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APPENDICES

A general FMEA form

Type of FMEA ________________ Involvement of others : ____________ Model / product : ______________

Title of FMEA: ________________ : ____________ FMEA date : ______________

Prepared by : ________________ FMEA revision date : __________

Page ____ of ____ pages FMEA Number: ______________

System/ design/ process/ service function	otential failure mode	Potential effect(s) of failure	▽	S E V	Potential cause(s) of failure	O C C	Detection method	D E T	R P N .	Recommende action	Responsibility & completion date	Action results				
												Action taken	S E V	O C C	D E T	R P N

Approval signatures : ________________ Concurring signatures : __________

Appendix B

Suggested evaluation criteria and ranking system for the Severity of Effects in a process FMEA

(http://www.fmeca.com/ffmethod/tables/pfmea.html)

Effect	*Criteria: Severity of Effect for PFMEA*	*Rank*
Hazardous – no warning	May endanger machine operator or assembly operator. Failure affects safe product operation or noncompliance with government regulation. Failure will occur without warning.	10
Hazardous - with warning	May endanger machine operator or assembly operator. Failure affects safe product operation or noncompliance with government regulation. Failure will occur with warning.	9
Very High	Major disruption to production line. 100% of product may have to be scrapped. The product is inoperable with loss of primary Function.	8
High	Minor disruption to production line. Product may have to be sorted and a portion scrapped. The product is operable, but at a reduced level of performance.	7
Moderate	Minor disruption to production line. A portion of the product may have to be scrapped (no sorting). Product is operable, but some comfort / convenience item(s) are inoperable.	6
Low	Minor disruption to production line. 100% of the product may have to be reworked. Product is operable, but some comfort / convenience items operate at a reduced level of performance.	5
Very Low	Minor disruption to production line. Product may have to be sorted and a portion reworked. Fit & finish or squeak & rattle item does not conform. Most Customers notice the defect.	4
Minor	Minor disruption to production line. A portion of the product may have to be reworked on-line but out-of-station. Fit & finish or squeak & rattle item does not conform. Average customers notice the defect.	3
Very Minor	Minor disruption to production line. A portion of the product may have to be reworked on-line but in-station. Fit & finish or squeak & rattle item does not conform. Discriminating customers notice the defect.	2
None	The Failure Mode has no Effect.	1

Appendix C

Suggested evaluation criteria and ranking system for the Severity of Effects in a design FMEA

(http://www.fmeca.com/ffmethod/tables/dfmea.html)

Effect	*Criteria: Severity of Effect for DFMEA*	*Rank*
Hazardous – no warning	Failure affects safe product operation or involves noncompliance with government regulation without warning.	10
Hazardous – with warning	Failure affects safe product operation or involves noncompliance with government regulation with warning.	9
Very High	Product is inoperable with loss of primary Function.	8
High	Product is operable, but at reduced level of performance.	7
Moderate	Product is operable, but comfort or convenience item(s) are inoperable.	6
Low	Product is inoperable, but comfort or convenience item(s) operate at a reduced level of performance.	5
Very Low	Fit & finish or squeak & rattle item does not conform. Most customers notice defect.	4
Minor	Fit & finish or squeak & rattle item does not conform. Average customers notice defect.	3
Very Minor	Fit & finish or squeak & rattle item does not conform. Discriminating customers notice defect.	2
None	No Effect.	1

Appendix D

Suggested evaluation criteria and ranking system for the Occurrence of Failure in a Process FMEA

(http://www.fmeca.com/ffmethod/tables/pfmea1.html)

Probability of Failure	***Failure Rates***	C_{pk}	***Rank***
Very High: Failure is almost inevitable	≥ 1 in 2	< 0.33	10
	1 in 3	≥ 0.33	9
High: Generally associated with processes similar to previous processes that have often failed	1 in 8	≥ 0.51	8
	1 in 20	≥ 0.67	7
Moderate: Generally associated with processes similar to pervious processes which have experienced occasional failures, but not in major proportions	1 in 80	≥ 0.83	6
	1 in 400	≥ 1.00	5
	1 in 2000	≥ 1.17	4
Low: Isolated failures associated with similar processes	1 in 15,000	≥ 1.33	3
Very Low: Only isolated failures associated with almost identical processes	1 in 150,000	≥ 1.50	2
Remote: Failure is unlikely. No failures ever associated with almost identical processes	≤ 1 in 1,500,000	≥ 1.67	1

Appendix E

Suggested evaluation criteria and ranking system for the Occurrence of Failure in a design FMEA

(http://www.fmeca.com/ffmethod/tables/dfmea1.html)

Probability of Failure	***Failure Rates***	***Rank***
Very High: Failure is almost inevitable	≥ 1 in 2	10
	1 in 3	9
High: Repeated failures	1 in 8	8
	1 in 20	7
Moderate: Occasional failures	1 in 80	6
	1 in 400	5
	1 in 2000	4
Low: Relatively few failures	1 in 15,000	3
Remote: Failure is unlikely	1 in 150,000	2
Remote: Failure is unlikely. No failures ever associated with almost identical processes	≤ 1 in 1,500,000	1

Appendix F

Suggested evaluation criteria and ranking system for the Detection of a Cause of failure or Failure Mode in a process FMEA

(http://www.fmeca.com/ffmethod/tables/pfmea2.html)

Detection	***Criteria: Likelihood of Detection by Process Control***	***Rank***
Almost Impossible	No known Controls available to detect Failure Mode or Cause	10
Very Remote	Very remote likelihood current Controls with detect Failure Mode or Cause	9
Remote	Remote likelihood current Controls with detect Failure Mode or Cause	8
Very Low	Very low likelihood current Controls with detect Failure Mode or Cause	7
Low	Low likelihood current Controls with detect Failure Mode or Cause	6
Moderate	Moderate likelihood current Controls with detect Failure Mode or Cause	5
Moderately High	Moderately high likelihood current Controls with detect Failure Mode or Cause	4
High	High likelihood current Controls with detect Failure Mode or Cause	3
Very High	Very high likelihood current Controls with detect Failure Mode or Cause	2
Almost Certain	Current Controls almost certain to Failure Mode or Cause. Reliable detection controls are known with similar processes.	1

Appendix G

Suggested evaluation criteria and ranking system for the Detection of a Cause of failure or Failure Mode in a design FMEA

(http://www.fmeca.com/ffmethod/tables/dfmea2.html)

Detection	*Criteria: Likelihood of Detection by Design Control*	*Rank*
Absolute Uncertainty	Design Control does not detect a potential Cause of failure or subsequent Failure Mode; or there is no Design Control	10
Very Remote	Very remote chance the Design Controls will detect a potential Cause of failure or subsequent Failure Mode	9
Remote	Remote chance the Design Controls will detect a potential Cause of failure or subsequent Failure Mode	8
Very Low	Very low chance the Design Controls will detect a potential Cause of failure or subsequent Failure Mode	7
Low	Low chance the Design Controls will detect a potential Cause of failure or subsequent Failure Mode	6
Moderate	Moderate chance the Design Controls will detect a potential Cause of failure or subsequent Failure Mode	5
Moderately High	Moderately high chance the Design Controls will detect a potential Cause of failure or subsequent Failure Mode	4
High	High chance the Design Controls will detect a potential Cause of failure or subsequent Failure Mode	3
Very High	Very high chance the Design Controls will detect a potential Cause of failure or subsequent Failure Mode	2
Almost Certain	Design Controls will almost certainly detect a potential Cause of failure or subsequent Failure Mode	1

Appendix H

Questionnaire

1. Suitability of upper and lower limit of the criteria

Criteria	L.L. too low	L.L. too high	U.L. too low	U.L. too high	Suitable
Severity of the effect					
Occurrence of the failure mode					
Detection of the failure mode					

2. Suitability of level width of criteria's level

Criteria	Too narrow	Suitable	To wide
Severity of the effect			
Occurrence of the failure mode			
Detection of the failure mode			

3. Other criteria should be considered

   1. ______________________________
   2. ______________________________
   3. ______________________________
   4. ______________________________

Appendix I

List of failure mode from suggestion activity

Table I-1: List of failure mode from suggestion activity

Section code	Process service function	Potential Failure Mode	Potential Effect (s) of Failure	S e v	Potential Cause(s) /Mechanism(s) of	O c c	Detection Method	D e t	R. P. N.	Recommended Action	Remark
VDU-1	Feed preheating section	-	-	-	-	-	-	-	-	-	-
VDU-2	Heater section	Heater's efficiency is low	Loss steam for atomizing and fuel oil	6	1. Too high air flow rate (excess air).	7	% Excess Oxygen. (directly effect to heater efficiency)	2	84	Reduce air flow to the heater.	-
					2. Too high vacuum (heater draft).	-	Fire box pressure indicator	2	-	-	can not calculate PRN becasue can not estimate the occurrence of the failure
VDU-3	Vacuum distillation column	Too much stripping steam	Loss of steam	-	steam control valve failure	-	Monitor %out put of the control valve	6	-	-	can not calculate PRN becasue can not estimate the loss of steam
VDU-4	Stripping section	-	-	-	-	-	-	-	-	-	-
PDA-1	Feed/Extraction section	Heating coil of the column is not working properly.	Loss steam	6	1. Steam trap does not function. (not open)	10	Heating rate to the column is not enough.	2	120	Check the function of steam traps.	-
					2. Steam trap does not function. (not close)	-	Higher consumption of steam flow to the heater.	2	-	-	Can not calculate the RPN because can not estimate the occurrence of the failure
					3. Heating coil is fouling	-	Heating rate to the column is not enough.	4	-	-	Can not calculate the RPN because can not estimate the occurrence of the failure
PDA-2	DAO recovery section	-	-	-	-	-	-	-	-	-	-

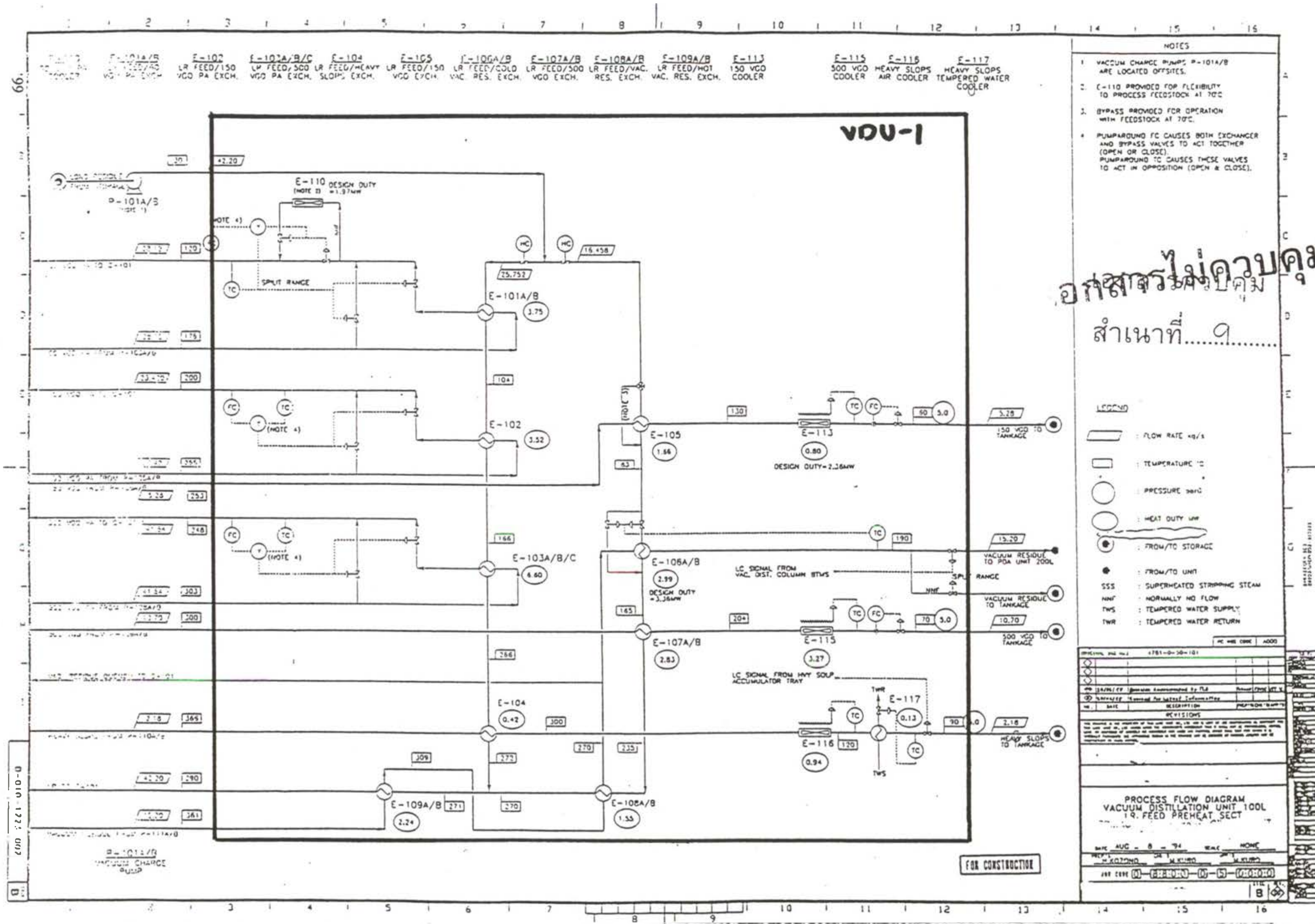
Section code	Process service function	Potential Failure Mode	Potential Effect (s) of Failure	S e v	Potential Cause(s) /Mechanism(s) of	O c c	Detection Method	D e t	R. P. N.	Recommended Action	Remark
PDA-3	Solvent recovery section	-	-	-	-	-	-	-	-	-	-
PDA-4	Asphalt recovery section	Hot oil exchanger fouling	loss of fuel oil	-	The exchanger has been used for long time	-	Monitor the effficiency of the exchanger	6	-	-	can not calculate PRN becasue can not estimate the loss of fuel oil occurrence of the failure
MPU-1	Feed/Extraction section	The temperature outlet of AFC is controlled by using	Loss of electricity.	4	The design is not optimization.	10	Measure the current consumed by AFC motor.	2	80	-	-
MPU-2	Raffinate recovery section	Too much stripping steam	Loss of steam	-	steam control valve failure	-	Monitor %out put of the control valve	6	-	-	Can not calculate the RPN because can not estimate the occurrence of the failure
MPU-3	Extract recovery section	Too much stripping steam	Loss of steam	-	steam control valve failure	-	Monitor %out put of the control valve	6	-	-	Can not calculate the RPN because can not estimate the occurrence of the failure
MPU-4	Solvent recovery section	-	-	-	-	-	-	-	-	-	-
HFU-1	Feed/Reactor section	Hot oil exchanger fouling	loss of fuel oil	-	The exchanger has been used for long time	-	Monitor the effficiency of the exchanger	7	-	-	Can not calculate the RPN because can not estimate the occurrence of the failure
HFU-2	Stripping section	Too much stripping steam	Loss of steam	-	steam control valve failure	-	Monitor %out put of the control valve	6	-	-	can not calculate PRN becasue can not estimate the loss of steam and occurrence
HFU-3	Hydrogen section	-	-	-	-	-	-	-	-	-	-

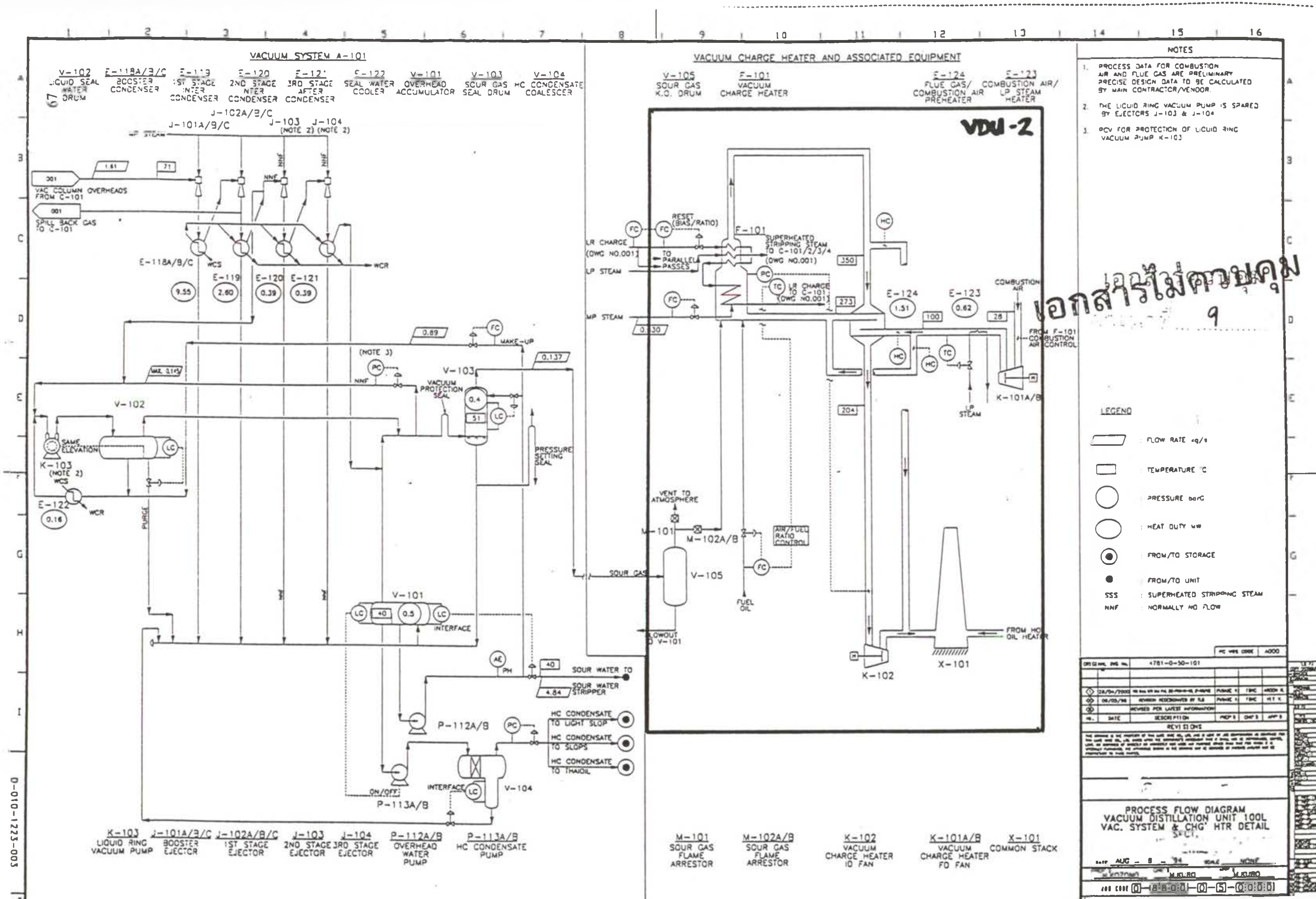
Section code	Process service function	Potential Failure Mode	Potential Effect (s) of Failure	S e v	Potential Cause(s) /Mechanism(s) of	O c c	Detection Method	D e t	R. P. N.	Recommended Action	Remark
SDU-1	Feed chilling section	DPC fouling	Loss of electricity.	-	wax removal ratating blade is not working	-	open the DPC cover and check	7	-	-	can not calculate PRN becasue can not estimate the loss of electricity and occurrence
SDU-2	Filter section	One side of the dewaxing filters does not need lighting all	Loss of electricity.	4	There is no separation switch to separately turn on/off for the	10	Visual checking and current indicator of electricity used for the filter's lighting.	7	280	Modify separation switch for each side of tho filter.	-
SDU-3	DWO recovery section	Hot oil exchanger fouling	loss of fuel oil	-	The exchanger has been used for long time	-	Monitor the effficiency of the exchanger	7	-	-	Can not calculate the RPN because can not estimate the occurrence of the failure
SDU-4	SLW recovery section	Hot oil exchanger fouling	loss of fuel oil	-	The exchanger has been used for long time	-	Monitor the effficiency of the exchanger	7	-	-	Can not calculate the RPN because can not estimate the occurrence of the failure
SDU-5	Solvent recovery section	-	-	-	-	-	-	-	-	-	-
BBU-1	Feed/Reactor section	The compressed air from the compressor is excess and always	Loss of electricity.	6	The air compressor on each unit is designed at over capacity.	10	Air pressure control valve % output.	2	120	Modify air common line in order to use only one compressor to	-
BBU-2	Off gas section	-	-	-	-	-	-	-	-	-	-
UT-1	Cooling water	The temperature of cooling water supply is lower than	Loss of electricity.	4	The cooling fan motor is fixed speed, so, it can not reduce its	10	Cooing water supply temperature indicator.	2	80	Install motor converter to vary the fan speed.	-
UT-2	Instrument air	The compressed air from the compressor is excess and always	Loss of electricity.	3	The minimum current setting is too high. So, the minimum	10	Air pressure control valve % output.	3	90	Study to reduce the minimum current setting of the	-

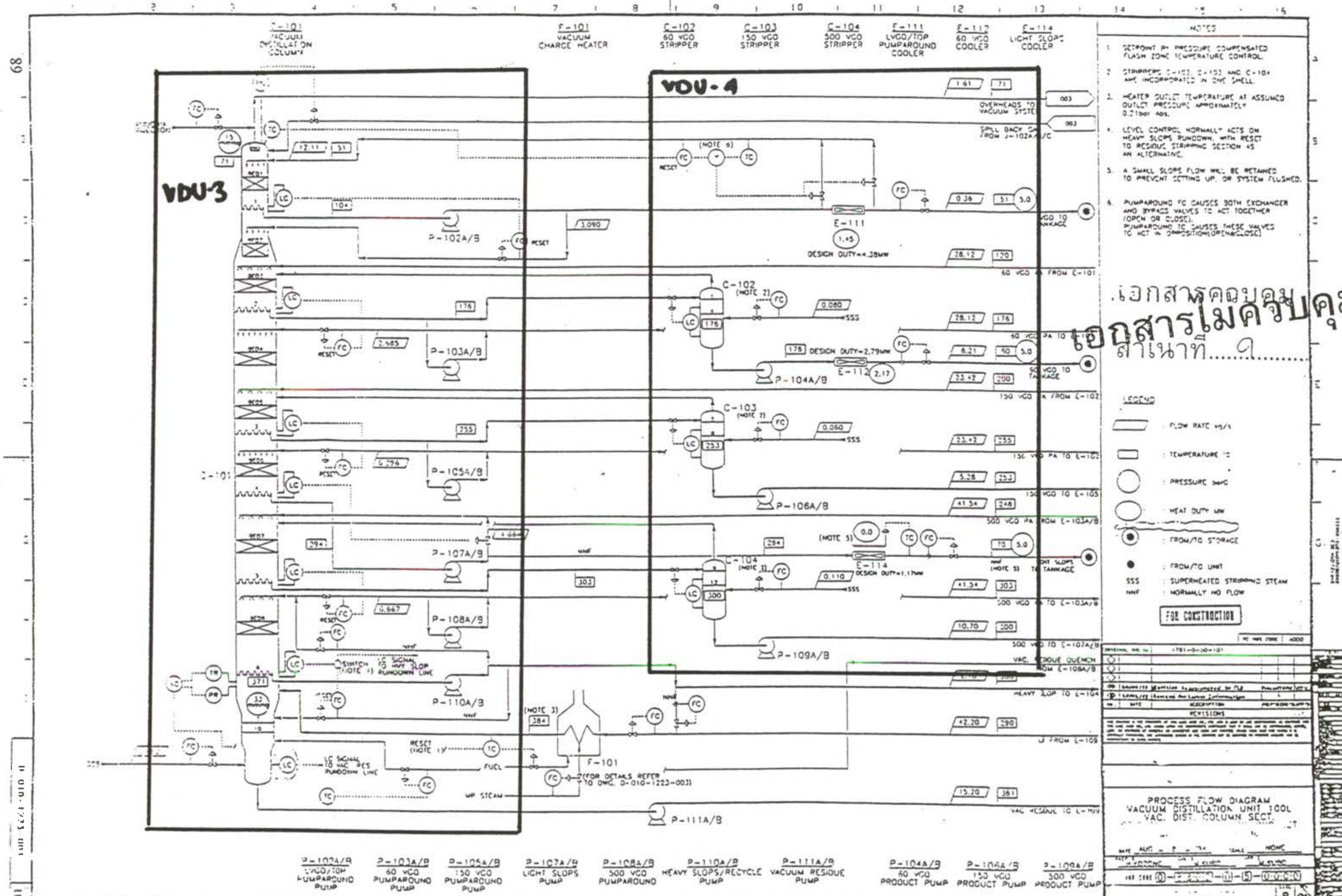
Section code	Process service function	Potential Failure Mode	Potential Effect (s) of Failure	S e v	Potential Cause(s) /Mechanism(s) of	O c c	Detection Method	D e t	R. P. N.	Recommended Action	Remark
UT-3	Steam/Condensat e	1. Steam trap failure	Loss steam	7	Corrosion in steam trap	5	Check steam trap working.	6	210	Fix or replace the steam traps which are not working.	-
		2. MP steam is letdown to LP steam with the rate of 4 - 5	Loss of energy (from steam and electricity)	6	No existing steam turbine suitable to support this flow rate.	10	% output of let down valve.	2	120	Modify by installing the now steam turbine.	-
UT-4	Hot oil heater	Heater's efficiency is low	Loss steam for atomizing and fuel oil	9	1. Too high air flow rate (excess air).	10	% Excess Oxygen. (directly effect to heater efficiency)	2	180	Reduce air flow to the heater.	-
	-	-	-		2. Too high vacuum (heater draft).	-	Fire box pressure indicator	-	-	-	-
UT-5	Sour water treating	Excess reboiling	1. Loss steam and increase amount of sour water (increase waste	5	Steam to reboiler is excess.	6	Sour water to steam ratio indicator.	3	90	Find out the suitable ratio and inform the concerning people.	-

Appendix J

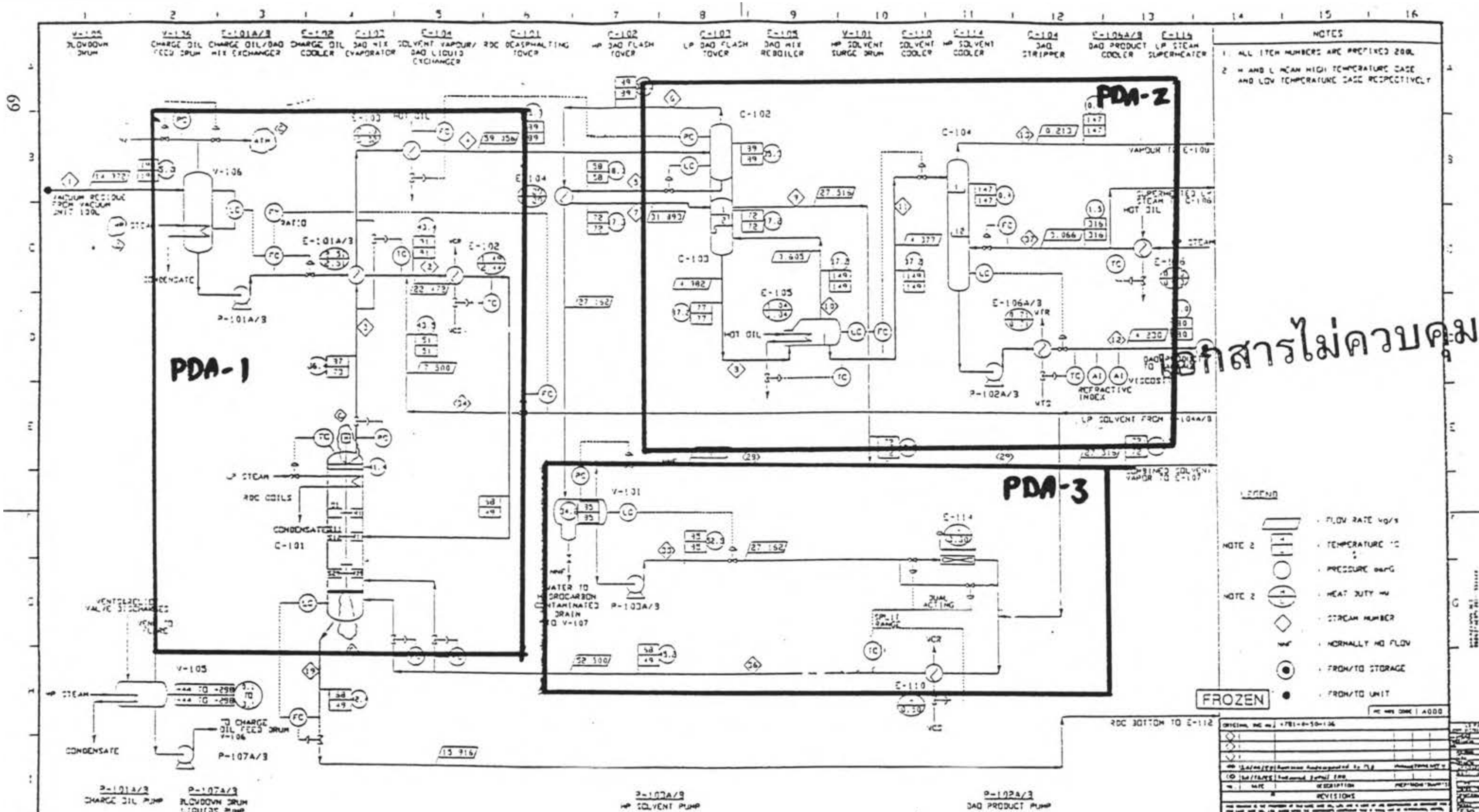
Dividing section of process for failure mode analysis


VDU-1
E-102 LR FEED/150 VGO PA EXCH.
E-103A/B/C LR FEED/500 VGO PA EXCH.
E-104 LR FEED/HEAVY SLOPS EXCH.
E-105 LR FEED/150 VGO EXCH.
E-106A/B LR FEED/COLD VAC. RES. EXCH.
E-107A/B LR FEED/500 VGO EXCH.
E-108A/B LR FEED/VAC. RES. EXCH.
E-109A/B LR FEED/HOT VAC. RES. EXCH.
E-113 150 VGO COOLER
E-115 500 VGO COOLER
E-116 HEAVY SLOPS AIR COOLER
E-117 HEAVY SLOPS TEMPERED WATER COOLER
NOTES
1 VACUUM CHARGE PUMPS P-101A/B ARE LOCATED OFFSITES.
2. E-110 PROVIDED FOR FLEXIBILITY TO PROCESS FEEDSTOCK AT 70°C
3. BYPASS PROVIDED FOR OPERATION WITH FEEDSTOCK AT 70°C.
4 PUMPAROUND FC CAUSES BOTH EXCHANGER AND BYPASS VALVES TO ACT TOGETHER (OPEN OR CLOSE). PUMPAROUND TC CAUSES THESE VALVES TO ACT IN OPPOSITION (OPEN & CLOSE).
E-110 DESIGN DUTY
SPLIT RANGE
E-101A/B
E-103A/B/C
E-106A/B
E-107A/B
E-108A/B
E-109A/B
DESIGN DUTY=2.38MW
LC SIGNAL FROM VAC. DIST. COLUMN BTMS
LC SIGNAL FROM HVY SOLP ACCUMULATOR TRAY
150 VGO TO TANKAGE
VACUUM RESIDUE TO PDA UNIT 200L
VACUUM RESIDUE TO TANKAGE
500 VGO TO TANKAGE
HEAVY SLOPS TO TANKAGE
P-101A/B VACUUM CHARGE PUMP
LEGEND
FLOW RATE
TEMPERATURE
PRESSURE
HEAT DUTY
FROM/TO STORAGE
FROM/TO UNIT
SSS : SUPERHEATED STRIPPING STEAM
NNF : NORMALLY NO FLOW
TWS : TEMPERED WATER SUPPLY
TWR : TEMPERED WATER RETURN
FOR CONSTRUCTION
PROCESS FLOW DIAGRAM
VACUUM DISTILLATION UNIT 100L
19. FEED PREHEAT SECT
AUG - 8 - 94
NONE
อกสารไม่ควบคุม
สำเนาที่ 9


VACUUM SYSTEM A-101
V-102 LIQUID SEAL WATER DRUM
E-118A/B/C BOOSTER CONDENSER
E-119 1ST STAGE INTER CONDENSER
E-120 2ND STAGE INTER CONDENSER
E-121 3RD STAGE AFTER CONDENSER
E-122 SEAL WATER COOLER
V-101 OVERHEAD ACCUMULATOR
V-103 SOUR GAS SEAL DRUM
V-104 HC CONDENSATE COALESCER
J-101A/B/C
J-102A/B/C
J-103 (NOTE 2)
J-104 (NOTE 2)
MP STEAM
VAC COLUMN OVERHEADS FROM C-101
SPILL BACK GAS TO C-101
WCS
WCR
E-118A/B/C
9.55
2.60
0.39
0.39
MAKE-UP
0.89
0.137
(NOTE 3)
NNF
V-103
VACUUM PROTECTION SEAL
V-102
SAME ELEVATION
K-103 (NOTE 2)
E-122
0.16
PURGE
PRESSURE SETTING SEAL
V-101
INTERFACE
SOUR WATER TO SOUR WATER STRIPPER
4.84
P-112A/B
P-113A/B
ON/OFF
V-104
HC CONDENSATE TO LIGHT SLOP
HC CONDENSATE TO SLOPS
HC CONDENSATE TO THAIOIL
K-103 LIQUID RING VACUUM PUMP
J-101A/B/C BOOSTER EJECTOR
J-102A/B/C 1ST STAGE EJECTOR
J-103 2ND STAGE EJECTOR
J-104 3RD STAGE EJECTOR
P-112A/B OVERHEAD WATER PUMP
P-113A/B HC CONDENSATE PUMP
VACUUM CHARGE HEATER AND ASSOCIATED EQUIPMENT
V-105 SOUR GAS K.O. DRUM
F-101 VACUUM CHARGE HEATER
E-124 FLUE GAS/ COMBUSTION AIR PREHEATER
E-123 COMBUSTION AIR/ LP STEAM HEATER
VDU-2
LR CHARGE (DWG NO.001)
LP STEAM
MP STEAM
RESET (BIAS/RATIO)
TO PARALLEL PASSES
SUPERHEATED STRIPPING STEAM TO C-101/2/3/4 (DWG NO.001)
LR CHARGE TO C-101 (DWG NO.001)
350
273
E-124
1.51
E-123
0.62
100
28
COMBUSTION AIR
FROM F-101 COMBUSTION AIR CONTROL
K-101A/B
LP STEAM
204
VENT TO ATMOSPHERE
M-101
M-102A/B
AIR/FUEL RATIO CONTROL
SOUR GAS
V-105
FUEL OIL
BLOWOUT TO V-101
K-102
X-101
FROM HOT OIL HEATER
M-101 SOUR GAS FLAME ARRESTOR
M-102A/B SOUR GAS FLAME ARRESTOR
K-102 VACUUM CHARGE HEATER ID FAN
K-101A/B VACUUM CHARGE HEATER FD FAN
X-101 COMMON STACK
NOTES
1. PROCESS DATA FOR COMBUSTION AIR AND FLUE GAS ARE PRELIMINARY PRECISE DESIGN DATA TO BE CALCULATED BY MAIN CONTRACTOR/VENDOR.
2. THE LIQUID RING VACUUM PUMP IS SPARED BY EJECTORS J-103 & J-104
3. PCV FOR PROTECTION OF LIQUID RING VACUUM PUMP K-103
LEGEND
FLOW RATE kg/s
TEMPERATURE °C
PRESSURE barG
HEAT DUTY MW
FROM/TO STORAGE
FROM/TO UNIT
SSS SUPERHEATED STRIPPING STEAM
NNF NORMALLY NO FLOW
เอกสารไม่ควบคุม
REVISIONS
PROCESS FLOW DIAGRAM VACUUM DISTILLATION UNIT 100L VAC. SYSTEM & CHG' HTR DETAIL
AUG - 8 - '94
0-010-1223-003
67



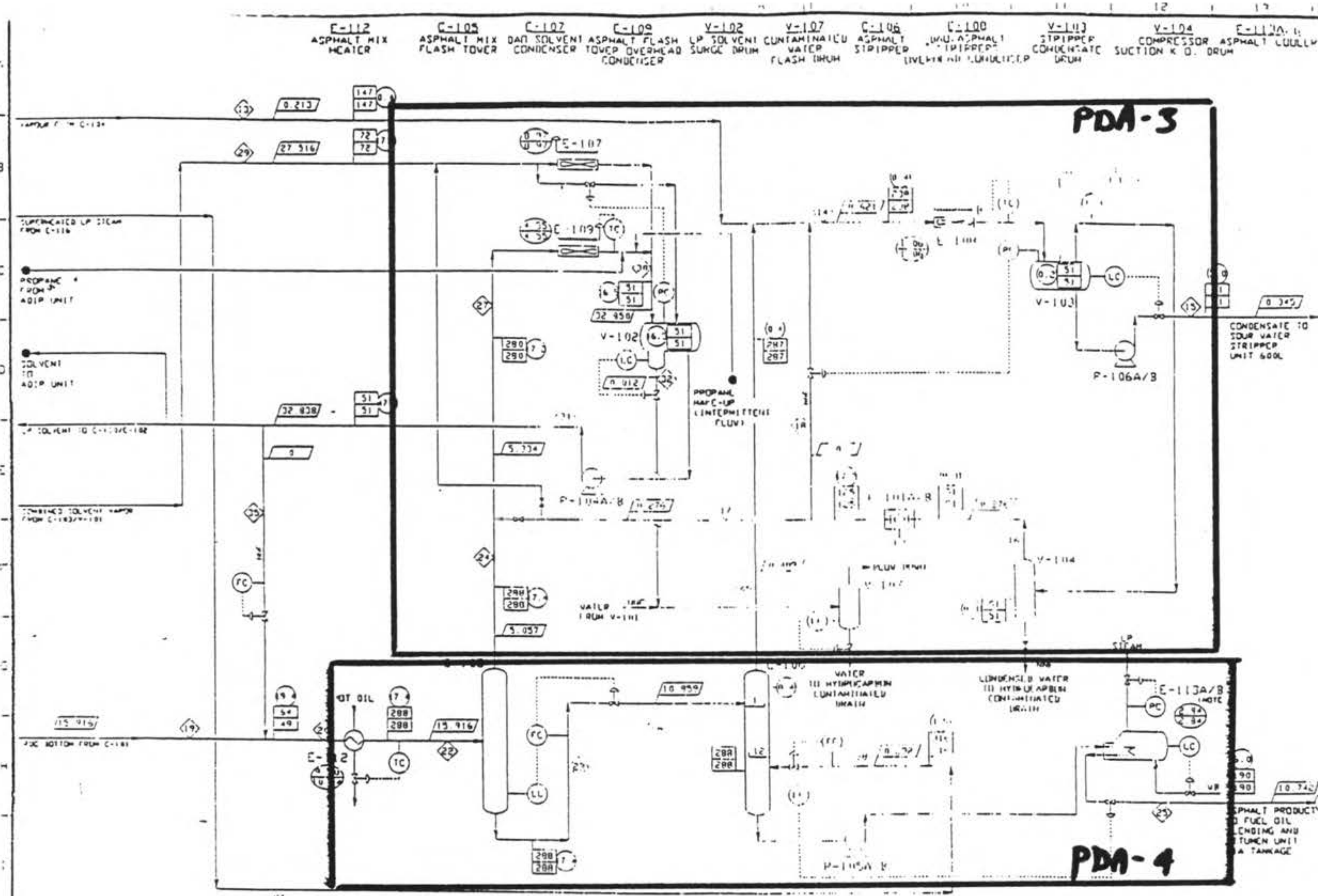
C-101 VACUUM DISTILLATION COLUMN
F-101 VACUUM CHARGE HEATER
C-102 60 VGO STRIPPER
C-103 150 VGO STRIPPER
C-104 500 VGO STRIPPER
E-111 LVGO/TOP PUMPAROUND COOLER
E-112 60 VGO COOLER
E-114 LIGHT SLOPS COOLER
VDU-3
VDU-4
NOTES
1. SETPOINT BY PRESSURE COMPENSATED FLASH ZONE TEMPERATURE CONTROL.
2. STRIPPERS C-102, C-103 AND C-104 ARE INCORPORATED IN ONE SHELL.
3. HEATER OUTLET TEMPERATURE AT ASSUMED OUTLET PRESSURE APPROXIMATELY 0.21bar abs.
4. LEVEL CONTROL NORMALLY ACTS ON HEAVY SLOPS RUNDOWN, WITH RESET TO RESIDUE STRIPPING SECTION AS AN ALTERNATIVE.
5. A SMALL SLOPS FLOW WILL BE RETAINED TO PREVENT SETTING UP, OR SYSTEM FLUSHED.
6. PUMPAROUND FC CAUSES BOTH EXCHANGER AND BYPASS VALVES TO ACT TOGETHER (OPEN OR CLOSE). PUMPAROUND TC CAUSES THESE VALVES TO ACT IN OPPOSITION(OPEN&CLOSE).
LEGEND
FLOW RATE
TEMPERATURE
PRESSURE
HEAT DUTY
FROM/TO STORAGE
FROM/TO UNIT
SSS SUPERHEATED STRIPPING STEAM
NNF NORMALLY NO FLOW
FOR CONSTRUCTION
เอกสารไม่ควบคุม
ลำดับที่......๑
OVERHEADS TO VACUUM SYSTEM
DESIGN DUTY=4.38MW
DESIGN DUTY=2.79MW
P-102A/B
P-103A/B
P-105A/B
P-107A/B
P-108A/B
P-110A/B
P-104A/B
P-106A/B
P-109A/B
P-111A/B
F-101
(FOR DETAILS REFER TO DWG. D-010-1223-003)
FUEL
MP STEAM
PROCESS FLOW DIAGRAM VACUUM DISTILLATION UNIT 100L VAC. DIST. COLUMN SECT.
P-102A/B LVGO/TOP PUMPAROUND PUMP
P-103A/B 60 VGO PUMPAROUND PUMP
P-105A/B 150 VGO PUMPAROUND PUMP
P-107A/B LIGHT SLOPS PUMP
P-108A/B 500 VGO PUMPAROUND
P-110A/B HEAVY SLOPS/RECYCLE PUMP
P-111A/B VACUUM RESIDUE PUMP
P-104A/B 60 VGO PRODUCT PUMP
P-106A/B 150 VGO PRODUCT PUMP
P-109A/B 500 VGO PRODUCT PUMP



MATERIAL BALANCE FOR HIGH & LOW TEMPERATURE CASES

STREAM NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	19	28	29	33	34	36	37
COMPONENT / DESCRIPTION		VAC RESIDUE FROM V.U.	V.R. AND OIL/SOLVENT TO FEED COOLER	R.D.C. OVERHEAD	HP DAO FLASH TOWER INLET	HP DAO FLASH TOWER BOTTOMS	VAP EXIT HP DAO FLASH TOWER	LP DAO FLASH TOWER INLET	LIQ EXIT LP DAO FLASH TOWER	VAP EXIT LP DAO FLASH TOWER	DAO REBOIL VAP TO LP FLASH TOWER	DAO REBOIL LIQ TO DAO STRIPPER	DAO TO B.L.	VAP EXIT DAO STRIPPER	RDC BOTTOM OUTLET	H.P. SOLV. DRUM VENT TO DAO SOLV COND.	COND VAP TO DAO SOLVENT CONDENSER	HP SOLVENT PUMP DISCHARGE	PREDILUTION SOLVENT TO RDC FEED	SOLVENT TO RDC TOWER	STEAM TO DAO STRIPPER
ETHANE	kg/s		3.102	8.746	8.746	0.270	3.476	0.279	3.361	0.269	5.001				0.070	NORMALLY NO FLOW	0.259	3.476	3.102	8.714	
PROPANE	kg/s		7.131	52.276	52.276	26.319	25.956	26.319	0.670	26.193	0.551	0.127		0.127	4.934		25.193	25.954	7.131	50.059	
I-BUTANE	kg/s		0.247	1.884	1.884	1.074	3.730	1.074	0.373	1.354	0.353	0.320		0.420	3.170		1.354	4.730	3.247	1.727	
WATER	kg/s													0.066							3.066
D.A.O.	kg/s			4.238	4.238	4.238		4.238	4.238			4.238	4.238								
ASPHALT	kg/s																				
VACUUM RESIDUE	kg/s	14.972	14.972												10.742						
WEIGHT % VAPOUR		-	-	-	45.7	42.7	100.0	83.4	-	100.0	100.0	-	-	100.0	-		100.0	-	-	-	100.0

0-020-1723-001



NOTES

1. ALL ITEM NUMBERS ARE PREFIXED 20##
2. H AND L MEAN HIGH TEMPERATURE CASE AND LOW TEMPERATURE CASE RESPECTIVELY
3. ONE OPERATIONAL, ONE STANDBY
4. HIGH TEMPERATURE CASE/LOW TEMPERATURE CASE

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สำเนาที่.....9

P-104A/B LP SOLVENT PUMP

P-105A/B ASPHALT PRODUCT PUMP

K-101A/B SOLVENT COMPRESSOR

P-106A/B CONTAMINATED CONDENSATE PUMP

MATERIAL BALANCE FOR HIGH/LOW TEMPERATURE CASES

STREAM NO		13	14	15	16	17	18	19	20	22
COMPONENT / DESCRIPTION		VAP EXIT DAO STRIPPER	VAP TO STRIPPERS O.C.	COND. WATER TO H/C CONT. DRAIN	VAP TO SOLVENT COMPRESSOR	COMP VAP TO ASPHALT STRIPPER O.C	COMP. VAP. LETDOWN TO STRIPPER O.C.	RDC BOTTOM OUTLET	ASPHALT MIX TO HEATER	INLET TO ASPHALT MIX FLASH TOWER
ETHANE	kg/s						NORMALLY NO FLOW	0.070	0.070	2.478
PROPANE	kg/s	0.127	0.238		0.238	0.238		4.734	4.734	4.734
I-BUTANE	kg/s	0.028	0.026		0.026	0.026		0.170	0.170	0.178
WATER	kg/s	0.366	0.357	0.345	0.012	0.012				
H2S	kg/s									
ASPHALT	kg/s							10.742	10.742	10.742
VACUUM RESIDUE	kg/s									
WEIGHT % VAPOUR		100.0	100.0	-	100.0	100.0			NOTE 4 [illegible]	11.8

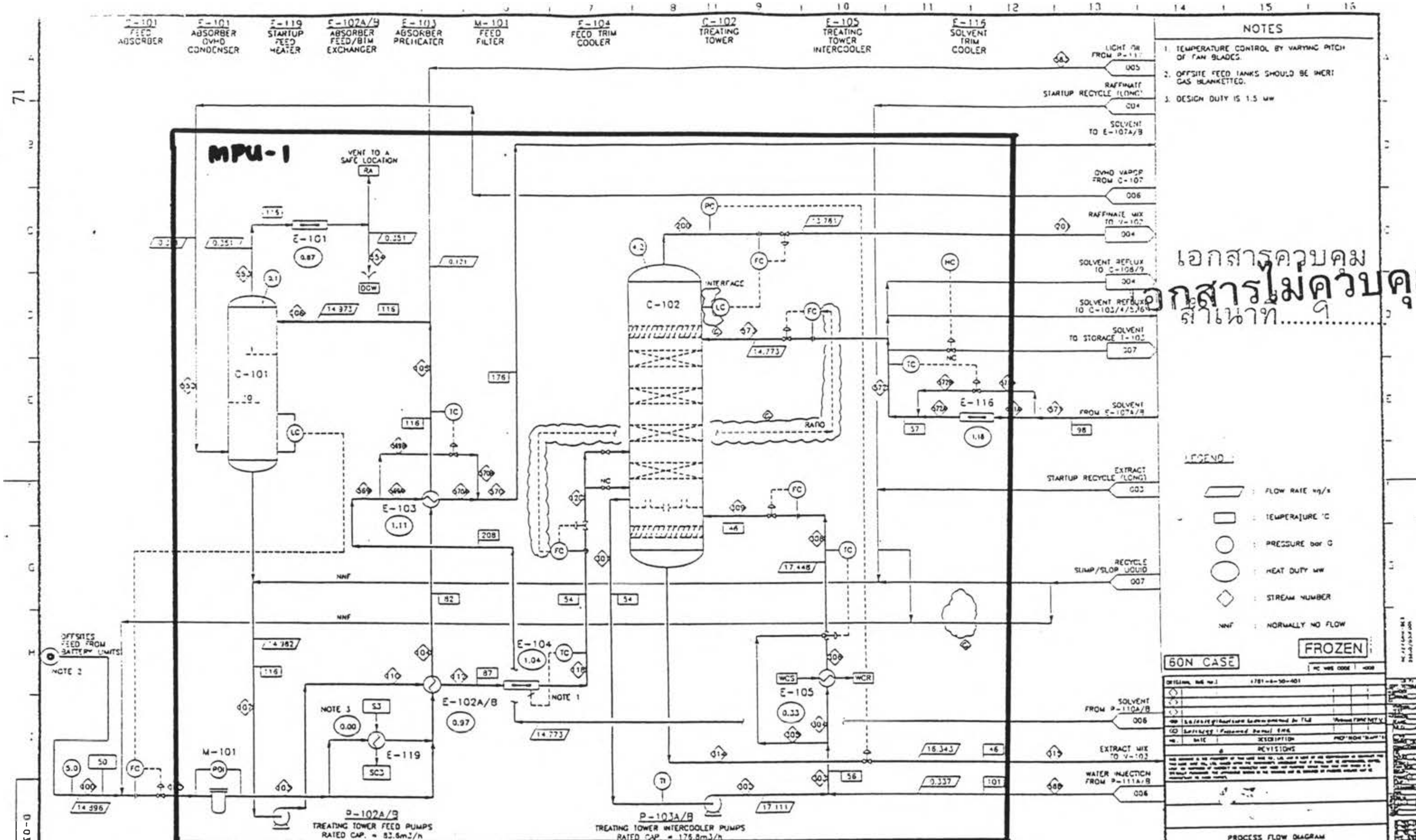
STREAM NO		23	24	25	26	27	28	30	31	32	35	36
COMPONENT / DESCRIPTION		LIQUID EXIT ASPHALT MIX FLASH TOWER	VAPOR EXIT ASPHALT MIX FLASH TOWER	ASPHALT TO B.L.	VAPOR EXIT ASPHALT STRIPPER	COMB. VAP. TO ASPHALT FLASH TOWER O.C.	COMB VAP TO DAO SOLVENT CONDENSER	INLET TO LP SOLVENT SURGE DRUM	LP SOLVENT PUMP DISCHARGE	COND WATER TO H/C CONT DRAIN	DILUTION OIL TO ASPHALT MIX EXIT RDC	STEAM TO ASPHALT STRIPPER
ETHANE	kg/s		0.478			0.471	1.264	0.348	0.348		NORMALLY NO FLOW	
PROPANE	kg/s	0.111	4.623		0.111	[illegible]	26.1[illegible]	31.254	31.254			
I-BUTANE	kg/s	0.006	0.164		[illegible]	[illegible]	1.[illegible]	1.244	1.244			
WATER	kg/s				[illegible]	[illegible]		0.012		0.012		0.292
H2S	kg/s											
ASPHALT	kg/s	10.742		10.742								
VACUUM RESIDUE	kg/s											
WEIGHT % VAPOUR			100.0		100.0	100.0	100.0		-	-		100.0

0-020-1223-002

PROCESS FLOW DIAGRAM
PROPANE DEASPHALTING UNIT 2000
RDC AND DAO PRODUCT SECTION

0-2800-0-5-0000 B

71



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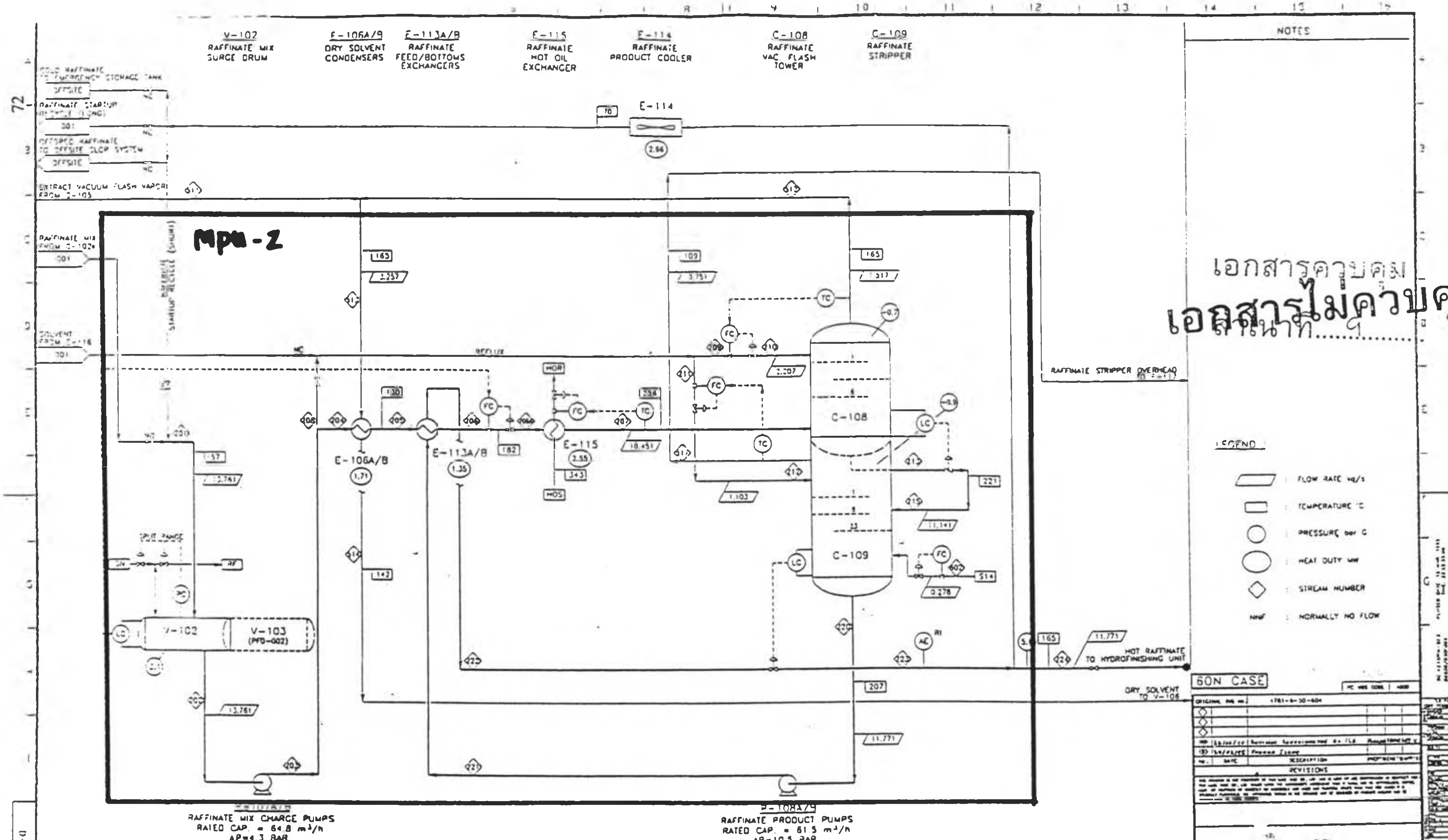
ลำนำที่.........

MATERIAL BALANCE FOR 60N OPERATION CASE

STREAM NO.		100	106	107	200	301	303	314	552	553	573
COMPONENT	DESCRIPTION	OIL FEED	ABSORBER FEED	ABSORBER BOTTOMS	TREATING TOWER OVERHEAD	INTERCOOLER CIRCULATION	INTERCOOLER CIRCULATION	TREATING TOWER BOTTOMS	STEAM TO ABSORBER	ABSORBER OVERHEAD	CIRCULATING SOLVENT
H2O	kg/s	0.000	0.000	0.010	0.000	0.058	0.394	0.390	0.359	0.349	3.344
NMP	kg/s	0.000	0.000	0.000	1.951	13.367	13.362	12.499	0.000	0.000	14.451
RAFFINATE	kg/s	11.769	11.808	11.906	11.810	0.000	0.000	0.000	0.000	0.007	0.000
EXTRACT	kg/s	3.127	3.165	3.166	0.000	3.691	3.593	3.454	0.002	0.000	0.277
TOTAL	kg/s	14.896	14.973	14.082	13.761	17.110	17.448	16.343	0.361	0.351	14.777

D-030-1223-001



MATERIAL BALANCE FOR 60N OPERATION CASE

STREAM NO		201	202	204	209	211	213	220	512	517	602
COMPONENT	DESCRIPTION	RAFFINATE	RAFFINATE	RAFFINATE	VACUUM FLASH REFLUX	RAFFINATE STRIPPER REFLUX	VACUUM FLASH BOTTOMS	RAFFINATE PRODUCT	RAFFINATE VACUUM FLASH OVERHEAD	RAFFINATE STRIPPER OVERHEAD	RAFFINATE STRIPPER STEAM
H2O	kg/s	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.278	0.278
NMP	kg/s	1.951	1.951	1.482	0.313	0.158	0.303	0.000	1.490	0.461	0.000
RAFFINATE	kg/s	11.810	11.810	8.969	1.894	0.947	10.838	11.771	0.027	0.012	0.000
EXTRACT	kg/s	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	kg/s	13.761	13.761	10.451	2.207	1.103	11.141	11.771	1.517	0.751	0.278

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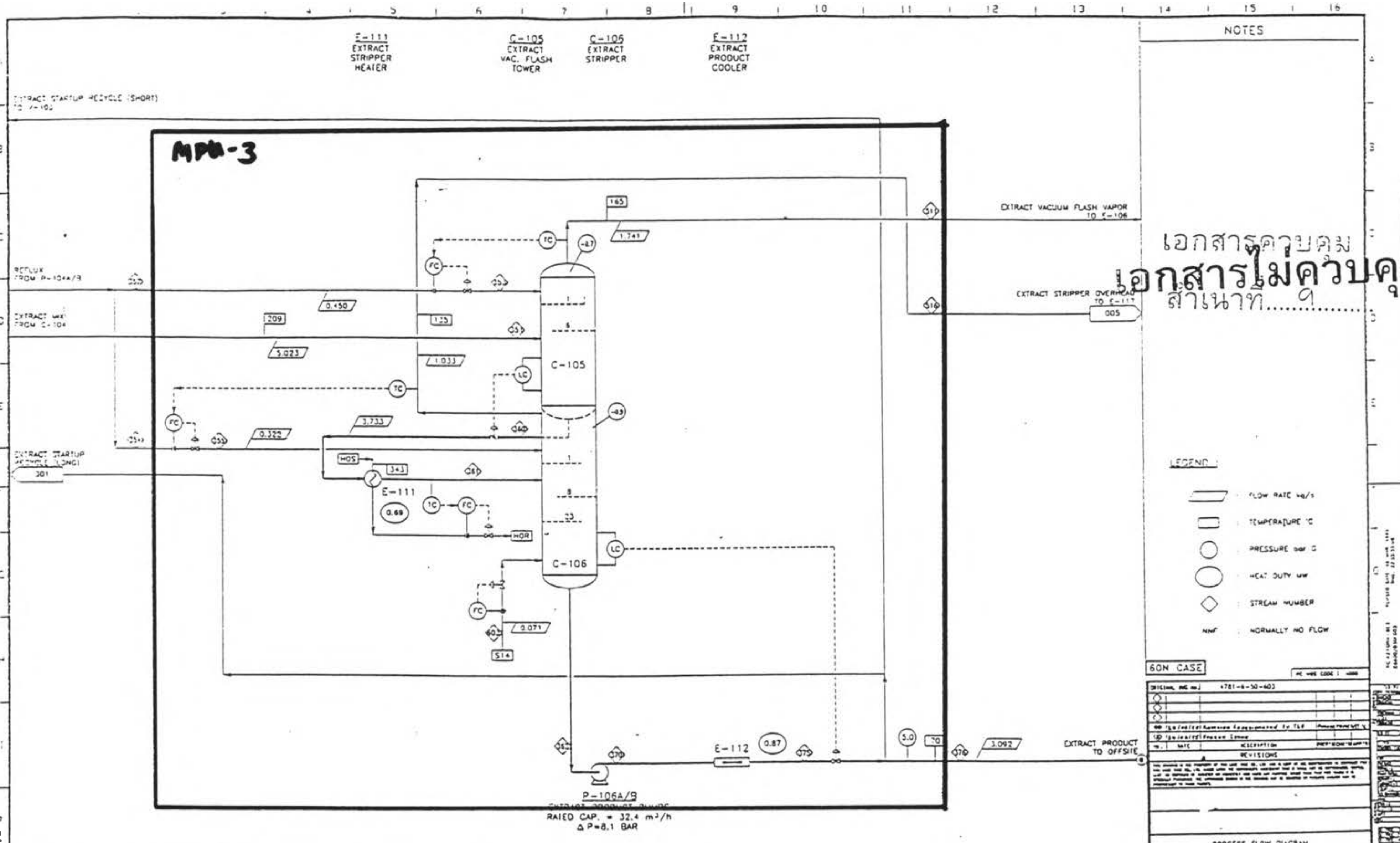
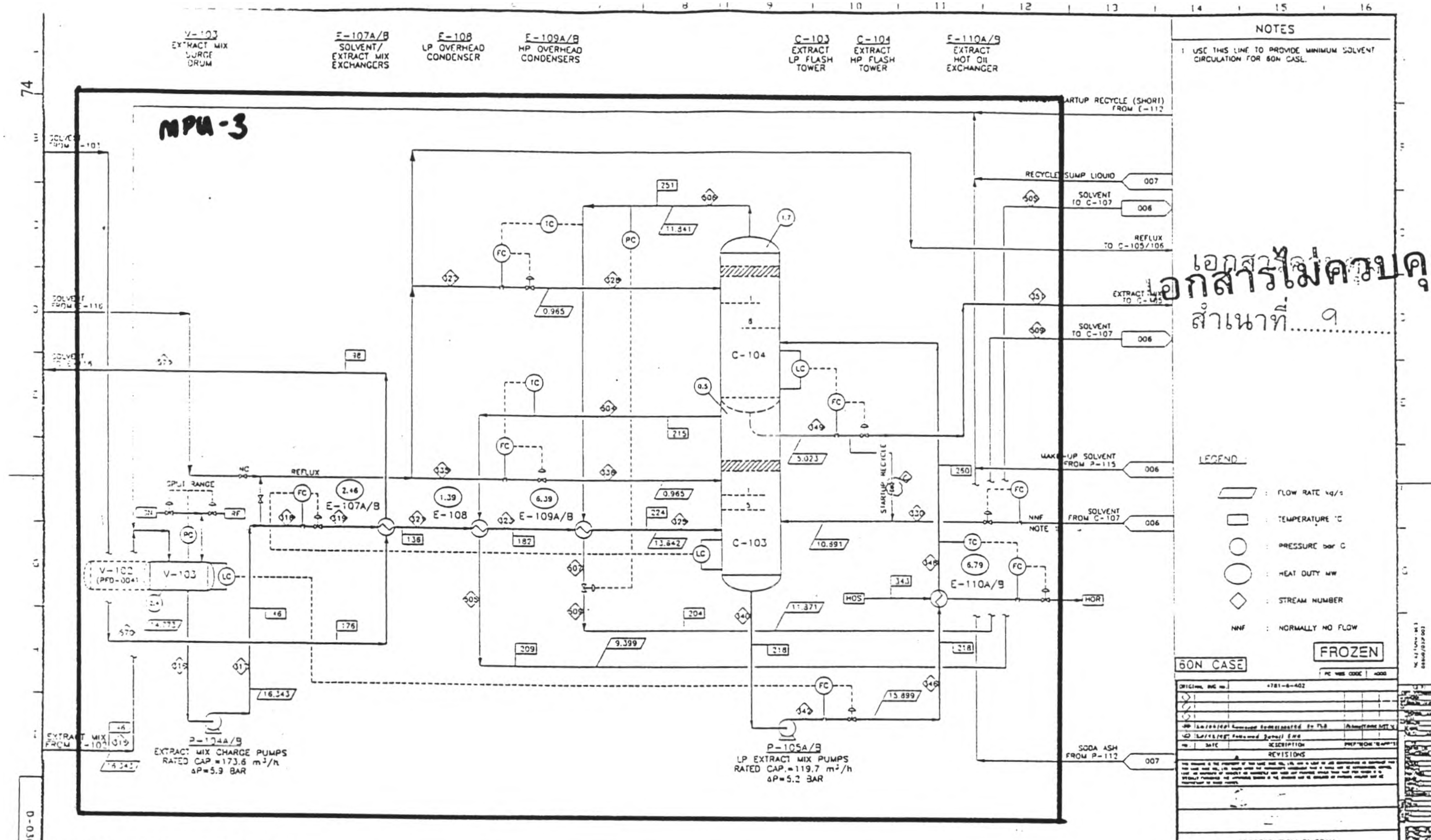


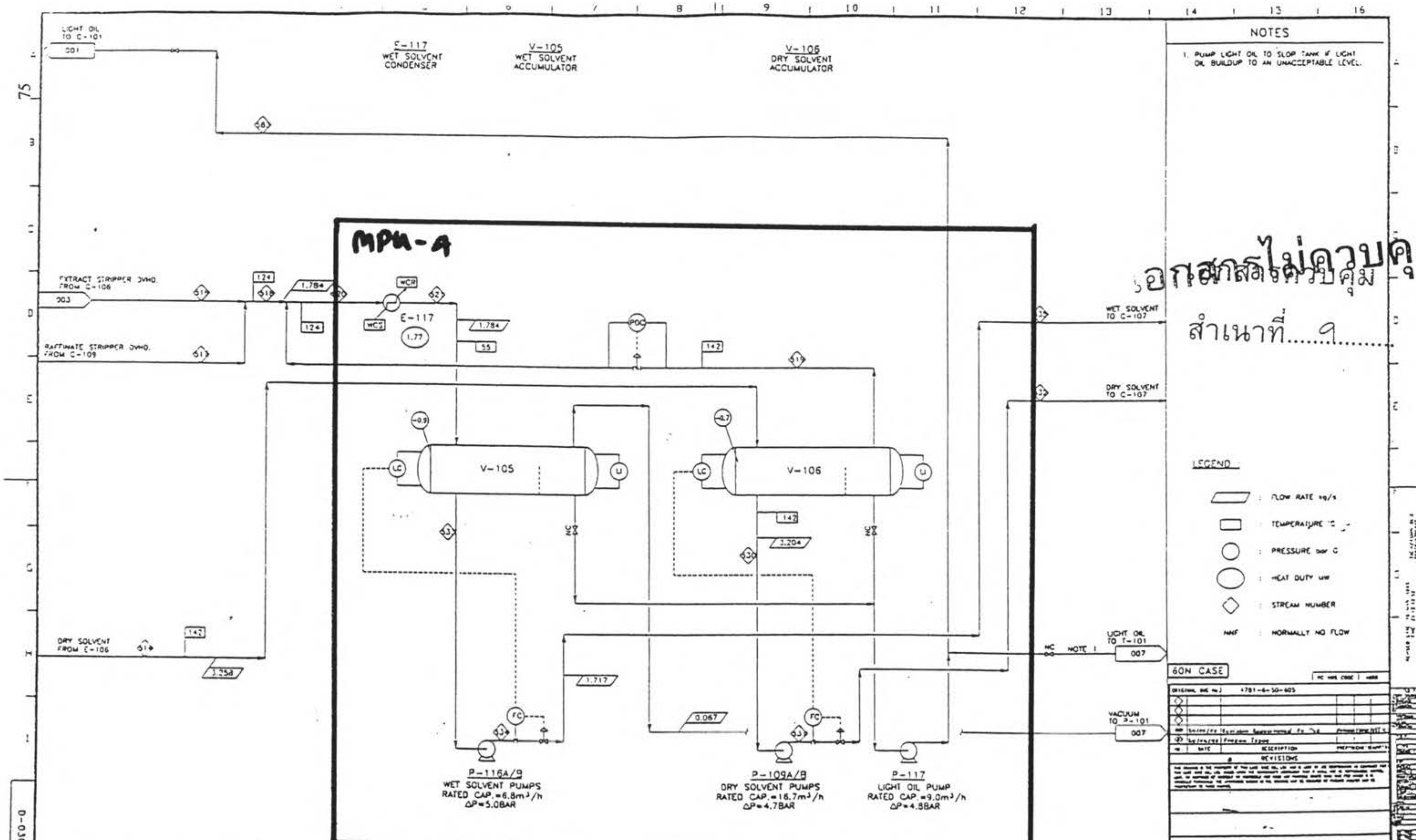
MATERIAL BALANCE FOR 60N OPERATION CASE

STREAM No.		351	352	354	360	362	511	516	603
DESCRIPTION / COMPONENT		VACUUM FLASH FEED	VACUUM FLASH REFLUX	EXTRACT STRIPPER REFLUX	VACUUM FLASH BOTTOMS	EXTRACT STRIPPER BOTTOMS	EXTRACT VACUUM FLASH OVERHEAD	EXTRACT STRIPPER OVERHEAD	EXTRACT STRIPPER STEAM
H2O	kg/s	0.000	0.011	0.008	0.000	0.000	0.011	0.079	0.071
NMP	kg/s	2.012	0.344	0.246	0.653	0.000	1.703	0.899	0.000
RAFFINATE	kg/s	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EXTRACT	kg/s	3.011	0.095	0.068	3.079	3.097	0.027	0.055	0.000
TOTAL	kg/s	5.023	0.450	0.322	3.733	3.097	1.741	1.033	0.071



MATERIAL BALANCE FOR 60N OPERATION CASE

STREAM NO.		315	316	318	327	330	335	340	349	504	506
DESCRIPTION / COMPONENT		EXTRACT MIX	EXTRACT MIX	EXTRACT MIX	HP FLASH REFLUX	MINIMUM CIRCULATION FLOW	LP FLASH REFLUX	LP FLASH BOTTOMS	HP FLASH BOTTOMS	LP FLASH OVERHEAD	HP FLASH OVERHEAD
H2O	kg/s	0.390	0.390	0.325	0.023	0.037	0.023	0.015	0.000	0.365	0.028
NMP	kg/s	12.499	12.499	10.433	0.738	10.458	0.738	12.769	2.012	8.860	11.495
RAFFINATE	kg/s	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EXTRACT	kg/s	3.454	3.454	2.883	0.204	0.701	0.204	3.115	3.011	0.174	0.307
TOTAL	kg/s	16.343	16.343	13.642	0.965	10.691	0.965	15.899	5.023	9.399	11.841



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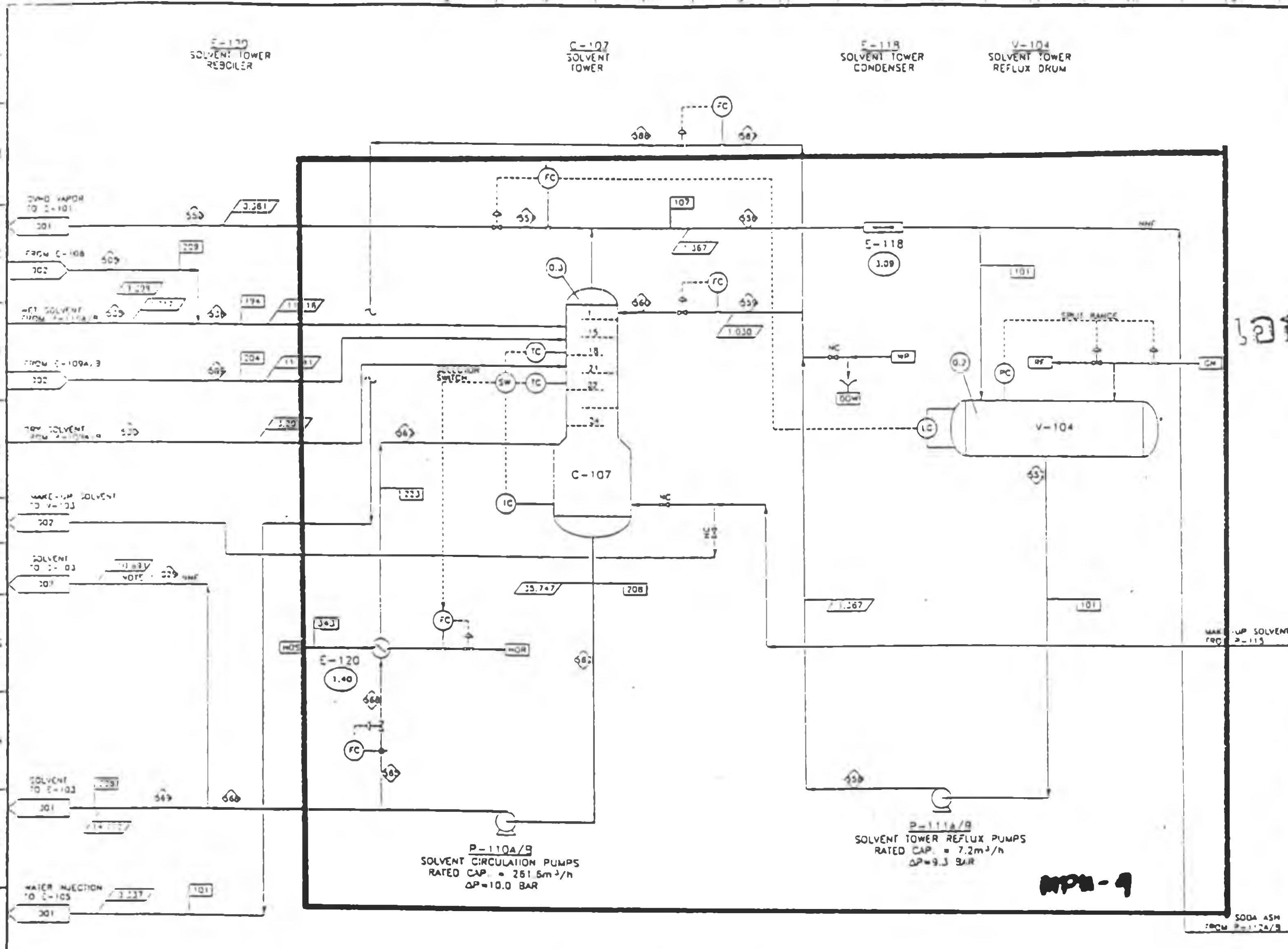
สำเนาที่.....๑

MATERIAL BALANCE FOR 60N OPERATION CASE

STREAM NO	514	519	520	530	533
DESCRIPTION / COMPONENT	DRY SOLVENT		WET SOLVENT	DRY SOLVENT	WET SOLVENT
H2O kg/s	0.011	0.000	0.357	0.011	0.357
NMP kg/s	3.193	0.000	1.360	3.193	1.360
RAFFINATE kg/s	0.027	0.000	0.012	0.000	0.000
EXTRACT kg/s	0.027	0.000	0.055	0.000	0.000
TOTAL kg/s	3.258	0.000	1.784	3.204	1.717



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สำเนาที่ ....๑.........

NOTES

1. USE THIS LINE TO PROVIDE MINIMUM SOLVENT CIRCULATION FOR SON CASE.

LEGEND

(parallelogram)	FLOW RATE kg/s
(rectangle)	TEMPERATURE °C
(circle)	PRESSURE bar G
(ellipse)	HEAT DUTY MW
(diamond)	STREAM NUMBER
NNF	NORMALLY NO FLOW

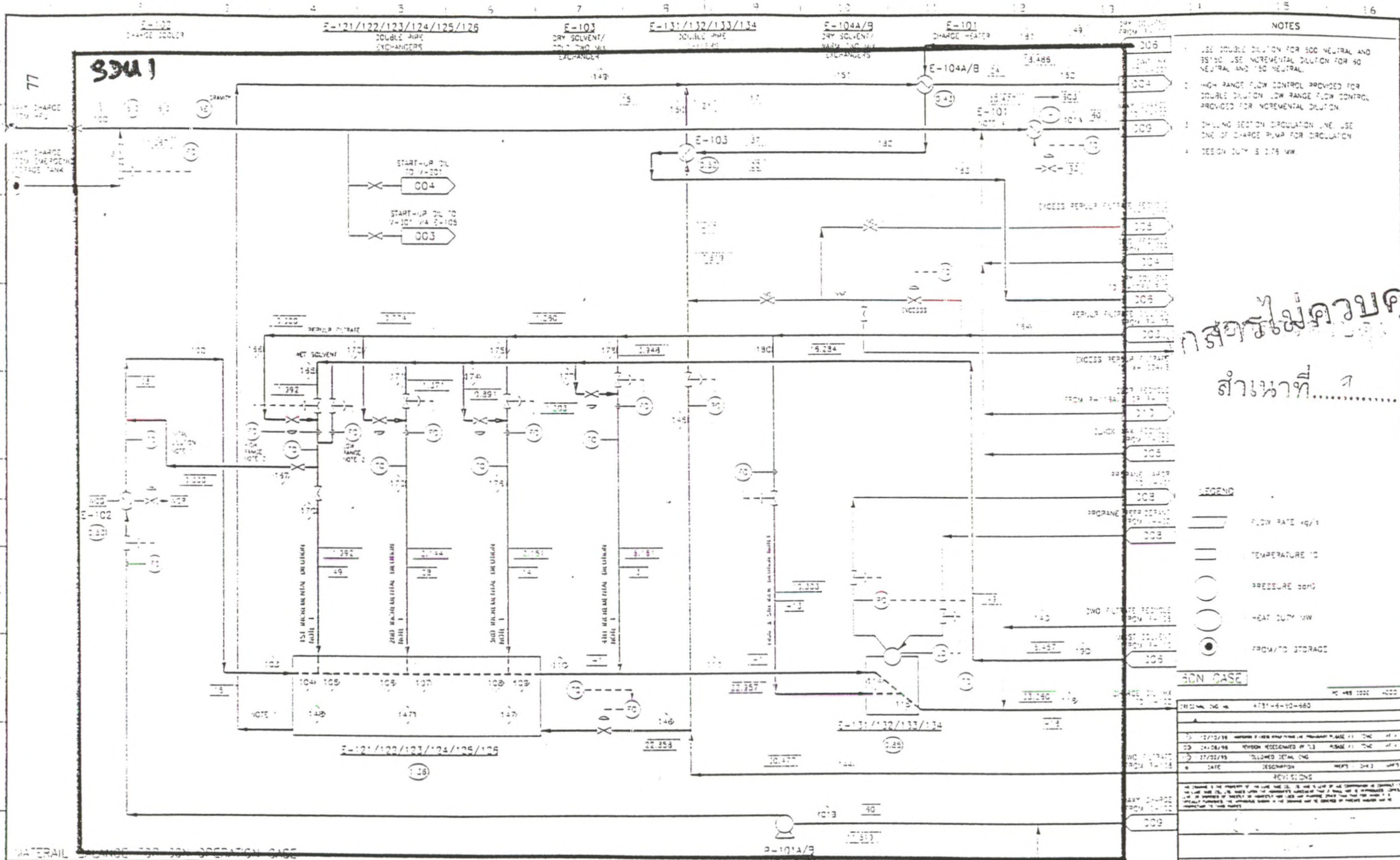
SON CASE

PROCESS FLOW DIAGRAM
MP REFINING UNIT 300L
MP DRYING (SON)

D-030-1723-006

MATERIAL BALANCE FOR SON OPERATION CASE

STREAM NO		509	532	538	551	556	557	559	562	566
COMPONENT	DESCRIPTION	MP FLASH OVERHEAD	DRY SOLVENT	WET SOLVENT TO C-107	SOLVENT TOWER OVERHEAD	SOLVENT TWR CONDENSER INLET	SOLVENT TWR CONDENSATE	SOLVENT TOWER REFLUX	SOLVENT TOWER BOTTOMS	SOLVENT TWR REBOILER INLET
[illegible]	[illegible]	[illegible]	0.211	[illegible]	0.359	1.361	1.361	1.026	0.107	[illegible]
NMP	[illegible]	[illegible]	[illegible]	[illegible]	0.000	0.000	0.000	0.000	34.969	10.060
RAFFINATE	[illegible]	0.000	0.000	2.000	0.000	2.000	0.000	0.000	0.000	2.000
EXTRACT	[illegible]	[illegible]	2.000	[illegible]	0.002	0.006	0.006	0.004	[illegible]	0.193
TOTAL	[illegible]	[illegible]	3.704	[illegible]	0.381	1.367	1.367	1.230	35.747	10.784

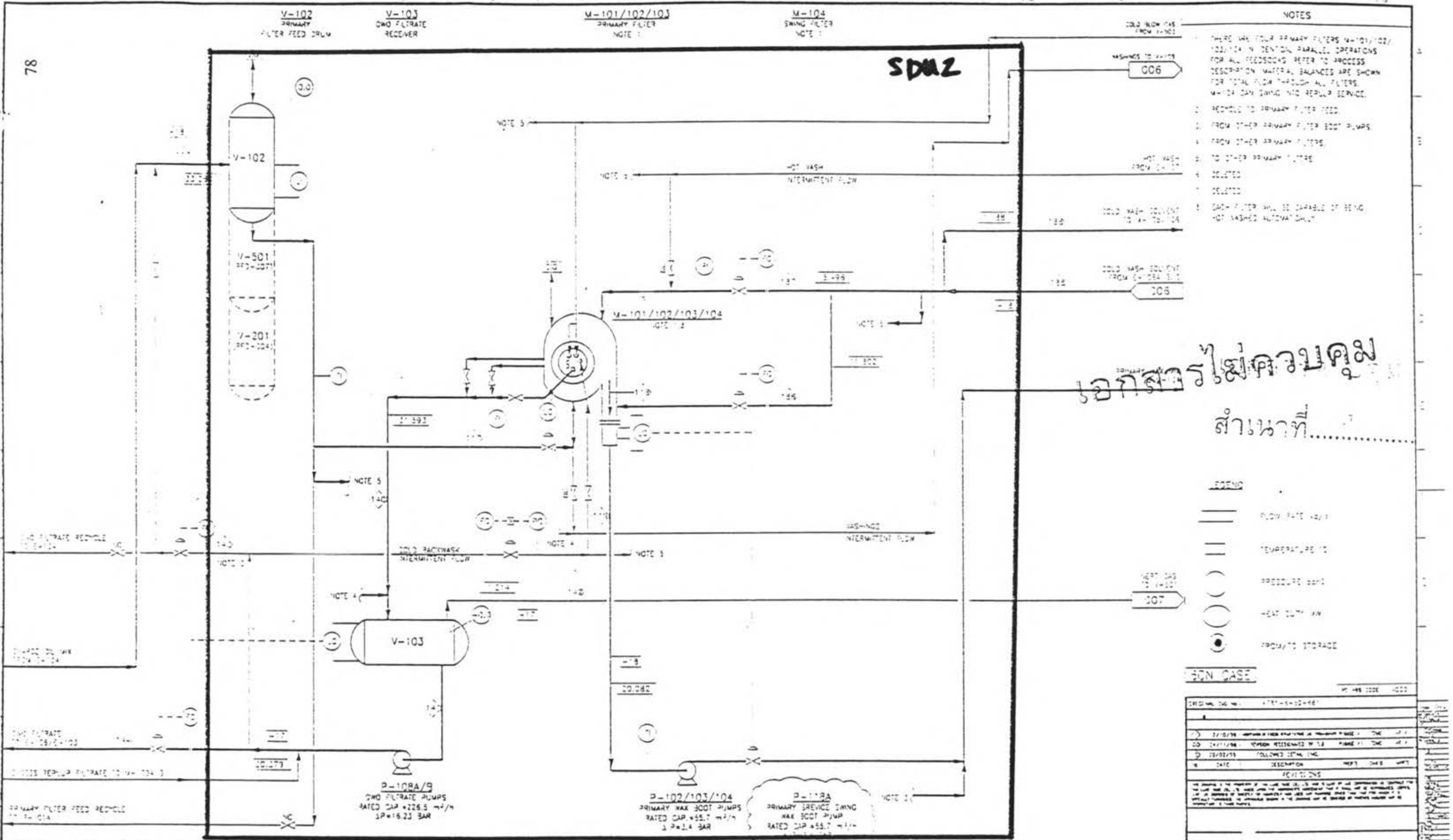


กลุ่มที่ไม่ควบคุม
สำเนาที่.....

MATERAIL BALANCE FOR 60N OPERATION CASE

COMPONENT	DESCRIPTION	WAXY CHARGE FROM	CHARGE WAX TO DPC	CHARGE WAX DWO DPC	DWO FILTRATE FROM	DWO WAX TO V-102	REPULP FILTRATE TO DPC & DPC	MOIST SOLVENT TO DPC
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PROCESS FLOW DIAGRAM
SOLVENT DEWAXING UNIT 4OOL
CHILLING SECTION (60N)



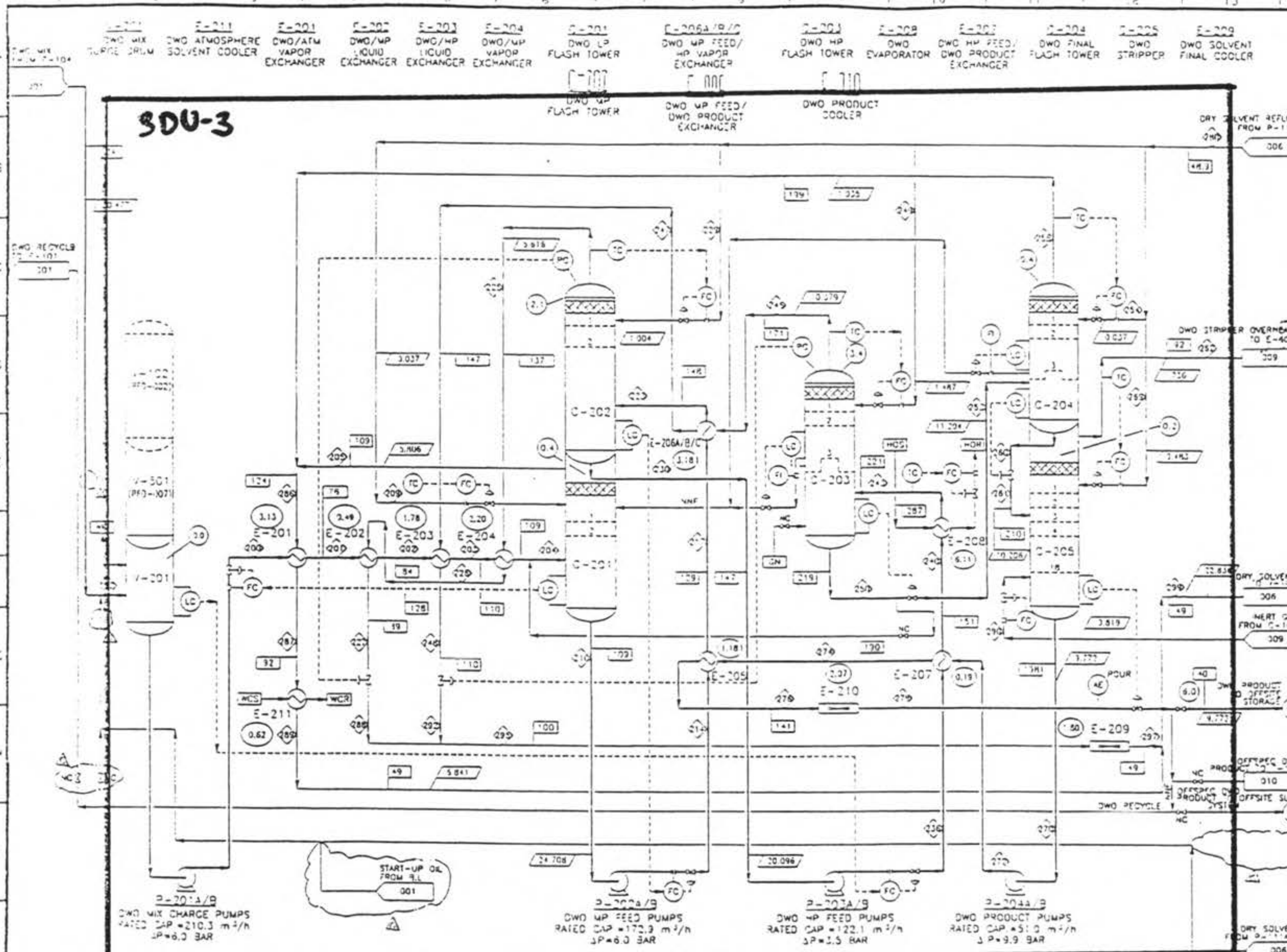
MATERAIL BALANCE FOR 60N OPERATION CASE

STREAM NO.		[illegible]	139	140	141	186	187
COMPONENT	DESCRIPTION	FEED TO V-102	WAX MIX FROM PRIM. FILTERS	DWO FILTRATE FROM PRIM. FILTERS	DWO FILTRATE FROM V-103	COLD WASH SOLVENT TO PRIM. FILTERS	COLD WASH SOLVENT TO PRIM. FILTERS
[illegible]	kg/s	0.000	0.000	1.116	0.002	0.000	0.000
[illegible]	kg/s	0.061	3.434	0.063	0.897	5.687	2.648
TOLUENE	kg/s	10.420	1.070	10.715	10.680	5.115	3.448
H2O	kg/s	0.000	0.000	0.000	0.000	0.000	0.000
DEWAXED OIL	kg/s	2.375	1.176	9.799	9.799	0.000	0.000
WAX	kg/s	0.000	0.000	0.000	0.000	0.000	0.000
WAXS	kg/s	1.403	1.403	0.000	0.000	0.000	0.000
TOTAL	kg/s	13.260	20.083	11.593	10.379	11.802	5.496

PROCESS FLOW DIAGRAM
SOLVENT DEWAXING UNIT 400L
PRIMARY FILTER SECTION (60N)

DATE 12 - SEP - 94 SCALE NONE

JOB CODE 0-6300-0-5-0000



NOTES

LEGEND

- FLOW RATE kg/s
- TEMPERATURE °C
- PRESSURE bar G
- HEAT DUTY MW
- STREAM NUMBER
- NNF : NORMALLY NO FLOW

FROZEN

60N CASE

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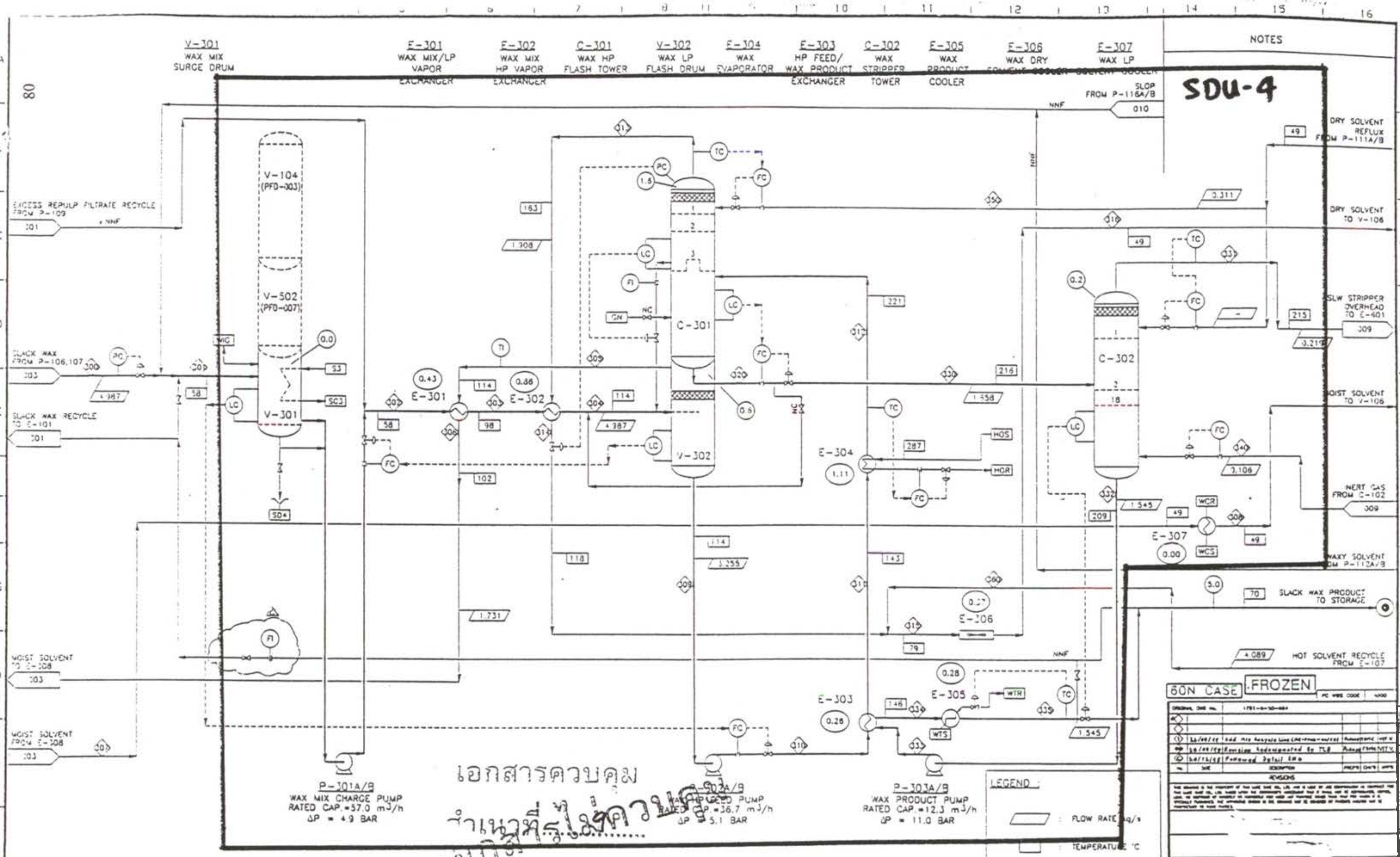
สำเนาที่ ๑

PROCESS FLOW DIAGRAM
SOLVENT DEWAXING UNIT 400L
DEWAXED OIL RECOVERY SECTION (60N)

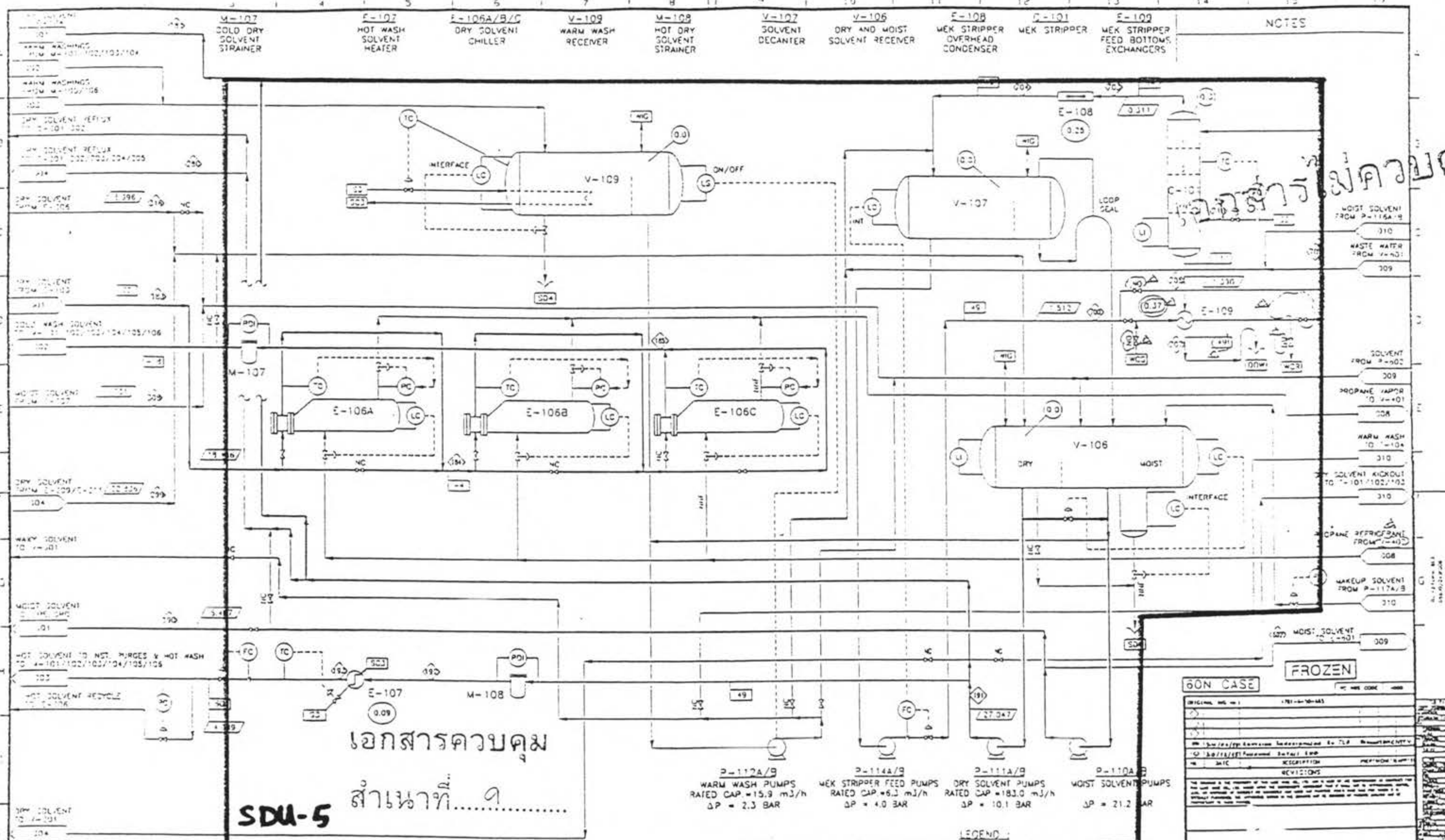
MATERIAL BALANCE FOR 60N OPERATION CASE

STREAM NO.	152	200	205	209	210	225	229	230	245	249	250	254	255	260	262	269	270	290
DESCRIPTION / COMPONENT	DWO MIX TO V-201	DWO MIX TO C-2011	OVERHEAD FROM C-201	DRY SOLVENT REFLUX TO C-201	BOTTOMS FROM C-201	OVERHEAD FROM C-202	DRY SOLVENT REFLUX TO C-202	BOTTOMS FROM C-202	OVERHEAD FROM C-203	DRY SOLVENT REFLUX TO C-203	BOTTOMS FROM C-203	DRY SOLVENT REFLUX TO C-204	OVERHEAD FROM C-204	BOTTOMS FROM C-204	OVERHEAD FROM C-205	DRY SOLVENT REFLUX TO C-205	BOTTOMS FROM C-205	INERT GAS TO C-205
[illegible] kg/s	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.817	0.000	0.002	0.819
MEK kg/s	9.963	9.963	3.684	0.018	6.297	3.221	0.484	0.559	3.987	0.716	0.289	0.018	0.253	0.154	0.257	0.233	0.000	0.000
TOLUENE kg/s	10.715	10.715	2.122	0.019	8.612	2.394	0.520	9.737	6.384	0.770	1.124	0.019	0.761	0.282	0.632	0.250	0.000	0.000
DEWAXED OIL kg/s	9.799	9.799	0.000	0.000	9.799	0.000	0.000	9.799	0.008	0.000	9.791	0.000	0.021	9.770	0.000	0.000	9.770	0.000
WAX kg/s	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL kg/s	30.477	30.477	5.806	0.037	24.708	5.616	1.004	20.096	10.379	1.487	11.204	0.037	1.035	10.206	1.736	0.483	9.772	0.819



MATERIAL BALANCE FOR 60N OPERATION CASE

STREAM NO.		300	302	305	309	313	320	331	332	340	350
DESCRIPTION / COMPONENT		SLACK WAX FROM P106/107	TO E-301T	OVERHEAD FROM V-302	BOTTOMS FROM V-302	OVERHEAD FROM C-301	BOTTOMS FROM C-301	OVERHEAD FROM C-302	BOTTOMS FROM C-302	INERT GAS TO C-302	DRY SOLVENT REFLUX C-301
N2	kg/s	0.000	0.000	0.000	0.000	0.000	0.000	0.106	0.000	0.106	0.000
MEK	kg/s	1.548	1.548	1.022	0.625	0.755	0.020	0.020	0.000	0.000	0.150
TOLUENE	kg/s	1.772	1.772	0.709	1.063	1.150	0.074	0.074	0.000	0.000	0.161
DEWAXED OIL	kg/s	0.164	0.164	0.000	0.164	0.000	0.164	0.003	0.161	0.000	0.000
WAXS	kg/s	1.403	1.403	0.000	1.403	0.002	1.401	0.017	1.384	0.000	0.000
TOTAL	kg/s	4.987	4.987	1.731	3.255	1.907	1.658	0.219	1.545	0.106	0.310



MATERIAL BALANCE FOR 60N OPERATION CASE

STREAM NO.		190	191	299	308	602	700	703	705	710
DESCRIPTION / COMPONENT		MOIST SOLVENT TO [illegible]	DRY SOLVENT FROM V-106	DRY SOLVENT TO V-106	MOIST SOLVENT TO V-106	SOLVENT REFLUX TO E-601	MEKFD	PRODLIQ	BTMS	STEAM
[illegible]	[illegible]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MEK	[illegible]	2.549	13.032	11.145	1.022	0.444	0.265	0.265	0.000	0.000
TOLUENE	[illegible]	2.968	14.015	11.562	0.709	0.478	0.000	0.000	0.000	0.000
DEWAXED OIL	[illegible]	0.000	0.000	0.029	0.000	0.000	0.000	0.000	0.000	0.000
WAX	[illegible]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
[illegible]	[illegible]	0.000	0.000	0.000	0.000	0.004	1.247	0.046	1.390	0.189
TOTAL	[illegible]	5.457	27.047	22.536	1.731	0.926	1.512	0.311	1.390	0.189

LEGEND:

- FLOW RATE kg/s
- TEMPERATURE °C
- PRESSURE bar G
- HEAT DUTY MW
- STREAM NUMBER
- NORMALLY NO FLOW

PROCESS FLOW DIAGRAM
SOLVENT DEWAXING UNIT 400L
SOLVENT SYSTEM (60N)

D-040-1223-006 B

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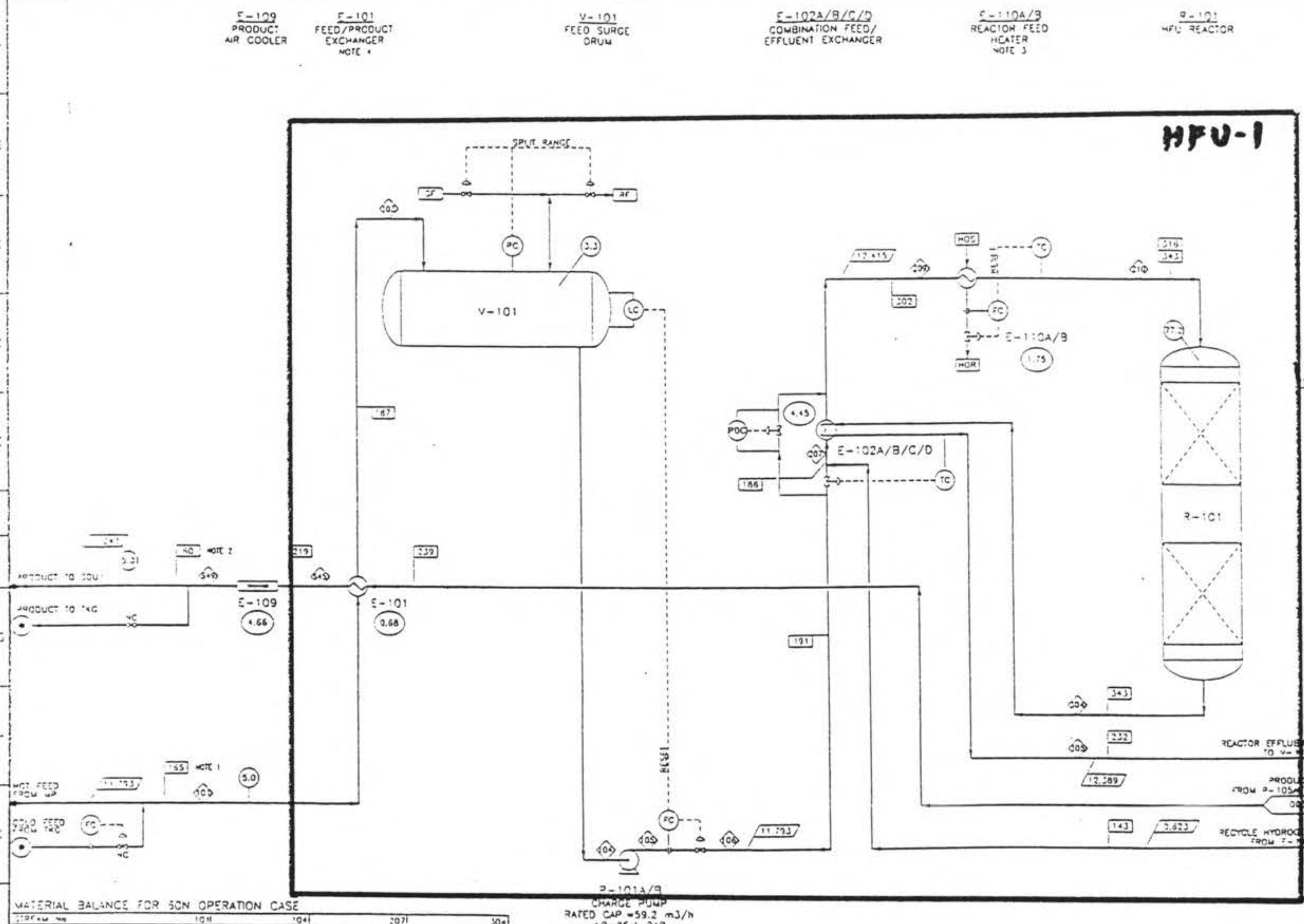

NOTES

1. MINIMUM = 50°C
2. DESIGN = 51°C
3. E-110A/B DESIGN DUTY IS 4.24 MW BASED ON COLD 500N FEED
4. E-101 DESIGN DUTY IS 1.41 MW BASED ON COLD 500N FEED

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สำเนาที่....
เอกสารไม่ควบคุม

LEGEND

- FLOW RATE kg/s
- TEMPERATURE °C
- SOR / EOR: TEMPERATURE FOR START OF RUN / TEMPERATURE FOR END OF RUN
- PRESSURE bar G
- HEAT DUTY MW
- STREAM NUMBER
- NNF: NORMALLY NO FLOW

500N CASE

MATERIAL BALANCE FOR 500N OPERATION CASE

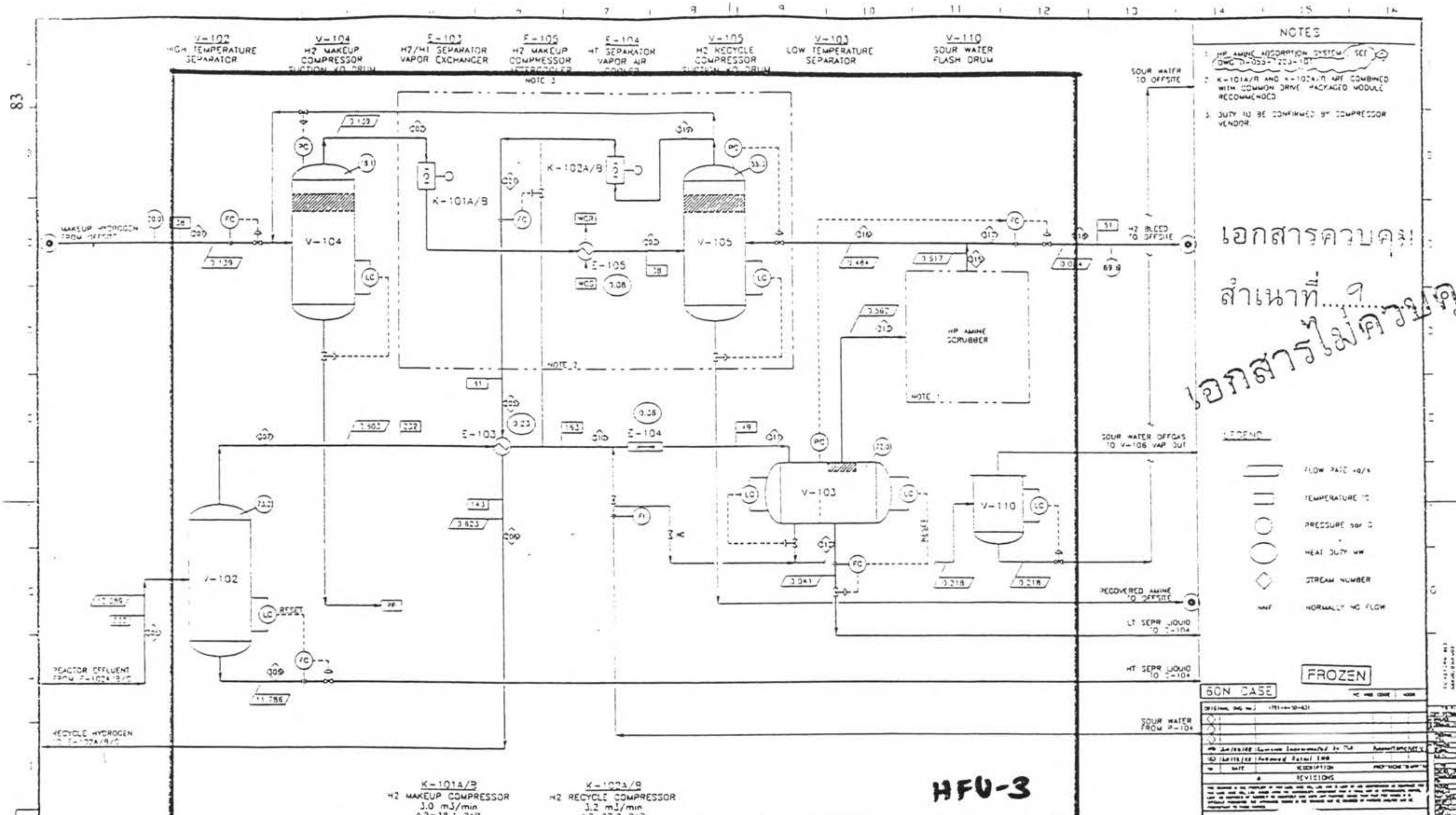
STREAM No		101	104	207	304
DESCRIPTION		RAFFINATE FROM BAT LIM	FEED PUMP P-101 SUCTION	COMB OIL-GAS TO RX FD-EFF EXCH E-102	RX EFFL L+V FR R-101 TO EX E-102
COMPONENT					
H2O	kg/s	0.000	0.000	0.000	0.000
H2	kg/s	0.000	0.000	0.179	0.154
H2S	kg/s	0.000	0.000	0.000	0.058
NH3	kg/s	0.000	0.000	0.001	0.001
C1	kg/s	0.000	0.000	0.093	0.107
C2	kg/s	0.000	0.000	0.130	0.126
C3	kg/s	0.000	0.000	0.100	0.094
C4	kg/s	0.000	0.000	0.094	0.094
C5+	kg/s	11.793	11.793	11.848	11.754
TOTAL	kg/s	11.793	11.793	12.415	12.389

PROCESS FLOW DIAGRAM
HYFINISHING UNIT 500L
FEED/REACTOR SYSTEM (500N)
THAI LUBE BASE COMPANY LIMITED
SRIRACHA LUBE BASE OIL PROJECT
SRIRACHA THAILAND

DATE 13 - SEP - 94 SCALE NONE

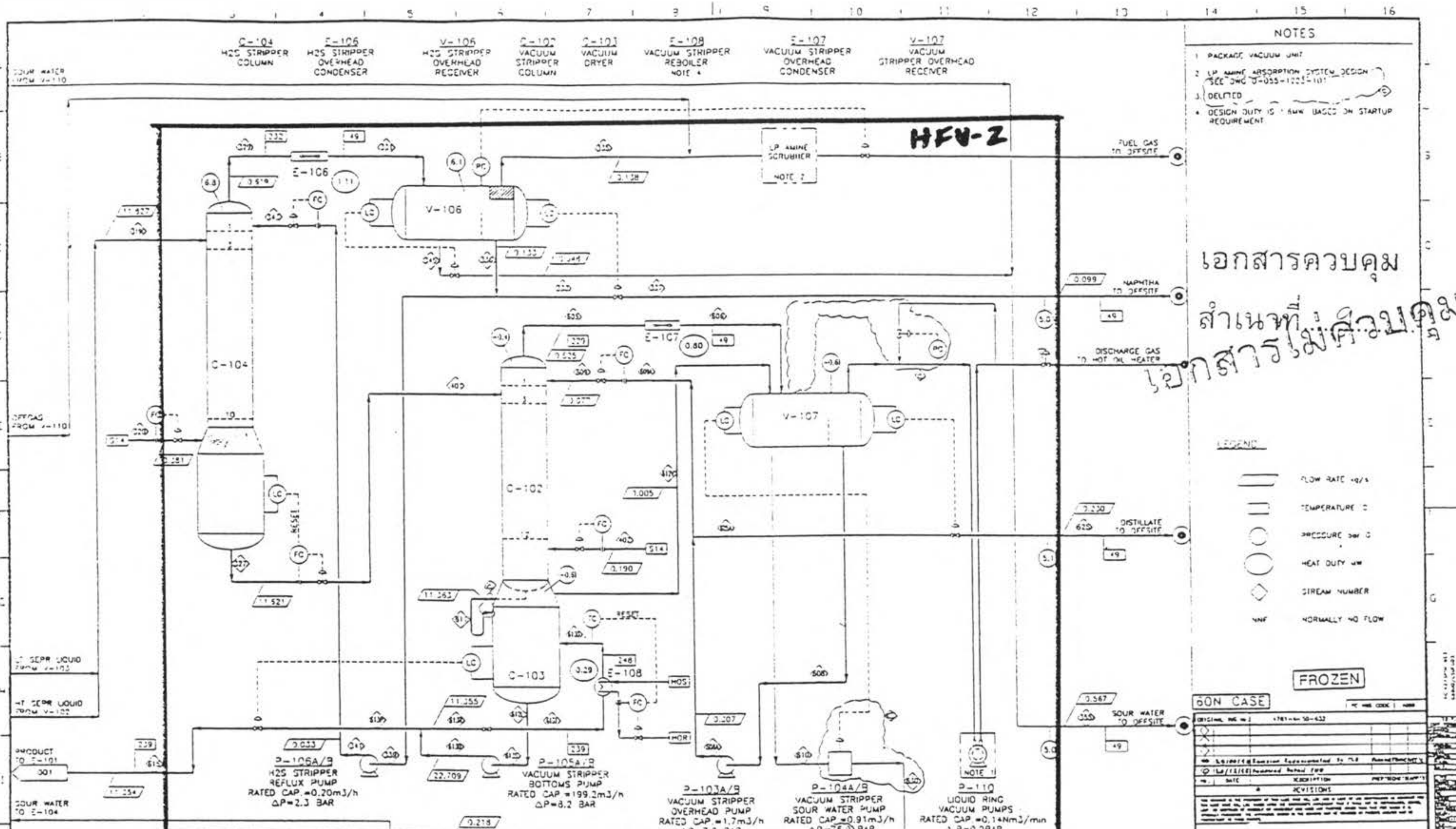
SARUHASHI T. SAITO M. OKADA

1 B



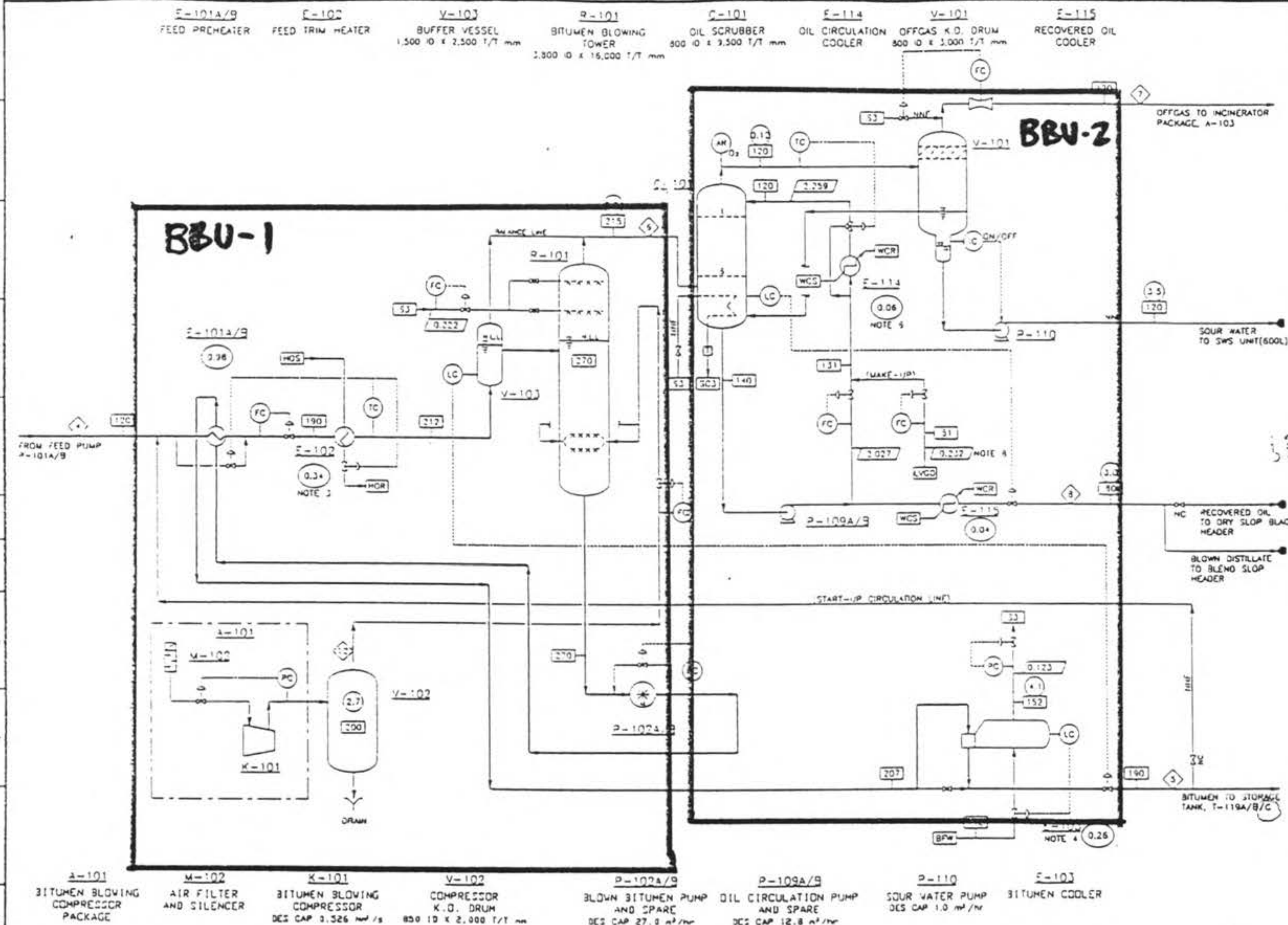
MATERIAL BALANCE FOR 50N OPERATION CASE

STREAM No.		201	202	206	207	210	211	212	216	219
COMPONENT	DESCRIPTION	MAKEUP GAS FROM BL TO SUCT KO V-104	MAKEUP GAS TO MU COMP K-101	LIQ FR HI T SEP V-102 TO H2S STR C-104	HIGH T SEP VAP TO E-103 H2-HTS V EX	HIGH T SEP OH FR E-103 TO AC E-104	LIQ FR LOW T SEP V-103 TO H2S STR C-104	LO T SEP VAP TO AMINE SCR C-104	REC GAS TO REC GAS COMP SUCT KO V-105	RECYCLE GAS COMP SUCT TO K-102
[illegible]	kg/s	0.000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.000
[illegible]	kg/s	0.043	0.043	0.008	0.146	0.146	0.0001	0.146	0.126	0.179
[illegible]	kg/s	0.000	0.0001	0.013	0.045	0.045	0.0001	0.044	0.0001	0.000
[illegible]	kg/s	0.000	0.0001	0.0001	0.001	0.001	0.0001	0.001	0.001	0.001
[illegible]	kg/s	0.010	0.010	0.009	0.098	0.098	0.0001	0.098	0.092	0.101
[illegible]	kg/s	0.027	0.027	0.022	0.103	0.103	0.009	0.103	0.096	0.123
[illegible]	kg/s	0.027	0.026	0.024	0.070	0.070	0.001	0.069	0.065	0.091
[illegible]	kg/s	0.014	0.014	0.013	0.062	0.062	0.002	0.060	0.056	0.072
[illegible]	kg/s	0.017	0.017	11.477	0.077	0.077	0.037	0.044	0.038	0.055
[illegible]	kg/s	0.129	0.129	11.786	0.603	1.603	0.041	0.562	0.484	0.623



MATERIAL BALANCE FOR 60N OPERATION CASE

STREAM No.		319C	320	327	329	335	336	342	345	407	505	508	509	510	511	512L	512V	512R
DESCRIPTION / COMPONENT		FEED TO H2S STRIPPER C-104	MP STEAM TO H2S STRIPPER C-104	H2S STR COL BTMS TO VAC STRIP C-102	GROSS OH VAP FROM H2S STR C-104	SOUR OFFGAS FR H2S STR OH REC V-106	LIQ DISTILL FR V-016 H2S STR OH REC	H2S STR OH REFLUX TO H2S STR C-104	SOUR WATER FR H2S STR OH REC V-106	MP STEAM TO VAC STRIPPER C-102	GROSS OH VAP FROM VAC STR C-107	LIQ DISTILL FR V-107 VAC STR OH REC	VAC STR OH REFLUX TO VAC STR C-102	SOUR WATER PUMP SUCT FR VAC STR OH REC	VAC STR BTM PROD TO VAC DRYER	VAC DRYER BTM LIQ TO P-105	VAC DRYER BTM VAP TO V-107	VAC STR BTM PUMP DISCH TO REB REGUL
H_2O	kg/s	0.000	0.281	0.031	0.350	0.002	0.000	0.000	0.348	0.190	0.218	0.000	0.000	0.218	0.003	0.002	0.002	0.001
H_2	kg/s	0.008	0.000	0.000	0.008	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
H_2S	kg/s	0.013	0.000	0.000	0.013	0.012	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NH_3	kg/s	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_1	kg/s	0.009	0.000	0.000	0.009	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_2	kg/s	0.023	0.000	0.000	0.023	0.022	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_3	kg/s	0.025	0.000	0.000	0.025	0.024	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_4	kg/s	0.035	0.000	0.000	0.036	0.030	0.006	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C_5+	kg/s	11.714	0.000	11.591	0.153	0.079	0.124	0.031	0.000	0.000	0.207	0.207	0.077	0.000	11.361	22.707	0.003	11.353
TOTAL	kg/s	11.427	0.281	11.623	0.619	0.138	0.133	0.033	0.348	0.190	0.425	0.207	0.077	0.218	11.363	22.709	0.005	11.355



NOTES

1. ALL EQUIPMENTS ON THIS DRAWING TO BE PREFIXED 4001, UNLESS SHOWN OTHERWISE.
2. STREAM FLOW RATES QUOTED ARE MINIMUM TO GIVE SYSTEM MASS BALANCE. BATCH TRANSFER OPERATION RESULTS IN HIGHER TRANSFER RATES.
3. FOLLOWING DESIGN CONDITIONS TO BE APPLIED TO E-102 TAKING START-UP OPERATION INTO CONSIDERATION
   - FEED INLET TEMP = 120°C
   - FEED OUTLET TEMP = 215°C
   - HEAT DUTY = 1.29MW
4. FOLLOWING DESIGN CONDITIONS TO BE APPLIED TO E-103 TAKING ALTERNATIVE FEED OPERATION INTO CONSIDERATION
   - BITUMEN INLET TEMP = 252°C
   - BITUMEN OUTLET TEMP = 190°C
   - HEAT DUTY = 0.97MW
   - GENERATION STEAM RATE = 0.461kg/s
5. BITUMEN SP GR. @25°C
6. FOLLOWING DESIGN CONDITIONS TO BE APPLIED TO E-114 TAKING OPERATIONAL FLEXIBILITY INTO CONSIDERATION
   - CIRC. OIL INLET TEMP = 140°C
   - CIRC. OIL OUTLET TEMP = 120°C
   - HEAT DUTY = 0.11MW
7. BRIGHTSTOCK EXTRACT IS USED FOR FEED BLENDING WITH THE FOLLOWING BLENDING RATIO.
   - PPA = 65%
   - BS EXTRACT = 35%
8. REPRESENTATIVE FLOW IS USED FOR DESIGN PURPOSE ONLY. ... MAKED-UP INTERMITTENTLY.

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LEGEND

- OPERATING TEMPERATURE (°C)
- STREAM NUMBER
- OPERATING PRESSURE (barG)
- HEAT DUTY (MW)
- TERMINATION OF LINES - FROM/TO STORAGE
- TERMINATION OF LINES - FROM/TO UNITS
- NC NORMALLY CLOSED
- NNF NORMALLY NO FLOW
- FLOW RATE (kg/s)

STREAM NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13
DESCRIPTION	PPA	EXTRACT (BRIGHT-STOCK)	FEED BLEND	FEED TO BLOWING	BLOWN BITUMEN	BLOWN OFF-GAS	SCRUBBED OFF-GAS	RECOVERED OIL	BITUMEN TO LOADING	BITUMEN TO ROAD CARS	BITUMEN TO DRUMMING	BLOWING AIR	LOADING RECYCLE
MASS FLOW kg/s	3.799	2.046	5.845	5.845	5.787	0.748	0.690	0.290	44.347	35.000	3.472	0.468	5.875
TEMPERATURE (°C)	190	70	120	120	190	215	120	30	190	190	190	200	190
PRESSURE (barG)	7.0	7.0	5.0			0.21	0.12	3.0				2.7	
SG AT 15.5°C (MW)	1.051	0.95-1.035	0.99-1.046	0.99-1.046	1.01-1.05	(28.0)	(24.0)	0.86	1.01-1.05	1.01-1.05	1.01-1.05	(28.4)	1.01-1.05
REMARKS	NOTE 2,7	NOTE 2,7	NOTE 2,7		NOTE 5				NOTE 5	NOTE 5	NOTE 5		NOTE 5

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สำเนาที่.....9..........

FROZEN

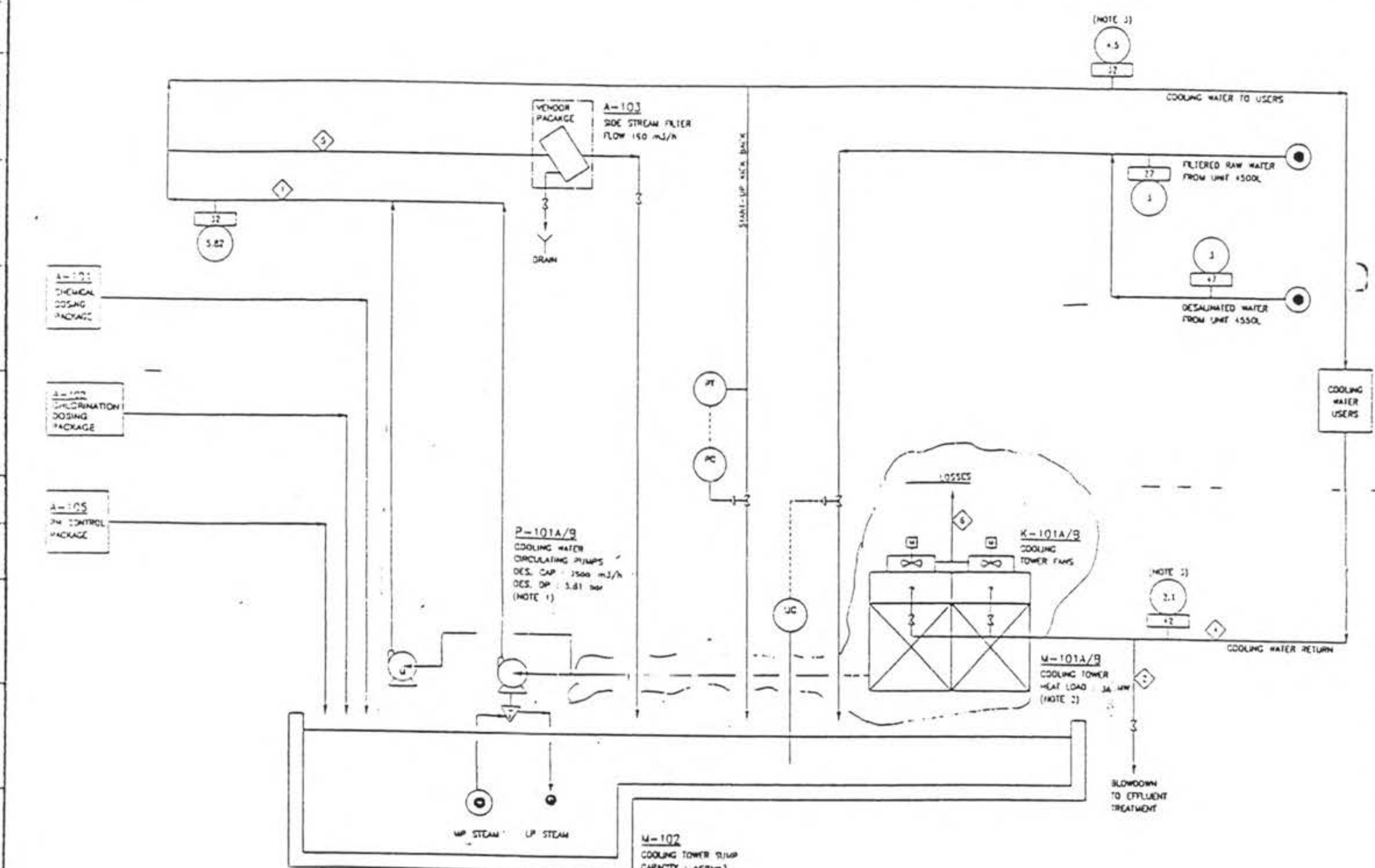
BITUMEN TRAIN No. 2

PROCESS FLOW DIAGRAM
BITUMEN UNIT 500L
BLOWING TOWER SECTION

201-1221 000-0 B

FILENAME: SCALE: 1/1
DATE, TIME:
PC NO.: BY:

COOLING WATER SYSTEM



NOTES:

1. THE STEAM TURBINE DRIVEN PUMP IS CONTINUOUSLY RUNNING WITH THE MOTOR DRIVEN PUMPS ON STAND-BY
2. TWO CELL COOLING TOWER UNIT OF CONCRETE CONSTRUCTION (MAIN CONTRACTOR TO CONFIRM.)
3. PRESSURE & TEMPERATURE AT USERS BATTERY LIMIT.
4. ALL PRESSURES REFERRED TO GRADE.
5. ALL VESSEL DIMENSIONS IN mm
6. ALL EQUIPMENT NOS. ARE PREFIXED AND BY "4700L-" FOR COOLING WATER.
7. CHEMICAL ADDITION CONNECTION.

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LEGEND

STREAM NUMBER

OPERATING PRESSURE (barG)

OPERATING TEMPERATURE (°C)

INPUT FROM PROCESS BATTERY LIMIT

OUTPUT TO PROCESS BATTERY LIMIT

NNF NORMALLY NO FLOW

THESE PROCESS DATA ARE FOR DESIGN PURPOSES ONLY. WHILE USEFUL AS A GUIDE TO OPERATION THEY DO NOT NECESSARILY REPRESENT EXACT OPERATING CONDITIONS.

FROZEN

REVISIONS

UT-1

FILE

PROCESS FLOW DIAGRAM
COOLING WATER UNIT 4700L

MATERIAL BALANCE

STREAM NUMBER			1	2	3	4	5	6
DESCRIPTION			CW SUPPLY	BLOW DOWN	CW MAKE-UP	CW RETURN	SIDE-FILTER	LOSSES
FLOW	[illegible]	m3/h	2912	16	67	2512	[illegible]	45
	[illegible]	m3/h	2748	16	67	2825	150	45
	[illegible]	m3/h	2417	16	67	2677	150	45
	[illegible]	m3/h	2714	16	67	2464	150	45
	[illegible]	m3/h	2150	16	67	[illegible]	150	45
TEMPERATURE (°C)			32	32	27/47	42	32	32
PRESSURE (barG)			5.8	5.8	3	2.1	5.8	-

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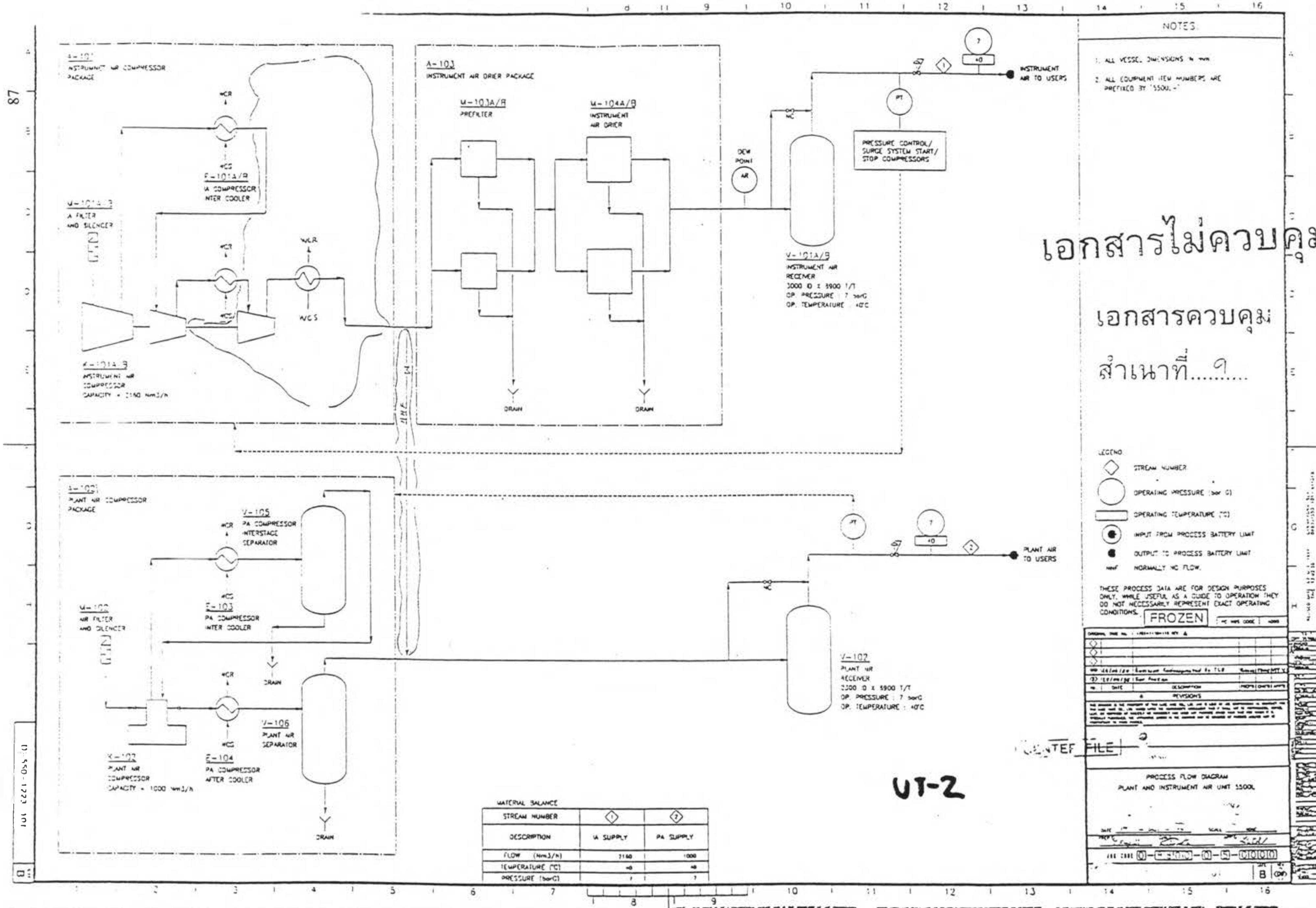

MATERIAL BALANCE

STREAM NUMBER	1	2
DESCRIPTION	IA SUPPLY	PA SUPPLY
FLOW (Nm3/h)	2160	1000
TEMPERATURE (°C)	40	40
PRESSURE (barG)	7	7

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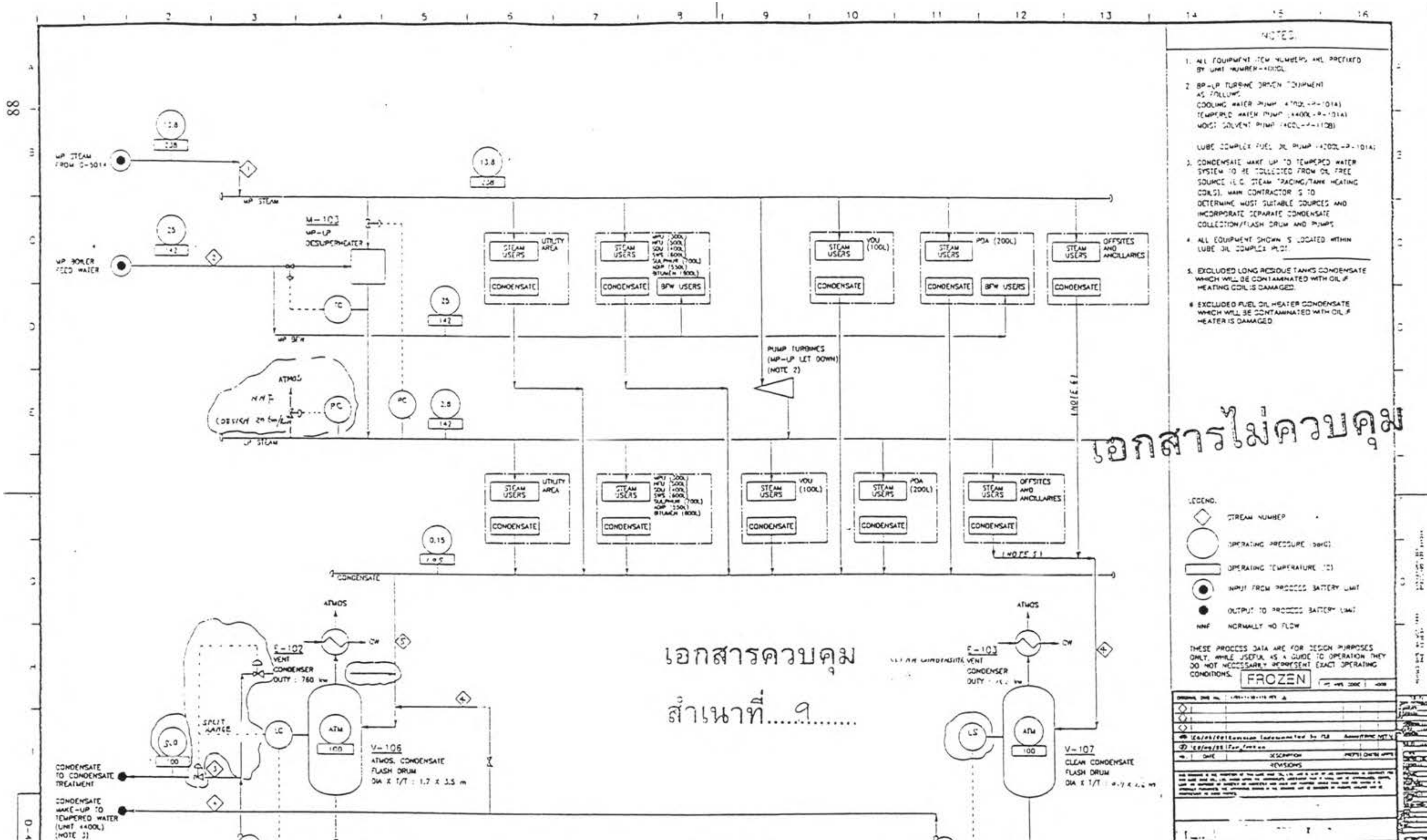
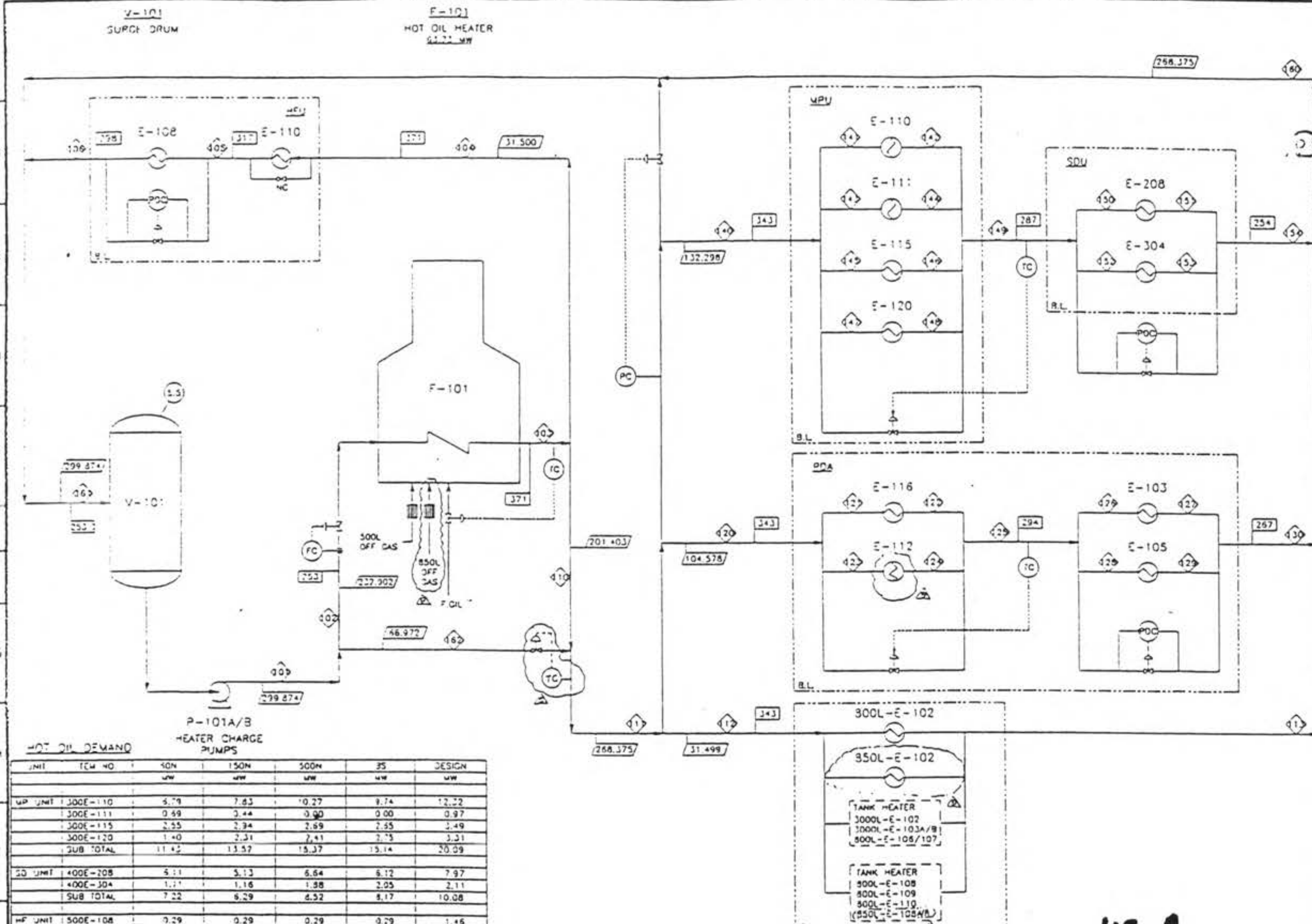


MATERIAL BALANCE

STREAM NUMBER			1	2	3	4	5
DESCRIPTION			MP STEAM FROM TURBINE GENERATOR	MP BFW	ATM. FLASH DRUM CONDENSATE	CLEAN CONDENSATE	ATM FLASH CONDENSATE FROM ON-SITE
FLOW	NOR	kg/h	49470	7750	11120	4260	17260
	150N	kg/h	49720	7750	11120	[illegible]	17160
	300N	kg/h	50490	7790	11340	[illegible]	17300
	150RS	kg/h	54150	7750	11120	[illegible]	17350
	DESIGN	kg/h	55000	10000	15000	7000	[illegible]
TEMPERATURE (°C)			238	142	100	100	105
PRESSURE (barG)			13.8	25	6	3	0.15



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NOTES

(1) HEATER DESIGN DUTY 64.00 MW

HOT OIL DEMAND

UNIT	ITEM NO	50N	150N	500N	3S	DESIGN
		MW	MW	MW	MW	MW
MP UNIT	300E-110	6.79	7.63	10.27	9.74	12.22
	300E-111	0.69	0.44	0.00	0.00	0.97
	300E-115	2.55	2.94	2.69	2.65	3.49
	300E-120	1.40	2.31	2.41	2.75	3.31
	SUB TOTAL	11.43	13.57	15.37	15.14	20.09
SD UNIT	400E-208	5.11	5.13	6.64	6.12	7.97
	400E-304	1.11	1.16	1.88	2.05	2.11
	SUB TOTAL	7.22	6.29	6.52	8.17	10.08
HF UNIT	500E-108	0.29	0.29	0.29	0.29	1.46
	500E-110	1.75	1.48	1.55	1.20	4.24
	SUB TOTAL	2.04	1.77	1.84	1.49	5.70
TANK						
BITUMEN	TOTAL	6.00	6.00	5.00	5.00	6.00
PDA UNIT	200E-103	2.18	2.18	2.18	2.18	5.32
	200E-105	1.04	1.04	1.04	1.04	1.36
	200E-112	9.90	9.90	9.90	9.90	10.54
	200E-116	0.13	0.13	0.13	0.13	0.13
	SUB TOTAL	13.25	13.25	13.25	13.25	17.35
	HEAT LOSS	5.00	6.00	5.00	6.00	6.00
HOT OIL TOTAL		[illegible]	[illegible]	[illegible]	[illegible]	65.22

UT-4

FROZEN

BITUMEN TRAIN NO.2

PROCESS FLOW DIAGRAM
HOT OIL BELT 540L

ORIGINAL DWG No. 1781-6-50-490

REVISIONS

JOB CODE 0-8800-0-5-0000

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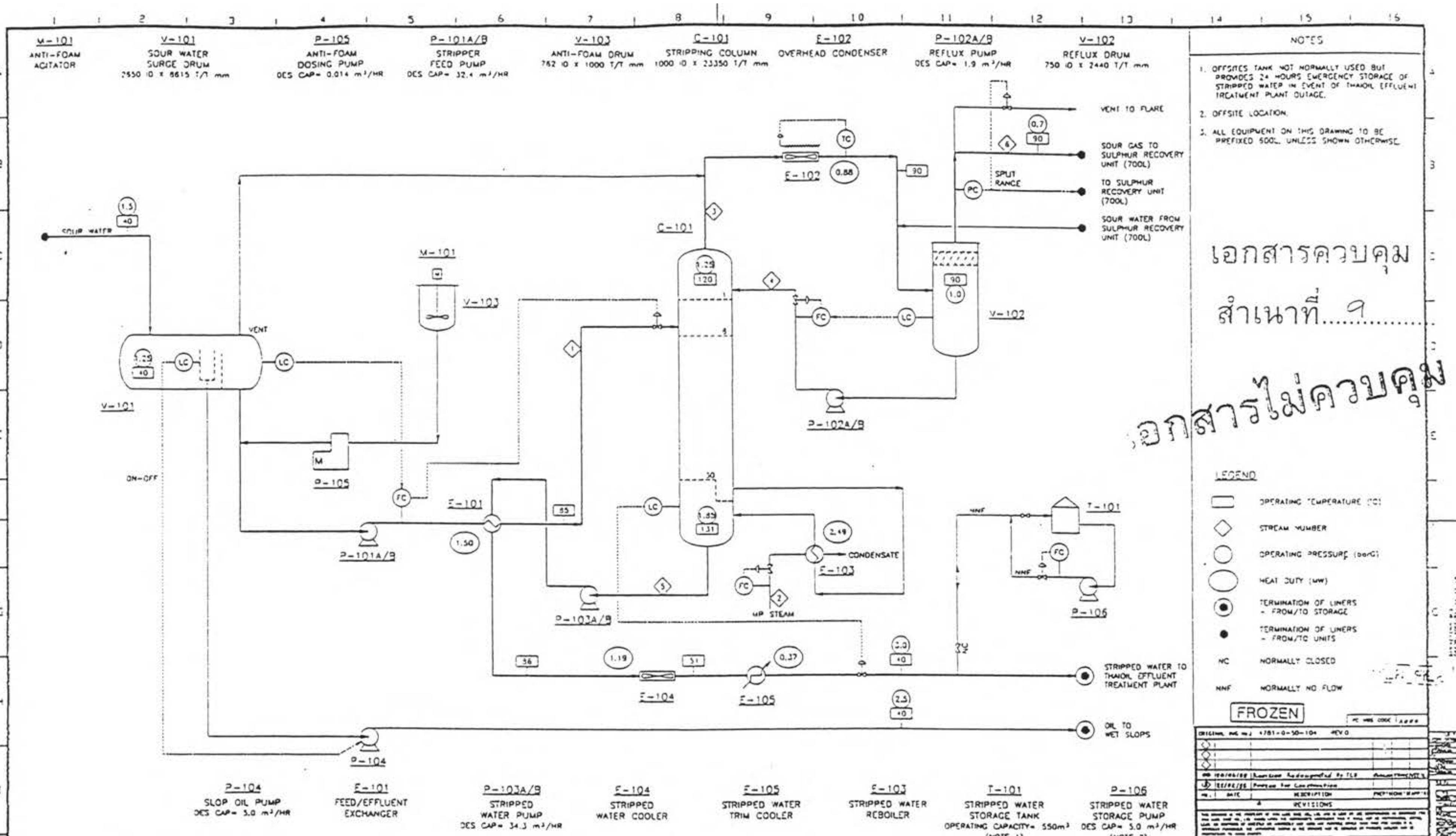

STREAM NUMBER		1	2	3	4	5	6
DESCRIPTION		STRIPPER TOTAL FEED	MP STEAM	STRIPPER OVERHEADS	REFLUX	STRIPPED WATER	SOUR GAS
MASS FLOW	kg/s	5.108	1.213	0.425	0.409	5.091	0.0160
	MT/sd	700.5	—	36.77	35.34	699.1	1.384
VOLUMETRIC	m³/s @15°×10³	5.120	—	—	0.435	5.100	—
FLOW	Nm³/s VAPOUR	—	—	0.513	—	—	0.0149
SG 15°/4° (MOL WT)		1.0	—	(18.60)	0.94	1.0	(24.11)
H2S kg/s ×10⁻⁶		9080	—	32464	23464	81	8999
NH3 kg/s ×10⁻⁶		3892	—	32964	29654	586	3305
TEMPERATURE (°C)		85	—	120	90	131	90
PRESSURE (barG)		1.92	—	1.25	1.00	1.85	1.00
REMARKS							

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Appendix K

The calculation of Risk Priority Number

Potential Failure Mode No. 1: *VDU Heater's efficiency is low*

Severity ranking

Assumptions

1. %Oxygen excess is increased from 3% to 5%

2. Heat of combustion of fuel oil = 42,000 kJ/kg

3. Flue gas temperature = 350 °C

From BP combustion guide chapter 6;

Table K-1

% of excess O2	*5%*	*3%*
%Excess air	30%	15%
% Efficiency	84.20%	86.60%
Fuel oil used (TPD)	21.9	21.3

Cost estimation

Different fuel oil used	=	0.6	Ton/day
	=	18	Ton/month
Fuel oil price	~	200	USD/Ton
Cost to be saved	~	3,600	USD/Month
	~	144,000	Baht/Month

From Table 3.5, *Severity Rank* = *6*

Occurrence Ranking

The process record shows that around 50% of the percent of excess Oxygen from the VDU's heater flue gas is around 5%.

From Table 3.6, *Occurrence Rank* = *7*

Detection Ranking

In the process control system, the percent of excess Oxygen from the furnace has indicated in the control room that can be monitored by process operator all the time.

From Table 3.7, *Detection Rank* = *2*

RPN = *6 x 7 x 2*

= *84*

Potential Failure Mode No. 2: *Hot oil Heater's efficiency is low*

Severity ranking

Assumptions

1. %Oxygen excess is increased from 3% to 5%

2. Heat of combustion of fuel oil = *42,000 kJ/kg*

3. Flue gas temperature = *380 °C*

From BP combustion guide chapter 6;

Table K-2

%O2	*7.5%*	*3.0%*
%Excess air	50%	15%
% Efficiency	78.00%	84.00%
Fuel oil used (TPD)	113	104.9

Cost estimation

Different fuel oil used	=	8.07	Ton/day
	=	242.1	Ton/month
Fuel oil price	~	200	USD/Ton
Cost to be saved	~	48,428.6	USD/Month
	~	1,937,143	Baht/Month

From Table 3.5, *Severity Rank* = *9*

Occurrence Ranking

The process record shows that the percent of excess Oxygen from the hot oil's heater flue gas is around 7.5% all time.

From Table 3.6, *Occurrence Rank* = *10*

Detection Ranking

In the process control system, the percent of excess Oxygen from the furnace has indicated in the control room that can be monitored by process operator all the time.

From Table 3.7, *Detection Rank* = *2*

RPN = *9 x 10 x 2*

= *180*

Potential Failure Mode No. 3: *Excess stripping steam (Sour water stripping unit)*

Severity ranking

Assumptions

1. Ratio of steam used in stripping and sour water flow is increased from 1:10 to 1:9

2. Sour water's flow rate = 400 TPD

3. Water treatment cost = 40 Baht/ton

Table K-3

Ratio	1:10	1:9
Steam used (TPD)	40	44.44

Loss of steam from over stripping = 4.44 Ton/day

Cost of loss of steam ~ 73,000Baht/month

Cost of additional water treatment ~ 5,300 Baht/month

Total additional cost ~ 78,300Baht/month

From Table 3.5, *Severity Rank* = *5*

Occurrence Ranking

From the control record, the steam and sour water ratio is out of control around 30%.

From Table 3.6, *Occurrence Rank* = *6*

Detection Ranking

In the process control system, the ratio of steam and sour water has indicated in the control room that can be monitored by process operator all the time.

From Table 3.7, *Detection Rank* = *2*

RPN = *5 x 6 x 2*

= *60*

Potential Failure Mode No. 4: *Failure of steam traps*

Severity ranking

Assumption

Estimated steam loss from steam trap = *2* *Ton/hour*

Steam price	=	550	Baht/ton
Estimated cost saving	=	26,400	Baht/day
	=	792,000	Baht/month

From Table 3.5, *Severity Rank* = *7*

Occurrence Ranking

From the steam trap surveying, the steam trap is not working around 25%.

From Table 3.6, *Occurrence Rank* = *5*

Detection Ranking

The steam trap working can not be visually checked and there is not any indicator to inform the responsible people to know its status. In order to check the working of steam trap, the surveying by inspection team is needed. So, the detection on the working of steam trap is low.

From Table 3.7, *Detection Rank* = *6*

RPN = *7 x 5 x 6*

= *210*

Potential Failure Mode No. 5: *One side of the dewaxing filters does not need lighting all the time.*

Severity ranking

Assumption: The lighting at spay nozzle side is used around 20% of the wax boot side.

Table K-4

	Before modification	*After modification*
Total elec. Used for the filter lighting. (kWH/M)	12,960	6,480
Electricity (Baht/Month)	25,920	12,960
Bulb cost (Baht/month)	8,100	4,050
Total cost (Baht/month)	46,980	23,490

Cost can be saved = 17,010 Baht/month

From Table 3.5, *Severity Rank* = *4*

Occurrence Ranking

This potential failure mode is occurred because of the design of the process does not provide the separation switch to separately control the lighting of both side of the filter.

From Table 3.6, *Occurrence Rank* = *10*

Detection Ranking

The occurrence of this failure mode can be checked by the technicians who work at the local and can not be detected from control room. The technicians are assigned to check the area every 6 hours, so, it can be said that the detection of this failure mode is very low.

From Table 3.7, *Detection Rank*	=	*7*
RPN	=	*4 x 10 x 7*
	=	*280*

Potential Failure Mode No. 6: *The compressed air from the compressor is excess and always blown to atmosphere.*

Severity ranking

Energy consumed from the air compressors when both compressors are run to support two units.

800L-K-101	=	150	kW (normal operation at 88% of full load)
850L-K-101	=	231	kW (normal operation at 88% of full load)

Energy consumed when 850L-K-101 is run to support two units.

850L-K-101	=	262.5	kW (100% of full load)

Energy reduced	=	150 – (262.5 – 231)	kW
	=	118.5	kW
Electricity price	=	2.0	Baht/kWh
Estimated energy cost saving	=	5,688	Baht/day
	=	170,640	Baht/month

Note The pay back time is depended on the running capacity of the bitumen units in case of the total production is less than 1,000 TPD.

From Table 3.5, *Severity Rank*	=	*6*

Occurrence Ranking

This potential failure mode is occurred because of the design of the process.

From Table 3.6, *Occurrence Rank* = *10*

Detection Ranking

The occurrence of this failure mode can be checked by using the indicator of the flow of the compressed air vented to atmosphere in the control room all the time.

From Table 3.7, *Detection Rank* = *2*

RPN = *6 x 10 x 2*

= *120*

Potential Failure Mode No. 7: *The compressed air from the compressor is excess and always blown to atmosphere.*

Severity ranking

It is estimated that the if the vented air from the compressor can be eliminated the current will be reduced from 60 Amp. to 50 Amp.

Due to the reduction of the current; power used will also be reduced from 22.8 kW to 19 kW.

Electricity price	=	2.0	Baht/kWh
Estimated energy cost saving	=	5,472	Baht/month

From Table 3.5, *Severity Rank* = *3*

Occurrence Ranking

This potential failure mode is occurred because of the design of the process.

From Table 3.6, *Occurrence Rank* = *10*

Detection Ranking

The occurrence of this failure mode can be checked by using the indicator of the % opening of the air-vented line in the control room all the time but the indicator is more difficult to monitor than the potential failure mode No.6

From Table 3.7, *Detection Rank*	=	*3*
RPN	=	*3 x 10 x 3*
	=	*90*

Potential Failure Mode No. 8: *The temperature of cooling water supply is lower than designed value.*

Severity ranking

The cooling water supply temperature is increased to 31.9 C when one cooling fan is switched to low speed mode.

Energy reduced	=	122.5 – 80.6	kW
	=	41.9	kW
Electricity price	=	2.0	Baht/kWh
Estimated energy cost saving	=	2,011.2	Baht/day
	=	60,336	Baht/month

From Table 3.5, *Severity Rank* = *5*

Occurrence Ranking

This potential failure mode is occurred because of the design of the process.

From Table 3.6, *Occurrence Rank* = *10*

Detection Ranking

The occurrence of this failure mode can be checked by using the indicator of the motor status in the control room all the time.

From Table 3.7, *Detection Rank* = *2*

RPN	=	*5 x 10 x 2*
	=	*100*

Potential Failure Mode No. 9: *The temperature outlet of AFC is controlled by using by-pass valve.*

<u>Severity ranking</u>

There are three temperature controllers use the control valves and the electricity power used for these AFC are shown below.

200L-E-107	=	193.6	kW
200L-E-114	=	16.4	kW
300L-E-116	=	40	kW
Total	=	250	kW

The estimated of power loss is 10% of the total power used

Estimated power loss	=	25	kW
Electricity price	=	2.0	Baht/kWh
Estimated energy cost saving	=	1,200	Baht/day
	=	36,000	Baht/month

From Table 3.5, *Severity Rank* = *4*

<u>Occurrence Ranking</u>

This potential failure mode is occurred because of the design of the process.

From Table 3.6, *Occurrence Rank* = *10*

<u>Detection Ranking</u>

The occurrence of this failure mode can be checked by using the indicator of the control valve in the control room all the time.

From Table 3.7, *Detection Rank*	=	*2*
RPN	=	*4 x 10 x 2*
	=	*80*

Potential Failure Mode No. 10: *MP steam is letdown to LP steam with the rate of 4 - 5 TPH constantly.*

Severity ranking

Basis

1. *When all of steam turbines except 4700L are running, the MP steam still let down to LP steam around 4 TPH.*
2. *Steam turbine consuming MP steam 4 TPH provides power at the same as 112 kW motor.*
3. *Electricity price = 2.0 Baht/kWh*

If modify an additional steam turbine that consumes MP steam at around 4 TPH

The electricity cost will be reduced = 5,376 Baht/day

= 161,280 Baht/month

From Table 3.5, *Severity Rank* = *6*

Occurrence Ranking

This potential failure mode is occurred because of the design of the process.

From Table 3.6, *Occurrence Rank* = *10*

Detection Ranking

The occurrence of this failure mode can be checked by using the opening percent indicator of the let down control valve in the control room all the time.

From Table 3.7, *Detection Rank* = *2*

RPN = *6 x 10 x 2*

= *120*

Potential Failure Mode No. 11: *Too low product run down temperature*

Severity ranking

Basis

1. Electricity price = 2.0 Baht/kWh

2. Product rundown's temperature = 90 C.

Table K-5

[redacted]	*Actual power (kW)*	*Expected power (kW)*	*Cost saving (/Month)*
1 100L-E-112	15.3	7.8	10,800
2 100L-E-113	4.4	2.53	2,692.8
3 100L-E-115	37.5	32.2	7,660.8
		Total	***21,153.6***

From Table 3.5, *Severity Rank* = *4*

Occurrence Ranking

This potential failure mode is occurred because of the design of the process.

From Table 3.6, *Occurrence Rank* = *10*

Detection Ranking

The occurrence of this failure mode can be monitored by the temperature indicator of the rundown product in the control room all the time.

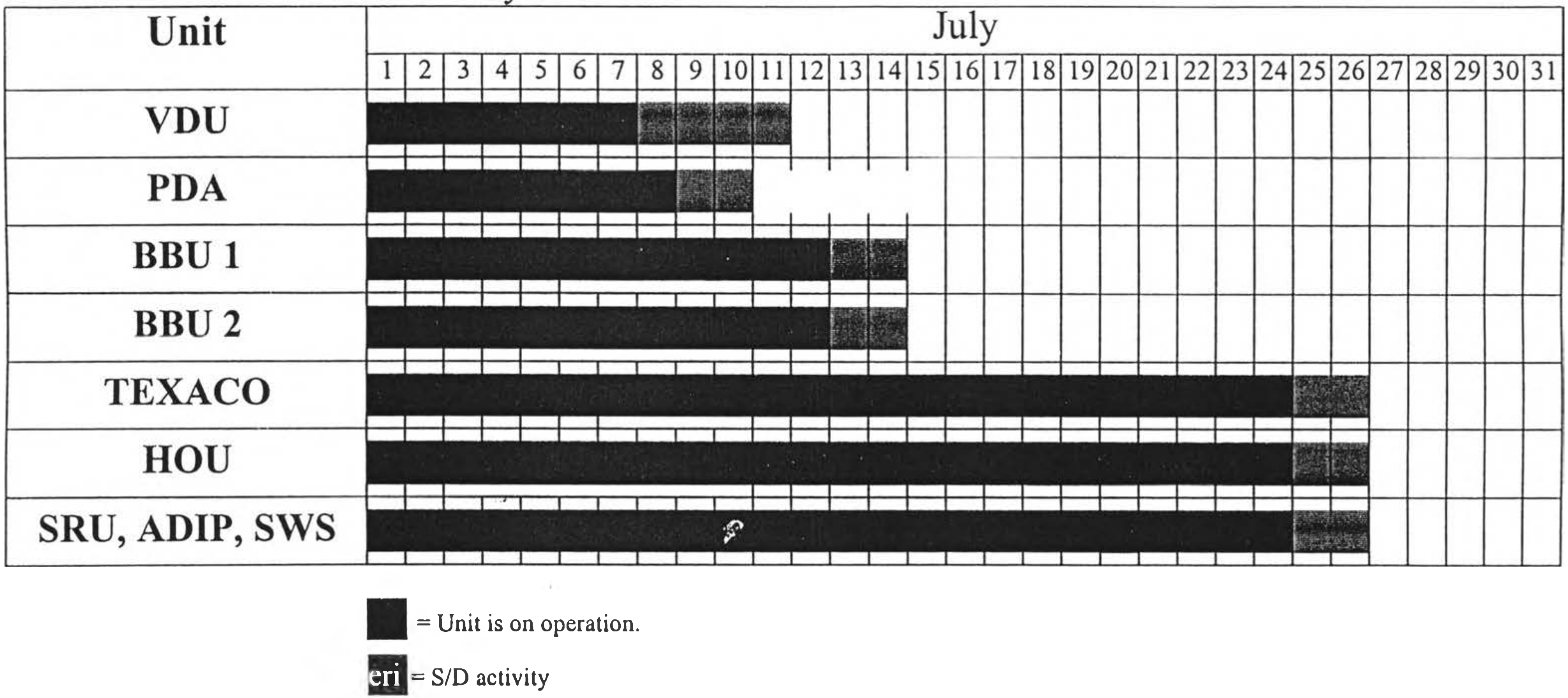
From Table 3.7, *Detection Rank* = *2*

RPN = *4 x 10 x 2*

= *80*

Appendix L

Plant's shut down schedule July 2001



Appendix M

Energy Intensity Index (EII) Calculation

Table M-1: Capacity and utilization before the actions' implementation

Unit Name	Total Capacity	Feed	Operation Hours	Operation Ratio	Each Mode Capacity	Nominal Solvent/Oil Ratio	Actual Processing	Actual Production	**Percent Capacity Utilized**	C.F.	EDC	**UEDC**	Energy Standard	Energy Standard
	BPSD		Hours	%	BPD	wt basis	BPD	BPD	%	-	KB/D	KB/D	KBTU/B	MBTU/D
Bitumen Manufacture BBU	7,341				7,341	-	5,072		69.09				115	**583**
Solvent Dewaxing SDU		*** On Production Basis**												
	5,460	60N	0	0.0	6,195	0.0		0		20.0	109	**69**	570.7	**1,961**
		150N	0	0.0	5,981	0.0		0						
		500N	180	65.2	5,792	3.7		3,467						
		150BS	96	34.8	4,836	4.2		3,377						
		Total	276	100.0				3,436	**62.9**					

Table M-2: Capacity and utilization after the actions' implementation

Unit Name	Total Capacity	Feed	Operation Hours	Operation Ratio	Each Mode Capacity	Nominal Solvent/Oil Ratio	Actual Processing	Actual Production	**Percent Capacity Utilized**	C.F.	EDC	**UEDC**	Energy Standard	Energy Standard
	BPSD		Hours	%	BPD	wt basis	BPD	BPD	%	-	KB/D	KB/D	KBTU/B	MBTU/D
Bitumen Manufacture BBU	7,341				7,341	-	5,600		76.28				115	**644**
Solvent Dewaxing SDU		*** On Production Basis**												
	5,653	60N	0	0.0	6,195	0.0		0		20.0	113	**90**	541.1	**2,448**
		150N	216	31.0	5,981	2.5		5,027						
		500N	336	48.3	5,792	3.9		4,782						
		150BS	144	20.7	4,836	4.2		3,172						
		Total	696	100.0				4,525	**80.0**					

Table M-3: EII Calculation

	Before implementation		*After implementation*	
Unit	SDU	BBU	SDU	BBU
Fuel oil (Ton/day)	18.0		19.9	
MP steam (Ton/day)	0.0	11.5	0.0	17.4
LP steam (Ton/day)	44.9	23.6	41.5	19.1
Electricity (KWH/D)	116,666	9063.23	105,216	5,038.45
Tatal Actual Consumption (foeKL/D)	34.1	3.3	35	3.1
Tatal Actual Consumption (MBTU/D)	1,272	124	1,304	114
Standard (MBTU/D)	1,961	583	2,448	644
EII	***65***	***21***	***53***	***18***

Note

1. Fuel oil latent heating value = 10,562 Kcal/ton
2. To convert electricity to foeL ; 1 foeL = kWh x 3,600/4.19/9,400
3. To convert steam to foeL ; 1 foeL = kg(steam) x 670/9,400

Appendix N

Equipment figures

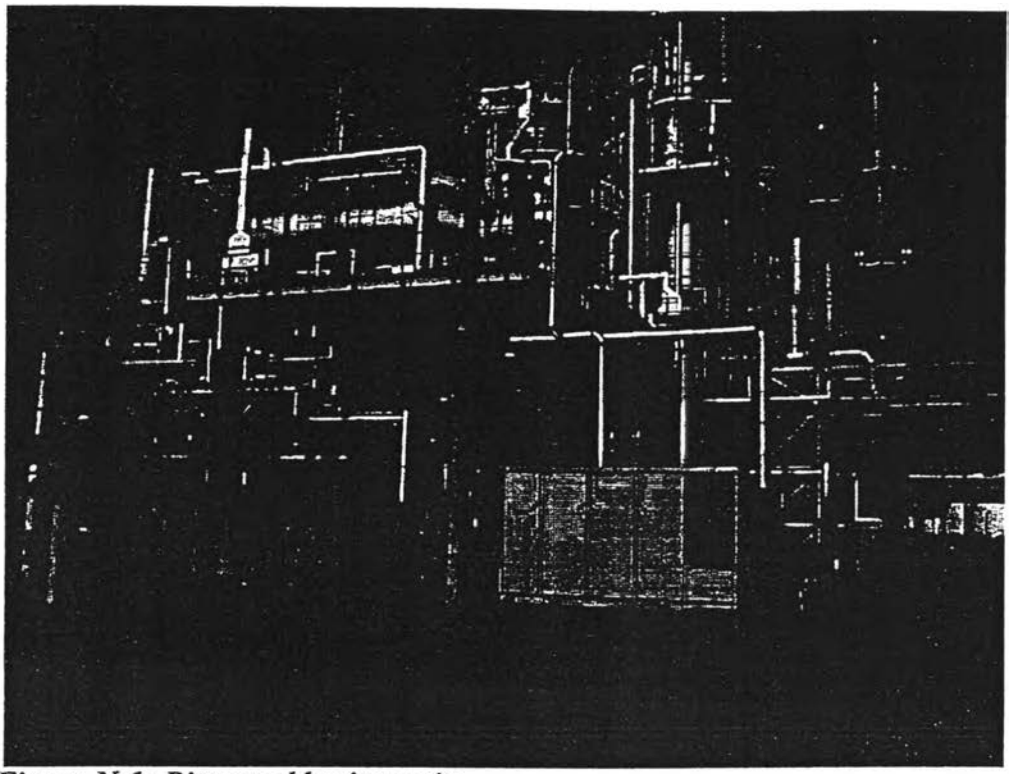


Figure N-1: Bitumen blowing units

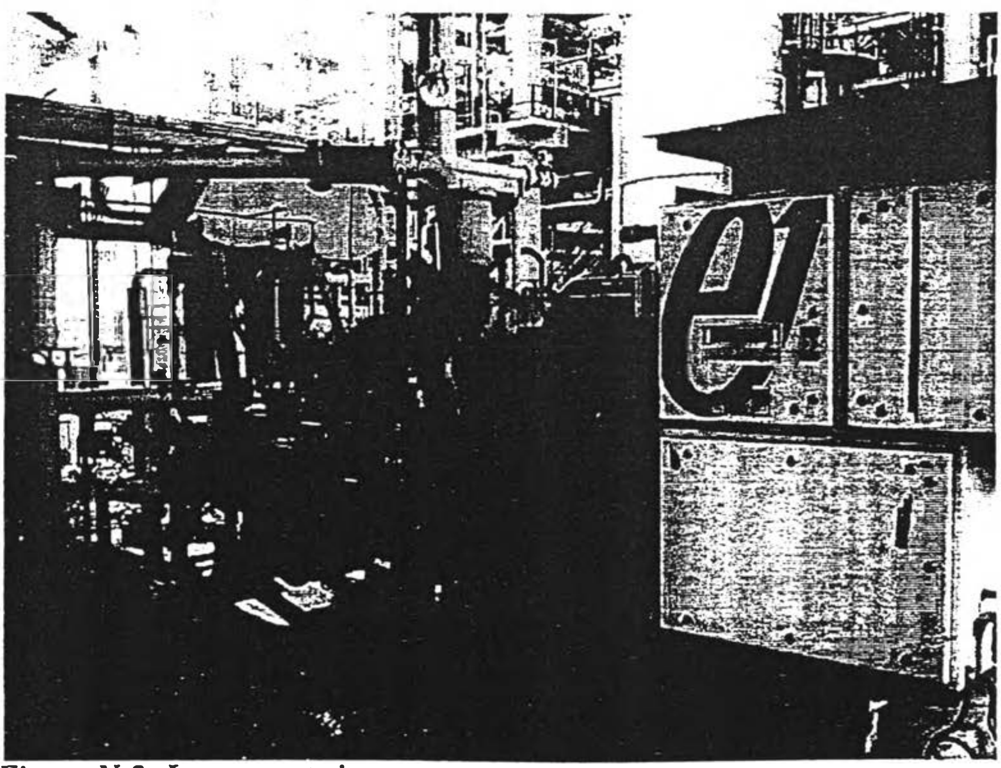


Figure N-2: Instrument air compressor

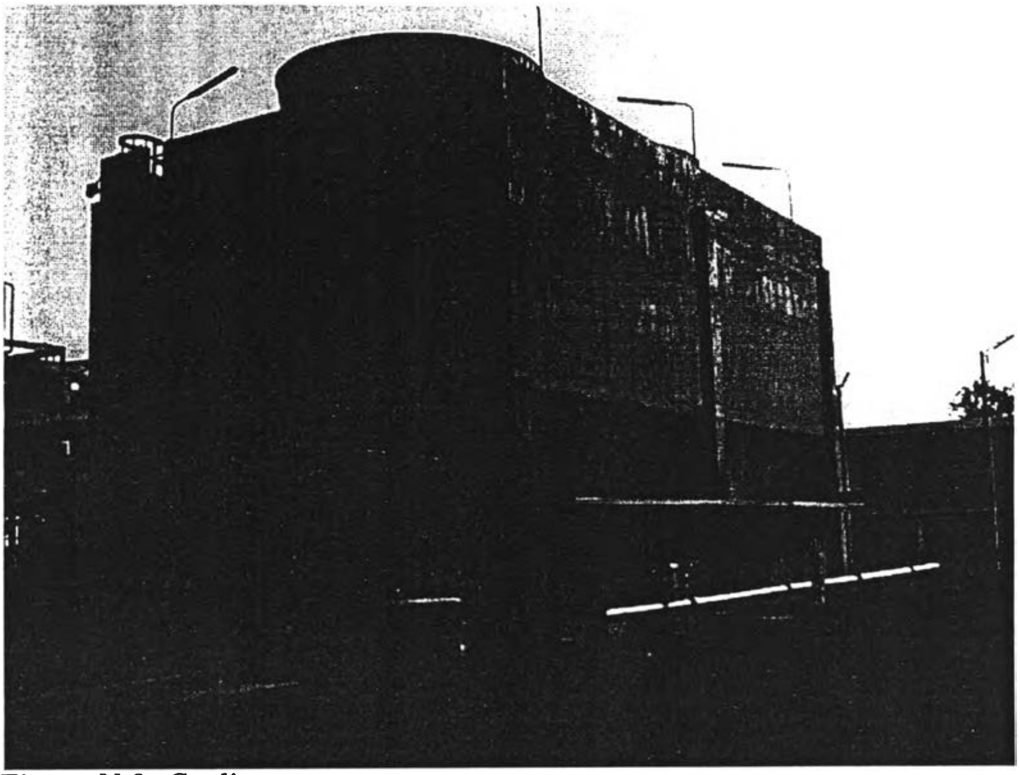


Figure N-3: Cooling water system

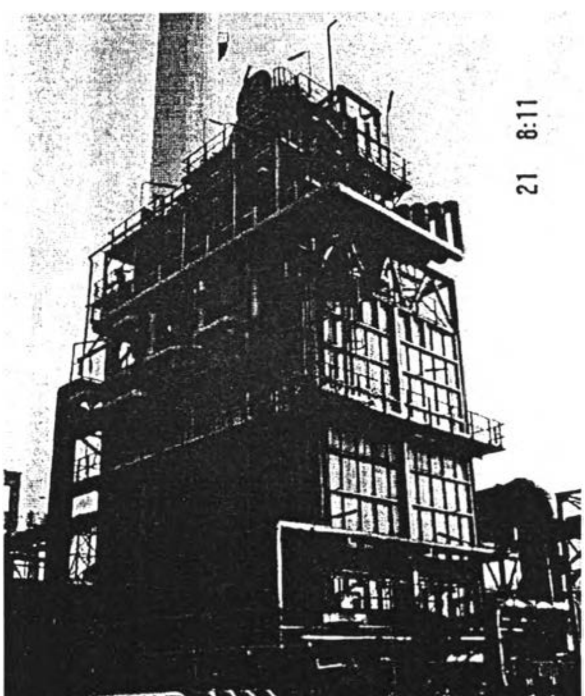


Figure N-4: Oil furnace

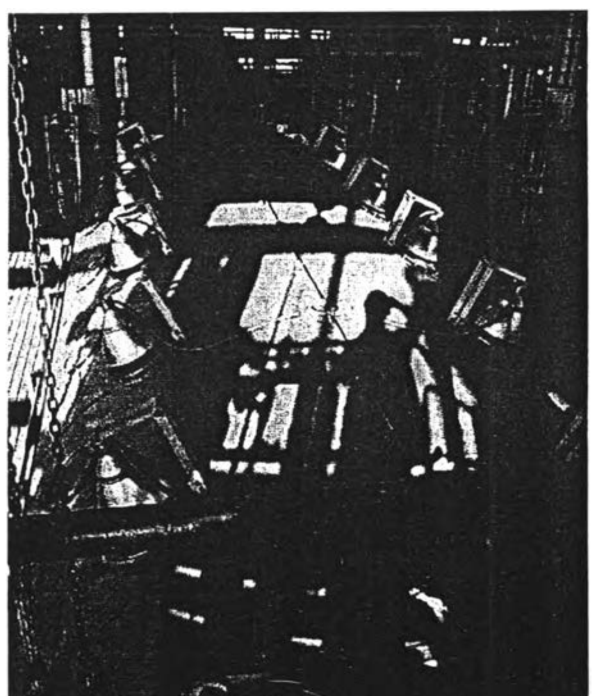


Figure N-5: Dewaxing filter

Biography

Non Siriprapapornchai was born on the October, 28, 1974 in Chonburi. He obtained his B.Eng. on Chulalongkorn University (Chemical Enginering) in 1995. He pursues a further study in a Master Degree course at the Regional Centre for Manufacturing Systems Engineering, Faculty of Engineering, Chulalongkorn University.