## 4.5 OFFSITE UNITS

Majority of the offsite units in Base Case II are very similar to those in Base Case I. Consequently, descriptions are not repeated; differences, principally capacities, are discussed below.

Unless stated otherwise, units are shown on Block Flow Diagram ZO-GEM-6986 in Sub-Section 4.4. In addition, units such as boilers, generators and water treaters are also included in Steam/BFW Balance ZO-GEM-6986 located in Sub-Section 4.6.

### 4.5.1 Oxygen Production Unit 221

Identical to Unit 121.

### 4.5.2 Boiler Unit 222

Differences are as follows:

Main Fuel

| | |
|---|---|
| Fine coal quantity (composition listed in Sub-Section 2.3) | 414.7 Mlb/hr |

Supplementary Fuels

| | |
|---|---|
| - Oil quantity (from Gas Liquor Separation Unit 207) | 46.49 Mlb/hr |
| - Vacuum tower residue (from Fractionation Unit 252) | |
| Quantity | 2.0 Mlb/hr |
| Low heating value | 17,750 Btu/lb |

Incineration Fuel

| | |
|---|---|
| Sour offgases (mainly from Sulfur Recovery Unit 206) | |
| Quantity | 1,827.7 Mlb/hr |
| Low heating value | 243 Btu/lb |

NOTE: The heat content of these gases (30 Btu/SCF) has not been included in the boiler thermal balance.

| | |
|---|---|
| Normal Capacity | 3,111.3 Mlb/hr |

### 4.5.3 Main Superheater Unit 223

Capacity is changed as follows:

| | |
|---|---|
| Normal Capacity | 3,111.3 Mlb/hr |

### 4.5.4 Superheater Unit 224

Duties are as follows:

| | 200 psig Steam | 100 psig Steam |
|---|---|---|
| Inlet pressure, psig | 200 | 100 |
| Outlet pressure, psig | 185 | 85 |

| | 200 psig Steam | 100 psig Steam |
|---|---|---|
| Inlet temperature, °F | 387 | 338 |
| Outlet temperature, °F | 586 | 469 |

Fuel consists of a portion of the oil recovered from Gas Liquor Separator Unit 107:

Oil quantity 5.22 Mlb/hr

Normal Capacity

Coil 1: 200 psig steam superheating 78.7 Mlb/hr
Coil 2: 100 psig steam superheating 777.1 Mlb/hr

4.5.5 Electrostatic Stack Gas Precipitator Unit 225

Normal Capacity 216.9 Mlb-mol/hr

4.5.6 Stack Gas Clean-Up Unit 226

Normal Capacity 216.9 Mlb-mol/hr containing 48.1 lb-mol/hr $SO_2$

4.5.7 Instrument and Plant Air Unit 227 (not shown)

Identical to Unit 127 (Estimated instrument air requirement for the total complex is 750 lb-mol/hr; see Paragraph 3.5.7.)

4.5.8 Coal Handling Unit 228 (See SFD ZO-GEM-6909, Sub-Section 3.5.)

Gasifier well-sized coal production is identical to Base Case I. Because of the higher energy requirements in Base Case II, the quantity of boiler feed coal is increased to 406.9 Mlb/hr.

4.5.9 Ash Handling Unit 229 (See SFD ZO-GEM-6911, Sub-Section 3.5.)

Identical to Unit 129

4.5.10 BFW Preparation Unit 231

Deaerator (231/1)

Normal Capacity

| | Temp., °F | Flow, Mlb/hr |
|---|---|---|
| MP condensate | 479 | 346.6 |
| LP condensate | 297 | 1,628.5 |
| Vacuum condensate | 173* | 2,221.1 |
| Methanation Unit 212 process condensate | 288 | 110.8 |
| BFW make-up water | 173* | 2,099.4 |
| Total | 221 | 6,406.4 |

*After heating in 250-E-03.

Demineralizer (231/2)

Normal Capacity 2,090.4 Mlb/hr

### 4.5.11 Cooling Water Make-Up Preparation Unit 232

Normal Capacity

| | Mlb/hr |
|---|---|
| Treated fresh water | 1,179.7 |
| Treated water from Unit 235 and humidity condensed in Unit 221 | 1,961.9 |
| Total | 3,141.6 |

### 4.5.12 Cooling Water Tower Unit 233

Normal Capacity

| | GPM |
|---|---|
| Steam turbine condenser duty | 174,300 |
| Trim cooler duty | 109,590 |
| Total | 283,890 |

### 4.5.13 Electric Power Generation Unit 234

Description

Generator 234-M-01 uses 48 psig, 378°F steam with Condensing Turbine 234-T-01. Back Pressure Turbine 234-T-02 of Generator 234-M-02 is fed with two superheated streams:

| | |
|---|---|
| 185 psig steam: | 78.7 Mlb/hr |
| 85 psig steam: | 777.1 |
| Total | 855.8 |

Normal Capacity

| | MW | Steam Flow, Mlb/hr |
|---|---|---|
| 234-M-01 | 52.5 | 1,069.3 |
| 234-M-02 | 8.9 | 855.8 |

### 4.5.14 Waste Water Treatment Unit 235

Normal Capacity

| Composition | Flow, Mlb/hr |
|---|---|
| Organic acids and phenols | 8.9 |
| Ammonia | 1.3 |
| Water containing some $H_2S$ | 2,093.4 |
| Total | 2,103.6 |

4.5.15 Flare and Blowdown Facilities 236 (not shown)

Normal Capacity

| | |
|---|---|
| Blowdown water to holding pond | 837.9 Mlb/hr |

4.5.16 Storage 237 (not shown)

The following is a summary of the product, intermediate and chemical storage tank capacities which are not located within the process offsite units:

Product Storage (15 days)

| | |
|---|---|
| Anhydrous ammonia | 1,700 ton (refrigerated) |
| Sulfur | 1,000 ton (covered) |
| Gasoline | 224,000 Bbl (floating roof) |
| Diesel fuel | 38,000 Bbl (cone roof) |
| Heavy fuel oil | 11,000 Bbl (cone roof) |
| Propane LPG | 18,500 Bbl (pressure) |
| Butane LPG | 2,400 Bbl (pressure) |
| Alcohols | 34,000 Bbl (floating roof) |

Intermediate Storage

| | |
|---|---|
| Hydrotreater Unit 251 feed (15 days) | 22,000 Bbl (floating roof) |
| Hydrotreater Unit 253 feed (15 days) | 188,000 Bbl (floating roof) |
| Reformer Unit 255 feed (5 days) | 24,000 Bbl (floating roof) |
| Polymerization Unit 257 feed (2 days) | 14,000 Bbl (pressure) |

Chemical Storage

| | |
|---|---|
| Diisopropyl ether | 1,500 Bbl |
| Methanol | 1,000 Bbl |

4.5.17 Interconnecting Pipeway 238 (not shown)

Requirements are somewhat larger than in Base Case I because of the greater number of onsite units needed for F-T product upgrading.

4.5.18 Refrigeration Unit 241

Normal Capacity

| Temperature Level | Duty, MMBtu/hr + 32°F | - 45°F |
|---|---|---|
| Purification Unit 205 including ammonia storage | 25.5 | 70.5 |
| HC Recovery Unit 210 | - | 43.4 |
| $H_2$ Purification Unit 261 | 2.1 | - |
| | 27.6 | 113.9 |

4.5.19 Gasoline Blending Unit 270

Except for additional blending steams, identical to Unit 154.

4.5.20 F-T Catalyst Preparation Unit 271

Purpose of the Unit is to prepare from magnetite iron ore ($Fe_3O_4$) a promoted, reduced iron catalyst for the fluid-bed Fischer-Tropsch reactors.

Technology Used

The catalyst plant design is based on literature articles describing: (a) the manufacture of iron ammonia catalysts, (17), and (b) the Sasol catalyst plant (13). An overall general design has only been developed. Promotors used and dosages, concentrate specifications, specific operating conditions, etc., are confidential and, thus, unavailable. This unit has been added to the offsites because of the quantity of fused catalyst required and the problems of shipping the sensitive catalyst under a $H_2$ or inert gas atmosphere.

Process Description

Catalyst preparation consists of 3 steps: iron ore purification, catalyst fusion and size reduction, and catalyst reduction. Equipment contained in the iron ore purification area includes:

- Ore unloading and storage
- Rotary drier for moisture removal before grinding
- Rod mill for size reduction required by air table
- Air separation table for tailings removal
- Concentrate storage

Concentrate yield has been assumed to be 50 percent.

Equipment in the catalyst fusion and size reduction step includes:

- Electric resistance furnace for melting/intimate mixing of concentrate and promotors
- Gyratory crusher and ball mill for size reduction required by the fluid-bed reactor
- Air separator for elimination of fines and oversize particles
- Catalyst storage

Equipment required in catalyst reduction includes:

- Fluidized-bed reactor for contact of hydrogen and unreduced F-T catalyst
- Hydrogen heater
- Heat exchangers for condensing water product
- Hydrogen recycle compressor
- Recycle gas drier for moisture control
- Reduced catalyst storage under $H_2$ or inert gas atmosphere

Reduction takes place under elevated temperature and pressure.

Normal Capacity

| | |
|---|---|
| Iron Ore | 91 T/SD |
| Reduced Catalyst | 30 T/SD |

BASE CASE II

## 4.6 UTILITY REQUIREMENTS AND STEAM/BFW BALANCE

### 4.6.1 Utility Requirements

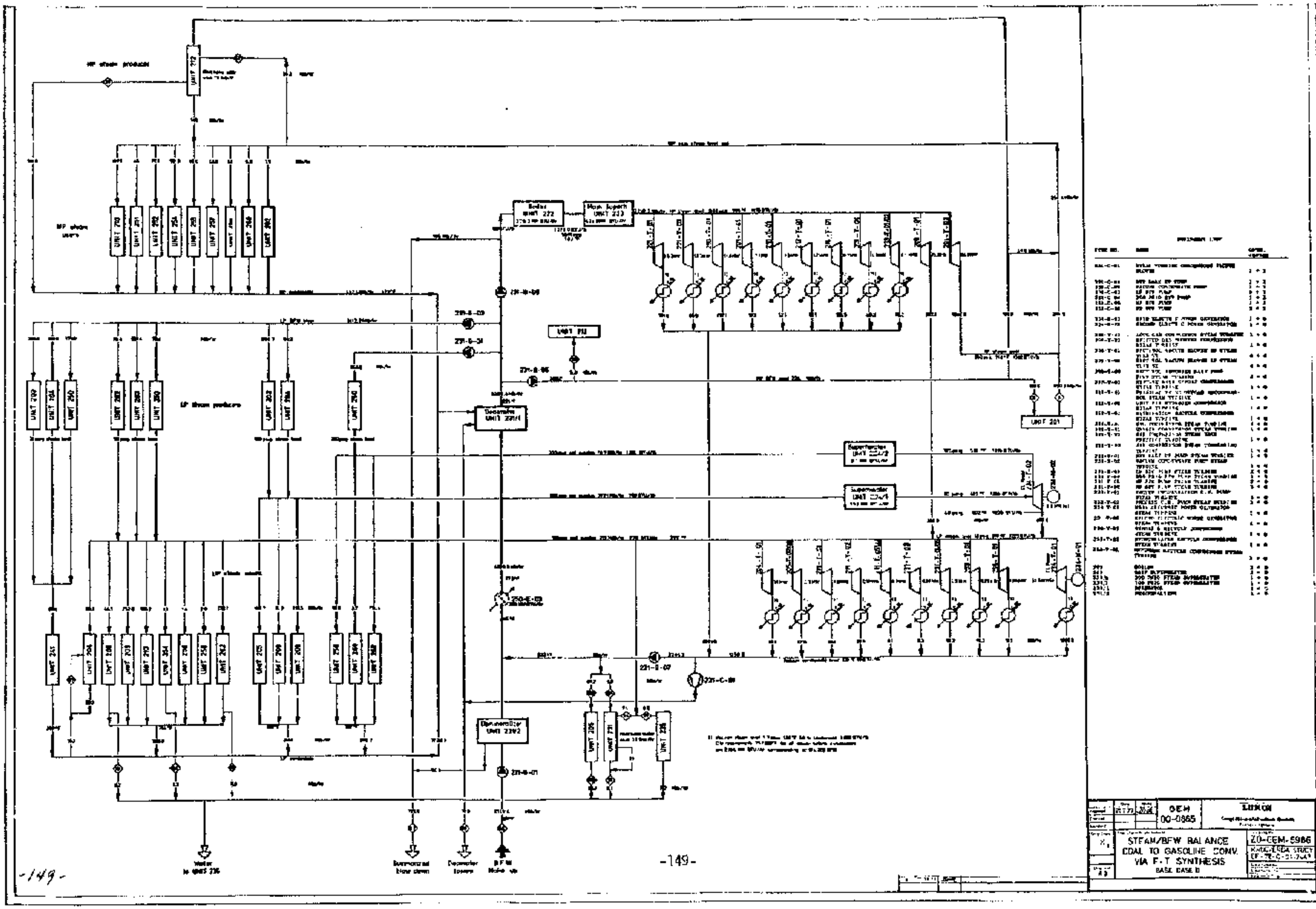
Utility requirements for the individual units can be found as follows:

| Utility | Source |
|---|---|
| Fuel | Type and stream number: BFD ZO-GEM-6988 (Sub-Section 4.4)<br>Quantity and composition: Material balance sheets (Appendix B) |
| Power | BFD ZO-GEM-6988 |
| Cooling water | BFD ZO-GEM-6988 |
| Boiler feed water | Steam/BFW Balance ZO-GEM-6986 (Sub-Section 4.6) |
| Steam | Steam/BFW Balance ZO-GEM-6986 |

In addition, offsite Sub-Section 4.5 contains utility information.

### 4.6.2 Steam/BFW Balance

The steam and boiler feed water flows are shown on Drawing ZO-GEM-6986. The steam/electric power balance is acceptable in accordance with the study bases. Only about 3 MW(e) is surplus in comparison with 268 MW of total electric and steam power required in the plant complex. In addition, all steam produced is utilized.


OEM
00-0865
STEAM/BFW BALANCE
COAL TO GASOLINE CONV.
VIA F-T SYNTHESIS
BASE CASE B
ZO-OEM-5986
UNIT 212
UNIT 272
UNIT 201
UNIT 2302
-149-

## BASE CASE II
## 4.7 TRAIN PHILOSOPHY

The train philosophy for the various units was selected on the basis of providing a plant complex having an onstream factor of 92%. Consequently, parallel trains have been used for many units to give flexibility in both operation and maintenance. Also, because of the large size of the complex, some units must be divided into parallel trains. In the hydrocarbon processing area, however, intermediate storage is used to provide this flexibility.

In addition, all normally operating pumps, reciprocating compressors and conveyors are provided with an 100% spare.

Since the same train philosophy is used for Base Case II as is used in Base Case I, only the philosophy of the new units in Base Case II are discussed below.

### Hydrocarbon Recovery Unit 210

Because of size limitation, two parallel trains are provided.

### F-T Synthesis Unit 250

Using a conservative scale-up factor of 2 over current commercial fluid-bed reactors, four reactors are required. In addition, a spare reactor is provided for catalyst changing and maintenance. Size considerations also require multiple towers, compressors, and pumps; see equipment list on PFD ZO-GEM-6977 in Sub-Section 4.4.

### F-T Product Upgrading Units 252 Through 262

These units are single trains as equipment sizes are small enough to be shop fabricated. The only exception is Catalyst Polymerization Unit 257 which is provided with two reactors for operating flexibility.

To achieve operating flexibility in the upgrading area, feedstock storage capacity has been provided for the following units:

| | | |
|---|---|---|
| Naphtha Hydrotreating Unit 251 | - | 15 days |
| F-T Product Hydrotreating Unit 253 | - | 15 days |
| Catalytic Reforming Unit 255 | - | 5 days |
| Catalytic Polymerization Unit 257 | - | 2 days |

### Offsite Units

The offsite units are designed for a minimum of two parallel trains. In cases where commercial-sized equipment is too large with two trains, the number of trains has been increased.

# SECTION 5

# SENSITIVITY CASES

The block flow diagram for each sensitivity case is placed at the end of its sub-section. The material balance of the new unit introduced in each sensitivity case is tabulated in Appendix C.

## 5.1. SENSITIVITY CASE I-A: METHANOL AND SNG COPRODUCTION

### 5.1.1 Material Balance

The overall material balance is shown below:

| Input | Mlb/hr |
|---|---|
| Coal, as mined | 2,277.8 (1) |
| Air | 5,874.8 |
| Water | 3,094.2 |
| | 11,246.8 |

| Output | Mlb/hr |
|---|---|
| Coal fines (excess) | 132.2 (2) |
| Ash | 138.6 |
| Products | 865.5 (3) |
| Byproducts | 13.7 |
| Blowdown water | 707.8 |
| Stack and evaporation losses | 9,389.0 |
| | 11,246.8 |

(1) 27,334 T/SD

(2) 1,586 T/SD

(3) 47,880 FOE Bbl/SD @ 6.0 MM Btu/FOE Bbl

Overall plant consumptions per FOE barrel of product are:

| | | |
|---|---|---|
| Coal: | 0.538 | T |
| Water: | 4.43 | Bbl |
| Air: | 1.47 | T |

Stack and evaporation losses amount to about 2.4 tons per FOE barrel of product.

### 5.1.2 Product Yields and Quality

Stream numbers are shown below for reference to BFD ZO-GEM-7037.

(a) SNG (49)

| | |
|---|---|
| Quantity | 16,070 lb-mol/hr |
| | 260.1 M lb/hr |
| | 146.4 MMSCF/SD |

Composition (only compounds greater than 0.1% are listed.)

| | Percent |
|---|---|
| Hydrogen | 1.7 |
| Methane | 95.9 |
| Carbon dioxide | 0.5 |
| Inerts ($N_2$ + Ar) | 1.9 |
| | 100.0 |

Other

| | |
|---|---|
| Heat of combustion, Btu/SCF | |
| HHV | 975 |
| LHV | 878 |
| Carbon monoxide (0.1% max.) | 0.01% |
| Water | 0.01% |
| Sulfur | None |

Compatibility Indexes (versus pure methane)

| Index | Calculated | Preferable | Objectionable |
|---|---|---|---|
| Lifting, $I_l$ | 1.03 | under 1.0 | above 1.06 |
| Flash-back, $I_f$ | 1.02 | under 1.15 | above 1.2 |
| Yellow-tip, $I_y$ | 1.06 | above 1.0 | under 0.8 |

The interchangeability of the SNG product with pure methane is satisfactory and, essentially, unchanged from Base Case I.

(b) Methanol (37.1)

| | |
|---|---|
| Quantity | 589.9 M lb/hr<br>6,420 metric T/SD<br>50,840 Bbl/SD |

Impurities

| | PPM |
|---|---|
| Light boiling compounds | 1,200 |
| Heavy boiling compounds | 700 |
| Water | 1,500 |

Only a fuel grade methanol is prepared. For direct blending in gasoline, it would have to be dehydrated further to about 1,000 ppm of water.

(c) Naphtha (100)

| | |
|---|---|
| Quantity | 15.5 M lb/hr<br>1,315 Bbl/SD |

Quality

| | |
|---|---|
| Gravity, °API | 43.5 |
| Octane, unleaded | |
| Research | 93 |
| Motor | 84.5 |
| Reid Vapor Pressure, lb | 3.5 |

The hydrotreated naphtha is a good gasoline pool blending stock.

(d) Byproducts

| | |
|---|---|
| Sulfur (29) | 61 T/SD |
| Anhydrous Ammonia (17) | 103 T/SD |
| Excess Power | - 6.55 MW(e) (required) |

(e) Coal Fines (2.1) — 132.2 M lb/hr

### 5.1.3 Thermal Efficiency

The overall plant thermal efficiency (HHV) is shown in Table 5.1.1. Deleting the Mobil methanol conversion technology increases the overall plant thermal efficiency from 62 to 66 percent. About half of this difference is caused by the inability to utilize the additional yield of low grade heat brought about by the methanol conversion to gasoline. (See Paragraph 5.1.6.)

### 5.1.4 Processing Description (BFD ZO-GEM-7037)

The sensitivity basis calls for the production of a fuel grade methanol. Consequently, Methanol Distillation Unit 115 is added for water removal only, with the trace non-methanol materials remaining. It is a two-stage tower system to minimize steam usage. Methanol Conversion Unit 150 and Units 152, 153 and 154 are deleted. The gasification and syngas purification areas are unchanged. Technology of the SNG train remains the same but the gas flow and composition differ slightly from those of Base Case I.

## TABLE 5.1.1
## SENSITIVITY CASE I-A - THERMAL EFFICIENCY

| | Quantity, Unit/SD | High Heating Value (HHV) | Total HHV, MM Btu/hr | Percent of Input |
|---|---|---|---|---|
| **Input** | | | | |
| Coal, DAF | 18,286 T | 12,720 Btu/lb | 19,383 | |
| Fines (excess) | (1,061) | " | (1,125) | |
| Net Coal | 17,225 T | | 18,258 | |
| Power (required) | 6.55 MW(e) | 3,415 Btu/kwh* | 22 | |
| Total | | | 18,280 | |
| **Output** | | | | |
| SNG | 146.4 MMSCF | 975 Btu/SCF | 5,948 | 32.5 |
| Methanol | 7,080 T | 9,724 Btu/lb | 5,737 | 31.4 |
| Naphtha | 1,315 Bbl | 5.2 MM Btu/Bbl | 285 | 1.5 |
| Sub-Total | | | 11,970 | 65.4 |
| Sulfur | 61 T | 3,780 Btu/lb | 19 | 0.1 |
| Ammonia | 103 T | 9,693 Btu/lb | 83 | 0.5 |
| Total | | | 12,072 | 66.0* |

*Direct thermal conversion used. If 10,000 Btu/kwh used, thermal efficiency becomes 65.8%.

### 5.1.5 Capacities of Process and Offsite Units

The following is a list of the process and offsite unit capacity ratios with Base Case I equaling 100 percent:

| Unit | Name | Ratio, % |
|---|---|---|
| 101 thru 109 | Gasification and Syngas Purification | 100 |
| 110 | Methanol Synthesis | 100 |
| 111 | $H_2$ Recovery | 100 |
| 112 | Methanation | 100 |
| 113 | $CO_2$ Removal | 98 (gas flow) |
| 114 | SNG Drying | 98 (gas flow) |
| 115 | Methanol Distillation | New Unit |
| 121 | Oxygen Production | 100 |
| 122/123 | Boiler/Superheater | 107 (heat fired) |
| 124 | Superheater | 88 (heat fired) |
| 125/126 | Stackgas Precipitator & Clean-Up | 94 (gas flow) |
| 127 | Instrument & Plant Air | 100 |
| 128/129 | Coal & Ash Handling | 100 |
| 131/1 & 2 | BFW Deaerator & Demineralizer | 96 |
| 132 | CW Make-Up Preparation | 89 |
| 133 | CW Towers | 89 |
| 134 | Electric Power Generation | 76 |
| 135 | Waste Water Treatment | 82 (water flow) |
| 136 | Relief and Blow Down Facilities | 88 |
| 137 | Storage | (1) |
| 138 | Interconnecting Piping | (2) |
| 141 | Refrigeration | 100 |
| 150 | Methanol Conversion | 0 |
| 151 | Naphtha Hydrotreating | 100 |
| 152 | Fractionation | 0 |
| 153 | HF Alkylation | 0 |
| 154 | Gasoline Blending | 0 |

(1) Product storage deleted: Gasoline, Propane LPG and Mixed Butanes.
Intermediate storage deleted: Methanol
Product storage added:

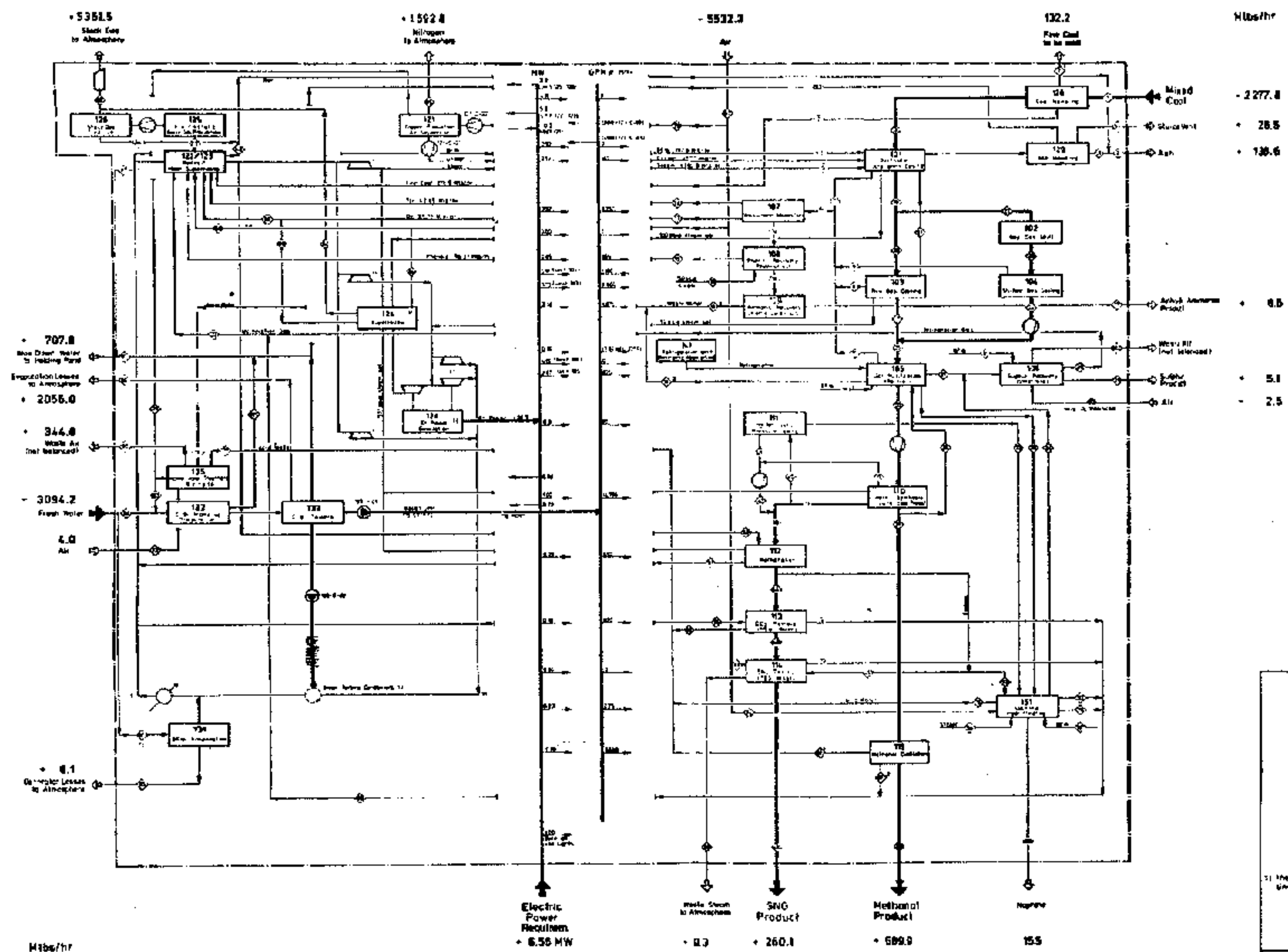
| | |
|---|---|
| Methanol (15 days) | 840,000 Bbl (floating roof) |
| Hydrotreated Naphtha (15 days) | 22,000 Bbl (floating roof) |
| Coal fines storage; | 11,500 T (silo) |

(2) Interconnecting piping requirements are reduced due to the deletion of Units 150, 152, 153 and 154.

5.1.6 Steam Balance (as related to Base Case I)

The deletion of LP steam producer Unit 150 and the addition of LP steam consumer Unit 115 results in a decrease in the LP steam available for power generation. Consequently, insufficient power is generated, or purchase power is required, without a major modification to the steam balance. On the other hand, the deletion of Unit 150 (recycle compressor) reduces the HP steam, or boiler, requirement and results in a small increase of fine coal for sales.

In Base Case I, which has a surplus of low grade heat available for boiler feed water heating, all BFW heating is accomplished in the Methanol Conversion Unit 150. For this sensitivity case, the BFW heating duty of about 375 MM Btu/hr is spread among Units 103, 104, 110 and/or 112, all of which in Base Case I have low grade heat wasted in fan coolers. The utilization of the "waste" low grade heat has been a major problem in this study.




1) The steam/BFW circuit of the complex is shown simplified

GEM
00-C855
LURGI
BLOCK FLOW DIAGRAM
COAL TO METHANOL
CONVERSION
SENSITIVITY CASE II-B
ZO-GEM-7037



-159-

## 5.2 SENSITIVITY CASE I-B: GASOLINE ONLY PRODUCTION

### 5.2.1 Material Balance

The overall material balance is shown below:

| Input | M lb/hr |
|---|---|
| Coal, as mined | 2,286.6 (1) |
| Air | 8,654.2 |
| Water | 3,419.3 |
| | 14,360.1 |

| Output | M lb/hr |
|---|---|
| Ash | 145.8 |
| Products | 448.5 (2) |
| Byproducts | 13.7 |
| Blowdown water | 971.2 |
| Stack and evaporation losses | 12,780.9 |
| | 14,360.1 |

(1) 27,439 T/SD

(2) 36,200 FOE Bbl/SD @ 6.0 MM Btu/FOE Bbl

Overall plant consumptions per FOE barrel of product are:

| | | |
|---|---|---|
| Coal: | 0.758 | T |
| Water: | 6.48 | Bbl |
| Air: | 2.87 | T |

Stack and evaporation losses amount to about 4.2 tons per FOE barrel of product.

Although methane reforming increases the $C_5$ plus hydrocarbon yield from 25,805 to 43,895 Bbl/SD, or 70 percent, the total hydrocarbon yield shrinks from 45,550 to 36,200 FOE Bbl/SD, or 20 percent. This decrease results in the larger overall plant consumptions shown above as compared to those for Base Case I.

## 5.2.2 Product Yields and Quality

Stream numbers are shown below for reference to BFD ZO-GEM-7036.

(a) Gasoline (50)

| | |
|---|---|
| Quantity | 37,430 Bbl/SD<br>397.2 M lb/hr |

Blending and Properties

The 10 RVP gasoline consisting of the same components as in Base Case I, essentially, has the same properties shown in Table 3.2.1 and, therefore, is of excellent quality.

(b) Mixed Butanes (103)

| | |
|---|---|
| Quantity | 3,800 Bbl/SD<br>31.6 M lb/hr |

Properties

Estimated properties are the same as for the mixed butanes obtained in Base Case I. (See Table 3.2.3.)

(c) Propane LPG (102)

| | |
|---|---|
| Quantity | 2,665 Bbl/SD<br>19.7 M lb/hr |

Properties

Estimated properties are the same as for the propane LPG obtained in Base Case I. (See Table 3.2.3.)

(d) Byproducts

| | |
|---|---|
| Sulfur (29) | 61 T/SD |
| Ammonia (17) | 103 T/SD |
| Excess Power | 1.38 MW(e) |

### 5.2.3 Thermal Efficiency

The overall plant thermal efficiency (HHV) is shown in Table 5.2.1. The addition of methane reforming for the elimination of SNG production reduces the overall plant thermal efficiency by about 15 percent. Only about 61% of the HHV energy in the SNG product of Base Case I is realized in additional $C_3$ plus liquid hydrocarbon products. In addition, the fine coal usage is slightly higher than in Base Case I.

### 5.2.4 Processing Description (BFD ZO-GEM-7036)

To maximize the production of gasoline - deletion of the SNG coproduct - Autothermal Reforming Unit 116 is added to convert the purge (38) and expansion (35) gases from Methanol Synthesis Unit 110 and the light gases (57) from Fractionation Unit 152 into an additional synthesis gas feed (42) for Unit 110. The SNG train units are deleted.

In the autothermal reforming process, direct partial combustion of the feed gases with oxygen produces the required heat of reaction. This technique, as opposed to tubes-in-firebox heating in the conventional steam reforming process, yields the maximum possible syngas.

Because of the nitrogen inerts in the oxygen feed and from the coal gasification itself, not all of the methanol unit purge gas can be recycled to Autoreforming Unit 116. A slipstream (39) of about 9% of the methanol unit purge gas (38) is required to maintain the inerts at a reasonable level in Methanol Synthesis Unit 110. This slipstream is used to fire Boiler 122. A partial slipstream reduction, thereby increasing somewhat the gasoline yield, could be achieved by the use of a higher purity oxygen plant. Because of the nitrogen yield in the gasification step - not all the coal nitrogen is converted into ammonia -, however, the slipstream cannot become zero.

TABLE 5.2.1
SENSITIVITY CASE I-B - THERMAL EFFICIENCY

| | Quantity, Unit/SD | High Heating Value (HHV) | Total HHV, MMBtu/hr | Percent of Input |
|---|---|---|---|---|
| Input | | | | |
| Coal, DAF | 18,357 T | 12,720 Btu/lb | 19,458 | |
| Output | | | | |
| $C_3$ LPG | 2,665 Bbl | 3.816 MMBtu/Bbl | 424 | 2.2 |
| $C_4$ LPG | 3,800 Bbl | 4.191 MMBtu/Bbl | 664 | 3.4 |
| 10 RVP Gasoline | 37,430 Bbl | 5.105 MMBtu/Bbl | 7,962 | 40.9 |
| Sub-Total | | | 9,050 | 46.5 |
| Sulfur | 61 T | 3,780 Btu/lb | 19 | 0.1 |
| Ammonia | 103 T | 9,693 Btu/lb | 83 | 0.5 |
| Power (excess) | 1.38 MW(e) | 3,415 Btu/kwh* | 5 | - |
| Total | | | 9,157 | 47.1 |

*Direct thermal conversion used.

### 5.2.5 Capacities of Process and Offsite Units

The following is a list of the process and offsite unit capacity ratios with Base Case I equaling 100%.

| Unit | Name | Ratio, % |
|---|---|---|
| 101 | Gasification | 100 |
| | Lock Gas Compressors | 107 (1) |
| 102 | Raw Gas Shift | 100 |
| 103 | Raw Gas Cooling | 100 |
| 104 | Shifted Gas Cooling | 100 |
| 105 | Gas Purification | 102 (2) |
| 106 | Sulfur Recovery | 100 (3) |
| 107 | Gas Liquor Separation | 100 |
| 108 | Phenol Recovery | 100 |
| 109 | Ammonia Recovery | 100 |
| 110 | Methanol Synthesis | 173 (methanol (4) yield) |
| 111 | $H_2$ Recovery | 100 |
| 112 | Methanation | 0 |
| 113 | $CO_2$ Removal | 0 |
| 114 | SNG Drying | 0 |
| 116 | Autothermal Reforming | New Unit |
| 121 | Oxygen Production | 153 (5) |
| 122 | Boiler | 124 (steam flow) |
| 123 | Main Superheater | 126 (steam flow) |
| 124 | Superheater | 115 (heat fired) |
| 125/126 | Stackgas Precipitation & Clean-Up | 120 (gas flow) |
| 127 | Instrument & Plant Air | 100 |
| 128/129 | Coal & Ash Handling | 100 |
| 131/1 & 2 | BFW Deaerator & Demineralizer | 96 |
| 132 | CW Make-Up Preparation | 124 |
| 133 | CW Towers | 124 |
| 134 | Electric Power Generation | 112 |
| 135 | Waste Water Treatment | 114 (water flow) |
| 136 | Relief and Blow Down Facilities | 100 |
| 137 | Storage | (6) |
| 138 | Interconnecting Piping | 100 (differences negligible) |
| 141 | Refrigeration | 100 |
| 150 | Methanol Conversion | 173 (methanol (7) feed) |
| 151 | Naphtha Hydrotreating | 100 |
| 152 | Fractionation | 173 |
| 153 | HF Alkylation | 171 |
| 154 | Gasoline Blending | 170 |

(1) Increased syngas compressor (110-C-01) losses from larger syngas feed to Methanol Synthesis Unit 110.

(2) A lower $CO_2$ content, clean synthesis gas is required from Unit 105 to maintain the $CO_2$ specification for Methanol Synthesis Unit 110 with the addition of synthesis gas from Autothermal Reforming Unit 116. Investment is estimated to be 2% higher.

(3) Feed to Unit 106 contains slightly more $CO_2$ than in Base Case I. Effect on investment is neglected.

(4) The $H_2$ and CO conversions are higher than those for Base Case I because of the lower methane content in the syngas.

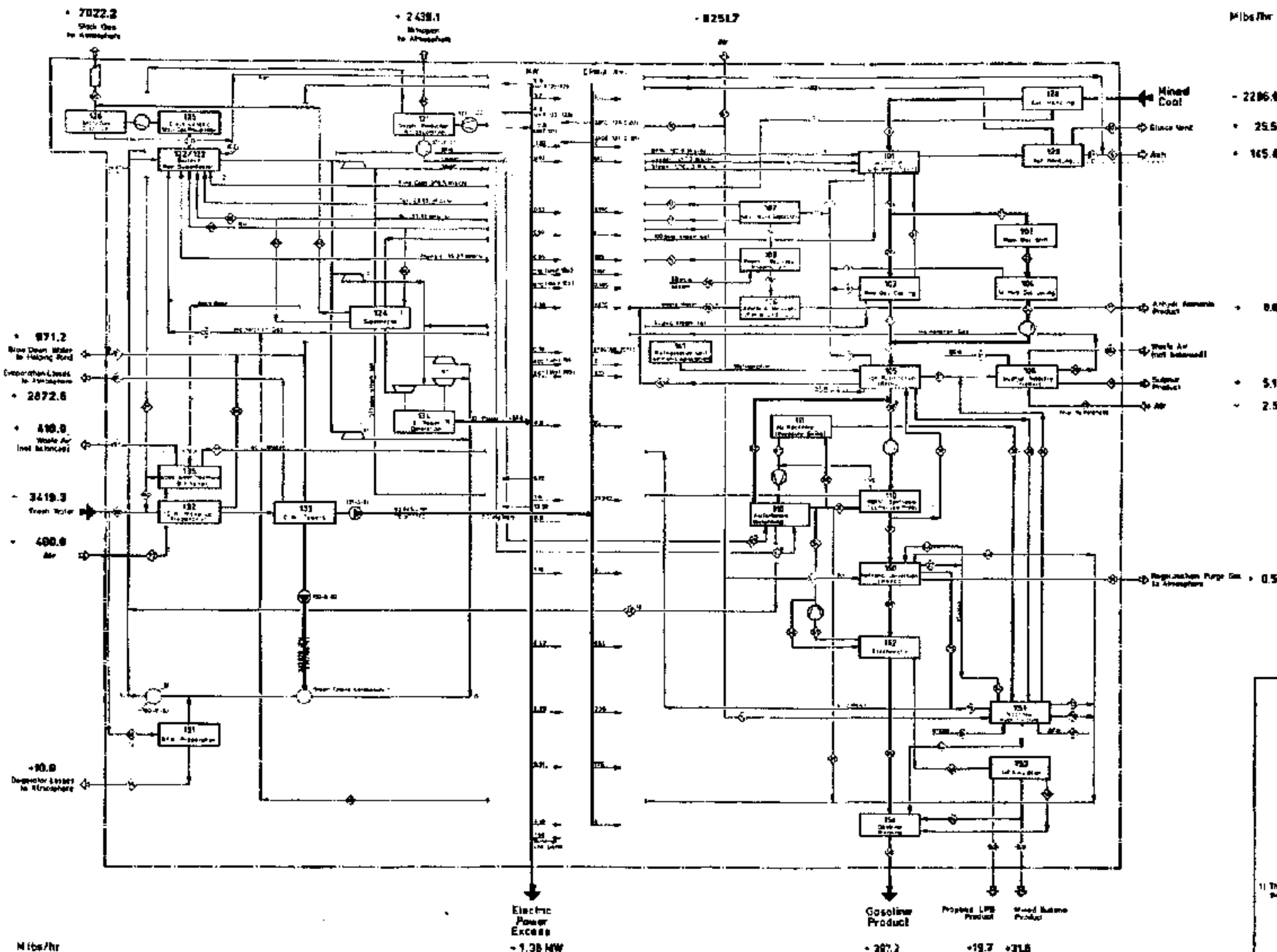
(5) The oxygen feed pressure required by Autothermal Reforming Unit 116 is the same as required by Gasification Unit 101.

(6) Storage capacity for crude methanol, $C_3$ LPG, $C_4$ LPG and 10 RVP gasoline is increased by 70%.

(7) Two parallel reactor trains are required.

5.2.6 Steam Balance (as related to Base Case I)

The HP steam (Boiler/Superheater Unit 122/123) requirement is increased to meet the needs of the larger oxygen plant, methanol synthesis unit and methanol conversion unit compressors. Additional boiler firing is with the methanol/autothermal reforming slipstream gas for inerts control and coal fines. The increased steam production in Methanol Synthesis Unit 110 reduces the amount of 550 psig steam generation from the HP steam system for feed to Gasification Unit 101. Electricity production is slightly higher due to the increase yield of LP steam from Methanol Conversion Unit 150.




1) The steam/BFW circuit of the complex is shown simplified

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|---|---|
| ITEM 00-0865 | |
| BLOCK FLOW DIAGRAM COAL TO GASOLINE VIA METHYL WITHOUT SNG PROD. | ZO-DEM-7035 |
| SENSITIVITY CASE I-X | |



-166-