



Dynamic Pharmaceuticals production of Acetonitrile

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Essissima



Outline

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- Process Flow Diagram
- Material & Energy Balance
- Aspen Simulation
- Simulation Convergence
- Specs of Major Equipment
- Estimates of Major Equipment(Cap Cost)
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- Project Milestones
- Hazop Analysis
- P&ID
- Safety Report
- Conclusion

Product

Acetonitrile

- Colorless liquid, sweet smell, toxic and flammable
- Primary uses include solvents, pesticides, batteries, acrylic nail removals, perfumes and, vitamins such as A and B1

Standard processing

- HPLC; high performance liquid chromatography
- A form of chromatography that pushes a mixture or solvent under a high pressure column



Process Description

Production:

- 30,000,000 lbs/yr.
- 3784 lbs/hr.
- 99.9% Purity Liquid Acetonitrile.
- 330 days of operation per year.



Process Selection: Acetonitrile via Ammoxidation of ethanol and pressure swing distillation.

Plant Location

Plant location

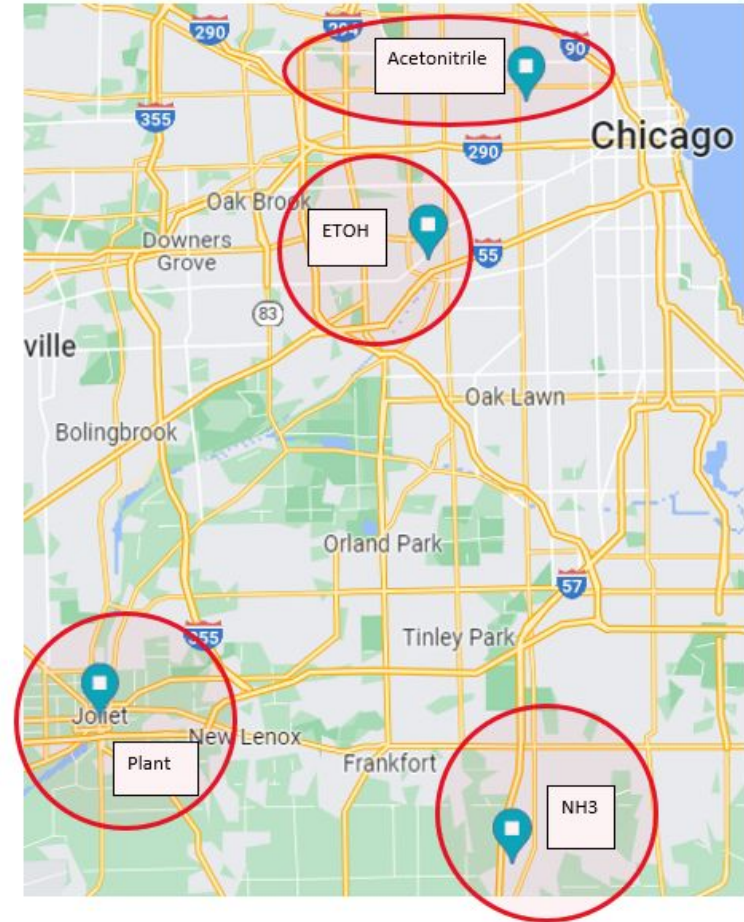
- Joliet, Illinois

Location of Raw Materials:

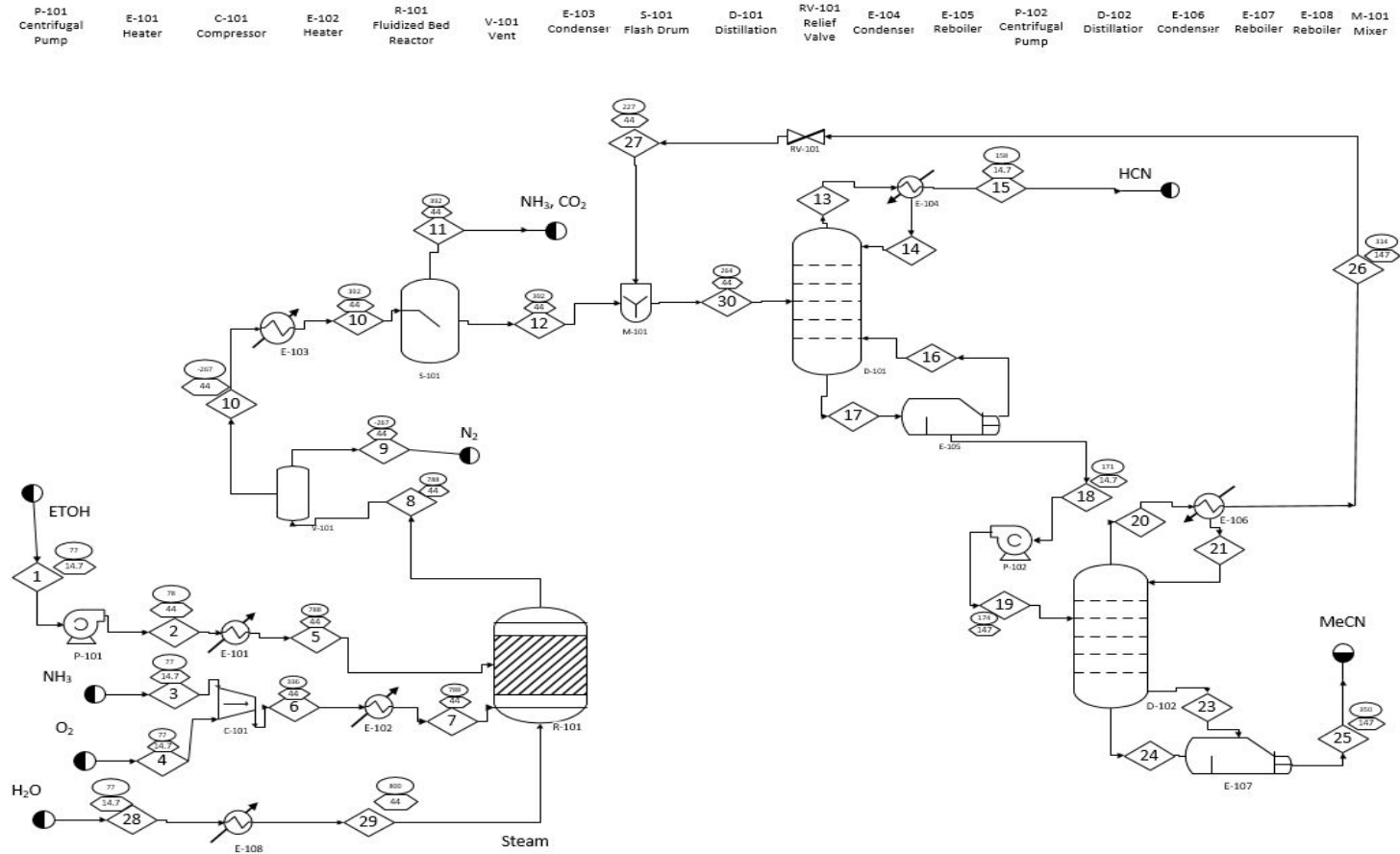
- ETOH - McCook, IL
- NH_3 - University Party, IL

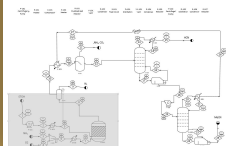
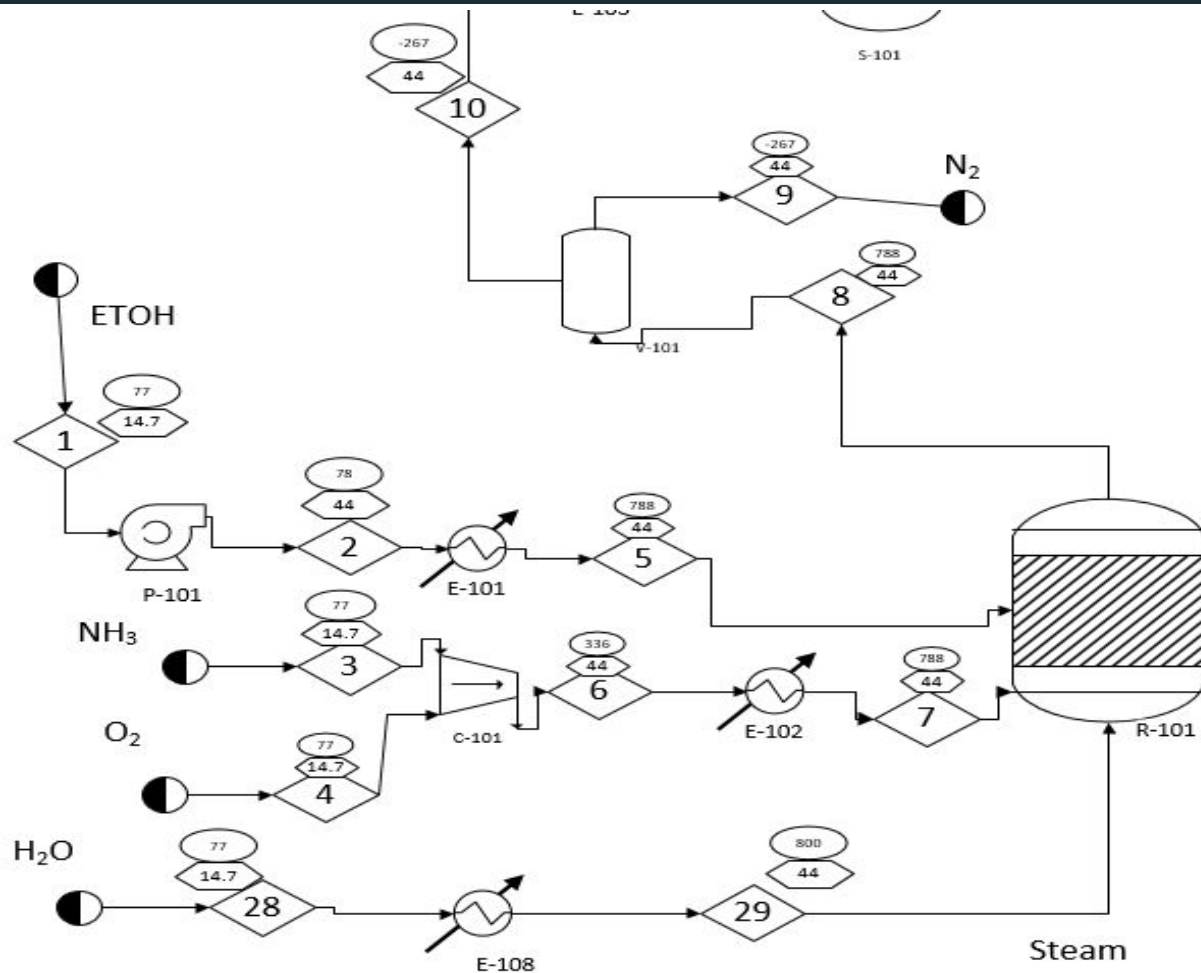
Client Location:

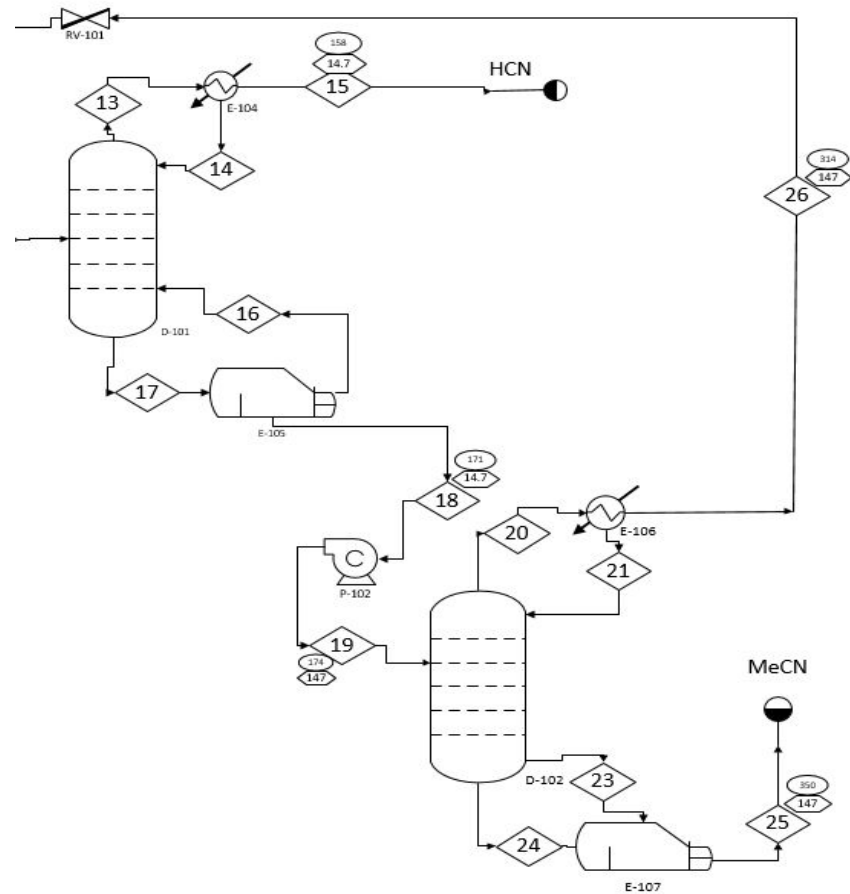
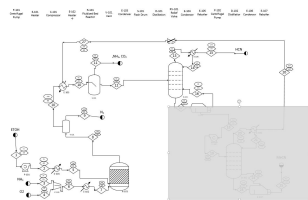
- Chicago, IL



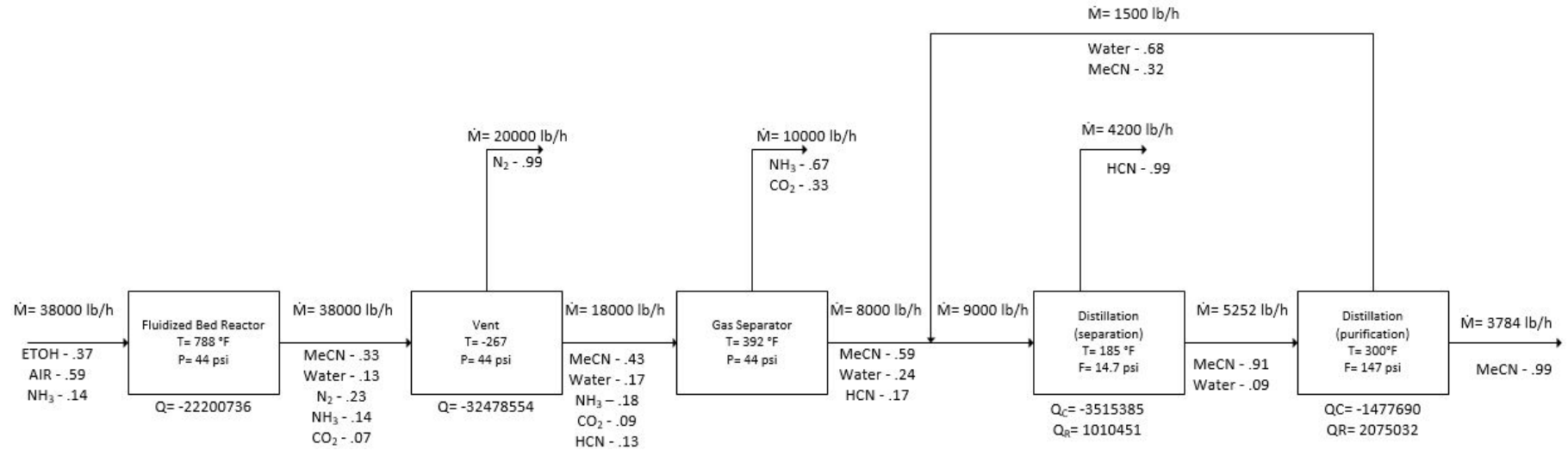
Process Flow Diagram



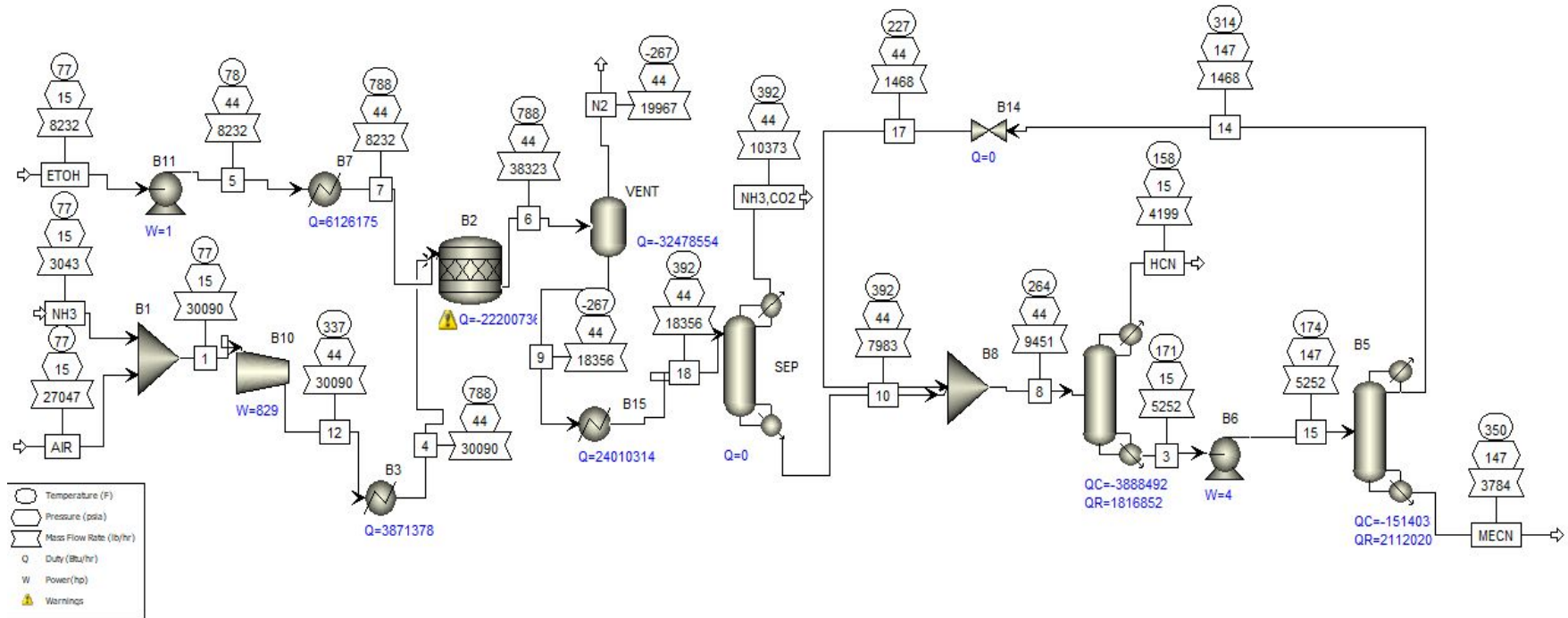




Material & Energy Balance



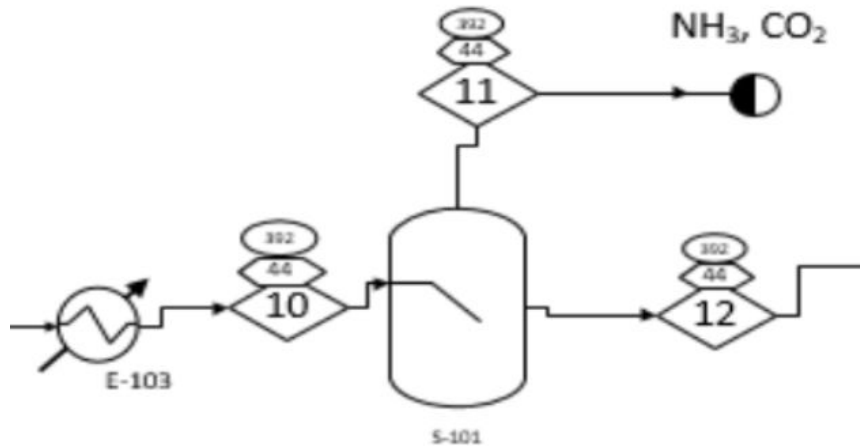
Acetonitrile Aspen Simulation



Simulation Convergence

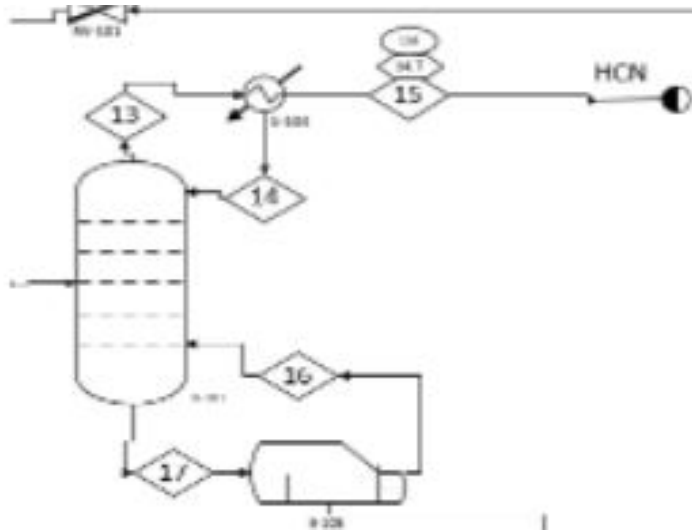
		Material																		
Stream Name	Units	ETOH	NH3	AIR	1	5	7	12	4	6	9	18	10	17	8	HCN	3	15	14	MECN
Description																				
From					B1	B11	B7	B10	B2	B2	VENT	B15	SEP	B14	B8	B4	B4	B6	B5	B5
To		B11	B1	B1	B10	B7	B2	B3	B2	VENT	B15	SEP	B8	B8	B4		B6	B5	B14	B5
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
Phase		Liquid Phase	Vapor Phase	Vapor Phase	Vapor Phase	Liquid Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Liquid Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Liquid Phase	Liquid Phase	Liquid Phase	Liquid Phase
Temperature	F	77	77	77	77	77.5808	788	336.912	788	788	-266.793	392	392	227.25	263.761	157.548	171.331	174.427	313.874	350.256
Pressure	psia	14.7	14.7	14.7	14.7	44.0878	44	44.0878	44	44	44	44	44	44	44	14.7	14.7	146.959	146.959	146.959
Molar Enthalpy	Btu/lbmol	-119203	-21491	-3.02E+13	-3318.19	-119186	-84911.4	-1420.75	2060.9	-24764.2	-32985.6	-59092	-1193.85	-30245.9	-5666.51	-34314	1554.21	1630.69	-30244.6	20493.9
Mass Enthalpy	Btu/lb	-2588.07	-1212.44	-1.05E+14	-122.618	-2587.71	-1843.55	-52.5012	76.157	-315.539	-3588.6	-2280.54	-29.4225	-737.63	-139.425	-854.52	37.8712	39.7348	-737.598	499.332
Molar Entropy	Btu/lbmol-R	-82.5098	-20.3173	0.961501	-1.46958	-82.4789	-37.5063	-0.770658	2.68671	1.15165	-84.1233	-8.11506	-15.118	-38.6335	-18.4075	-23.4603	-36.1626	-36.0466	-39.1324	-26.7876
Mass Entropy	Btu/lb-R	-1.79141	-1.14626	0.0334251	-0.054306	-1.79074	-0.814319	-0.028478	0.0932826	0.0425769	-3.24657	-0.313185	-0.372583	-0.942187	-0.452917	-0.584232	-0.881167	-0.87834	-0.954354	-0.65251
Molar Density	lbmol/cuft	1.08602	0.0025524	0.0025524	0.0025524	1.08552	0.0032862	0.0051574	0.0032862	2.31421	0.0048142	0.0048142	0.0274455	0.0056676	0.0022193	1.08235	1.07911	0.915041	0.873659	
Mass Density	lb/cuft	50.0206	0.0452427	0.0734227	0.0630718	49.9974	0.151358	0.139566	0.088929	0.0888881	59.9645	0.124743	0.195342	1.12538	0.230343	0.0891192	44.4191	44.286	37.5205	35.8664
Enthalpy Flow	Btu/hr	-2.13E+07	-3.69E+06	-2.84E+10	-3.69E+06	-2.13E+07	-1.52E+07	-1.58E+06	2.29E+06	-3.51E+07	-6.59E+07	-4.19E+07	-234884	-1.08E+06	-1.32E+06	-3.53E+06	198899	208687	-1.08E+06	1.89E+06
Average M/W		46.0585	17.7254	28.7658	27.0612	46.0585	46.0585	27.0612	27.0612	27.0612	25.9114	25.9114	40.5762	41.0041	40.6421	40.1559	41.0394	41.0394	41.0041	41.0531
Mole Flow s	lbmol/hr	178.738	171.682	940.256	1111.94	178.738	178.738	1111.94	1416.8	708.402	708.402	196.745	35.8013	232.546	104.571	127.975	127.975	35.8013	92.1732	
WATER	lbmol/hr	0	0	0	0	0	0	0	0	409.148	409.148	409.148	8.18296	2.5191	10.7021	8.18297	2.51909	2.51909	2.51905	3.69E-05
ETHANOL	lbmol/hr	176.91	0	0	0	176.91	176.91	0	0	40.832	40.832	40.832	40.832	11.2233	52.0553	40.8217	11.2336	11.2336	11.223	0.0106155
HCN	lbmol/hr	0	0	0	0	0	0	0	0	0.913879	0.913879	0.913879	0.913879	0.0001244	0.914004	0.913879	0.0001244	0.0001244	0.0001244	2.98E-10
CH3CN	lbmol/hr	0	0	0	0	0	0	0	0	136.078	136.078	136.078	136.078	22.0588	158.137	43.9151	114.222	114.222	22.0591	92.1626
CO2	lbmol/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O2	lbmol/hr	0	0	177.504	177.504	0	0	177.504	177.504	41.4263	10.7377	10.7377	10.7377	0	10.7377	10.7377	2.14E-27	2.14E-27	0	0
N2	lbmol/hr	0	0	762.752	762.752	0	0	762.752	762.752	85.0386	85.0386	85.0386	85.0386	0	0	0	0	0	0	0
NH3	lbmol/hr	0	160.818	0	160.818	0	0	160.818	160.818	13.8757	13.8757	13.8757	13.8757	0	0	0	0	0	0	0
CO	lbmol/hr	0	10.8643	0	10.8643	0	0	10.8643	10.8643	0	0	0	0	0	0	0	0	0	0	0
Mole Fractions																				
WATER		0	0	0	0	0	0	0	0	0.288782	0.577585	0.577585	0.0415918	0.0703635	0.0460213	0.0782526	0.0196843	0.0196843	0.070362	4.01E-07
ETHANOL		0.989774	0	0	0	0.989774	0.989774	0	0	0.0288198	0.0576396	0.0576396	0.207538	0.313488	0.22385	0.390372	0.0877798	0.0877798	0.31348	0.0001152
HCN		0	0	0	0	0	0	0	0	0.000645	0.0012901	0.0012901	0.004645	3.47E-06	0.0039304	0.0087393	9.72E-07	9.72E-07	3.47E-06	3.23E-12
CH3CN		0	0	0	0	0	0	0	0	0.0960458	0.192092	0.192092	0.691648	0.616145	0.680024	0.419953	0.892535	0.892535	0.616155	0.993884
CO2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O2		0	0	0.188783	0.159635	0	0	0.159635	0.159635	0.0292393	0.0151576	0.0151576	0.0545768	0	0.0461745	0.102683	1.67E-29	1.67E-29	0	0
N2		0	0	0.811217	0.685966	0	0	0.685966	0.685966	0.538361	0.120043	0.120043	0	0	0	0	0	0	0	0
NH3		0	0.936719	0	0.144629	0	0	0.144629	0.144629	0.0097937	0.0195874	0.0195874	0	0	0	0	0	0	0	0
HCONH2		0.0102259	0	0	0.0102259	0.0102259	0	0	0.0083732	0.0166264	0.0166264	0	0	0	0	0	0	0	0	0
CO		0	0.0632814	0	0.0097706	0	0	0.0097706	0.0097706	0	0	0	0	0	0	0	0	0	0	0
Mass Flows	lb/hr	8232.4	3043.14	27047.3	30090.4	8232.4	8232.4	30090.4	30090.4	38322.8	18355.7	18355.7	7983.15	1468	9451.15	4199.15	5252	5252	1468	3784
WATER	lb/hr	0	0	0	0	0	0	0	0	7370.91	7370.91	7370.91	147.418	45.3824	192.801	147.419	45.3821	45.3821	45.3814	0.0006651
ETHANOL	lb/hr	8150.08	0	0	0	8150.08	8150.08	0	0	1881.09	1881.09	1881.09	1881.09	517.045	2398.14	1880.62	517.52	517.52	517.031	0.489048
HCN	lb/hr	0	0	0	0	0	0	0	0	24.6982	24.6982	24.6982	24.6982	0.0033608	24.7016	24.6982	0.003361	0.003361	0.003361	8.05E-09
CH3CN	lb/hr	0	0	0	0	0	0	0	0	5586.35	5586.35	5586.35	5586.35	905.57	6491.92	1802.83	4689.09	4689.09	905.584	3783.51
CO2	lb/hr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O2	lb/hr	0	0	5679.93	5679.93	0	0	5679.93	5679.93	1325.59	343.593	343.593	343.593	0	343.593	343.593	6.83E-26	6.83E-26	0	0
N2	lb/hr	0	0	21367.3	21367.3	0	0	21367.3	21367.3	21367.3	21367.3	21367.3	21367.3	0	0	0	0	0	0	0
NH3	lb/hr	0	2738.82	0	2738.82	0	0	2738.82	2738.82	236.311	236.311	236.311	236.311	0	0	0	0	0	0	0
CO	lb/hr	0	304.314	0	304.314	0	0	304.314	304.314	0	0	0	0	0	0	0	0	0	0	0

Specifications of Major Equipment: Flash Separator



Flash Drum				
Identification	Item:	Vertical Vessel		
	Item No:		Date:	4/19/2022
	No. Required	1	By:	Jarred Essissima
	C (\$)			
Function: Separates vapor- liquid mixture of Acetonitrile, Nitrogen, Hydrogen Cyanide, Water, and Carbon Dioxide.				
Operation: Vaporization				
	Feed Stream(lb/hr)	Vapor Stream(lb/hr)	Liquid Stream (lb/hr)	
Material Handled:				
Ammonia	1051	1051	0	
Water	1051	0	1051	
Hydrogen Cyanide	1577	0	1552	
Acetonitrile	2454	0	2404	
Carbon Dioxide	2629	2705	0	
Total	8766	3757	5009	
Temperature (F)	185	56	56	
Pressure (psia)	15	44	44	
Area (ft ²)	490			
Height (ft)	7			
Diameter (ft)	12			
Volume (ft ³)	778			
Material of Construction	Stainless Steel			
Vapor Velocity (ft/s)	.0245			

Specifications of Major Equipment: 1st Distillation Column



Distillation Column 2			
Products:		Hydrogen Cyanide Acetonitrile/Water	
Identification			
	Item No.	V-102	
Operation	Pressure Swing		
Design Data			
Diameter(ft)	4.37	Tray Spacing(ft)	2
Height(ft)	16	Tray Type	Sieve
Number of Trays	9	Tray Material	Stainless Steel
Actual No. of Stages	5	Equipment Type	Vertical
Efficiency (%)	54.3	Relative Volatility	13.03
Column Material	Stainless Steel		

Estimates of Major Equipment Cap Cost: Direct Costs

Direct Costs					
Purchased equipment, E'					10.054
Delivery, fraction of E'	0.10	0.10	0.10	0.10	1.005
Subtotal: delivered equipment					11.059
Purchased equipment installation	0.45	0.39	0.47	0.47	5.198
Instrumentation & Controls (installed)	0.18	0.26	0.36	0.36	3.981
Piping (installed)	0.16	0.31	0.68	0.68	7.520
Electrical systems (installed)	0.10	0.10	0.11	0.11	1.217
Buildings (including services)	0.25	0.29	0.18	0.18	1.991
Yard improvements	0.15	0.12	0.10	0.10	1.106
Service facilities (installed)	0.40	0.55	0.70	0.70	7.742
Total direct costs	1.69	2.02	2.60	2.60	39.814

Estimates of Operating Costs

Indirect Costs					
Engineering and supervision	0.33	0.32	0.33	0.33	3.650
Construction expenses	0.39	0.34	0.41	0.41	4.534
Legal expenses	0.04	0.04	0.04	0.04	0.442
Contractor's fee	0.17	0.19	0.22	0.22	2.433
Contingency	0.35	0.37	0.44	0.44	4.866
Total indirect costs	1.28	1.26	1.44	1.44	15.926
Fixed capital investment (FCI)	55.739				
Working capital (WC)	0.70	0.75	0.89	0.89	9.843
Total capital investment (TCI)	65.582				

Capcost details

NPV=\$10,054,409

- Equipment cost(cost index December 2021/cost index 2016)
- \$7,013,500(777/542)

Total Capital Investment \$65,582,000 Capcost Evaluation

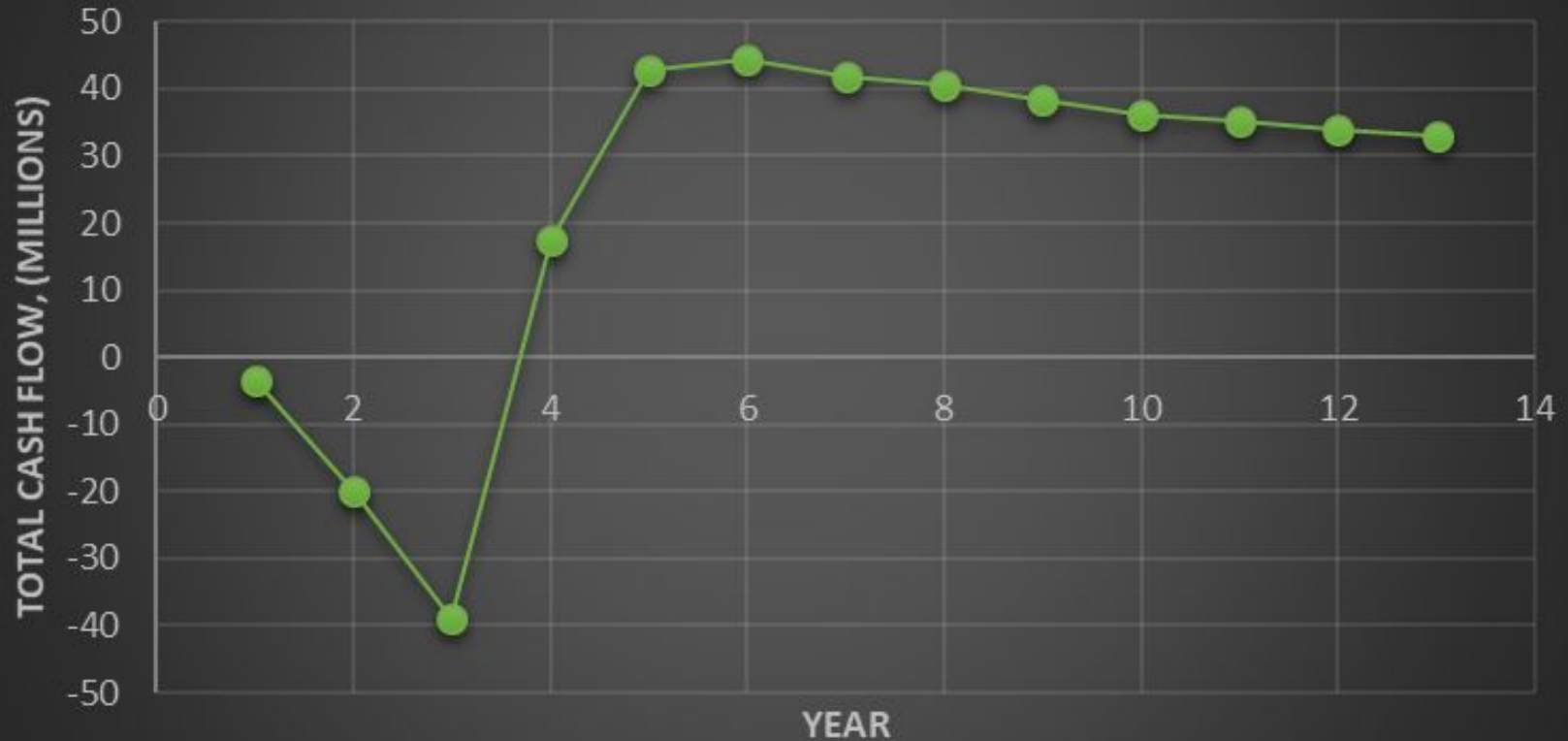
Rate of Return on Investment= ((Average Annual Net Profit/Fixed Capital Cost))-1/n;

- n= plant life
- 10.98=11%

Payback period

- (Investment/cash flow)=(65,582,000/9,843,000)=6.6 7 years

Cash Flow Diagram



\$	-3.36091	-19.899	-38.8368	17.46505	42.76772	44.25298	41.73992	40.70458	38.52501	36.32433	35.22561	34.10492	32.96182
Year	1	2	3	4	5	6	7	8	9	10	11	12	13

Project Milestone

Project Start: Mon, 30-Aug-2021
Display Week: 22

24-Jan-22							31-Jan-22							7-Feb-22							14-Feb-22							21-Feb-22							28-Feb-22						
24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5	6
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun

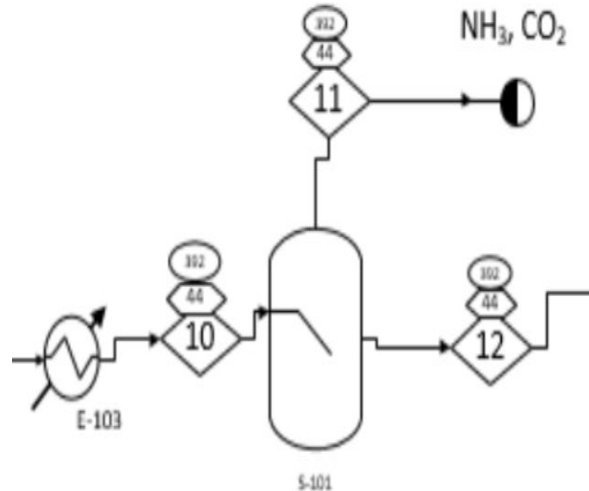
Task	Start	End	
Phase 1			
Simulation& safety	18-Jan-22	25-Feb-22	
Design of equipment	25-Feb-22	30-Mar-22	
Material Selection	30-Mar-22	25-Apr-22	
final safety review	18-Apr-22	1-May-22	
Economic evaluation	27-Feb-22	1-May-22	

Project Start: Mon, 30-Aug-2021
Display Week: 30

21-Mar-22							28-Mar-22							4-Apr-22							11-Apr-22							18-Apr-22							25-Apr-22						
21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun

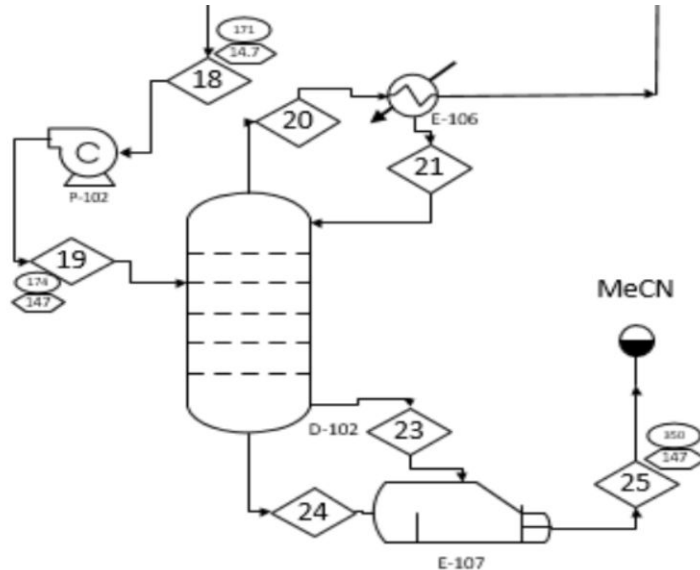
Task	Start	End	
Phase 1			
Simulation& safe	18-Jan-22	25-Feb-22	
Design of equipr	25-Feb-22	30-Mar-22	
Material Selectic	30-Mar-22	25-Apr-22	
final safety revie	18-Apr-22	1-May-22	
Economic evalua	27-Feb-22	1-May-22	

HAZOP Analysis: Flash Separator



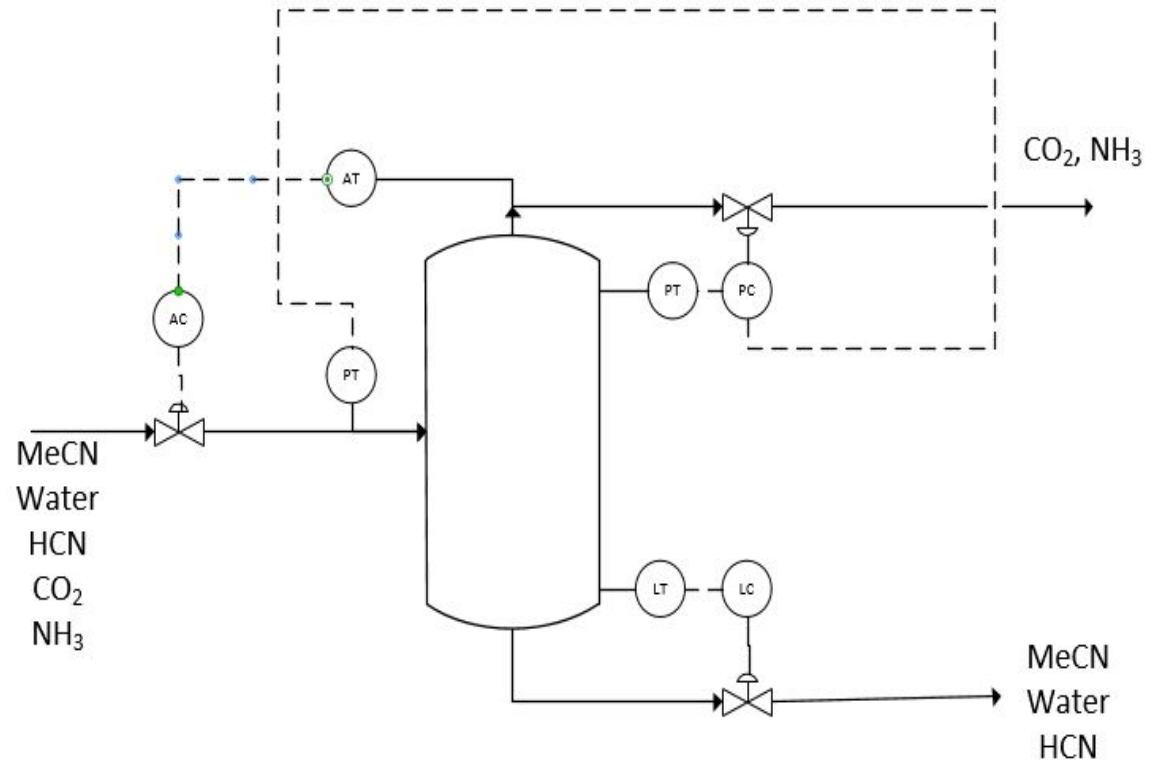
Flow				
Process Parameter	Deviations	Possible causes	Possible Consequences	Action required
Flow	Low	Valve fully open	Components are not fully separated.	Always check the condition of valve
Flow	High	Valve opening too small	Flow of the product too slow	Install pump
Pressure				
Process Parameter	Deviations	Possible causes	Possible Consequences	Action required
Pressure	Low	1. Lower feed drum temperature	1. Higher liquid level	1. Install pressure & temperature controller for the drum.
		2. Leakage In the flash drum	2. Lower CO2 vapor recovered at the top of flash drum.	2. Install pressure indicator in flash drum
Pressure	High	1. Higher feed temperature	1. Lower liquid level.	1. Install pressure & temperature controller for the drum.
		2. Blockage in vapor stream.	2. Risk of drum explosion.	2. Install pressure alarm.
Level				
Process Parameter	Deviations	Possible causes	Possible Consequences	Action required
Level	Low	1. Blockage in inlet stream	1. No separation occurs.	1. Low Level alarm
		2. The Inlet stream too hot.	2. No separation occurs. The pump might get damage.	2. Install temperature controller at the feed stream.
Level	High	1. Inlet stream too cold.	1. No separation occurs.	1. Install temperature controller at the feed.
		2. Blockage in vapor stream.	2. Risk of drum explosion.	2. Install pressure alarm.

HAZOP Analysis: 2nd Distillation Column



Distillation 2 HAZOP Chart					
Node	Guideword	Process parameters	Cause	Consequence	Action
Distillation	Low	Low Level	Inadequate supply of feed to the column	Level decrease in level Backflow of material	Install control valve Install low level alarm
Distillation	High	High Level	Output blockage	Overpressure	Install High level alarm
Distillation	Low	Temperature	Less Steam Flow Loss of Heating (steam leakage)	-separation efficiency lowers Product loss leading to decrease in profit margins	Install Temperature gauge
Distillation	High	Temperature	More Steam Flow Pressure higher than process conditions	Overpressure column leading to column failure Changes in Product quality	Install Pressure gauge and pressure control valve
Distillation	Low	Pressure	Low discharge pressure	Vacuum conditions will be heightened in the column leading to a unit collapse	Low Pressure Alarm
Distillation	High	Pressure	Excessive Vapor Flow	-Flooding -Larger pressure drop -separation efficiency lowers	-Decrease feed rate High pressure alarm

Process Control Scheme: Flash Separator



Safety Report

Acetonitrile

- Storage in a cool, dry area out of direct sunlight
- Very toxic and flammable; gas and liquid phases
- Explosion proof containment
- Use adequate ventilation to avoid toxic emissions.

Hydrogen Cyanide

- Extremely poisonous and flammable
- Should be liquified in order to transport
- Storage below 78 Fahrenheit

Contemporary

Industry

- Processing and licensing fees volatility
- Volatility of components
- Covid
- Before plant execution; a detailed analysis should be reviewed

Society

- Job market
- Reduce the time other plants need to be active
- Global Economic shut down

References

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Acknowledgements

Dr Martin

Dr. Dada

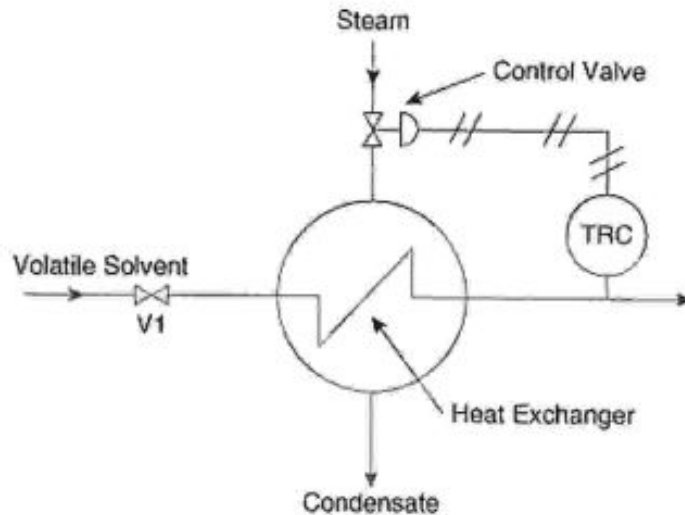
CHEG Engineering Department

CHEG Evaluators

Dynamic Pharmaceuticals



Specifications of Major Equipment: Feed Heat Exchanger

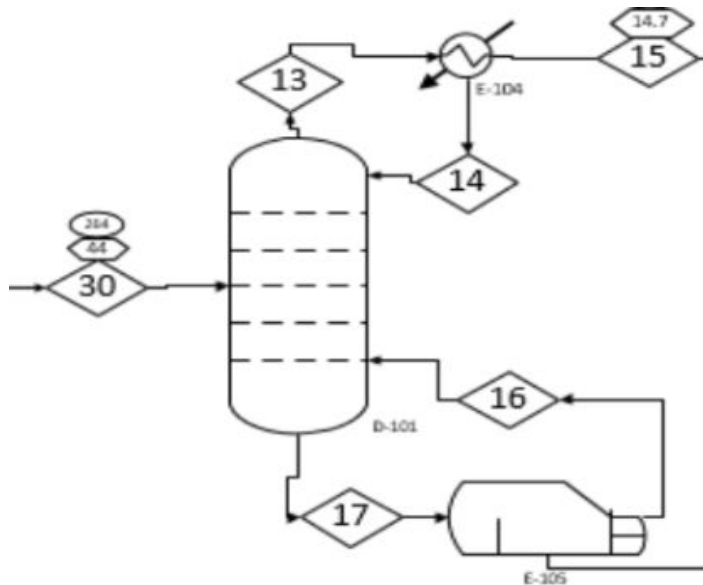


Feed Heat Exchanger				
Identification	Item:	1-2 Shell and Tube Heat Exchanger		
	Item No:		Date:	4/22/2022
	No. Required	1	By:	Jarred Essissima
	C (\$)			
Function: Supplies heat to liquid ethanol feed.				
Operation: Conduction				
	Cold In	Cold Out	Hot In	Hot Out
Material Handled:				
Total Flow (lb/hr):	4246.74	4246.74		
Volumetric Flow (ft ³ /min)	164.657	54390.10		
Component Feed Temperature:				
Ethanol (T)	77	788	0	0
Water (T)	0	0	800	800
Total	116827	99510	17317	
Temperature (F)	77	788	800	800
Pressure (psia)	14.7	14.7	14.7	14.7
Vapor Fraction:				
			1.00	1.00
Design Data:				
Q (MMBTU/hr):	3.8	LMTD (°F):	123.47	
U _c (BTU/(ft ² *h*°F):	300	Material:	Stainless Steel	
Area (ft ²):	104.52			
Shell Diameter (ft):	.0625			
Number of Tubes:	27			

ITEM	STUDY NODE	PROCESS PARAMETER S	DEVIATION S	POSSIBLE CAUSES	POSSIBLE CONSEQUENCES	ACTION REQUIRED
1A	Hot solvent from the heat exchanger	Flow	No	1a.1 The feed line valve is closed (v1) 2. Feed line may have a blockage or leak 3. Solvent supply is exhausted	1a.1.1 No hot solvent leaving the heat exchanger which could affect future processes	1a.1.1.1 Install a new alarm system 1.1b Install a new flow meter to check solvent flow 2. Clear blockages in the feed lines 3. Put stoichiometric quantity
1B			Less	1b.1 The flow of the cold solvent is low 1b.2 V1 is not fully open	1b.1.1 The decrease in the output from the heat exchanger could impact the downstream process	1b.1.1.1 We will need to check the feed line for any leaks 1b.1.1.2 We will need to install a flow meter 1b.2.1.1 Open the valve fully before continuing
1C			More	1c.1 The solvent flow is excessive	1.c.1.1The outflow of the hot solvent is too fast which affects the downstream process	1.c.1.1.1 We will need to recalculate the flow meter so that our outcome would be our desired flowrate
1D			As well as	1d.1The stream from the coil leaks	1d.1.1 Less quantity and or low quality will further affect the process	1d.1.1.1 We will need to repair the solvent line and steam coil leakages

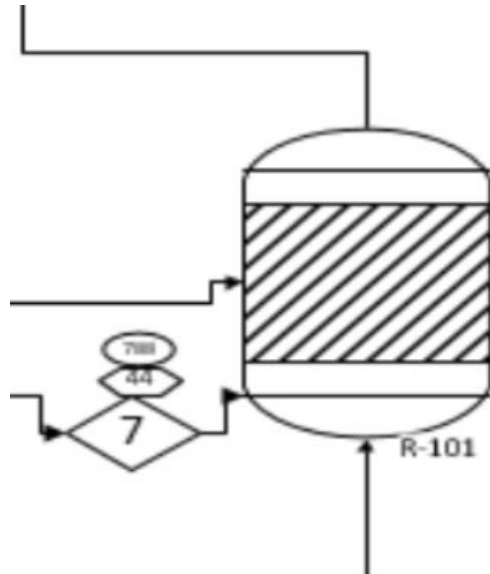
				into the solvent 1d.2 Contaminated solvent	1d.2.1 Continued process will be compromised or ineffective	1d.2.1.1 Follow the procedures: Proper storage and handling
1E			Reverse	Downstream accumulation or pressure build up	Backflow possible	1. Include a backflow tank in the design 2. Adjust the flow of outputs 3. Double check the downstream process
1F			Other than	Incorrect chemicals in the supply line	Future process cannot be continued	Introduce both checks and systems
1G			Sooner than	1e.1 Open valve V1 before the streamline is ready 1e.2 Open valve V1 before downstream process is ready	1e.1 Solvent emerges cold Usage of solvent cannot be is not available	Make sure downstream process is Immediately stopped Install a line for recycling of the solvent
1H			Later than	Open valve V1 late(r)	No hot solvent exiting from heat exchanger; affecting further processes	Installation of alarms must be updated for checking both the valve and temperature Immediate stop to the downstream process
1I			Where else	Leak in the solvent line of the heat exchanger	Leakage of the hot solvent into the heat exchanger	Installation of alarms must be updated Immediate stop to the downstream process

Specifications of Major Equipment: Distillation Column 1



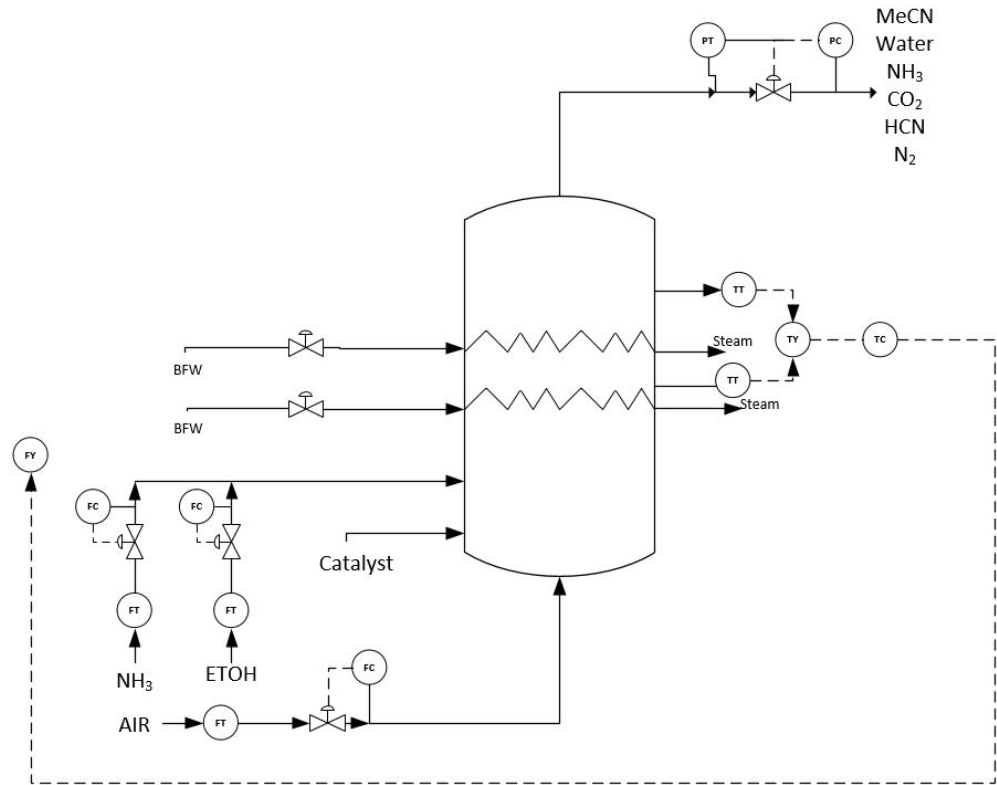
Distillation Column 1			
Products		Hydrogen Cyanide Acetonitrile/Water	
Identification			
	Item No.	V-102	
Operation	Pressure Swing		
Design Data			
Diameter(ft)	4.66	Tray Spacing(ft)	1.6
Height(ft)	29.6	Tray Type	Sieve
Number of Trays	44	Tray Material	Stainless Steel
Actual No. of Stages	39	Equipment Type	Vertical
Efficiency (%)	63.7	Relative Volatility	46.6
Column Material	Stainless Steel		

Fluidized bed reactor Specifications



Reactor				
Identification	Item:	Fluidized Bed Reactor		
	Item No:		Date:	4/22/2022
	No. Required	1	By:	Jarred Essissima
	C (\$)			
Function: Reacts ethanol, ammonia, and oxygen to produce acetonitrile product.				
Operation: Conduction				
	Inlet	Outlet		
Material Handled:				
Total Flow (lb/hr):	8766.32	8766.32		
Volumetric Flow (ft³/hr):	392,754	431,129		
Component Flows (lb/hr):				
Ethanol	4246.74	0		
Oxygen	2949.76	0		
Ammonia	1569.82	1051.95		
Hydrogen Cyanide	0	1577.94		
Carbon Dioxide	0	2629.90		
Water	0	1051.95		
Total	8766.32	8766.32		
Temperature (F)	77	788		
Pressure (psia)	44	14.7		
Design Data:				
		Material:	Stainless Steel	
Area (cm²):	103.86			

Fluidized Bed Reactor Control Scheme:



Distillation Column 2 Control Scheme:

