Phoenix Equipment Corporation
130 Maple Ave, Unit 4A, Red Bank, NJ, 07701
www.phxequip.com

Plant # 583

DMF Recovery and Distillation System - 588 lbs/Hr

Capacity: 588 lbs/hour

Products: Dimethylformamide

Major Equipment

- Feed Preheater (HE-7001, 50 sq ft 316L SS shell and tube heat exchanger)
- Steam Heater (HE-7002, 9 sq ft 316L SS shell and tube heat exchanger)
- Distillation Column (CL-7001, 36" Dia, 40 trays, 59'3" tall)
- Bottoms Pump (PU-7002, 7.5 HP Hastelloy pump)
- Reboiler (HE-7003, 832 sq ft Hastelloy C276 shell and tube heat exchanger)
- Bottom Purge Cooler (HE-7006, 19 sq ft Hastelloy C276 shell and tube heat exchanger)
- 3-stage dual cartridge filters
- Bottoms Pump (PU-7002, 7.5 HP Hastelloy pump)
- Feed Preheater (HE-7001, 50 sq ft 316L SS shell and tube heat exchanger)
- Product Cooler (HE-7004, 50 sq ft 316L SS shell and tube heat exchanger)
- Column Condenser (HE-7005, 305 sq ft heat exchanger)
- Reflux Drum (TK-7002, 150-gallon SS tank)
- Reflux Pump (PU-7004, 2 HP pump)
- Heat Recovery Condenser (HE-7007, 305 sq ft

Brief Plant Description

The used skid-mounted DMF (Dimethylformamide) distillation system, designed by KOCH, recovers 14-35% DMF from wastewater. It includes a Distillation Column (CL-7001) with Koch-Glitsch valve trays, as well as several heat exchangers: Feed Preheater (HE-7001), Steam Heater (HE-7002), Reboiler (HE-7003), Product Cooler (HE-7004), Column Condenser (HE-7005), Bottom Purge Cooler (HE-7006), and Heat Recovery Condenser (HE-7007), plus the Reflux Drum (TK-7002) and pumps PU-7002, PU-7003, and PU-7004. Steam, cooling water, electricity, and instrument air power the system.

Wastewater containing DMF, water, and formic acid is fed into the system via the Feed Preheater and Steam Heater into the Distillation Column, operating at atmospheric pressure. The bottoms circulate through the Reboiler, where steam at 180 psig strips water from the feed. A formic acid-DMF azeotrope is removed via a small purge stream, cooled to 115°F, and filtered before partial recycling.

A vapor draw containing dry DMF is condensed and cooled to 115°F in the Product Cooler. Remaining vapor, containing steam and trace DMF, is condensed and subcooled in the Column Condenser. Condensate flows to the Reflux Drum, where it is either returned to the column as reflux or disposed of. When the Heat Recovery Condenser is used, vapors are partially condensed before final cooling. The DMF product contains less than 150 ppm water, with a distillate containing less than 0.1% DMF by weight.

For more information contact
David Emen, Business Development
david@phxequip.com
+1 732.709.7155 (Direct Dial)
+1 848.219.1750 (Mobile)

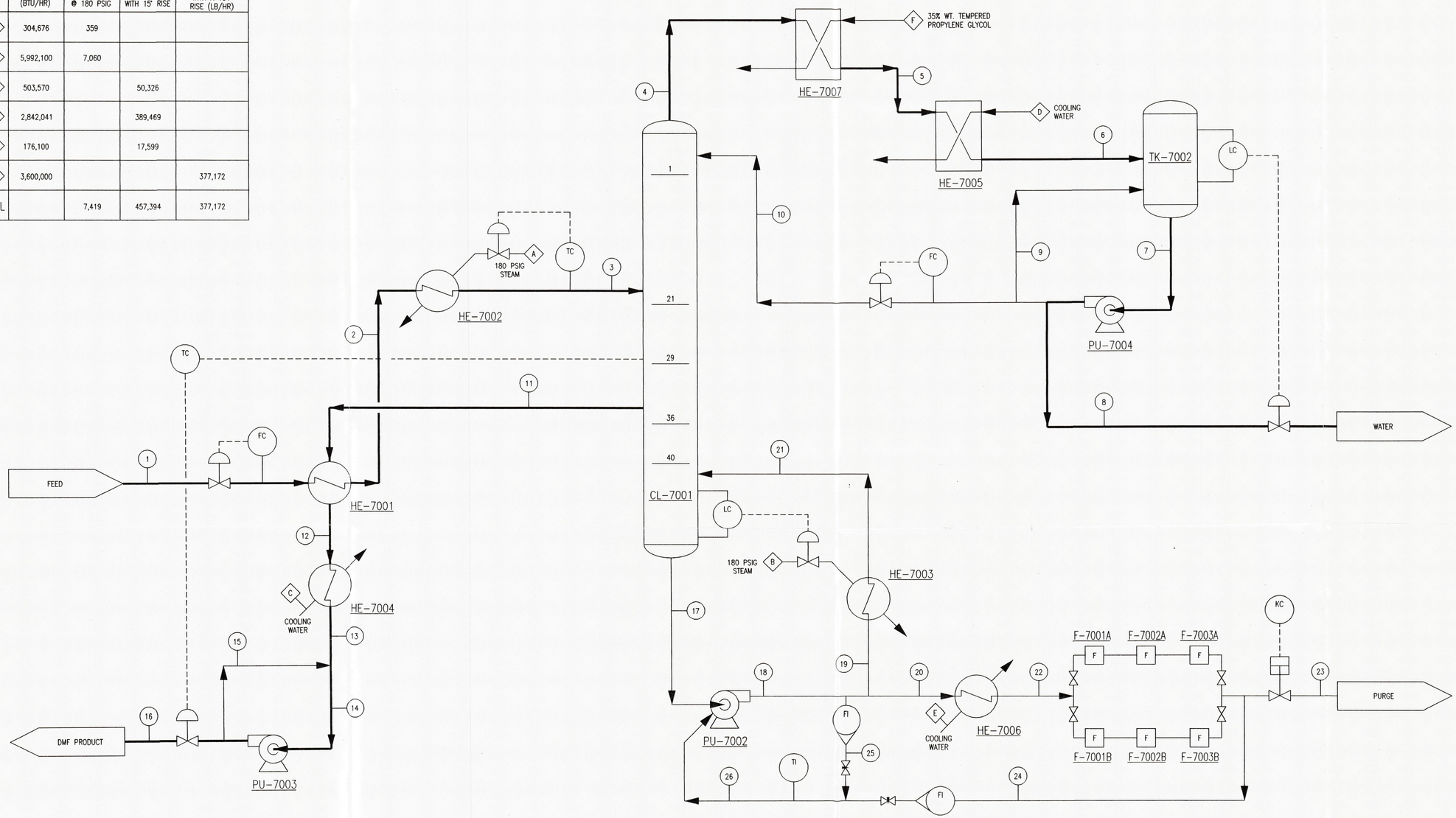
To discuss plants you are selling
Jesse Spector
plants@phxequip.com
+1 732.709.7157 (Direct Dial)
+1 908.902.8854 (Mobile)

UTILITIES

STREAM LABEL	HEAT DUTY (BTU/HR)	STEAM SUPPLY @ 180 PSIG	COOLING WATER @ 85°F WITH 15° RISE	35% WT PROPYLENE GLYCOL @ 194°F WITH A 10°F RISE (LB/HR)
A	304,676	359		
B	5,992,100	7,060		
C	503,570		50,326	
D	2,842,041		389,469	
E	176,100		17,599	
F	3,600,000			377,172
TOTAL		7,419	457,394	377,172

EQUIPMENT LIST

ITEM	DESCRIPTION	MATERIAL
CL-7001	DISTILLATION COLUMN	316LSS/HASTELLOY C-276
F-700X	BOTTOMS FILTERS	316SS
HE-7001	FEED PREHEATER	SHELL: CARBON STEEL TUBES: 316LSS
HE-7002	STEAM HEATER	SHELL: CARBON STEEL TUBES: 316LSS
HE-7003	REBOILER	SHELL: CARBON STEEL TUBES: HASTELLOY C-276
HE-7004	PRODUCT COOLER	SHELL: CARBON STEEL TUBES: 316LSS
HE-7005	COLUMN CONDENSER	304SS/GASKETS EPDM
HE-7006	BOTTOM PURGE COOLER	SHELL: CARBON STEEL TUBES: HASTELLOY C-276
HE-7007	HEAT RECOVERY CONDENSER	304SS/GASKETS EPDM
PU-7002	BOTTOMS PUMP	HASTELLOY C
PU-7003	PRODUCT PUMP	316SS
PU-7004	REFLUX PUMP	316SS
TK-7002	REFLUX DRUM	316LSS



NOTES:

1. MATERIAL BALANCE SHOWN IS FOR 15% WT DMF AVERAGE FEED COMPOSITION.
2. UTILITIES DATA REFLECT MAXIMUM DUTY ACROSS THE 14-35% WT RANGE FOR THE DMF FEED.
3. WHEN HE-7007 IS NOT IN SERVICE STREAM 5 WILL BE AS STRRAM 4.
4. FOR MATERIAL BALANCE PURPOSE SOLIDS ARE CONSIDERED TO BE COMPLETELY REMOVED BY FILTERS.
5. NO ALLOWANCE IS MADE FOR SOLVENT LOSSES DUE TO CHANGING OF FILTERS.

MATERIAL BALANCE STREAM NUMBER & IDENTITY

	COMPONENT	MOL. WT.	(1) COLD FEED TO FEED PREHEATER HE-7001	(2) WARM FEED TO STREAM HEATER HE-7002	(3) HOT FEED COLUMN CL-7001	(4) CL-7001 OVERHEAD VAPORS	(5) FEED TO HE-7005 (NOTE 3)	(6) CONDENSED OVERHEAD VAPORS TO TK-7002	(7) CONDENSED OVERHEAD VAPORS TO PU-7004	(8) DISTILLATE PRODUCT TO SEWER	(9) MIN. FLOW RECYCLE FOR PUMP PU-7004	(10) REFLUX TO COLUMN CL-7001	(11) DMF VAPOR SIDE DRAW TO HE-7001	(12) CONDENSED DMF TO PRODUCT COOLER HE-7004	(13) COOLED DMF FROM PRODUCT COOLER HE-7004	(14) DMF PRODUCT TO PRODUCT PUMP PU-7003	(15) MIN. FLOW RECYCLE FOR PUMP PU-7003	(16) DMF PRODUCT TO STORAGE	(17) COLUMN BOTTOMS TO PUMP PU-7002	(18) COLUMN BOTTOMS FROM PUMP PU-7002	(19) COLUMN BOTTOMS TO REBOILER HE-7003	(20) PURGE STREAM TO HE-7006	(21) REBOILER RETURN TO COLUMN CL-7001	(22) COOLED PURGE STREAM TO FILTERS	(23) COOLED BOTTOMS PURGE TO TREATMENT (BY OTHERS)	(24) COLD/FILTERED BOTTOMS LIQUID RECYCLE	(25) HOT BOTTOMS LIQUID RECYCLE	(26) MIN. FLOW MAGNET FLUSH TO PUMP PU-7002
1	WATER	18.015	3369.7	3369.7	3369.7	5487.2	5487.2	5487.2	5487.2	3369.6	3369.6	2117.5	0.1	0.1	0.1	0.1	0.1	0.1	0.9	1.0	0.9	0.0	0.9	0.0	0.00	0.0	0.0	0.0
2	DIMETHYLFORMAMIDE	73.095	594.7	594.7	594.7	5.5	5.5	5.5	5.5	3.4	3.4	2.1	588.1	588.1	588.1	588.1	469.1	588.1	110616.5	114027.2	110613.4	1517.6	110613.4	1517.6	3.16	1514.4	1896.3	3410.7
3	FORMIC ACID	46.026	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.1	0.2	1487.7	1533.6	1487.7	20.4	1487.7	20.4	0.04	20.4	25.5	45.9
4	SOLIDS	-	4.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1147.9	1167.3	1132.3	15.5	1132.3	15.5	0.00	0.0	19.4	19.4
	TOTAL	LB/HR	3969	3969	3969	5493	5493	5493	7950	3373.0	2457.6	2119.7	588.4	588.4	588.4	2907.8	2319.4	588.4	113253.1	116729.1	113234.3	1553.5	113234.3	1553.5	3.2	1534.8	1941.2	3476.0
	TEMPERATURE	°F	70	121	200	218	218	140	140	140	140	140	328	200	115	115	115	115	330	328	328	328	330	115	115	115	328	234
	PRESSURE	PSIG	40	15.7	3.5	2.0	1.0	0.3	22.5	20.0	43.8	2.0	4.8	4.5	10.0	10.0	35.0	15.0	8.6	26.5	6.0	26.5	4.9	25.0	5.0	20.0	26.5	9.0
	DENSITY	LB/FT^3	61.755	60.967	59.319	0.04011	59.685	61.522	61.522	61.281	61.281	61.281	0.176	54.843	57.703	57.703	57.703	57.703	51.534	51.546	51.546	51.546	0.174	57.9	57.703	57.703	51.546	54.171
	VISCOSITY	cP	0.970	0.553	0.304	0.012	0.275	0.474	0.474	0.463	0.463	0.463	0.010	0.394	0.634	0.634	0.634	0.634	0.249	0.249	0.249	0.249	0.011	0.634	0.634	0.634	0.249	0.396
	FLOW	GPM(ACFM)	8.0	8.1	8.3	(2282)	11.5	11.1	16.1	6.9	5.0	4.3	(55.8)	1.3	1.3	6.3	5.0	1.3	274.0	282.3	273.9	3.8	(10846)	3.3	0.01	3.3	4.7	8.0
	HEAT CAPACITY	BTU/LB°F	0.922	0.924	0.934	0.500	1.002	1.000	1.000	0.998	0.998	0.998	0.412	0.526	0.503	0.503	0.503	0.503	0.575	0.575	0.575	0.575	0.413	0.503	0.503	0.503	0.575	0.546
	THERMAL COND.	BTU/HR°F.FT	0.261	0.252	0.347	0.014	0.393	0.371	0.371	0.373	0.373	0.373	0.011	0.091	0.101	0.101	0.101	0.101	0.081	0.081	0.081	0.081	0.011	0.100	0.100	0.100	0.081	0.089
	MOLECULAR WEIGHT	LB/LBMOLE	20.311	20.311	20.311	18.029	18.029	18.029	18.029	18.029	18.029	18.029	73.048	73.048	73.048	73.048	73.048	73.048	72.857	72.857	72.857	72.857	72.857	72.857	72.857	72.857	72.857	72.857

REV.	DESCRIPTION	DATE	APP'D
0	AS BUILT	8-19-98	CJB
P	FOR CUSTOMER APPROVAL	3-2-98	CJB

REVISIONS

THIS INFORMATION OR DATA CONTAINED HEREIN IS PROPRIETARY TO KOCH PROCESS TECHNOLOGY, INC. AND IS NOT TO BE COPIED, REPRODUCED, DUPLICATED, OR DISCLOSED TO OTHERS, IN WHOLE OR IN PART, WITHOUT PRIOR WRITTEN CONSENT OF KOCH PROCESS TECHNOLOGY, INC.

KOCH

KOCH PROCESS TECHNOLOGIES INC

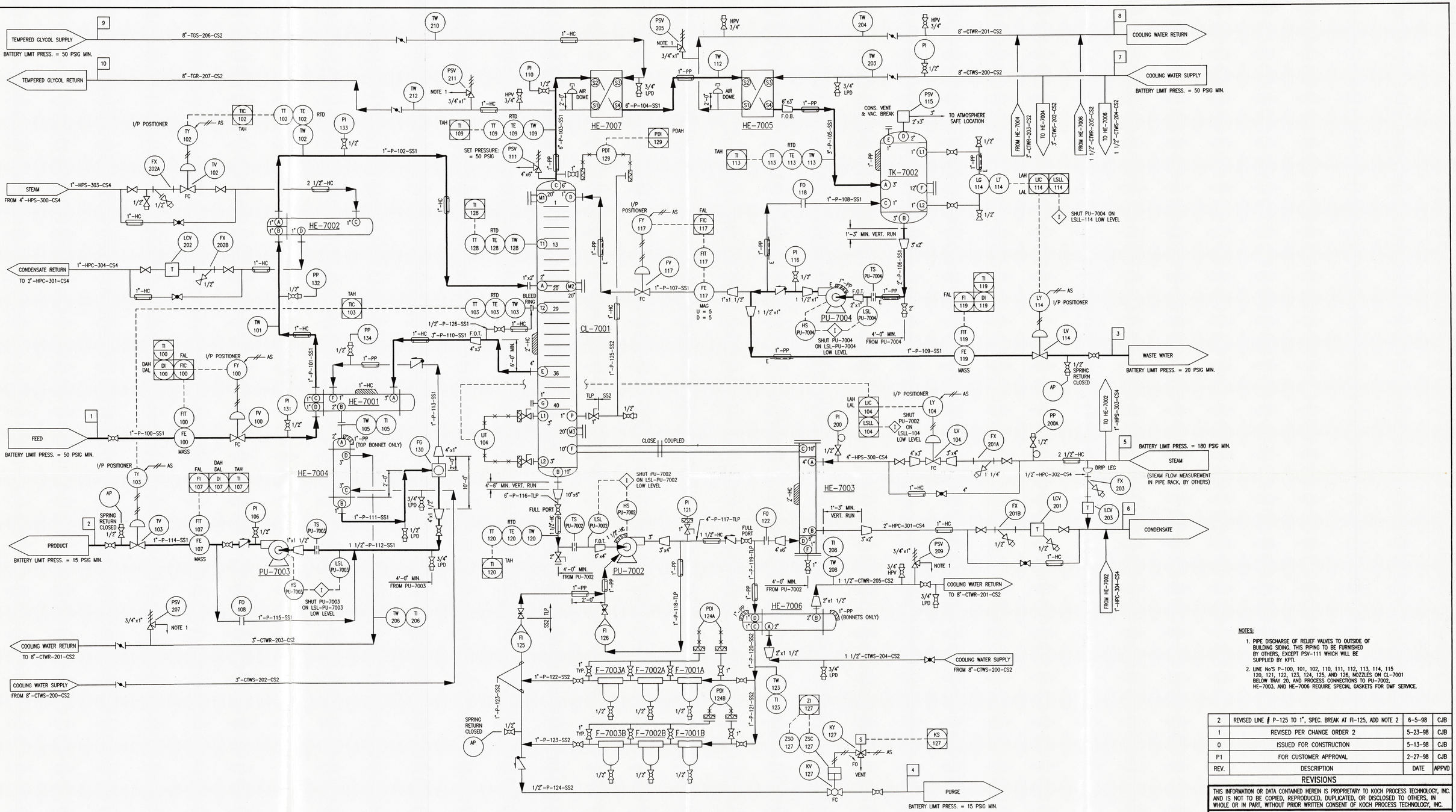
CLIENT INFORMATION
PROJ NO.
PO NO.

PROCESS FLOW DIAGRAM

SCALE	NONE		
DRAWN	BENDEROTH	DATE	2-27-98
DESIGNED		DATE	
ENGR.	SANFORD	DATE	3-2-98

JOB NO. T97-1222

DRAWING NO. D-1222-00-01 REV. 0



NOTES:

1. PIPE DISCHARGE OF RELIEF VALVES TO OUTSIDE OF BUILDING SIDING. THIS PIPING TO BE FURNISHED BY OTHERS, EXCEPT PSV-111 WHICH WILL BE SUPPLIED BY KPTI.
2. LINE No'S P-100, 101, 102, 110, 111, 112, 113, 114, 115 120, 121, 122, 123, 124, 125, AND 126, NOZZLES ON CL-7001 BELOW TRAY 20, AND PROCESS CONNECTIONS TO PU-7002, HE-7003, AND HE-7006 REQUIRE SPECIAL GASKETS FOR DMF SERVICE.

HE-7002
STEAM HEATER

TYPE: BEM 6-48
A = 9 FT²
Q = 304,676 BTU/HR
SHELL: 6 5/8" O.D.
MAT'L: CARBON STEEL
DES. PRESS: 200 PSIG
DES. TEMP: 450°F
TUBES: 12 TUBES
0.75" O.D. x 4'-0" LG., 16 BWG
MAT'L: 316LSS
DES. PRESS: 100 PSIG/FV
DES. TEMP: 400°F
NO. OF PASSES: 4

CL-7001
DISTILLATION COLUMN

36" O.D. x 59'-6" T/T
SHELL: 316LSS/HAST. C276
DES. PRESS: 50 PSIG/FV
DES. TEMP: 400°F
INTERNALS: 20 KOCH-GLITSCH FLEXITRAYS & 20 KOCH-GLITSCH BI-FRAC TRAYS
MAT'L: 316LSS

HE-7007
HEAT RECOVERY CONDENSER

TYPE: PLATE
A = 303 FT²
Q = 3,600,000 BTU/HR
PLATES: 73 PLATES
MAT'L: 304SS
DES. PRESS: 100 PSIG
DES. TEMP: 230°F

HE-7005
COLUMN CONDENSER

TYPE: PLATE
A = 600 FT²
Q = 5,842,041 BTU/HR
PLATES: 95 PLATES
MAT'L: 304SS
DES. PRESS: 100 PSIG
DES. TEMP: 230°F

PU-7004
REFLUX PUMP

MODEL: KONTRO GT
SIZE: 1 x 1 x 5
20 GPM @ 50' TDH
MAT'L: 316LSS
SEAL: SEAL-LESS
DRIVE: 2 HP, 3600 RPM
480V/3-PHASE/60 HZ

TK-7001
REFLUX TANK

CAPACITY (NOM): 150 GALLONS
30" O.D. x 4'-3" T/T
SHELL: 316LSS
DES. PRESS: 50 PSIG/FV
DES. TEMP: 400°F

PU-7003
PRODUCT PUMP

MODEL: KONTRO GT
SIZE: 1 x 1 x 5
10 GPM @ 63' TDH
MAT'L: 316LSS
SEAL: SEAL-LESS
DRIVE: 2 HP, 3600 RPM
480V/3-PHASE/60 HZ

HE-7001
FEED PREHEATER

TYPE: BEM 8-96
A = 25 FT²
Q = 442,068 BTU/HR
SHELL: 8 5/8" O.D.
MAT'L: 316LSS
DES. PRESS: 100 PSIG/FV
DES. TEMP: 400°F
TUBES: 16 TUBES
0.75" O.D. x 8'-0" LG., 16 BWG
MAT'L: 316LSS
DES. PRESS: 100 PSIG/FV
DES. TEMP: 400°F
NO. OF PASSES: 8

HE-7004
PRODUCT COOLER

TYPE: BEM 6-120
A = 50 FT²
Q = 503,570 BTU/HR
SHELL: 6 5/8" O.D.
MAT'L: CARBON STEEL
DES. PRESS: 100 PSIG
DES. TEMP: 330°F
TUBES: 26 TUBES
0.75" O.D. x 10'-0" LG., 16 BWG
MAT'L: 316LSS
DES. PRESS: 100 PSIG/FV
DES. TEMP: 400°F
NO. OF PASSES: 1

PU-7002
BOTTOMS PUMP

MODEL: KONTRO A-RANGE
SIZE: 6 x 4 x 8H
280 GPM @ 50' TDH
MAT'L: HASTELLOY C276
SEAL: SEAL-LESS
DRIVE: 7.5 HP, 1800 RPM
480V/3-PHASE/60 HZ

HE-7003
REBOILER

TYPE: NEN 21-174
A = 832 FT²
Q = 5,992,100 BTU/HR
SHELL: 22" O.D.
MAT'L: CARBON STEEL
DES. PRESS: 200 PSIG
DES. TEMP: 450°F
TUBES: 222 TUBES
1.0" O.D. x 14'-6" LG., 16 BWG
MAT'L: HASTELLOY C276
DES. PRESS: 50 PSIG/FV
DES. TEMP: 350°F
NO. OF PASSES: 1

HE-7006
BOTTOMS PURGE COOLER

TYPE: BEM 6-96
A = 19 FT²
Q = 176,100 BTU/HR
SHELL: 6 5/8" O.D.
MAT'L: CARBON STEEL
DES. PRESS: 100 PSIG
DES. TEMP: 330°F
TUBES: 12 TUBES
0.75" O.D. x 8'-0" LG., 16 BWG
MAT'L: HASTELLOY C276
DES. PRESS: 100 PSIG/FV
DES. TEMP: 400°F
NO. OF PASSES: 6

REV.	DESCRIPTION	DATE	APPVD
P1	FOR CUSTOMER APPROVAL	2-27-98	CJB
0	ISSUED FOR CONSTRUCTION	5-13-98	CJB
1	REVISED PER CHANGE ORDER 2	5-23-98	CJB
2	REVISED LINE # P-125 TO 1", SPEC. BREAK AT FI-125, ADD NOTE 2	6-5-98	CJB

REVISIONS

THIS INFORMATION OR DATA CONTAINED HEREIN IS PROPRIETARY TO KOCH PROCESS TECHNOLOGY, INC. AND IS NOT TO BE COPIED, REPRODUCED, DUPLICATED, OR DISCLOSED TO OTHERS, IN WHOLE OR IN PART, WITHOUT PRIOR WRITTEN CONSENT OF KOCH PROCESS TECHNOLOGY, INC.

KOCH PROCESS TECHNOLOGY INC

CLIENT INFORMATION
PROJ NO.
PO NO.

SCALE NONE

DRAWN BENDEROTH DATE 1-16-98

DESIGNED DATE

ENGR. DATE

P&ID
DMF DISTILLATION SYSTEM

JOB NO. T97-1222

DRAWING NO. D-1222-01-01

REV. 2

DMF Distillation Process Description

GENERAL PROCESS DESCRIPTION

The DMF Distillation System consists of a Distillation Column (CL-7001) with Koch-Glitsch valve trays, Feed Preheater (HE-7001),
Steam Heater (HE-7002), Reboiler (HE-7003), Product Cooler (HE-7004), Column Condenser (HE-7005), Bottom Purge Cooler (HE-7006),
Heat Recovery Condenser (HE-7007), Reflux Drum (TK-7002), Bottoms Pump (PU-7002), Product Pump (PU-7003) and Reflux Pump (PU-7004).
Utilities consist of steam, cooling water, electricity and instrument air.

The feed containing DMF, water and formic acid is fed via Feed Preheater (HE-7001) and Steam Heater (HE-7002) to the Distillation
Column (CL-7001) operating at atmospheric pressure. The column bottoms are circulated by pump PU-7002, through Reboiler (HE-7003)
where 180 psig steam is used to generate vapors to strip water from the feed.

The formic acid in the feed forms a maximum boiling point azeotrope with the DMF and is rejected in a small purge stream from the
reboiler loop. Prior to leaving the unit this purge stream is cooled in the Bottoms Purge Cooler (HE-7006) to 115°F and filtered by
3-stage dual cartridge filters. Part of the filtered purge stream is recycled to the suction of pump PU-7002 as coolant for the magnets.

A vapor side draw is taken which contains the dry DMF product. The vapor product is condensed on the shell side of feed preheater
(HE-7001) and then cooled to 115°F in Product Cooler (HE-7004) using 85°F cooling water.

The vapor from the stripping section, containing steam and a small quantity of DMF, is condensed in Column Condenser (HE-7005) and
subcooled to 140°F. The condensate flows by gravity to the Reflux Drum from where it is pumped by PU-7004, either returning to the
column as reflux or to battery limits of the system for disposal. When the Heat Recovery Condenser (HE-7007) is in service the vapors
are first partially condensed in HE-7007 by 35%wt Propylene Glycol before passing to HE-7005 for remaining condensation and
subcooling as before.

The DMF product contains less than 150 ppm wt water. The DMF concentration in the distillate product is less than 0.1% wt.

DESIGN CRITERIA

The expected performance of the system is based on computer simulations. The expected flow rates for the DMF distillation are
presented below. Note that the content of formic acid in the products is based on the feed composition and does not include for
decomposition of the DMF.

Wastewater Feed

DMF: 14-35 %wt
Water: 64.8-84.9 %wt
Formic Acid: 50 ppm
Solids: 0.05-0.15 %wt
Total (gpm): 8.0
Temperature (°F): 70
Pressure (psig): 20

Wastewater Distillate

Water: 99.9 %wt
DMF: 0.1 %wt
Flow rate (lb/h): 3373
Temperature (°F): 140
Pressure (psig): 20

DMF Product

Water: < 150 ppm wt
DMF: > 99.96 % wt
Formic Acid: < 400 ppm wt
Flow rate (lb/h): 588.4
Temperature (°F): 115
Pressure (psig): 15

Bottoms Purge Stream

DMF: 98.8 %wt
Formic Acid: 1.2 %wt
Solids: < 5.0 %wt
Flow rate (lb/h): 3.2
Temperature (°F): 115

Pressure (psig): 5.0

Utilities

Steam: 7419 lb/hr @ 180 psig (saturated)
Cooling Water: 915 GPM @ 60 psig and 85°F, 15°F temperature rise
Electricity: 480V, 3 phase, 6.2 kW (11.5 H.P. total connected)
Instrument Air: Approximately 75 SCFH, @ 100 psig, -40°F dew point, oil and water free