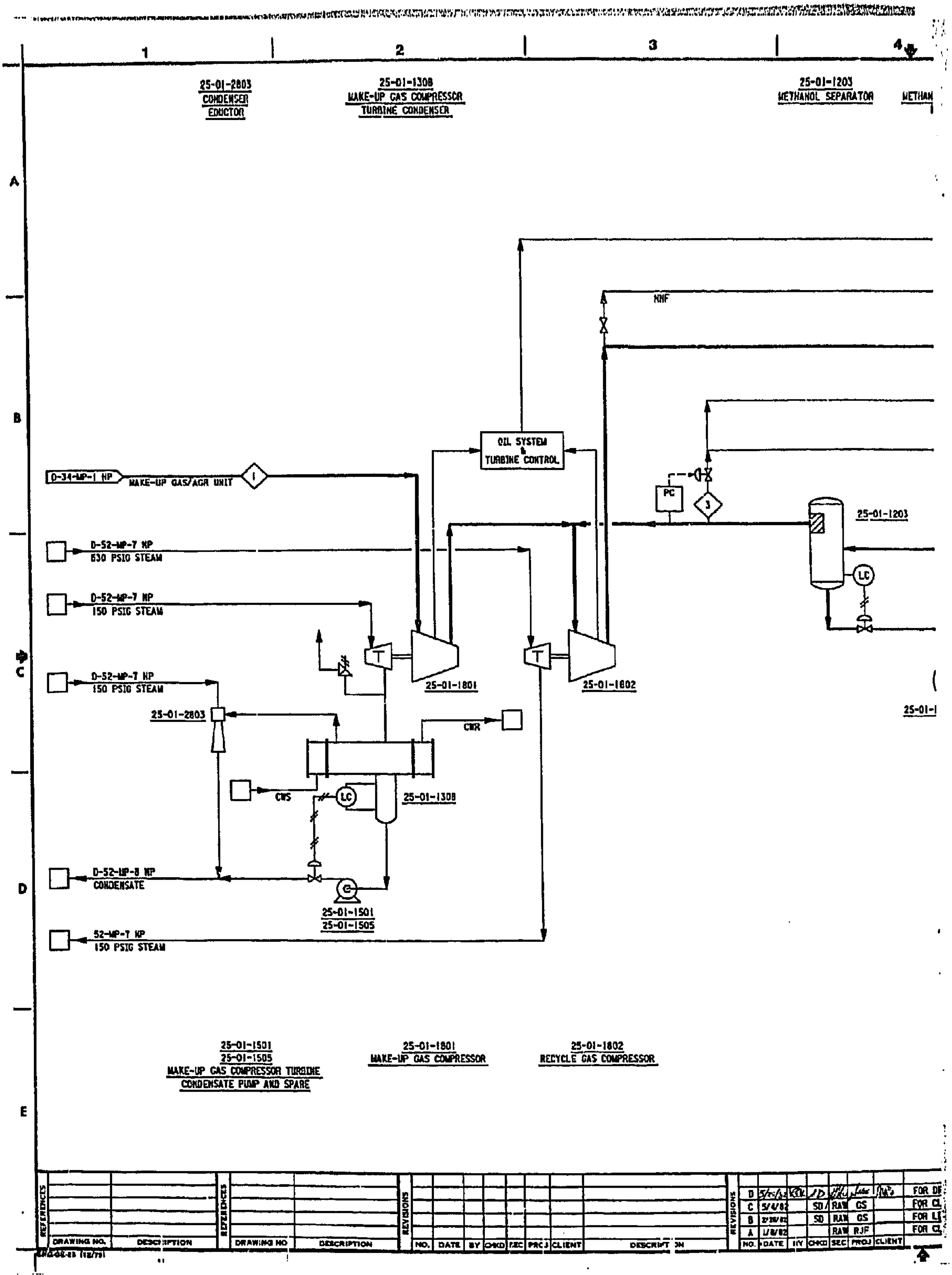
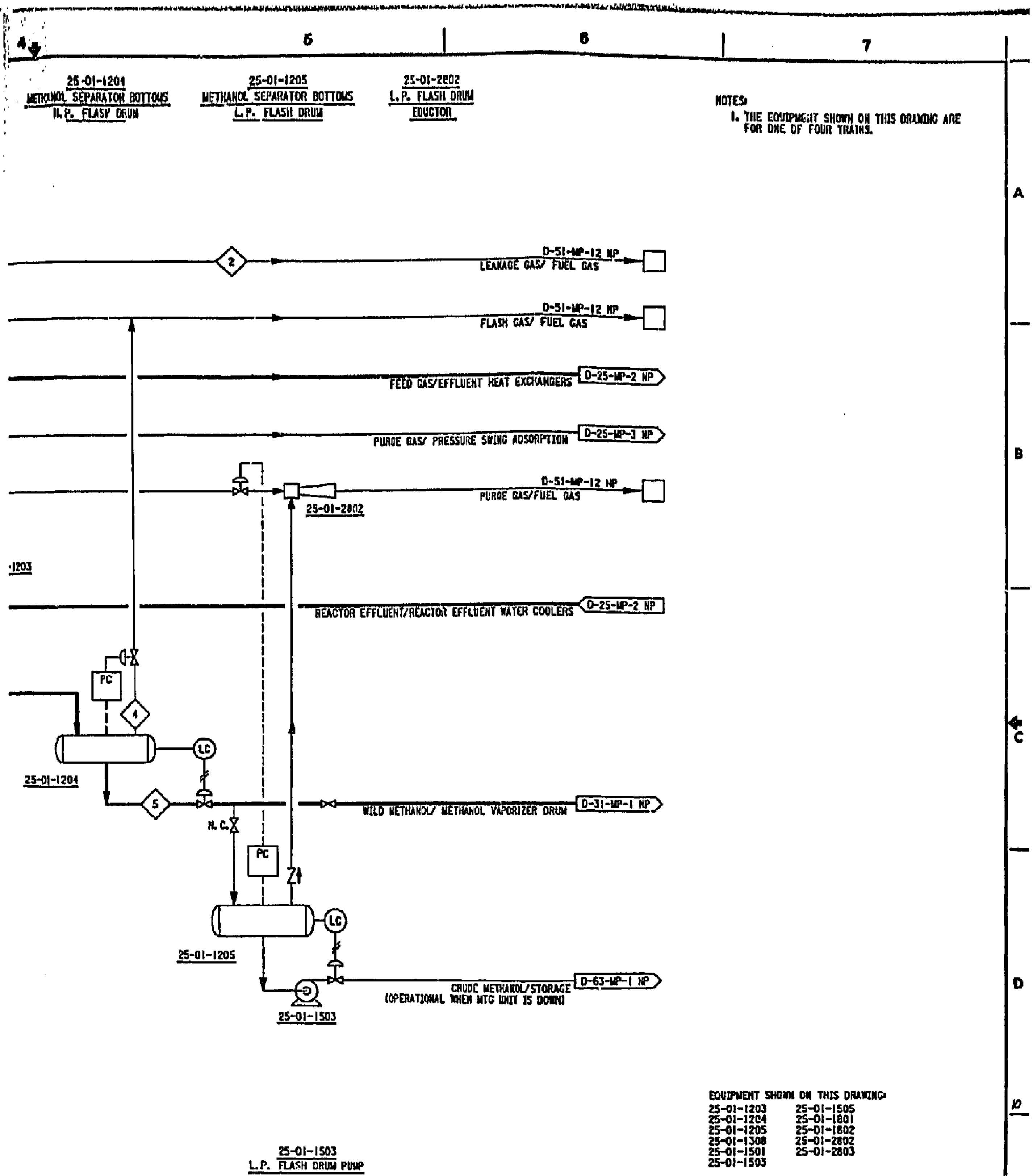


1
2
3
4
A
B
C
D
E
25-01-2803
CONDENSER
EDUCTOR
25-01-1308
MAKE-UP GAS COMPRESSOR
TURBINE CONDENSER
25-01-1203
METHANOL SEPARATOR
METHAN
NNF
OIL SYSTEM
&
TURBINE CONTROL
D-34-MP-1 HP
MAKE-UP GAS/AGR UNIT
1
PC
3
25-01-1203
LC
D-52-MP-7 HP
630 PSIG STEAM
D-52-MP-7 HP
150 PSIG STEAM
T
T
25-01-1801
25-01-1802
D-52-MP-7 HP
150 PSIG STEAM
25-01-2803
CWR
25-01-
CWS
LC
25-01-1308
D-52-MP-8 HP
CONDENSATE
25-01-1501
25-01-1505
52-MP-7 HP
150 PSIG STEAM
25-01-1501
25-01-1505
MAKE-UP GAS COMPRESSOR TURBINE
CONDENSATE PUMP AND SPARE
25-01-1801
MAKE-UP GAS COMPRESSOR
25-01-1802
RECYCLE GAS COMPRESSOR
REFERENCES
DRAWING NO.
DESCRIPTION
REFERENCES
DRAWING NO
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
REVISIONS
D
C 5/4/82 SD RAW GS
B SD RAW GS
A RAW RJF
NO. DATE BY CHKD SEC PROJ CLIENT
FOR DE
FOR CL
FOR LE
FOR CL




NOTES:

1. THE EQUIPMENT SHOWN ON THIS DRAWING ARE FOR ONE OF FOUR TRAINS.

EQUIPMENT SHOWN ON THIS DRAWING:

| | |
|---|---|
| 25-01-1203 | 25-01-1505 |
| 25-01-1204 | 25-01-1801 |
| 25-01-1205 | 25-01-1802 |
| 25-01-1308 | 25-01-2802 |
| 25-01-1501 | 25-01-2803 |
| 25-01-1503 | |

D25MP1NP.DGA

LURGI — Lurgi Kohle und Mineraloeltechnik GmbH

| | |
|---|---|
| FOR DESIGN REPORT | |
| FOR CLIENT APPROVAL | |
| FOR LICENSOR APPROVAL | |
| FOR CLIENT 50% REVIEW | |
| DESCRIPTION | |

RMP — THE RALPH M. PARSONS COMPANY, PASADENA, CALIFORNIA

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY

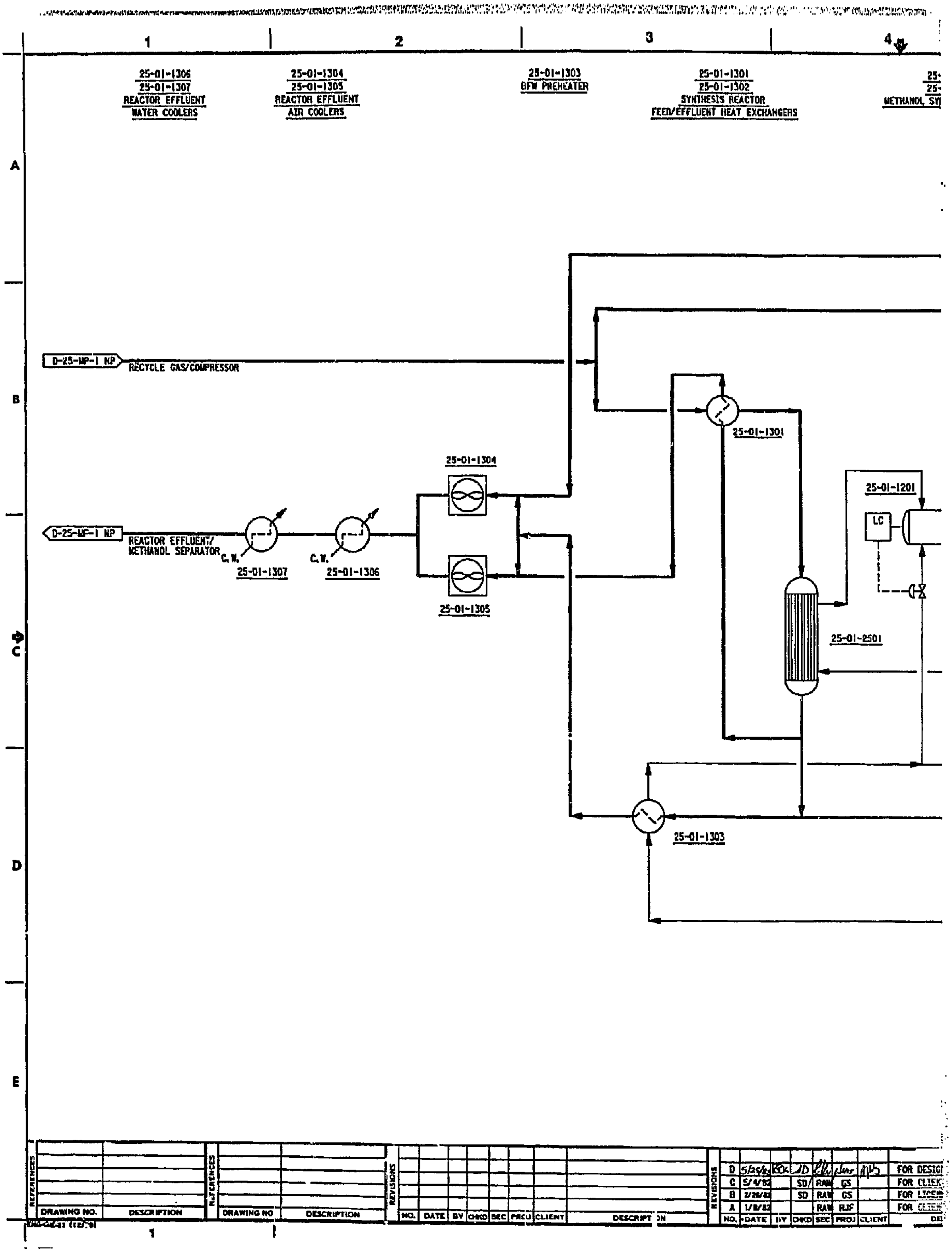
50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

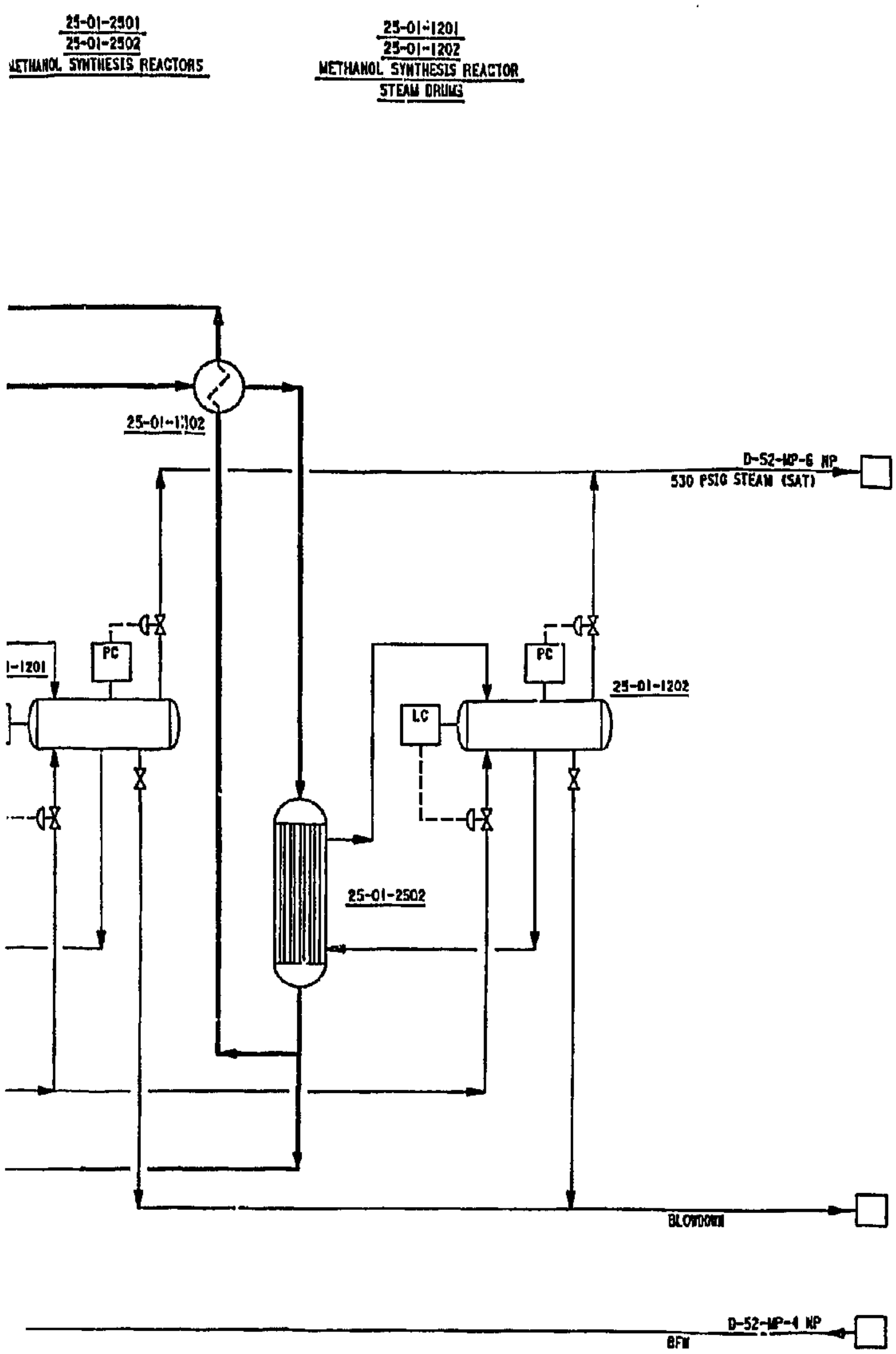
TITLE: PROCESS FLOW AND CONTROL DIAGRAM METHANOL SYNTHESIS - UNIT 25 GAS COMPRESSION

| SCALE | ACCOUNT NUMBER | JOB NUMBER |
|---|---|---|
| NONE | 2800 | 6182 |

D-25-MP-1 NP



1
2
3
4
25-01-1306
25-01-1307
REACTOR EFFLUENT
WATER COOLERS
25-01-1304
25-01-1305
REACTOR EFFLUENT
AIR COOLERS
25-01-1303
BFW PREHEATER
25-01-1301
25-01-1302
SYNTHESIS REACTOR
FEED/EFFLUENT HEAT EXCHANGERS
A
B
C
D
E
D-25-MF-1 NP
RECYCLE GAS/COMPRESSOR
D-25-MF-1 NP
REACTOR EFFLUENT/
METHANOL SEPARATOR
C.W.
25-01-1307
C.W.
25-01-1306
25-01-1304
25-01-1305
25-01-1301
25-01-1201
LC
25-01-2501
25-01-1303
REFERENCES
DRAWING NO.
DESCRIPTION
REFERENCES
DRAWING NO
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
REVISIONS
D
C 5/4/82 SD RAW GS FOR CLIENT
B 2/26/82 SD RAW GS FOR LICEN
A 1/8/82 RAW RJF
NO. DATE BY CHKD SEC PROJ CLIENT
FOR DESIGN
1




NOTES:
1. THE EQUIPMENT SHOWN ON THIS DRAWING ARE FOR ONE OF FOUR TRAINS.

EQUIPMENT SHOWN ON THIS DRAWING:

| | |
|---|---|
| 25-01-1201 | 25-01-1305 |
| 25-01-1202 | 25-01-1306 |
| 25-01-1301 | 25-01-1307 |
| 25-01-1302 | 25-01-2501 |
| 25-01-1303 | 25-01-2502 |
| 25-01-1304 | |

D25MP2NP.DGA

LURGI Lurgi Kohle und Mineraloeltechnik GmbH

RMP THE RALPH M. PARSONS COMPANY PASADENA, CALIFORNIA

| | FOR |
|---|---|
| FOR DESIGN REPORT | DRAWN |
| FOR CLIENT APPROVAL | CHECKED |
| FOR LICENSOR APPROVAL | APVD SECT HD |
| FOR CLIENT 50% REVIEW | APVD PROJ MGR |
| DESCRIPTION | APVD CLIENT |

U.S. DEPARTMENT OF ENERGY

BASKETT W.R. GRACE & CO. KENTUCKY

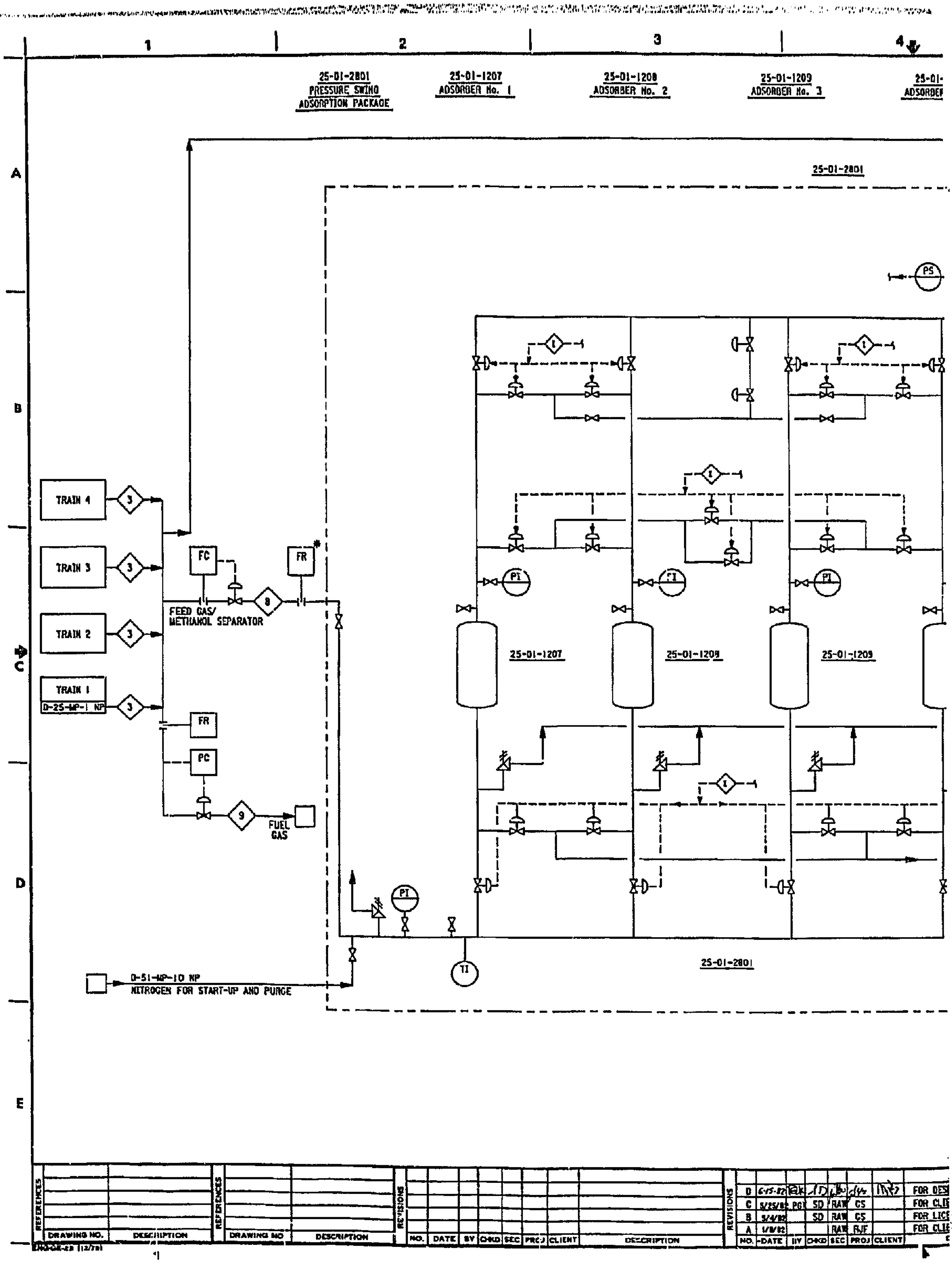
50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: PROCESS FLOW AND CONTROL DIAGRAM METHANOL SYNTHESIS - UNIT 25 GAS REACTION

| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| NONE | 2800 | 6182 | 0 |

DOCUMENT NUMBER: D-25-MP-2 NP


1
2
3
4
A
B
C
D
E
25-01-2801
PRESSURE SWING
ADSORPTION PACKAGE
25-01-1207
ADSORBER No. 1
25-01-1208
ADSORBER No. 2
25-01-1209
ADSORBER No. 3
25-01-2801
PS
TRAIN 4
TRAIN 3
TRAIN 2
TRAIN 1
D-25-MP-1 NP
3
FC
FR
8
FEED GAS/
METHANOL SEPARATOR
FR
PC
9
FUEL
GAS
PI
TI
25-01-1207
25-01-1208
25-01-1209
25-01-2801
D-51-MP-10 NP
NITROGEN FOR START-UP AND PURGE
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
D
C
B
A
SD
RAW
CS
RJF
FOR DES
FOR CLI
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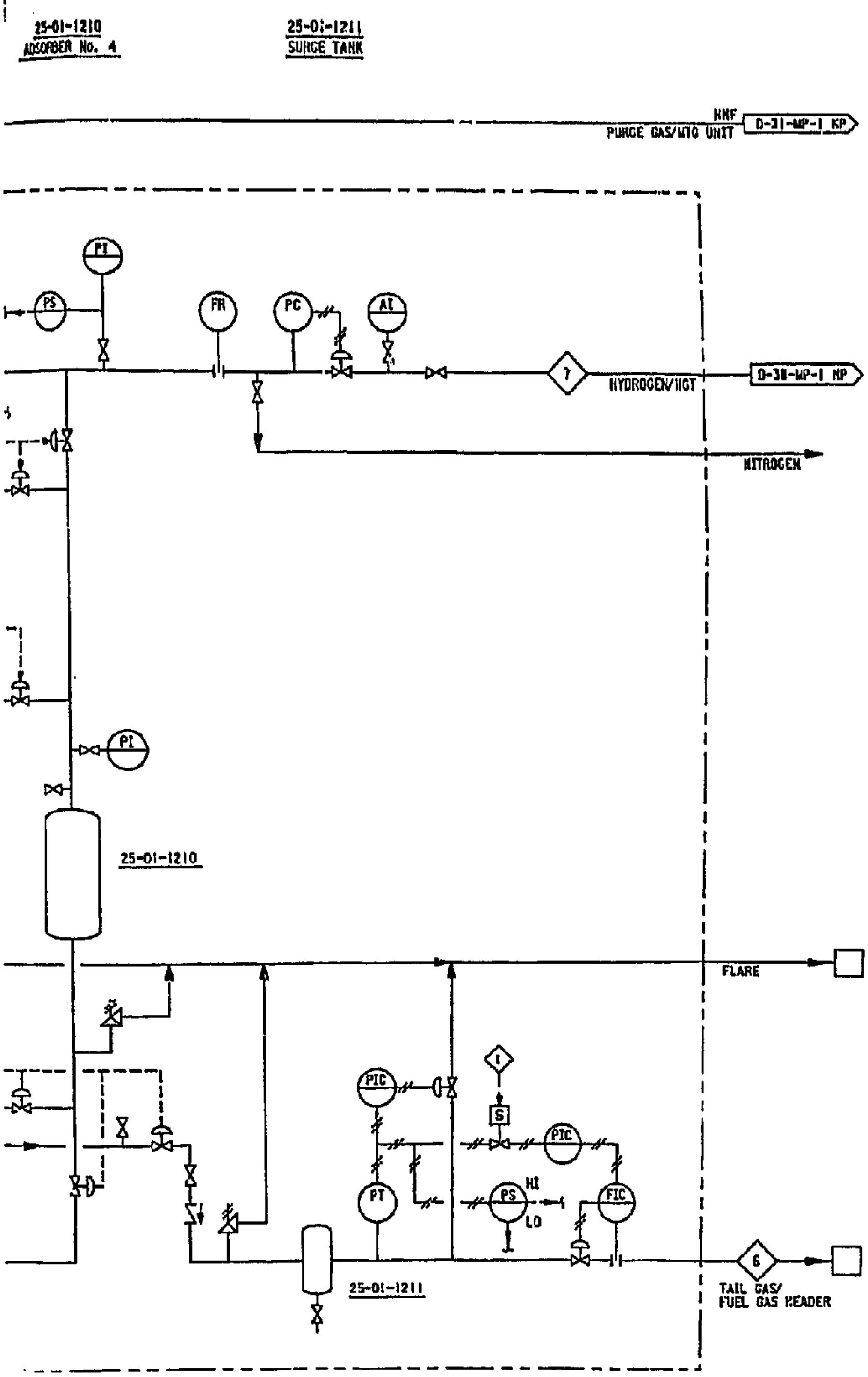
FOR CLI

4 | 5 | 6 | 7




NOTES:
1. ALL PIPING, INSTRUMENTATION AND EQUIPMENT WILL BE FURNISHED BY OTHERS.
2. PANEL INSTRUMENTS MOUNTED ON LOCAL PANEL.

EQUIPMENT SHOWN ON THIS DRAWING:
25-01-2801

D25MP3NP.DGA

U.S. DEPARTMENT OF ENERGY

BASKETT | W.R. GRACE & CO. | KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

| DESCRIPTION | FOR | | |
|---|---|---|---|
| FOR DESIGN REPORT | DRAWN | | |
| FOR CLIENT APPROVAL | CHECKED | | |
| FOR LICENSOR APPROVAL | APVD SECT HD | | |
| FOR CLIENT 50% REVIEW | APVD PROJ MGR | | |
| | APVD CLIENT | | |

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

TITLE: PROCESS FLOW AND CONTROL DIAGRAM
METHANOL SYNTHESIS - UNIT 25
PRESSURE SWING ADSORPTION

| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| NONE | 2800 | 6132 | 0 |

DOCUMENT NUMBER: D-25-MP-3 NP

| COMPONENT | MOL WEIGHT | 1 MAKE-UP GAS (VAPOR) LBMOL/HR | MOL % | LBS/HR | 2 LEAKAGE GAS (VAPOR) LBMOL/HR | MOL % | LBS/HR | 3 PURGE GAS (VAPOR) LBMOL/HR | MOL % | LBS/HR | LBMOL/HR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $H_2$ | 2.02 | 24,203.44 | 67.54 | 48,794.13 | 125.65 | 69.98 | 253.31 | 870.02 | 71.43 | 1,755.58 | 67.6 |
| $CH_4$ | 16.043 | 80.65 | 0.22 | 1,293.83 | 4.58 | 2.55 | 73.56 | 54.02 | 4.43 | 866.60 | 7.4 |
| CO | 28.11 | 10,206.60 | 28.48 | 285,897.00 | 24.55 | 13.67 | 687.60 | 43.54 | 3.57 | 1,219.67 | 4.9 |
| $CO_2$ | 44.011 | 1,075.13 | 3.00 | 47,317.65 | 5.34 | 2.97 | 234.80 | 34.17 | 2.80 | 1,503.97 | 7.1 |
| $N_2$ | 28.02 | 203.55 | 0.57 | 5,702.73 | 14.51 | 8.08 | 406.44 | 161.49 | 13.25 | 4,524.24 | 15.3 |
| Ar | 39.94 | 68.32 | 0.19 | 2,728.70 | 4.39 | 2.44 | 175.24 | 50.16 | 4.11 | 2,003.19 | 6.1 |
| $CH_3OH$ | 32.043 | | | | 0.55 | 0.31 | 17.62 | 4.96 | 0.41 | 158.93 | 1.1 |
| HYDROCARBONS | 101.16 | | | | | | | | | | |
| H. BOILER | 53.530 | | | | | | | | | | |
| L. BOILER | 57.210 | | | | | | | | | | 0.0 |
| TOTAL DRY | | 35,837.69 | 100.00 | 391,733.94 | 179.57 | 100.00 | 1,848.57 | 1,219.16 | 100.00 | 12,032.18 | 105.9 |
| $H_2O$ | 18.02 | | | | | | | 0.01 | | 0.09 | 0.0 |
| TOTAL FLOW | | 35,837.69 | | 391,733.94 | 179.57 | | 1,848.57 | 1,219.17 | | 12,032.27 | 105.9 |
| MOL WEIGHT | | 10.93 | | | 10.29 | | | 9.87 | | | |
| PRESSURE | PSIA | 750 | | | MAX. 750 | | | 994 | | | |
| TEMPERATURE | °F | 82 | | | APPROX. 127 | | | 100 | | | |

| COMPONENT | MOL WEIGHT | 6 PSA TAIL GAS TO FUEL GAS LBMOL/HR | MOL % | LBS/HR | 7 HYDROGEN LBMOL/HR | MOL % | LBS/HR | 8 PURGE GAS TO PSA LBMOL/HR | MOL % | LBS/HR | LBMOL/HR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $H_2$ | 2.02 | 236.97 | 51.18 | 477.75 | 329.06 | 99.90 | 663.38 | 566.03 | 71.43 | 1,141.13 | 2,917.2 |
| $CH_4$ | 16.043 | 35.13 | 7.58 | 563.29 | | | | 35.13 | 4.43 | 563.29 | 180.9 |
| CO | 28.11 | 28.32 | 6.11 | 792.79 | | | | 28.32 | 3.57 | 792.79 | 145.8 |
| $CO_2$ | 44.011 | 22.12 | 4.78 | 977.58 | | | | 22.12 | 2.80 | 977.58 | 114.4 |
| $N_2$ | 28.02 | 104.73 | 22.62 | 2,933.76 | 0.25 | 0.08 | 7.00 | 104.98 | 13.25 | 2,940.76 | 540.9 |
| Ar | 39.94 | 32.54 | 7.03 | 1,298.87 | 0.08 | 0.02 | 3.20 | 32.62 | 4.11 | 1,302.07 | 168.0 |
| $CH_3OH$ | 32.043 | 3.23 | 0.70 | 103.30 | | | | 3.23 | 0.41 | 103.30 | 16.6 |
| HYDROCARBONS | 101.16 | | | | | | | | | | |
| H. BOILER | 53.530 | | | | | | | | | | |
| L. BOILER | 57.210 | | | | | | | | | | |
| TOTAL DRY | | 463.04 | 100.00 | 7,147.34 | 329.39 | | 673.58 | 792.43 | 100.00 | 7,820.92 | 4,084.2 |
| $H_2O$ | 18.02 | 8 PPMV | | 0.06 | | | | 3 PPM | | 0.06 | 0.0 |
| TOTAL WET | | 463.04 | 100.00 | 7,147.40 | 329.39 | 100.00 | 673.58 | 792.43 | | 7,820.98 | 4,084.2 |
| MOL WEIGHT | | 15.44 | | | 2.04 | | | 9.87 | | | |
| PRESSURE | PSIA | 60 | | | 650 | | | 994 | | | |
| TEMPERATURE | °F | 100 | | | 110 | | | 100 | | | |

| REFERENCES DRAWING NO. | DESCRIPTION | REFERENCES DRAWING NO. | DESCRIPTION |
|---|---|---|---|

| NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| F | 7-14-82 | | SD | [illegible] | [illegible] | NRS | FOR DESIGN REPORT |

| NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| E | [illegible] | | SD | RAW | GS | | REVISED |
| D | [illegible] | PGK | SD | RAW | GS | NRS | FOR DES |
| C | [illegible] | | SD | RAW | GS | | FOR CLD |
| B | [illegible] | | SD | RAW | GS | | FOR LTC |
| A | 1/8/82 | | | RAW | RJE | | FOR CLD |

CHG-04-13 (12/78)

NOTES:

1. MATERIAL BALANCE POINTS FOR THE METHANOL SYNTHESIS UNIT (POINTS 1 THRU 5, INCLUSIVE) REFLECT ONE OF FOUR MODULES AT NORMAL OPERATING CONDITIONS. THE STREAM RATES MUST BE MULTIPLIED BY FOUR FOR THE TOTAL GASOLINE PLANT RATES AND QUANTITIES. POINTS 6 THRU 9, INCLUSIVE, APPLICABLE TO THE PSA UNIT, REFLECT TOTAL PLANT CAPACITIES.
2. NORMAL OPERATING CASE IS BASED ON THE "DESIGN COAL ANALYSIS".

| 4 FLASH GAS (VAPOR) | | | 5 "WILD" METHANOL (LIQUID) | | |
|---|---|---|---|---|---|
| LBMOL/HR | MOL % | LBS/HR | LBMOL/HR | MOL % | LBS/HR |
| 67.69 | 61.56 | 136.47 | 29.83 | 0.24 | 60.13 |
| 7.49 | 6.81 | 120.24 | 14.55 | 0.12 | 233.42 |
| 4.99 | 4.54 | 139.70 | 5.48 | 0.05 | 153.64 |
| 7.19 | 6.54 | 316.55 | 72.72 | 0.60 | 3,200.70 |
| 15.34 | 13.95 | 429.70 | 12.22 | 0.10 | 342.36 |
| 6.12 | 5.56 | 244.33 | 7.68 | 0.06 | 305.94 |
| 1.12 | 1.02 | 35.73 | 11,023.20 | 90.59 | 353,216.24 |
| | | | 0.18 | | 17.30 |
| | | | 13.28 | 0.11 | 710.08 |
| 0.03 | 0.02 | 1.57 | 9.28 | 0.08 | 530.82 |
| 109.97 | 100.00 | 1,424.29 | | | |
| 0.01 | | 0.14 | 980.12 | 8.05 | 17,657.84 |
| 109.98 | | 1,424.43 | 12,168.50 | 100.00 | 376,428.67 |
| 12.95 | | | 30.93 | | |
| 415 | | | 415 | | |
| 100 | | | 100 | | |

| 9 PURGE GAS TO FUEL GAS HEADER | | |
|---|---|---|
| LBMOL/HR | MOL % | LBS/HR |
| 2,917.29 | 71.43 | 5,881.19 |
| 180.97 | 4.43 | 2,903.11 |
| 145.86 | 3.57 | 4,085.89 |
| 114.47 | 2.80 | 5,038.30 |
| 540.99 | 13.25 | 15,156.20 |
| 168.04 | 4.11 | 6,710.69 |
| 16.62 | 0.41 | 532.42 |
| | | |
| | | |
| | | |
| 4,084.20 | 100.00 | 40,307.80 |
| 0.03 | | 0.30 |
| 4,084.23 | | 40,308.10 |
| 9.87 | | |
| 994 | | |
| 100 | | |

| | |
|---|---|
| REVISED FOR CLIENT APPROVAL | FOR |
| FOR DESIGN REPORT | DRAWN |
| FOR CLIENT APPROVAL | CHECKED |
| FOR LICENSOR APPROVAL | APVD SECT HD |
| FOR CLIENT 50% REVIEW | APVD PROJ MGR |
| DESCRIPTION | APVD CLIENT |

LURGI Lurgi Kohle und Mineraloeltechnik GmbH

RMP THE RALPH M. PARSONS COMPANY PASADENA, CALIFORNIA

D25MP4NP.DGA

U.S. DEPARTMENT OF ENERGY

BASKETT **W.R. GRACE & CO.** KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: MATERIAL BALANCE METHANOL SYNTHESIS - UNIT 25

SCALE: NONE | 2800 | 6182

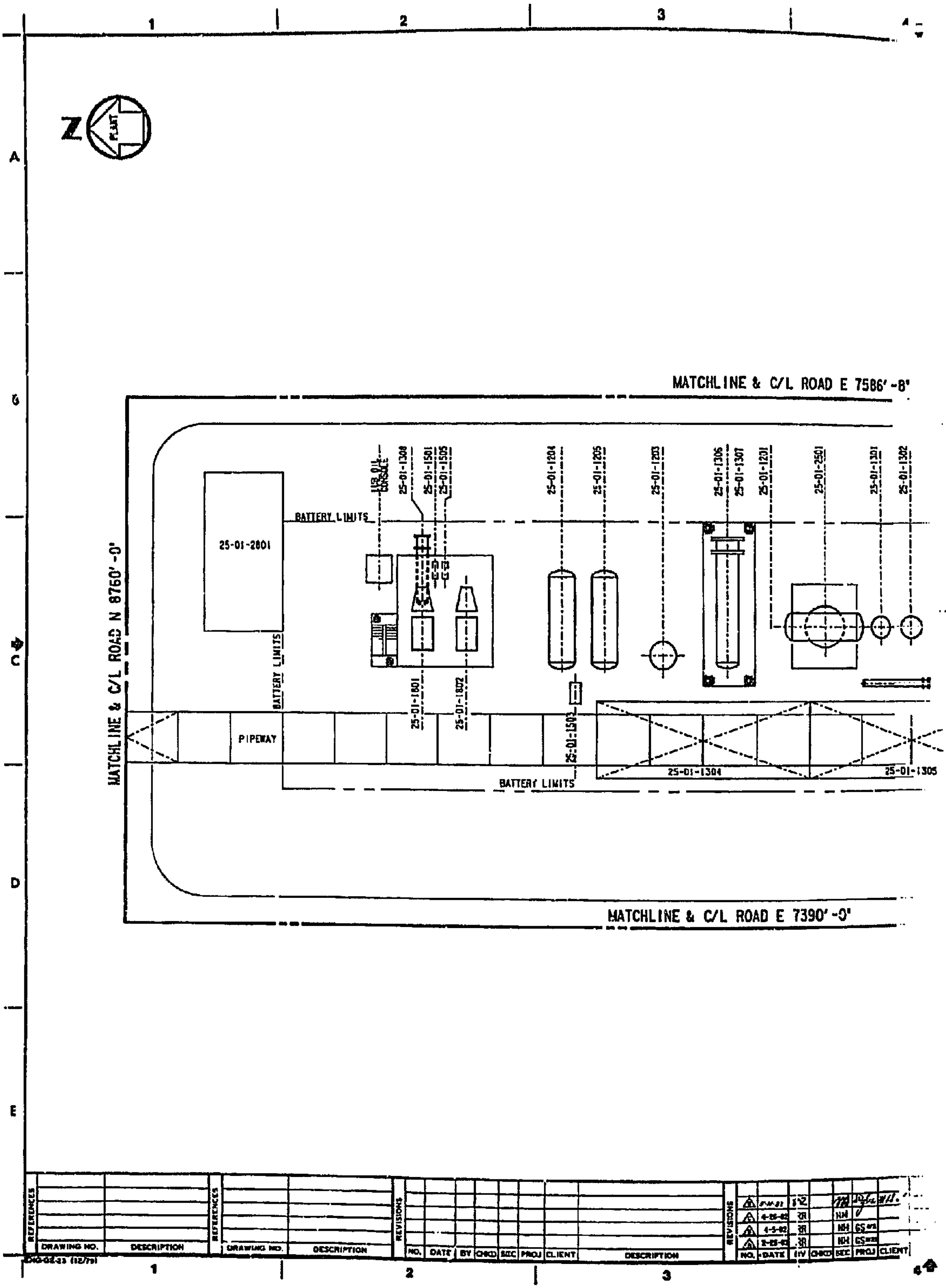
DOCUMENT NUMBER: D-25-MP-4 NP

REVISION: F

F. Plot Plan/General Arrangement Drawings

Plot Plan/General Arrangement Drawings for Methanol Synthesis Unit 25 are as follows:

| Drawing No. | Title |
|---|---|
| D-25-PD-1NP | Plot Plan - Unit 25 Methanol Synthesis |
| D-25-PD-2NP | Elevation - Unit 25 Methanol Synthesis |

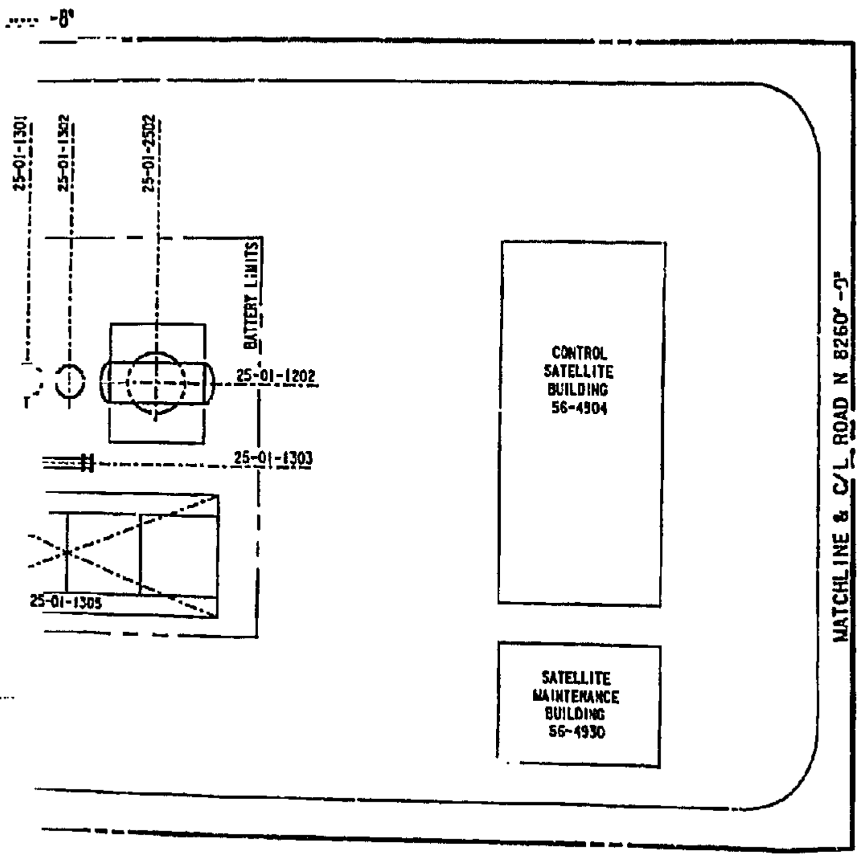


1
2
3
4
A
B
C
D
E
N
PLANT
MATCHLINE & C/L ROAD E 7586'-8"
MATCHLINE & C/L ROAD N 8760'-0"
MATCHLINE & C/L ROAD E 7390'-0"
25-01-2801
BATTERY LIMITS
BATTERY LIMITS
BATTERY LIMITS
PIPEWAY
LUB OIL CONSOLE
25-01-1308
25-01-1501
25-01-1505
25-01-1204
25-01-1205
25-01-1203
25-01-1306
25-01-1307
25-01-1201
25-01-2501
25-01-1301
25-01-1302
25-01-1801
25-01-1802
25-01-1503
25-01-1304
25-01-1305
REFERENCES
DRAWING NO.
DESCRIPTION
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT

## EQUIPMENT LIST

| | |
|---|---|
| 25-01-1201 | METHANOL SYNTHESIS REACTOR STEAM DRUM |
| 25-01-1202 | METHANOL SYNTHESIS REACTOR STEAM DRUM |
| 25-01-1203 | METHANOL SEPARATOR |
| 25-01-1204 | METHANOL SEPARATOR BOTTOMS H.P. FLASH DRUM |
| 25-01-1205 | METHANOL SEPARATOR BOTTOMS L.P. FLASH DRUM |
| 25-01-1301 | SYNTHESIS REACTOR FEED/EFFLUENT HEAT EXCHANGER |
| 25-01-1302 | SYNTHESIS REACTOR FEED/EFFLUENT HEAT EXCHANGER |
| 25-01-1303 | BFW PREHEATER |
| 25-01-1304 | REACTOR EFFLUENT AIR COOLER |
| 25-01-1305 | REACTOR EFFLUENT AIR COOLER |
| 25-01-1306 | REACTOR EFFLUENT WATER COOLER |
| 25-01-1307 | REACTOR EFFLUENT WATER COOLER |
| 25-01-1308 | MAKE-UP GAS COMPRESSOR TURBINE CONDENSER |
| 25-01-1501 | MUG COMPRESSOR TURBINE CONDENSATE PUMP |
| 25-01-1503 | LOW PRESSURE FLASH DRUM PUMP |
| 25-01-1505 | MUG COMPRESSOR TURBINE CONDENSATE PUMP SPARE |
| 25-01-1801 | MAKE-UP GAS COMPRESSOR |
| 25-01-1802 | RECYCLE GAS COMPRESSOR |
| 25-01-2501 | METHANOL SYNTHESIS REACTOR |
| 25-01-2502 | METHANOL SYNTHESIS REACTOR |
| 25-01-2801 | P S A PACKAGE: 25-01-1207 ADSORBER NO. 1; 25-01-1208 ADSORBER NO. 2; 25-01-1209 ADSORBER NO. 3; 25-01-1210 ADSORBER NO. 4; 25-01-1211 SURGE TANK |
| *25-01-2802 | L.P. FLASH DRUM EDUCTOR |
| *25-01-2803 | CONDENSER EDUCTOR |

*EQUIPMENT NOT SHOWN ON THIS DWG.




NOTES:

1. THIS PLOT PLAN IS MODULE 1 OF 4 MODULES.
2. THERE IS ONLY ONE PSA UNIT FOR ALL 4 MODULES. PSA IS LOCATED WITH MODULE 1, ONLY.
3. SATELLITE CONTROL BLDG. 56-4904 IS LOCATED IN MODULE 1 ONLY.
4. SATELLITE MAINTENANCE BLDG. 56-4930 IS LOCATED IN MODULE 1 ONLY.
5. PROCESS CONTROL BLDG. 56-4911 IS LOCATED IN MODULE 2 ONLY. SEE DWG. NO. D-01-PD-1INP FOR LOCATION.
6. MATCHLINE CO-ORDINATES APPLY TO MODULE 1 ONLY.

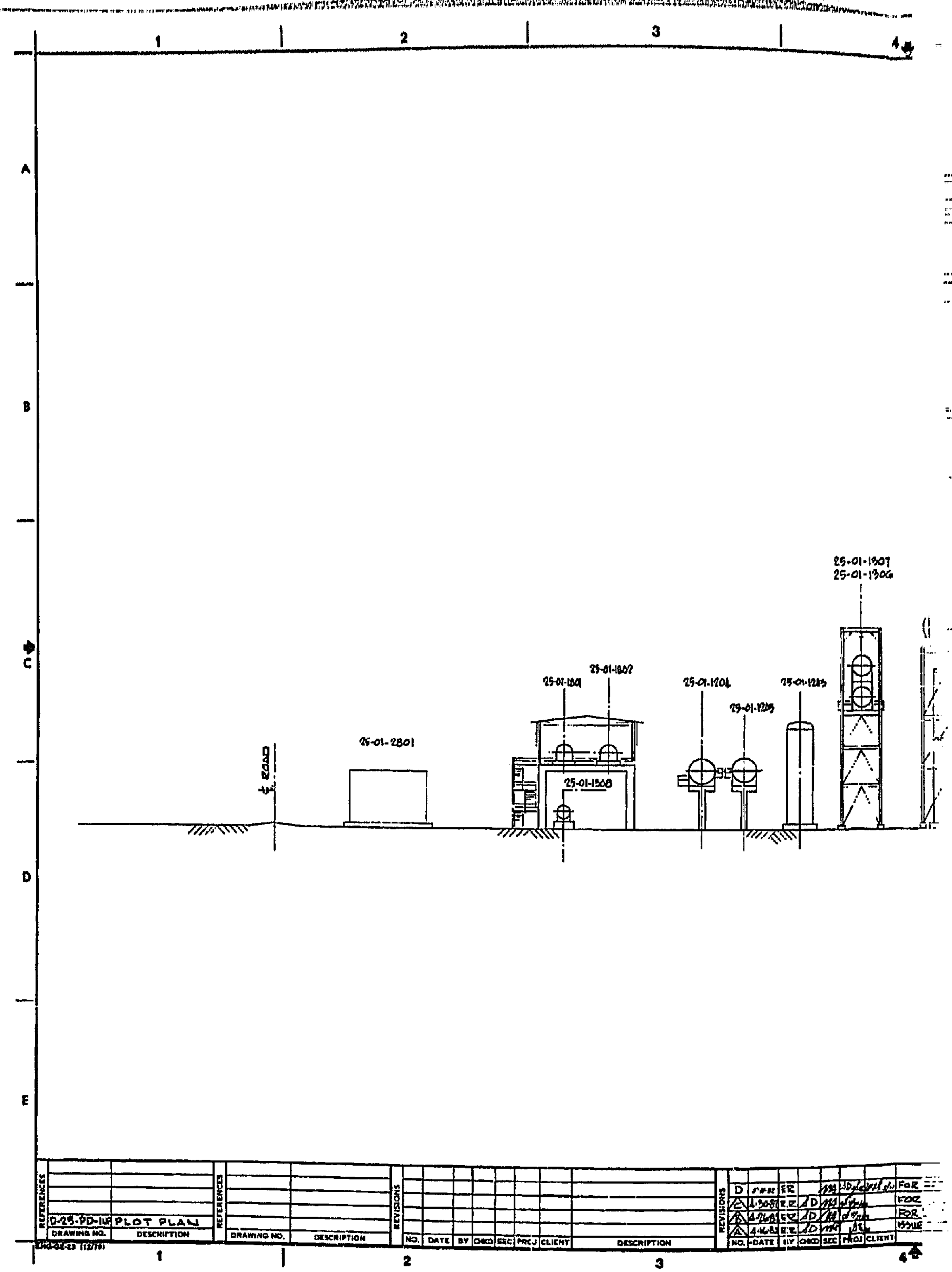
SCALE 1" = 20'-0"

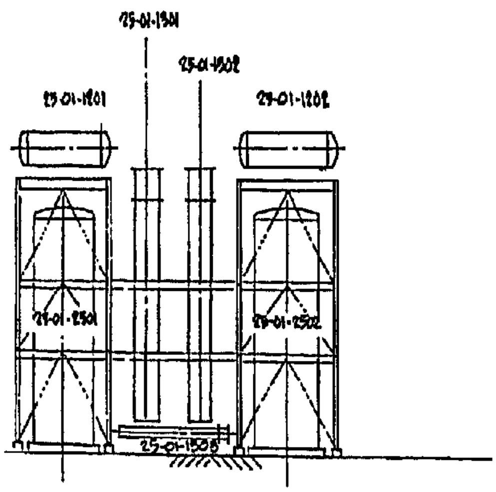
| | | | |
|---|---|---|---|
| FOR DESIGN REPORT | DRAWN | JB/CAD | 2-24-82 |
| FOR CLIENT APPROVAL | CHECKED | | |
| FOR LICENSOR APPROVAL | APVD MGT MG | NH | 2-25-82 |
| ISSUE CLIENT REVIEW 50% COMP. | APVD PROJ MGR | GS | 2-25-82 |
| DESCRIPTION | APVD CLIENT | | |

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

U.S. DEPARTMENT OF ENERGY
BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

| TITLE | SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|---|
| PLOT PLAN UNIT 25 METHANOL SYNTHESIS | 1"-20'-0" | 7423 | 6182 | 0 |
| | DOCUMENT NUMBER: D-25-PD-1NP | | | |


25-01-1307
25-01-1306
25-01-2801
25-01-1508
ROAD
PLOT PLAN
DRAWING NO.
DESCRIPTION
REFERENCES
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT




NOTES:

1. THIS ELEVATION IS MODULE 1 OF 4 MODULES.

1" = 20FT

| | | | |
|---|---|---|---|
| DESIGN REPORT | FOR | | |
| FOR CLIENT APPROVAL | DRAWN | EE | |
| FOR LICENSOR APPROVAL | CHECKED | | |
| ISSUE CLIENT REVIEW FOR COMP. | APVD SECT HD | | |
| DESCRIPTION | APVD PROJ MGR | | |
| | APVD CLIENT | | |

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PASADENA, CALIF.

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY

50,000 B.P.D.

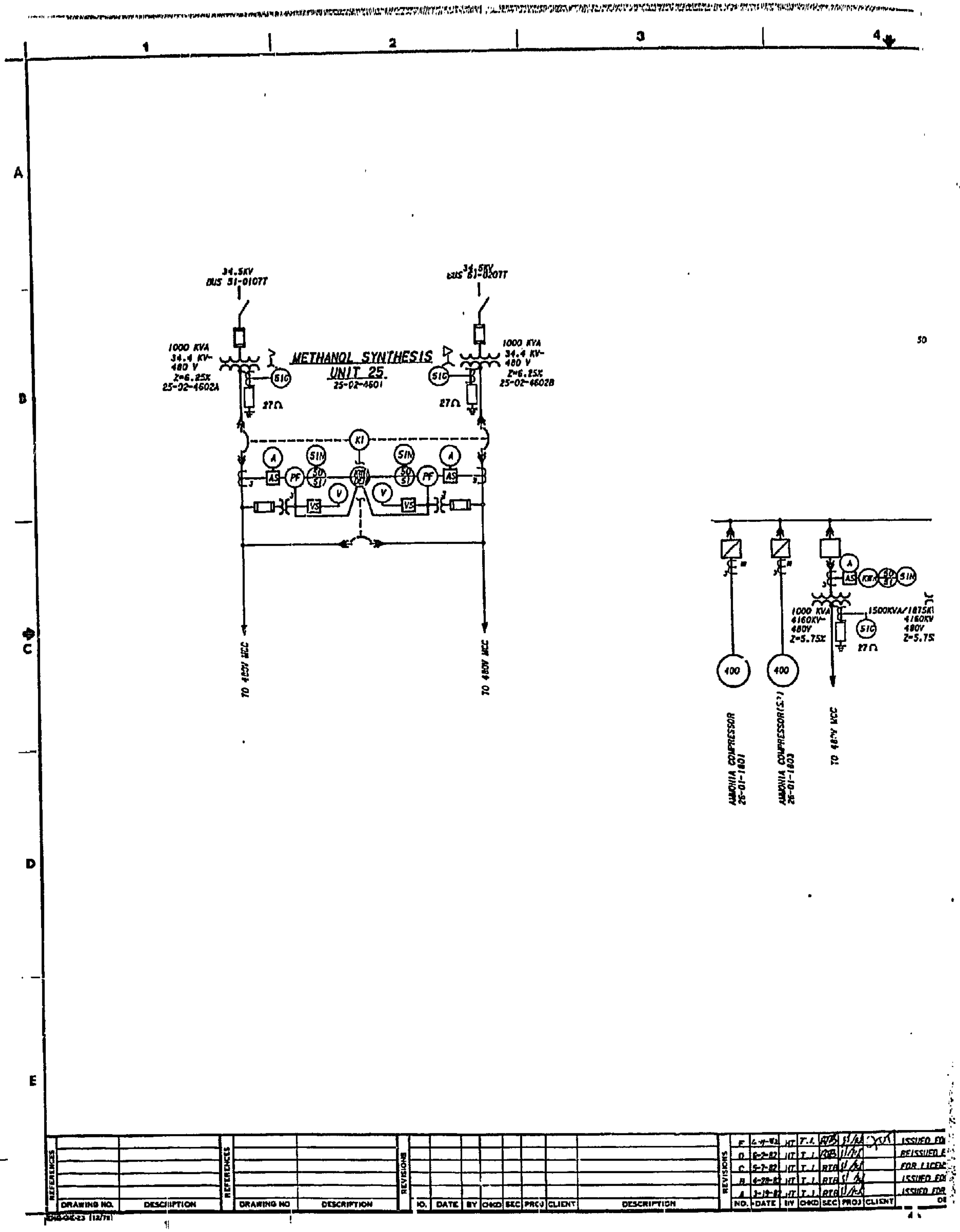
COAL - TO - METHANOL - TO - GASOLINE PLANT

| TITLE | SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|---|
| ELEVATION UNIT 25 METHANOL SYNTHESIS | 1" = 20'-0" | 7243 | G182 | D |
| | DOCUMENT NUMBER: D-25-PD-2NP | | | |

G. <u>Single-Line Diagram</u>

Single-Line Diagram for Methanol Synthesis Unit 25 is as follows:

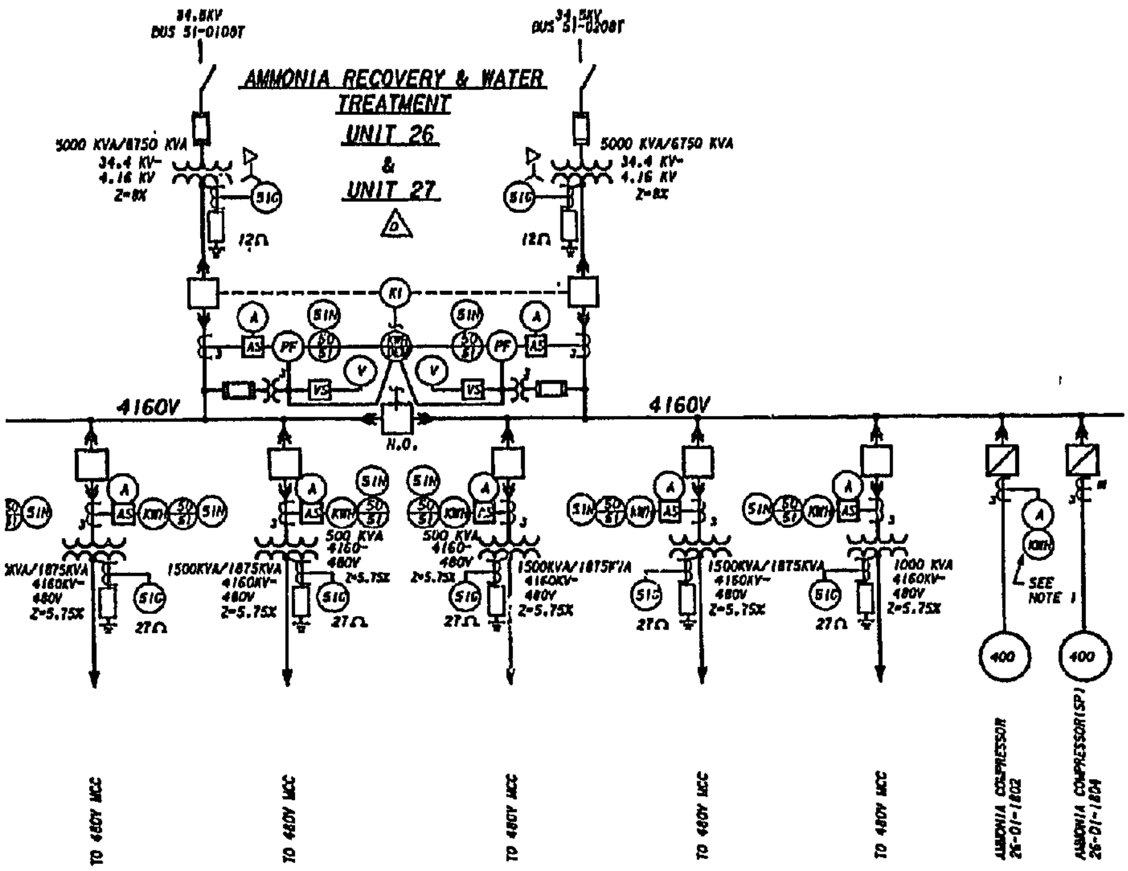
| Drawing No. | Title |
|---|---|
| D-51-EE-5NP | One-Line Diagram - Units 25, 26, and 27 |



METHANOL SYNTHESIS
UNIT 25
25-02-4601
34.5KV
BUS 51-0107T
1000 KVA
34.4 KV-
480 V
Z=6.25%
25-02-4602A
25-02-4602B
27Ω
TO 480V MCC
AMMONIA COMPRESSOR
26-01-1801
26-01-1803
1000 KVA
4160KV-
480V
Z=5.75%
TO 480V MCC
DRAWING NO.
DESCRIPTION
REFERENCES
REVISIONS
DATE
BY
CHKD
SEC
PROJ
CLIENT
ISSUED FOR
REISSUED

## NOTES:

1. PROVIDE AM & KWH METERS AT ALL LOCATIONS MARKED *




| | | | |
|---|---|---|---|
| ISSUED FOR DESIGN REPORT | FOR | | |
| REISSUED FOR CLIENT APPROVAL | DRAWN | HT | |
| FOR LICENSOR APPROVAL | CHECKED | | |
| ISSUED FOR CLIENT APPROVAL | APVD SECT HD | | |
| ISSUED FOR CLIENT 50% REVIEW | APVD PROJ MGR | | |
| DESCRIPTION | APVD CLIENT | | |

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COAL - TO - METHANOL - TO - GASOLINE PLANT

| TITLE | SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|---|
| ONE LINE DIAGRAM<br>METHANOL SYNTHESIS U-25<br>AMMONIA RECOVERY U-26<br>WATER TREATMENT U-27 | NONE | 4600 | 6182 | E |
| | DOCUMENT NUMBER: D-51-EE-5NP | | | |

DT- 59# IN-1186

## 1.2.10 AMMONIA RECOVERY - UNIT 26

Unit 26, Ammonia Recovery compresses and liquefies the ammonia vapor stream from Effluent Water Treatment (Texaco) - Unit 27. The unit normally produces about 43 stpd of anhydrous ammonia. The product is pumped to Ammonia Storage and Shipping - Unit 57.

The vapor feed is compressed to 205 psig in a two-stage reciprocating compressor. Knockout drums are used upstream of each stage of the compressor to remove entrained liquid. The compressed ammonia is condensed at 100°F and stored in the ammonia accumulator, which provides surge time for delivery to the storage area.

### A. Basis of Design

Unit 26 consists of one train capable of handling the total ammonia vapor stream from Unit 27. Turndown capability is 50%.

**Feed Streams**

| Component | Ammonia Rich Gas From Effluent Water Treatment - Unit 27 (lb mol/hr) | (mol%) |
|---|---|---|
| $NH_3$ | 210.90 | 98.64 |
| $H_2S$ | traces | - |
| Total Dry, lb mol/hr | 210.90 | - |
| $H_2O$ | 2.91 | 1.36 |
| Total Wet, lb mol/hr | 213.81 | 100.00 |
| Total, lb/hr | 3,644 | - |
| Pressure, psia | 70 | - |
| Temperature, °F | 100 | - |

## Product Streams

| Component | Anhydrous Ammonia (lb mol/hr) | Anhydrous Ammonia (mol %) | Condensate (lb mol/hr) | Condensate (mol%) |
|---|---|---|---|---|
| $NH_3$ | 210.50 | 99.07 | 0.40 | 30.00 |
| $H_2S$ | trace | - | trace | - |
| Total Dry, lb mol/hr | 210.50 | - | 0.40 | - |
| $H_2O$ | 1.97 | 0.93 | 0.94 | 70.00 |
| Total Wet, lb mol/hr | 212.47 | 100.00 | 1.34 | 100.00 |
| Total, lb/hr | 3,620 | | 24 | |
| Pressure, psia | 215 | | 103 | |
| Temperature, °F | 100 | | 100 | |

B. Process Selection Rationale

The production of liquid anhydrous ammonia from ammonia-rich vapor by compression is a simple, reliable, and proven commercial process with wide application worldwide.

The present state of the art in ammonia compressor technology allows a long period of trouble-free performance with proper scheduled maintenance and ensures a high degree of flexibility for turndown purpose.

C. Process Description

Refer to Document No. D-26-MP-1NP, the process flow and control diagram for the Ammonia Recovery Systems, Unit 26.

The vapor stream from Unit 27 contains about 98.6 mol% ammonia, 1.4 mol% moisture, and possible trace quantities of hydrogen sulfide. The vapor feed stream plus any compressor spillback enters Feed Drum 26-01-1201. Very little water condenses at operating conditions. Liquid from the feed drum is returned to Unit 27 on level control.

Vapor exiting the feed drum passes through Suction Filter 26-01-2701 to ensure clean feed to the first-stage compressor. Filters are installed to protect the compressor from possible damage caused by solid or liquid entrainment. Typically, the feed streams contain only traces of contaminants.

The ammonia vapor stream is compressed from 42 psig to about 92 psig in the first-stage of Ammonia Compressor 26-01-1801. The compressor discharge temperature is about 218°F. The discharge stream is cooled to about 100°F in Ammonia Compressor Intercooler 26-01-1301. Water condenses at these operating conditions. The condensate collects in First-Stage Ammonia Knockout Drum 26-01-1202 and is returned to Unit 27 on level control. Vapor from the knockout drum enters the second-stage of Ammonia Compressor 26-01-1801, where it is compressed to 205 psig. The compressor discharge temperature is about 238°F.

The compressed vapor stream is condensed at 100°F in Ammonia Product Condenser 26-01-1302. The stream is condensed as anhydrous ammonia. This stream enters Ammonia Accumulator 26-01-1203. The accumulator was designed to allow separation of the vapor/liquid stream and to provide sufficient surge time to smooth out feed to storage, Unit 57.

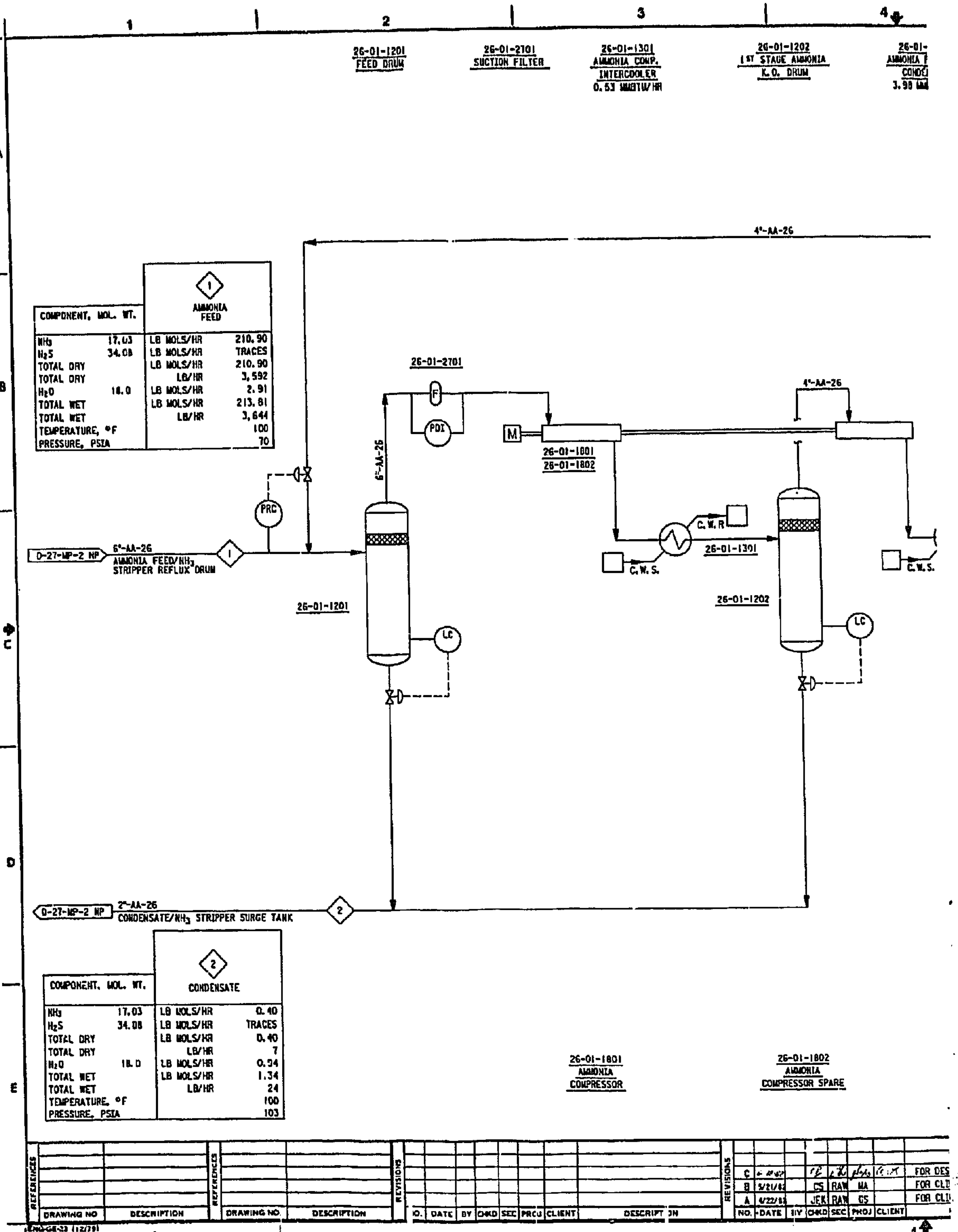
D. Risk Assessment

The Ammonia Recovery Unit is composed of two knockout drums, two 2-stage compressors (one operating and one spare) with an intercooler and ammonia product condenser, and one ammonia accumulator. The operation of the unit is simple and routine; no process risks are anticipated.

E. Process Flow and Control Diagram (Including Material Balance)

The Process Flow and Control Diagram for Ammonia Recovery Unit 26 is as follows:

| Drawing No. | Title |
|---|---|
| D-26-MP-1NP | PFCD Ammonia Recovery - Unit 26 |




| COMPONENT, MOL. WT. | | 1 AMMONIA FEED | |
|---|---|---|---|
| $NH_3$ | 17.03 | LB MOLS/HR | 210.90 |
| $H_2S$ | 34.08 | LB MOLS/HR | TRACES |
| TOTAL DRY | | LB MOLS/HR | 210.90 |
| TOTAL DRY | | LB/HR | 3,592 |
| $H_2O$ | 18.0 | LB MOLS/HR | 2.91 |
| TOTAL WET | | LB MOLS/HR | 213.81 |
| TOTAL WET | | LB/HR | 3,644 |
| TEMPERATURE, °F | | | 100 |
| PRESSURE, PSIA | | | 70 |

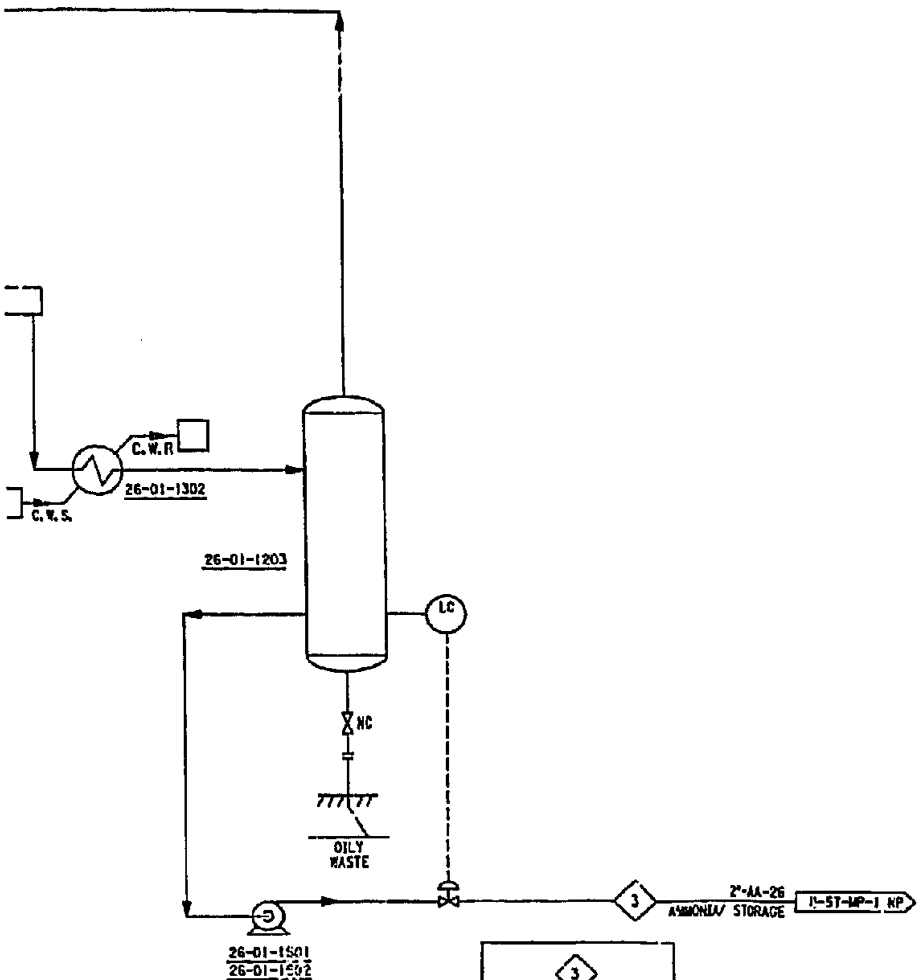
| COMPONENT, MOL. WT. | | 2 CONDENSATE | |
|---|---|---|---|
| $NH_3$ | 17.03 | LB MOLS/HR | 0.40 |
| $H_2S$ | 34.08 | LB MOLS/HR | TRACES |
| TOTAL DRY | | LB MOLS/HR | 0.40 |
| TOTAL DRY | | LB/HR | 7 |
| $H_2O$ | 18.0 | LB MOLS/HR | 0.94 |
| TOTAL WET | | LB MOLS/HR | 1.34 |
| TOTAL WET | | LB/HR | 24 |
| TEMPERATURE, °F | | | 100 |
| PRESSURE, PSIA | | | 103 |

26-01-1302
AMMONIA PRODUCT
CONDENSER
3.38 MMBTU/HR

26-01-1203
AMMONIA
ACCUMULATOR

NOTE:

1. THE EQUIPMENT SHOWN ON THIS DRAWING IS FOR ONE TRAIN. THE PLANT WILL CONTAIN ONLY ONE TRAIN.
2. MATERIAL BALANCE IS FOR NORMAL OPERATING CONDITION.




| COMPONENT, | MOL. WT. | | 3 AMMONIA PRODUCT |
|---|---|---|---|
| $NH_3$ | 17.03 | LB MOLS/HR | 210.50 |
| $H_2S$ | 34.08 | LB MOLS/HR | TRACES |
| TOTAL DRY | | LB MOLS/HR | 210.50 |
| TOTAL DRY | | LB/HR | 3,585 |
| $H_2O$ | 18.0 | LB MOLS/HR | 1.97 |
| TOTAL WET | | LB MOLS/HR | 212.47 |
| TOTAL WET | | LB/HR | 3,620 |
| TEMPERATURE, °F | | | 100 |
| PRESSURE, PSIA | | | 215 |

26-01-1501
26-01-1502
AMMONIA PRODUCT PUMP
AND SPARE

EQUIPMENT SHOWN ON THIS DRAWING:

26-01-1201
26-01-1202
26-01-1203
26-01-1301
26-01-1302
26-01-1501
26-01-1502
26-01-1801
26-01-1802
26-01-2701

D26MP1NP.DGA

| | |
|---|---|
| FOR DESIGN REPORT | △ FOR SPARK |
| FOR CLIENT APPROVAL | CHECKED |
| FOR CLIENT 50% REVIEW | APVD SECT HD |
| DESCRIPTION | APVD PROJ MGR |
| | APVD CLIENT |

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BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: PROCESS FLOW & CONTROL DIAGRAM
AMMONIA RECOVERY - UNIT 26

| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| NONE | 2800 | 6182 | C |

DOCUMENT NUMBER: D-26-MP-1 NP

DC-MP17 DT-42C IH-1217

F. <u>Plot Plan/General Arrangement Drawings</u>

See Volume II, 1.2.11(F) for Plot Plan and General Arrangement Drawings for Ammonia Recovery - Unit 26.

G. <u>Single-Line Diagram</u>

See Volume II, 1.2.9(G) for Single-Line Diagram for Ammonia Recovery Unit 26.

## 1.2.11 EFFLUENT WATER TREATMENT (TEXACO) - UNIT 27

The Texaco Effluent Water Treatment Process was utilized to process the wastewater from the gasification plant. The Texaco Effluent Water Treatment Process is a proprietary process supplied by the Texaco Development Corporation.

The Texaco Effluent Water Treatment Unit produces ammonia-rich gas for recovery as anhydrous liquid ammonia and treated clarified water for reuse. By-product sludges are produced in the precipitation section and the biological section. The sludge from the precipitation section is considered toxic since sufficient data are not available at this time to support a more favorable classification; therefore, it is routed to the water treatment solid waste disposal area. The biotreatment sludge undergoes further treatment and is disposed of as nonhazardous inert landfill.

### A. Basis of Design

The effluent water treatment plant features common storage and pumping facilities for ferrous sulfate solution, lime slurry, caustic solution, and sand filter backwash water. In case of failure of any one of the strippers, the piping interconnection between the trains permits the strippers in operation to process the total design flow of wastewater.

A common sludge sump is used for both biotreatment trains. The clarified, treated, stripped water is suitable for reuse.

## Feed Streams

| Components | Blowdown from Gasification Unit (lb mol/hr) |
|---|---|
| pH | 8 |
| TOC, ppmw | 140 |
| TIC, ppmw | 104 |
| TDS, ppmw | 2,000 |
| TSS, ppmw | 132 |
| COD, ppmw | 500 |
| Organics, ppbw | 9 |
| Ammonia | 215.66 |
| Bromide | 0.03 |
| Chloride | 116.20 |
| Fluoride | 21.11 |
| Cyanide | 3.96 |
| Formate | 26.58 |
| Nitrate | 0.35 |
| Sulfide | 6.94 |
| Sulfate | 0.50 |
| Thiocyanate | 0.31 |
| Dissolved Solids, lb/hr | 4,596 |
| Water, lb/hr | 2,291,480 |
| Total, lb/hr | 2,296,080 |
| gpm | 4,700 |
| Pressure, psia | 70 |
| Temperature, °F | 170 |

Note: This stream does not include 4,596 lb/hr of ash/slag.

## Product Streams

| Components | Ammonia Rich Gas to Ammonia Recovery Unit (lb mol/hr) | (mol%) |
|---|---|---|
| Ammonia | 210.90 | 98.6390 |
| Sulfide | Traces | Traces |
| Total Dry, lb mol/hr | 210.90 | 98.6390 |
| Water | 2.91 | 1.3610 |
| Total Wet, lb mol/hr | 213.81 | 100.0000 |
| Total, lb/hr | 3,644.00 | |
| Pressure, psia | 70 | |
| Temperature, °F | 100 | |

Product Streams (Contd)

| Components | Biotreated Water (lb mol/hr) | (mol%) |
|---|---|---|
| pH | 6.5 | |
| TOC, ppmw | 4 | |
| TDS, ppmw | 447 | |
| TSS, ppmw | 110 | |
| COD, ppmw | 17 | |
| Organics, ppbw | 1 | |
| Ammonia | 2.06 | 0.0015 |
| Bromide | 0.03 | 0.00002 |
| Chloride | 102.62 | 0.0772 |
| Fluoride | 0.32 | 0.0002 |
| Cyanide | 0.15 | 0.0001 |
| Formate | 1.23 | 0.0009 |
| Nitrate | 0.30 | 0.0002 |
| Sulfide | 0.003 | 0.000002 |
| Sulfate | 1.49 | 0.0011 |
| Thiocyanate | 0.01 | 0.00001 |
| Calcium carbonate | trace | - |
| Phosphate | 0.69 | 0.0005 |
| Total Dry, lb mol/hr | 108.90 | 0.0819 |
| Water | 162,246.39 | 99.9181 |
| Total Wet, lb mol/hr | 162,355.29 | 100.0000 |
| Total, lb/hr | 2,924,390.00 | |
| gpm | 5,850 | |
| Pressure, psia | 15 | |
| Temperature, °F | 70 | |

B. Process Selection Rationale

The process wastewater effluent from the Texaco Coal Gasifier Process is a major stream that requires treatment to make it suitable for reuse in the complex. The treatment process is a demonstrated system that can be relied upon to perform dependably and consistently. Process aberrations resulting in unacceptable quality of the treated water cannot be tolerated. Thus, adequate capacity, equipment sparing, and means for reprocessing the wastewater were provided. Several parallel modules were provided together with miscellaneous equipment common to the modules. Turnaround or shutdown of one stripper does not impair operation of the gasifier.

Because the process wastewater contains a variety of metal ions and a substantial quantity of anions, it is not readily processed via the common systems of steam or air stripping. The pH adjustment to facilitate stripping fixes some components in solution while releasing some components that create difficult disposal problems. Reducing the pH tends to release acids such as hydrochloric, hydrofluoric, nitric, sulfuric, hydrogen sulfide, and hydrobromic. On the other hand, increasing the pH tends to precipitate most of the metallic ions as hydroxides, fix sulfides in solution, and release ammonia.

The Texaco wastewater chemical treating process results in the disposition of sulfides, cyanides, and carbonates as insoluble sludges; the production of useful by-product anhydrous ammonia; and a stream that is amenable to biotreatment. Furthermore, the inclusion of minor quantities of soluble organics does not interfere with the Texaco wastewater chemical treating process. Most of the organic components are removed in the biotreatment.

## C. Process Description

The arrangement of equipment and material balances for Effluent Water Treatment (Unit 27) are presented on Process Flow Control Diagrams D-27-MP-1NP, D-27-MP-2NP, D-27-MP-3NP, and D-27-MP-4NP.

The Effluent Water Treatment (Texaco) - Unit 27 applies the Texaco Effluent Water Treatment process to treat the wastewater generated from Gasification - Unit 21. Ammonia vapor and biotreated stripped water are the products. Texaco design criteria were used in the design.

Wastewater enters the battery limit at 170°F and 70 psia. An in-line mixer is installed on the wastewater line leading to the chemical mix drums for the injection of caustic solution to adjust the pH to the desired range if required.

At the proper pH, the volatile form of hydrogen sulfide is kept at minimal level. The caustic drum holds a 7-day supply of NaOH for the entire unit. A metering pump delivers the needed quantity of caustic solution to the wastewater line through the in-line mixer, and a pH controller is used to regulate its flow.

The wastewater is discharged to the first compartment of the chemical mix drum, where it is mixed with ferrous sulfate solution. The reaction of ferrous sulfate with hydrogen sulfide and the cyanides produces insoluble ferrous sulfide and iron-cyanide complexes.

The ferrous sulfate solution is stored in the ferrous sulfate storage tank, with a net capacity of 7-day supply. A mixer is provided to maintain the homogeneity of the solution. To prevent oxidation, the tank is blanketed with nitrogen. The ferrous sulfate pump supplies the chemical mix tank with the solution from the storage tank.

Lime slurry is added to the second compartment of the chemical mix tank. The addition of lime frees the fixed ammonia from the ammonium salts in the effluent, precipitates the sulfate, and raises the pH. The calcium salts formed by these reactions precipitate and are removed by filtering. The flow of lime feed is regulated by a pH controller mounted on the outlet of the chemical mix tank. To ensure the completeness of these reactions and to keep the precipitates in suspension, mixers are installed on the chemical mix drum.

Lime slurry is diluted in the lime supply tanks. Dilution and mixing take place in the tank to maintain a continuous flow of lime to the chemical mix drum through the lime supply pump.

After treatment with ferrous sulfate solution and lime slurry, the treated effluent is pumped by the sludge separator feed pump to the sludge separator. The supernatant is drawn off near the top of the vessel while the concentrated sludge exits from the bottom. Part of the sludge is pumped by the sludge recycle pump to the chemical mix drum to supply nuclei for producing precipitates during lime addition. The remainder of the sludge is directed to the plate and frame filters by the filter press pump.

The flow controller on the line to the plate and frame filters responds to the level in the chemical mix drum and regulates the flow of the supernatant from the separator.

The sludge enters the parallel plate and frame filters, where the water is separated from the solids, leaving a clear water stream and a sludge discharge. The sludge is removed from each filter by a screw conveyor. A belt conveyor is used to collect the sludge discharged from the screw conveyors. These belt conveyors discharge onto a main belt conveyor, common to all trains, for disposal. The filtrate is piped to the inlet of the sand filter feed pump.

The combined water stream enters the sand filter feed pump, which pumps the stream through the sand filters to the ammonia stripper surge tank. The sand filter performs a polishing function, removing whatever solids remain in the wastewater after settling and dewatering operations.

Water is pumped under flow control from the surge compartment of the ammonia stripper surge tank by the stripper feed pump to the feed/product exchangers, where the temperature will be raised. The water then enters the ammonia stripper.

Within the stripper, steam is provided by the reboiler to strip the ammonia. The overhead gas enters the overhead condenser, which cools the gas, causing a portion of the gas to condense. The two-phase stream then enters the ammonia stripper reflux drum, where the phases separate. The liquid phase is pumped back to the top tray of the stripper by the reflux pump. The ammonia-rich gas is sent to the Ammonia Recovery - Unit 26, where ammonia is recovered in liquid anhydrous form. The bottoms pump discharges the hot stripped water through the feed/product exchanger, and the stripped water is cooled further in the bottoms cooler.

The cooled stripped water pH is adjusted by addition of sulfuric acid in the neutralization basin. Phosphoric acid is added to provide the necessary nutrients for bacteria growth. The neutralization basin is divided by baffles with over- and underflow into three equal compartments. A mixer is installed in each compartment to ensure the homogeneity of the solution that flows from one compartment to the next.

The overflow from the last compartment goes into the trickling filter feed pump that sends the water to the trickling filter through the rotating sprinklers. The filter contains trickling media on the surface of which a gelatinous film of aerobic bacteria develops. As the water trickles over the film, dissolved and suspended organic matter is removed by adsorption. The adsorbed material is oxidized by the metabolic processes of the bacteria. Effluent from the trickling filter is split into two streams, one of which is directed to the clarifier by the clarifier feed pump, and the other is recycled through the trickling filter recirculation pump. The sludge exits through the bottom and flows by gravity to the sludge sump. Sodium carbonate is added to the clarifier to precipitate the soluble calcium salts. The clarifier sludge pump operates intermittently under level controls to send the sludge to the sludge handling facility.

The clarified effluent from the clarifier overflow launder is discharged by the clarifier effluent pump to reuse.

The biotreated water flow is 5,489 gpm at ambient temperature in normal operating conditions.

D. Risk Assessment

1. Chemical Treatment. The chemical treatment of the Texaco Coal Gasifier water blowdown is based upon demonstrated technology consisting of the addition of ferrous sulfate, caustic, and lime to remove such pollutants as sulfide, cyanide, and carbonates. The chemical additions are monitored to maintain rates required to achieve the reduction of pollutants needed. The pH control is effected by caustic and lime to maximize the pollutant removal for the actual chemical consumptions in the process.

Risks in chemical treatment are realized by inadequate attention given to pH control and chemical addition rates. If pH is too low, corrosion of equipment is accelerated and acid gases such as $H_2S$, HCN, and $CO_2$ may be released. If the pH is too high, insoluble hydroxides may be precipitated, thus adding to the sludge load. Risks from poor pH control and improper chemical additions consist of excessive use of chemicals, failure to remove pollutants, and possible increased equipment corrosion.

The release of toxic pollutants is not a danger because any acid gases released will go to the relief system.

2. Biotreatment. The biotreating facility is a conventional system such as is available in commercial use worldwide. If maloperation of the biotreatment occurs due to failure to provide adequate nutrition for the bacteria or if toxins are introduced into the biotreating system, high BOD and COD may occur in the effluent stream. This can be corrected by adjusting the chemical nutrients and/or reseeding the biomass with sanitary sludge.

3. Ammonia Recovery. Recovery of ammonia is effected by steam stripping the chemically treated wastewater at an appropriate pH, condensing the ammonia and pumping it to storage.

The process risks involved are improper pH adjustment and selection of pressures and temperatures in the stripper that yield excess water vapor mixed with the ammonia vapor. With a low pH, the ammonia is not stripped and the biotreatment may be adversely affected, producing excessive BOD and COD in the treated water. If the ammonia stripper pressure and temperature are improper, excessive water vapor is carried out with the ammonia. This may interfere with the marketability and use of the ammonia product.

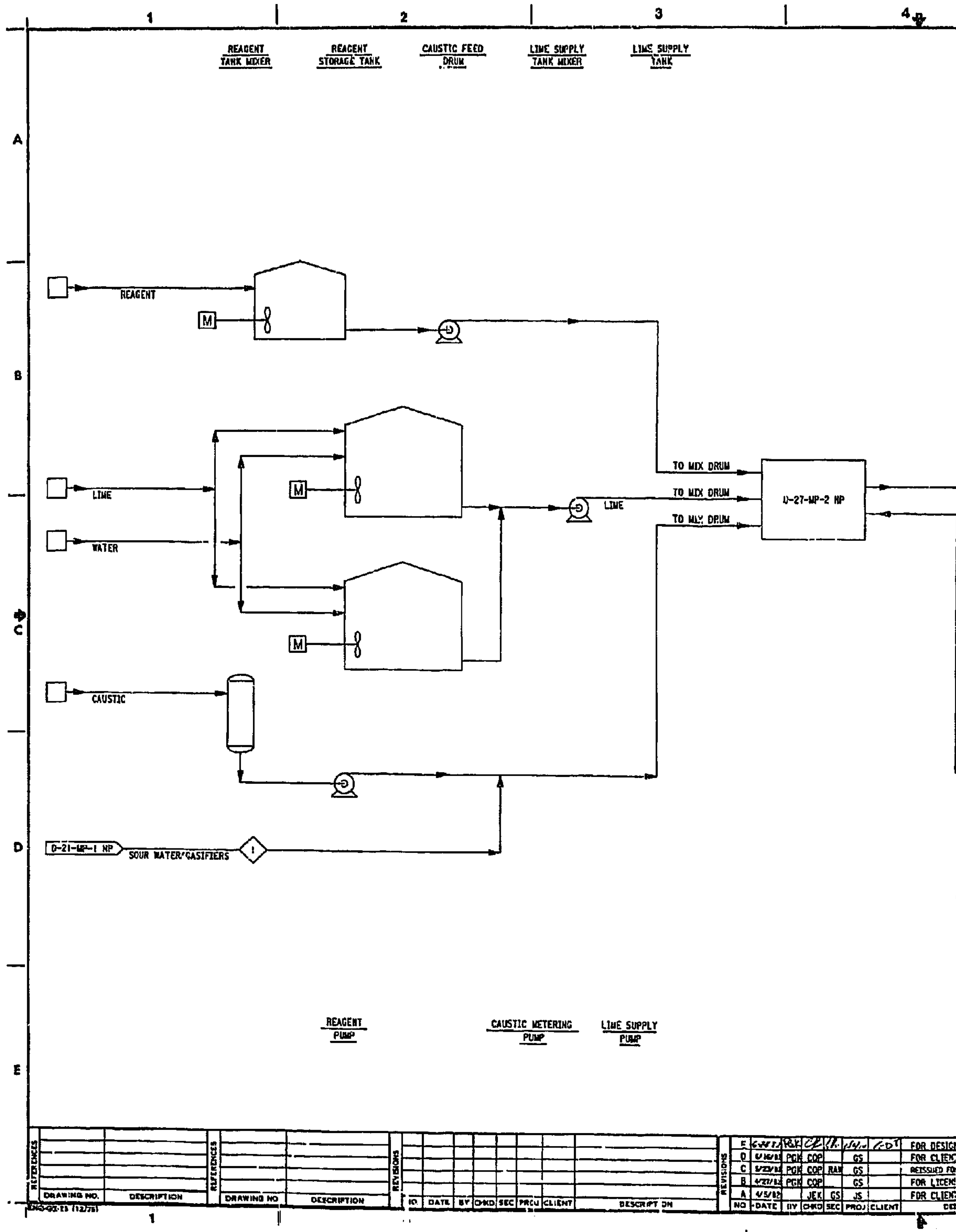
It is anticipated that the designs presented are satisfactory for any likely variations in the feed to the wastewater chemical and biotreatment systems. Similarly, the ammonia stripper accepts major variations in its feed composition and quantity. The only adjustments expected are those within the capability of the equipment specified.

Pertinent to feed composition is the selection of materials of construction. The presence of cyanide and chlorides were considered. The problems of corrosion were considered and accounted for in the design choice of metallurgy.

E. Process Flow and Control Diagrams (Including Material Balance)

Process Flow and Control Diagrams for Effluent Water Treatment Unit 27 are as follows:

| Drawing No. | Title |
|---|---|
| D-27-MP-1NP | PFCD Effluent Water Treatment - Unit 27 Unit Storage |
| D-27-MP-2NP | PFCD Effluent Water Treatment - Unit 27 Sludge Separation/Ammonia Stripping |
| D-27-MP-3NP | PFCD Effluent Water Treatment - Unit 27 Biotreatment |
| D-27-MP-4NP | Effluent Water Treatment - Unit 27 Material Balance |



1
2
3
4
A
B
C
D
E
REAGENT TANK MIXER
REAGENT STORAGE TANK
CAUSTIC FEED DRUM
LIME SUPPLY TANK MIXER
LIME SUPPLY TANK
REAGENT
M
LIME
WATER
CAUSTIC
TO MIX DRUM
TO MIX DRUM
TO MIX DRUM
D-27-MP-2 HP
D-21-MP-1 HP
SOUR WATER/GASIFIERS
REAGENT PUMP
CAUSTIC METERING PUMP
LIME SUPPLY PUMP
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO
DATE
BY
CHKD
SEC
PROJ
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DESCRIPTION
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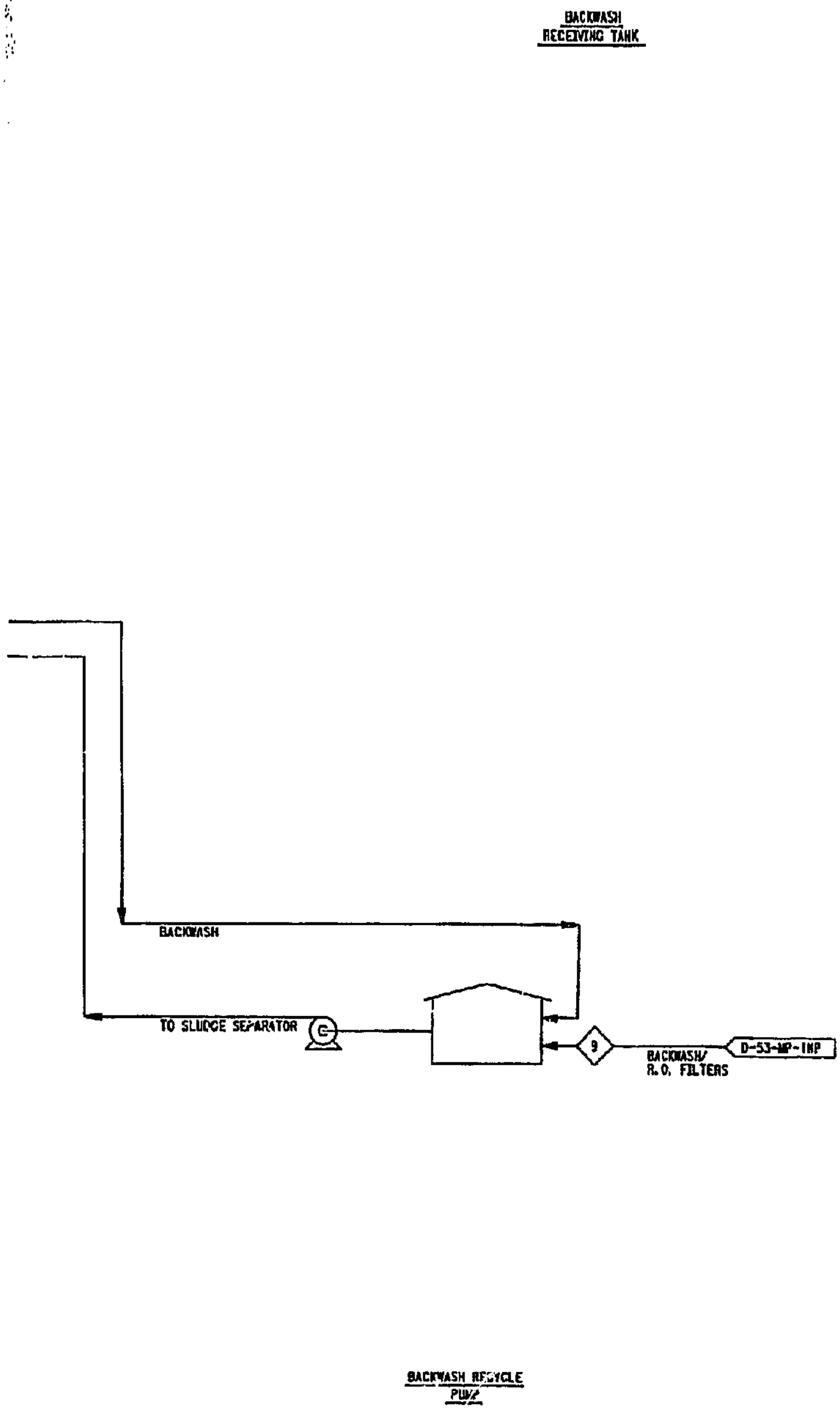



NOTES:
1. FOR EFFLUENTS SEE DWG D-27-MP-2-NP AND D-27-MP-3-NP.

D27MP1NP.CCA

| DESCRIPTION | |
|---|---|
| FOR DESIGN REPORT | FOR |
| FOR CLIENT APPROVAL | DRAWN |
| REISSUED FOR LICENSOR APPROVAL | CHECKED |
| FOR LICENSOR APPROVAL | APVD PECT NO |
| FOR CLIENT SOX REVIEW | APVD PROJ MGR |
| | APVD CLIENT |

TEXACO DEVELOPMENT CORPORATION

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

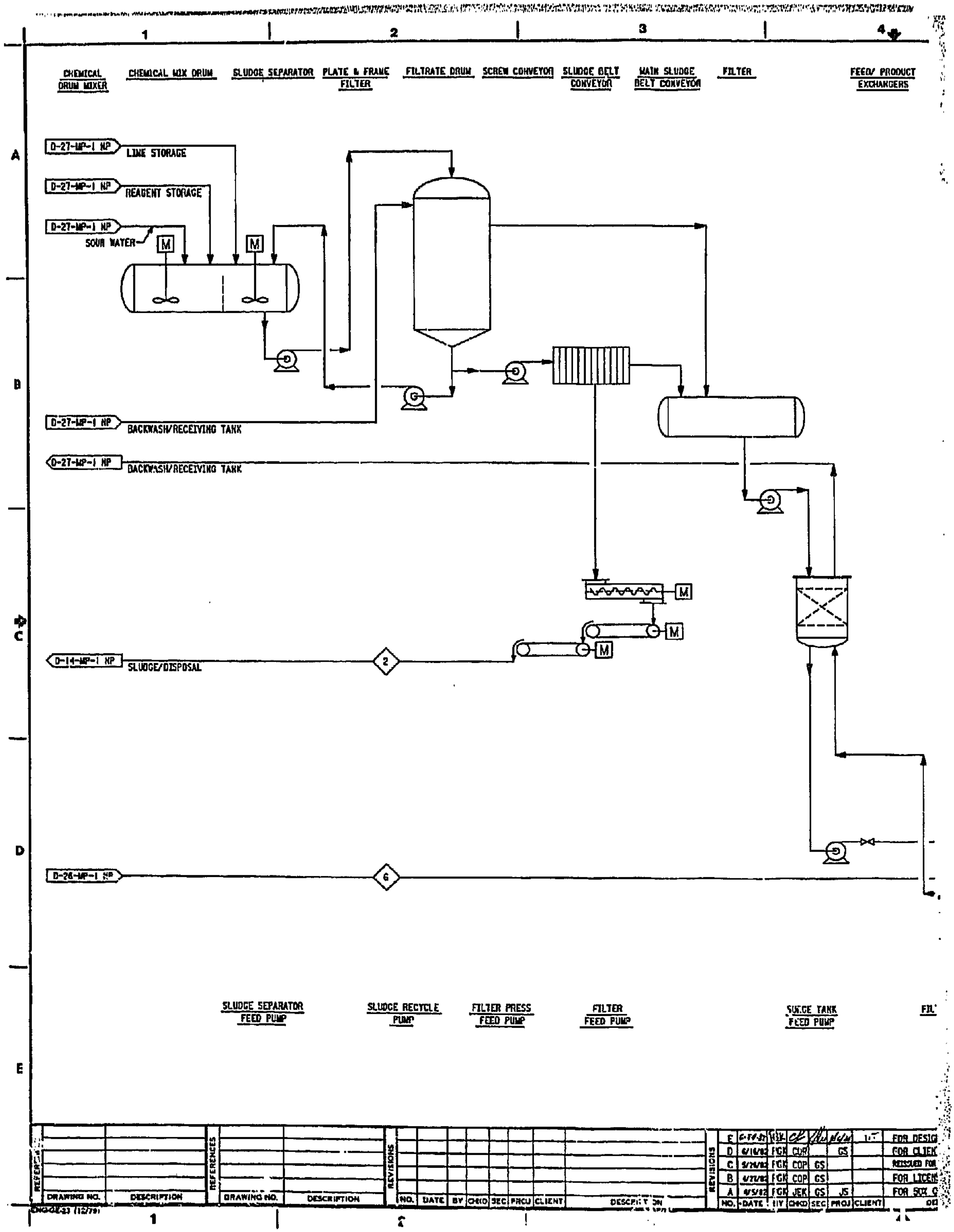
U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: PROCESS FLOW AND CONTROL DIAGRAM
EFFLUENT WATER TREATMENT -- UNIT 27
UNIT STORAGE

| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| NONE | 2800 | 6182 | E |

DOCUMENT NUMBER: D-27-MP-1 NP


1
2
3
4
CHEMICAL DRUM MIXER
CHEMICAL MIX DRUM
SLUDGE SEPARATOR
PLATE & FRAME FILTER
FILTRATE DRUM
SCREW CONVEYOR
SLUDGE BELT CONVEYOR
MAIN SLUDGE BELT CONVEYOR
FILTER
FEED/ PRODUCT EXCHANGERS
A
B
C
D
E
D-27-MP-1 NP
LIME STORAGE
D-27-MP-1 NP
REAGENT STORAGE
D-27-MP-1 NP
SOUR WATER
M
M
D-27-MP-1 NP
BACKWASH/RECEIVING TANK
D-27-MP-1 NP
BACKWASH/RECEIVING TANK
M
M
M
D-14-MP-1 NP
SLUDGE/DISPOSAL
2
D-26-MP-1 NP
6
SLUDGE SEPARATOR FEED PUMP
SLUDGE RECYCLE PUMP
FILTER PRESS FEED PUMP
FILTER FEED PUMP
SURGE TANK FEED PUMP
DRAWING NO.
DESCRIPTION
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
REVISIONS
E
D
6/16/82
FGK
COP
GS
FOR CLIENT
C
5/24/82
FGK
COP
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B
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A
4/5/82
FGK
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DATE
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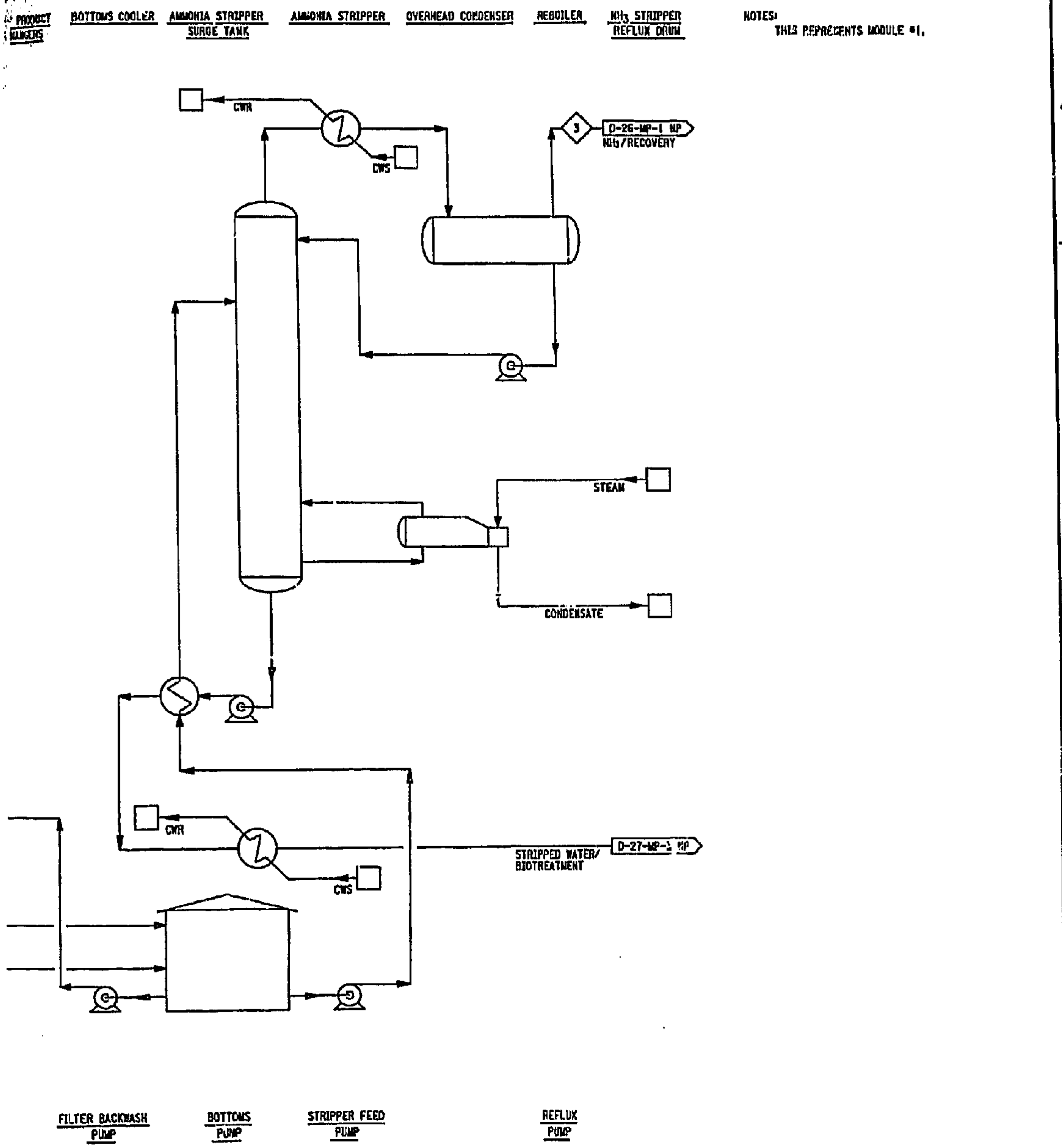
CHKD
SEC
PROJ
CLIENT
ENG-OE-33 (12/79)
1




NOTES:
THIS REPRESENTS MODULE #1.

D27MP2NP.DGN

| | |
|---|---|
| FOR DESIGN REPORT | |
| FOR CLIENT APPROVAL | |
| REISSUED FOR LICENSOR APPROVAL | |
| FOR LICENSOR APPROVAL | |
| FOR 50% CLIENT REVIEW | |
| DESCRIPTION | |

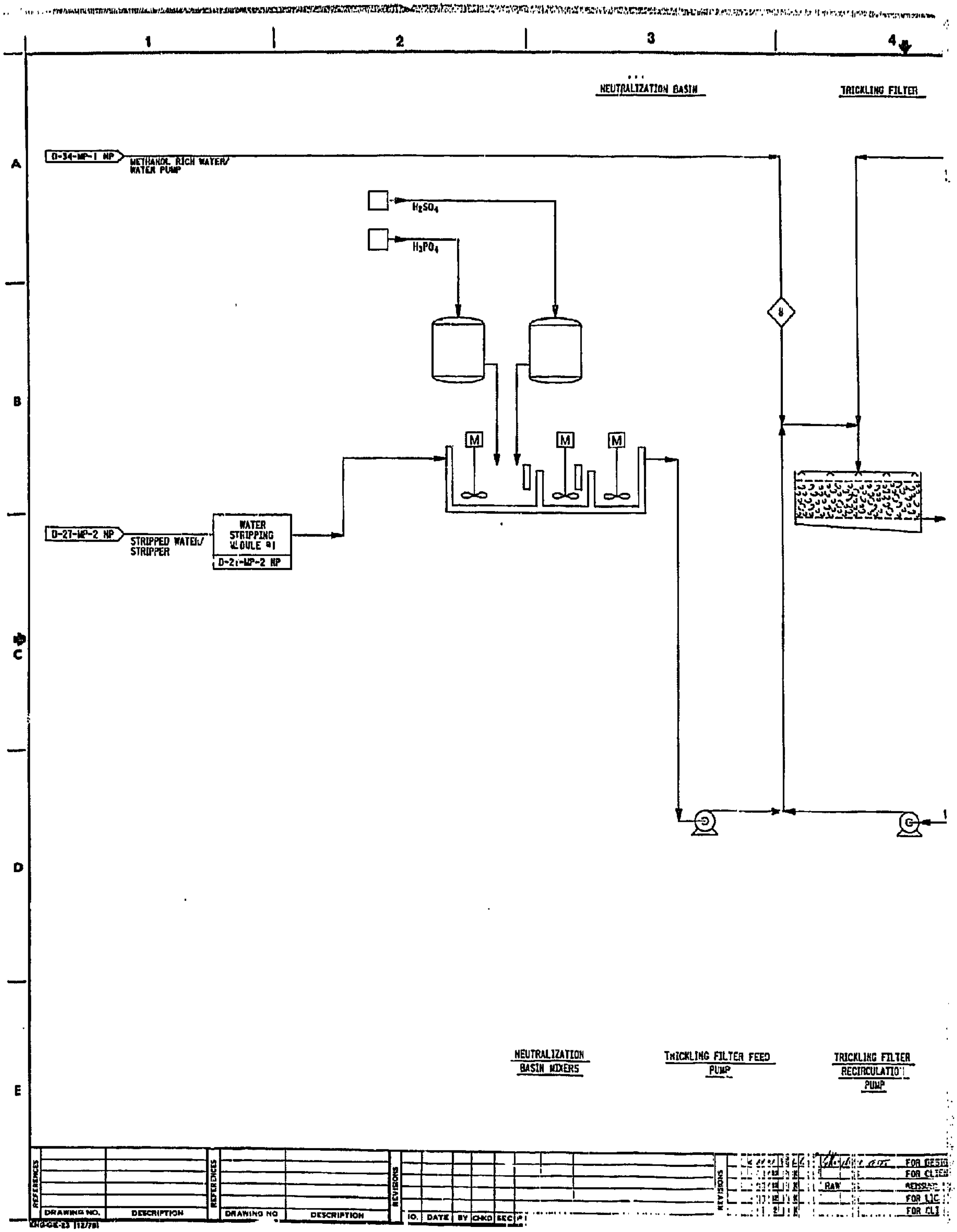
TEXACO DEVELOPMENT CORPORATION
2000 WESTCHESTER AVENUE
WHITE PLAINS, NEW YORK 10650

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

U.S. DEPARTMENT OF ENERGY
BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: PROCESS FLOW AND CONTROL DIAGRAM
EFFLUENT WATER TREATING - UNIT 27
SLUDGE SEPARATION/AMMONIA STRIPPING

SCALE: NONE | 2800 | 6182
D-27-MP-2 NP



1
2
3
4
A
B
C
D
E
NEUTRALIZATION BASIN
TRICKLING FILTER
D-34-MP-1 NP
METHANOL RICH WATER/
WATER PUMP
$H_2SO_4$
$H_3PO_4$
M
M
M
D-27-MP-2 NP
STRIPPED WATER/
STRIPPER
WATER
STRIPPING
MODULE #1
NEUTRALIZATION
BASIN MIXERS
TRICKLING FILTER FEED
PUMP
TRICKLING FILTER
RECIRCULATION
PUMP
REFERENCES
DRAWING NO.
DESCRIPTION
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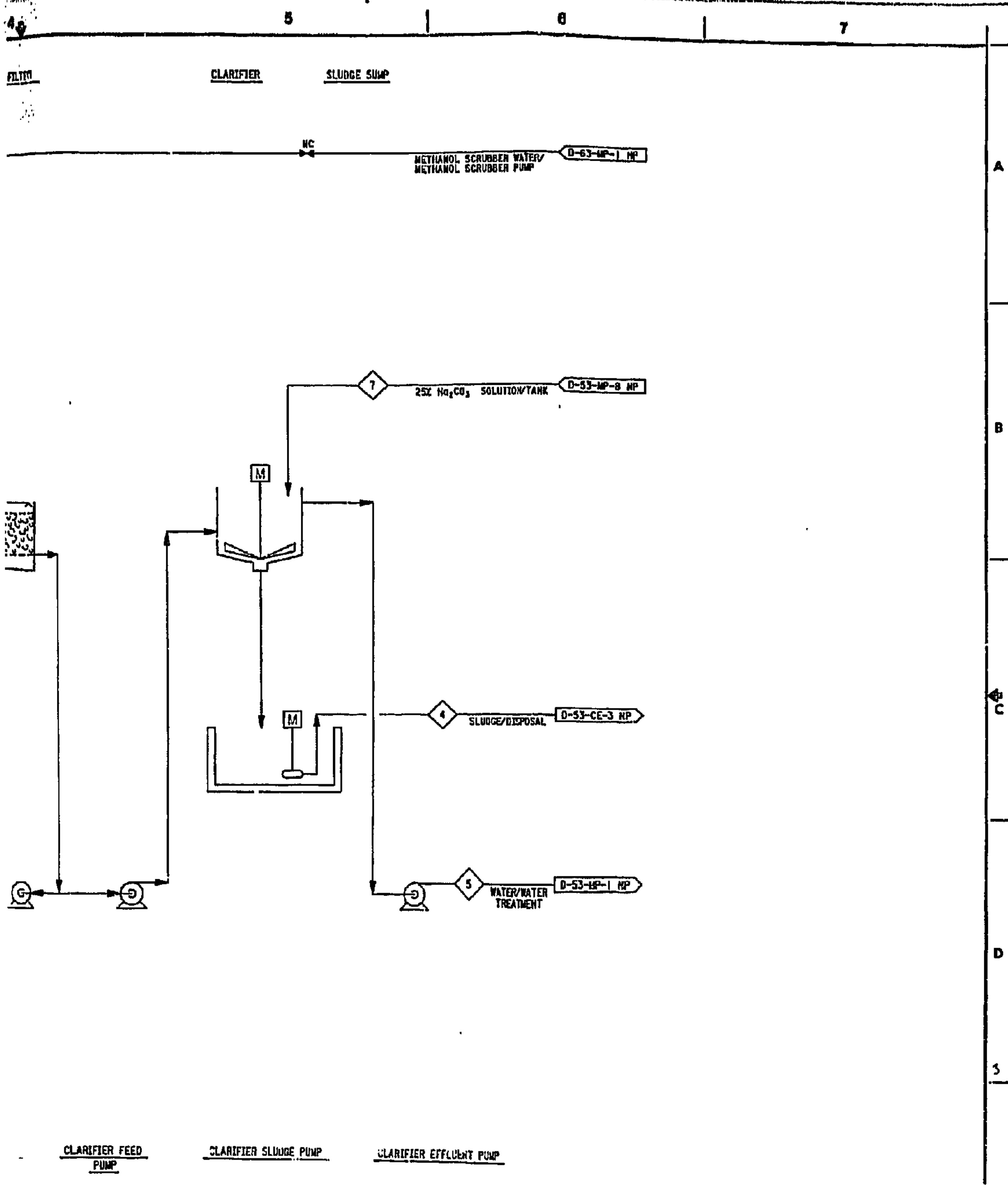


D27MP3NP.TMP

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50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

| | |
|---|---|
| FOR DESIGN REPORT | FOR |
| APPROVAL | DRAWN |
| LICENSOR APPROVAL | CHECKED |
| LICENSOR APPROVAL | APVD SECT HD. |
| REVIEW | APVD PROJ MGR |
| DESCRIPTION | APVD CLIENT |

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

TITLE: PROCESS FLOW AND CONTROL DIAGRAM
EFFLUENT WATER TREATMENT - UNIT 27
BIOTREATMENT

| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| NONE | 2800 | 6182 | E |

DOCUMENT NUMBER: D-27-MP-3 NP

5

DC-MP17

CT-468 IH-1253

| COMPONENT | M.W. | | ⟨1⟩ SOUR WATER FEED | ⟨2⟩ CHEMICAL SLUDGE | ⟨3⟩ AMMONIA VAPOR | ⟨4⟩ BIO-TREATED SLUDGE | ⟨5⟩ BIO-TREATED WATER |
|---|---|---|---|---|---|---|---|
| TOC | | PPMW | 140 | — | — | — | 4 |
| TIC | | PPMW | 104 | — | — | — | — |
| TDS | | PPMW | 2,000 | — | — | — | 447 |
| TSS | | PPMW | 132 | — | — | — | 110 |
| COD | | PPMW | 500 | — | — | — | 17 |
| METHANOL | 32.0 | LB MOLS/HR | — | — | — | — | — |
| AMMONIA | 17.0 | LB MOLS/HR | 215.66 | 2.65 | 210.90 | 0.06 | 2.06 |
| CALCIUM CARBONATE | 100.0 | LB MOLS/HR | — | — | — | 52.98 | TRACE |
| BROMIDE | 79.9 | LB MOLS/HR | 0.03 | — | — | — | 0.03 |
| CHLORIDE | 35.4 | LB MOLS/HR | 116.20 | 14.06 | — | 0.06 | 102.62 |
| FLUORIDE | 19.0 | LB MOLS/HR | 21.11 | 20.79 | — | — | 0.32 |
| CYANIDE | 26.0 | LB MOLS/HR | 3.98 | 3.54 | — | 0.27 | 0.15 |
| FORMATE | 45.0 | LB MOLS/HR | 26.58 | 3.22 | — | — | .23 |
| NITRATE | 62.0 | LB MOLS/HR | 0.35 | 0.05 | — | — | 0.30 |
| SULFIDE | 33.0 | LB MOLS/HR | 6.94 | 6.91 | TRACES | 0.03 | 0.003 |
| SULFATE | 96.0 | LB MOLS/HR | 0.50 | 16.73 | — | — | 1.49 |
| THIOCYANATE | 58.0 | LB MOLS/HR | 0.31 | 0.63 | — | 0.27 | 0.01 |
| PHOSPHATE | 79.0 | LB MOLS/HR | — | — | — | — | 0.69 |
| SODIUM CARBONATE | 106.0 | LB MOLS/HR | — | — | — | — | — |
| CARBON DIOXIDE | 44.0 | LB MOLS/HR | — | — | — | — | — |
| ORGANICS | | PPBW | 9 | 88 | — | — | 1 |
| TOTAL DRY | | LB MOLS/HR | 391.63 | 67.98 | 210.90 | 53.67 | 108.90 |
| TOTAL DRY | | LB/HR | *4,596 | 3,285 | 3,592 | 5,325 | 3,952 |
| WATER | 18.0 | LB MOLS/HR | 127,191.6 | 1,574.61 | 2.91 | 1,678.22 | 162,246.39 |
| TOTAL WET | | LB MOLS/HR | — | 1,642.59 | 213.81 | 1,731.89 | 162,355.29 |
| TOTAL WET | | LB/HR | 2,296,080 | 31,628 | 3,644 | 35,533 | 2,924,387 |
| TEMPERATURE, °F | | | 170 | 150 | 100 | 70 | 70 |
| PRESSURE, PSIA | | | 70 | 15 | 70 | 15 | 15 |
| GPM @ T&P | | | 4,699 | — | — | 65 | 5,489 |

*NOTE 2

REFERENCES — DRAWING NO. — DESCRIPTION

REFERENCES — DRAWING NO. — DESCRIPTION

REVISIONS — NO. — DATE — BY — CHKD — SEC — PROJ — CLIENT

REISSUED FOR DES

FOR CL

ENG-08-23 (12/79)

4 5 6 7

NOTES:

1. THE MATERIAL BALANCE IS FOR 100% NORMAL OPERATING CONDITIONS FOR A 50,000 BPSD GASOLINE PLANT.
2. THIS INDICATES THE TOTAL DISSOLVED SOLIDS.

| 5 -TREATED WATER | 6 CONDENSATE | 7 SODIUM CARBONATE SOLUTION | 8 METHANOL RICH WATER | 9 BACKWASH FROM UNIT 53 |
|---|---|---|---|---|
| 4 | — | — | — | — |
| — | — | — | — | — |
| 447 | — | — | — | — |
| 110 | — | — | — | 4,000 |
| 17 | — | — | — | — |
| — | — | — | 12.0 | — |
| 2.06 | 0.40 | 0.013 | — | — |
| TRACE | — | — | — | — |
| 0.03 | — | TRACES | — | — |
| 102.62 | — | 0.60 | — | — |
| 0.32 | — | 0.002 | — | — |
| 0.15 | — | 0.001 | — | — |
| 1.23 | — | 0.009 | — | — |
| 0.30 | — | 0.002 | — | — |
| 0.003 | TRACES | TRACES | — | — |
| 1.49 | — | 0.011 | — | — |
| 0.01 | — | TRACES | — | — |
| 0.69 | — | 0.006 | — | — |
| — | — | 52.98 | — | — |
| — | — | — | 21.6 | — |
| 1 | — | — | — | — |
| 108.90 | 0.40 | 51.62 | 33.60 | — |
| 3,952 | 7.00 | 5,639 | 1,334 | 270 |
| 82,246.39 | 0.94 | 934.72 | 27,258.30 | — |
| 82,355.29 | 1.34 | 988.34 | 27,291.90 | 3,735 |
| 2,924,307 | 24.00 | 22,464 | 491,568 | 67,500 |
| 70 | 100.00 | 90 | 65 | 70 |
| 15 | 103.00 | 30 | 17 | 40 |
| 5,485 | — | 45 | 984 | 135 |

| REV | DESCRIPTION |
|---|---|
| | REISSUED FOR DESIGN REPORT |
| | FOR DESIGN REPORT |
| | FOR CLIENT APPROVAL |
| | FOR CLIENT AND PARSONS REVIEW |

FOR / DRAWN / CHECKED / APVD PROJ ENG / APVD PROJ MGR / APVD CLIENT

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

027MP-1P.DGA

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: EFFLUENT WATER TREATMENT - UNIT 27 MATERIAL BALANCE NORMAL OPERATING CASE

SCALE: NONE — 6182

D-27-MP-4 NP

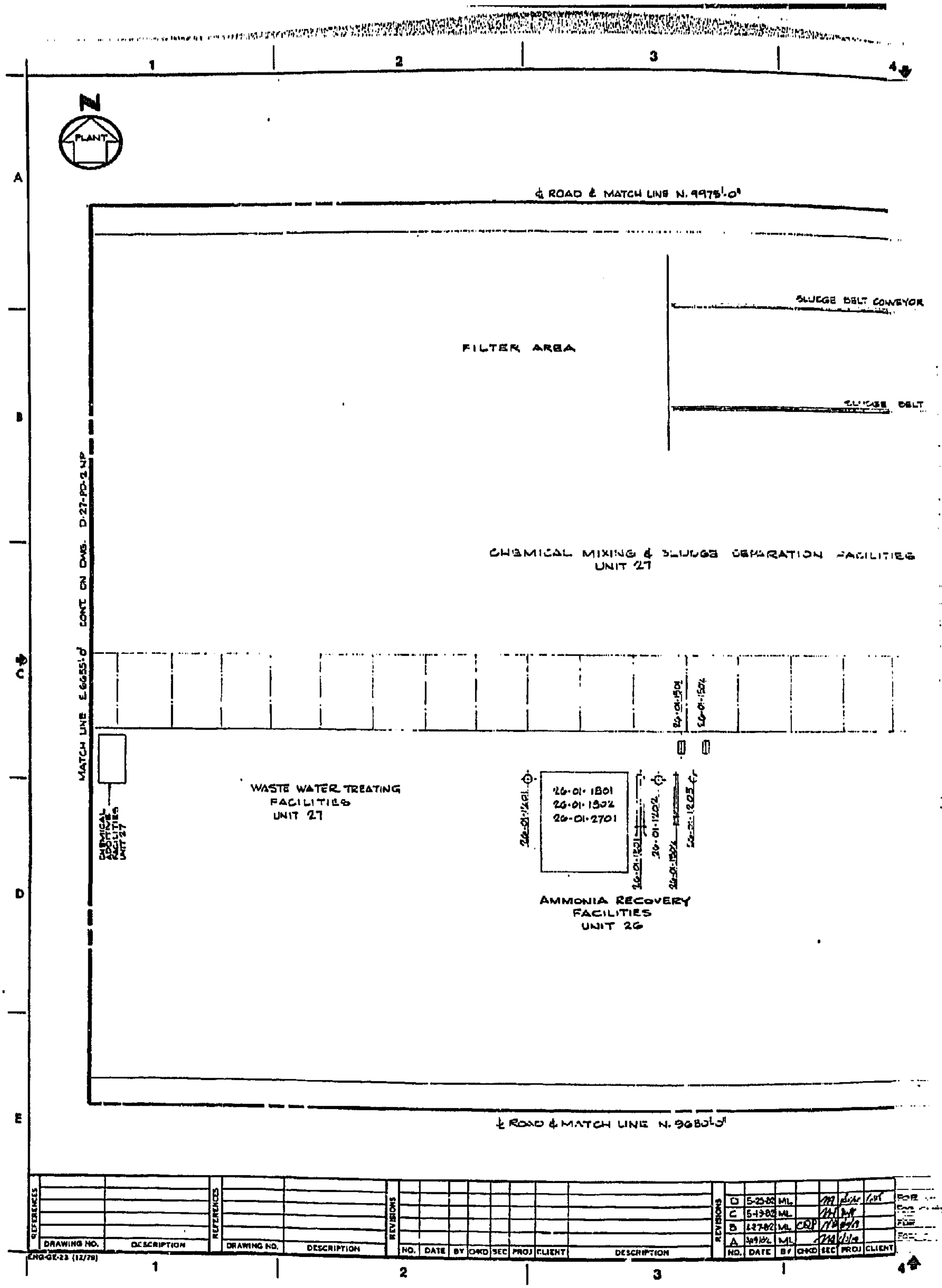
REV: 0

4 5 6

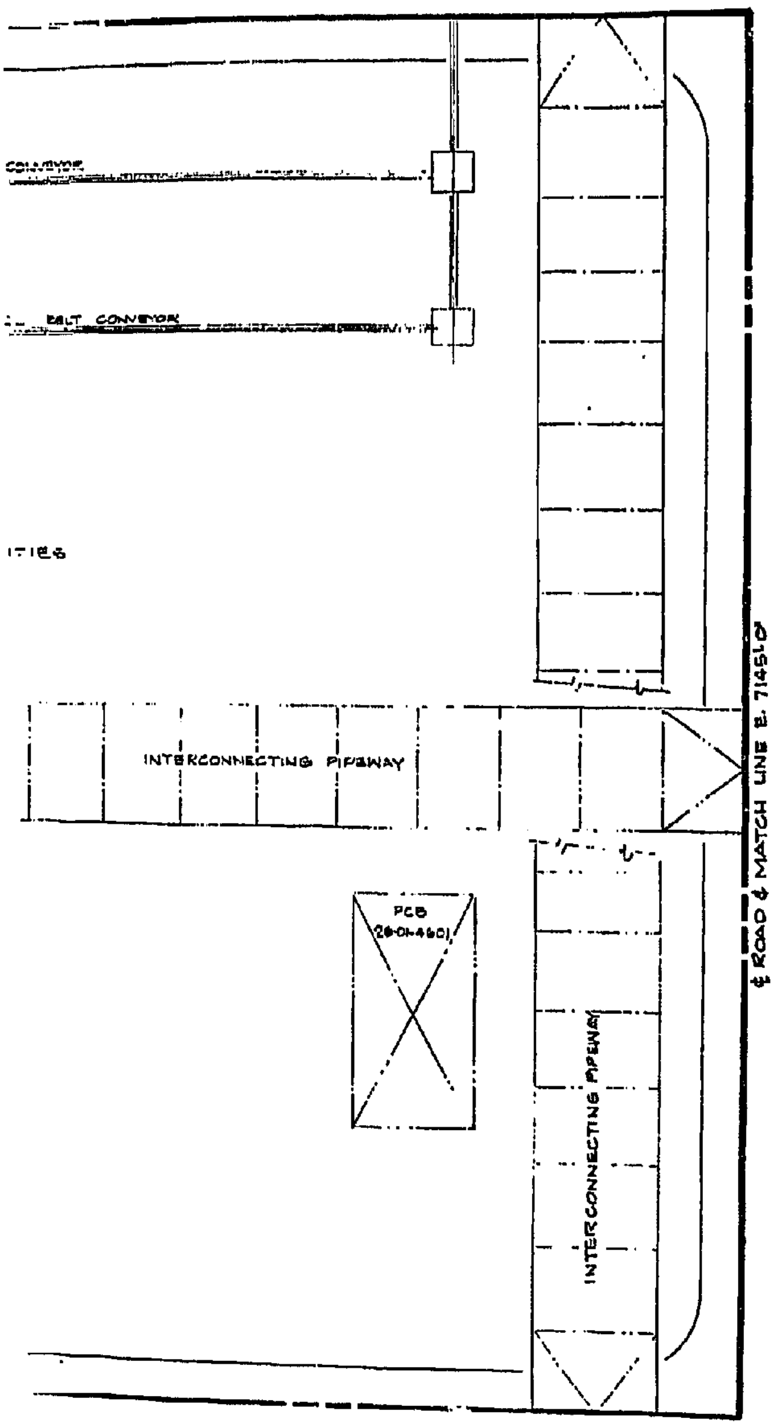
## F. Plot Plan/General Arrangement Drawings

Plot Plan and General Arrangement Drawings for Effluent Water Treatment Unit 27 are as follows:

| Drawing No. | Title |
|---|---|
| D-27-PD-1NP | Plot Plan - Unit 26 and Unit 27 Ammonia Recovery and Effluent Water Treating |
| D-27-PD-2NP | Plot Plan - Unit 26 and Unit 27 Ammonia Recovery and Effluent Water Treating |
| D-27-PD-3NP | Plot Plan - Unit 27 Effluent Water Treating |



PLANT
N
℄ ROAD & MATCH LINE N. 9975'-0"
SLUDGE BELT CONVEYOR
FILTER AREA
SLUDGE BELT
CHEMICAL MIXING & SLUDGE SEPARATION FACILITIES
UNIT 27
MATCH LINE E.6655'-0" CONT ON DWG. D-27-PD-2 UP
26-01-1501
WASTE WATER TREATING
FACILITIES
UNIT 27
CHEMICAL ADDITIVE FACILITIES UNIT 27
26-01-1801
26-01-1502
26-01-2701
26-01-1201
26-01-1202
AMMONIA RECOVERY
FACILITIES
UNIT 26
℄ ROAD & MATCH LINE N. 9680'-0"
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO. DATE BY CHKD SEC PROJ CLIENT
D 5-25-82 ML
C 5-13-82 ML
B 4-27-82 ML
A ML
ENG-GE-23 (12/78)




EQUIPMENT LIST

| | |
|---|---|
| 26-01-1201 | FEED DRUM |
| 26-01-1202 | 1ST STAGE AMMONIA K.O. DRUM |
| 26-01-1203 | AMMONIA ACCUMULATOR |
| 26-01-1501 | AMMONIA COMPRESSOR INTERCOOLER |
| 26-01-1502 | AMMONIA PRODUCT CONDENSER |
| 26-01-1801 | AMMONIA PRODUCT PUMP |
| 26-01-1802 | AMMONIA PRODUCT PUMP SPARE |
| 26-01-1801 | AMMONIA COMPRESSOR |
| 26-01-1802 | AMMONIA COMPRESSOR SPARE |
| 26-01-2701 | SUCTION FILTER |

NOTES

1. ITEMS WITH TAG NO. 26 ARE NON-PROPRIETY EQUIPMENT.

1" = 20 FT

| DESCRIPTION | FOR | |
|---|---|---|
| FOR DESIGN REPORT | DRAWN | ML |
| FOR CLIENT APPROVAL | CHECKED | |
| FOR LICENSOR APPROVAL | APVD SECT MR | 7/9 |
| FOR CLIENT 50% REVIEW | APVD PROJ MGR | |
| | APVD CLIENT | |

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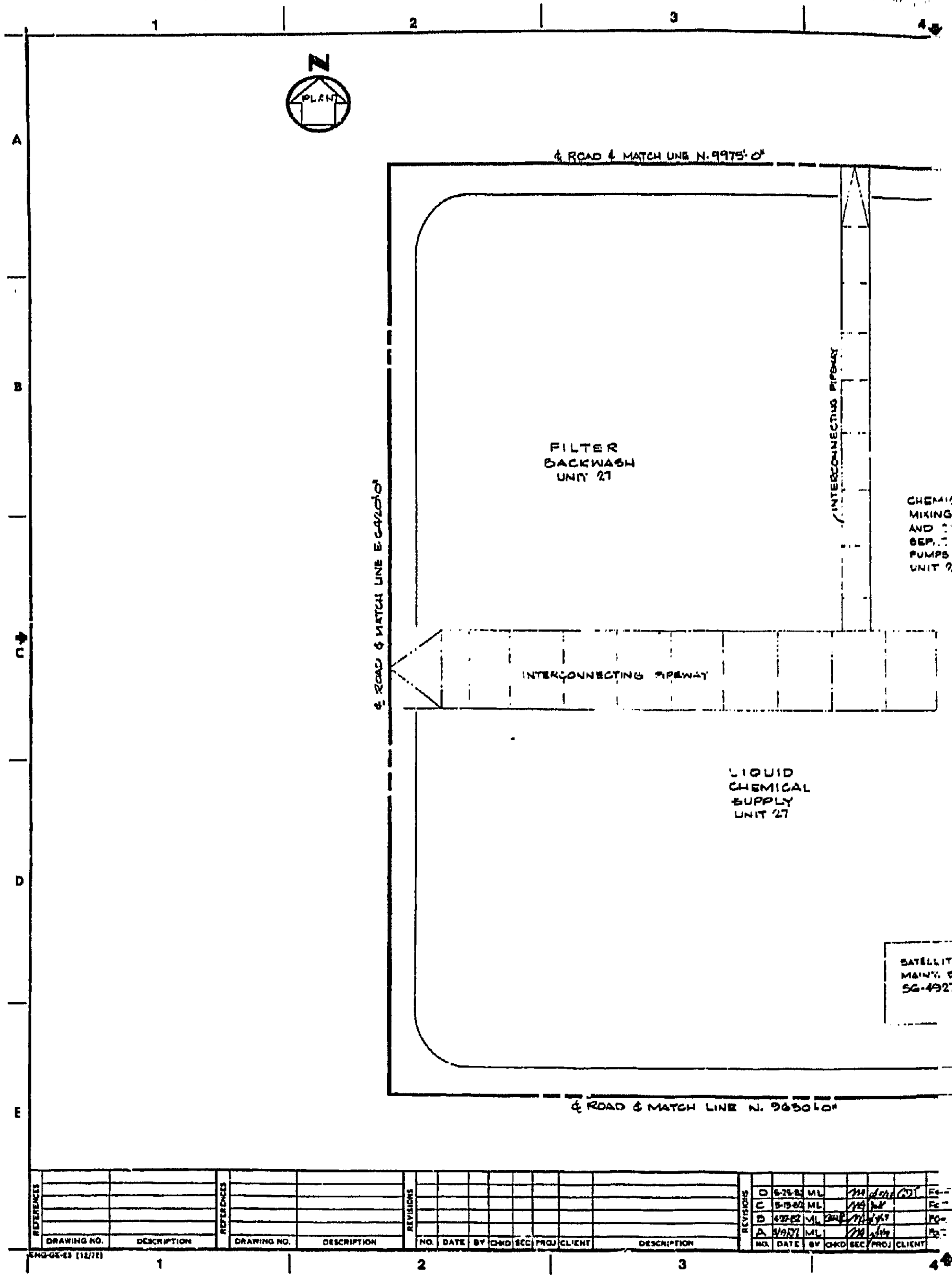
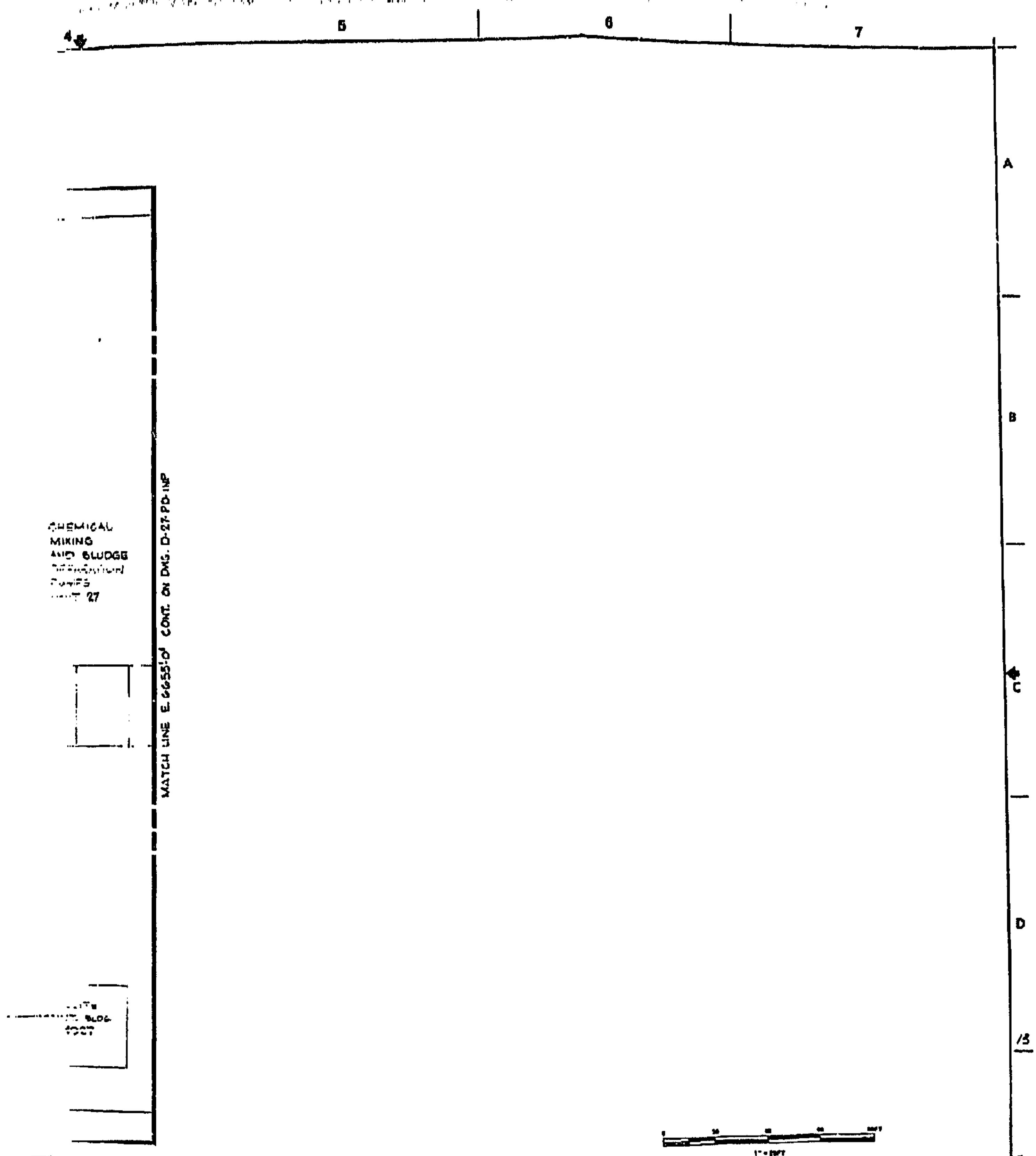
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

| TITLE | SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|---|
| PLOT PLAN UNIT 26 & UNIT 27 AMMONIA RECOVERY EFFL BIO WATER TREATING | 1"=20'-0" | 7243 | 3182 | D |
| | DOCUMENT NUMBER: D 27-PD-1F | | | |


PLANT
N
₵ ROAD & MATCH LINE N. 9975'-0"
₵ ROAD & MATCH LINE E. 6420'-0"
FILTER
BACKWASH
UNIT 27
INTERCONNECTING PIPEWAY
INTERCONNECTING PIPEWAY
LIQUID
CHEMICAL
SUPPLY
UNIT 27
SATELLITE
5G-4927
₵ ROAD & MATCH LINE N. 9650'-0"
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
D
C
B
A
ML
ENG-GE-23 (12/72)
A
B
C
D
E
1
2
3
4

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BASKETT — W.R. GRACE & CO. — KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

PLOT PLAN
UNIT 26 & UNIT 27
AMMONIA RECOVERY
EFFLUENT WATER TREATING

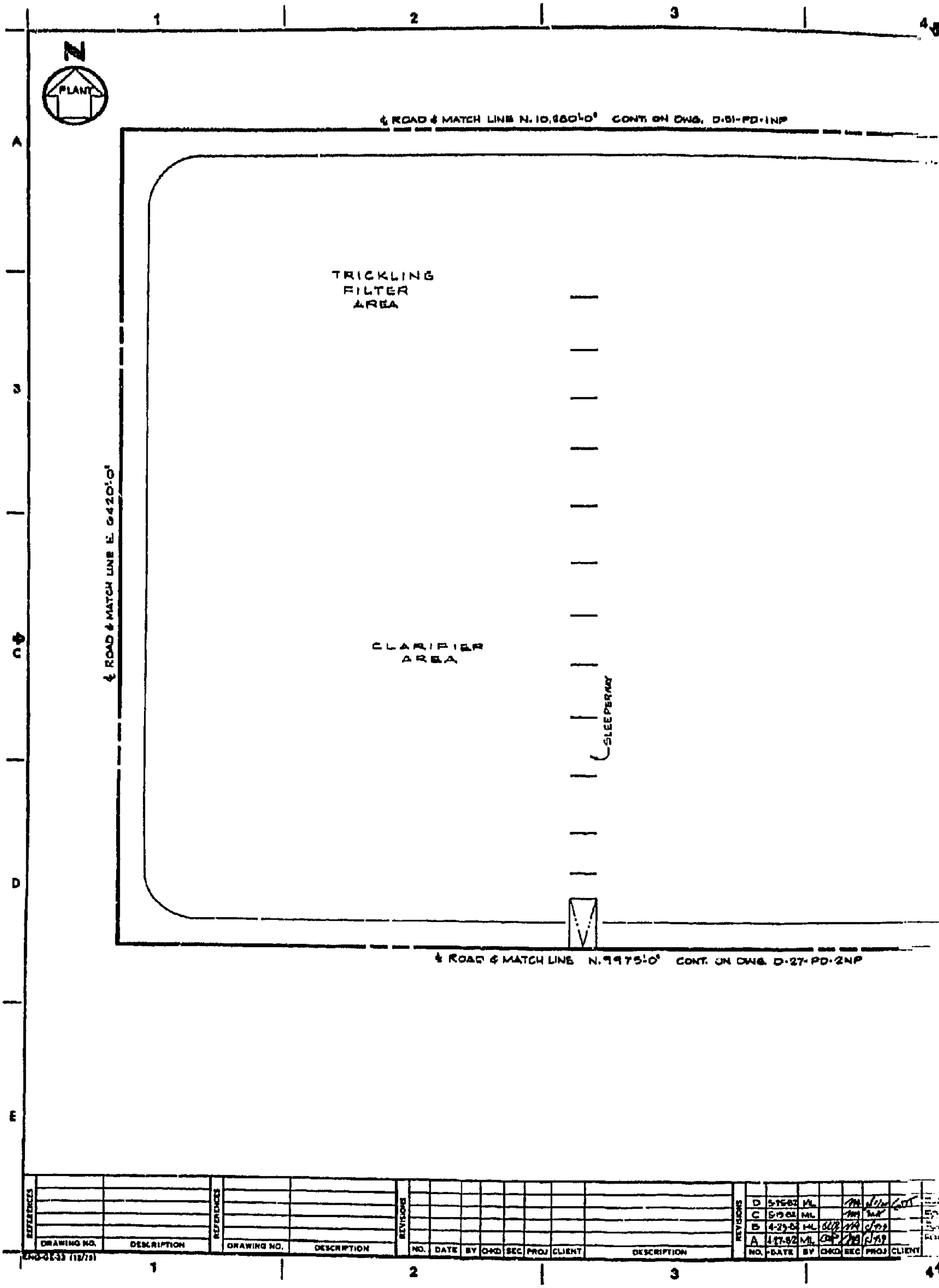
| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| 1" = 20'-0" | 7245 | 6182 | D |

D-27-PD-2NP

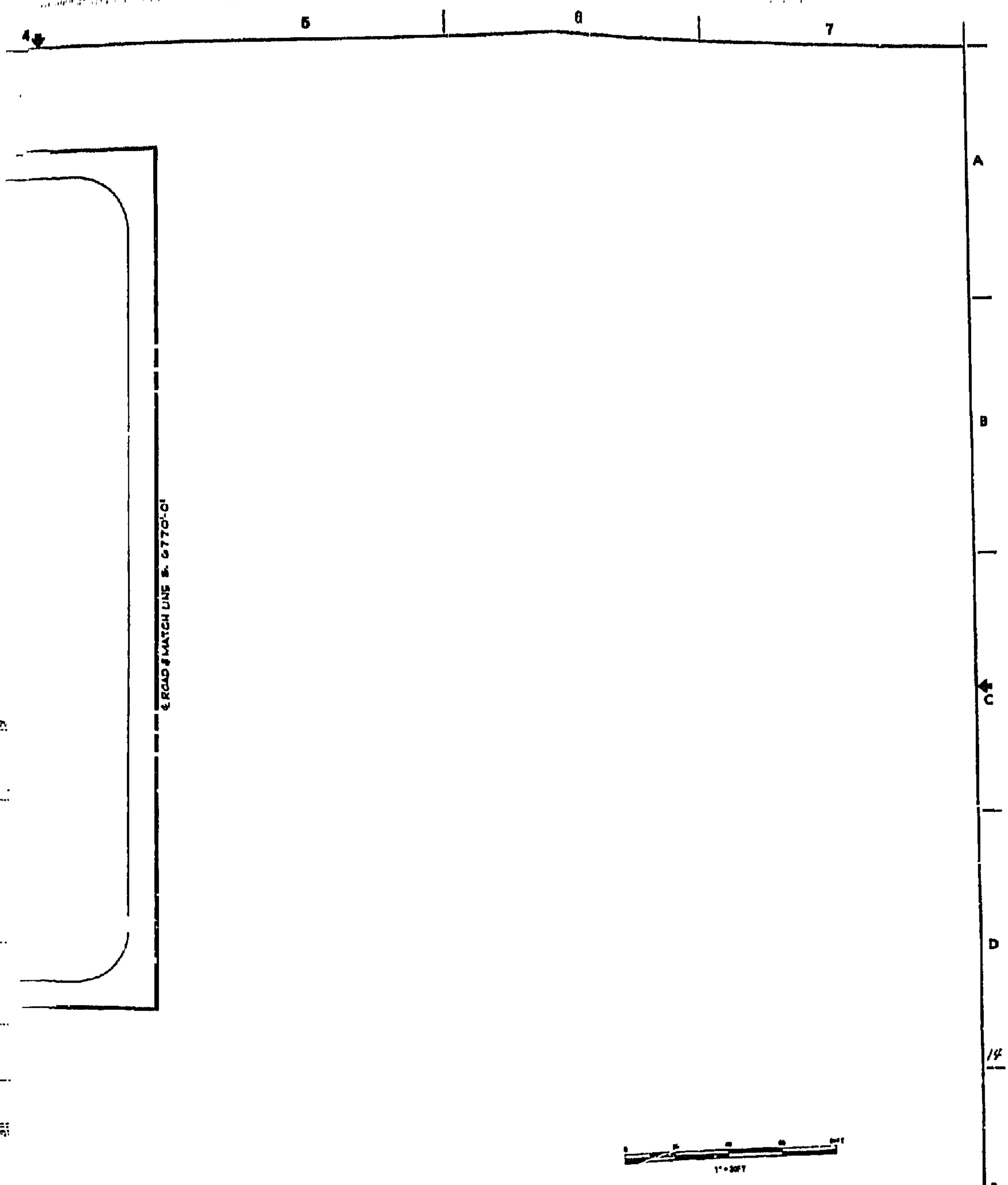
| DESCRIPTION | | |
|---|---|---|
| FOR DESIGN REPORT | DRAWN | ML |
| FOR CLIENT APPROVAL | CHECKED | |
| FOR LICENSOR APPROVAL | APVD SECT HD | |
| FOR CLIENT 50% REVIEW | APVD PROJ MGR | |
| | APVD CLIENT | |

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

DT-556 JN-1120



PLANT
℄ ROAD ℄ MATCH LINE N. 10,580'-0" CONT. ON DWG. D-51-PD-1NP
TRICKLING
FILTER
AREA
℄ ROAD ℄ MATCH LINE E. 6420'-0"
CLARIFIER
AREA
SLEEPERWAY
℄ ROAD ℄ MATCH LINE N. 9975'-0" CONT. ON DWG. D-27-PD-2NP
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
ENG-01-33 (12/73)




U.S. DEPARTMENT OF ENERGY

BASKETT — KENTUCKY

**W.R. GRACE & CO.**
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

| | |
|---|---|
| DESIGN REPORT | DRAWN ML |
| FOR CLIENT APPROVAL | CHECKED |
| FOR LICENSOR APPROVAL | APVD SECT HD |
| FOR CLIENT 50% REVIEW | APVD PROJ MGR |
| DESCRIPTION | APVD CLIENT |

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

TITLE: PLOT PLAN
UNIT 27
EFFLUENT WATER TREATING

SCALE: 1"=20'-0" | 7243 | 6182
DOCUMENT NUMBER: D-27-PD-3 NP
REVISION: 0

G. <u>Single-Line Diagram</u>

See Volume II, 1.2.9(G) for Single-Line Diagram for Effluent Water Treatment Unit 27.

## 1.2.12 METHANOL-TO-GASOLINE - UNIT 31

This subsection describes the process design and key equipment mechanical design features of a battery limits methanol-to-gasoline (MTG) plant to produce a nominal 50,000 bpd of gasoline. This design is the fixed-bed, version of Mobil Research and Development Corporation's MTG technology.

The MTG plant requires a feedstock of approximately 131,000 bpsd of crude methanol derived from coal. The MTG Reaction unit described here converts the methanol to raw gasoline plus light gases, with all hydrocarbons being sent to Gas Fractionation - Unit 32. Significant amounts of process water are separated from the hydrocarbon stream and sent to Process Water Treatment - Unit 39 for biotreatment of minor organic constituent.

### A. Basis of Design

Production of finished gasoline from methanol by Mobil's proprietary MTG process requires the arrangement of units shown in Figure II-1.2.12-1. This processing scheme includes MTG Reaction, Gas Fractionation, Heavy Gasoline Treating, and Process Water Treatment. A supply of hydrogen and facilities for gasoline blending and product storage also are necessary. The information presented in this section is limited to the MTG reaction unit.

The MTG reaction unit is sized for a methanol feed rate of 18,256 short tons (131,000 barrels) per stream day, including 5 wt% water and the dissolved gases of methanol production. It produces raw gasoline, light gases, and process water. Following fractionation of the hydrocarbons, heavy gasoline treating, alkylation, and blending, 52,460 barrels of gasoline are produced along with LPG (propane), isobutane, and fuel gas. The feed composition, product stream rates, and physical properties are presented in subsection 1 below. The product volumes vary slightly with the MTG catalyst life and cycle; average values are given. The blended gasoline is estimated to have an (R+M)/2 Octane number of 88 and an API gravity of 63°. It contains no detectable sulfur, nitrogen, or oxygenates and is suitable for sale after the addition of normal additives.

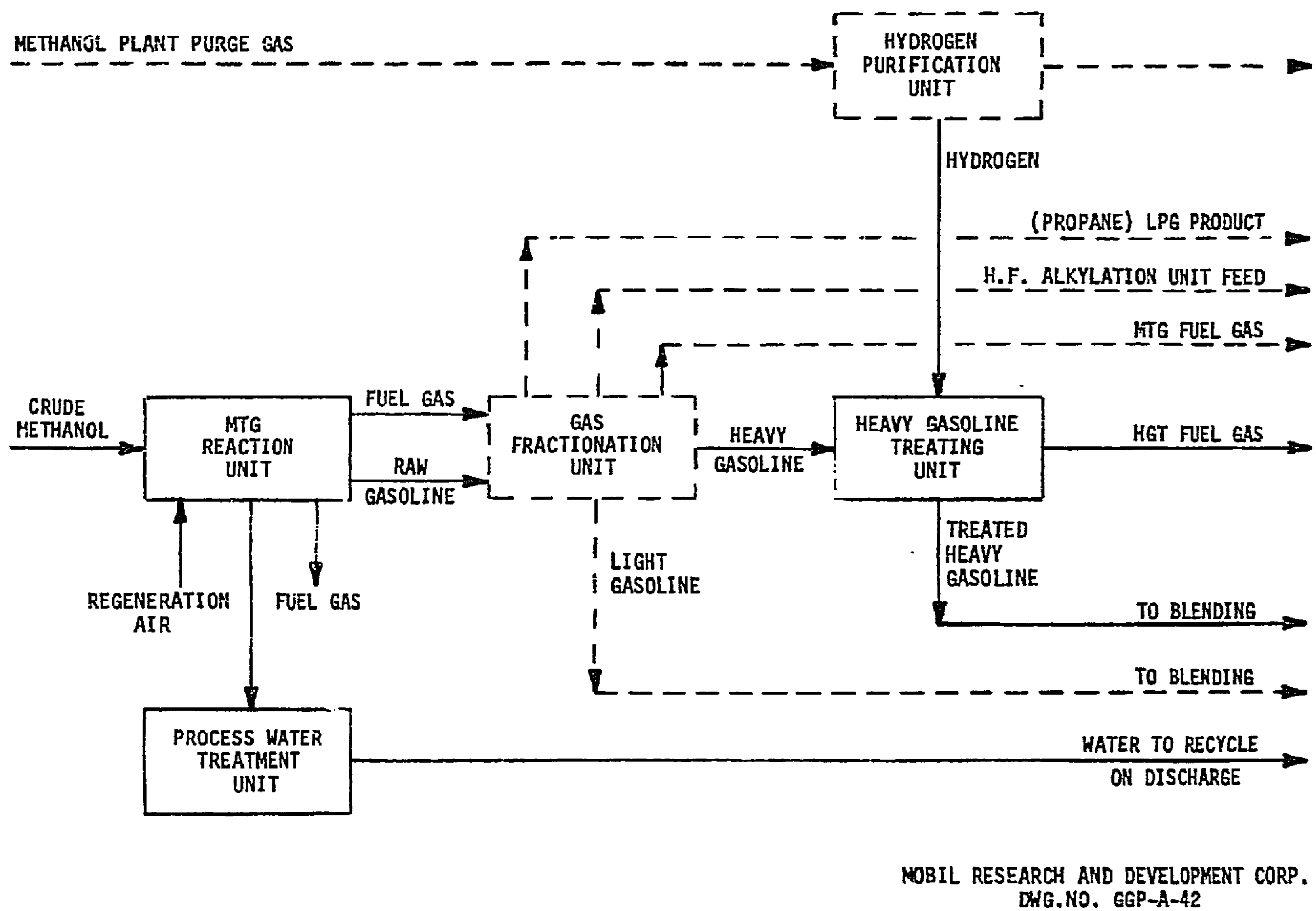



Figure II-1.2.12-1 - MTG Plant Block Flow Diagram

1. Feedstocks and Products. The methanol feed to the MTG plant contains about 5 wt% water and dissolved gases as shown on the next page. The product streams from the MTG plant are shown on the subsequent page.

The MTG Reaction unit is designed to produce the following streams and quantities:

| | |
|---|---|
| Hydrocarbon Liquids | 61,330 bpsd |
| Mixed Light Gases | 9,140 mscfsd |
| Process Water | 1,750 gpm |

The hydrocarbon liquids and gases are sent to Gas Fractionation - Unit 32. The process water stream, containing minor quantities of various organics, is biotreated in Process Water Treatment - Unit 39.

2. Plant Design Basis. This subsection summarizes key considerations and basic design philosophy that have been incorporated in the design of Methanol-to-Gasoline - Unit 31.

a. Number of Trains and Turndown Flexibility. For a nominal 50,000 bpsd of finished gasoline, three MTG trains equipped with one dehydration and five conversion reactors in each train are required. Each train is designed to operate at full capacity while one reactor is undergoing catalyst regeneration.

To provide for less than full capacity operation, the Gas Fractionation unit is designed with a turndown so that it can be operated to fractionate the products of one MTG train. To accommodate startup and upsets, intermediate crude methanol storage facilities are provided.

b. Layouts. A key consideration in the layout of the MTG reaction unit was provision for adequate room for the expansion bends needed for the large-diameter lines, the effluent/recycle gas exchangers, and for

## MTG Plant Feedstock

| Component | Wild Methanol Feed (lb mol/hr) |
|---|---|
| Hydrogen | 83.70 |
| Methane | 380.10 |
| Carbon Monoxide | 31.38 |
| Carbon Dioxide | 366.15 |
| Nitrogen | 5.22 |
| Methanol | 44,212.80 |
| Dimethylether | 52.32 |
| Butanol | 58.23 |
| Water | 4,139.85 |
| Total, lb mol/hr | 49,329.75 |
| Total, lb/hr | 1,521,390 |
| bpsd | 131,000 |
| Pressure, psia | 390 |
| Temperature, °F | 100 |

MTG Plant Product Streams

| Component | Hydrocarbon Vapor Product (lb mol/hr) | Hydrocarbon Liquids Product (lb mol/hr) | MTG Process Water (lb mol/hr) |
|---|---|---|---|
| Hydrogen | 83.71 | 6.18 | - |
| Methane | 479.25 | 204.33 | - |
| Carbon Monoxide | 32.46 | 5.01 | - |
| Carbon Dioxide | 174.33 | 190.50 | - |
| Nitrogen | 4.59 | 0.63 | - |
| Ethene | 3.15 | 4.65 | - |
| Ethane | 26.70 | 57.87 | - |
| Propene | 3.93 | 24.45 | - |
| Propane | 79.77 | 565.44 | - |
| Isobutane | 55.08 | 889.86 | - |
| 1-Butene | 5.8[illegible] | 113.97 | - |
| N-Butane | 12.18 | 279.51 | - |
| Isopentane | 18.99 | 1,013.04 | - |
| 1-Pentene | 3.60 | 189.27 | - |
| N-Pentane | 1.65 | 115.74 | - |
| Cyclopentane | 0.21 | 20.64 | - |
| 2-Methylpentane | 5.79 | 867.15 | - |
| C6+ Heavier | 8.94 | 3,004.35 | - |
| Total, lb mol/hr | 1,002.15 | 7,552.59 | 48,436.50 |
| Total, lb/hr | 28,080 | 618,690 | 874,170 |
| bpsd | - | 61,330 | - |
| mscfsd | 9,140 | - | - |
| gpm | - | - | 1,750 |
| Pressure, psia | 193.0 | 193.0 | 193.0 |
| Temperature, °F | 100 | 100 | 100 |

the large motor-operated valves around each conversion reactor. The major pipeway is sized to contain the process and regeneration lines. The effluent/recycle gas exchangers will not have space for bundle pulling, but adequate space is provided to remove an entire exchanger by mobile crane or other means.

The layout of the MTG equipment is based on having good access to equipment as well as fire and safety considerations. The layout was reviewed against the spacing standards for the overall plant.

## B. Process Selection Rationale

Mobil Research and Development Corporation's Methanol-to-Gasoline (MTG) process was preselected by W. R. Grace & Co. and specified for use in the preliminary design of the Coal-to-Methanol-to-Gasoline facility as a part of the Cooperative Agreement. This selection reflects the selectivity of the MTG process for maximum gasoline production.

## C. Process Description

In the MTG process, low-energy methanol is catalytically converted and dehydrated and catalytically converted to high-energy gasoline, with water a by-product of the conversion. The initial step in the transformation of methanol is the reversible catalytic dehydration of methanol to dimethylether. These two oxygenates dehydrate further over the conversion catalyst to give light olefins, which in turn react to form heavier olefins. Finally, most of the olefins rearrange to paraffins, cycloparaffins and aromatics. Almost no hydrocarbons will be found higher than $C_{10}$ due to the shape selective nature of the conversion catalyst.

The reaction path is as follows:

$$2(CH_3OH) \rightleftharpoons CH_3OCH_3 + H_2O$$

$$\downarrow$$

$$\text{Light Olefins} + H_2O$$

$$\uparrow\downarrow$$

$$(C_5 \text{ Olefins})$$

$$\downarrow$$

$$\text{Paraffins, Cycloparaffins, Aromatics}$$

Three trains of methanol conversion are provided in the MTG reaction unit to produce raw gasoline for blending to a nominal 50,000 bpsd. Each train operates independently. The following description addresses the design and operation of one methanol conversion train.

The process operates at essentially 100% conversion of methanol to hydrocarbons and water until the catalyst deactivates by carbon (coke) formation to an activity level such that only partial conversion of methanol occurs. As the catalyst deactivates, methanol breakthrough occurs when unconverted methanol (e.g., 0.1 wt%) appears in the aqueous phase product, the cycle is terminated. The catalyst in the conversion reactor then undergoes regeneration.

Catalyst regeneration is cyclic and is achieved by controlled combustion of the coke using air diluted with nitrogen.

The dehydration reactor operates for about a year before dehydration catalyst regeneration to remove coke is needed. The conversion reactor regeneration system is used to burn off the coke from the dehydration catalyst. With the conversion reactors in parallel in a single methanol conversion train, only one is typically undergoing catalyst regeneration. Thus, at any time the remaining reactors are converting methanol in each train.

The stoichiometric yield for every 100 tons of pure methanol converted is 44 tons of hydrocarbons and 56 tons of water. Approximately 85% of the hydrocarbons are processed into high-quality gasoline.

The conversion is an exothermic reaction. About 750 Btus of heat are released per pound of methanol converted. The heat is released in two steps. About 20% of the heat release occurs in the dehydration reactor, and the remainder occurs in the conversion reactors. To control the conversion reactor temperature rise, effluent gases are recycled and mixed with the methanol feed downstream of the dehydration reactor. This mixture is then fed to the conversion reactors. The recycled effluent gases act as a heat sink to absorb the heat of reaction. To improve process thermal efficiency, the heat of reaction is also used to vaporize the methanol feed and to heat the recycle gas stream.

1. Plant Design. The mechanical design of the MTG unit follows principles used commonly in the design of petroleum refineries. A few items require special attention.

a. Conversion Reactors. The mechanical design of the MTG conversion reactor is important in maintaining proper flow patterns. The conversion reaction starts at the top of the catalyst bed and slowly moves downward in a horizontal band. This downward movement occurs evenly throughout the bed or premature methanol breakthrough occurs and the catalyst is underutilized.

Valving arrangements are provided for isolation of any one conversion reactor during regeneration. Isolation is achieved by using an appropriate block valve and bleed system.

b. Heat Exchangers. Also of importance are the conversion reactor effluent heat exchangers. Each methanol conversion train has a large heat exchanger per reactor consisting of two shells in a series. Adequate room and sufficient load-bearing capacity have been provided around the exchangers to allow equipment to be brought in to remove the exchangers, if necessary. These exchangers are designed to have very low-pressure drops.

c. Compressors. Each methanol conversion train is equipped to compress recycle gas. In addition to its normal operation of recycling gas for cooling the conversion catalyst, the recycle gas compressor operates in the startup mode circulating nitrogen. A regeneration gas compressor is also used during startup and purging operations, flowing nitrogen.

d. Process Controls. The MTG unit requires process controls similar to those used in petroleum refineries. A distributive control system using microprocessor based electronic instruments with local controllers is incorporated in the design consistent with the plant instrumentation design criteria.

A programmable logic controller (PLC) is required to switch each of the reactors individually from process operation to the catalyst regeneration mode. A shutdown system that operates in conjunction with the PLC is required to close off a conversion reactor, to shut off methanol feed, and to depressure the methanol feed system in the event of an emergency.

2. Operating Procedures. Precommissioning activities are completed prior to the initial operation of the MTG reaction unit of the plant. Pressure testing, utility availability checkout, equipment lubrication, instrumentation checkout, verification of relief valve settings, line cleaning, valve closure, and installation of isolation blinds at battery limits, etc., are required. Catalysts are then loaded into the reactors in accordance with the procedures provided by Mobil, the catalyst manufacturer. All equipment is secured and readied for startup.

a. Normal Operation. The normal MTG plant operation starts with the crude methanol entering the MTG reaction unit battery limits. The methanol is preheated, vaporized, and superheated in the crude methanol preheaters, vaporizer/reactor effluent exchangers and the superheater/reactor effluent exchanger. The heat of vaporization and superheat are provided by cooling a portion of the hot conversion reactor effluent. The dehydration reactor is a downflow fixed bed adiabatic reactor in which the methanol feed is converted to an equilibrium mixture of methanol, dimethylether, and water. The exothermic reaction heat is absorbed by the equilibrium reaction product.

The effluent from the dehydration reactor is mixed with recycle gas from the recycle gas/reactor effluent exchangers and distributed to the operating conversion reactors.

The conversion reactor is a downflow fixed bed adiabatic reactor. The feed mixture is converted selectively to gasoline components and water in the conversion reactors. The conversion reaction is highly exothermic. The recycle gas serves as a heat sink to limit the temperature rise across the reactor.

The reactor effluent from each recycle gas/reactor effluent exchanger is combined with the reactor effluent flow from the methanol preheat exchangers and enters the reactor effluent coolers. Reactor effluent is partially condensed and flows to the product separator, in which the liquid stream separates into a liquid hydrocarbon phase and an aqueous phase. The liquid hydrocarbons are pumped to the gas fractionation unit. The MTG water aqueous phase is transferred to the Process Water Treatment unit.

Part of the gas from the product separator forms the recycle to the conversion reactors and the remainder is sent to the gas fractionation unit.

b. Catalyst Regeneration. When methanol appears in the reactor effluent, the reactor is switched to the regeneration mode. Regeneration consists of burning off the coke with oxygen supplied from controlled quantities of air. After regeneration is completed, the reactor is ready for operation.

The dehydration reactor catalyst is regenerated in the same manner as the conversion catalyst.

3. Catalysts. The catalysts required for the MTG Reaction Unit are as follows:

| Service | Dehydration | Conversion |
|---|---|---|
| Type: | Mobil Dehydration | ZSM-5 |
| Size, inch | 1/16 | 1/16 |
| Volume: $ft^3$ | | |
| per train | 2,951 | 11,460 |
| per plant | 8,853 | 34,380 |
| Loading Density: $lbs/ft^3$ | 32 | 32 |

4. Environmental Considerations. The MTG plant is relatively free from troublesome emissions. However, water from the MTG reaction unit requires treatment. Other emissions are similar to those of other hydrocarbon processing plants.

a. Solid Wastes. The primary solid wastes generated by the MTG process are spent catalysts and the sludges resulting from wastewater treatment. An MTG plant has two types of spent catalysts which require disposal. Estimates of the quantities are given in Table II-1-2.12-1.

The MTG conversion catalyst is proprietary and must be returned to the supplier in accordance with the licensing agreement. The dehydration catalyst is used commercially and has posed no disposal problem.

b. Atmospheric Emissions. The two main categories of atmospheric emissions are the normal process emissions when the MTG plant is in operation and the abnormal emissions that occur on startup, shutdown, and during emergencies.

The greater part of the normal emissions consists of flue gas from the fired heaters and the fugitive emissions. Other normal emissions arise from periodic regeneration of the catalysts.

Table II-1.2.12-1 - Spent Catalysts for Disposal

| Service | Dehydration | Conversion |
|---|---|---|
| Quantity, | | |
| Volume: $ft^3$ | 8,853 | 34,380 |
| Weight | 283,000[a] | 1,107,000[a] |
| Type: | 1/16-in. diameter extrudate | Zeolite 1/16-in. diameter extrudate |
| Disposition | Landfill | Return to Mobil |

[a]These values do not include the weight of coke on the catalysts. The catalysts are assumed to be regenerated before removal from the reactors.

Regeneration offgases will contain products of coke combustion with air. The primary pollutant will be approximately 5 lb/hr of carbon monoxide during part of the regeneration.

D. Risk Assessment

Besides the MTG process, Mobil has in operation today numerous petroleum refining and chemical processes using the Mobil ZSM-5 zeolite catalyst. These include M-Forming for octane upgrading, Distillate Dewaxing, Ethylbenzene Synthesis, and Lube Oil Dewaxing. Mobil estimates there are more than a half-million pounds of various ZSM-5 zeolite catalysts at work in operating facilities around the world. All of these processes use fixed-bed catalytic reactors that were scaled up from bench-scale pilot plant data.

Mobil presently has plans for two new MTG projects, a commercial plant and a pilot plant. In New Zealand, a commercial scale 14,000-bpd plant will use methanol from natural gas and will utilize the established fixed-bed catalyst technology. In West Germany, a 100-bpd pilot plant will use methanol from coal to test the feasibility of a fluid bed catalyst system.

The MTG design incorporated in the gasoline plant is the fixed-bed catalytic process with regeneration of the catalyst initiated when methanol breakthrough occurs in the reactor effluent. Regeneration consists of burning off the coke by oxygen supplied from controlled quantities of air.

This type of regeneration has been used for many years in catalytic reforming processes in petroleum refining facilities where a swing reactor was placed onstream during the regeneration period. The burning operation is the same in both cases, the main difference being the higher frequency of regeneration in the MTG process.

Because of this, Mobil has specified process controls similar to those used in existing catalytic regenerative processes. A programmable logic system is used to switch each of the reactors individually from normal process operation to the catalyst regeneration mode.

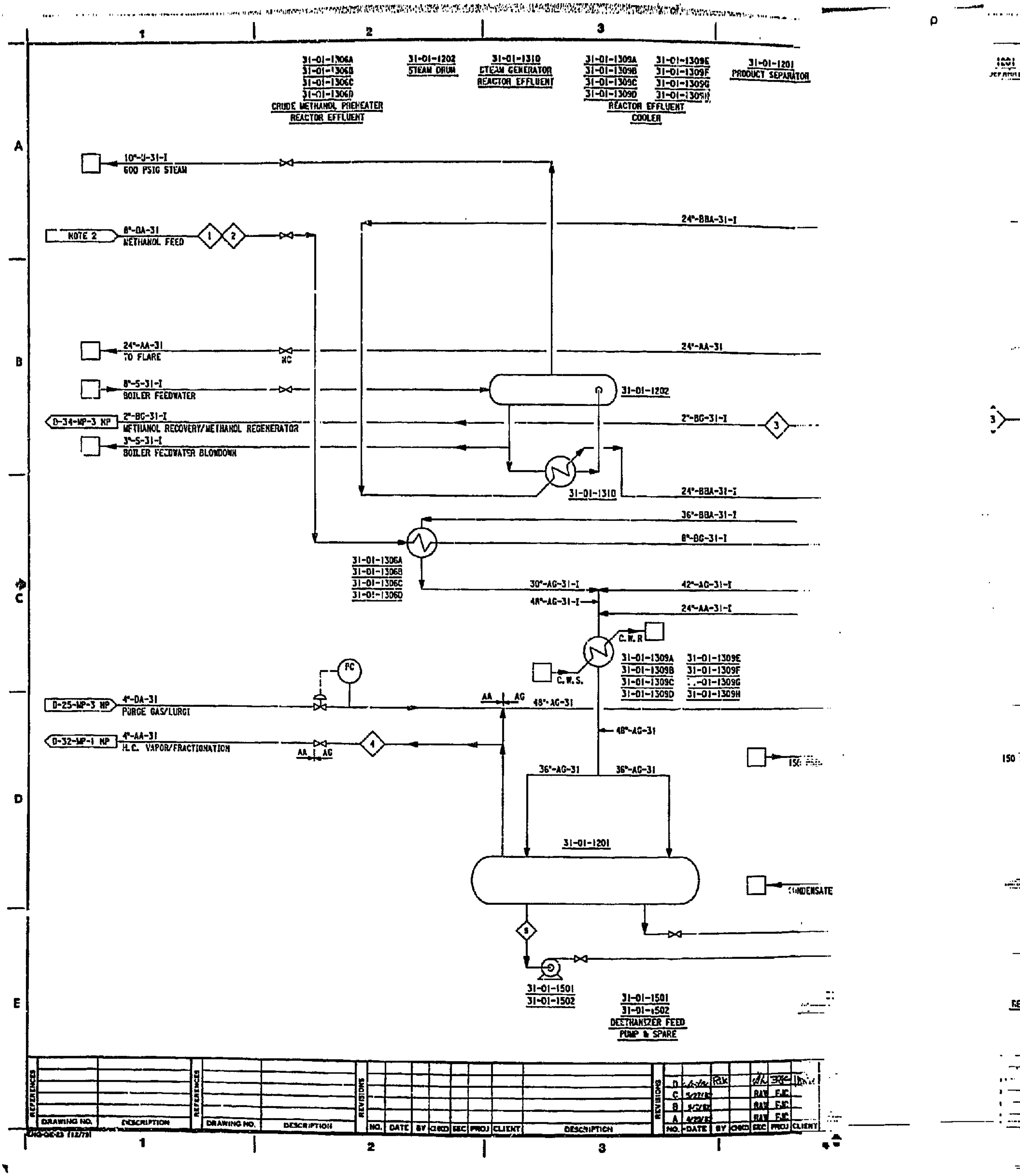
An emergency shutdown system is also provided to shut off methanol feed if recycle gas circulation is lost due to compressor failure. In case of an abnormal temperature rise across a reactor, provisions have been incorporated in the design to cool the reactor and to protect downstream equipment. This is done by injecting propane vapor into the reactor inlet and outlet streams as a coolant by activation of a standby propane vaporizer system.

Although the process for the conversion of methanol to gasoline is relatively new, the catalyst is presently in use in several operating facilities throughout the world. Thus, the scale up of equipment is similar to the design of existing petroleum refining processes. The operational aspects of the MTG unit are also similar to petroleum refining facilities in present day operation. Consideration has been given to safety requirements by carefully instrumenting the regeneration, emergency shutdown, and reactor temperature control systems. Corrosion is not a problem based on similar experience with construction materials in methanol and hydrocarbon processing. Equipment reliability should be comparable to present day refinery equipment from the standpoint of onstream time. In conclusion, the MTG plant design and operation present a low technical risk.

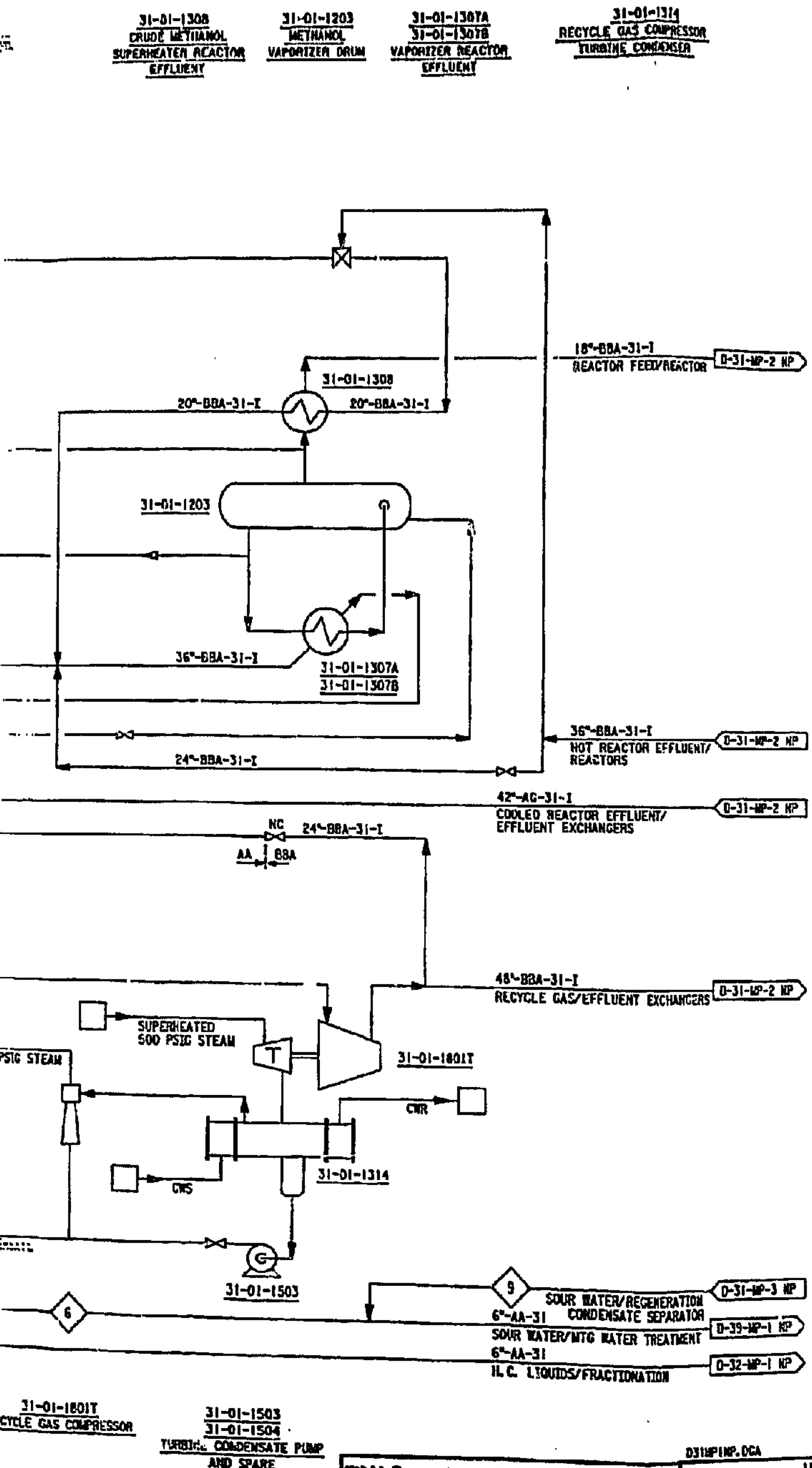
E. <u>Process Flow and Control Diagrams</u> (Including Material Balance)

Process Flow and Control Diagrams for Methanol-to-Gasoline Unit 31 are as follows:

| Drawing No. | Title |
|---|---|
| D-31-MP-1NP | PFCD MTG - Methanol Vaporization |
| D-31-MP-2NP | PFCD MTG - Conversion Reactors |
| D-31-MP-3NP | PFCD MTG - Regeneration |
| D-31-MP-4NP | Material Balance - Methanol-to-Gasoline |



31-01-1306A
31-01-1306B
31-01-1306C
31-01-1306D
CRUDE METHANOL PREHEATER REACTOR EFFLUENT
31-01-1202
STEAM DRUM
31-01-1310
STEAM GENERATOR REACTOR EFFLUENT
31-01-1309A
31-01-1309B
31-01-1309C
31-01-1309D
31-01-1309E
31-01-1309F
31-01-1309G
31-01-1309H
REACTOR EFFLUENT COOLER
31-01-1201
PRODUCT SEPARATOR
10"-J-31-I
600 PSIG STEAM
NOTE 2
8"-DA-31
METHANOL FEED
24"-BBA-31-I
24"-AA-31
TO FLARE
NC
8"-S-31-I
BOILER FEEDWATER
D-34-MP-3 NP
2"-BG-31-I
METHANOL RECOVERY/METHANOL REGENERATOR
3"-S-31-I
BOILER FEEDWATER BLOWDOWN
36"-BBA-31-I
8"-BG-31-I
30"-AG-31-I
42"-AG-31-I
48"-AG-31-I
24"-AA-31-I
C.W.R
C.W.S.
FC
D-25-MP-3 NP
4"-DA-31
PURGE GAS/LURGI
AA
AG
48"-AG-31
D-32-MP-1 NP
4"-AA-31
H.C. VAPOR/FRACTIONATION
36"-AG-31
CONDENSATE
31-01-1501
31-01-1502
DEETHANIZER FEED PUMP & SPARE
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
A
B
C
D
E
1
2
3




NOTE:

1. THE EQUIPMENT SHOWN ON THESE DRAWINGS IS FOR ONE TRAIN. THREE IDENTICAL TRAINS ARE REQUIRED.
2. METHANOL FEED TO A SINGLE TRAIN OF UNIT 31, METHANOL-TO-GASOLINE(MTG), WILL BE A SINGLE BRANCH FROM THE UNIT 31 METHANOL HEADER. SOURCES OF METHANOL TO THE HEADER ARE UNIT 25 AND THE INTERMEDIATE STORAGE AREA (UNIT 53). THE MATERIAL BALANCE IS GIVEN FOR THE NORMAL OPERATING CASE FOR ONE MTG TRAIN.

EQUIPMENT SHOWN ON THIS DRAWING:

| | | |
|---|---|---|
| 31-01-1201 | 31-01-1308 | 31-01-1310 |
| 31-01-1202 | 31-01-1309A | 31-01-1314 |
| 31-01-1203 | 31-01-1309B | 31-01-1501 |
| 31-01-1306A | 31-01-1309C | 31-01-1502 |
| 31-01-1306B | 31-01-1309D | 31-01-1503 |
| 31-01-1306C | 31-01-1309E | 31-01-1504 |
| 31-01-1306D | 31-01-1309F | 31-01-1801 |
| 31-01-1307A | 31-01-1309G | |
| 31-01-1307B | 31-01-1309H | |

D31MP1NP.DGA

Mobil Research and Development Corporation

DESIGN REPORT
FOR CLIENT APPROVAL
FOR LICENSOR APPROVAL
FOR SOX CLIENT REVIEW
DESCRIPTION

FOR / DRAWN / CHECKED / APPVD SECT MGR / APPVD PROJ MGR / APPVD CLIENT

RMP

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY

50,000 B.P.D.

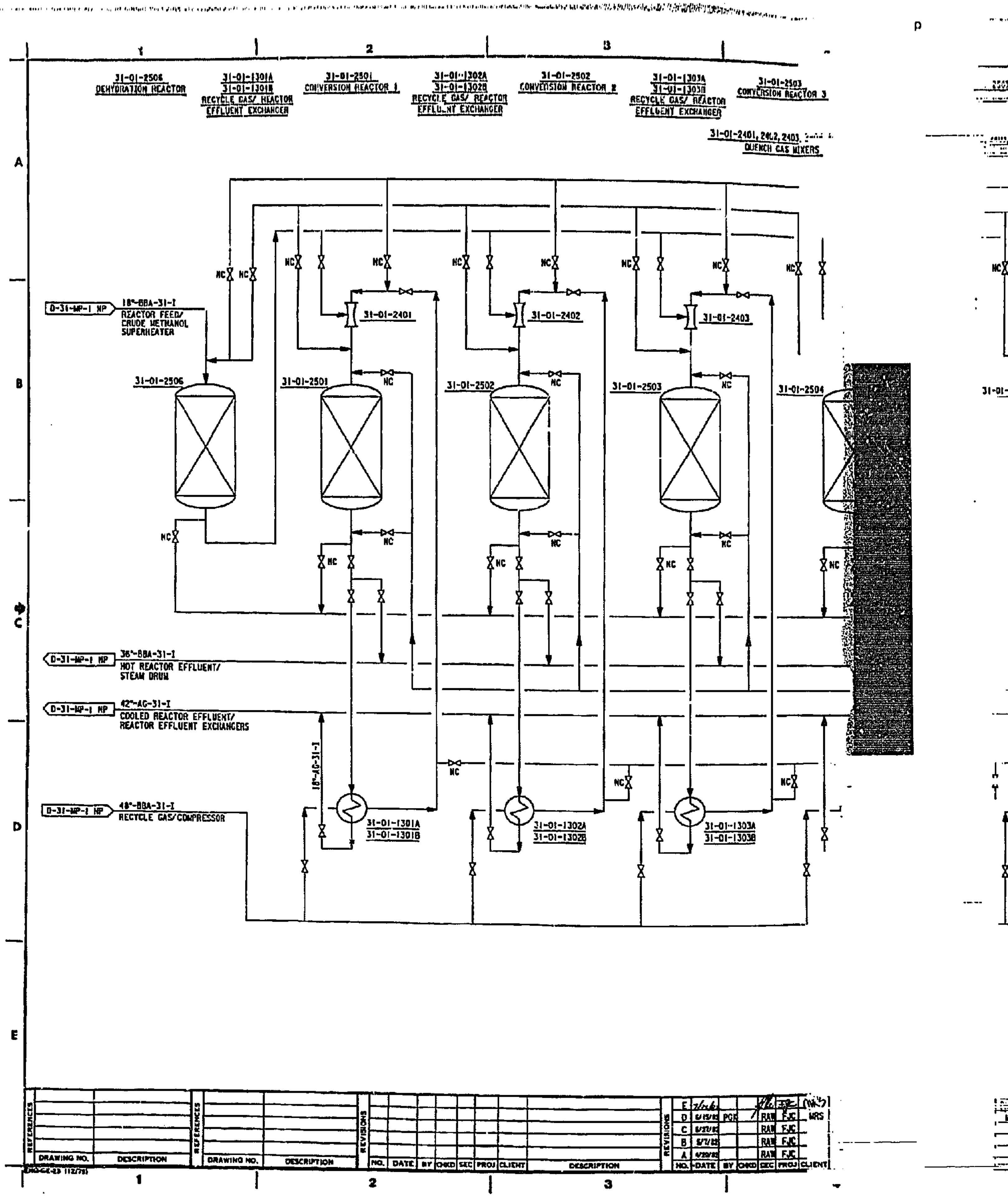
COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: PROCESS FLOW AND CONTROL DIAGRAM
METHANOL TO GASOLINE - UNIT 31
METHANOL VAPORIZATION

SCALE: NONE | 2800 | 6182

DOCUMENT NUMBER: D-31-MP-1 NP

REVISION: D



31-01-2506
DEHYDRATION REACTOR
31-01-1301A
31-01-1301B
RECYCLE GAS/ REACTOR EFFLUENT EXCHANGER
31-01-2501
CONVERSION REACTOR 1
31-01-1302A
31-01-1302B
RECYCLE GAS/ REACTOR EFFLUENT EXCHANGER
31-01-2502
CONVERSION REACTOR 2
31-01-1303A
31-01-1303B
RECYCLE GAS/ REACTOR EFFLUENT EXCHANGER
31-01-2503
CONVERSION REACTOR 3
31-01-2401, 2402, 2403
QUENCH GAS MIXERS
D-31-MP-1 NP
18"-BBA-31-I
REACTOR FEED/ CRUDE METHANOL SUPERHEATER
31-01-2401
31-01-2402
31-01-2403
31-01-2504
NC
36"-BBA-31-I
HOT REACTOR EFFLUENT/ STEAM DRUM
42"-AG-31-I
COOLED REACTOR EFFLUENT/ REACTOR EFFLUENT EXCHANGERS
18"-AG-31-I
48"-BBA-31-I
RECYCLE GAS/COMPRESSOR
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
E
D
C
B
A
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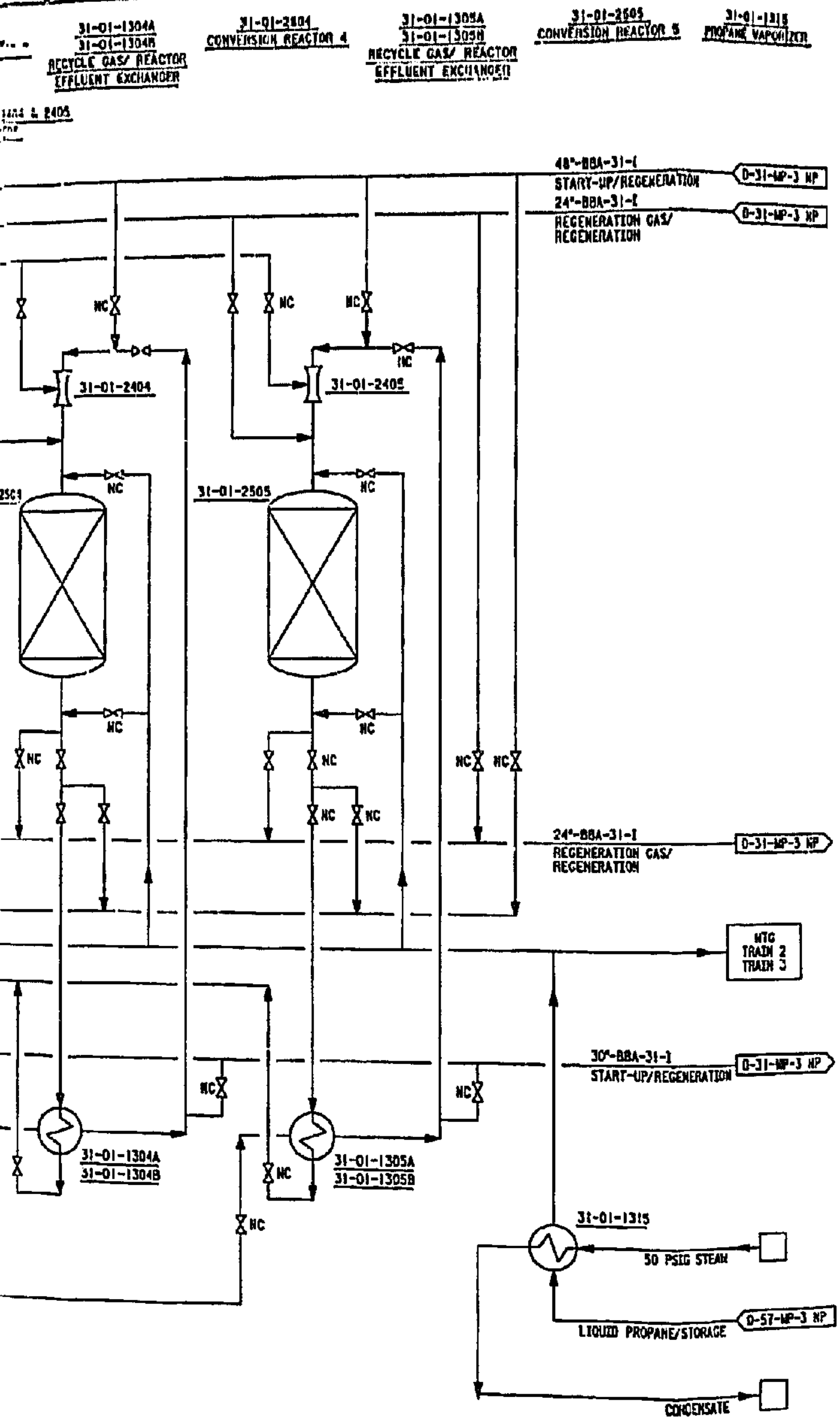
FJC
MRS




NOTES:

1. EQUIPMENT SHOWN ON THESE DRAWINGS IS FOR ONE TRAIN. THREE IDENTICAL TRAINS ARE REQUIRED.
2. THE VALVING FOR CONVERSION REACTOR 31-01-2305 IS INDICATED FOR REGENERATION.

EQUIPMENT SHOWN ON THIS DRAWING:

| | |
|---|---|
| 31-01-1301A | 31-01-2401 |
| 31-01-1301B | 31-01-2402 |
| 31-01-1302A | 31-01-2403 |
| 31-01-1302B | 31-01-2404 |
| 31-01-1303A | 31-01-2405 |
| 31-01-1303B | 31-01-2501 |
| 31-01-1304A | 31-01-2502 |
| 31-01-1304B | 31-01-2503 |
| 31-01-1305A | 31-01-2504 |
| 31-01-1305B | 31-01-2505 |
| 31-01-1314 | 31-01-2506 |

REVISED FOR DESIGN REPORT
FOR DESIGN REPORT
FOR CLIENT APPROVAL
FOR LICENSOR APPROVAL
FOR CLIENT 50% REVIEW
DESCRIPTION

Mobil Research and Development Corporation

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

D31MP2NP.DGA

U.S. DEPARTMENT OF ENERGY

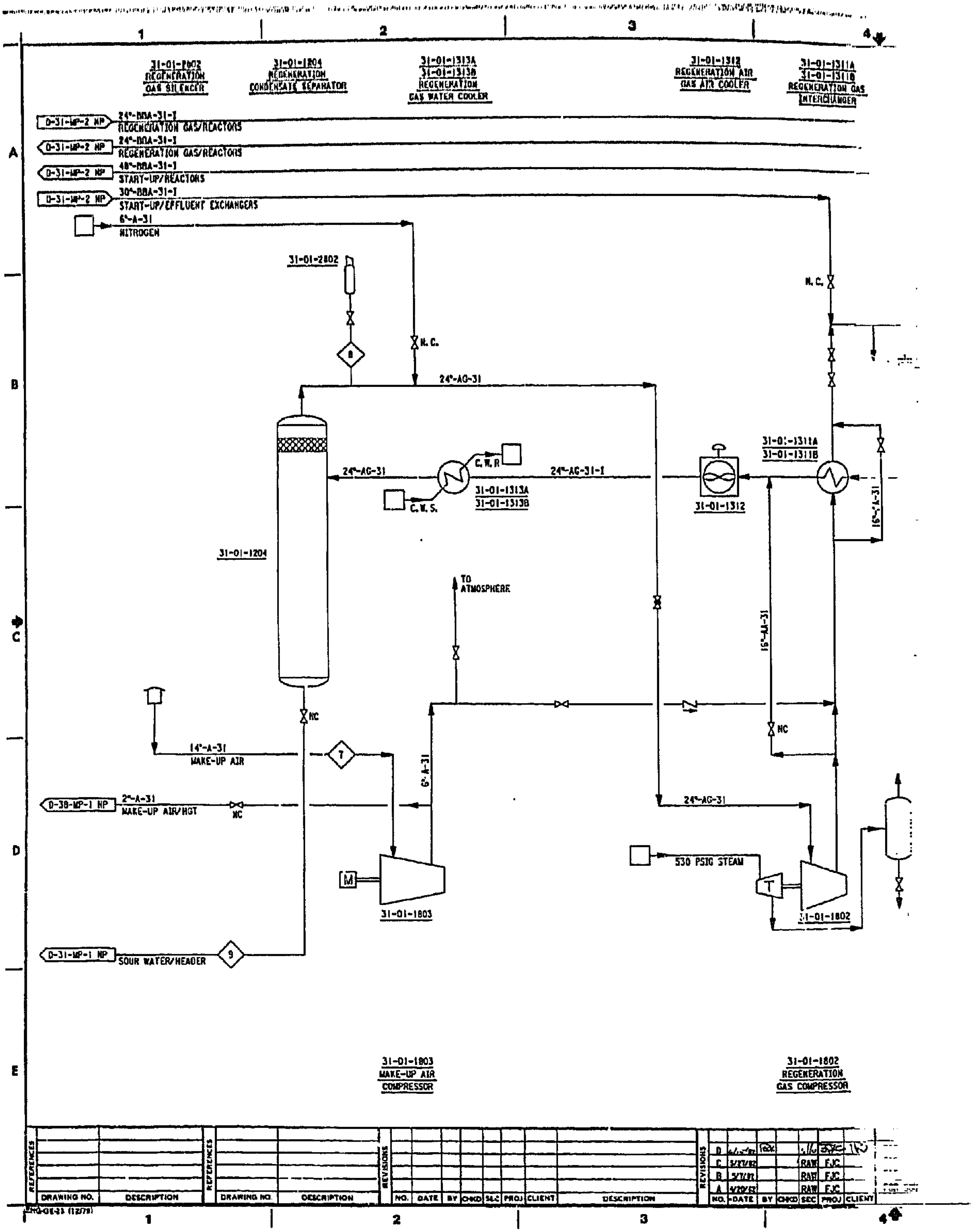
BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: PROCESS FLOW AND CONTROL DIAGRAM
METHANOL TO GASOLINE - UNIT 31
CONVERSION REACTORS

SCALE: NONE | 2800 | 6182

D-31-MP-2 NP

E



31-01-2802
REGENERATION
GAS SILENCER
31-01-1204
REGENERATION
CONDENSATE SEPARATOR
31-01-1313A
31-01-1313B
REGENERATION
GAS WATER COOLER
31-01-1312
REGENERATION AIR
GAS AIR COOLER
31-01-1311A
31-01-1311B
REGENERATION GAS
INTERCHANGER
D-31-MP-2 NP
24"-BBA-31-1
REGENERATION GAS/REACTORS
D-31-MP-2 NP
24"-BBA-31-1
REGENERATION GAS/REACTORS
D-31-MP-2 NP
48"-BBA-31-1
START-UP/REACTORS
D-31-MP-2 NP
30"-BBA-31-1
START-UP/EFFLUENT EXCHANGERS
6"-A-31
NITROGEN
31-01-2802
N. C.
24"-AG-31
24"-AG-31
C. W. R
24"-AG-31-1
C. W. S.
31-01-1313A
31-01-1313B
31-01-1312
31-01-1311A
31-01-1311B
16"-A-31
31-01-1204
TO
ATMOSPHERE
16"-AA-31
NC
NC
14"-A-31
MAKE-UP AIR
6"-A-31
D-38-MP-1 NP
2"-A-31
MAKE-UP AIR/HGT
NC
24"-AG-31
530 PSIG STEAM
M
T
31-01-1803
31-01-1802
D-31-MP-1 NP
SOUR WATER/HEADER
31-01-1803
MAKE-UP AIR
COMPRESSOR
31-01-1802
REGENERATION
GAS COMPRESSOR
REFERENCES
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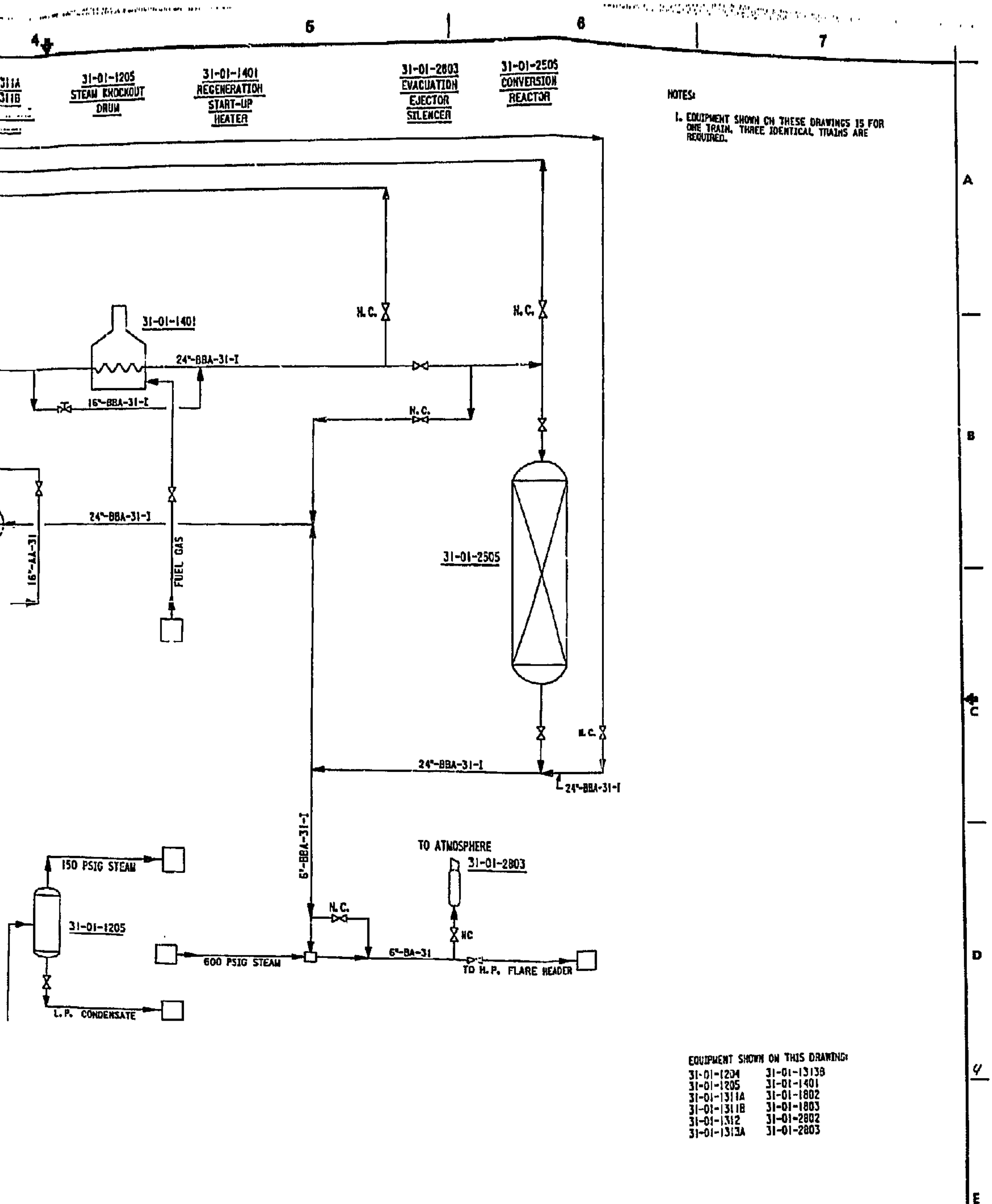
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
RAW
FJC




NOTES:

1. EQUIPMENT SHOWN ON THESE DRAWINGS IS FOR ONE TRAIN. THREE IDENTICAL TRAINS ARE REQUIRED.

EQUIPMENT SHOWN ON THIS DRAWING:

| | |
|---|---|
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| 31-01-1205 | 31-01-1401 |
| 31-01-1311A | 31-01-1802 |
| 31-01-1311B | 31-01-1803 |
| 31-01-1312 | 31-01-2802 |
| 31-01-1313A | 31-01-2803 |

D31MP3NP.DGA

| DESCRIPTION | |
|---|---|
| FOR DESIGN REPORT | |
| FOR CLIENT APPROVAL | |
| FOR LICENSOR APPROVAL | |
| FOR 50% CLIENT REVIEW | |

FOR / DRAWN / CHECKED / APVD SECT HD / APVD PROJ MGR / APVD CLIENT

Mobil Research and Development Corporation
ENGINEERING DEPARTMENT
P.O. BOX 1026
PRINCETON, NEW JERSEY 08540

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: PROCESS FLOW AND CONTROL DIAGRAM METHANOL TO GASOLINE - UNIT 31 REGENERATION

| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| NONE | 2800 | 6182 | 0 |

DOCUMENT NUMBER: D-31-MP-3 NP

| STREAM | | ◇1 CRUDE METHANOL FEED | ◇2 METHANOL BLOWDOWN RETURN | ◇3 METHANOL BLOWDOWN | ◇4 HYDROCARBON VAPOR PRODUCT | ◇5 HYDROCARBON LIQUIDS PRODUCT | ◇6 MTO PROCESS WATER | AIR |
|---|---|---|---|---|---|---|---|---|
| BPSD | | 43,816 | 446 | 446 | | 20,444 | 20,011 | |
| MSCFD | | | | | 3,047 | | | |
| LB/HR | | 507,130 | 5,280 | 5,280 | 9,360 | 208,230 | 291,390 | |
| API OR SG @ 60°F | | 0.60 | 0.81 | 0.81 | | 0.69 | 1.0 | |
| MW | | 30.84 | 30.15 | 30.15 | 28.03 | 81.03 | 18.05 | |
| GPM | | 1309 | 18 | 18 | | 612 | 595 | |
| CFM | | | | | 165 | | | |
| COMPONENT | MW | | | | | | | |
| HYDROGEN | 2.02 | 27.90 | 0.01 | 0.01 | 28.57 | 2.06 | | |
| METHANE | 16.04 | 126.70 | 0.13 | 0.13 | 159.75 | 68.11 | | |
| CARBON MONOXIDE | 28.01 | 10.46 | 0.01 | 0.01 | 10.32 | 1.67 | | |
| CARBON DIOXIDE | 44.01 | 122.05 | 0.17 | 0.17 | 58.11 | 63.50 | | |
| NITROGEN | 28.01 | 1.74 | | | 1.53 | 0.21 | | |
| ETHENE | 28.05 | | | | 1.05 | 1.55 | | |
| ETHANE | 30.07 | | | | 8.90 | 19.29 | | |
| PROPENE | 42.08 | | | | 1.31 | 8.15 | | |
| PROPANE | 44.10 | | | | 26.59 | 188.48 | | |
| ISOBUTANE | 58.12 | | | | 18.38 | 296.62 | | |
| 1-BUTENE | 56.11 | | | | 1.94 | 37.99 | | |
| N-BUTANE | 58.12 | | | | 4.06 | 93.17 | | |
| ISOPENTANE | 72.15 | | | | 6.33 | 337.68 | | |
| 1-PENTENE | 70.13 | | | | 1.20 | 63.09 | | |
| N-PENTANE | 72.15 | | | | 0.55 | 38.58 | | |
| CYCLOPENTANE | 70.13 | | | | 0.07 | 6.88 | | |
| 2-METHYLPENTANE | 86.18 | | | | 1.93 | 289.05 | | |
| C6+HEAVIER | | | | | 2.98 | 1,001.45 | | |
| METHANOL | 32.04 | 14,737.60 | 144.80 | 144.80 | | | | |
| N-BUTANOL | 74.12 | 19.41 | 1.56 | 1.56 | | | | |
| DI METHYLETHER | 46.07 | 17.44 | 0.04 | 0.04 | | | | |
| WATER | 18.02 | 1,379.95 | 28.28 | 28.28 | | | | |
| OXYGEN | 32.00 | | | | | | | |
| TOTAL MPH | | 16,443.23 | 175.00 | 175.00 | 334.07 | 2,517.53 | 16,145.50 | |

REFERENCES: DRAWING NO. | DESCRIPTION

REVISIONS: NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT | DESCRIPTION

| NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT |
|---|---|---|---|---|---|---|
| D | [illegible] | | | | | |
| C | [illegible] | RAW | | FJC | | |
| B | [illegible] | RAW | | FJC | | |
| A | [illegible] | RAW | | FJC | | |

NOTES:
1. THIS MATERIAL BALANCE IS GIVEN FOR THE NORMAL OPERATING CASE FOR ONE TRAIN.

| 7 AIR TO MAKE-UP COMPRESSOR | 8 VENT GAS ($H_2$, $CO_2$, ETC) | 9 WATER TO TREATMENT PLANT |
|---|---|---|
| | | 74 |
| 8,353 | 7,326 | |
| 25,786 | 24,753 | 1,063 |
| | | 1.0 |
| 28.12 | 30.82 | 18,016 |
| | | 2.2 |
| 6,423 | 615 | |
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| | | |
| | | |
| | 144.55 | |
| 675.13 | 652.75 | |
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| | | |
| | | |
| 62.50 | 5.96 | 59.24 |
| 179.47 | | |
| 917.0 | 803.26 | 59.24 |

| DESCRIPTION | |
|---|---|
| FOR DESIGN REPORT | FOR |
| FOR CLIENT APPROVAL | DRAWN |
| FOR LICENSOR APPROVAL | CHECKED |
| FOR CLIENT 50% REVIEW | APVD SECT MGR |
| | APVD PROJ MGR |
| | APVD CLIENT |

Mobil Research and Development Corporation

RMP

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

D31MP4NP.DGA

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: MATERIAL BALANCE UNIT 31

SCALE: NONE | ACCOUNT NUMBER: 2800 | JOB NUMBER: 6182

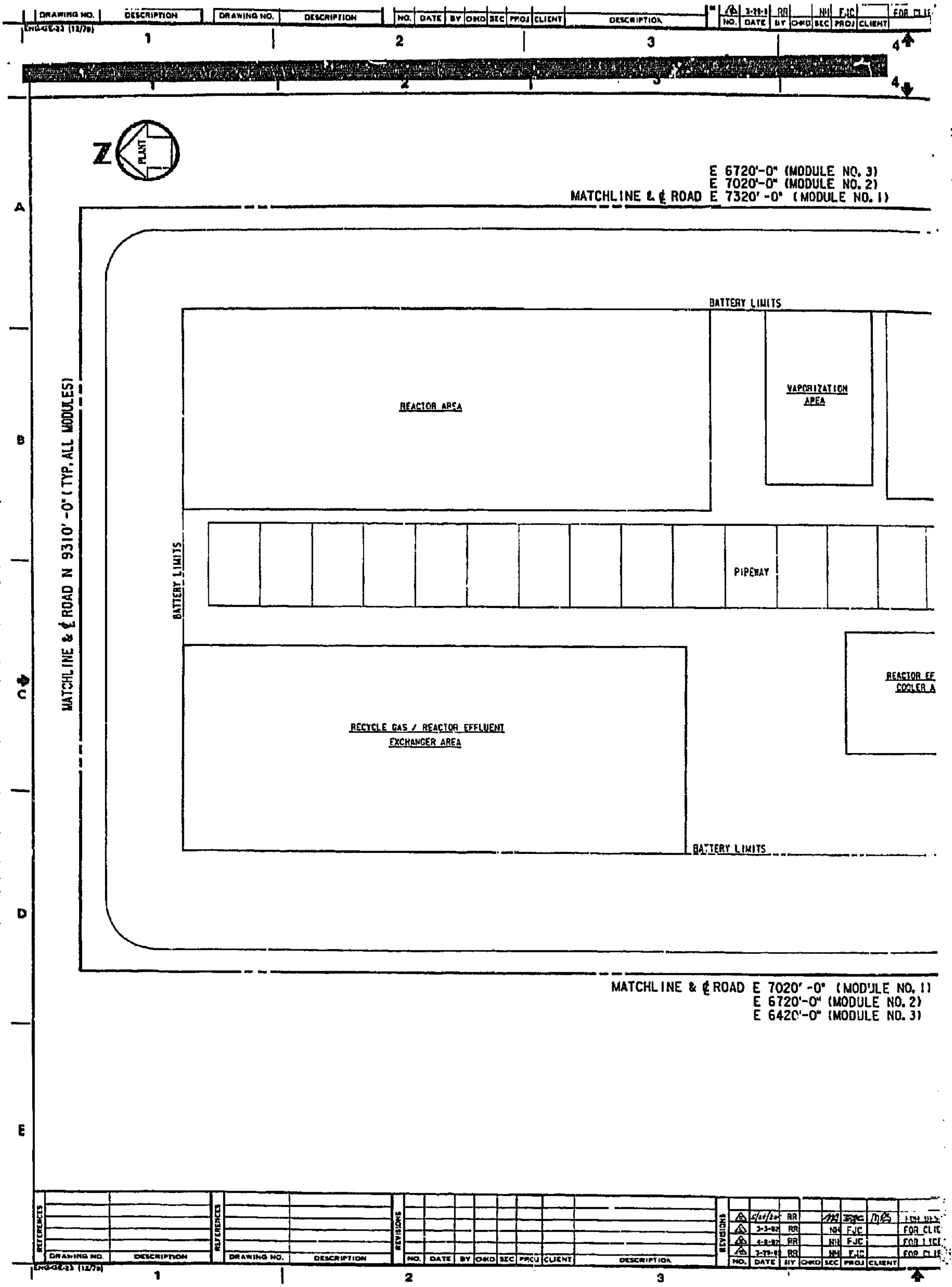
DOCUMENT NUMBER: D-31-MP-4 NP

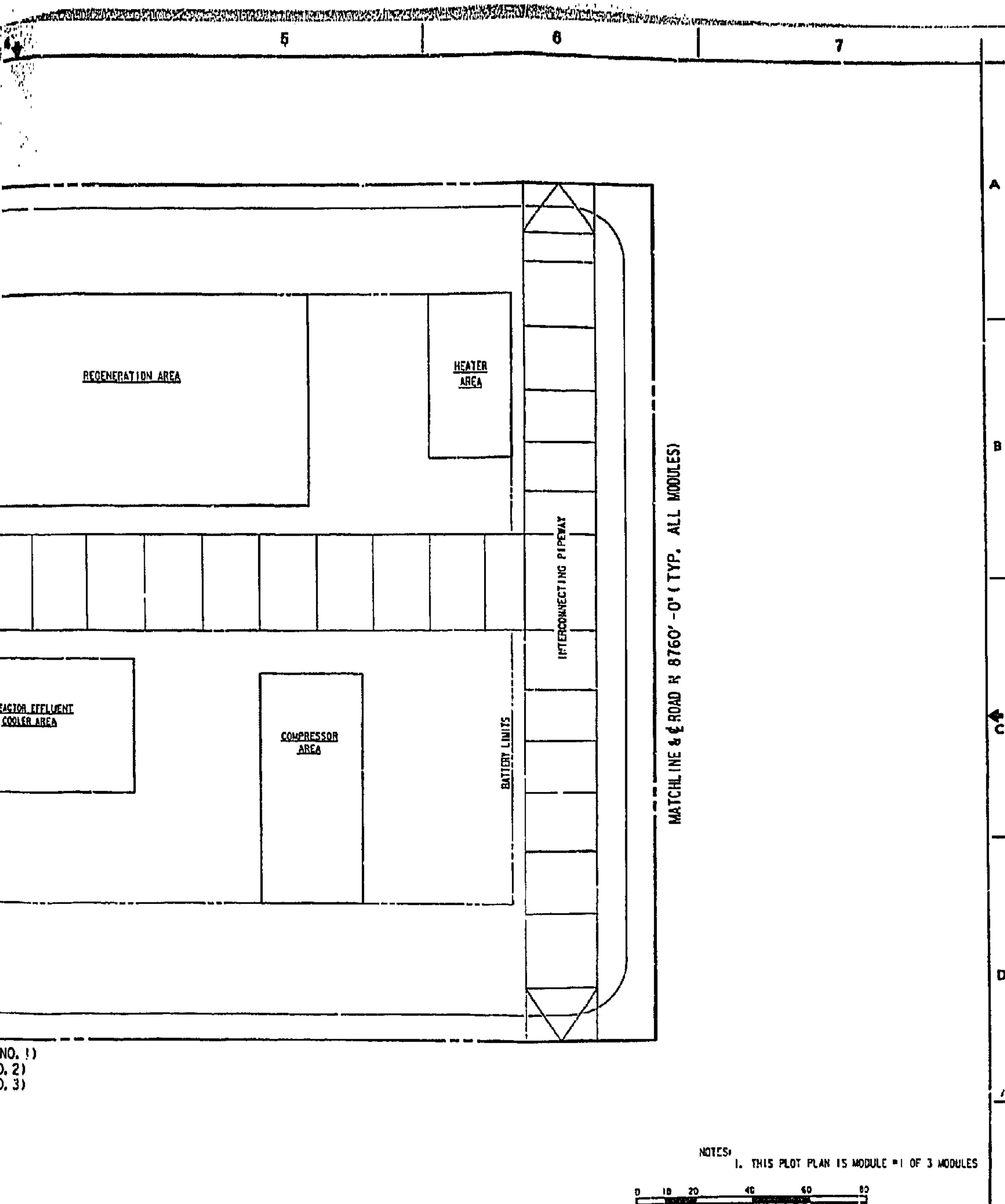
REVISION: D

## F. Plot Plan/General Arrangement Drawing

The Plot Plan and General Arrangement Drawing for Methanol-to-Gasoline Unit 31 is as follows:

| Drawing No. | Title |
|---|---|
| D-31-PD-1NP | Plot Plan - Unit 31 Methanol-to-Gasoline |


PLANT
E 6720'-0" (MODULE NO. 3)
E 7020'-0" (MODULE NO. 2)
MATCHLINE & ℄ ROAD E 7320'-0" (MODULE NO. 1)
MATCHLINE & ℄ ROAD N 9310'-0" (TYP. ALL MODULES)
BATTERY LIMITS
REACTOR AREA
VAPORIZATION AREA
PIPEWAY
BATTERY LIMITS
REACTOR EF
COOLER A
RECYCLE GAS / REACTOR EFFLUENT EXCHANGER AREA
BATTERY LIMITS
MATCHLINE & ℄ ROAD E 7020'-0" (MODULE NO. 1)
E 6720'-0" (MODULE NO. 2)
E 6420'-0" (MODULE NO. 3)
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
RR
FJC
FOR CLIE




NOTES:
1. THIS PLOT PLAN IS MODULE #1 OF 3 MODULES

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

| | | |
|---|---|---|
| FOR DESIGN REPORT | DRAWN | JW/CAD |
| CLIENT APPROVAL | CHECKED | |
| LICENSOR APPROVAL | APVD SECT HD | NH |
| FOR CLIENT REVIEW 50% COMP | APVD PROJ MGR | |
| DESCRIPTION | APVD CLIENT | |

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

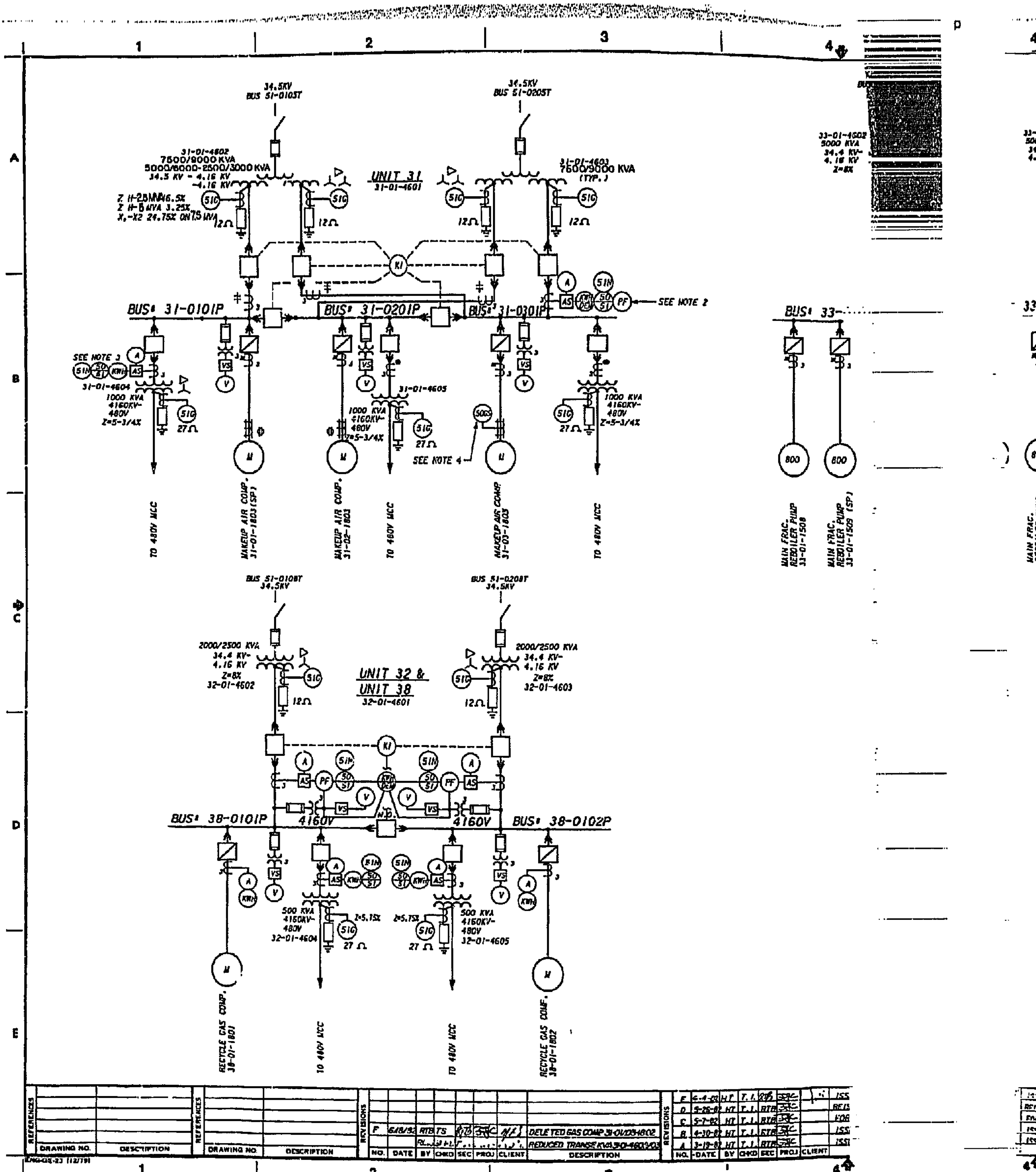
| TITLE | SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|---|
| PLOT PLAN UNIT 31 METHANOL TO GASOLINE | 1" = 20'-0" | 7243 | 6182 | D |
| | DOCUMENT NUMBER: D-31-PD-1NP | | | |

4 5 6 7

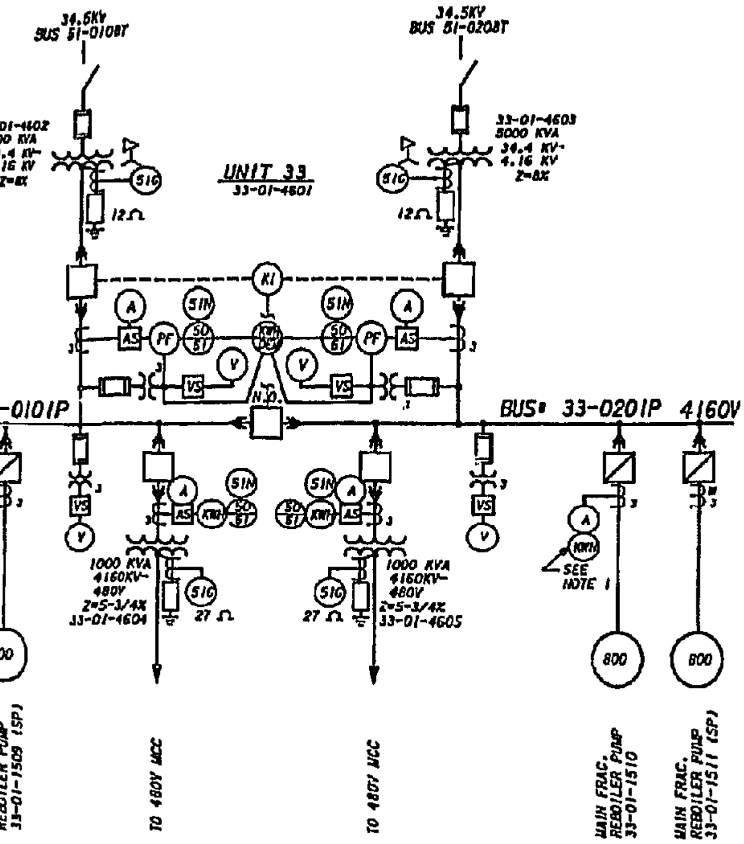
G. Single-Line Diagram

The Single-Line Diagram for Methanol-to-Gasoline Unit 31 is as follows:

| Drawing No. | Title |
|---|---|
| D-51-EE-6NP | One-Line Diagram - Units 31, 32, 33, and 38 |



UNIT 31
31-01-4601
34.5KV
BUS 51-0105T
34.5KV
BUS 51-0205T
31-01-4602
7500/9000 KVA
5000/6000-2500/3000 KVA
34.5 KV - 4.16 KV
-4.16 KV
31-01-4603
7500/9000 KVA
(TYP.)
12Ω
BUS# 31-0101P
BUS# 31-0201P
BUS# 31-0301P
SEE NOTE 2
SEE NOTE 3
31-01-4604
1000 KVA
4160KV-
480V
Z=5-3/4%
27Ω
31-01-4605
SEE NOTE 4
TO 480V MCC
MAKEUP AIR COMP.
31-01-1803 (SP)
MAKEUP AIR COMP.
31-02-1803
MAKEUP AIR COMP
31-03-1803
BUS# 33-
800
MAIN FRAC.
REBOILER PUMP
33-01-1508
MAIN FRAC.
REBOILER PUMP
33-01-1509 (SP)
33-01-4602
5000 KVA
34.4 KV-
4.16 KV
Z=8%
BUS 51-0108T
34.5KV
BUS 51-0208T
34.5KV
2000/2500 KVA
34.4 KV-
4.16 KV
Z=8%
32-01-4602
32-01-4603
UNIT 32 &
UNIT 38
32-01-4601
BUS# 38-0101P
4160V
BUS# 38-0102P
500 KVA
4160KV-
480V
32-01-4604
32-01-4605
Z=5.75%
27 Ω
RECYCLE GAS COMP.
38-01-1801
RECYCLE GAS COMP.
38-01-1802
TO 480V MCC
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
F 6/8/92 RTB TS DELETED GAS COMP 38-01/03-1802
REDUCED TRANSF KVA 31-01-4602/03
E 6-4-03 HT T.I.
D 5-26-82 HT T.I. RTB
C 5-7-82 HT T.I. RTB
B 4-30-82 HT T.I. RTB
A 3-19-82 HT T.I. RTB
NO. DATE BY CHKD SEC PROJ CLIENT DESCRIPTION
1
2
3
4
A
B
C
D
E




## NOTE:

1. PROVIDE AM & KWH METERS AT ALL LOCATIONS MARKED ■.
2. PROVIDE AM, PF, 50, 51 & 51N, KWH & DEM. METERS, POT. XFMRS. AND RELAYS AT ALL LOCATIONS MARKED ‡. KWH & DEMAND METER CONNECTED TO READ TOTAL POWER FOR ALL FOUR FEEDERS (FROM SPLIT SECONDARIES).
3. PROVIDE AM, KWH, 50 & 51 & 51N METERS & RELAYS AT ALL LOCATIONS MARKED ●.
4. PROVIDE 50GS RELAY TO ALL MOTOR MARKED ◊

| | |
|---|---|
| DESIGN REPORT | FOR |
| CLIENT APPROVAL | DRAWN HT |
| LICENSOR APPROVAL | CHECKED |
| CLIENT APPROVAL | APVD SECT MG |
| CLIENT SOE REVIEW | APVD PROJ MGR |
| DESCRIPTION | APVD CLIENT |

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: ONE LINE DIAG. U-31,32,33,38 METH. TO GAS-GAS FRACT. H.F. ALKYL.-HEAVY GAS TREAT.

SCALE: NONE | ACCOUNT NUMBER: 4600 | JOB NUMBER: 6182 | REVISION: F

DOCUMENT NUMBER: D-51-EE-6NP

1.2.13 GAS FRACTIONATION - UNIT 32

The Gas Fractionation Unit is designed to separate the liquid and vapor streams from the Mobil (MTG) unit into feed streams to other units for further processing, interim streams to gasoline blending, and product streams to sales. The Gas Fractionation Unit is a single train consisting of four fractionation towers, as follows:

(1) Absorber-Deethanizer
(2) Depentanizer
(3) Gasoline Splitter
(4) Depropanizer

The process configuration of combining multitrain and single train units requires a highly coordinated design philosophy for the continuous operation of the gasoline plant. Adequate storage capacity has been provided to ensure continuous operation during scheduled maintenance and unscheduled downtime. The gas fractionation system is a conventional petroleum refinery-type facility based on in-house process and mechanical design by The Ralph M. Parsons Company.

A. Basis of Design

The feed streams for the single train Gas Fractionation unit are derived from the three Mobil MTG units. These feed streams result from the conversion of methanol to gasoline in a Mobil MTG unit and consist of a full range of hydrocarbons from methane through raw gasoline, the heaviest hydrocarbons being $C_9$ aromatics in the gasoline range.

The product streams from the gas fractionation unit consist of the following:

(1) Fuel gas
(2) HF alkylation unit feed
(3) LPG (propane)

(4) Light gasoline
(5) Heavy gasoline

The origin and disposition of these product streams in the gas fractionation unit will be as follows:

The feed streams are sent to an absorber-deethanizer tower initially to remove ethane and lighter hydrocarbons for fuel gas and to recover the propane and heavier fraction for further processing. The absorber-deethanizer operates at low pressure, which allows vapor flow from the MTG unit product separator without the use of a compressor. The low-pressure absorber-deethanizer system uses depentanizer bottoms (lean oil) as the absorbent, which eliminates the high-pressure condensation requirement for conventional refluxed deethanizers. Also, the low-pressure deethanization ensures that the equilibrium approach temperature is below the critical values of the gasoline components in the feed. The absorber-deethanizer system design prepares the MTG unit feed for further fractionation in the depentanizer. Fuel gas from the absorber-deethanizer overhead, with a heating value of about 800 Btu/scf (HHV), will be sent to the fuel gas drum for plant consumption.

Deethanizer bottoms are fractionated in the depentanizer to produce feed streams to both the gasoline splitter and the depropanizer. Generally, hydrocarbons higher than $C_5$ flow to the gasoline splitter and the depentanizer overheads are further processed in the depropanizer.

Light gasoline containing hydrocarbons in the $C_5$ through $C_9$ range exists as gasoline splitter overheads and is sent to gasoline storage to be blended to 10-Reid Vapor Pressure (RVP) gasoline. Heavy gasoline containing hydrocarbons in the $C_9$ range is separated as gasoline splitter bottoms to concentrate durene in the feed to the splitter. Durene has a high freeze point, which may cause carburetor problems if not reduced in the final gasoline product. The gasoline splitter bottoms consisting of approximately 50% durene are sent to MRDC's Heavy Gasoline Treating (HGT) for conversion of durene to high-octane branched-chain hydrocarbons of low freeze point.

Depentanizer overheads are split in the depropanizer, resulting in an LPG product streams available for sales and an alkylation feed stream containing primarily $C_4$ and $C_5$ hydrocarbons.

Compositions of the Gas Fractionation unit feed and product streams are given in the following tables.

Feed Streams

| Component | Deethanizer Liquid Feed (lb mol/hr) | Deethanizer Vapor Feed (lb mol/hr) |
|---|---|---|
| Hydrogen | 6.18 | 85.71 |
| Methane | 204.33 | 479.25 |
| Carbon Monoxide | 5.01 | 32.46 |
| Carbon Dioxide | 190.50 | 174.33 |
| Nitrogen | 0.63 | 4.59 |
| Ethene | 4.65 | 3.15 |
| Ethane | 57.87 | 26.70 |
| Propene | 24.45 | 3.93 |
| Propane | 565.44 | 79.77 |
| Isobutane | 889.86 | 55.14 |
| 1-Butene | 113.97 | 5.82 |
| N-Butane | 279.51 | 12.18 |
| Isopentane | 1,013.04 | 18.99 |
| 1-Pentene | 189.27 | 3.60 |
| N-Pentane | 115.74 | 1.65 |
| Cyclopentane | 20.64 | 0.21 |
| 2-Methylpentane | 867.15 | 5.79 |
| $C_6$ + Heavier | 2,995.47 | 3.54 |
| Total Dry, lb mol/hr | 7,543.71 | 996.81 |
| $H_2O$ | 8.43 | 5.28 |
| Total Wet, lb mol/hr | 7,552.14 | 1,002.09 |
| Total, lb/hr | 618,651.60 | 28,075.59 |
| Pressure, psia | 183.0 | 183.0 |
| Temperature, °F | 100 | 100 |

## Product Streams

| Component | Fuel Gas[a] (lb mol/hr) | Alkylation Feed[b] (lb mol/hr) | LPG[c] (lb mol/hr) | Light Gasoline[d] (lb mol/hr) | Heavy Gasoline[e] (lb mol/hr) |
|---|---|---|---|---|---|
| Hydrogen | 91.62 | - | - | - | - |
| Methane | 682.10 | - | - | - | - |
| Carbon Monoxide | 37.35 | - | - | - | - |
| Carbon Dioxide | 364.14 | - | 0.02 | - | - |
| Nitrogen | 5.20 | - | - | - | - |
| Ethene | 7.78 | - | 0.01 | - | - |
| Ethane | 79.22 | - | 5.18 | - | - |
| Propene | 3.77 | 0.01 | 24.60 | - | - |
| Propane | 64.99 | 1.92 | 578.16 | - | - |
| Isobutane | 1.15 | 933.70 | 10.15 | - | - |
| 1-Butene | 0.04 | 119.29 | 0.46 | - | - |
| N-Butane | 0.03 | 291.43 | 0.23 | - | - |
| Isopentane | 0.59 | 1,016.53 | - | 14.91 | - |
| 1-Pentene | 0.10 | 192.54 | - | 0.23 | - |
| N-Pentane | 0.04 | 107.88 | - | 9.47 | - |
| Cyclopentane | - | 11.03 | - | 9.82 | - |
| 2-Methylpentane | 5.03 | 59.99 | | 807.91 | |
| $C_6$ + Heavier | 3.16 | 4.14 | - | 2,484.24 | 508.07 |
| Total Dry, lb mol/hr | 1,346.31 | 2,738.46 | 618.81 | 3,326.58 | 508.07 |
| $H_2O$ | - | - | - | - | - |
| Total Wet, lb mol/hr | 1,346.31 | 2,738.46 | 618.81 | 3,326.58 | 508.07 |
| Total, lb/hr | 34,770.65 | 178,898.66 | 27,306.81 | 337,761.72 | 67,658.58 |
| Pressure, psia | 173.1 | 225.5 | 215.0 | 20.0 | 31.4 |
| Temperature, °F | 55 | 237 | 112 | 210 | 442 |

[a]Deethanizer Vapor Overhead
[b]Depropanizer Bottoms
[c]Depropanizer Overhead
[d]Splitter Overhead
[e]Splitter Bottoms

B. Process Selection Rationale

The process selection for the Gas Fractionation Unit was based on an evaluation of fractionation configurations to arrive at an optimum scheme from both economic and operating viewpoints. Since four processs separations are involved, that is, deethanization, depentanization, depropanization, and gasoline splitting, the order in which the separations occur was evaluated. The progression recommended by The Ralph M. Parsons Company places the separation processes in the following order:

(1) Absorber-Deethanizer

(2) Depentanizer

(3) Gasoline Splitting

(4) Depropanizer

This process scheme allows a low-pressure absorber-deethanizer system using depentanizer bottoms (lean oil) to the absorber, thereby eliminating the high-pressure condensation requirement for conventional refluxed deethanizers. Also, the low-pressure deethanization ensures that the equilibrium approach temperature is below the critical values of the gasoline components in the feed.

In the design of the gas fractionation process, no compressors are required. All fractionation is relatively low pressure, and refrigeration is required only on the Absorber-Deethanizer vapor to recover gasoline components. From an operating and maintenance standpoint, the facility is similar to a petroleum refinery gas plant.

1. Operability. The Gas Fractionation unit has a turndown ratio of 5:1. It can be brought to full-load operation within a few hours.

2. Reliability. The plant is designed with pumps spared and with block valves and bypass valves installed around control valves. This design permits maintenance on such items without shutting down.

3. Onstream Time. The operating factor for the Gas Fractionation Unit is estimated at 95%.

4. Maintenance Costs. Maintenance costs for the Gas Fractionation unit are estimated to be about 3% per year of unit capital cost.

The Gas Fractionation unit is scheduled for a maintenance turnaround 18 months after startup and every 2 years thereafter. The downtime is estimated to be 14 days.

5. Equipment Lead Time. With the exception of the valve trays in the fractionation towers, which have stainless steel valves, the Gas Fractionation unit is designed entirely of carbon steel, which makes for a normal equipment lead time.

6. Commercial Experience. The Ralph M. Parsons Company has built several petroleum refineries that are in operation containing gas plants of a design similar to that incorporated in the W. R. Grace & Co plant.

The Gas Fractionation unit does not discharge any liquids or gases to the atmosphere; all relief systems are vented to the Gasoline Plant flare system. The impact of the unit to the environment will be minimal.

C. Process Description

1. Absorber-Deethanizer. Hydrocarbon liquid feed from the methanol conversion unit product separator at 100°F is pumped to Absorber-Deethanizer 32-01-1101 and will enter on tray 26. Hydrocarbon vapor from the methanol conversion unit at 100°F flows to tray 27 of the absorber by pressure drop from the methanol conversion unit product separator.

The Absorber-Deethanizer contains 26 four-pass valve trays in the deethanizer section and 23 one-pass valve trays in the absorber section. The overhead vapor combined with lean oil at 161°F enters Absorber-Deethanizer Air Coolers 32-01-1301-A and -B, where it is cooled to 109°F. The cooled stream then enters Absorber-Deethanizer Chiller 32-01-1302, where it is chilled to 55°F by liquid ammonia at 40°F. The chilled stream temperature is controlled by regulating the flow of ammonia vapor. A level controller maintains ammonia level in the chiller from Refrigeration Package 32-01-2801.

The resultant liquid and vapor mixture is separated in Absorber-Deethanizer Contact Drum 32-01-1203. Vapor is withdrawn as an overhead product and flows to the fuel gas header. The Absorber-Deethanizer top pressure will be held at 165 psig by a pressure controller, which regulates the overhead product flow from the Absorber-Deethanizer Contact Drum.

The Absorber-Deethanizer Contact Drum also separates water from hydrocarbons. The water flows to Water Knockout Drum 32-01-1204 and from the water knockout drum on level control to a wastewater treatment system. The hydrocarbon liquid from the Absorber-Deethanizer Contact Drum is returned to the Absorber-Deethanizer as reflux by Cold Lean Oil Pump 32-02-1501.

Reboil heat for the Absorber-Deethanizer is provided by Absorber-Deethanizer Reboiler 32-01-1303. This is a kettle reboiler that uses 150-psig steam on flow control reset by a temperature controller from tray 3 vapor of the Absorber-Deethanizer column. Additional reboil heat is provided by Absorber-Deethanizer Side Reboiler 32-01-1321. This is a horizontal reboiler that uses lean oil controlled by a temperature controller on reboiler vapor-liquid mixture at 287°F leaving the reboiler.

Water drawoff from the Absorber-Deethanizer trays 25, 26, 28, and 29 flows to Water Draw Drums 32-01-1201 and -2, where hydrocarbon vapor is disengaged and returned to the Absorber-Deethanizer. The water flows from the water draw drums on level control to the water knockout drum, where any residual vapor is separated and vapor sent to the low-pressure flare and water sent to wastewater treatment.

The Absorber-Deethanizer bottoms on level control flows to two parallel Depentanizer Feed/Bottoms Exchangers 32-01-1319 A and -B, where they are heated to 254°F by exchange with depentanizer bottoms. The stream then enters Depentanizer 32-01-1102 on tray 19.

2. Depentanizer. The depentanizer contains 19 four-pass valve trays in the bottom section and 22 two-pass valve trays in the top section of the column. The overhead vapor at 151°F is partially condensed in four-bay Depentanizer Air Coolers 32-01-1304 A, -B, -C, and -D to a temperature of 137°F. The cooled stream then enters two-parallel, two-series Depentanizer Overhead Condensers 32-01-1305 A, -B, -C, and -D, where the remaining vapor is condensed with the liquid accumulating in Depentanizer Reflux Drum 32-01-1205 at 101°F. These are flooded condensers that control changes in overhead vapor rate by covering and uncovering tubes. The Depentanizer top pressure is maintained at 58 psig by pressure control of a hot vapor bypass to the depentanizer reflux drum. Reflux is returned to tray 41 by Depentanizer Reflux Pump 32-01-1507.

The overhead product on level control will be pumped by Depentanizer Overhead Pump 32-01-1509 to Depropanizer Feed/Bottoms Exchanger 31-01-1312. The depentanizer reflux drum also separates water from the hydrocarbon streams. Since water is not expected in depentanizer feed, flow to the water knockout drum is normally closed.

Reboil heat for the depentanizer is provided by parallel Depentanizer Reboilers, 32-01-1306 A and -B. The two parallel kettle reboilers use 150-psig steam on flow control reset by temperature controllers from tray 14 vapor of the depentanizer column.

The depentanizer bottoms at 333°F are split into two liquid streams. One stream, designated as lean oil, is pumped by Lean Oil Pump 32-01-1503 on flow control to absorber-deethanizer Side Reboiler 32-01-1321 before finally combining with absorber-deethanizer overhead vapor. The other stream is gasoline splitter feed, which is pumped by Depentanizer Bottoms Pump 32-01-1505 to parallel Depentanizer Feed/Bottoms Exchangers 32-01-1319 A and -B and then to parallel Gasoline Splitter Feed/Overhead Exchangers 32-01-1320 A and -B.

3. Gasoline Splitter. The gasoline splitter contains 17 four-pass valve trays in the bottom section and 14 two-pass valve trays in the top section of the column. Feed to the splitter enters at tray 17 following heat exchange with splitter overhead in Gasoline Splitter Feed/Overhead Exchangers 32-01-1320 A and B. The overhead vapor from the splitter is partially condensed in parallel Gasoline Splitter Feed/Overhead Exchangers 32-01-1320 A and -B to a temperature of 291°F. The cooled stream then enters a four-bay Gasoline Splitter Air Cooler (32-01-1308 A, -B, -C, and -D), where it is condensed with the liquid accumulating in Gasoline Splitter Reflux Drum 32-01-1206 at 210°F.

The gasoline splitter top pressure is controlled by varying the overhead product rate. This results in operating the gasoline splitter air cooler as a flooded condenser and controlling changes in overhead vapor rate by covering and uncovering tubes. The overhead product and reflux are pumped by Gasoline Splitter Product/Reflux Pump 32-01-1517, with the reflux on flow control to the top tray of the splitter. The overhead product liquid is cooled in Light Gasoline Product Air Cooler 32-01-1310 to 110°F, further cooled in Light Gasoline Product Cooler 32-01-1311 to 100°F, and then sent to gasoline storage for blending.

Reboil heat for the gasoline splitter is provided by parallel Gasoline Splitter Reboilers 32-01-1309 A and -B. The two parallel kettle reboilers use 600-psig steam on flow control reset by temperature controllers from tray 13 vapor of the gasoline splitter column.

The gasoline splitter bottoms are normally pumped to the HGT unit by the first gasoline splitter bottoms pump, 32-01-1515. Provisions are included in the Design for pumping splitter bottoms to storage during Heavy Gasoline Treating (HGT) unit regeneration. This stream is the total splitter bottoms flow and is cooled to 175°F in Splitter Bottoms Air Cooler 32-01-1307 before going to storage for a 14-day period during HGT regeneration. The splitter bottoms storage tank will be held at 175°F to prevent solidification due to the high durene content of the liquid. Rundown of storage is accomplished by makeup to the HGT feed downstream of Gasoline Splitter Bottom Pump No. 1.

4. Depropanizer. The depropanizer contains 31 two-pass valve trays in the bottom section and 13 two-pass valve trays in the top section of the column. Feed from the depentanizer enter the depropanizer at tray 31 following heat transfer in Depropanizer Feed/Bottoms Exchanger 32-01-1312. Overhead vapor from the depropanizer at 116°F is condensed in parallel Depropanizer Reflux Condensers 32-01-1314 A and -B to a temperature of 112°F, with the liquid accumulating in Depropanizer Reflux Drum 32-01-1207. These are flooded condensers that control changes in overhead vapor rate by covering and uncovering tubes. The depropanizer top pressure is maintained at 205 psig by pressure control of a hot vapor bypass to the depropanizer reflux drum. Reflux is returned to tray 44 by Depropanizer Reflux/Product Pump 32-01-1519.

The condensed portion of the overhead product on level control is pumped by the depropanizer reflux/product pump to Propane Product Cooler 32-01-1316, where it is cooled to 105°F and sent to propane storage.

Reboil heat for the depropanizer is provided by Depropanizer Reboiler 32-01-1315. This is a kettle reboiler that uses 150-psig steam on flow control reset by a temperature controller from tray 4 vapor of the depropanizer column.

The depropanizer bottoms on level control flow to Depropanizer Feed/Bottoms Exchanger 32-01-1312, where they are cooled to 160°F by exchange with depentanizer overhead. They then enter Alkylation Feed Air Cooler 32-01-1313, where they are cooled to 110°F and then enter Alkylation Feed Water Cooler 32-01-1317, where they are cooled to 100°F and sent to HF Alkylation Unit feed storage tank.

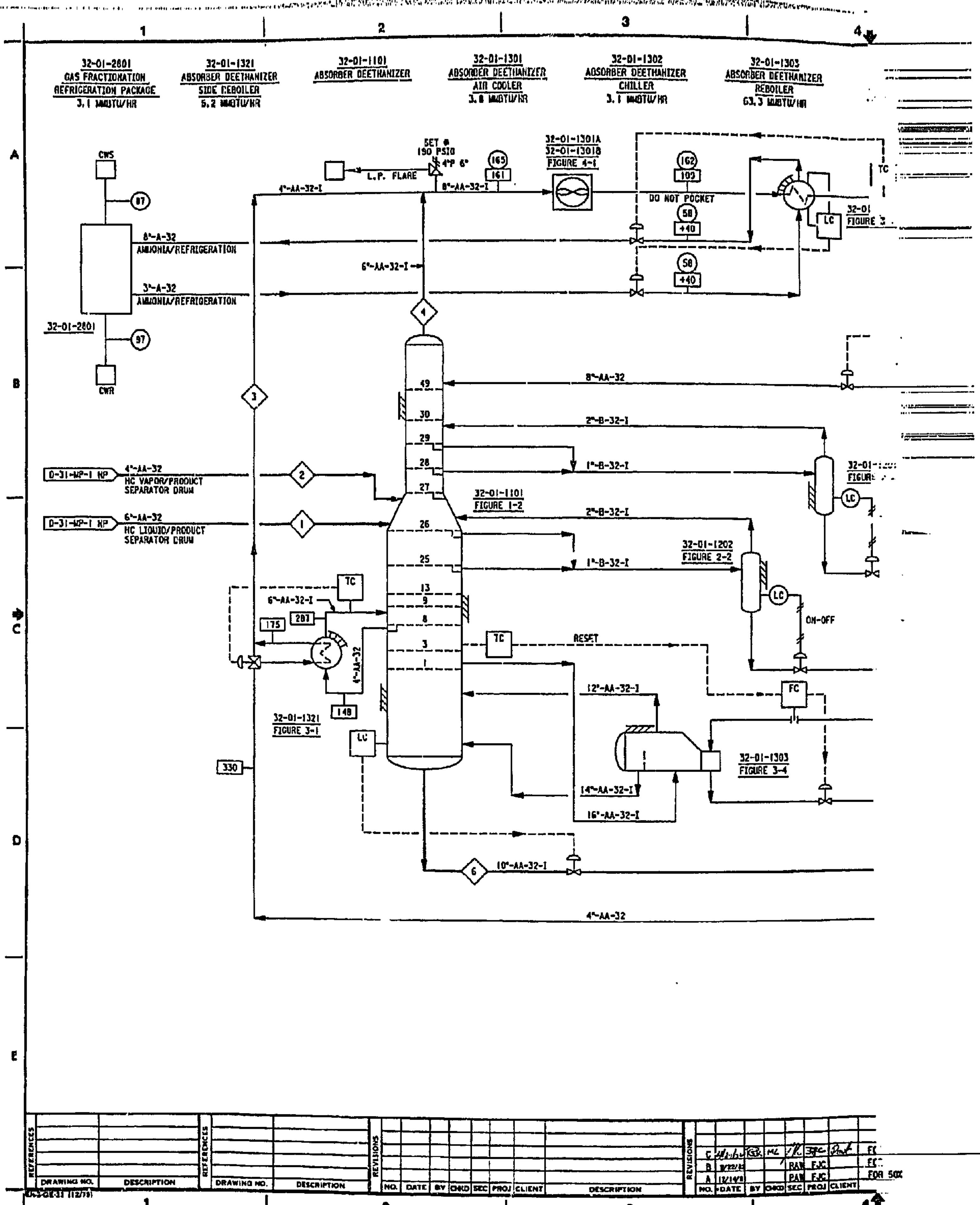
D. Risk Assessment

The Gas Fractionation unit contains conventional petroleum refinery-type equipment that has a high reliability from the standpoint of onstream time. The plant is designed with all pumps spared and with block valves and bypass valves installed around control and relief valves. The design permits maintenance on such items without shutting down the operation. The operational aspect of the unit is similar to petroleum refining facilities in present-day operation. Corrosion is not a problem and equipment fouling is not expected to occur. The technical risk is considered to be minimal.

E. Process Flow and Control Diagrams (Including Material Balance)

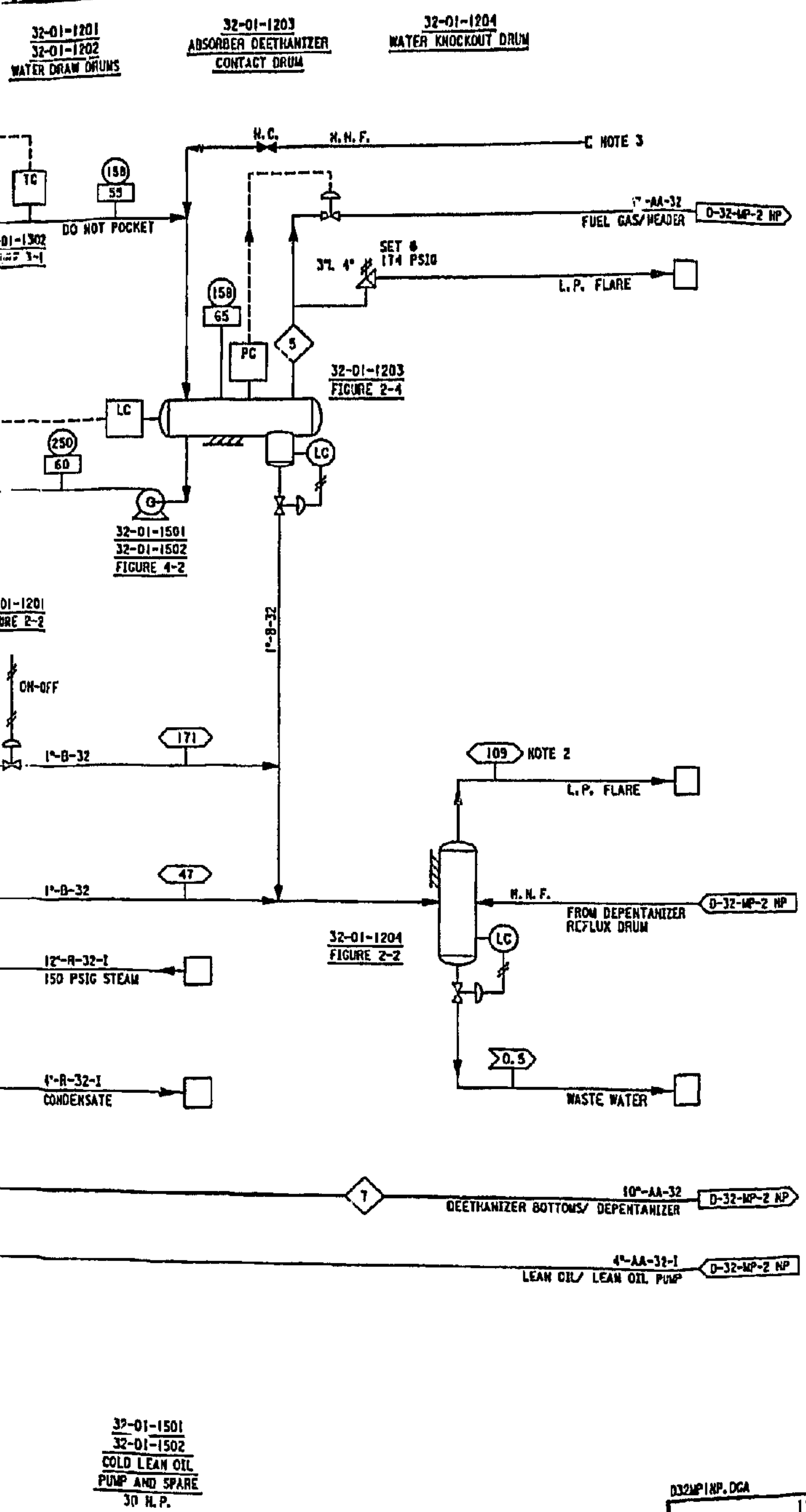
Process Flow and Control Diagrams for Gas Fractionation Unit 32 are as follows:

| Drawing No. | Title |
|---|---|
| D-32-MP-1NP | PFCD Gas Fractionation - Depentanization |
| D-32-MP-2NP | PFCD Gas Fractionation - Depentanization |
| D-32-MP-3NP | PFCD Gas Fractionation - Gasoline Splitting |
| D-32-MP-4NP | PFCD Gas Fractionation - Depropanization |
| D-32-MP-5NP | Material Balance - Gas Fractionation |



32-01-2801
GAS FRACTIONATION
REFRIGERATION PACKAGE
3.1 MMBTU/HR
32-01-1321
ABSORBER DEETHANIZER
SIDE REBOILER
5.2 MMBTU/HR
32-01-1101
ABSORBER DEETHANIZER
32-01-1301
ABSORBER DEETHANIZER
AIR COOLER
3.8 MMBTU/HR
32-01-1302
ABSORBER DEETHANIZER
CHILLER
3.1 MMBTU/HR
32-01-1303
ABSORBER DEETHANIZER
REBOILER
63.3 MMBTU/HR
CWS
CWR
8"-A-32
AMMONIA/REFRIGERATION
3"-A-32
AMMONIA/REFRIGERATION
32-01-2801
SET @
190 PSIG
4"P 6"
L.P. FLARE
4"-AA-32-I
8"-AA-32-I
32-01-1301A
32-01-1301B
FIGURE 4-1
DO NOT POCKET
TC
LC
32-01
FIGURE 3
6"-AA-32-I
8"-AA-32
2"-B-32-I
1"-B-32-I
32-01-1101
FIGURE 1-2
2"-B-32-I
1"-B-32-I
32-01-1202
FIGURE 2-2
D-31-MP-1 NP
4"-AA-32
HC VAPOR/PRODUCT
SEPARATOR DRUM
D-31-MP-1 NP
6"-AA-32
HC LIQUID/PRODUCT
SEPARATOR DRUM
6"-AA-32-I
4"-AA-32
32-01-1321
FIGURE 3-1
ON-OFF
RESET
FC
12"-AA-32-I
14"-AA-32-I
16"-AA-32-I
32-01-1303
FIGURE 3-4
10"-AA-32-I
4"-AA-32
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
RAW
FJC
FOR 50%

5 6 7




NOTES:

1. THE EQUIPMENT SHOWN ON THIS DRAWING IS FOR ONE TRAIN. THE PLANT WILL CONTAIN ONLY ONE TRAIN.
2. TOTAL LIGHT HYDROCARBONS AVERAGE MOLECULAR WEIGHT = 44.0
3. METHANOL IS ADDED AS REQUIRED TO INHIBIT HYDRATE FORMATION. METHANOL IS NOT REQUIRED FOR NORMAL OPERATION
4. THE FIGURE NUMBERS REFER TO THE TYPICAL EQUIPMENT CONFIGURATIONS SHOWN ON DRAWING D-01-MP-2.

A B C D E

EQUIPMENT SHOWN ON THIS DRAWING:

| | |
|---|---|
| 32-01-1101 | 32-01-1501 |
| 32-01-1201 | 32-01-1502 |
| 32-01-1202 | 32-01-2801 |
| 32-01-1203 | |
| 32-01-1204 | |
| 32-01-1301 | |
| 32-01-1302 | |
| 32-01-1303 | |
| 32-01-1321 | |

D32MP1NP.DGA

| | | | |
|---|---|---|---|
| FOR DESIGN REPORT | CHECKED | REK | 12/2/1 |
| FOR CLIENT APPROVAL | APVD SECT MGR | FC | 12/2/1 |
| FOR 50% CLIENT REVIEW | APVD PROJ MGR | FJC | 12/2/1 |
| DESCRIPTION | APVD CLIENT | | |

RMP THE RALPH M. PARSONS COMPANY PASADENA, CALIFORNIA

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

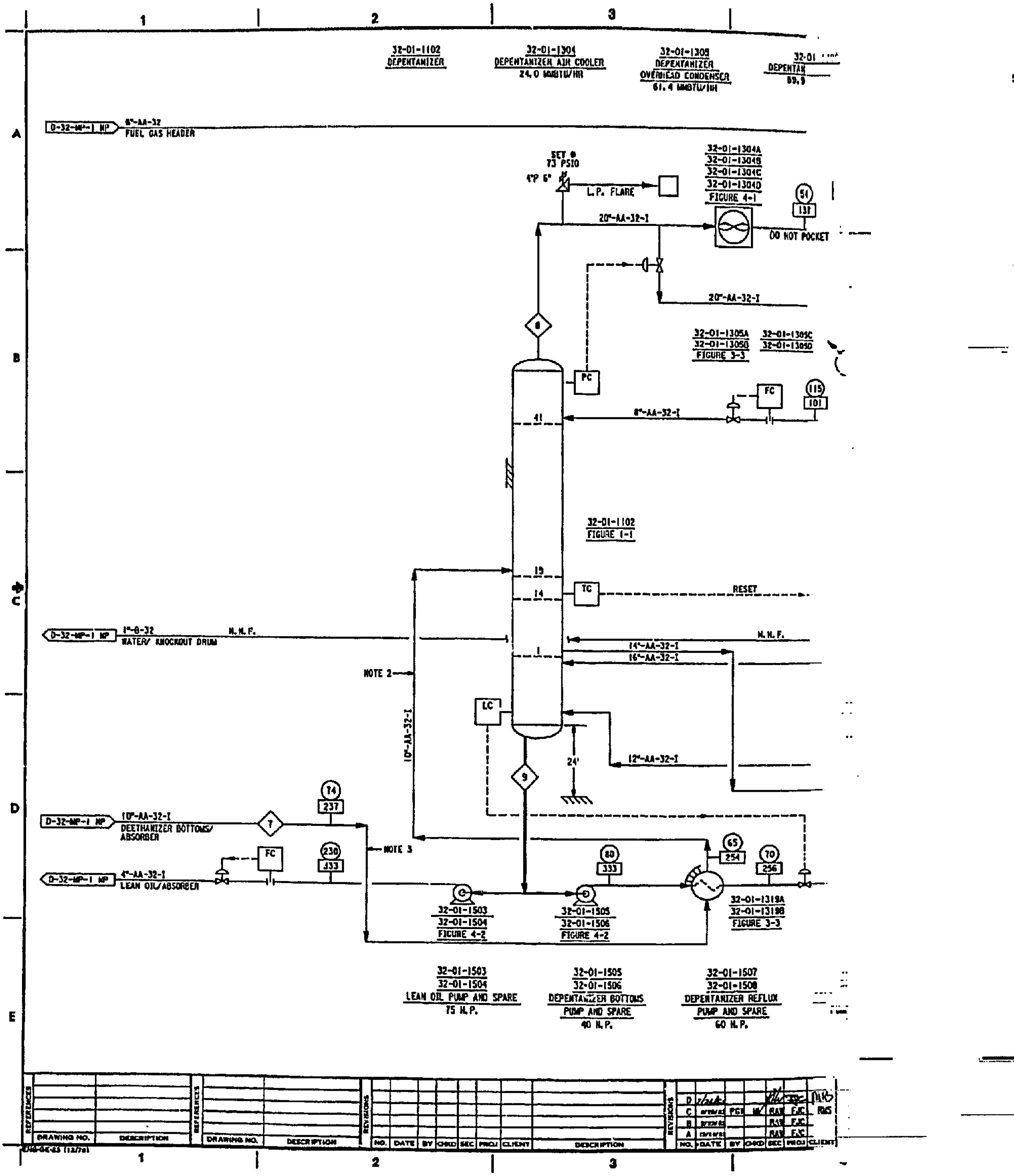
TITLE: PROCESS FLOW AND CONTROL DIAGRAM GAS FRACTIONATION - UNIT 32 DEETHANIZATION

SCALE: NONE

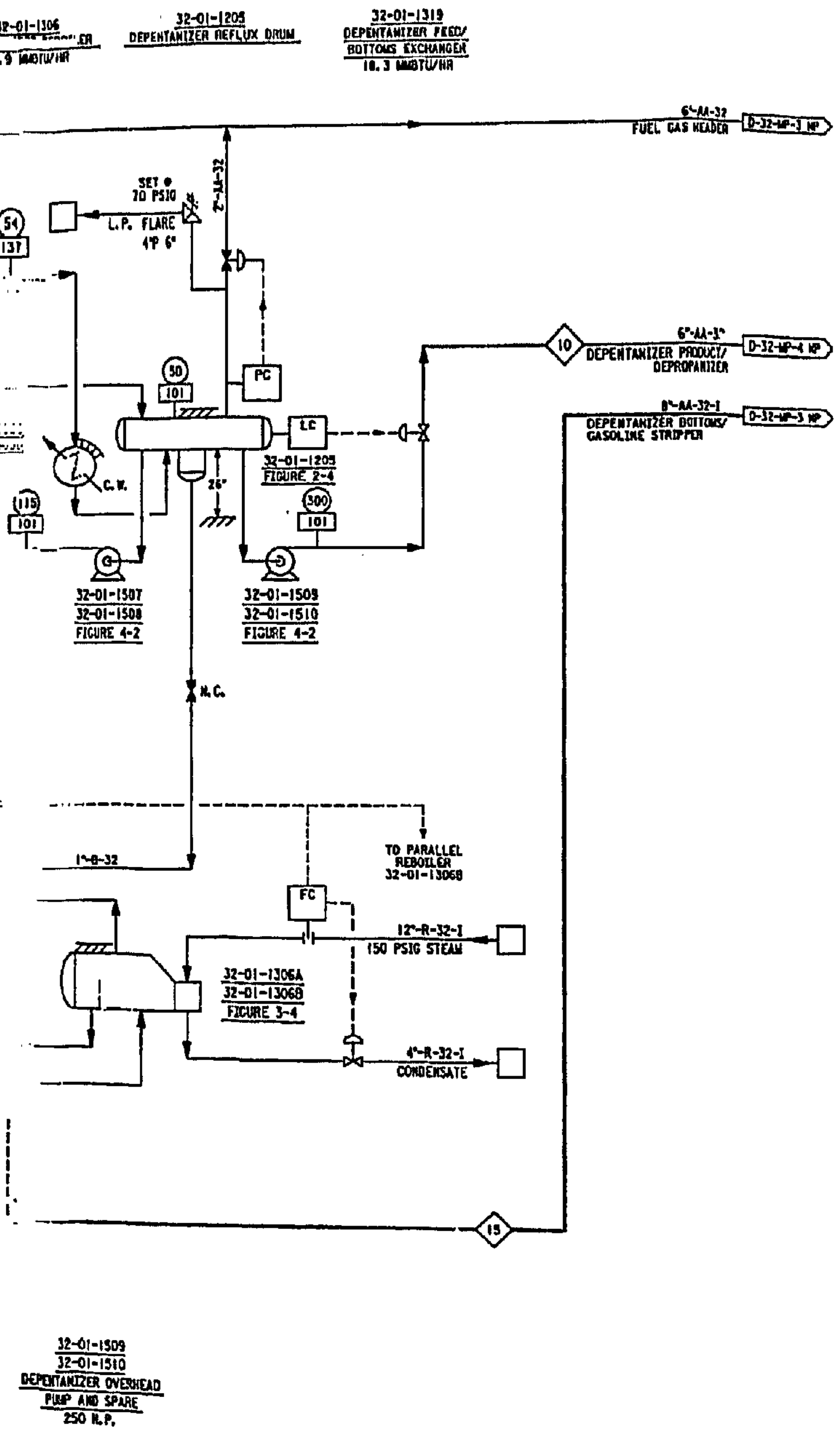
JOB NUMBER: 6182

DOCUMENT NUMBER: D-32-MP-1 NP

REVISION: C



32-01-1102
DEPENTANIZER
32-01-1304
DEPENTANIZER AIR COOLER
24.0 MMBTU/HR
32-01-1305
DEPENTANIZER
OVERHEAD CONDENSER
61.4 MMBTU/HR
D-32-MP-1 NP
6"-AA-32
FUEL GAS HEADER
SET @
73 PSIG
4"P 6"
L.P. FLARE
32-01-1304A
32-01-1304B
32-01-1304C
32-01-1304D
FIGURE 4-1
20"-AA-32-I
DO NOT POCKET
20"-AA-32-I
32-01-1305A
32-01-1305B
FIGURE 3-3
32-01-1305C
32-01-1305D
PC
FC
8"-AA-32-I
41
32-01-1102
FIGURE 1-1
19
14
TC
RESET
1"-B-32
WATER/ KNOCKOUT DRUM
N.N.F.
N.N.F.
1
14"-AA-32-I
16"-AA-32-I
NOTE 2
10"-AA-32-I
LC
24'
12"-AA-32-I
10"-AA-32-I
DEETHANIZER BOTTOMS/
ABSORBER
NOTE 3
FC
4"-AA-32-I
LEAN OIL/ABSORBER
32-01-1503
32-01-1504
FIGURE 4-2
32-01-1505
32-01-1506
FIGURE 4-2
32-01-1319A
32-01-1319B
FIGURE 3-3
32-01-1503
32-01-1504
LEAN OIL PUMP AND SPARE
75 H.P.
32-01-1505
32-01-1506
DEPENTANIZER BOTTOMS
PUMP AND SPARE
40 H.P.
32-01-1507
32-01-1508
DEPENTANIZER REFLUX
PUMP AND SPARE
60 H.P.
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION




NOTES:

1. THE EQUIPMENT SHOWN ON THIS DRAWING IS FOR ONE TRAIN. THE PLANT WILL CONTAIN ONLY ONE TRAIN.
2. VAPOR 43% (MOLE)
   VAPOR MOLECULAR WEIGHT = 70.0
3. VAPOR 25% (MOLE)
   VAPOR MOLECULAR WEIGHT = 65.4
4. THE FIGURE NUMBERS REFER TO THE TYPICAL EQUIPMENT CONFIGURATIONS SHOWN ON DRAWING D-01-MP-2.

EQUIPMENT SHOWN ON THIS DRAWING:

| | |
|---|---|
| 32-01-1102 | 32-01-1503 |
| 32-01-1205 | 32-01-1504 |
| 32-01-1304 | 32-01-1505 |
| 32-01-1305 | 32-01-1506 |
| 32-01-1306 | 32-01-1507 |
| 32-01-1319 | 32-01-1508 |
| | 32-01-1509 |
| | 32-01-1510 |

| | | | |
|---|---|---|---|
| ISSUED FOR DESIGN REPORT | DRAWN | | |
| FOR DESIGN REPORT | CHECKED | REK | 12/2/8 |
| FOR CLIENT APPROVAL | | FC | 12/2/ |
| FOR 50% CLIENT REVIEW | | FJC | 12/2/8 |
| DESCRIPTION | | | |

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

D32MP2NP.DGA

U.S. DEPARTMENT OF ENERGY

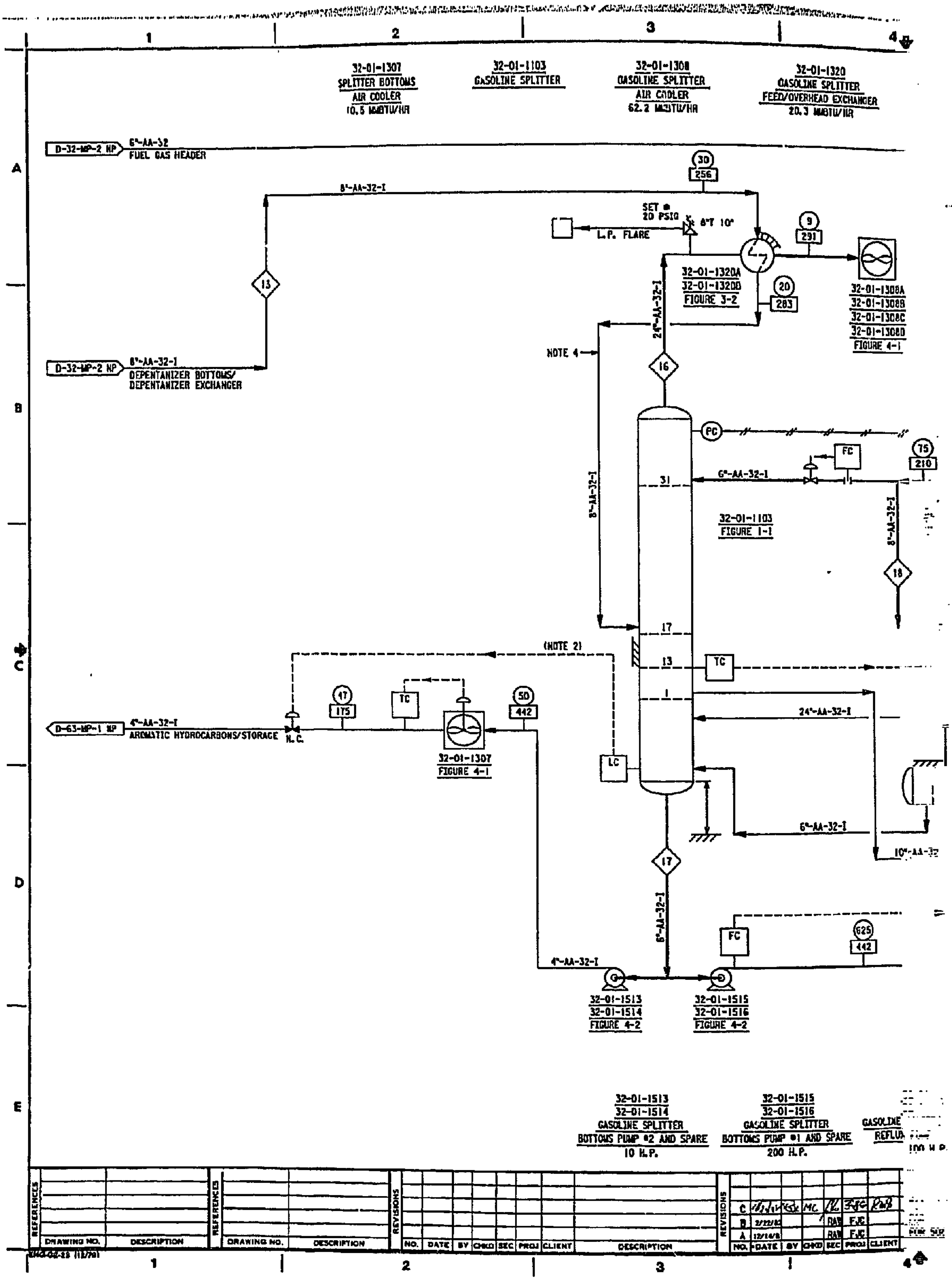
BASKETT — KENTUCKY

W.R. GRACE & CO.
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

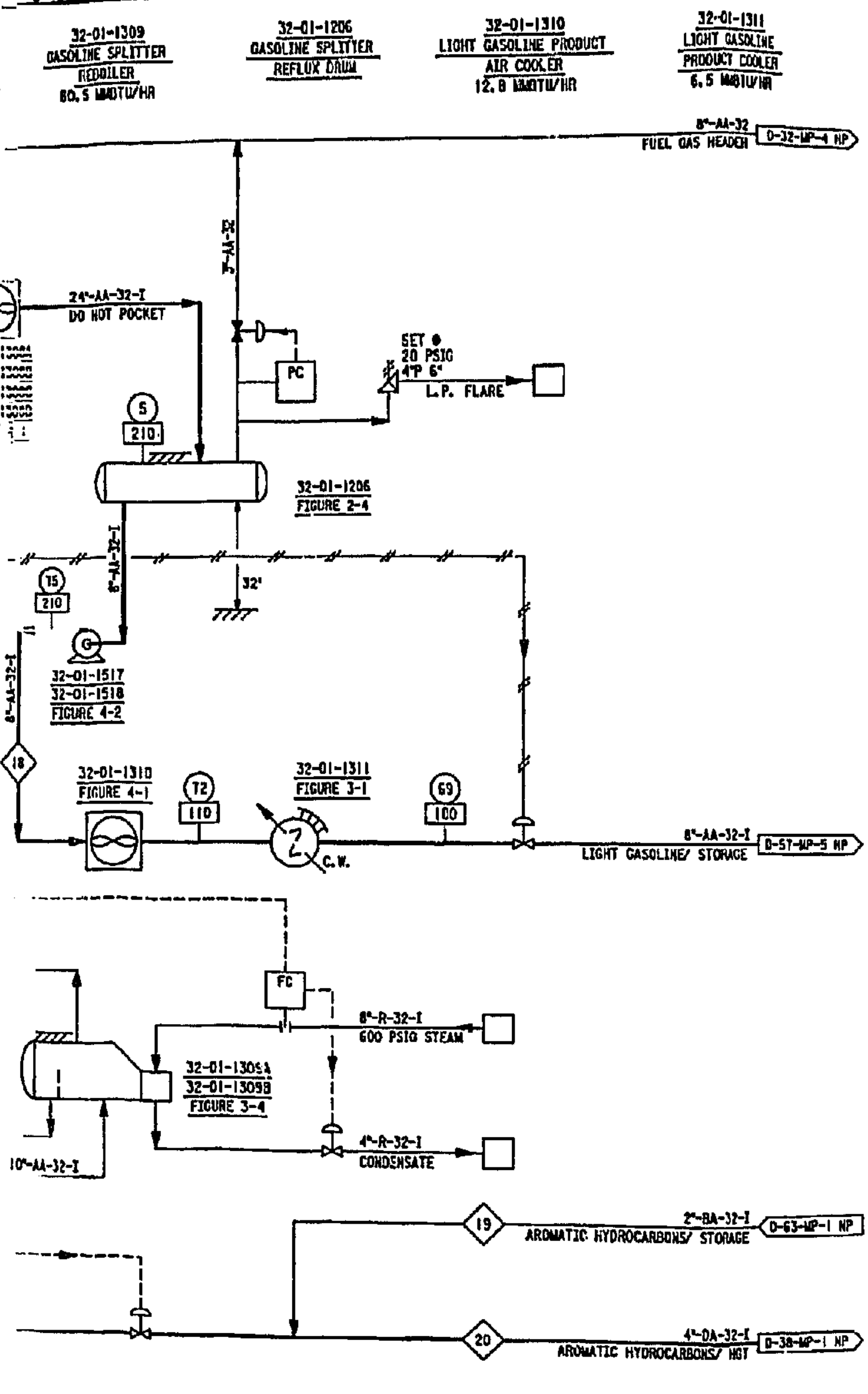
TITLE: PROCESS FLOW AND CONTROL DIAGRAM
GAS FRACTIONATION - UNIT 32
DEPENTANIZATION

SCALE: NONE — 6182

DOCUMENT NUMBER: D-32-MP-2 NP — REV. D



32-01-1307
SPLITTER BOTTOMS
AIR COOLER
10.5 MMBTU/HR
32-01-1103
GASOLINE SPLITTER
32-01-1308
GASOLINE SPLITTER
AIR COOLER
62.2 MMBTU/HR
32-01-1320
GASOLINE SPLITTER
FEED/OVERHEAD EXCHANGER
20.3 MMBTU/HR
D-32-MP-2 NP
6"-AA-32
FUEL GAS HEADER
8"-AA-32-I
SET @ 20 PSIG
8"T 10"
L.P. FLARE
32-01-1320A
32-01-1320B
FIGURE 3-2
32-01-1308A
32-01-1308B
32-01-1308C
32-01-1308D
FIGURE 4-1
24"-AA-32-I
NOTE 4
D-32-MP-2 NP
8"-AA-32-I
DEPENTANIZER BOTTOMS/
DEPENTANIZER EXCHANGER
PC
FC
6"-AA-32-I
32-01-1103
FIGURE 1-1
(NOTE 2)
TC
LC
D-63-MP-1 NP
4"-AA-32-I
AROMATIC HYDROCARBONS/STORAGE
N.C.
32-01-1307
FIGURE 4-1
6"-AA-32-I
10"-AA-32
32-01-1513
32-01-1514
FIGURE 4-2
32-01-1515
32-01-1516
FIGURE 4-2
32-01-1513
32-01-1514
GASOLINE SPLITTER
BOTTOMS PUMP #2 AND SPARE
10 H.P.
32-01-1515
32-01-1516
GASOLINE SPLITTER
BOTTOMS PUMP #1 AND SPARE
200 H.P.
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT




NOTES:

1. THE EQUIPMENT SHOWN ON THIS DRAWING IS FOR ONE TRAIN. THE PLANT WILL CONTAIN ONLY ONE TRAIN.
2. DURING HGT UNIT REGENERATION, A 14 DAY PERIOD, GASOLINE SPLITTER BOTTOMS IS SENT TO STORAGE BY SWITCHING CONTROL VALVES AND ACTIVATING THE GASOLINE SPLITTER BOTTOMS PUMP #2 TO PUMP SPLITTER BOTTOMS TO STORAGE.
3. DURING HGT UNIT OPERATION, THE GASOLINE SPLITTER BOTTOMS STORAGE PUMP IS OPERATED FOR A 168 DAY PERIOD TO PROVIDE THE ADDED FEED REQUIRED TO THE HGT UNIT TO MEET THE MTG PLANT STREAM DAY FACTOR OF 93%. THE HGT UNIT OPERATION IS BASED ON A STREAM DAY FACTOR OF 85%. GASOLINE SPLITTER BOTTOMS PUMP #1 IS ALSO OPERATED DURING HGT UNIT OPERATION.
4. VAPOR 34% (MOLE)
   VAPOR MOLECULAR WEIGHT= 94.6
5. THE FIGURE NUMBERS REFER TO THE TYPICAL EQUIPMENT CONFIGURATIONS SHOWN ON DRAWING D-01-MP-2.

EQUIPMENT SHOWN ON THIS DRAWING:

| | |
|---|---|
| 32-01-1103 | 32-01-1513 |
| 32-01-1205 | 32-01-1514 |
| 32-01-1307 | 32-01-1515 |
| 32-01-1308 | 32-01-1516 |
| 32-01-1309 | 32-01-1517 |
| 32-01-1310 | 32-01-1518 |
| 32-01-1311 | |
| 32-01-1320 | |

32-01-1517
32-01-1518
SPLITTER PRODUCT/ SPARE
100 H.P.

| | | | |
|---|---|---|---|
| FOR DESIGN REPORT | CHECKED | REK | 12/2/8 |
| FOR CLIENT APPROVAL | APVD SECT HD | FC | 12/2/8 |
| FOR 50% CLIENT REVIEW | APVD PROJ MGR | FJC | 12/2/8 |
| DESCRIPTION | APVD CLIENT | | |

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

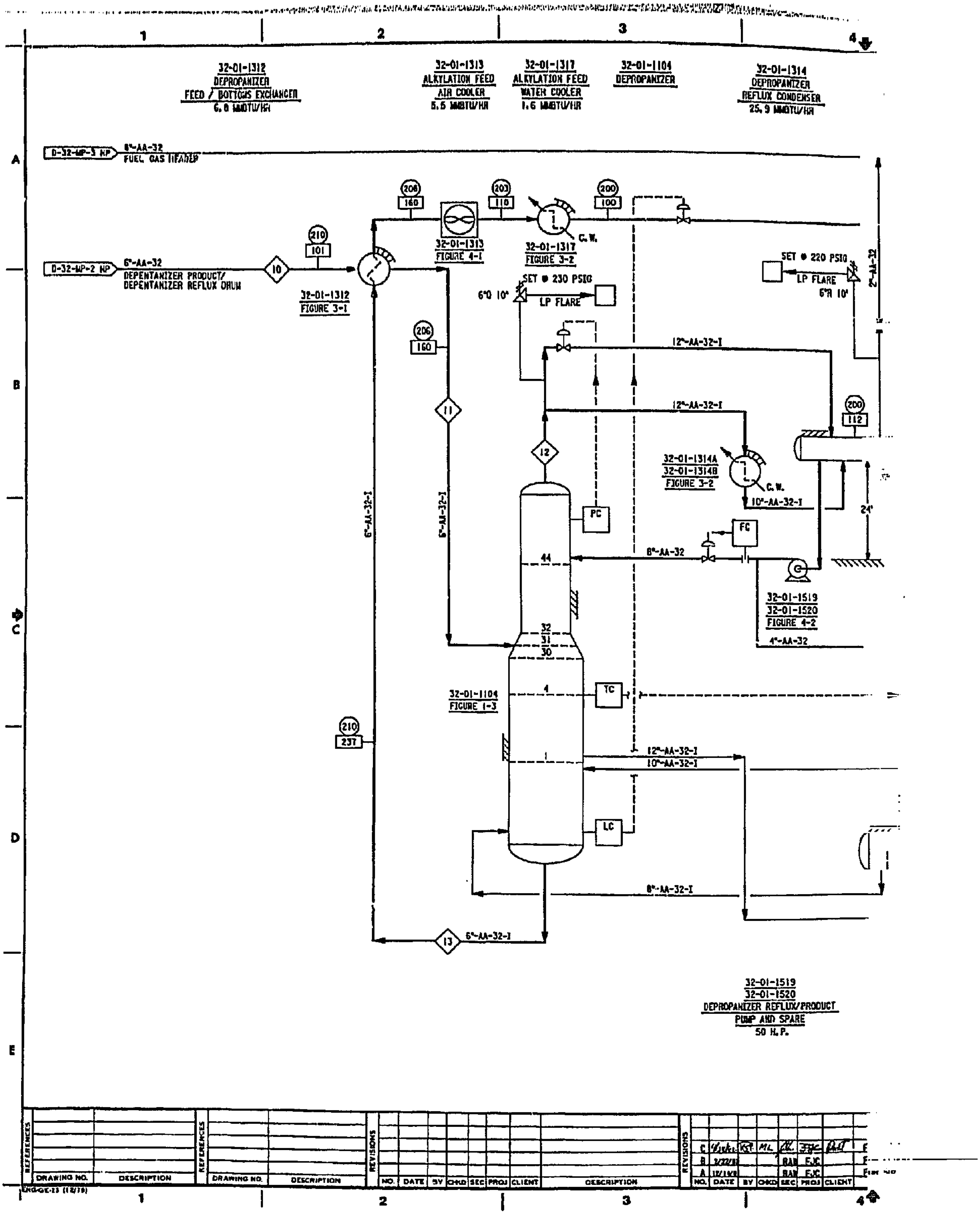
032MP3NP.DGA

U.S. DEPARTMENT OF ENERGY

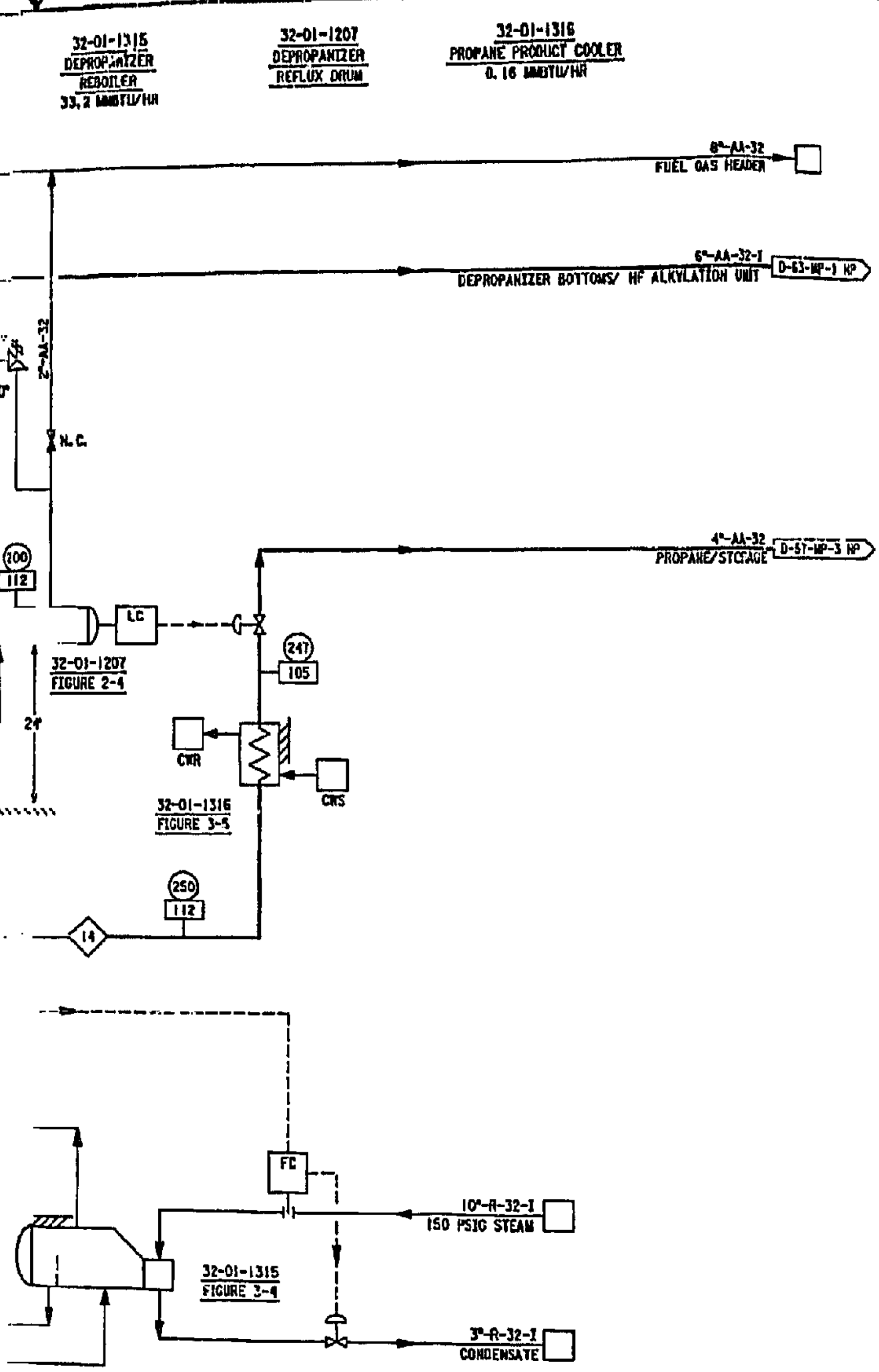
BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: PROCESS FLOW AND CONTROL DIAGRAM
GAS FRACTIONATION - UNIT 32
GASOLINE SPLITTING

SCALE: NONE | JOB NUMBER: 6182 | DOCUMENT NUMBER: D-32-MP-3 NP | REVISION: C



32-01-1312
DEPROPANIZER
FEED / BOTTOMS EXCHANGER
6.0 MMBTU/HR
32-01-1313
ALKYLATION FEED
AIR COOLER
5.5 MMBTU/HR
32-01-1317
ALKYLATION FEED
WATER COOLER
1.6 MMBTU/HR
32-01-1104
DEPROPANIZER
32-01-1314
DEPROPANIZER
REFLUX CONDENSER
25.9 MMBTU/HR
D-32-MP-3 HP
8"-AA-32
FUEL GAS HEADER
D-32-MP-2 HP
6"-AA-32
DEPENTANIZER PRODUCT/
DEPENTANIZER REFLUX DRUM
32-01-1312
FIGURE 3-1
32-01-1313
FIGURE 4-1
32-01-1317
FIGURE 3-2
C.W.
SET @ 230 PSIG
6"Q 10"
LP FLARE
SET @ 220 PSIG
LP FLARE
6"R 10"
2"-AA-32
12"-AA-32-I
12"-AA-32-I
32-01-1314A
32-01-1314B
FIGURE 3-2
C.W.
10"-AA-32-I
PC
FC
8"-AA-32
24"
32-01-1519
32-01-1520
FIGURE 4-2
4"-AA-32
6"-AA-32-I
6"-AA-32-I
TC
LC
32-01-1104
FIGURE 1-3
12"-AA-32-I
10"-AA-32-I
8"-AA-32-I
6"-AA-32-I
32-01-1519
32-01-1520
DEPROPANIZER REFLUX/PRODUCT
PUMP AND SPARE
50 H.P.
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
ENG-GE-23 (12/79)




NOTES:

1. THE EQUIPMENT SHOWN ON THIS DRAWING IS FOR ONE TRAIN. THE PLANT WILL CONTAIN ONLY ONE TRAIN.
2. DURING HGT UNIT REGENERATION, A 14 DAY PERIOD, GASOLINE SPLITTER BOTTOMS IS SENT TO STORAGE BY SWITCHING CONTROL VALVES AND ACTIVATING THE GASOLINE SPLITTER BOTTOMS PUMP #2 TO PUMP SPLITTER BOTTOMS TO STORAGE.
3. DURING HGT UNIT OPERATION, THE GASOLINE SPLITTER BOTTOMS STORAGE PUMP IS OPERATED FOR A 169 DAY PERIOD TO PROVIDE THE ADDED FEED REQUIRED TO THE HGT UNIT TO MEET THE MTG PLANT STREAM DAY FACTOR OF 93%. THE HGT UNIT OPERATION IS BASED ON A STREAM DAY FACTOR OF 85%. GASOLINE SPLITTER BOTTOMS PUMP #1 IS ALSO OPERATED DURING HGT UNIT OPERATION.
4. VAPOR 34% (MOLE)
   VAPOR MOLECULAR WEIGHT= 94.6
5. THE FIGURE NUMBERS REFER TO THE TYPICAL EQUIPMENT CONFIGURATIONS SHOWN ON DRAWING D-01-MP-2.

EQUIPMENT SHOWN ON THIS DRAWING:
32-01-1104
32-01-1207
32-01-1312
32-01-1313
32-01-1314
32-01-1315
32-01-1316
32-01-1317
32-01-1519
32-01-1520

032MP4NP.DGA

| | | | |
|---|---|---|---|
| FOR DESIGN REPORT | CHECKED | REK | 12/2/8 |
| FOR CLIENT APPROVAL | APVD ENGR MGR | FC | 12/2/8 |
| FOR 5% CLIENT REVIEW | APVD PROJ MGR | FJC | 12/2/8 |
| DESCRIPTION | APVD CLIENT | RMJ | |

RMP

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

U.S. DEPARTMENT OF ENERGY

BASKETT — KENTUCKY

W.R. GRACE & CO.
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: PROCESS FLOW AND CONTROL DIAGRAM
GAS FRACTIONATION - UNIT 32
DEPROPANIZATION

SCALE: NONE

JOB NUMBER: 6182

DOCUMENT NUMBER: D-32-MP-4 NP

REVISION: C

| COMPONENT | M.W. | 1 DEETHANIZER LIQUID FEED | 2 DEETHANIZER VAPOR FEED | 3 DEETHANIZER LEAN OIL FEED | 4 DEETHANIZER VAPOR OVERHEAD | 5 DEETHANIZER REFLUX DRUM OVERHEAD |
|---|---|---|---|---|---|---|
| HYDROGEN | 2.016 | 6.18 | 85.71 | | 98.292 | 91.62 |
| METHANE | 16.042 | 204.33 | 479.25 | | 731.184 | 682.10 |
| CARBON MONOXIDE | 28.010 | 5.01 | 32.46 | | 39.474 | 37.35 |
| CARBON DIOXIDE | 44.010 | 190.50 | 174.33 | | 429.040 | 364.14 |
| NITROGEN | 28.016 | 0.63 | 4.59 | | 5.488 | 5.20 |
| ETHENE | 28.052 | 4.65 | 3.15 | | 9.093 | 7.78 |
| ETHANE | 30.068 | 57.87 | 26.70 | | 98.072 | 79.22 |
| PROPENE | 42.078 | 24.45 | 3.93 | | 6.419 | 3.77 |
| PROPANE | 44.094 | 565.44 | 79.77 | | 117.995 | 64.99 |
| ISO BUTANE | 58.120 | 889.86 | 55.14 | | 4.430 | 1.15 |
| 1-BUTENE | 56.104 | 113.97 | 5.82 | | 0.176 | 0.04 |
| N-BUTANE | 58.120 | 279.51 | 12.18 | | 0.138 | 0.03 |
| ISO PENTANE | 72.146 | 1,013.04 | 18.99 | 5.57 | 0.812 | 0.59 |
| 1-PENTENE | 72.146 | 189.27 | 3.60 | 1.12 | 0.135 | 0.10 |
| N-PENTANE | 72.146 | 115.74 | 1.65 | 0.56 | 0.058 | 0.04 |
| CYCLO PENTANE | 70.130 | 20.64 | 0.21 | 0.06 | 0.003 | 0.00 |
| 2 METHYL PENTANE | 86.172 | 867.15 | 5.79 | 159.79 | 7.027 | 5.03 |
| $C_6$+HEAVIER | | 2,995.47 | 3.54 | 554.69 | 3.74 | 2.58 |
| WATER | 18.016 | 8.43 | 5.28 | | | |
| | | | | | | |
| TOTAL - MOL/HR (DRY) | | 7,543.71 | 996.84 | 721.79 | 1,526.304 | 1,346.31 |
| TOTAL - LB/HR | | 618,499.86 | 27,980.55 | 76,100.75 | 42,057. | 34,770.65 |
| MOLECULAR WEIGHT | | 81.98 | 28.07 | 105.43 | 27.55 | 25.83 |
| BBL/STREAM DAY | | 61,236. | — | 6,815. | — | — |
| MSCFD | | — | 9,076.82 | — | 13,901.0 | 12,258.94 |
| PRESSURE - PSIG | | 168.30 | 168.30 | 170.30 | 165.40 | 158.40 |
| TEMP - °F | | 100. | 100. | 206. | 66.23 | 55. |
| H - MBTU/HR | | 79,818.81 | 6,855.10 | 13,580.00 | | 6,718.01 |

| COMPONENT | M.W. | 11 DEPROPANIZER FEED | 12 DEPROPANIZER VAPOR OVERHEAD | 13 DEPROPANIZER BOTTOMS | 14 DEPROPANIZER OVERHEAD | 15 SPLITTER FEED |
|---|---|---|---|---|---|---|
| HYDROGEN | 2.016 | | 0.000 | | | |
| METHANE | 16.042 | | 0.000 | | | |
| CARBON MONOXIDE | 28.010 | | 0.000 | | | |
| CARBON DIOXIDE | 44.010 | 0.02 | 0.034 | | 0.02 | |
| NITROGEN | 28.016 | | 0.000 | | | |
| ETHENE | 28.052 | 0.01 | 0.014 | | 0.01 | |
| ETHANE | 30.068 | 5.18 | 34.334 | | 5.18 | |
| PROPENE | 42.078 | 24.61 | 169.269 | 0.01 | 24.60 | |
| PROPANE | 44.094 | 580.08 | 3978.127 | 1.92 | 578.16 | |
| ISO BUTANE | 58.120 | 943.85 | 69.939 | 933.70 | 10.15 | |
| 1-BUTENE | 56.104 | 119.75 | 2.797 | 119.29 | 0.46 | |
| N-BUTANE | 58.120 | 291.66 | 1.600 | 291.43 | 0.23 | |
| ISO PENTANE | 72.146 | 1016.53 | 0.009 | 1016.53 | | 14.91 |
| 1-PENTENE | 72.146 | 192.54 | 0.001 | 192.54 | | 0.23 |
| N-PENTANE | 72.146 | 107.88 | | 107.88 | | 9.47 |
| CYCLO PENTANE | 70.130 | 11.03 | | 11.03 | | 9.82 |
| 2 METHYL PENTANE | 86.172 | 59.99 | | 59.99 | | 807.91 |
| C +HEAVIER | | 4.14 | — | 4.14 | — | 2992.31 |
| WATER | 18.016 | | | | | |
| | | | | | | |
| TOTAL - MOL/HR | | 3,357.25 | 4,257.660 | 2,738.45 | 618.80 | 3,834.65 |
| TOTAL - LB/HR | | 206,240.46 | 187,884. | 178,898.66 | 27,306.81 | 405,411.21 |
| MOLECULAR WEIGHT | | 61.43 | 44.13 | 65.33 | 44.13 | 105.72 |
| BBL/STREAM DAY | | 24,014. | — | 20,332. | 3,680. | 36,290. |
| MSCFD | | — | 38,777.14 | — | — | — |
| PRESSURE - PSIG | | 207.30 | 205.30 | 210.80 | 200.30 | 30.0 |
| TEMP - °F | | 160. | 115.91 | 237. | 112. | 256. |
| H - MBTU/HR | | 37,080.90 | | 39,891.35 | 4,480.75 | 97,254.01 |

| REFERENCES DRAWING NO. | DESCRIPTION | REFERENCES DRAWING NO. | DESCRIPTION | REVISIONS NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT | DESCRIPTION | REVISIONS NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | C | | | | | | |
| | | | | | | | | | | | | B | 5/21/82 | | | RAN | EJC | |
| | | | | | | | | | | | | A | 5/1/82 | | | RAN | EJC | FOR |

| 5 REFLUX DRUM OVERHEAD | 6 DEETHANIZER LIQUID PRODUCT BOTTOMS | 7 DEPENTANIZER FEED | 8 DEPENTANIZER VAPOR OVERHEAD | 9 DEPENTANIZER BOTTOMS | 10 DEPENTANIZER REFLUX PRODUCT |
|---|---|---|---|---|---|
| 91.62 | | | 0.000 | | |
| 692.10 | | | 0.000 | | |
| 37.35 | | | 0.000 | | |
| 364.14 | 0.02 | 0.02 | 0.013 | | 0.02 |
| 5.20 | | | 0.000 | | |
| 7.78 | 0.01 | 0.01 | 0.005 | | 0.01 |
| 79.22 | 5.18 | 5.18 | 12.695 | | 5.18 |
| 3.77 | 24.61 | 24.61 | 62.606 | | 24.61 |
| 64.99 | 580.08 | 580.08 | 1475.801 | | 580.08 |
| 1.15 | 943.85 | 943.85 | 2405.699 | | 943.85 |
| 0.04 | 119.75 | 119.75 | 305.255 | | 119.75 |
| 0.03 | 251.66 | 291.66 | 743.500 | | 291.66 |
| 0.59 | 1031.01 | 1037.01 | 2590.993 | 20.48 | 1016.53 |
| 0.10 | 193.89 | 193.89 | 490.870 | 1.35 | 192.54 |
| 0.04 | 117.91 | 117.91 | 276.840 | 10.03 | 107.88 |
| 0.00 | 20.90 | 20.90 | 31.029 | 9.88 | 11.03 |
| 5.03 | 1027.69 | 1027.69 | 150.047 | 967.71 | 59.99 |
| 2.58 | 3551.03 | 3551.03 | 9.846 | 3547.01 | 4.14 |
| — | | | | | |
| — | | | | | |
| 1,346.31 | 7,913.69 | 7,913.69 | 8,555.753 | 4,556.46 | 3,357.25 |
| 34,770.65 | 687,739.58 | 687,739.58 | 525,503. | 481,511.96 | 206,240.46 |
| 25.83 | 86.91 | 86.91 | 61.42 | 105.68 | 61.43 |
| — | 67,055. | 52,600. | — | 43,043. | 24,014. |
| 12,258.94 | — | 17,932. | 77,922.50 | — | — |
| 158.40 | 172.00 | 74.0 | 58.30 | 63.88 | 50.30 |
| 55. | 274. | 237. | 151.27 | 333. | 101. |
| 6,718.01 | 154,856.71 | 154,776.20 | | 118,312.97 | 30,311.64 |

| [illegible] | 16 GASOLINE SPLITTER VAPOR OVERHEAD | 17 SPLITTER BOTTOMS | 18 SPLITTER OVERHEAD | 19 SPLITTER BOTTOMS TO HGT FROM STORAGE | 20 TOTAL SPLITTER BOTTOMS TO HGT |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
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| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 14.91 | 20.491 | | 14.91 | | |
| 0.23 | 0.342 | | 0.23 | | |
| 9.47 | 12.959 | | 9.47 | | |
| 9.82 | 13.426 | | 9.82 | | |
| 807.91 | 1104.559 | | 807.91 | | |
| [illegible] | 3397.392 | 508.07 | 2484.24 | 40.58 | 548.65 |
| | | | | | |
| | | | | | |
| [illegible] | 4,549.169 | 508.07 | 3,326.58 | 40.58 | 548.65 |
| [illegible] | 461,877. | 67,658.58 | 337,761.72 | 5,403.94 | 73,079.97 |
| 105.72 | 101.53 | 133.17 | 101.53 | 133.17 | 133.20 |
| [illegible] | — | 5,208. | 31,021. | 416. | 5,624. |
| — | 41,432.09 | — | — | — | — |
| 30.0 | 13.30 | 16.66 | 75.0 | 625.00 | 575.00 |
| 256. | 302.60 | 442. | 210. | 175. | 415. |
| [illegible] | | 18,447.94 | 61,351.67 | | |

NOTES:

1. THIS MATERIAL BALANCE IS FOR ONE TRAIN. THE PLANT WILL CONTAIN ONLY ONE TRAIN.
2. METHANOL IS ADDED AS REQUIRED TO INHIBIT HYDRATE FORMATION. METHANOL IS NOT REQUIRED FOR NORMAL OPERATION.
3. DURING HGT UNIT REGENERATION, A 14 DAY PERIOD, GASOLINE SPLITTER BOTTOMS IS SENT TO STORAGE BY SWITCHING CONTROL VALVES AND ACTIVATING THE GASOLINE SPLITTER BOTTOMS PUMP #2 TO PUMP SPLITTER BOTTOMS TO STORAGE.
4. DURING HGT UNIT OPERATION, THE GASOLINE SPLITTER BOTTOMS STORAGE PUMP IS OPERATED FOR A 169 DAY PERIOD TO PROVIDE THE ADDED FEED REQUIRED TO THE HGT UNIT TO MEET THE MTG PLANT STREAM DAY FACTOR OF 93%. THE HGT UNIT OPERATION IS BASED ON A STREAM DAY FACTOR OF 85%. GASOLINE SPLITTER BOTTOMS PUMP #1 IS ALSO OPERATED DURING HGT UNIT OPERATION.
5. AN INTERFACE TEMPERATURE DIFFERENCE OF THE HGT UNIT FEED STREAM, 415°F VERSUS 322°F, EXISTS. NO EQUIPMENT CHANGES WILL BE MADE AT THIS TIME TO COMPENSATE FOR THE TEMPERATURE DIFFERENCE.
6. THE INTERFACE DIFFERENCE BETWEEN UNIT 31 AND UNIT 32 MATERIAL BALANCES, MTG UNIT PRODUCT STREAMS VS GAS FRACTIONATION UNIT FEED STREAMS, APPEARS IN THE $C_6$+ HEAVIER COMPONENTS DUE TO DIFFERENCES IN COMPUTER PHYSICAL PROPERTY DATA FOR THE HEAVY FRACTIONS.

FOR DESIGN REPORT
FOR CLIENT APPROVAL
FOR ~~30%~~ CLIENT REVIEW
DESCRIPTION

FOR / DRAWN / CHECKED / APVD SECT MGR / APVD PROJ MGR / APVD CLIENT

RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

032MP5NP.DGA

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: MATERIAL BALANCE GAS FRACTIONATION - UNIT 32

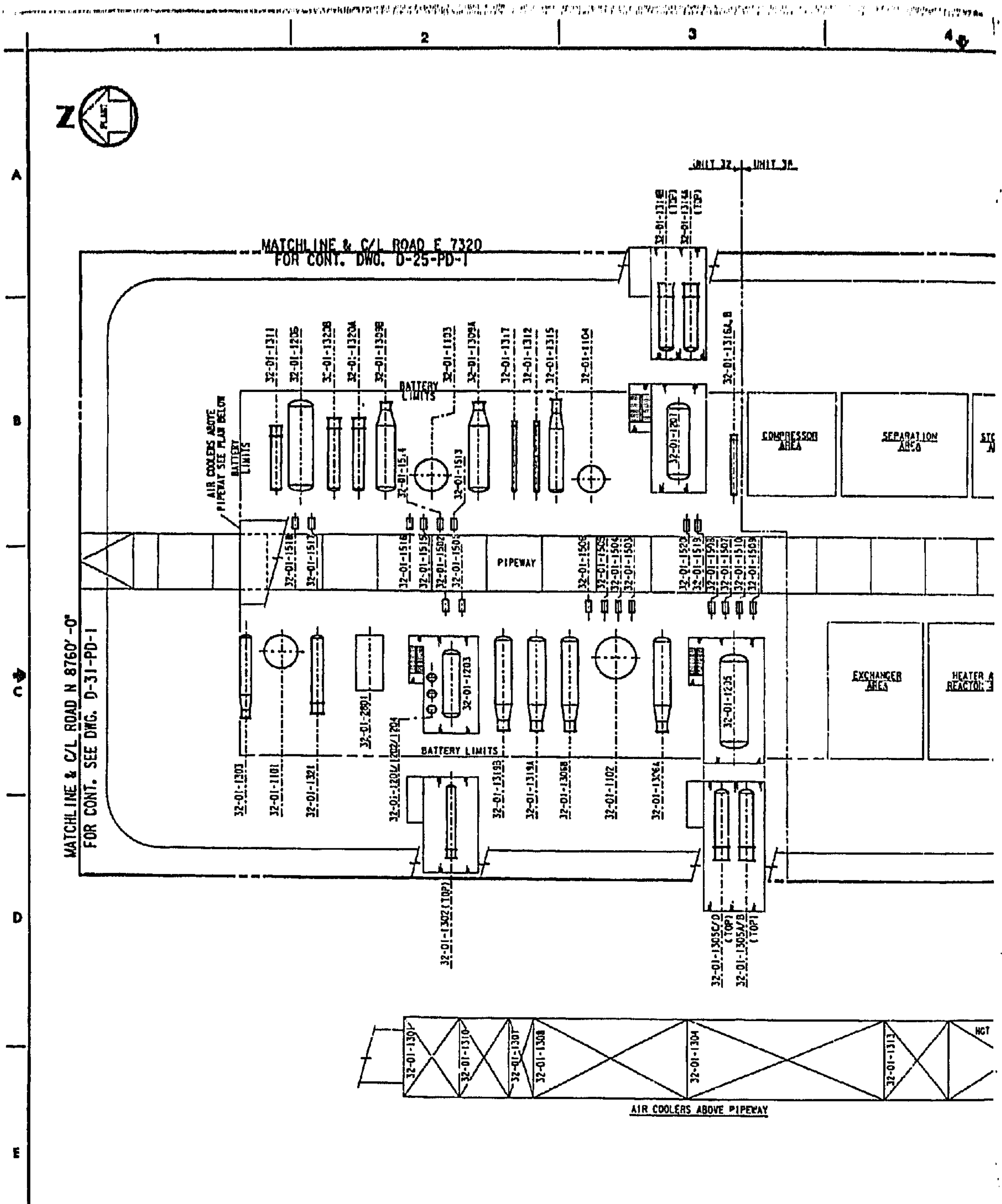
| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| NONE | 2800 | 6182 | C |

DOCUMENT NUMBER: D-32-MP-5 NP

## F. Plot Plan/General Arrangement Drawings

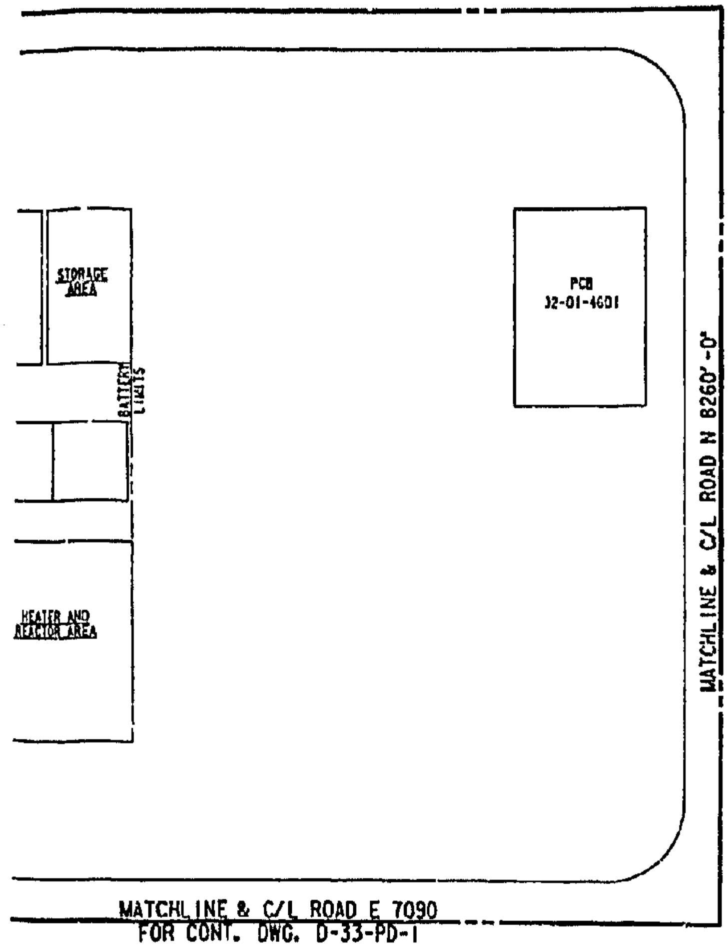
Plot Plan and General Arrangement Drawings for Gas Fractionation Unit 32 are as follows:

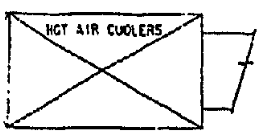
| Drawing No. | Title |
|---|---|
| D-32-PD-1NP | Plot Plan - Unit 32 and Unit 38 Gas Fractionation and HGT |
| D-32-PD-2NP | Elevation - Unit 32 and Unit 38 Gas Fractionation and HGT |




| REFERENCES | | REFERENCES | |
|---|---|---|---|
| DRAWING NO. | DESCRIPTION | DRAWING NO. | DESCRIPTION |

| NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT | DESCRIPTION |
|---|---|---|---|---|---|---|---|
| D | 6/1/82 | 3R | | | | | FOR DESIG |
| C | 5-3-82 | 3R | | NH | FJC | | FOR CLIE |
| B | 4-1-82 | 3R | | NH | FJC | | FOR LICE |
| A | 3-24-82 | 3R | | NH | FJC | | ISSUED CL |




**EQUIPMENT LIST**

**FRACTIONATION UNIT 32**

| | |
|---|---|
| 32-01-1101 | ABSORBER DEETHANIZER |
| 32-01-1102 | DEPENTANIZER |
| 32-01-1103 | GASOLINE SPLITTER |
| 32-01-1104 | DEPROPANIZER |
| 32-01-1201 | WATER DRAW DRUM 1 |
| 32-01-1202 | WATER DRAW DRUM 2 |
| 32-01-1203 | ABSORBER DEETHANIZER REFLUX DRUM |
| 32-01-1204 | WATER K.O. DRUM |
| 32-01-1205 | DEPENTANIZER REFLUX DRUM |
| 32-01-1206 | GASOLINE SPLITTER REFLUX DRUM |
| 32-01-1207 | DEPROPANIZER REFLUX DRUM |
| 32-01-1301 | ABSORBER DEETHANIZER AIR COOLER |
| 32-01-1302 | ABSORBER DEETHANIZER CHILLER |
| 32-01-1303 | ABSORBER DEETHANIZER REBOILER |
| 32-01-1304 | DEPENTANIZER AIR COOLER |
| 32-01-1305A, B, C, D | DEPENTANIZER OVHD. CONDENSER |
| 32-01-1306A, B | DEPENTANIZER REBOILER |
| 32-01-1307 | SPLITTER BOTTOMS AIR COOLER |
| 32-01-1308 | GASOLINE SPLITTER AIR COOLER |
| 32-01-1309A, B | GASOLINE SPLITTER REBOILER |
| 32-01-1310 | LIGHT GASOLINE PRODUCT AIR COOLER |
| 32-01-1311 | LIGHT GASOLINE PRODUCT COOLER |
| 32-01-1312 | DEPROPANIZER FEED/BOTTOMS EXCHANGER |
| 32-01-1313 | ALKYLATION FEED AIR COOLER |
| 32-01-1314A, B | DEPROPANIZER REFLUX CONDENSER |
| 32-01-1315 | DEPROPANIZER REBOILER |
| 32-01-1316A, B | PROPANE PRODUCT COOLER |
| 32-01-1317 | ALKYLATION FEED WATER COOLER |
| 32-01-1319A, B | DEPENTANIZER FEED/BOTTOMS EXCHANGER |
| 32-01-1320-A, B | GASOLINE SPLITTER FEED/OVHD. EXCHANGER |
| 32-01-1321 | ABSORBER DEETHANIZER SIDE REBOILER |
| 32-01-1501, 1502 | COLD LEAN OIL PUMP AND SPARE |
| 32-01-1503, 1504 | LEAN OIL PUMP AND SPARE |
| 32-01-1505, 1506 | DEPENTANIZER BOTTOMS PUMP AND SPARE |
| 32-01-1507, 1508 | DEPENTANIZER REFLUX PUMP AND SPARE |
| 32-01-1509, 1510 | DEPENTANIZER OVHD. PUMP AND SPARE |
| 32-01-1513, 1514 | GASOLINE SPLITTER BOTTOMS PUMP NO. 2 AND SPARE |
| 32-01-1515, 1516 | GASOLINE SPLITTER BOTTOMS PUMP NO. 1 AND SPARE |
| 32-01-1517, 1518 | GASOLINE SPLITTER PRODUCT/REFLUX PUMP AND SPARE |
| 32-01-1519, 1520 | DEPROPANIZER REFLUX PUMP AND SPARE |
| 32-01-2801 | GAS FRACTIONATION REFRIGERATION PACKAGE |

NOTE:
UNIT 38 IS PROPRIETARY.

SCALE: 1" = 20'-0"

U.S. DEPARTMENT OF ENERGY

BASKETT | W.R. GRACE & CO. | KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

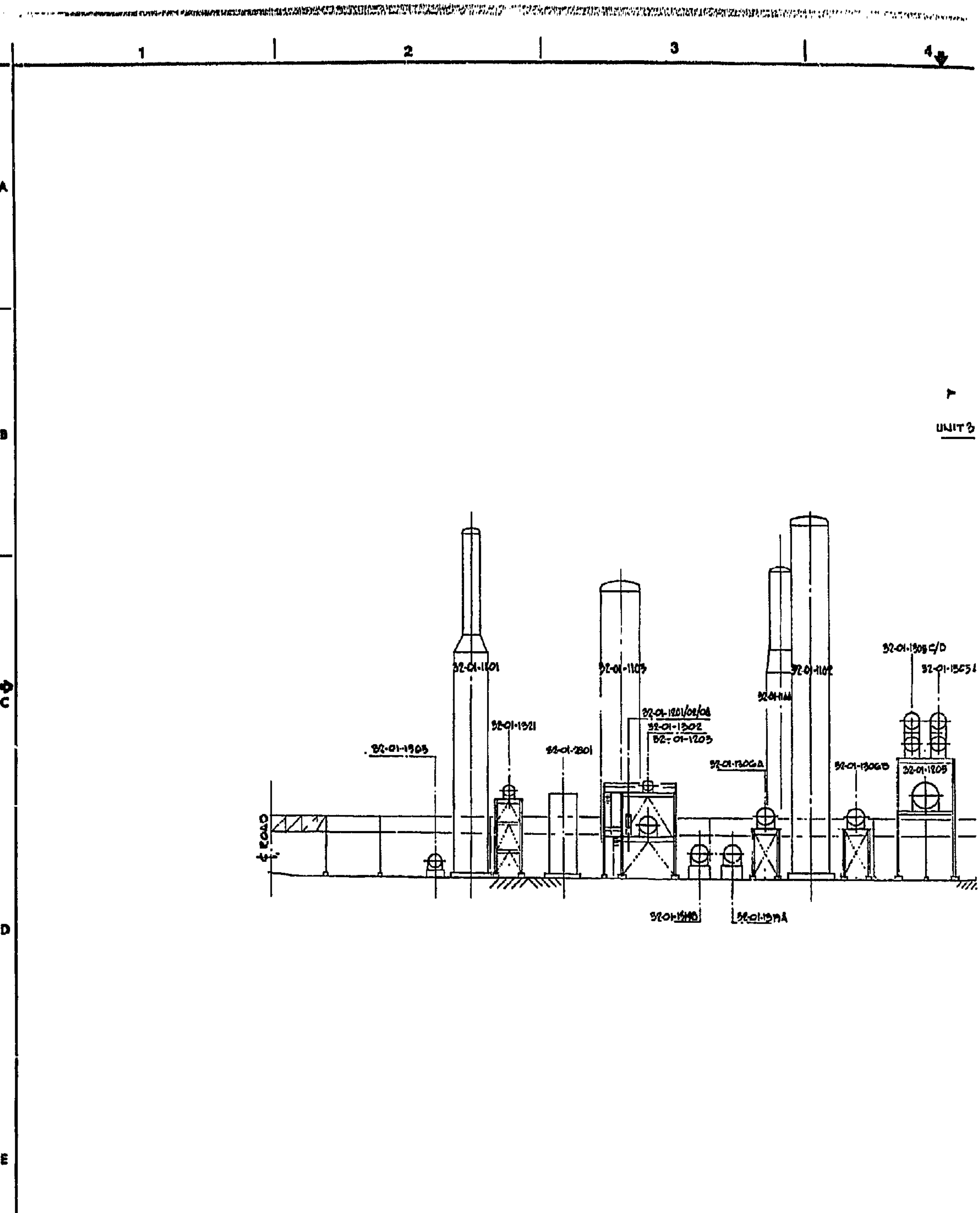
| DESCRIPTION | | |
|---|---|---|
| FOR DESIGN REPORT | DRAWN | RR |
| FOR CLIENT APPROVAL | CHECKED | |
| FOR LICENSOR APPROVAL | APVD SECT HD | NH |
| ISSUED CLIENT REVIEW 50% COMP | APVD PROJ MGR | FJC |
| | APVD CLIENT | |

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

TITLE: PLOT PLAN
UNIT 32 AND UNIT 38
FRACTIONATION AND HGT

| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| 1"=20'-0" | 7243 | 6182 | D |

DOCUMENT NUMBER: D-32-PD-1NP




| REFERENCES | | | REFERENCES | | REVISIONS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | D-32-PD-1 | PLOT PLAN | | | | | | | | | | | |
| | DRAWING NO. | DESCRIPTION | DRAWING NO | DESCRIPTION | | NO. | DATE | BY | CHKD | SEC | PRCU | CLIENT | DESCRIPT |

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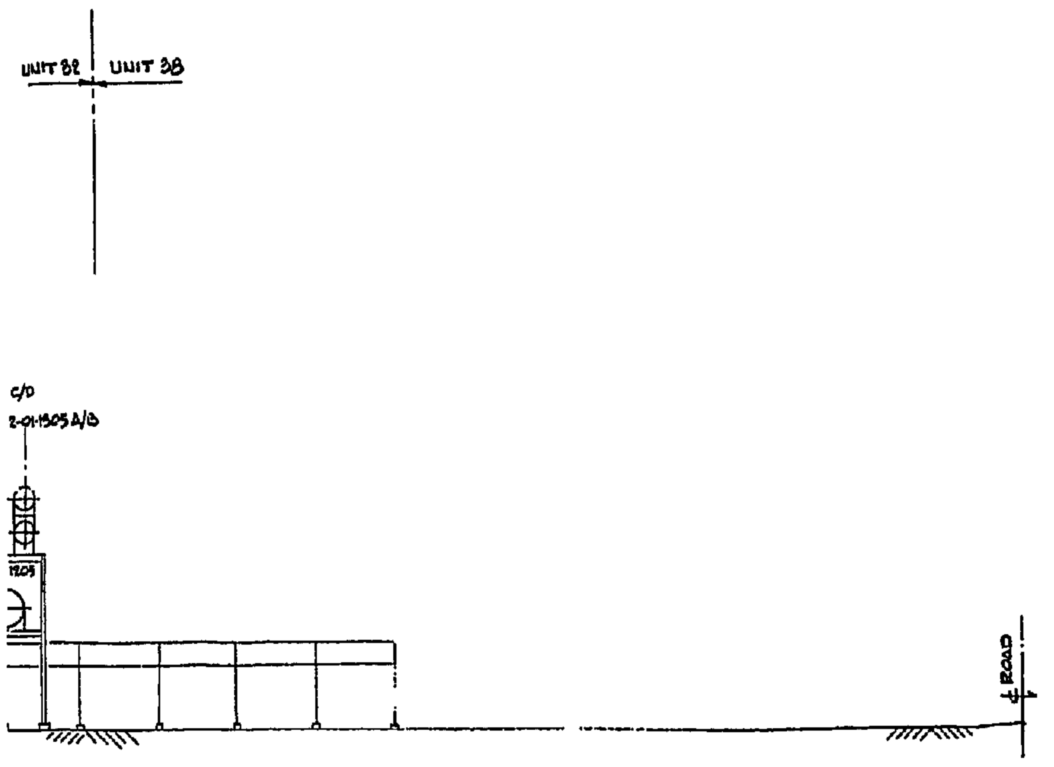



NOTE:- UNIT 38 IS PROPRIETARY

1" = 20FT

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

| | | | | |
|---|---|---|---|---|
| FOR DESIGN REPORT | DRAWN | RR | | |
| FOR CLIENT APPROVAL | CHECKED | | | |
| ISSUE CLIENT REVIEW | APVD SECT HD | | | |
| | APVD PROJ MGR | | | |
| DESCRIPTION | APVD CLIENT | | | |

RMP

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

TITLE: ELEVATION
UNIT 32 AND UNIT 38
FRACTIONATION AND HGT

| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| 1" = 20'-0" | 7245 | 6182 | C |

DOCUMENT NUMBER: D-32-PD-2NP

G. <u>Single-Line Diagram</u>

See Volume II, 1.2.12(G) for the Single-Line Diagram for Gas Fractionation Unit 32.

## 1.2.14 HF ALKYLATION - UNIT 33

### A. Basis of Design

A hydrofluoric acid (HF) alkylation unit has been selected for the conversion of a mixture of butylenes, amylenes, and isobutane to produce alkylate as a blending component of finished gasoline. The HF Alkylation Unit is a conventional-type facility without octane upgrading. The HF Alkylation Unit selected is based on a proprietary alkylation process licensed by Phillips Petroleum Company.

The feed stream is derived from the conversion of methanol to gasoline in a Mobil MTG unit with subsequent fractionation to separate the butylene and amylene components in depentanizer and depropanizer towers. The feed is depentanized to keep the $C_6$+ fraction at a low level so that the hexane fraction is less than 0.2% by volume of alkylation feed. This is necessary to reduce tar and decrease acid consumption during the alkylation process. The feed is also depropanized to keep total propanes at a low level for alkylation and to reduce acid losses that occur when propane is vented.

The feed contains a high-amylene content with about 60% dry volume amylenes to the total olefins present in the feed. Phillips has experience processing feeds with a high-amylene content, up to about 31% by volume amylenes to the total olefins present in the feed.

The HF Alkylation unit product streams consist of alkylate as a gasoline-blending component, n-butane to adjust gasoline vapor pressure, and isobutane to adjust gasoline vapor pressure with the excess to sales. The synthetic alkylate product is about 7.5% by volume of the total gasoline pool, with $C_5$+ naphtha about 88% by volume and the remainder butanes. Since n-butane is in short supply and there is excess isobutane in the feed, some isobutane is added to gasoline when needed for vapor pressure adjustment of finished gasoline.

Provision for an n-butane side-cut from the deisobutanizer is included in the HF Alkylation unit design. The alkylate product should be flexible in n-butane content to allow for a Reid vapor pressure (RVP) of total alkylate of about 5 to 6 psi for storage. When blending alkylate with naphtha for storage, a higher RVP is allowed; for instance, about 8 to 9 psi.

Since the feed contains excess isobutane, the overhead product from the deisobutanizer is exported for sales. The isobutane product is a high-purity stream with less than 0.5% by volume n-butane content. Alkylation unit feed and product stream compositions are presented in the following tables.

HF Alkylation Unit Feedstock

| Component | lb mol/hr | mol% |
|---|---|---|
| Propene | 0.01 | - |
| Propane | 1.92 | 0.07 |
| Isobutane | 933.70 | 34.11 |
| 1-Butene | 119.29 | 4.36 |
| n-Butane | 291.43 | 10.64 |
| Isopentane | 1,016.53 | 37.14 |
| 1-Pentene | 192.54 | 7.03 |
| n-Pentane | 107.88 | 3.94 |
| Cyclopentane | 11.03 | 0.40 |
| 2-Methylpentane | 59.99 | 2.19 |
| $C_6$+ Heavier | 4.14 | 0.14 |
| Total, lb mol/hr | 2,738.45 | 100.00 |
| Total, lb/hr | 178,900 | |
| Pressure, psia | 45 | |
| Temperature, °F | 100 | |

## Product Streams

| Component | Isobutane Product (lb mol/hr) | (mol%) | n-Butane Product (lb mol/hr) | (mol%) | Alkylate Product (lb mol/hr) | (mol%) |
|---|---|---|---|---|---|---|
| Propene | - | - | - | - | - | - |
| Propane | 1.92 | 0.35 | - | - | - | - |
| Isobutane | 552.13 | 99.22 | 12.20 | 4.42 | - | - |
| 1-Butene | - | - | - | - | - | - |
| n-Butane | 2.41 | .43 | 244.24 | 88.47 | 44.87 | 2.80 |
| Isopentane | - | - | 19.56 | 7.11 | 1,067.42 | 66.55 |
| 1-Pentene | - | - | - | - | - | - |
| n-Pentane | - | - | - | - | 107.95 | 6.73 |
| Cyclopentane | - | - | - | - | 11.03 | 0.69 |
| 2-Methylpentane | - | - | - | - | 59.97 | 3.74 |
| $C_6$+ Heavier | - | - | - | - | 0.54 | 0.04 |
| Alkylate | - | - | - | - | 312.00 | 19.45 |
| Total, lb mol/hr | 556.46 | 100.00 | 276.00 | 100.00 | 1,603.78 | 100.00 |
| Total, lb/hr | 32,315 | | 16,310 | | 130,196 | |
| Pressure, psia | 85 | | 60 | | 5-6 | |
| Temperature, °F | 110 | | 110 | | 110 | |

## B. Process Selection Rationale

The Phillips HF Alkylation Process is a commercially proven technology. Phillips has about 80 plants operating successfully throughout the world. Its capital and operating costs are lower than for the other processes examined. Phillips experience with high-amylene feeds fits well with the present design, which contains about 60% by volume amylenes to total olefins in the feed. The process provides reliability with a good turndown ratio.

1. Operability. The HF Alkylation Unit can be operated at about 50% of design capacity. It can be brought to full-load operation within a few hours.

2. Reliability. The plant is designed with all pumps spared and with block valves and bypass valves installed around control and relief valves. The design will permit maintenance on such items without shutting down.

3. Onstream Time. The operating factor for HF alkylation will be better than that of a fluid catalytic cracking unit and is estimated at about 95% stream factor.

4. Maintenance Costs. The maintenance cost estimate for the HF Alkylation unit is 3.5% of unit capital cost.

5. Equipment Lead Time. With the exception of the HF regenerator, the Phillips alkylation plant is designed entirely of carbon steel. The acid regenerator can be of either Monel-clad or solid Monel construction. Monel construction is a major factor in determining the equipment lead time.

6. Commercial Experience. Table II-1.2.14-1 summarizes plants using Phillips HF Alkylation Process in operation and under construction.

Table II-1.2.14-1 - Recent Phillips HF Alkylation Licensees

| Company | Refinery Location | Startup Year | Design (bpsd) | Capacity (mtpd) |
|---|---|---|---|---|
| Gulf Oil Corporation | Philadelphia, PA | 1973 | 15,000 | 1,667 |
| Marathon Oil Company | Texas City, TX | 1974 | 11,000 | 1,222 |
| Getty Oil Company | El Dorado, KS | 1976 | 10,000 | 1,111 |
| Texas City Refining | Texas City, TX | 1979 | 6,000 | 667 |
| Lindsey Oil Limited | Killingholme, England | 1981 | 4,200 | 467 |
| BP Trading Limited | Rotterdam, Holland | 1982 | 5,000 | 556 |
| BP Trading Limited | Grangemouth, UK | 1981 | 4,200 | 467 |
| Marathon Oil Company | Garyville, LA | 1980 | 21,000 | 2,333 |
| Texaco-Gulf | Pembroke, Wales | 1982 | 18,000 | 2,067 |
| Amoco-Murphy Limited | Milford Haven, Wales | 1981 | 3,000 | 333 |
| Mobil Oil Corporation | Croydon, England | 1982 | 14,500 | 1,611 |
| Mobil Oil Corporation | Durban, South Africa | 1981 | 2,500 | 278 |
| Gulf Oil Corporation | Cincinnati, OH | 1980 | 2,000 | 222 |
| BP Trading Limited | Kwinana, Australia | 1981 | 3,000 | 333 |
| CFR | LaMede, France | 1981 | 3,000 | 333 |
| Mobil Oil Corporation | Saudi Arabia | 1984 | 14,500 | 1,611 |
| Petrobras | Cubatao, Brazil | 1984 | 3,000 | 333 |
| Trintoc | Point Fortin, Trinidad | 1984 | 5,500 | 611 |
| NNPC | Warri, Nigeria | 1983 | 3,000 | 333 |
| Albatross Oil Processing | Antwerp, Belgium | 1984 | 4,800 | 538 |
| Saber Refining | Corpus Christi, TX | 1983 | 7,700 | 859 |
| Tenneco Oil | Chalmette, LA | 1984 | 16,000 | 1,778 |

C. Process Description

Refer to Process Flow and Control Diagrams D-33-MP-1NP, -2NP, -3NP, and -4NP for equipment arrangement and material balance.

Depropanized hydrocarbon liquid from the Gas Fractionation Section flows to Feed Surge Tank 33-01-1205, which has an 8-hr holdup to ensure continuous hydrocarbon flow to the HF Alkylation Unit. The hydrocarbon feed composition is shown in the above table as a mixture consisting of butylene and amylene olefins.

The total hydrocarbon olefinic feed, along with recycle isobutane, is charged to the reactor section of the HF Alkylation unit. The combined feed is dispersed through spray nozzles and mixed with hydrofluoric acid before entering the reactor riser. The reactor operates by differential gravity flow and has no moving parts such as impellers or mixers; also, acid circulation pumps are not required. Total conversion of reactants to high-quality alkylate occurs almost instantly.

From the reaction zone, the hydrocarbon components and acid catalyst flow upward to the settling zone. Here, acid catalyst breaks out as a bottom phase and flows by gravity on a return cycle through the shell side of parallel Acid Coolers 33-01-1301 and -1302 to the reaction zone, where the reaction cycle is repeated. Heat of reaction is removed by heat exchange with a large volume of coolant flowing through the tubes. Cooling water used is available for further cooling elsewhere in the unit. The hydrocarbon phase from the settling zone, containing minute quantities of propane, recycle isobutane, normal butane, pentanes, cyclopentane, and alkylate, is charged to Main Fractionator 33-01-1101 for recovery of product streams.

The main fractionator overhead is charged to HF-Isobutane Stripper 33-01-1103 for HF acid removal overhead. The bottoms isobutane product is catalytically defluorinated, KOH treated, and yielded as isobutane product. Recycle isobutane, essential for favorable control of reaction mechanisms, is produced as a vapor overhead stream from the main fractionator and also from the HF isobutane stripper bottoms. The condensed and cooled recycle isobutane is returned to the reaction zone.

The alkylate bottom product from the main fractionator containing about 2% n-butane is acceptable for motor fuel blending. An n-butane product of about 85% purity and suitable for motor fuel blending is taken as a vapor side-draw near the bottom of the main fractionator. This sidestream is condensed and sent to storage for vapor pressure blending in gasoline.

A small slipstream of acid is withdrawn from Acid Settler 33-01-1202 and fed to Acid Rerun Tower 33-01-1102 to remove dissolved water and polymerized hydrocarbons. The overhead product from the rerun column is clean hydrofluoric acid, which is condensed and returned to the system. The bottom product from the rerun tower is a mixture of acid-soluble oils and an HF water azeotrope. This stream is sent to Main Fractionator Heater 33-01-1401 to be disposed of by burning.

Auxiliary systems included within the battery limits include (1) Acid Relief Neutralizer 33-01-1201 to remove HF from relief gas leaving the battery limits, (2) Recycle Acid Rerun Tower 33-01-1102 to remove acid-soluble oils that occur in the reactor acid, (3) Acid Storage Tank 33-01-1203 for anhydrous HF acid during periods when the unit is shut down for turnaround, (4) HF Acid Neutralizer 33-01-4102 for surface drainage and sewer drainage in the acid area, and (5) a change room and storage room for cleaning and storing necessary protective clothing required on occasion by operating and maintenance personnel.

Process hydrocarbon vapors from the relief gas header containing HF acid are contacted in Acid Relief Neutralizer 33-01-1201 with dilute aqueous sodium hydroxide prior to entering the flare system. Calcium chloride is used to precipitate calcium fluoride from spent caustic in Calcium Fluoride Precipitator 33-01-4101. Insoluble calcium fluoride settles out to form an inert sludge, which has been successfully used as a sanitary landfill without known environmental problems.

From product streams that require KOH treaters, the spent KOH is processed through a spent caustic neutralizer using $Na_2CO_3$. Drainage from the spent caustic neutralizer flows to the plant wastewater treatment system.

Product streams such as LPG, are defluorinated over an activated alumina bed. After the bed is "spent," it is considered inert and can be disposed of in a sanitary landfill.

D. Risk Assessment

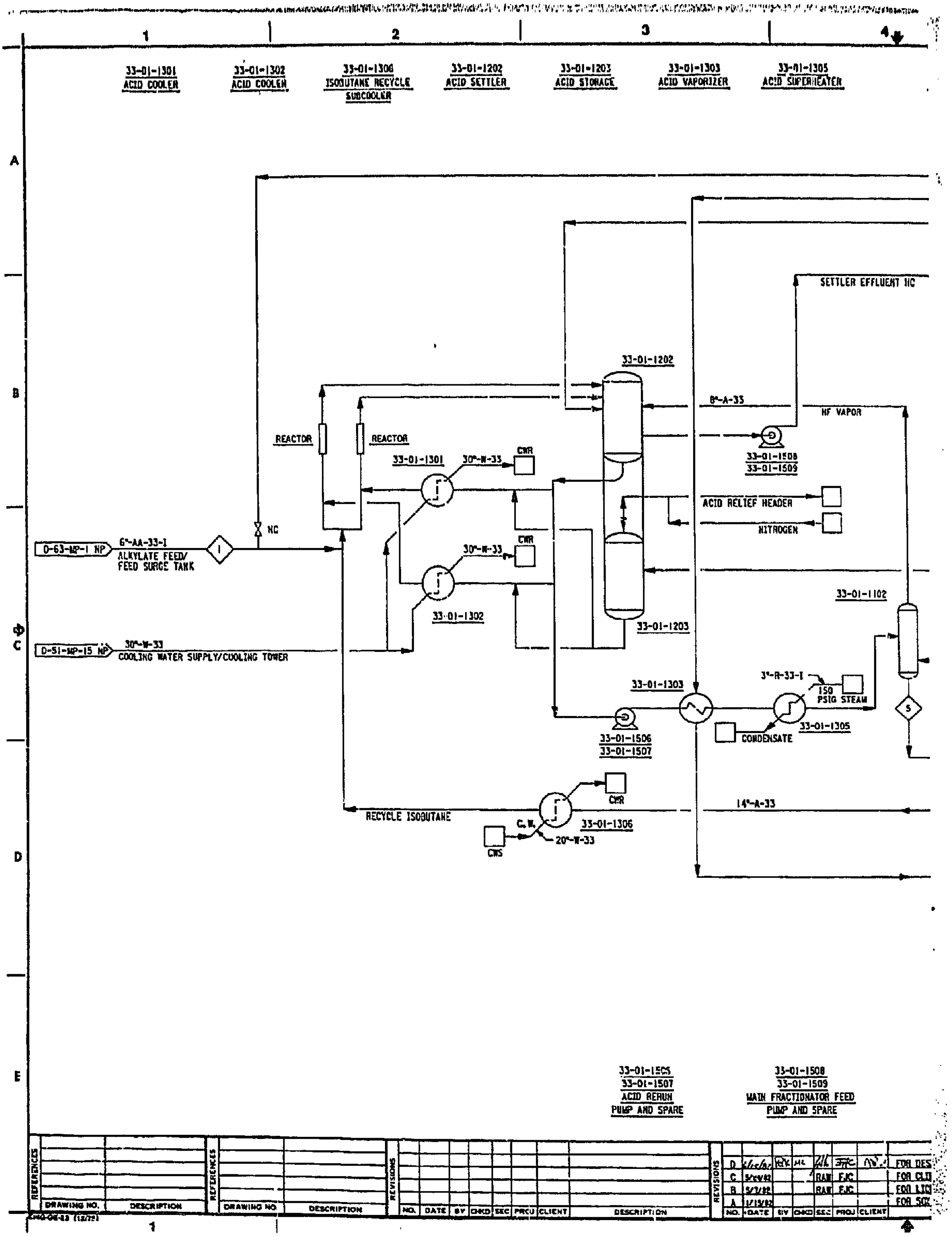
The hydrofluoric acid (HF) alkylation unit designed by Phillips Petroleum Company converts a mixture of butylenes, amylenes, and isobutane to produce alkylate as a blending component of finished gasoline.

The Phillips HF Alkylation Process is a commercially proven technology. Phillips has about 80 plants operating throughout the world. Phillips experience with high-amylene feeds fits well with the present design, which contains about 60% by volume amylenes to total olefins in the feed. The process provides reliability with a high-onstream factor. The plant is designed with all pumps spared and with block valves and bypass valves installed around control and relief valves. The design permits maintenance on such items without shutting down. Corrosion and equipment fouling are not expected to be problems. The technical risk is considered minimal.

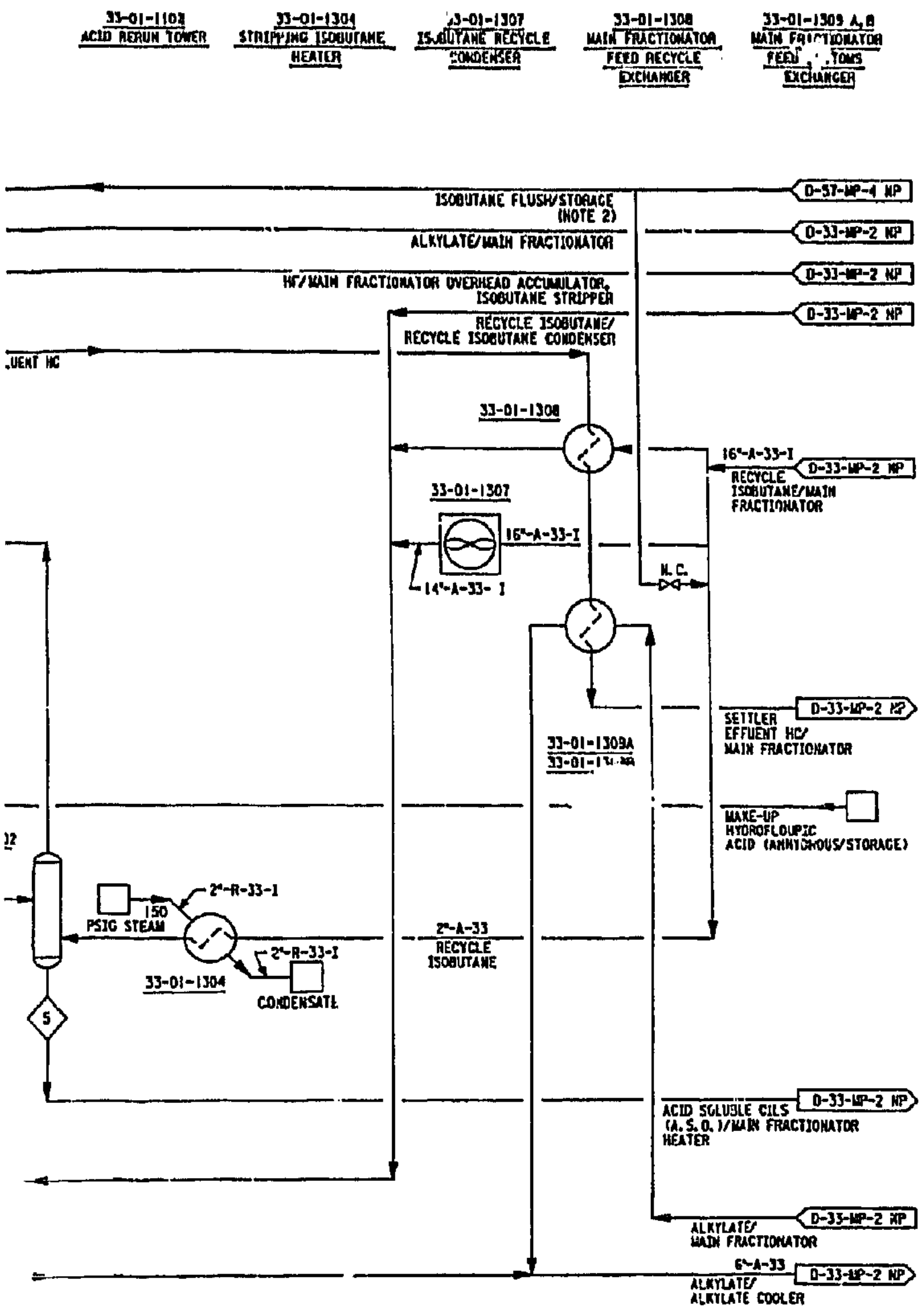
E. <u>Process Flow and Control Diagrams</u> (Including Material Balance)

Process Flow and Control Diagrams for HF Alkylation Unit 33 are as follows:

| Drawing No. | Title |
|---|---|
| D-33-MP-1NP | PFCD HF Alkylation - Acid System |
| D-33-MP-2NP | PFCD HF Alkylation - Fractionation |
| D-33-MP-3NP | Material Balance - HF Alkylation |
| D-33-MP-4NP | PFCD HF Alkylation - Waste Disposal |


1
2
3
4
33-01-1301
ACID COOLER
33-01-1302
ACID COOLER
33-01-1306
ISOBUTANE RECYCLE
SUBCOOLER
33-01-1202
ACID SETTLER
33-01-1203
ACID STORAGE
33-01-1303
ACID VAPORIZER
33-01-1305
ACID SUPERHEATER
A
B
C
D
E
SETTLER EFFLUENT HC
33-01-1202
8"-A-33
HF VAPOR
REACTOR
REACTOR
33-01-1301
30"-W-33
CWR
33-01-1508
33-01-1509
ACID RELIEF HEADER
NITROGEN
D-63-MP-1 NP
6"-AA-33-I
ALKYLATE FEED/
FEED SURGE TANK
1
NC
30"-W-33
CWR
33-01-1302
33-01-1102
33-01-1203
D-51-MP-15 NP
30"-W-33
COOLING WATER SUPPLY/COOLING TOWER
3"-R-33-I
150
PSIG STEAM
33-01-1303
5
CONDENSATE
33-01-1305
33-01-1506
33-01-1507
CWR
14"-A-33
RECYCLE ISOBUTANE
C.W.
33-01-1306
CWS
20"-W-33
33-01-1506
33-01-1507
ACID RERUN
PUMP AND SPARE
33-01-1508
33-01-1509
MAIN FRACTIONATOR FEED
PUMP AND SPARE
REFERENCES
DRAWING NO.
DESCRIPTION
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
REVISIONS
D
C
B
A
RAW
FJC
RAW
FJC
FOR DES
FOR CLI
FOR LIC
FOR SOL
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
1

4 | 5 | 6 | 7




NOTES:
1. THE COOLING WATER FACILITY FOR THE H.F. ALKYLATION UNIT IS A SEGREGATED SYSTEM. SEE DRAWING D-51-MP-15 NP.
2. THE ISOBUTANE FLUSH LINE TIES INTO THE ISOBUTANE STORAGE FACILITY AT THE PUMP DISCHARGE LINE. (NORMALLY NO FLOW DURING UNIT OPERATION).

A | B | C | D | E

EQUIPMENT SHOWN ON THIS DRAWING

| | |
|---|---|
| 33-01-1102 | 33-01-1307 |
| 33-01-1202 | 33-01-1308 |
| 33-01-1203 | 33-01-1309A |
| 33-01-1301 | 33-01-1309C |
| 33-01-1302 | 33-01-1506 |
| 33-01-1303 | 33-01-1507 |
| 33-01-1304 | 33-01-1508 |
| 33-01-1305 | 33-01-1509 |
| 33-01-1306 | |

D33MP1NP.DGA

PHILLIPS PETROLEUM COMPANY
BARTLESVILLE, OKLAHOMA

U.S. DEPARTMENT OF ENERGY
BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

| | | | |
|---|---|---|---|
| REPORT | DRAWN | | |
| FOR CLIENT APPROVAL | CHECKED | | |
| APPROVAL | APVD SECT HD | REK | 1/12/82 |
| CLIENT REVIEW | APVD PROJ MGR | FJC | 1/12/82 |
| DESCRIPTION | APVD CLIENT | | |

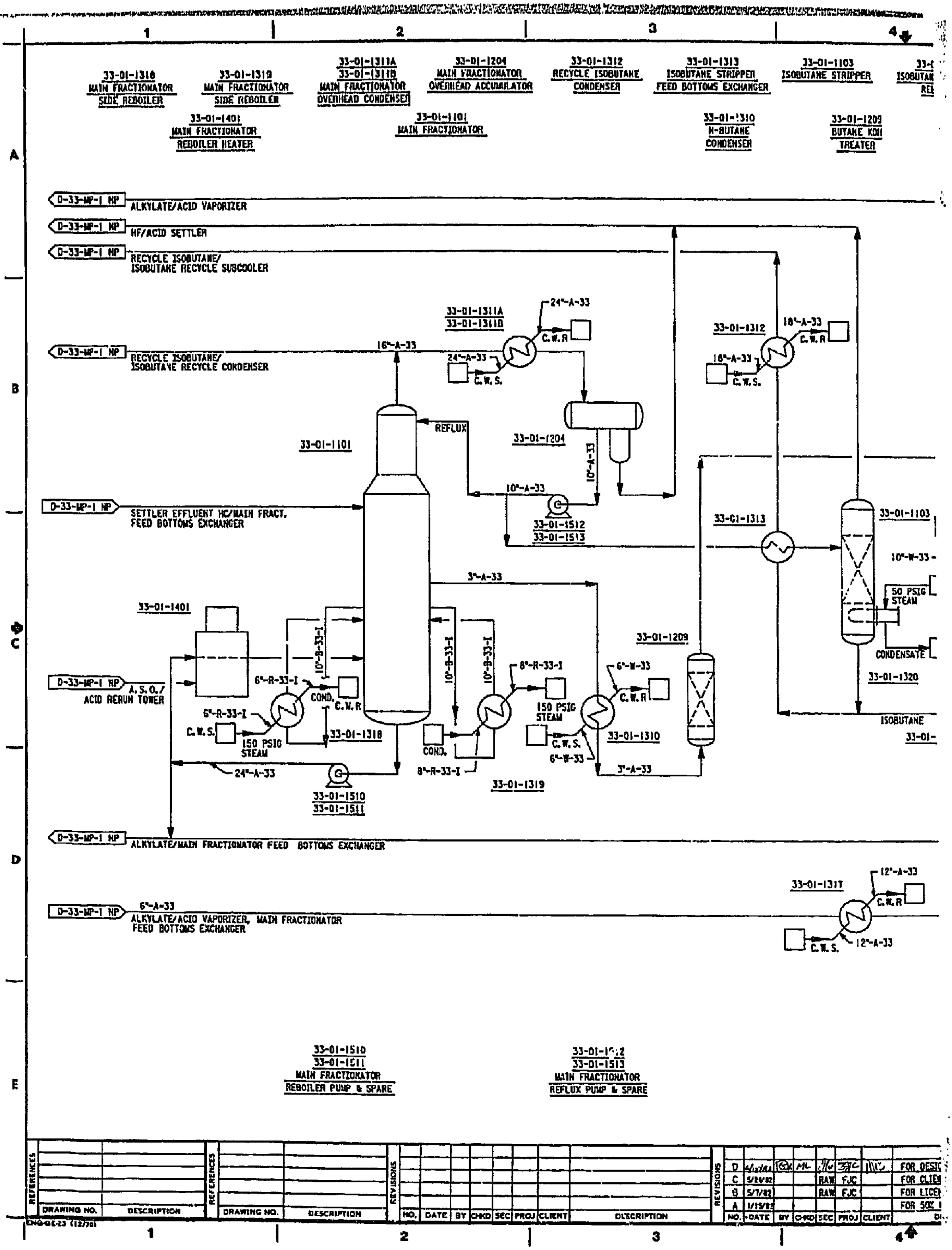
RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

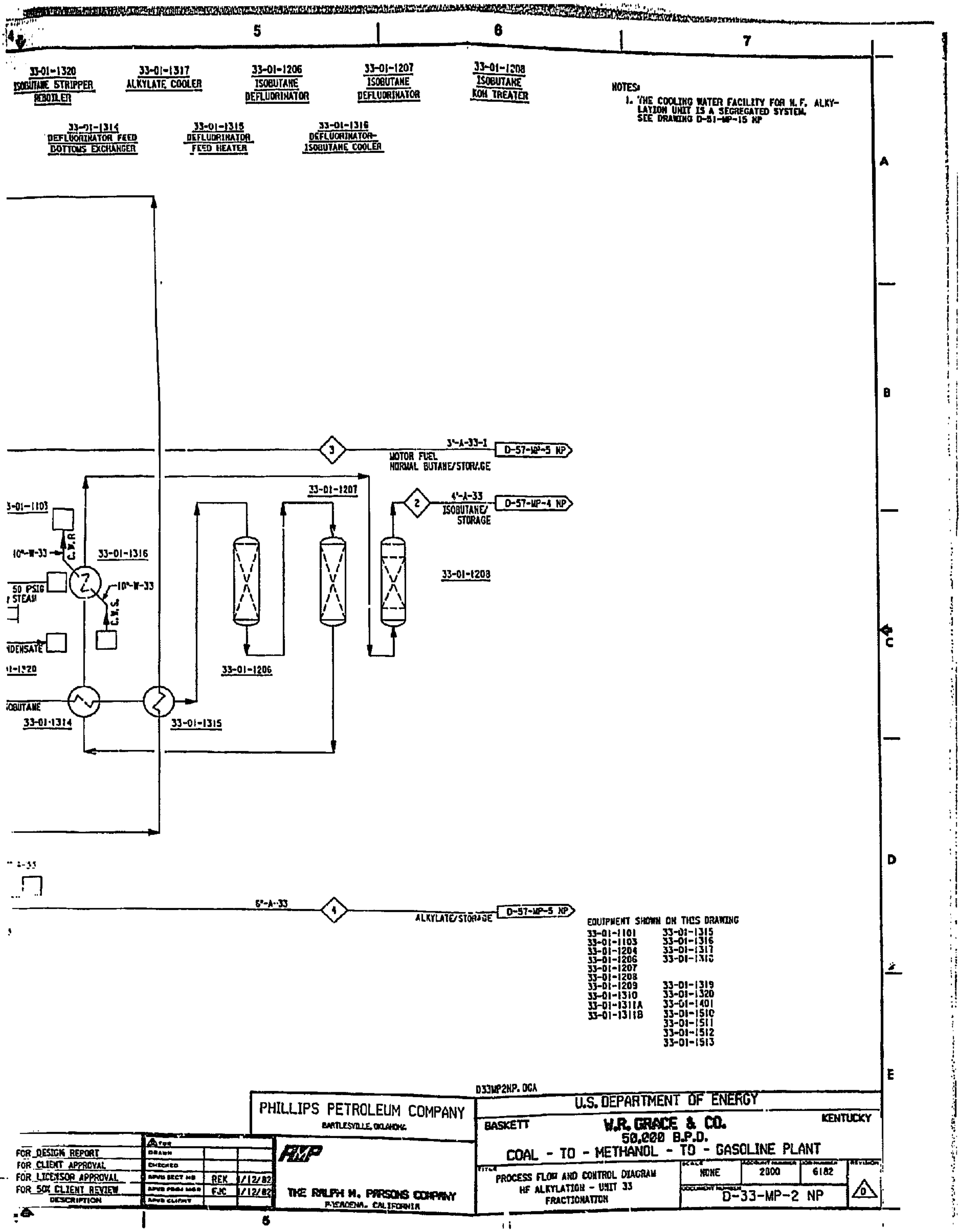
TITLE: PROCESS FLOW AND CONTROL DIAGRAM
HF ALKYLATION - UNIT 33
ACID SYSTEM

| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| NONE | 2800 | 6182 | 0 |

DOCUMENT NUMBER: D-33-MP-1 NP

4 | 5 | 6


33-01-1318
MAIN FRACTIONATOR
SIDE REBOILER
33-01-1319
MAIN FRACTIONATOR
SIDE REBOILER
33-01-1311A
33-01-1311B
MAIN FRACTIONATOR
OVERHEAD CONDENSER
33-01-1204
MAIN FRACTIONATOR
OVERHEAD ACCUMULATOR
33-01-1312
RECYCLE ISOBUTANE
CONDENSER
33-01-1313
ISOBUTANE STRIPPER
FEED BOTTOMS EXCHANGER
33-01-1103
ISOBUTANE STRIPPER
33-01-1401
MAIN FRACTIONATOR
REBOILER HEATER
33-01-1101
MAIN FRACTIONATOR
33-01-1310
N-BUTANE
CONDENSER
33-01-1209
BUTANE KOH
TREATER
D-33-MP-1 NP
ALKYLATE/ACID VAPORIZER
HF/ACID SETTLER
RECYCLE ISOBUTANE/
ISOBUTANE RECYCLE SUBCOOLER
RECYCLE ISOBUTANE/
ISOBUTANE RECYCLE CONDENSER
16"-A-33
24"-A-33
C.W.R
C.W.S.
18"-A-33
REFLUX
10"-A-33
SETTLER EFFLUENT HC/MAIN FRACT.
FEED BOTTOMS EXCHANGER
33-01-1512
33-01-1513
10"-W-33
50 PSIG
STEAM
CONDENSATE
3"-A-33
A.S.O./
ACID RERUN TOWER
6"-R-33-I
10"-B-33-I
COND.
150 PSIG
STEAM
8"-R-33-I
6"-W-33
33-01-1320
ISOBUTANE
33-01-1510
33-01-1511
ALKYLATE/MAIN FRACTIONATOR FEED BOTTOMS EXCHANGER
33-01-1317
12"-A-33
6"-A-33
ALKYLATE/ACID VAPORIZER, MAIN FRACTIONATOR
FEED BOTTOMS EXCHANGER
33-01-1510
33-01-1511
MAIN FRACTIONATOR
REBOILER PUMP & SPARE
33-01-1512
33-01-1513
MAIN FRACTIONATOR
REFLUX PUMP & SPARE
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
D
C 5/24/82 RAW FJC FOR CLIEN
B 5/7/82 RAW FJC FOR LICEN
A 1/15/82 FOR 50%
FOR DESIG
ENG-GE-23 (12/78)


5
6
7
33-01-1320
ISOBUTANE STRIPPER REBOILER
33-01-1317
ALKYLATE COOLER
33-01-1206
ISOBUTANE DEFLUORINATOR
33-01-1207
ISOBUTANE DEFLUORINATOR
33-01-1208
ISOBUTANE KOH TREATER
33-01-1314
DEFLUORINATOR FEED BOTTOMS EXCHANGER
33-01-1315
DEFLUORINATOR FEED HEATER
33-01-1316
DEFLUORINATOR-ISOBUTANE COOLER
NOTES:
1. THE COOLING WATER FACILITY FOR H.F. ALKYLATION UNIT IS A SEGREGATED SYSTEM. SEE DRAWING D-51-MP-15 NP
A
B
C
D
E
3"-A-33-1
D-57-MP-5 NP
MOTOR FUEL
NORMAL BUTANE/STORAGE
33-01-1207
4"-A-33
D-57-MP-4 NP
ISOBUTANE/
STORAGE
33-01-1103
10"-W-33
C.W.R.
33-01-1316
10"-W-33
C.W.S.
50 PSIG
STEAM
CONDENSATE
33-01-1208
33-01-1320
33-01-1206
ISOBUTANE
33-01-1314
33-01-1315
6"-A-33
ALKYLATE/STORAGE
D-57-MP-5 NP
EQUIPMENT SHOWN ON THIS DRAWING
33-01-1101
33-01-1103
33-01-1204
33-01-1206
33-01-1207
33-01-1208
33-01-1209
33-01-1310
33-01-1311A
33-01-1311B
33-01-1315
33-01-1316
33-01-1317
33-01-1318
33-01-1319
33-01-1320
33-01-1401
33-01-1510
33-01-1511
33-01-1512
33-01-1513
D33MP2NP.DGA
PHILLIPS PETROLEUM COMPANY
BARTLESVILLE, OKLAHOMA
U.S. DEPARTMENT OF ENERGY
BASKETT
W.R. GRACE & CO.
KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT
FOR DESIGN REPORT
FOR CLIENT APPROVAL
FOR LICENSOR APPROVAL
FOR 50% CLIENT REVIEW
DESCRIPTION
DRAWN
CHECKED
REK 1/12/82
FJC 1/12/82
RMP
THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA
PROCESS FLOW AND CONTROL DIAGRAM
HF ALKYLATION - UNIT 33
FRACTIONATION
NONE
2000
6182
D-33-MP-2 NP
0

| COMPONENT | MOL. WT. | ① HYDROCARBON FEED | ② ISOBUTANE PRODUCT | ③ N-BUTANE PRODUCT | ④ ALKYLATE PRODUCT | ⑤ ASO |
|---|---|---|---|---|---|---|
| PROPENE | 42.08 | 0.01 | | | | |
| PROPANE | 44.09 | 1.92 | 1.92 | | | |
| ISOBUTANE | 58.12 | 933.70 | 552.13 | 12.20 | | |
| I-BUTENE | 56.10 | 119.29 | | | | |
| N-BUTANE | 58.12 | 291.43 | 2.41 | 244.24 | 44.87 | |
| ISOPENTANE | 72.15 | 1,016.53 | | 19.56 | 1,067.42 | |
| I-PENTENE | 70.13 | 192.54 | | | | |
| N-PENTANE | 72.15 | 107.88 | | | 107.95 | |
| CYCLOPENTANE | 70.13 | 11.03 | | | 11.03 | |
| 2-METHYLPENTANE | 86.17 | 59.99 | | | 59.97 | |
| $C_9$ + HEAVIER | | 4.14 | | | | |
| ALKYLATE | 118.00 | — | | | 312.00 | |
| | | | | | | |
| TOTAL | LB MOL/HR | 2,738.45 | 556.46 | 276.00 | 1,603.78 | — |
| TOTAL | LBS/HR | 178,898.6 | 32,315.0 | 16,309.6 | 130,195.0 | 76.6 |
| | BPSD | 20,332 | 3,915.0 | 1,909 | 13,840 | — |
| | LBS/Bbl | 211.28 | 198.10 | 205.05 | 225.8 | — |
| | MW | 65.3 | 58.1 | 59.1 | 81.2 | — |

| REVISIONS NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT | |
|---|---|---|---|---|---|---|---|
| D | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | FOR DES |
| C | 5/21/82 | | | RAM | FJC | | FOR CLI |
| B | 5/7/82 | | | RAM | FJC | | FOR LIC |
| A | 1/15/82 | | | | | | FOR 50% |

REFERENCES: DRAWING NO. | DESCRIPTION

REVISIONS: NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT | DESCRIPTION

ENG-GE-23 (12/79)

NOTES:

1. THE COOLING WATER FACILITY FOR H.F. ALKYLATION UNIT IS A SEGREGATED SYSTEM.
2. THE ISOBUTANE FLUSH LINE TIES INTO ISOBUTANE STORAGE FACILITY ON PUMP DISCHARGE LINE. (NORMALLY NO FLOW DURING UNIT OPERATION).

76.6

D33MP3NP.DGA

| DESCRIPTION | FOR | | |
|---|---|---|---|
| FOR DESIGN REPORT | DRAWN | | |
| FOR CLIENT APPROVAL | CHECKED | | |
| FOR LICENSOR APPROVAL | APVD SECT MG | REK | ?/12/82 |
| FOR 50% CLIENT REVIEW | APVD PROJ MGR | FJC | ?/12/82 |
| | APVD CLIENT | | |

PHILLIPS PETROLEUM COMPANY
BARTLESVILLE, OKLAHOMA

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

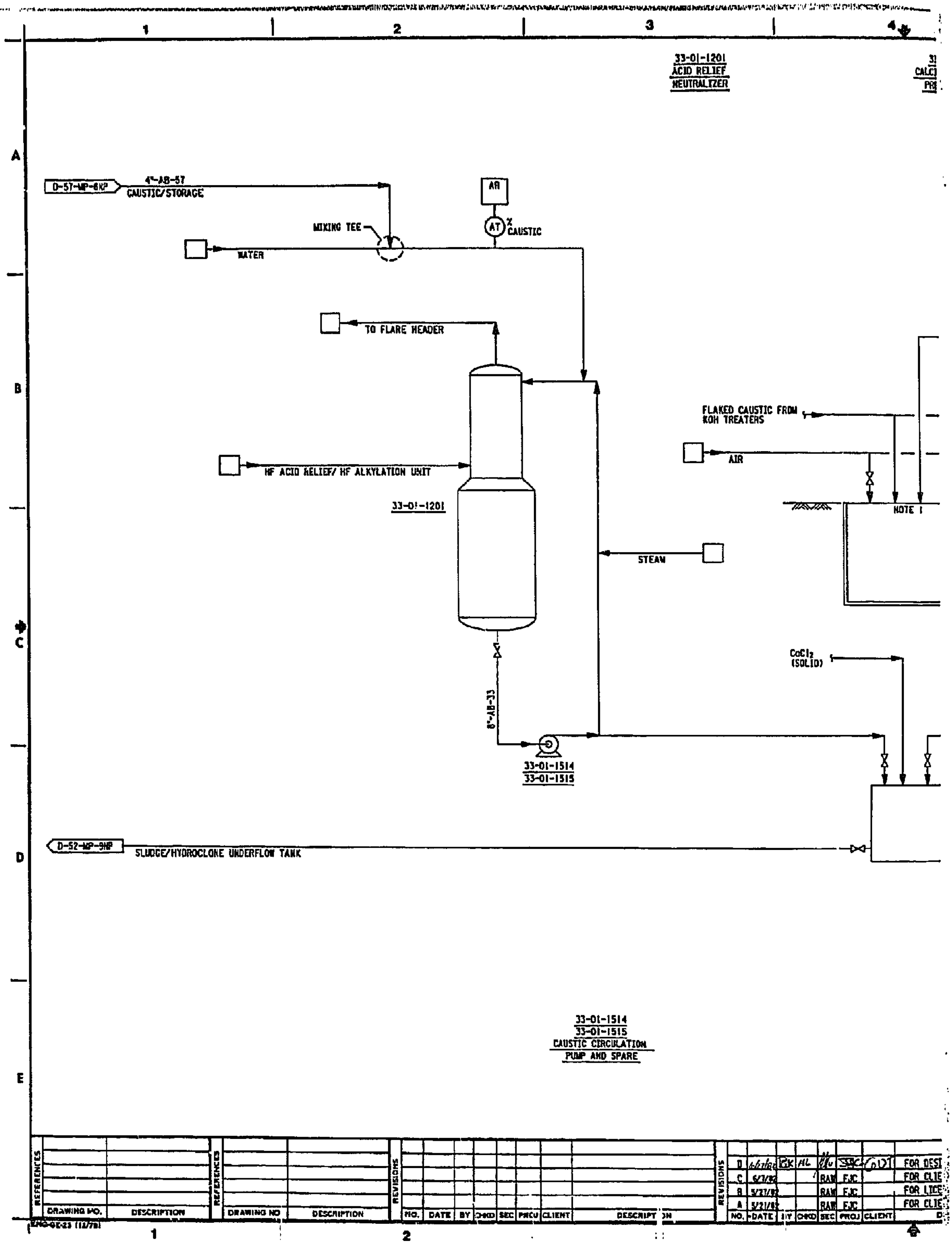
U.S. DEPARTMENT OF ENERGY

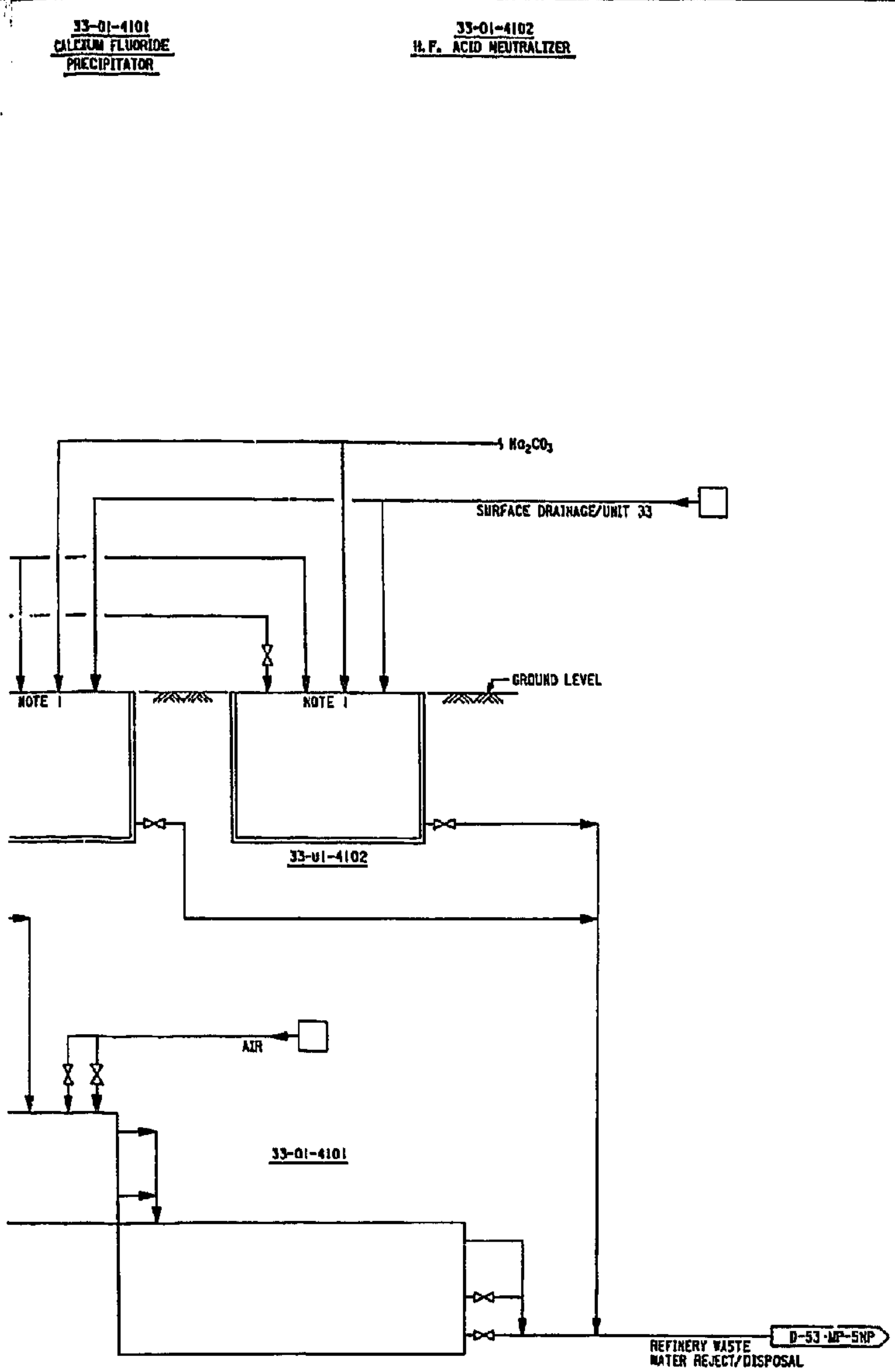
BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

TITLE: MATERIAL BALANCE
HF ALKYLATION - UNIT 33

SCALE: NONE | ACCOUNT NUMBER: 2800 | JOB NUMBER: 6182 | REVISION: 0

DOCUMENT NUMBER: D-33-MP-3 NP


1
2
3
4
A
B
C
D
E
33-01-1201
ACID RELIEF
NEUTRALIZER
D-57-MP-8KP
4"-AB-57
CAUSTIC/STORAGE
AR
AT
% CAUSTIC
MIXING TEE
WATER
TO FLARE HEADER
FLAKED CAUSTIC FROM
KOH TREATERS
AIR
HF ACID RELIEF/ HF ALKYLATION UNIT
33-01-1201
NOTE 1
STEAM
CoCl2
(SOLID)
8"-AB-33
33-01-1514
33-01-1515
D-52-MP-9HP
SLUDGE/HYDROCLONE UNDERFLOW TANK
33-01-1514
33-01-1515
CAUSTIC CIRCULATION
PUMP AND SPARE
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
DESCRIPTION
D
C
6/7/82
B
5/27/82
A
5/21/82
RAW
FJC
FOR DESI
FOR CLIE
FOR LICE
FOR CLIE
ENG-OE-23 (12/78)




NOTES:
1. REMOVABLE GRATING FOR $Na_2CO_3$ ADDITION.

EQUIPMENT SHOWN ON THIS DRAWING:
33-01-1201
33-01-1514
33-01-1515
33-01-4101
33-01-4102

D33MP4NP.DGA

| | |
|---|---|
| FOR DESIGN REPORT | DRAWN |
| FOR CLIENT APPROVAL | CHECKED |
| FOR LICENSOR APPROVAL | APVD SECT HD |
| FOR CLIENT 50% REVIEW | APVD PROJ MGR |
| DESCRIPTION | APVD CLIENT |

THE RALPH M. PARSONS COMPANY
PASADENA, CALIFORNIA

U.S. DEPARTMENT OF ENERGY

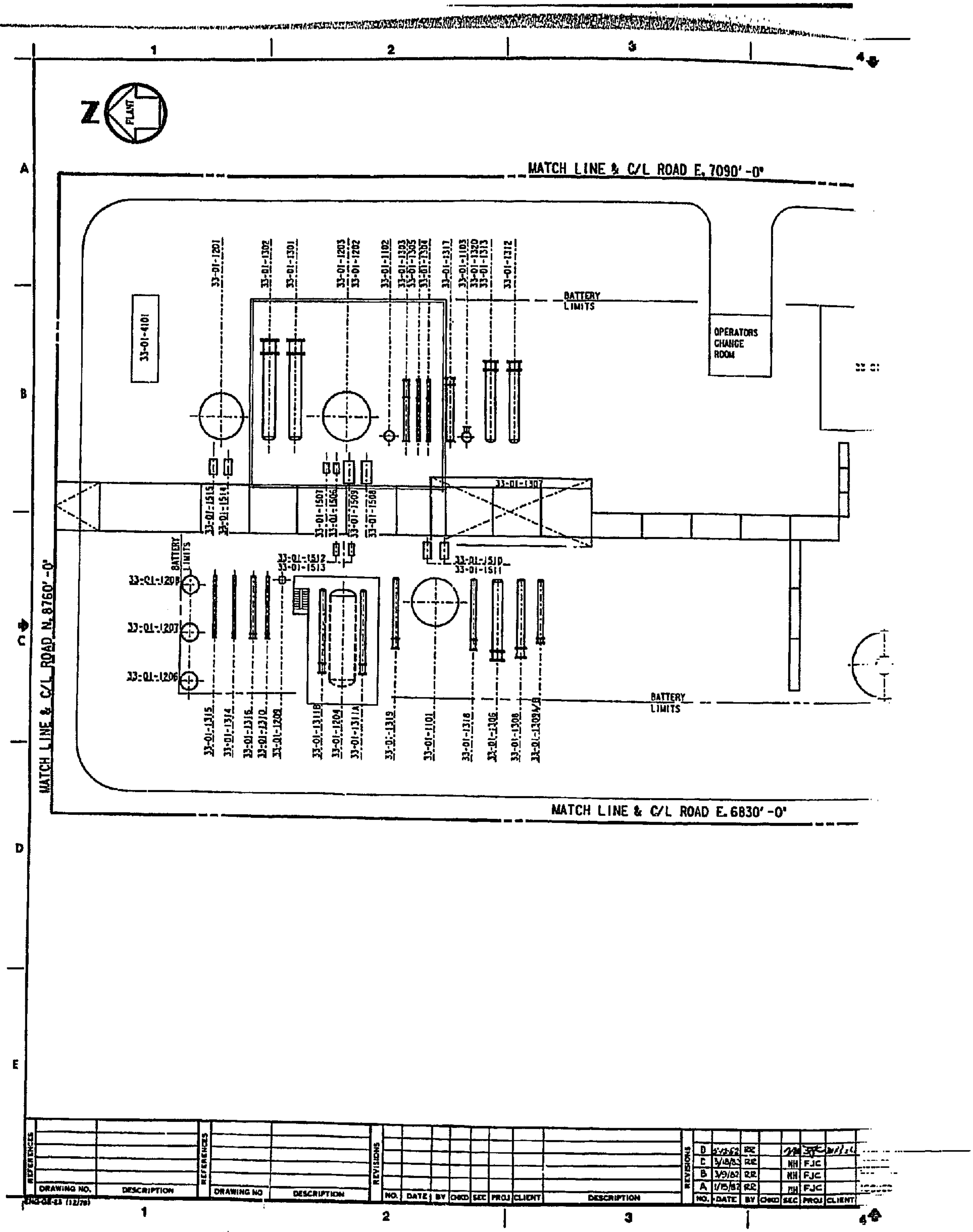
BASKETT — W.R. GRACE & CO. — KENTUCKY
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

| TITLE | SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|---|
| PROCESS FLOW AND CONTROL DIAGRAM HF ALKYLATION - UNIT 33 WASTE DISPOSAL | NONE | 2800 | 6182 | D |
| | DOCUMENT NUMBER D-33-MP-4 NP | | | |

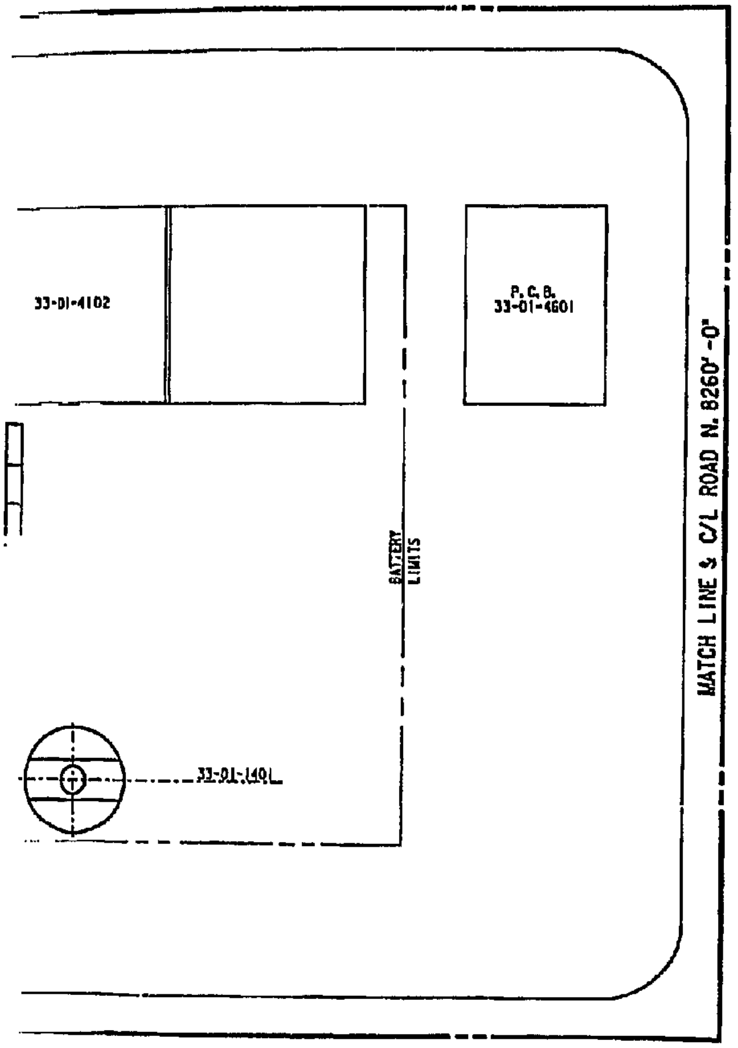
F. Plot Plan/General Arrangement Drawings

Plot Plan and General Arrangement Drawings for HF Alkylation Unit 33 are as follows:

| Drawing No. | Title |
| --- | --- |
| D-33-PD-1NP | Plot Plan - Unit 33 HF Alkylation |
| D-33-PD-2NP | Elevation - Unit 33 HF Alkylation |



PLANT
MATCH LINE & C/L ROAD E. 7090'-0"
MATCH LINE & C/L ROAD E. 6830'-0"
MATCH LINE & C/L ROAD N. 8760'-0"
BATTERY LIMITS
OPERATORS CHANGE ROOM
33-01-4101
33-01-1201
33-01-1302
33-01-1301
33-01-1203
33-01-1202
33-01-1102
33-01-1317
33-01-1103
33-01-1312
33-01-1307
33-01-1515
33-01-1514
33-01-1507
33-01-1506
33-01-1509
33-01-1508
33-01-1512
33-01-1513
33-01-1510
33-01-1511
33-01-1208
33-01-1207
33-01-1206
33-01-1315
33-01-1314
33-01-1316
33-01-1210
33-01-1209
33-01-1311B
33-01-1204
33-01-1311A
33-01-1101
33-01-1318
33-01-1306
33-01-1308
REFERENCES
DRAWING NO.
DESCRIPTION
REVISIONS
NO.
DATE
BY
CHKD
SEC
PROJ
CLIENT
D
C
B
A
RR
NH
FJC




## EQUIPMENT LIST

| | |
|---|---|
| **COLUMNS** | |
| 33-01-1101 | MAIN FRACTIONATOR COLUMN |
| 33-01-1102 | ACID RERUN COLUMN |
| 33-01-1103 | ISOBUTANE STRIPPER COLUMN |
| **VESSELS** | |
| 33-01-1201 | ACID RELIEF NEUTRALIZER |
| 33-01-1202 | ACID SETTLER |
| 33-01-1203 | ACID STORAGE |
| 33-01-1204 | MAIN FRACTIONATOR OVERHEAD ACCUM. |
| 33-01-1206 | ISOBUTANE DEFLUORINATOR |
| 33-01-1207 | ISOBUTANE DEFLUORINATOR |
| 33-01-1208 | ISOBUTANE KOH TREATER |
| 33-01-1209 | BUTANE KOH TREATER |
| **HEAT EXCHANGERS AND CONDENSERS** | |
| 33-01-1301 | ACID COOLER |
| 33-01-1302 | ACID COOLER |
| 33-01-1303 | ACID VAPORIZER |
| 33-01-1304 | STRIPPING ISOBUTANE HEATER |
| 33-01-1305 | ACID SUPERHEATER |
| 33-01-1306 | ISOBUTANE RECYCLE SUBCOOLER |
| 33-01-1307 | ISOBUTANE RECYCLE CONDENSER |
| 33-01-1308 | MAIN FRACT. FD. RECYCLE EXCHANGER |
| 33-01-1309A, B | MAIN FRACT. FD. BTMS. EXCHANGER |
| 33-01-1310 | N-BUTANE CONDENSER |
| 33-01-1311A, B | MAIN FRACT. OVERHEAD COND. |
| 33-01-1312 | RECYCLE ISOBUTANE COND. |
| 33-01-1313 | ISOBUTANE STRIP. FD. BTMS. EXCH. |
| 33-01-1314 | DEFLUORINATOR FD. BTMS. EXCH. |
| 33-01-1315 | DEFLUORINATOR FD. HEATER |
| 33-01-1316 | DEFLUORINATOR ISOBUTANE CLR. |
| 33-01-1317 | ALKYLATE COOLER |
| 33-01-1318 | MAIN FRACT. SIDE REBOILER |
| 33-01-1319 | MAIN FRACT. SIDE REBOILER |
| 33-01-1320 | ISOBUTANE STRIPPER REBOILER |
| **HEATER** | |
| 33-01-1401 | MAIN FRACT. REBOILER HEATER |
| **PUMPS** | |
| 33-01-1506 | ACID RERUN PUMP |
| 33-01-1507 | ACID RERUN PUMP(SPARE) |
| 33-01-1508 | MAIN FRACT. FEED PUMP |
| 33-01-1509 | MAIN FRACT. FEED PUMP(SPARE) |
| 33-01-1510 | MAIN FRACT. REBOILER PUMP |
| 33-01-1511 | MAIN FRACT. REBOILER PUMP(SPARE) |
| 33-01-1512 | MAIN FRACT. REFLUX PUMP |
| 33-01-1513 | MAIN FRACT. REFLUX PUMP(SPARE) |
| 33-01-1514 | CAUSTIC CIRC. PUMP |
| 33-01-1515 | CAUSTIC CIRC. PUMP(SPARE) |
| **MISCELLANEOUS** | |
| 33-01-4101 | CALCIUM FLUORIDE PRECIPITATOR |
| 33-01-4102 | HF ACID NEUTRALIZER |

SCALE: 1" = 20'-0"

U.S. DEPARTMENT OF ENERGY

BASKETT — W.R. GRACE & CO. — KENTUCKY

50,000 B.P.D.

COAL - TO - METHANOL - TO - GASOLINE PLANT

PLOT PLAN
UNIT 33
ALKYLATION

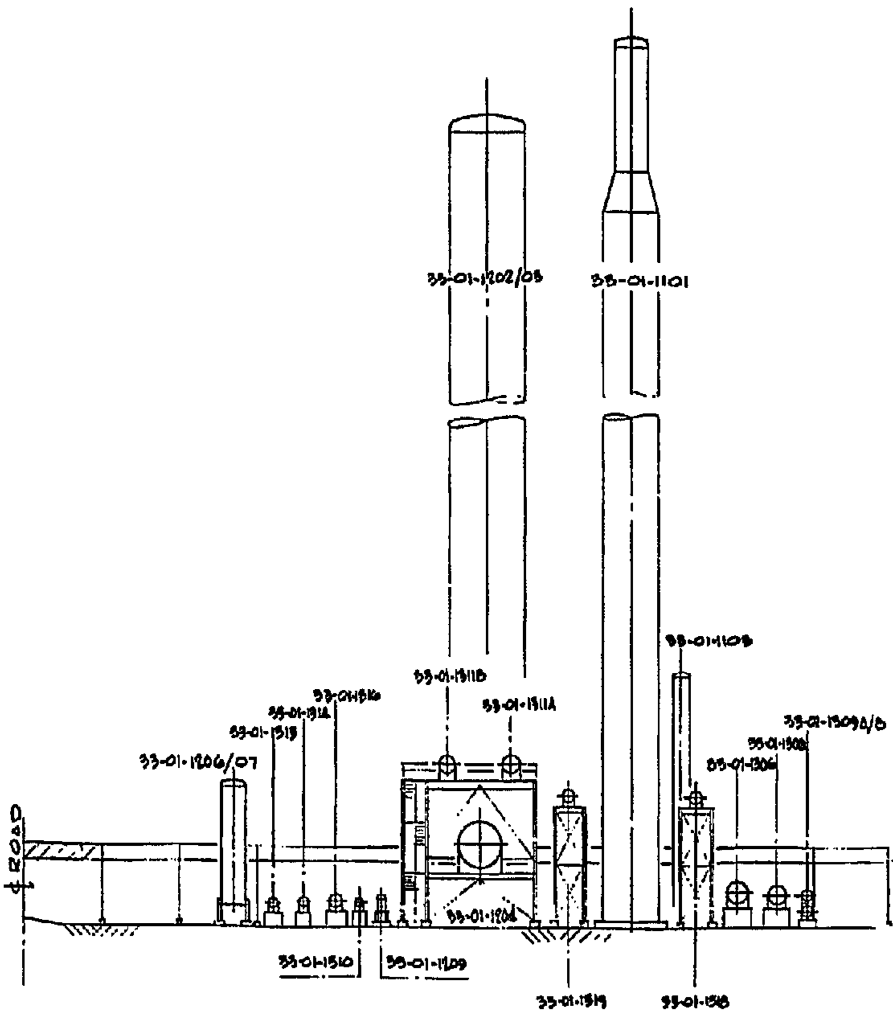
| SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|
| 1" = 20'-0" | 7243 | 6182 | D |

DOCUMENT NUMBER: D-33-PD-INP

RMP — THE RALPH M. PARSONS COMPANY, PASADENA, CALIFORNIA

| DESCRIPTION | | |
|---|---|---|
| ... REPORT | DRAWN | HY/CAD |
| ISSUED FOR APPROVAL | CHECKED | |
| FOR LICENSOR APPROVAL | APVD SECT HD | NH |
| ISSUED CLIENT 50% REVIEW | APVD PROJ MGR | |
| | APVD CLIENT | |

1 2 3 4



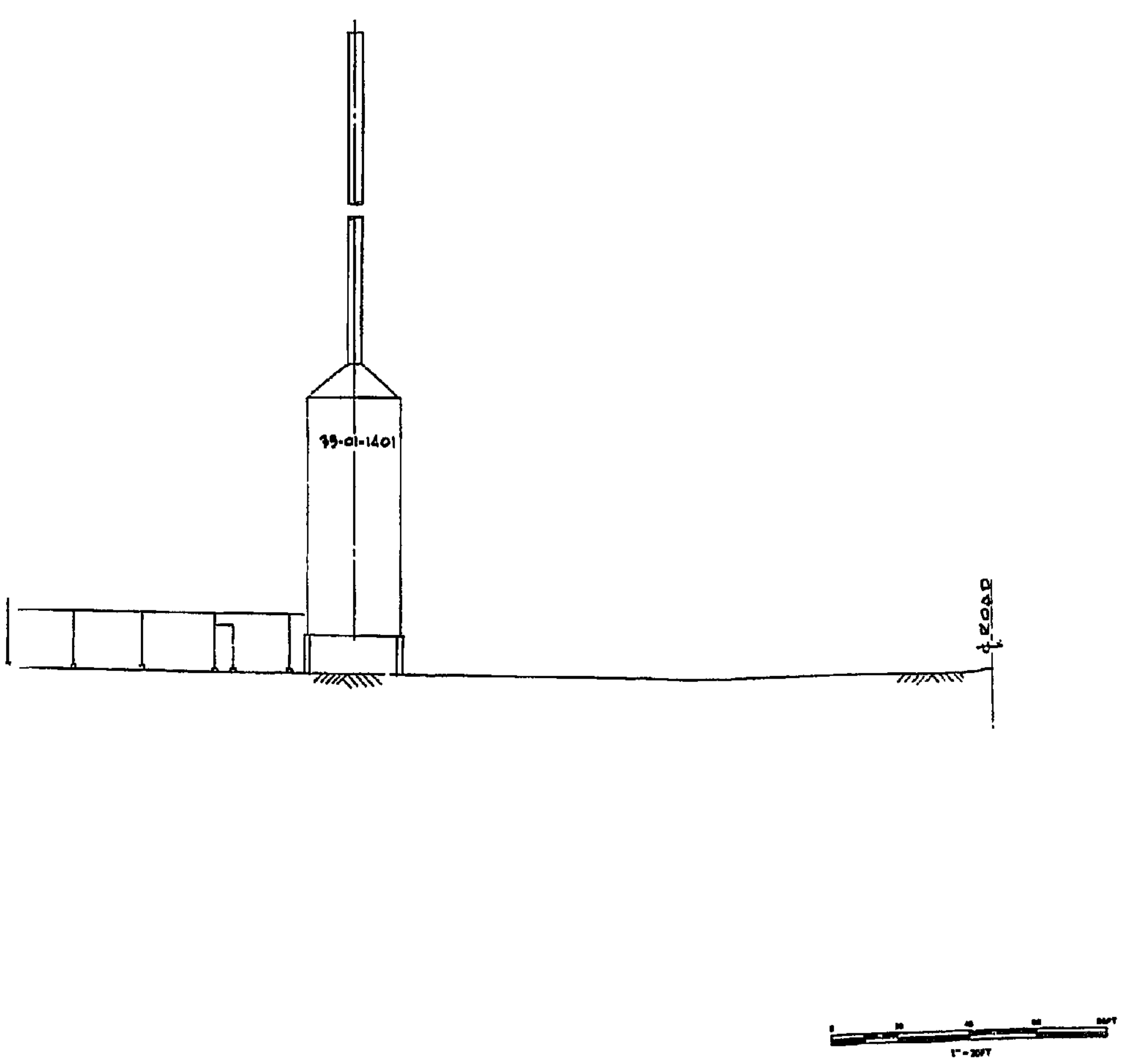

| REFERENCES | |
|---|---|
| D-33-PD-INP | PLOT PLAN |
| DRAWING NO. | DESCRIPTION |

| REFERENCES | |
|---|---|
| DRAWING NO. | DESCRIPTION |

| REVISIONS | | | | | | | |
|---|---|---|---|---|---|---|---|
| NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT | DESCRIPTION |

| REVISIONS | | | | | | |
|---|---|---|---|---|---|---|
| D | 5/24/83 | AR | | [illegible] | [illegible] | [illegible] |
| C | 5/6/82 | RE | | [illegible] | [illegible] | |
| B | [illegible] | RE | | [illegible] | [illegible] | |
| A | [illegible] | RE | | [illegible] | [illegible] | |
| NO. | DATE | BY | CHKD | SEC | PROJ | CLIENT |

1 2 3 4




| | | | |
|---|---|---|---|
| FOR DESIGN REPORT | FOR | | |
| FOR CLIENT APPROVAL | DRAWN | RR | |
| FOR LICENSOR APPROVAL | CHECKED | | |
| HAVE CLIENT REVIEW 50% COMPL | RPMU SECT HD | JM | |
| | RPMU PROJ MGR | | |
| DESCRIPTION | RPMU CLIENT | | |

RMP
THE RALPH M. PARSONS COMPANY
PASADENA CALIFORNIA

U.S. DEPARTMENT OF ENERGY
BASKETT — KENTUCKY
W.R. GRACE & CO.
50,000 B.P.D.
COAL - TO - METHANOL - TO - GASOLINE PLANT

| TITLE | SCALE | ACCOUNT NUMBER | JOB NUMBER | REVISION |
|---|---|---|---|---|
| ELEVATION UNIT 33 ALKYLATION | 1" = 20'-0" | 7245 | 6152 | D |
| | DOCUMENT NUMBER: D-33-PD-2NP | | | |

G. Single-Line Diagram

See Volume II, 1.2.12(G) for the Single-Line Diagram for HF Alkylation Unit 33.