
Operating	73 psi		
Design	118 psi		
Temperature			
Operating	770 °F		
Design	847 °F		
Utilities: Fuel	Natural Gas		
Flow rate	760000 SCFM		
Controls:	NA		
Insulation:	1.25 in		
Tolerances:	NA		
Comments:	None		

Absorption Column

Identification: D-220

Date 4/2/99

by Team 2

Function:

Purchased Cost \$ 378 000 Cost Index 1 02 Base 382 Current 390

Installed Cost: \$ 551.880

Design:

Column

Material of construction	Carbon steel	Functional Height	41 ft
Pressure		Inner diameter	12 ft
Operating	10 psi	Working stress	13700 psi
Design	55 psi	Joint efficiency	0.8
Temperature		Corrosion allowance	0.125 in
Operating	181 °F	Thickness of shell	1.1875 in
Design	258 °F	Weight of shell	617 lb

Head Information

Material of construction	Carbon steel	Joint efficiency	0.8
Head type	hemi-spherical	Corrosion allowance	0.125 in
Inner diameter	12 ft	Weight of head	10946 lb
Thickness	1.1875 in		
Working stress	13700 psi		

Trays

Material of construction	Carbon steel		
No. of trays	27		
Tray spacing	18 in		
Diameter	12 ft		
Tray thickness	0.125 in		
Weir height	2 in		
Flooding factor	85		
No. of downcomers/ tray	1		
Downcomer area/tray area	0.27		
Downcomer width	10 in (min)		
Overall pressure drop	1.72 psi		
Pressure drop/tray	0.065 psi		0.6.

Tray type

Sieve	
Hole area	1140 in ²
Hole diam.	0.1875 in

Utilities: None

Controls: NA

Insulation: NA

Tolerances: NA

Comments: None

Absorber Condenser Reflux Drum

Identification: F-222

Date 4/2/99
by Team 2

Function: To separate gases and liquids from the refluxed absorber

Purchased Cost: \$ 38,000 **Cost Index** 1.02 **Base** 382 **Current** 390

Installed Cost: \$ 55,480

Design Data:

Vessel

Material of construction	Carbon Steel	Functional height	12.5 ft
Shape	Cylindrical	Inner diameter	2.5 ft
Configuration	Vertical	Thickness	0.4375 in
Pressure		Hold-up time	5 min
Operating	8 psi	Volume	61 ft ³
Design	15 psig	% full (liquid)	50
Temperature		Corrosion allowance	0.125 in
Operating	150 °F	Joint efficiency	0.8
Design	227 °F		

Head

Material of construction	Carbon Steel	Joint efficiency	0.8
Head type	Hemispherical	Corrosion allowance	0.125 in
Inner diameter	2.5 ft	Weight	175 lb
Thickness	0.4375 in		
Working stress	13700 psi		

Auxiliaries

Platforms	Raised to Column Height
Ladders	1
Inlet location	6.5 ft
Outlet location	0, 12.5 ft
Mist separator	None

Utilities: None

Controls: NA

Insulation: 0.5 in

Tolerances: NA

Comments: None

Expander

Identification: X-210

Date 4/2/99
by Team 2

Function: To recover energy from the reactor effluent while reducing the pressure of the gas.

Purchased Cost: \$ 924,000 Cost Index 1.02 Base 382 Current 390

Installed Cost: \$ 1,349,040

Type: Radial-flow

Material of construction: Carbon steel

Expansion ratio: 5.3

Volumetric flowrate: 441,000 ft³/hr (inflow) 2,205,000 ft³/hr (outflow)

Pressure

Operating 72.13 psi to 10.01 psi

Design 117 psi

Temperature

Operating 482 °F to 220.3 °F

Design 527 °F

Motor:

Motor efficiency 52%

Brake horsepower 4940 hp

Power production 2590 hp

← An expander is a motor

Utilities: Electrical Power Produced

Controls: NA

Insulation: NA

Tolerances: NA

Comments: None