

EDS COAL LIQUEFACTION PROCESS DEVELOPMENT

PHASE V

EDS Commercial Plant Study Design Update
Offsite Design Basis - Wyoming Coal Case

Interim Report

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EDS COAL LIQUEFACTION PROCESS DEVELOPMENT-PHASE V
COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS
WYOMING COAL CASE

Abstract

This report is an Interim Report for U.S. Department of Energy Cooperative Agreement No. DE-FC01-77ET10069 for EDS (Exxon Donor Solvent) Coal Liquefaction Process Development-Phase V. This report covers the Offsite Design Basis for the Wyoming Coal Case of the EDS Commercial Plant Study Design Update. Funding is shared by U.S. Department of Energy, Exxon Company, U.S.A (a division of Exxon Corporation), Electric Power Research Institute, Japan Coal Liquefaction Development Company, Philips Coal Company, ARCO Coal Company, Ruhrkohle AG and Agip S.p.A. The agreement covers the period January 1, 1977 through December 31, 1982. The Laboratory Process Research and Development studies was conducted at various Exxon Research and Engineering (ER&E) facilities: Research and Development Division at Baytown, Texas; Products Research Division at Linden, New Jersey; and the Exxon Research and Development Laboratories at Baton Rouge, Louisiana. The engineering research and development studies were performed at the Synthetic Fuels Engineering Department and Exxon Engineering Technology Department at Florham Park, New Jersey.

The Wyoming Coal Case is being developed as a sensitivity to locating a commercial EDS plant in a northeast Wyoming location using the once-through liquefaction mode. Operating conditions in liquefaction are 840°F, 60 minutes nominal residence time at a solvent-to-coal ratio of 1.6/1. The Wyoming Coal Case of the SDU utilizes partial oxidation of about one half of the vacuum pipestill bottoms for hydrogen generation and FLEXICOKING* of the remaining bottoms to make low Btu gas (LBG) for use as plant fuel. This configuration is essentially the same as used in the Illinois Coal Market Flexibility Sensitivity Case. The methane/ethane product will be sold as high Btu gas (HBG). HBG will also serve as backup fuel for the onsite area.

The quality of the offsite design is to be equivalent to a screening quality study design. Wherever possible, the previous study designs are to be used to develop the offsite design for the Wyoming Coal Case. The offsite design effort will be concentrated on the water, fuel, steam and power systems and the wastewater treating facilities, and product shipping facilities. There will be minimum efforts (i.e., hold constant, prorate, or use judgement relative to the Illinois cases) on the remainder of the offsites.

The onsite design basis for the Wyoming Coal Case was documented as Interim Report FE-2893-59.

*"Service Mark"

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS
WYOMING COAL CASE

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EDS COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS
WYOMING COAL CASE

This report presents the offsite design basis for the EDS Commercial Plant Study Design Update (SDU) - Wyoming Coal Case. The bases for the design of all offsite facilities are covered in this report. The onsite basis of the Wyoming coal case has been documented earlier (Reference 1). The offsites will include typical facilities, i.e., utilities, tankage, wastewater treating, waste disposal facilities, etc. Offsite facilities will also include transportation of coal from the mine, coal storage, and crushing and distribution of the crushed coal to the slurry driers and offsite boilers (if coal-fired boilers are required).

Two study designs have already been developed for Illinois No. 6 Bituminous Coal; the Illinois Coal Base Case and Market Flexibility Sensitivity (MFS) Case (References 2, 3, 4, 5). The Illinois Coal Base Case is a maximum C₄+ liquids case which includes FLEXICOKING to process vacuum bottoms and steam reforming of C₂ gas to supply hydrogen. The Illinois Coal MFS Case is a higher thermal efficiency case where partial oxidation of part of the vacuum bottoms is used to produce hydrogen. A FLEXICOKING unit is employed in the MFS Case to process the remaining vacuum bottoms, and C₂ is sold as high Btu gas.

For the Wyoming Coal Case, the plant is to be located in North-eastern Wyoming and the feed coal is to be Wyoming subbituminous coal. The dry coal feed rate to liquefaction is to be 25.0 kST/SD (36.3 kST/SD of "as received" coal); the same dry feed basis as in the Illinois Coal Base Case and MFS Case. The process configuration is to be identical to that of the Illinois MFS Case, i.e., the use of FLEXICOKING and partial oxidation to produce plant fuel and hydrogen, respectively. However, the offsite bases have changed because of the different plant site and differences in the properties and process yields of Wyoming vs. Illinois Coal.

The quality of the offsite design is to be equivalent to a screening quality study design. Wherever possible, the previous study designs are to be used to develop the offsite design for the Wyoming Coal Case. The offsite design effort will be concentrated on the water, fuel, steam and power systems and the wastewater treating facilities, and product shipping facilities. There will be minimum efforts (i.e., hold constant, prorate, or use judgement relative to the Illinois cases) on the remainder of the offsites.

Process Configuration

The process configuration for the major processing blocks is shown in Figure 1. Coal, received in coal preparation, is crushed to the desired size, and is sent to the slurry driers. In the slurry driers, the coal is dried and slurried with solvent. The coal slurry is processed in a plant consisting of two onsite trains, each containing two lines of liquefaction furnaces, reactors and separators with common treat gas facilities. The

two liquefaction lines in each train share common atmospheric and vacuum fractionation facilities (APS/VPS) to separate coal liquids into spent solvent, raw product streams (C_2^- , $C_3/400^\circ\text{F}$ and VGO), and vacuum bottoms. A major portion of the spent solvent is sent to solvent hydrogenation to produce hydrogenated recycle solvent; the remaining spent solvent (liquefaction mid-distillate) is blended into the fuel oil. Each train has a single solvent hydrogenation section consisting of a furnace, several hydrogenation reactors, separators, a fractionator and H_2 treat gas facilities. Solvent hydrogenation produces the hydrogenated (H_2 donor) recycle solvent and raw product streams (C_2^- and $C_3/400^\circ\text{F}$). Hydrogenated solvent is recycled back to the slurry driers.

The vacuum pipestill (VPS) bottoms cut point is different for each train in the plant, since each train feeds a different bottoms processing step. In Train No. 1, the vacuum bottoms cut point is 850°F . The $850^\circ\text{F}+$ vacuum bottoms stream is sent to two FLEXICOKING units which produce ash residue (sent to waste disposal), low Btu gas (LBG), and raw product streams (C_2^- , $C_3/400^\circ\text{F}$ and coker liquids). The LBG is utilized as plant fuel. In train No. 2, the vacuum bottoms cut point is 900°F . The $900^\circ\text{F}+$ vacuum bottoms stream is sent to the four partial oxidation units in the plant to produce hydrogen. The hydrogen produced is utilized as makeup to liquefaction and solvent hydrogenation. Oxygen required by the partial oxidation units is produced in oxygen plants by cryogenic fractionation of air.

Each train has a H_2 recovery section where H_2 purge gas (from liquefaction and solvent hydrogenation) and C_2^- gas are processed in a cryogenic system to recover hydrogen and C_1/C_2 product gas. Some C_3+ material is also recovered and sent to the light ends unit. Each train also has a light ends unit where C_3 LPG, C_4 LPG, $C_5/350^\circ\text{F}$ naphtha, and a $350/400^\circ\text{F}$ heavy naphtha are recovered from all the $C_3/400^\circ\text{F}$ material. The heavy naphtha ($350/400^\circ\text{F}$) is blended into the fuel oil product along with the liquefaction mid-distillate, vacuum gas oil (VGO) and coker liquids. Not shown in Figure 1 is the gas and water treating facilities.

Major Bases and Concepts

The following are plant site related bases and other major bases and concepts:

- The plant feed coal is to be Wyoming subbituminous coal.
- The plant will require one (above-ground) mine, with the EDS plant located 1/2 mile from the mine.
- Plant Site
 - The plant site is to be a hypothetical location in Northeastern Wyoming.

- Meteorological design conditions for the plant site are shown in Table 1.
- The terrain is assumed to be rolling hills with an average elevation of about 4600 feet above sea level. The elevation difference across the site is on average of 10 feet with a maximum of 50 feet (10% of site).
- Site bases are for a "typical" site in Northeastern Wyoming.
- Purchased power is to be supplied by the local utility to the plant battery limits.
- All the steam required by the EDS plant is to be generated in the plant.
- Sufficient reliability is to be included in all units such that no more than one onsite train is forced down simultaneously.
- All onsite facilities are designed to allow a 50% turndown.
- Flaring of plant fuel during normal operation is to be avoided.
- Plant construction is not to be staged.
- Major step out in application of new technology in peripheral areas including offsites is to be avoided.
- The offsite design for the Illinois Coal Market Flexibility Sensitivity Case is to be used wherever applicable.

Coal Storage and Handling System

The coal storage and handling system is to provide for the receipt and stacking of coal at the plant, the reclamation and distribution of the coal to the crushers, and the feeding of crushed coal to the slurry driers and boiler pulverizers (if coal-fired boilers are required). These facilities are to be designed consistent with the following bases:

- The mine will supply as much coal as required by the plant. The coal throughput to liquefaction is 36.3 kST/SD "as received". Additional coal may be burned as fuel in the offsite boilers to meet steam requirements.
- Crushed coal will be supplied from one mine located about 1/2 mile from the plant. Refer to Table 2 for the crushed coal size distribution and characteristics.
- The coal mine is to be operated 5 days per week and 24 hours per day.

- Mine and coal transportation facilities

- Mining facilities, activities and costs are excluded from this study.
- Facilities for transporting coal from the mine to the EDS plant are to be provided as part of the plant.
- Facilities for loading coal are provided by the mine and will be included in the cost of the coal.
- The preferred transportation method for the coal is to be determined during the offsite design.

- Coal storage and handling

- The quality of coal received from the mine is assumed to be constant.
- A long-term (dead) coal storage pile is not required. The mine maintains a 60 day reserve of coal in the pit.
- A short-term (live) coal storage pile is to be provided with a capacity of 5 days of coal feed to the plant.
- Reclamation of the live storage pile is to be provided.
- Coal is to be stored and reclaimed in a manner such that safety and environmental problems are prevented.
- Fugitive dust control is to be, as a minimum, equivalent to present power plant practice.
- Conveyors, surge bins, impact crushers, belt conveyors, distributor bins, feeders, and all other coal handling equipment is to be provided such that any single contingency equipment stoppage will allow no less than 20 hours of continuous full rate coal feed to the plant.
- Facilities are to be provided for crushing the coal feed to the liquefaction units to minus 8 mesh. No drying facilities for this coal need to be provided. Figure 2 shows the crushed coal size distribution utilized in the design of the onsite facilities.
- Exposure of the coal to oxygen (particularly after crushing) at temperatures above ambient is to be minimized. However, an inert atmosphere is not required to prevent oxidation of the coal for processing reasons.

- Facilities for transporting the coal feed to the five slurry driers in the plant (two per train, plus a common spare) are to be provided.
- Distribution of feed coal to the slurry driers is to be controlled through the use of gravimetric feeders or the equivalent.
- The slurry drier coal feed system is to provide at least two coal entry points per drier. Slurry driers are 40 ft in height and will be elevated 10 ft above grade.
- Oxygen concentration in the slurry drier vent gas is not to exceed 2.0 mol% at any time.
- Vapor from the slurry drier may not be allowed to escape to the atmosphere through the coal feed system.
- The feed point of coal into the slurry driers (downstream of the feeders) marks the onsite/offsite interface for the coal feed.
- A sketch of the coal storage and handling facilities is shown in Figure 3.

Utilities

The following are the bases for providing all utilities to the onsite units within the EDS plant. All utility loads do not include any load growth or reserve capacity factors. Utility contingency factors for load growth and reserve capacity are to be related to the level of engineering development and will be determined during the offsites design phase. All utilities are to be delivered to the onsite units battery limit block valves.

● Fuel System

Three different fuels are to be utilized in the plant. Low Btu gas (LBG) is the major plant fuel. The composition of LBG is given in Table 3. C₂⁻ high Btu gas (HBG) will be used as backup for the onsite fuel system. HBG will also serve as startup and emergency fuel for the offsite fuel system. The composition of HBG is given in Table 4. Both LBG and Wyoming coal could be fired in the offsite boilers. Refer to Table 2 for the coal composition. The LBG fuel system is to include the collection of the LBG at the battery limits of the H₂S removal units in FLEXICOKING and its delivery to the users at the unit battery limits. Likewise, the C₂⁻ HBG backup fuel system is to include the delivery of HBG to the battery limits of the slurry furnace area. Onsite fuel balances for the various plant operating modes are given in Table 5. These balances and the following guidelines form the basis for the fuel system:

- LBG is available for all onsite process furnace needs.
- The LBG is available at the FLEXICOKING unit battery limits at 110°F and 22 psig.
- The plant fuel is to be available at the user's battery limits at a minimum pressure of 10 psig.
- The use of auxiliary fuel or pilot burners is not required for the combustion of LBG. No preheating is required for its ignition.
- C₂⁻ HBG backup fuel system is to be provided. Both LBG and HBG will be utilized in the liquefaction slurry furnaces when insufficient LBG is being produced. Facilities are to be provided to deliver up to 7500 SCFM of HBG to the battery limits of the slurry furnace area.
- Startup, emergency and backup fuel in the offsite area is to be C₂⁻ HBG. HBG is to be supplied from the pipeline provided for HBG product sales (see page 12).
- Startup fuel for the onsite area is to be HBG and LBG:
 - + Each FLEXICOKING unit requires 100 MBtu/hr of HBG (~1700 SCFM) as auxiliary fuel during startup. FLEXICOKING units are to be started up one at a time.
 - + Other onsite startup fuel needs are to be met by LBG from the FLEXICOKING unit. During initial startup, the FLEXICOKING unit is to be commissioned early using petroleum residuum as feed. Subsequent startups will utilize stored product (FLEXICOKING gas oil and scrubber liquids) as feed. Commissioning is to be done at 75% throughput (20 kB/D). The feed stream is to be available at 60 psig at the FLEXICOKING unit battery limits.
 - + Maximum FLEXICOKING unit throughput feeding stored coker products is about 75% (20 kB/D).
- Offsite coal-fired boilers are to be used for steam generation as necessary.
- Offsite boilers may be dual fired (coal/LBG) if desired.
- The variability in the LBG heating-value/rate is expected to be ± 5%.
- The variability in the onsite fuel needs is small, (+10% of the solvent hydrogenation requirements).
- The total variability in the onsite fuel system is expected to occur in a continuous random fashion. This variability could occur over a one-hour period.

- The short-term onsite fuel system variability is to be accommodated by varying the coal firing rate in the offsite boilers.
 - The spillover of LBG into the offsite boilers is to be at least twice the variability in the onsite fuel system.
 - Flaring of LBG in the safety flare system is an unacceptable method for the disposal of surplus fuel.
 - The fuel system is to be designed such that no operating problems are encountered during a plant turnaround or during a FLEXICOKING unit outage.
 - Pilot fuel for the safety flare system and for all furnaces is to be LBG. The LBG for the pilot burners in onsite furnaces is to be provided from the user's main fuel supply line, upstream of the fuel control valve. Onsite furnaces are to be provided with a low pressure cut-out in the pilot fuel line. The pilot fuel system for the onsite furnaces will be provided with the onsite facilities.
 - The slurry drier vent gas and VPS offgas streams are to be sent to the offsite boilers to be burned. The rates and composition of these streams are given in Table 6.
 - During an H₂ recovery unit outage, as much of its feed as possible (fractionator offgas and H₂ purge gas) is to be burned in the offsite boilers:
 - + Initially, after H₂ recovery unit outage, its feed is sent to the safety flare system.
 - + Facilities are to be provided to subsequently send as much of this gas as possible to the offsite boilers.
 - + As much coal as possible should be backed out from the offsite boilers while maintaining the minimum coal firing rate.
 - + LBG production from FLEXICOKING will be reduced in an orderly and timely manner, and only the minimum spillover of LBG will be sent to offsites.
 - + The outage will last 2 days.
 - + The rate and composition of fractionator offgas and H₂ purge gas are given in Table 7. The gases are available at the H₂ recovery battery limits.
- Raw Water/Boiler Feedwater
 - Raw water supply

- + Raw water is to be provided from a source 45 miles from the plant site. A reservoir is required for the storage of water during low flow periods in the river. The reservoir is to be provided as part of the EDS plant offsites.
- + Raw water quality is assumed to be equal to that from the Powder River (see Table 8).
- + Flow rates for the water supply source are given in Table 8. The annual average use of raw water is to be no more than 10,000 gpm. The maximum raw water rate to the reservoir is to be no more than 30% of the total flow of the river.
- + The right-of-way from the reservoir requires one river/road crossing per mile. The terrain is assumed to be rolling and steep hills with a maximum elevation difference of 200 ft per mile. The reservoir site is about 250 ft higher in elevation than the plant site.
- + Electric power is available at the battery limits of the reservoir at a voltage level of 345 kV.
- The onsite requirements for industrial water are given in Table 9.
- Boiler feedwater is to be provided at 250°F and 700 psig. Onsite requirements are given in Table 10. These loads exclude blowdown; blowdown rate is to be decided during the offsites design phase.
- Demineralized water is to be provided at 150 psig. Onsite requirements, including blowdown, are given in Table 11.
- Steam/Condensate
 - High pressure steam is to be provided to the onsite unit battery limits at 600 psig and 750°F.
 - Low pressure steam is to be provided to the onsite unit battery limits at 125 psig and 450°F.
 - All condensate returned from the onsite units is clean. Condensate is delivered to the condensate manifold from the onsite steam traps.
 - No equipment will be provided in the onsite units to prevent the liquid condensate from vaporizing after the steam traps.
 - Onsite requirements and generation of high pressure steam and condensate are summarized in Table 12.
 - Onsite requirements and generation of low pressure steam and condensate are summarized in Table 13.

- Cooling Water

- Cooling water was assumed to be provided at 85°F (max.) and 60 psig (min.) in the onsite design.
- The combined return temperature for cooling water from the onsite units is 110°F (average) and 117°F (max.).
- Onsite requirements for cooling water are given in Table 14. These loads exclude cooling water requirements for condensing steam turbines.

- Inert Gas

- Nitrogen is available as a waste stream from the process oxygen plants at 1 psig. About 37,000 SCFM of N₂ is available during normal operation (18,000 SCFM during turnaround operation).
- N₂ is to be compressed and distributed at 150 psig by offsite equipment.
- A backup N₂ system is to be provided to supply inert gas when the oxygen plants are not operating.
- Inert gas requirements are given in Table 15.

- Compressed Air

- Instrument air is to be provided at 90 psig. Requirements are given in Table 16.
- Industrial air is to be provided at 90 psig. Requirements are given in Table 17.

- Electrical Power

- All electrical power can be purchased from the local utility, with the supply available at the plant battery limits and the river site.
- Voltage level of the purchased power is to be 345 kV.
- Onsite requirements for electric power are given in Table 18. Requirements are listed under two columns:
 - + "All Electric" assumes the use of electric motors for all drivers.
 - + "With Steam Turbines" lists the loads excluding power to large drivers for the FLEXICOKING units, O₂ plants, and H₂ recovery units. These drivers may be driven by electric motors or steam turbines.
- The use of onsite steam turbines or offsite power generation is to be evaluated during the offsite design phase.

Tankage, Product Handling, and Shipping

Estimated product, byproduct and intermediate stream rates are given in Table 19. Storage facilities for these streams are to be provided in the offsites area unless otherwise indicated. Facilities for transporting the stored material to its ultimate disposition (product sales, onsite units, etc.) are also to be provided. The bases for providing these offsite facilities are described below:

- Tankage and Interconnecting Lines
 - The minimum required tankage for products and intermediate streams is shown in Table 20.
 - Rundown conditions and physical properties for streams going to tankage are shown in Table 21.
 - All product storage facilities are sized to allow 70% of normal deliveries during a major turnaround (T/A) (35 days duration per train, back-to-back).
 - Offsites tankage to be sized using maximum production rates. Fuel oil tankage to be sized on the maximum rate excluding flux material.
 - Minimum tankage requirements shown in Table 20 do not include blending tanks for the fuel oil. Blending facilities for the fuel oil (including any blending tanks) are to be provided in the offsite area.
 - Fuel oil is to be blended from liquefaction mid-distillate (excess spent solvent), 350/400°FVT heavy naphtha, liquefaction vacuum gas oil (VGO) and FLEXICOKING unit products. Blendstock storage has been specified for each component. Total blendstock and fuel oil product storage is sized to maintain 70% of normal deliveries during a major T/A. The bulk of the storage is to be for blendstock with storage for fuel oil product sized for a 10 day advanced/delay of railroad shipments.
 - Fuel oil product is to have no more than 0.58 wt% sulfur (equivalent to less than 0.8 lb SO₂/MBtu) and no more than 0.15 wt% solids (equivalent to less than 0.1 lb particulate/MBtu). Blendstock quality is such that normal production rates will satisfy the fuel oil quality specifications, including blending tolerances.
 - Tankage of VGO and FLEXICOKING products does not require blanketing.
 - Facilities for storage of C₂⁻ HBG (i.e., gas holder) are not required.
 - Facilities are to be provided to return intermediate streams to the appropriate onsite unit. These facilities should be sized as follows:

- + Vacuum bottoms - Facilities are to be sized such that both FLEXICOKING units can be fed stored vacuum bottoms at the normal vacuum bottoms rate (560 k lb/hr total for 2 units excluding flux). Pressure level of the vacuum bottoms is to be 60 psig at the FLEXICOKING unit battery limits.
- + Liquefaction spent solvent - Facilities are to be sized to allow one solvent hydrogenation unit to operate using stored spent solvent. Material is to be delivered at 150 psig to the battery limits of the solvent hydrogenation units or the slurry drying units.
- + Liquefaction hydrogenated recycle solvent - Facilities are to be sized to allow two liquefaction units (one onsite train) to operate simultaneously while using stored recycle solvent. Material is to be delivered to the battery limits of the slurry drying units at 150 psig.
- + FLEXICOKING products - Facilities are to be sized to return 20 kB/SD of these products to the FLEXICOKING units as startup feed. The material is to be delivered at 100 psig to the FLEXICOKING unit battery limits.
- + Phenolic/sour water - Facilities are to be sized to allow one sour water stripping unit to operate at its full capacity using stored water. Pressure level at the battery limits of the sour water stripping unit is to be 75 psig.
- During a FLEXICOKING unit outage, the excess vacuum bottoms feed is to be stored. The vacuum bottoms in storage are to be fluxed with VGO. Facilities are to be provided for adding VGO as flux such that the vacuum bottoms in storage contain 35.6 wt% VGO. The maximum expected rate of vacuum bottoms to storage is 100% of the normal rate to the FLEXICOKING units.
- The 900°F+ vacuum bottoms feed to partial oxidation will not be stored.
- Vacuum bottoms will polymerize with time and cause the viscosity to increase. The maximum age of fluxed vacuum bottoms is about 25 days before it becomes unpumpable and must be withdrawn from tankage. Facilities are required to withdraw and dispose of the stored vacuum bottoms on an emergency basis.
- Vapor released from stored vacuum bottoms may not be released to the atmosphere. The composition and rate of vapor release from vacuum bottoms plus flux oil are given in Table 22. Facilities are to be provided for the recovery or disposal of this vapor.

- The vacuum bottoms storage facilities are to be blanketed with an inert gas. Blanketing is required to keep O₂ out of the vacuum bottoms in storage.
 - Facilities will be provided in the onsite units to flush all the lines carrying slurry streams. This will include lines carrying vacuum bottoms to and from tankage.
 - + Spent solvent or recycle solvent from storage is to serve as flushing oil for all slurry lines except the vacuum bottoms lines. Pumping facilities are to be sized for 170 kB/SD. The solvent is to be delivered to the battery limits of slurry drying at 150 psig.
 - + VGO from storage is to serve as flushing oil for the vacuum bottoms lines. Pumping facilities are to be sized for 900 gpm. VGO flushing oil is to be delivered to the FLEXICOKING battery limits at 400°F and 150 psig.
 - + Pumping for flushing services to be available under any contingency.
 - During turnaround (T/A) the single vacuum pipestill in operation will have a 850°F bottoms cut point. Therefore, during turnarounds both FLEXICOKING and partial oxidation will process 850°F+ vacuum bottoms.
- Product Handling and Shipping
- Product loading facilities are to be provided for all products and byproducts.
 - Facilities are to be provided for the shipment of C₂⁻ HBG by pipeline. A commercial gas pipeline is assumed to be available about 10 miles from the EDS plant battery limits. The production rate and composition of C₂⁻ gas are given in Table 4. The C₂⁻ gas is available at the hydrogen recovery section battery limits at 1000 psig. No further compression of C₂⁻ HBG is required.
 - Facilities are to be provided for the import of C₂⁻ HBG as necessary for startup and backup fuel.
 - Fuel oil, naphtha, C₃ LPG, C₄ LPG, ammonia, sulfur, and phenol are to be shipped by tank car or tank truck. Railroad shipping facilities are to be sized for the full plant production. Tank truck shipping facilities are to be sized for 25% of the plant production.
 - Fuel oil facilities are to be maintained at 160°F.
 - Railroad lines and roads are available about 25 miles from the plant battery limits for product shipment (and receipt). The railroad provides all the necessary equipment except for the required loading

facilities, and the rail spur from the main railroad lines. Rail cars can be either provided by the railroad or purchased.

- Railroad and tank truck shipments are to be made daily, seven days per week, during one eight-hour shift.
- Products shipped by pipelines are to be metered. All other products need only to be gauged.

Chemicals, Catalyst and Miscellaneous Raw Materials

Facilities for providing chemicals, catalysts and other miscellaneous raw materials are to be designed consistent with the following bases:

- Chemicals and catalyst storage requirements are given in Table 23.
- Chemicals and miscellaneous raw materials are to be received by rail or trucks on a weekly basis, during one eight-hour shift. All railroad facilities are to be sized for receipt of all the plant requirements. Truck facilities are to be sized for handling 25% of the plant requirements.
- Catalysts are to be received by rail when necessary. Adequate catalyst storage and handling facilities are to be provided.
- All catalysts and chemicals except for caustic, isopropyl ether, CO₂ removal solution and inhibitor, H₂S removal solution, and DEA are to be received in bags.
- Solvent hydrogenation catalyst is to be received in bulk.
- Caustic is to be received by tank cars or tank trucks as 50° Bé solution.
- H₂S removal solution, CO₂ removal catalyst and CO₂ removal inhibitor are to be received by tank cars or tank trucks.
- Isopropyl ether (IPE) is to be received by tank cars or tank trucks as 100 wt% IPE. Pure IPE is to be provided to the gas and water treating battery limits at 50 psig.
- DEA is to be received by tank cars or tank trucks as 100 wt% DEA. Facilities for diluting it to a 30 wt% solution are to be provided. These facilities are to include pumps to transfer the dilute solution to the onsite tankage. Dilute DEA solution is to be provided to the gas and water treating battery limits at 50 psig.
- Caustic is to be provided to the gas and water treating battery limits at 65 psig.

- Caustic is also to be provided to the light ends battery limits at 50 psig and a maximum rate of 20 gpm.
- Hydrogen generation uses a solution made up of 30 wt% potassium hydroxide, 10 wt% CO₂ removal catalyst and 60 wt% water. Facilities are to be provided for blending the solution and transferring it to the hydrogen generation battery limits at a pressure level of 50 psig.
- H₂S removal solution is to be provided to the H₂S removal units' battery limits at 50 psig.
- Sand and gravel are to be received in bulk.
- Facilities are to be provided to receive 6000 ST of petroleum coke. This coke is to be transferred to the onsite coke silos for use in the initial startup of the FLEXICOKING units. Unloading facilities are not needed for petroleum coke (contractor will handle unloading of petroleum coke).
- Facilities are to be provided to receive 150 kB of petroleum residuum. The residuum is to be stored in the FLEXICOKING unit products tank for use in the initial startup of the FLEXICOKING unit.
- Railroad lines and roads will be available about 25 miles from the plant battery limits.

Environmental Issues

The plant is to be designed to meet, at startup, the projected emission control standards for 1987. The following basis should be used in designing all plant facilities:

- Air
 - The projected air pollution standards are shown in Table 24.
 - Flaring LBG during normal operations is not an acceptable method for disposal of surplus fuel.
- Water
 - The projected water effluent standards do not require zero wastewater discharge. However, to minimize raw water intake, zero wastewater discharge with maximum water reuse is to be provided.
 - Sufficient reliability is to be built into the wastewater treatment units to insure that no more than one onsite process train is out of service at a time as a result of outages in the treatment facilities.

- Wastewater contaminant levels and the wastewater rate from the onsite treating facilities are shown in Table 25.
- Wastewater is to be utilized as makeup water in the ash handling facilities.
- Solid Waste
 - The disposal area for plant solid waste is to be isolated from that for mine wastes.
 - Mine waste disposal will not be covered in this SDU. Likewise, treatment of leachate from the mine wastes will not be included.
 - Costs for mine wastes disposal and leachate treating will be included in the coal costs. In the final design of a commercial plant, treatment of leachate from mine wastes would likely be combined with other wastewater treating.
 - Solid wastes from the EDS process plant are to be disposed of in an area initially 1/2 mile from the plant. Disposal area for a 30 year plant life is to be provided.
 - EDS solid wastes are to be placed in conventional secure landfills and impoundments (similar to those currently used for mine waste). The secure area must include an impermeable barrier layer.
 - A drainage collection system is to be provided for the EDS plant solid waste disposal area. The leachate collected is to be routed to the EDS wastewater treatment facilities prior to reuse or disposal.
 - A summary of the rates and characteristics of all the solid wastes produced in the onsite area is shown in Table 26.
 - Provisions for land-farming of the wastewater treatment sludge are to be included in the plant.

Safety and Fire Protection

Facilities are to be provided for personnel protection and safe operation of the plant including safety blowdown, knockout drums and emergency flares. The facilities are to be sized to handle the maximum safety valve releases from the plant; these releases are given in Table 27. For fire protection, firewater is to be provided at a minimum rate of 8000 gpm for each risk area.

Miscellaneous Offsite Bases

- Any mobile equipment required for operation of the plant is to be provided by offsites.
- Direct digital control is to be used in all onsite process units. Sufficient space (2000 ft²) for these facilities is to be provided in the control room.
- A plot plan for the entire plant is shown in Figure 4. The offsite facilities shown here represent the offsite design for the Illinois Coal Market Flexibility Sensitivity Case. The offsite layout is to be updated during the offsite design phase.

REFERENCE

1. EDS Commercial Plant Study Design Update, Onsite Design Basis - Wyoming Coal Case, Interim Report FE-2893-59.
2. EDS Commercial Plant Study Design Update, Revised Onsite Design Basis - Illinois Coal Base Case, Interim Report FE-2893-32.
3. EDS Commercial Plant Study Design Update, Offsite Design Basis - Illinois Coal Base Case, Interim Report FE-2893-33.
4. EDS Commercial Plant Study Design Update, Onsite Design Basis - Illinois Coal Market Flexibility Sensitivity Case, Interim Report FE-2893-36.
5. EDS Commercial Plant Study Design Update, Offsite Design Basis - Illinois Coal Market Flexibility Sensitivity Case, Interim Report FE-2893-37.

TABLE 1
EDS COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS - WYOMING COAL CASE
METEOROLOGICAL DESIGN CONDITIONS⁽¹⁾

Temperatures

Dry Bulb, Max. Design	95°F
Min. Design	-30°F
Wet Bulb, Max. Design	65°F

Precipitation

Average Annual Precipitation	0.042 in./24 hrs.
Frequency of Precipitation	40 days/yr. ⁽²⁾
Maximum Precipitation	4.1 in./24 hrs.
Design Snow Load	12.5 lbs/ft ³

Average Barometric Pressure 12.5 psia⁽³⁾

Notes:

- (1) Meteorological information is typical for Northeastern Wyoming locations.
- (2) Average number of days per year when the melted equivalent precipitation is 0.10 inches or more.
- (3) Estimated average barometric pressure based on elevation of 4600 ft.

TABLE 2

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS - WYOMING COAL CASE

COAL CHARACTERISTICS
WYOMING SUBBITUMINOUS COAL (1)

Coal Composition (2)

	<u>Dry Wt%</u>	<u>"As Received" Wt% (3)</u>
C	66.92	46.09
H	4.87	3.35
O (By difference)	19.78	13.62
N	0.88	0.61
S	0.37	0.25
Ash (SO ₃ free)	7.18	4.96
Water	--	<u>31.12</u>
Total	100.00	100.00

Ash Composition (2)

	<u>Wt%</u>	
	<u>Dry</u>	<u>SO₃ Free</u>
P ₂ O ₅	0.95	1.16
SiO ₂	29.14	35.55
Fe ₂ O ₃	4.49	5.48
Al ₂ O ₃	14.32	17.47
TiO ₂	0.90	1.10
CaO	25.00	30.51
MgO	5.39	6.58
SO ₃	18.02	-
K ₂ O	0.40	0.49
Na ₂ O	<u>1.39</u>	<u>1.69</u>
Total	100.00	100.00

TABLE 2 (CONT'D)

COAL CHARACTERISTICS

Coal Size Distribution -
"As Received"

<u>Size</u>	<u>Wt%</u>
+4"	0.9
4" to 3"	1.1
3" to 2"	4.0
2" to 1"	16.0
1" to 1/2"	21.0
1/2" to 1/4"	19.0
1/4" to 8 mesh	19.0
8 mesh to 16 mesh	8.0
16 mesh to 30 mesh	5.0
-30 mesh	6.0
Total	100.0

Coal Physical Properties

● Specific Gravity	
+ Ash	2.7
+ Organic	1.4
● Bulk Density, lb/ft ³	45.0-50.0
● Angle of Repose, degrees	40
● Hardgrove Grindability Index	58.0
● Heating Value, Btu/lb (dry)	
+ Higher	11723
+ Lower	11010
● Surface Moisture, %	0-1.0

Notes:

- (1) Coal characteristics are for coal from the Wyodak mine.
- (2) Compositions are average.
- (3) Coal "as received" from the mining operations.

TABLE 3

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS-WYOMING COAL CASE

LOW BTU GAS COMPOSITION

<u>Composition, Mole %</u>	<u>"Normal"</u>	<u>Design</u>
CH ₄	1.6	1.6
H ₂	20.0	19.6
CO	18.4	18.3
CO ₂	11.3	11.3
N ₂	45.0	45.5
H ₂ O	<u>3.7</u>	<u>3.7</u>
	100.0	100.0
H ₂ S, VPPM	3	3
COS, VPPM	11	11
<u>Heating Value, Btu/SCF</u>		
Lower Heating Value (dry)	133	131
Higher Heating Value (dry)	139	138

TABLE 4

COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS-WYOMING COAL CASE
C₂ GAS PRODUCTION AND COMPOSITION

<u>C₂ Gas Production Rate</u>	<u>"Normal"</u>	<u>Maximum</u>	<u>Minimum</u>
SCFM	51,100	53,500	25,100
MBtu/hr	3,120	3,260	1,530

H₂ Recovery Battery Limit Conditions

Temperature, °F ⁽¹⁾	150
Pressure, psig ⁽¹⁾	1000
High Heating Value, Btu/SCF	1124
Low Heating Value, Btu/SCF	1017

<u>Composition</u>	<u>Mole %</u>	<u>wt.%</u>
H ₂	3.5	0.4
CO	4.7	6.4
N ₂	3.8	5.4
Methane	63.8	50.8
Ethane	21.8	31.5
Propane	1.9	4.1
Butane	0.2	0.6
Pentane ⁺	<u>0.3</u>	<u>0.8</u>
Total	100.0	100.0

Note:

- (1) C₂ gas is also available at 60 psig and 120°F for use as backup fuel at the H₂ recovery battery limits.

TABLE 5

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS-WYOMING COAL CASE

ONSITE FUEL BALANCE

"Normal" Operation (1)

	<u>Fuel, MBtu/hr</u>
Fuel Fired	
Slurry Drying	0
Liquefaction	1790
Fractionation (APS/VPS)	0
Solvent Hydrogenation	162 ± 16
FLEXICOKING	130
H ₂ Generation/O ₂ Plant	0
H ₂ Recovery	0
Gas & Water Treating	0
Light Ends	0.1
Total	2082 ± 16
Fuel Production	
FLEXICOKING (LBG)	3100 ± 155
H ₂ Recovery (C ₂ ⁻ HBG)	0
Total	3100 ± 155
Fuel to Offsites (LBG)	1018 ± 171

TABLE 5 (CONT'D)

ONSITE FUEL BALANCE

<u>Maximum Operation (2)</u>	<u>Fuel, MBtu/hr</u>
Fuel Fired	
Slurry Drying	0
Liquefaction	1790
Fractionation (APS/VPS)	0
Solvent Hydrogenation	190 + <u>19</u>
FLEXICOKING	183
H ₂ Generation/O ₂ Plant	0
H ₂ Recovery	0
Gas & Water Treating	0
Light Ends	<u>0.1</u>
Total	2163 + <u>19</u>
Fuel Production	
FLEXICOKING (LHG)	4420 + <u>221</u>
H ₂ Recovery (C ₂ HBG)	<u>0</u>
Total	4420 + <u>221</u>
Fuel to Offsites (LHG)	2257 + <u>240</u>

TABLE 5 (CONT'D)

ONSITE FUEL BALANCE

<u>Minimum Operation</u> (3)	<u>Fuel, MBtu/hr</u>
Fuel Fired	
Slurry Drying	0
Liquefaction	895
Fractionation (APS/VPS)	0
Solvent Hydrogenation	68 ± 7
FLEXICOKING	67
H ₂ Generation/O ₂ Plant	0
H ₂ Recovery	0
Gas & Water Treating	0
Light Ends	<u>0.1</u>
Total	1030 ± 7
Fuel Production	
FLEXICOKING (LBG)	1588 ± 79
H ₂ Recovery (C ₂ ⁻ HBG)	<u>0</u>
Total	1588 ± 79
Fuel to Offsites (LBG)	558 ± 86

TABLE 5 (CONT'D)

ONSITE FUEL BALANCE

FLEXICOKING Unit Outage-EOR⁽⁴⁾

	<u>Fuel, MBtu/hr</u>
Fuel Fired	
Slurry Drying	0
Liquefaction	1790
Fractionation (APS/VPS)	0
Solvent Hydrogenation	190 + 19
FLEXICOKING	95
H ₂ Generation/O ₂ Plant	0
H ₂ Recovery	0
Gas & Water Treating	0
Light Ends	<u>0.1</u>
Total	2075 + 19
Fuel Production	
FLEXICOKING (LBG)	2335 + 117
H ₂ Recovery (C ₂ HBG)	<u>12</u>
Total	2347 + 117
Fuel to Offsites (LBG)	272 + 136

Notes:

- (1) "Normal" Operation: All units operating at normal throughput (average of SOR and EOR).
- (2) Maximum Operation: Represents simultaneous maximum for the plant. Occurs during vacuum bottoms inventory pull-down at EOR.
- (3) Minimum Operation: Represents simultaneous minimum for the plant. Occurs during plant turnaround at SOR.
- (4) FLEXICOKING Unit Outage-EOR: During this operation, the maximum amount of coal is fired in the offsite boilers.

TABLE 6

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS-WYOMING COAL CASE

ONSITE GENERATED GAS TO OFFSITE BOILERS

	<u>Slurry Drier Vent Gas</u>	<u>VPS Offgas</u>
<u>Characteristics</u>		
Rate, MSCFD Per Plant	10.7	0.7
Temperature, °F	490	130
Pressure, psig	20	5
Molecular wt	27.1	36.7
<u>Composition, mol%</u>		
O ₂	-	7.5
N ₂	84.8	28.7
H ₂ O	14.5	11.3
Hydrocarbon	0.7 ⁽¹⁾	47.5 ⁽²⁾
H ₂ S	30 vppm	5.0
Total	100.0	100.0

Notes:

(1) Slurry Drier Vent Gas Hydrocarbon Average MW = 108.7

(2) VPS Offgas Hydrocarbon Average MW = 46.2

TABLE 7

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS-WYOMING COAL CASE

HYDROGEN RECOVERY FEED GAS RATE AND COMPOSITION⁽¹⁾

	<u>Offgas</u>	<u>Purge Gas</u>
Maximum Rate, MSCF/SD (dry)	53.1	55.9
<u>Battery Limits Conditions</u>		
Temperature, °F	120	117
Pressure, psig	50	1535
<u>Composition, wt%</u>		
H ₂	4.5	11.2
CO	12.8	12.0
N ₂	6.7	8.0
C ₁	20.1	35.9
C ₂	14.6	16.9
C ₃	13.2	10.3
C ₄	7.2	3.0
C ₅₊	19.3	2.5
H ₂ O	1.6	0.2
Molecular Wt.	18.4	10.6

Note:

- (1) Immediately following a H₂ recovery unit outage, these streams are to be sent to the safety flare. Afterwards, part of the gas is to be diverted to the offsite boilers in an orderly manner.

TABLE 8**EDS COMMERCIAL PLANT STUDY DESIGN UPDATE****OFFSITE DESIGN BASIS-WYOMING COAL CASE****RAW WATER QUALITY AND RATE**⁽¹⁾

<u>Constituent</u>	<u>Units</u>	<u>Yearly Average</u>	<u>Maximum</u> ⁽²⁾
<u>Cations</u>			
Calcium (Ca ⁺⁺)	mg/l	155	200
Magnesium (Mg ⁺⁺)	mg/l	50	95
Iron (Fe ⁺⁺)	mg/l	Trace	Trace
Sodium (Na ⁺)	mg/l	260	740
Potassium (K ⁺)	mg/l	5.5	12
Ammonium (NH ₄ ⁺)	mg/l	None	None
Boron (B ⁺⁺⁺)	mg/l	2	4
 <u>Anions</u>			
Bicarbonate (HCO ₃ ⁻)	mg/l	250	480
Carbonate (CO ₃ ⁻⁻)	mg/l	None	None
Sulfate (SO ₄ ⁻⁻)	mg/l	570	1400
Sulfite (SO ₃ ⁻⁻)	mg/l	None	None
Sulfides (S ⁻⁻)	mg/l	None	None
Chloride (Cl ⁻)	mg/l	165	540
Nitrate (NO ₃ ⁻)	mg/l	0.35	0.75
Phosphate (PO ₄ ⁻⁻⁻⁻)	mg/l	None	None
Total Hardness (Ca, Mg)	mg/l	480	850
Turbidity	J.T.U.	150	3000
Carbon Dioxide, Free	mg/l	None	None
Silica (SiO ₂)	mg/l	9.1	14
Hydrazine (N ₂ H ₂)	mg/l	None	None
pH		8.8	

TABLE 8 (CONT'D)

RAW WATER QUALITY AND RATE⁽¹⁾

<u>River Flow Rate</u>	<u>kgpm</u>
Annual Average	123
Minimum	no flow
Monthly Averages:	
January	30.2
February	49.4
March	141.8
April	202.0
May	429.1
June	141.4
July	53.4
August	57.5
September	21.9
October	123.9
November	68.2
December	34.3

Note:

- (1) Characteristics for the Powder River, (Sheridan County, WY).
- (2) Maximum usually occurs during periods of low flow.

TABLE 9

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

INDUSTRIAL WATER SUMMARY⁽¹⁾

<u>Requirements, gpm Per Plant</u>	<u>"Normal"</u> ⁽²⁾	<u>Maximum</u>
Slurry Drying	0	0
Liquefaction	0	48
Fractionation (APS/VPS)	0	0
Solvent Hydrogenation	0	72
FLEXICOKING	694	1000
Hydrogen Generation	0	0
Oxygen Plant	0	0
Hydrogen Recovery	0	0
Gas and Water Treating	0	0
Light Ends	<u>0</u>	<u>0</u>
Total Normal	694	
Simultaneous Maximum		1000

Notes:

(1) Industrial water can be equal in quality to treated wastewater of less than 2500 ppm total dissolved solids. It is to be available at 75 psig.

(2) Rates during "normal" operation are approximately equal to average.

TABLE 10

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

BOILER FEED WATER SUMMARY ^{(1) (2)}

<u>"Normal" Operation</u> ⁽³⁾	<u>Requirements,</u> <u>gpm Per Plant</u>
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	1098
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	-
	<u>1098</u>
<u>Maximum Operation</u> ⁽⁴⁾	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	1608
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	-
	<u>1608</u>

TABLE 10 (CONT'D)

BOILER FEED WATER SUMMARY (1) (2)

<u>Minimum Operation (5)</u>	<u>Requirements, gpm Per Plant</u>
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	562
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	-
	<hr style="width: 50px; margin-left: auto; margin-right: 0;"/> 562
<u>FLEXICOKING Unit Outage - EOR (6)</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	840
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	-
	<hr style="width: 50px; margin-left: auto; margin-right: 0;"/> 840

TABLE 10 (CONT'D)

BOILER FEED WATER SUMMARY (1) (2)

- (1) Boiler feed water is to be demineralized water from the high pressure steam deaerator available at 250°F and 700 psig.
- (2) Assumes zero blowdown.
- (3) "Normal" Operation: All units operating at normal throughput (average of SOR and EOR). Rates are approximately equal to average.
- (4) Maximum Operation: Represents simultaneous maximum for the plant. Occurs during vacuum bottoms inventory pulldown at EOR.
- (5) Minimum Operation: Represents simultaneous minimum for the plant. Occurs during plant turnaround at SOR.
- (6) FLEXICOKING Unit Outage - EOR: During this operation, the maximum amount of coal is fired in the offsite boilers.

TABLE J 1
EDS COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS - WYOMING COAL CASE
DEMINERALIZED WATER SUMMARY ⁽¹⁾

<u>"Normal" Operation ⁽²⁾</u>	<u>Requirements, gpm Per Plant</u>
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	40
FLEXICOKING ⁽³⁾	103
Hydrogen Generation ⁽⁴⁾	1510
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	120
Light Ends	-
	<u>1773</u>
<u>Maximum Operation ⁽⁵⁾</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	80
FLEXICOKING ⁽³⁾	111
Hydrogen Generation ⁽⁶⁾	1547
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	130
Light Ends	-
	<u>1868</u>

TABLE 11 (CONT'D)
DEMINERALIZED WATER SUMMARY⁽¹⁾

<u>Minimum Operation⁽⁷⁾</u>	<u>Requirements, gpm Per Plant</u>
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	20
FLEXICOKING ⁽³⁾	53
Hydrogen Generation ⁽⁸⁾	736
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	60
Light Ends	<u>-</u>
	869
 <u>FLEXICOKING Unit Outage⁽⁹⁾</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	40
FLEXICOKING ⁽³⁾	78
Hydrogen Generation ⁽⁶⁾	1547
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	120
Light Ends	<u>-</u>
	1785

TABLE 11 (CONT'D)

DEMINERALIZED WATER SUMMARY⁽¹⁾

Notes:

- (1) Demineralized water available at 150 psig.
- (2) "Normal" Operation: All units operating at normal throughput (average of SOR and EOR). Rates are approximately equal to average.
- (3) Used in H₂S Removal solution.
- (4) The demineralized water utilized in H₂ Generation is process related; therefore, it should not have a load-growth factor. It is used to provide makeup water to the H₂ Generation deaerator (this water is chemically consumed in the shift reactors).
- (5) Maximum Operation: Represents simultaneous maximum for the plant. Occurs during vacuum bottoms inventory pulldown at EOR.
- (6) The demineralized water utilized in H₂ Generation is process related; therefore, it should not have a load-growth factor. It is used to provide makeup water to the H₂ Generation deaerator (this water is chemically consumed in the shift reactors).
- (7) Minimum Operation: Represents simultaneous minimum for the plant. Occurs during plant turnaround at SOR.
- (8) The demineralized water utilized in H₂ Generation is process related; therefore, it should not have a load-growth factor. It is used to provide makeup water to the H₂ Generation deaerator (this water is chemically consumed in the shift reactors).
- (9) FLEXICOKING Unit Outage - EOR: During this operation, the maximum amount of coal is fired in the offsite boilers.

TABLE 12

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

HIGH PRESSURE STEAM/CONDENSATE SUMMARY ⁽¹⁾

"NORMAL OPERATION" ⁽²⁾

<u>Steam 600-psig Requirement</u>	<u>k lb/hr Per Plant</u>
Slurry Drying	1346
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	25
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	22
Gas and Water Treating	-
Light Ends	203
Total	<u>1596</u>
 <u>Steam-600 psig Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	549
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	-
Total	<u>549</u>
 <u>High Pressure Condensate Production</u>	
Slurry Drying	1346
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	22
Gas and Water Treating	-
Light Ends	203
Total	<u>1571</u>

TABLE 12 (CONT'D)

HIGH PRESSURE STEAM/CONDENSATE SUMMARY⁽¹⁾

MAXIMUM OPERATION⁽³⁾

<u>Steam-600 psig Requirement</u>	<u>k lb/hr Per Plant</u>
Slurry Drying	1346
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	40
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	23
Gas and Water Treating	-
Light Ends	<u>203</u>
Total	1612
 <u>Steam-600 psig Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	804
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	-
Total	<u>804</u>
 <u>High Pressure Condensate Production</u>	
Slurry Drying	1346
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	23
Gas and Water Treating	-
Light Ends	<u>203</u>
Total	1572

TABLE 12 (CONT'D)

HIGH PRESSURE STEAM/CONDENSATE SUMMARY⁽¹⁾

MINIMUM OPERATION⁽⁴⁾

<u>Steam-600 psig Requirement</u>	<u>k lb/hr Per Plant</u>
Slurry Drying	673
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	13
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	11
Gas and Water Treating	-
Light Ends	<u>101</u>
Total	<u>798</u>
 <u>Steam-600 psig Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	281
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	-
Total	<u>281</u>
 <u>High Pressure Condensate Production</u>	
Slurry Drying	673
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	11
Gas and Water Treating	-
Light Ends	<u>101</u>
Total	<u>785</u>

TABLE 12 (CONT'D)

HIGH PRESSURE STEAM/CONDENSATE SUMMARY⁽¹⁾

FLEXICOKING UNIT OUTAGE-EOR⁽⁵⁾

<u>Steam-600 psig Requirement</u>	<u>k lb/hr Per Plant</u>
Slurry Drying	1346
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	18
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	23
Gas and Water Treating	-
Light Ends	<u>203</u>
Total	1590
 <u>Steam-600 psig Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	420
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	<u>-</u>
Total	420
 <u>High Pressure Condensate Production</u>	
Slurry Drying	1346
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	23
Gas and Water Treating	-
Light Ends	<u>203</u>
Total	1572

TABLE 12 (CONT'D)

Notes:

- (1) 600 psig steam is to be available at 750°F.
- (2) "Normal" Operation: All units operating at normal throughput (average of SOR and EOR).
- (3) Maximum Operation: Represents simultaneous maximum for the plant. Occurs during vacuum bottoms inventory pulldown at EOR.
- (4) Minimum Operation: Represents simultaneous minimum for the plant. Occurs during plant turnaround at SOR.
- (5) FLEXICOKING Unit Outage - EOR: During this operation, the maximum amount of coal is fired in the offsite boilers.

TABLE 13

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

LOW PRESSURE STEAM/CONDENSATE SUMMARY⁽¹⁾

"NORMAL" OPERATIONS⁽²⁾

<u>Steam-125 psig Requirement</u>	<u>k lb/hr Per Plant</u>
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	26
Solvent Hydrogenation	25
FLEXICOKING	562
Hydrogen Generation ⁽³⁾	458
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	668
Light Ends	<u>14</u>
Total	1753
 <u>Steam-125 psig Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	<u>-</u>
Total	0
 <u>Low Pressure Condensate Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	668
Light Ends	<u>14</u>
Total	682

TABLE 13 (CONT'D)

LOW PRESSURE STEAM/CONDENSATE SUMMARY⁽¹⁾

MAXIMUM OPERATION⁽⁴⁾

<u>Steam-125 psig Requirement</u>	<u>k lb/hr Per Plant</u>
Slurry Drying	-
Liquefaction ⁽⁵⁾	-
Fractionation (APS/VPS)	30
Solvent Hydrogenation ⁽⁶⁾	25
FLEXICOKING	835
Hydrogen Generation ⁽⁷⁾	470
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	668
Light Ends	<u>14</u>
Total	2042
 <u>Steam-125 psig Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	-
Total	<u>0</u>
 <u>Low Pressure Condensate Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	668
Light Ends	<u>14</u>
Total	682

TABLE 13 (CONT'D)

LOW PRESSURE STEAM/CONDENSATE SUMMARY (1)

MINIMUM OPERATION (8)

<u>Steam-125 psig Requirement</u>	<u>k lb/hr Per Plant</u>
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	13
Solvent Hydrogenation	12
FLEXICOKING (9)	287
Hydrogen Generation	224
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	334
Light Ends	7
Total	<u>877</u>
<u>Steam-125 psig Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	-
Total	<u>0</u>
<u>Low Pressure Condensate Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	334
Light Ends	7
Total	<u>341</u>

TABLE 13 (CONT'D)

LOW PRESSURE STEAM/CONDENSATE SUMMARY⁽¹⁾

FLEXICOKING UNIT OUTAGE-EOR⁽¹⁰⁾

<u>Steam-125 psig Requirement</u>	<u>k lb/hr Per Plant</u>
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	26
Solvent Hydrogenation	25
FLEXICOKING	412
Hydrogen Generation ⁽⁷⁾	470
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	668
Light Ends	<u>14</u>
Total	1615
 <u>Steam-125 psig Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	-
Light Ends	-
Total	<u>0</u>
 <u>Low Pressure Condensate Production</u>	
Slurry Drying	-
Liquefaction	-
Fractionation (APS/VPS)	-
Solvent Hydrogenation	-
FLEXICOKING	-
Hydrogen Generation	-
Oxygen Plant	-
Hydrogen Recovery	-
Gas and Water Treating	668
Light Ends	<u>14</u>
Total	682

TABLE 13 (CONT'D)

Notes:

- (1) 125 psig steam is to be available at 450°F.
- (2) "Normal" Operation: All units operating at normal throughput (average of SOR and EOR).
- (3) In addition to the 125 psig steam requirement, there is a 15 psig steam requirement of 114 k lb/hr to the H₂ plant deaerator.
- (4) Maximum Operation: Represents simultaneous maximum for the plant. Occurs during vacuum bottoms inventory pulldown at EOR.
- (5) Maximum 125 psig steam requirement for Liquefaction is 151 klb/hr per plant during turnaround.
- (6) Maximum 125 psig steam requirement for Solvent Hydrogenation is 109 klb/hr per plant during turnaround,
- (7) In addition to the 125 psig steam requirement, there is a 15 psig steam requirement of 117 klb/hr to the H₂ plant deaerator.
- (8) Minimum Operation: Represents simultaneous minimum for the plant. Occurs during plant turnaround at SOR.
- (9) In addition to the 125 psig steam requirement, there is a 15 psig steam requirement of 56 klb/hr to the H₂ plant deaerator.
- (10) FLEXICOKING Unit Outage-EOR: During this operation the maximum amount of coal is fired in the offsite boilers.

TABLE 14

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

COOLING WATER SUMMARY⁽¹⁾

<u>Requirements, gpm Per Plant</u>	<u>"Normal"</u>	<u>Maximum</u>
Slurry Drying	6275	6275
Liquefaction	4530	4530
Fractionation (APS/VPS)	4316	4316
Solvent Hydrogenation	6878	6878
FLEXICOKING	22630	22630
Hydrogen Generation	11160	11160
Oxygen Plant	23500	23500
Hydrogen Recovery	5720	5720
Gas and Water Treating	10415	10415
Light Ends	<u>5766</u>	<u>5766</u>
Total Normal ⁽²⁾	101190	101190
Simultaneous Maximum ⁽³⁾		

Notes:

- (1) Cooling water supply at 85°F (max), 60 psig (min) was assumed in onsite design. Meteorological conditions allow a lower cooling water supply temperature, (~65°F). Cooling water return at exchanger outlet at 130°F (max), 30 psig (min). Cooling water return actual temperature is about 110°F (average) and 117°F (maximum).
- (2) Normal rate is approximately equal to average.
- (3) Simultaneous maximum occurs during vacuum bottoms inventory pulldown.

TABLE 15

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

INERT GAS SUMMARY

<u>Requirements, SCFM Per Plant</u>	<u>Normal</u>	<u>Maximum</u>
Slurry Drying	7000	7000(1)
Liquefaction	0	1250 ⁽²⁾
Fractionation (APS/VPS)	0	0
Solvent Hydrogenation	0	2930 ⁽³⁾
FLEXICOKING	680	2440
Hydrogen Generation	0	0
Oxygen Plant	0	0
Hydrogen Recovery	0	0
Gas and Water Treating	0	0
Light Ends	<u>0</u>	<u>0</u>
Total Normal	7680	
Simultaneous Maximum		9400

Notes:

- (1) Slurry Drying requires inert gas at 50 psig.
- (2) Liquefaction requires 450,000 SCF of inert gas at 150 psig for a 6 hour period during startup (S/U).
- (3) Solvent Hydrogenation requires 1,055,000 SCF of inert gas at 150 psig for a 6 hour period during S/U.

TABLE 16

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

INSTRUMENT AIR SUMMARY⁽¹⁾

<u>Requirements, SCFM Per Plant</u>	<u>Normal</u>	<u>Maximum</u>
Slurry Drying	} 400	} 400
Liquefaction		
Fractionation (APS/VPS)	215	215
Solvent Hydrogenation	200	200
FLEXICOKING	160	225
Hydrogen Generation	} 1400	} 1500
Oxygen Plant		
Hydrogen Recovery		
Gas and Water Treating	440	440
Light Ends	<u>100</u>	<u>100</u>
Total Normal	2915	
Simultaneous Maximum ⁽²⁾		3080

Notes:

(1) Instrument air is to be available at 90 psig.

(2) Simultaneous maximum occurs during vacuum bottoms inventory pulldown.

TABLE 17

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

INDUSTRIAL AIR SUMMARY⁽¹⁾

<u>Requirements, SCFM Per Plant</u>	<u>Normal</u>	<u>Maximum</u>
Slurry Drying	0	0
Liquefaction	0	1415
Fractionation (APS/VPS)	0	0
Solvent Hydrogenation	0	2120
FLEXICOKING	0	0
Hydrogen Generation	0	0
Oxygen Plant	0	0
Hydrogen Recovery	0	0
Gas and Water Treating	0	0
Light Ends	<u>30</u>	<u>30</u>
Total Normal	30	
Simultaneous Maximum ⁽²⁾		3565

Notes:

- (1) Industrial air is to be available at 90 psig.
- (2) Simultaneous maximum occurs during vacuum bottoms inventory pulldown.

TABLE 18

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

ONSITE ELECTRIC POWER LOADS

<u>"Normal" Operation</u> ⁽²⁾	<u>Requirements, kW Per Plant</u>	
	<u>All Electric</u>	<u>With Steam Turbines</u> ⁽¹⁾
Slurry Drying	13339	13339
Liquefaction	26312	26312
Fractionation (APS/VPS)	2900	2900
Solvent Hydrogenation	17943	17943
FLEXICOKING	42314	8314 ⁽³⁾
Partial Oxidation Gasifier	3060	3060
H ₂ Generation (ex. Gasifier)	43770	43770
Oxygen Plant	100240	0 ⁽⁴⁾
Hydrogen Recovery	48300	18000 ⁽⁵⁾
Gas and Water Treating	5701	5701
Light Ends	<u>501</u>	<u>501</u>
	304380	139840
<u>Maximum Operation</u> ⁽⁶⁾		
Slurry Drying	13339	13339
Liquefaction	26312	26312
Fractionation (APS/VPS)	2900	2900
Solvent Hydrogenation	18547	18547
FLEXICOKING	58085	9770 ⁽⁷⁾
Partial Oxidation Gasifier	3140	3140
H ₂ Generation (ex. Gasifier)	44890	44890
Oxygen Plant	102800	0 ⁽⁸⁾
Hydrogen Recovery	51500	19190 ⁽⁹⁾
Gas and Water Treating	5701	5701
Light Ends	<u>501</u>	<u>501</u>
	327715	144290

TABLE 18 (CONT'D)

ONSITE ELECTRIC POWER LOADS

<u>Minimum Operation</u> (10)	<u>Requirements, kW Per Plant</u>	
	<u>All Electric</u>	<u>With Steam Turbines</u> (1)
Slurry Drying	6670	6670
Liquefaction	13156	13156
Fractionation (APS/VPS)	1450	1450
Solvent Hydrogenation	8670	8670
FLEXICOKING	39045	4245 (11)
Partial Oxidation Gasifier	1490	1490
H ₂ Generation (ex. Gasifier)	21325	21325
Oxygen Plant	48900	0 (12)
Hydrogen Recovery	23500	8775 (13)
Gas and Water Treating	2850	2850
Light Ends	<u>250</u>	<u>250</u>
	167306	68881
<u>FLEXICOKING Unit Outage - EOR</u> (14)		
Slurry Drying	13339	13339
Liquefaction	26312	26312
Fractionation (APS/VPS)	2900	2900
Solvent Hydrogenation	18547	18547
FLEXICOKING	30395	6195 (15)
Partial Oxidation Gasifier	3140	3140
H ₂ Generation (ex. Gasifier)	44890	44890
Oxygen Plant	102800	0 (8)
Hydrogen Recovery	49460	16600 (16)
Gas and Water Treating	5701	5701
Light Ends	<u>501</u>	<u>501</u>
	297985	138125

TABLE 18 (CONT'D)

ONSITE ELECTRIC POWER LOADS

Notes:

- (1) Onsite electric power loads excluding power to large drivers for the FLEXICOKING units, O₂ plants and H₂ recovery units. These drivers may be driven by electric motors or steam turbines.
- (2) "Normal" Operation: All units operating at normal throughput (average of SOR and EOR).
- (3) Power for gasifier air blower driver excluded. BHP per blower = 22,100. No. of blowers per plant = 2.
- (4) Power to compressors excluded. Air compressors: BHP per driver = 30,880. No. of drivers per plant = 3. O₂ compressors: BHP per driver = 13,911. No. of drivers per plant = 3.
- (5) Power to offgas compressors and C₂- product compressors excluded. Offgas compressors: BHP per driver = 8,403. No. of drivers per plant = 2. C₂- product compressors: BHP per driver = 9,611. No. of drivers per plant = 2.
- (6) Maximum Operation: Represents simultaneous maximum for the plant. Occurs during vacuum bottoms inventory pulldown at EOR.
- (7) Power for gasifier air blower driver excluded. BHP per blower = 31,400. No. of blower per plant = 2.
- (8) Power to compressors excluded. Air compressors: BHP per driver = 32,350. No. of drivers per plant = 3. O₂ compressors: BHP per driver = 13,580. No. of drivers per plant = 3.
- (9) Power to offgas compressors and C₂- product compressors excluded. Offgas compressors: BHP per driver = 10,165. No. of drivers per plant = 2. C₂- product compressors: BHP per driver = 11,500. No. of drivers per plant = 2.
- (10) Minimum Operation: Represents simultaneous minimum for the plant. Occurs during plant turnaround at SOR.
- (11) Power for gasifier air blower driver excluded. BHP per blower = 22,600. No. of blowers operating per plant = 1.
- (12) Power to compressors excluded. Air compressors: BHP per driver = 22,600. No. of drivers operating per plant = 2. O₂ compressors: BHP per driver = 10,180. No. of drivers operating per plant = 2.

TABLE 18 (CONT'D)

ONSITE ELECTRIC POWER LOADS

Notes:

- (13) Power to offgas compressors and C₂- product compressors excluded. Offgas compressors: BHP per driver = 9,538. No. of drivers per plant = 1. C₂- product compressors: BHP per driver = 10,785. No. of drivers per plant = 1.
- (14) FLEXICOKING Unit Outage - EOR: During this operation, the maximum amount of coal is fired in the offsite boilers.
- (15) Power for gasifier air blower excluded. BHP per blower = 31,500. No. of blowers operating per plant = 1.
- (16) Power to offgas compressors and C₂- product compressors excluded. Offgas compressors: BHP per driver = 9,113. No. of drivers per plant = 2. C₂- product compressors: BHP per driver = 10,423. No. of drivers per plant = 2.

TABLE 19

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

PRODUCT, BYPRODUCT AND INTERMEDIATE STREAM RATES

Coal ("As Received")^{(1) (2)}

36.3 k ST/SD to Liquefaction

k lb/hr (kB/SD) Per Plant

<u>Products</u>	<u>"Normal"</u>		<u>Maximum</u>	
C ₂ HBG	164.5	(12.3 kFOEB/SD)	171.5	(12.8 kFOEB/SD)
C ₃ LPG	36.4	(4.92)	36.5	(4.93)
C ₄ LPG	20.3	(2.40)	20.5	(2.43)
Naphtha (C ₅ /350°F)	343.0	(30.27)	351.1	(30.97)
Fuel Oil				
Heavy Naphtha (350/400°F)	82.0	(6.24)	82.0	(6.24)
Liq'n VGO	53.3	(3.30)	53.3	(3.30)
Liq'n Mid-distillate	34.9	(2.47)	37.5	(2.65)
FLEXICOKING Products (incl. Flux)	121.4	(7.27)	293.7	(17.49)
Total Fuel Oil (incl. Flux) ⁽³⁾	291.6	(19.28)	466.5	(29.60)
(excl. Flux)	291.6	(19.28)	342.7	(22.05)
<u>Byproducts</u>				
Sulfur	6.0		6.4	
NH ₃	5.2		6.5	
Phenol	22.4	(1.46)	22.4	(1.46)
<u>Intermediate Streams</u>				
Recycle Solvent	1667 k lb/hr (118.6 k B/SD) Per Train			
Spent Solvent	1835 k lb/hr (129.8 k B/SD) Per Train			
Vacuum Bottoms (excess during FLEXICOKING outage)	168 k lb/hr (8.4 k B/SD) Per Plant (w/o Flux)			
(maximum rate to FLEXICOKING units)	784 k lb/hr (39.5 k B/SD) Per Plant (w/o Flux)			
(normal rate to FLEXICOKING units)	560 k lb/hr (28.2 k B/SD) Per Plant			
Phenolic Water ⁽⁴⁾	953 k lb/hr (65.3 k B/SD) Per Train			

TABLE 19 (CONT'D)

PRODUCT, BYPRODUCT AND INTERMEDIATE STREAM RATES

Notes:

- (1) Composition as shown in Table 1.
- (2) Feed coal to liquefaction unit; does not include coal to coal-fired boilers.
- (3) Flux (VGO) is introduced into the FLEXICOKING unit with the vacuum bottoms from storage during vacuum bottoms inventory pulldown.
- (4) Rate includes all contaminants.

TABLE 20

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS-WYOMING COAL CASE

STORAGE REQUIREMENTS

	Service	Basis	Net Size, kB
• C ₃ LPG	Product tankage (requires pressurized storage)	20 day holdup of plant production	108 (including two 5.4 kB drums)
• C ₄ LPG	Product tankage (requires pressurized storage)	20 day holdup of plant production	51 (including two 2.5 kB drums)
• Naphtha	Product tankage (requires floating roof storage)	20 day holdup of plant production	639
• Heavy Naphtha	Fuel oil blendstock tankage	14 day holdup of plant production	90
• Vacuum Gas Oil	Fuel oil blendstock and flux oil tankage (requires storage at 300°F)	14 day holdup of plant production (for blendstock) plus 94 kB (for flux oil)	146
• Liquefaction Mid-distillate	Fuel oil blendstock tankage (requires storage at 160°F)	14 day holdup of plant production	39
• FLEXICOKING Unit Products	Tankage for FLEXICOKING unit gas oil and scrubber bottoms. Serves as fuel oil blendstock and FLEXICOKING unit startup feed (required storage at 300°F)	14 day holdup of plant production	256
• Fuel Oil	Product tankage (requires storage at 160°F)	10 day holdup of plant production	242
• Phenol	Product tankage	20 day holdup of plant production	29
• NH ₃ (Anhydrous)	Product tankage (requires pressurized storage)	20 day holdup of plant production	16
• Sulfur	Product tankage (requires molten storage)	20 day holdup of plant production	5
• Liquefaction Spent Solvent ⁽¹⁾	Intermediate storage to protect against a solvent hydrogenation outage (requires storage at 160°F)	5 day holdup of one train spent solvent circulation	678
• Liquefaction Hydrogenated Recycle Solvent ⁽¹⁾	Intermediate storage to protect against a solvent hydrogenation outage (requires storage at 160°F). Also used for storage of start up solvent.	5 day holdup of one train recycle solvent circulation	673
• Sour Water/Phenolic Water	Intermediate storage to protect against a sour water or a phenolic water treating unit outage.	7-1/2 day holdup of one train production of phenolic water	490
• Vacuum Bottoms	Intermediate storage to protect against a 15 day FLEXICOKING unit outage (requires storage at 450°F with flux added)	15 day holdup of excess vacuum bottoms production (fluxed to contain 35.6 wt% VGO)	222 (including flux)

TABLE 20 (CONT'D)

STORAGE REQUIREMENTS

	<u>Service</u>	<u>Basis</u>	<u>Net Size, kb</u>
• Isopropyl Ether	Phenolic water treating unit makeup	20 day holdup of makeup for the plant	0.5
• DEA	DEA unit makeup	To be provided with onsite facilities	
• Caustic	Makeup for various units	20 day holdup of makeup for the plant	14
• H ₂ S Removal Solution	Makeup for H ₂ S Removal Unit	20 day holdup of makeup for the plant	1.1
• Light Emergency Storage	Intermediate storage for unstabilized naphtha and off-spec LPG (requires pressurized storage)	2 day holdup of one train raw naphtha production	40
• Cold Rerun Storage	Rerun storage for wet streams or streams containing naphtha (requires storage below 180°F)	Holdup for a 36 hr. flushing operation in one train	260
• Hot Rerun Storage	Rerun storage for dry streams not containing naphtha (requires storage above 300°F)	3 day holdup of one train APS bottoms production	140

Notes:

- (1) Either spent solvent or recycle solvent will be used as flushing oil to clear slurry lines of solids during a shutdown. Material from the storage facilities for both solvents is to be able to be delivered to the slurry drying units.

TABLE 21
EDS COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS-WYOMING COAL CASE
RUNDOWN CONDITION FOR STREAMS TO TANKAGE

	Run-down Condition		Density, lb/ft ³ , (at Storage Temperature °F)	Gravity, (at 60°F)	Viscosity
	Temperature, °F	Pressure, psig			
C ₃ LPG	110	200	28.83 @ 110°F	0.51	0.084 cp @ cond.
C ₄ LPG	100	200	34.68 @ 100°F	0.58	0.135 cp @ cond.
Naphtha, C ₅ /350°F ⁽¹⁾	110	75	46.99 @ 110°F	0.78	0.44 @ cond.
Fuel Oil ⁽²⁾	160	75	61.74 @ 160°F	1.04	
Liquefaction VGO ⁽³⁾	400	75	61.50 @ 400°F	1.11	75.9 cp @ cond.
Heavy Naphtha, 350/400°F ⁽⁴⁾	110	75	54.80 @ 110°F	0.90	1.17 cp @ cond.
Liquefaction Mid-distillate ⁽⁴⁾	160	75	57.91 @ 160°F	0.97	1.99 cp @ cond.
FLEXICOKING Products ⁽⁵⁾	300	50	68.57 @ 300°F	1.20	10 p @ 300°F 1000 p @ 200°F 0.165 cp @ cond.
Ammonia	110	248	35.89 @ 110°F		
Sulfur	280	75	111.60 @ 280°F		10.0 cp @ 260°F 8.0 cp @ 280°F 4.08 cp @ 113°F 2.58 cp @ 140°F 1.99 cp @ cond.
Phenol	125	75	65.45 @ 125°F		
Spent Solvent ^{(4) (6)}	160	75	57.91 @ 160°F	0.97	
Recycle Solvent ^{(4) (7)}	160	75	53.00 @ 160°F	0.90	3.00 cs @ 100°F 1.40 cs @ 210°F
Raw Naphtha ⁽⁸⁾	110	350	48.66 @ 110°F	0.80	0.73 cs @ 100°F 0.43 cs @ 210°F
Vacuum Bottoms ⁽⁹⁾	450	50	75.47 @ 450°F	1.36	1.0 p @ 450°F ⁽¹⁰⁾
Sour/Phenolic Water ⁽¹¹⁾	110	50	61.85 @ 110°F	1.0-0.98	0.69 cs @ 100°F 0.30 cs @ 210°F

TABLE 21 (CONT'D)

RUNDOWN CONDITIONS TO PRODUCT TANKAGE

Notes:

- (1) The product naphtha RVP is 3.5 psia.
- (2) The fuel oil product pour point is $\sim 40^{\circ}\text{F}$ and its flash point is $\sim 140^{\circ}\text{F}$.
- (3) VGO flash point is 440°F . VGO viscosity measured at 500 sec^{-1} shear rate.
- (4) Flash point is $< 140^{\circ}\text{F}$.
- (5) Contains about 0.60 wt% solids.
- (6) The spent solvent stream is available at $\sim 525^{\circ}\text{F}$ and is cooled (by heat exchange with recycle solvent) to 160°F before entering the storage facilities.
- (7) Onsite facilities have been provided to increase the temperature of the recycle solvent from 160°F to about 400°F before returning the stream to the slurry driers.
- (8) Raw naphtha RVP is 50.5 psia.
- (9) The vacuum bottoms to FLEXICOKING contain 44.2 wt% solids (14.2 wt% ash, 30.0 wt% MEK insolubles).
- (10) Viscosity of vacuum bottoms fluxed to contain 35.6 wt% VGO product and measured at 21.4 sec^{-1} shear rate. The viscosity increases in 27 days to about 25 p at 450°F .
- (11) Sour water contains up to 1.5 wt% H_2S and 1.6 wt% NH_3 .

TABLE 22

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

VAPOR RELEASE IN VACUUM BOTTOMS/VGO FLUX TANKAGE

Devolatization

Vapor, wt% during duration of release (24 hours)	0.5
Composition, wt%	
H ₂	5
CO ₂	87
Hydrocarbons ⁽¹⁾	8
Duration of Release	1st 24 hours

Weathering

Vapor, wt% during duration of release (15 days)	0.02
Composition, wt%	
Hydrocarbons ⁽²⁾	100
Duration of Release	15 days

Notes:

- (1) Ave. M.W. = 22, LHV = 20,700 Btu/lb
- (2) Ave. M.W. = 165, LHV = 17,700 Btu/lb

TABLE 23

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

CHEMICALS AND CATALYST SUMMARY

<u>Catalyst Storage Requirements</u>	<u>ft.³</u>	<u>Type</u>	<u>ρ, lb./ft.³</u>
● Slurry Drying	0		
● Liquefaction	0		
● Fractionation (APS/VPS)	0		
● Solvent Hydrogenation	58,600	Nickel Moly	40
● FLEXICOKING	0		
● Hydrogen Generation/Recovery	0		
+ High Temperature Shift	7,300	Chromia-Fe ₂ O ₃	70
+ Low Temperature Shift	4,000	Cu-ZnO	70
+ Molecular Sieve	4,450	Zeolite	43
+ Hydrotreater	825	Nickel Moly	50
● Gas and Water Treating	0		
● Light Ends	0		

Inert Balls Storage Requirements

	<u>ft.³</u>	
	<u>3/8" Dia.</u>	<u>1" Dia.</u>
● Slurry Drying	0	0
● Liquefaction	0	0
● Fractionation (APS/VPS)	0	0
● Solvent Hydrogenation	3,200	1,400
● FLEXICOKING	0	0
● Hydrogen Generation/Recovery	3,435	0
● Gas and Water Treating	0	0
● Light Ends	0	0
 Total	 6,635	 1,400

TABLE 23 (CONT'D)

Chemicals

● Slurry Drying	0
● Liquefaction	0
● Fractionation (APS/VPS)	0
● Solvent Hydrogenation - Coarse Sand (10 mesh), ft ³	4,200 (every year)
● FLEXICOKING	
+ H ₂ S Removal Solution Makeup, gal/day	5,400
+ Caustic (20° Be') Makeup, gpm ⁽¹⁾	30 (at startup)
● Hydrogen Generation ⁽²⁾	
+ CO ₂ Removal Catalyst, gal ⁽³⁾	25,000
+ Potassium Hydroxide, lb	275,000
● Gas and Water Treating	
+ Isopropyl Ether Makeup (pure) ⁽⁴⁾ , 16/SD	6,800
+ Caustic (20° Be') Makeup ⁽⁴⁾ , gpm	20
+ DEA Makeup (30 wt% solution) ⁽⁴⁾ , gal/SD	192
● Light Ends	
+ Calcium Chloride, ft ³	1,050
+ Coarse Sand, (1/16 - 1/4"), ft ³	110
+ Fine Gravel (1/4 - 3/4"), ft ³	165 (every 2 months)
+ Coarse Gravel, (3/4 - 3"), ft ³	100
+ C ₃ /C ₄ Treating Reagent, lb	55
+ Caustic - LPG Prewash, gal	4,700 (weekly)
- Extraction/Regeneration, gal	10,600 (every 3 months)

Notes:

- (1) Caustic injection is required during startup of a FLEXICOKING unit for duration of 10 days. The caustic is to be provided at 100 psig.
- (2) Hydrogen generation uses a solution made up of 30 wt% KOH, 10 wt% CO₂ removal catalyst and 60 wt% water in the CO₂ removal absorber.
- (3) Density of CO₂ removal catalyst is 76.7 lb/ft³.
- (4) Storage is in tanks, see tankage requirement.

TABLE 24
EDS COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS-WYOMING COAL CASE
PROJECTED AIR POLLUTION STANDARDS

Projected Emission Limits

●	SO ₂	
-	Process	250 vppm
-	Combustion	1.2 lb/MBtu max ⁽¹⁾ (coal-fired) 0.8 lb/MBtu max (oil-fired) 85% sulfur removal
●	CO	
-	Process	500 vppm
-	Combustion	500 vppm
●	NO _x	
-	Combustion	0.2 lb/MBtu (gas fired) 0.5 lb/MBtu (coal fired)
●	H ₂ S	10 vppm
●	Particulates	
-	Process	-
-	Combustion	0.1 lb/MBtu
●	Opacity	
-	Combustion	20%
●	Hydrocarbons	160 μgm/m ³ ⁽²⁾

Notes:

(1) If 85% sulfur removal drops emissions below 0.2 lb/MBtu, the limit is to be 0.2 lb/MBtu regardless of the percentage sulfur removal.

(2) Maximum 3 hour average ambient concentration at ground level.

TABLE 25

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

WASTEWATER CONTAMINANT LEVELS AND RATE

	<u>Contaminant Level,⁽¹⁾ ppm</u>
NH ₃	80
H ₂ S	1
CO ₂	80
Free CN ⁻	Nil
SCN ⁻	10
Cl ⁻	5
Na ⁺ (added during stripping)	500
Ca ⁺² (as CaCO ₃)	10
Mg ⁺² (as CaCO ₃)	130
Fe ^{+2,+3} (as CaCO ₃)	20
Phenolics	
+ Phenol	10
+ Resorcinol	12
+ Alkyl Resorcinol	5
+ Others	Nil
Organic Acids	
+ Acetic Acid	1700
+ Propanoic Acid	900
+ Butanoic, Pentanoic and Hexanoic Acids	1000
Aldehydes and Ketones	
Isopropyl Ether (residual extraction solvent)	2
Oil and Grease	10
BOD ₅	50
COD	3300
TOC	5200
TSS (2)	1700
TDS (2)	30
Hardness (as CaCO ₃)	4200
	200
Wastewater Flow Rate, gpm per plant	3400 (ave.) ⁽³⁾ 3900 (max.)
Wastewater Temperature, °F	120

TABLE 25 (CONT'D)

WASTEWATER CONTAMINANT LEVELS AND RATE

Notes:

- (1) Estimated quality of EDS process wastewater after sour water stripping and phenolics extraction.
- (2) TDS includes bicarbonate formed by oxidation of organic acids in biox.
- (3) Approximate estimate of the annual average wastewater flow rate. This rate is not based on a detailed consideration of the different modes of operation for the EDS plant.

TABLE 26

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE

OFFSITE DESIGN BASIS - WYOMING COAL CASE

ONSITE SOLID WASTES

Slurry Drying

- Solids accumulated in the slurry driers are available at the unit battery limits for pickup by mobile equipment.

Solid rate,	45.0 ST per drier
Frequency	every 3 months
Duration	one 8 hour shift
Characteristics:	
bulk density, lb/ft ³	80.0
particle density, lb/ft ³	160.0
particle size distribution	> 8 mesh

FLEXICOKING

- Dry fines are available at the bed coke silo of each FLEXICOKING unit. Fines include material both from tertiary cyclones and a heater bed purge. Carrier air is available from the gasifier air blowers at 63 psia.

Solid rate, average/max	1214/1978 ST/SD per plant
Frequency	Continuous
Characteristics	
bulk density, lb/ft ³	33
particle density	100
particle size distribution	cumulative wt%
< 400 microns	93
< 300 microns	91
< 200 microns	89
< 100 microns	52
< 90 microns	36
< 80 microns	22
< 50 microns	18
< 30 microns	17
< 20 microns	15
< 10 microns	6
< 5 microns	2

- Fines from the venturi scrubbers will be available as a water slurry (6 wt% solids) at the unit battery limits at 125 psia.

Solid rate, average/max	214/347 ST/SD per plant
Frequency	continuous
Characteristics	
particle density, lb/ft ³	100

TABLE 26 (CONT'D)

ONSITE SOLID WASTES

Water Impurities	wppm
NH ₃	10
H ₂ S	<1
Chlorides	20
Cyanides	≤1
S ₂ O ₃	75
Phenols	<5
pH, normal/startup	8.0-9.0/6.8

- Heater chunks are available at the unit battery limits for pickup by mobile equipment.

Solid rate, average/max	30/40 ST/SD per plant
Frequency	daily
Duration	one 8-hour shift
Characteristics	
bulk density, lb/ft ³	65
particle size distribution	wt%
28 mesh to 1/4"	50
1/4" to 1"	40
greater than 1"	10

Partial Oxidation

- Slag from the gasifier in the Synthesis Gas Gasifier containing 10 wt% water available at the unit battery limits.(1)

Solids rate, average/max	737/756 ST/SD per plant
Frequency	continuous
Characteristics	
bulk density, lb/ft ³	100
particle density, lb/ft ³	200
particle size distribution	wt%
100 mesh to 8 mesh	50
8 mesh to 3 mesh	50

TABLE 2.6 (CONT'D)

ONSITE SOLID WASTES

- Fines from the Synthesis Gas Generator scrubber will be available as a water slurry (20 wt% solids) at the unit battery limits.

Solid rate, average/max	167/171 ST/SD per plant
Frequency	continuous
Pressure at Battery Limits, psig	60
Characteristics	
particle density, lb/ft ³	150
Water Impurities	wppm
NH ₃	10
H ₂ S	<1
Chlorides	20
Cyanides	<1
S ₂ O ₃	75
Phenols	<5
pH	7.2

Note:

- (1) Slag is discharged from the gasifier as a 75 wt% solids slurry onto a vibrating screen. The return water (water that goes through the screen) contains 10% of the original solids (as fines). Slag is discharged from the vibrating screen which is less than 20 ft above grade. However, there will be adequate clearance beneath the screen for a conveyor at ground level to pick up the slag.

TABLE 27

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS-WYOMING COAL CASE
MAXIMUM SAFETY VALVE RELEASES

Hydrocarbon Vapor

The following releases occur simultaneously.

From Area	Liquefaction, Solvent Hydro & Fractionation	FLEXICOKING
Contingency	Power Failure	Power Failure
Temperature, °F	650	755
Pressure, psig	1915	30
Molecular Wt.	30.9	28.2
Maximum Rate, k lbs/hr	580	277
Composition, wt%		
H ₂	2.00	0.40
H ₂ S	0.19	0.11
CO	1.83	0.58
CO ₂	5.86	1.46
N ₂	1.58	0.71
NH ₃	0.28	0.07
C ₁	7.66	2.59
C ₂	4.18	0.73
C ₃	3.18	0.30
C ₄	1.36	0.15
C ₅ /400°F	12.36	0.41
400/700°F	44.02	4.90
700/1000°F	0.33	31.85
1000°F+	-	5.17
H ₂ O	15.17	52.57
Disposition	Flare	Flare

TABLE 27 (CONT'D)

MAXIMUM SAFETY VALVE RELEASES

Hydrocarbon Vapor

The following releases occur simultaneously.

From Area	Cryogenic H ₂ Recovery	Cryogenic H ₂ Recovery
Contingency	Unit Outage ⁽¹⁾	Unit Outage ⁽¹⁾
Temperature, °F	120	117
Pressure, psig	50	1535
Molecular Wt.	18.4	10.6
Maximum Rate, k lbs/hr	109	65
Composition, wt%		
H ₂	4.5	11.2
CO	12.8	12.0
N ₂	6.7	8.0
C ₁	20.1	35.9
C ₂	14.6	16.9
C ₃	13.2	10.3
C ₄	7.2	3.0
C ₅ ⁺	19.3	2.5
H ₂ O	1.6	0.2
Disposition	Flare	Flare

Note:

(1) Is not simultaneous with a power failure.

TABLE 27 (CONT'D)

MAXIMUM SAFETY VALVE RELEASES

Cold Hydrocarbon

From Area	Cryogenic H ₂ Recovery
Contingency	Operating Failure
Temperature, °F	-250
Pressure, psig	680
Molecular Wt.	19.1
Maximum Rate, k lbs/hr	66.6
Composition, wt%	
H ₂	0.37
CO	7.91
N ₂	6.67
C ₁	60.24
C ₂	20.46
C ₃	4.06
C ₄	0.29
Disposition	Flare

Hydrocarbon Liquid

From Area	FLEXICOKING
Stream	Vacuum Bottoms
Contingency	Line Blockage
Temperature, °F	600
Specific Gravity, (@ Cond.)	1.36
Pressure, psig	50
Maximum Rate, gpm (@ Cond.)	830
Disposition	Vacuum Btms. Storage

TABLE 27 (CONT'D)

MAXIMUM SAFETY VALVE RELEASES

H₂S-Rich Vapor

The following releases do not occur simultaneously.

From Area	DEA Regeneration	Sulfur Plant
Contingency	Power Failure	Operating Failure
Temperature, °F	208	200
Pressure, psig	15	10
Molecular Wt.	31.6	40.7
Maximum Rate, k lbs/hr	89	76
Composition, wt%		
H ₂ S	2.7	3.5
CO ₂	70.7	91.8
NH ₃	2.2	1.5
H ₂ O	24.4	3.2
Disposition	Flare	Flare

Low Btu Gas

From Area	FLEXICOKING
Contingency	Cooling Failure
Temperature, °F	110
Pressure, psig	20
Molecular Wt.	24.0
Maximum Rate, k lbs/hr	2207
Composition, wt%	
H ₂	1.7
CO	21.3
CO ₂	20.9
N ₂	52.2
C ₁	1.1
H ₂ O	2.8
Disposition	Stack

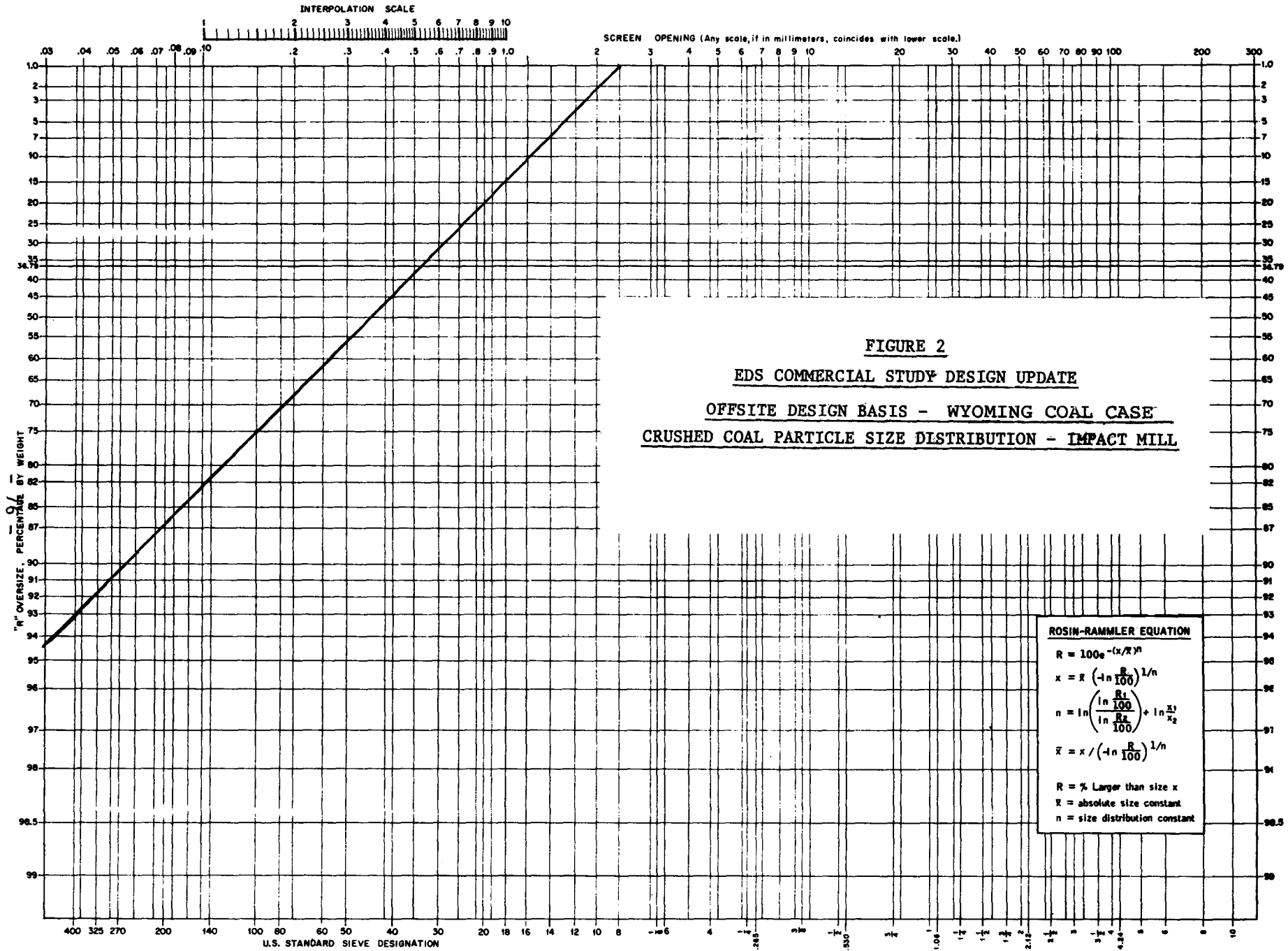


FIGURE 2
EDS COMMERCIAL STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS - WYOMING COAL CASE
CRUSHED COAL PARTICLE SIZE DISTRIBUTION - IMPACT MILL

ROSIN-RAMMLER EQUATION

$$R = 100e^{-(x/\bar{x})^n}$$

$$x = \bar{x} \left(-\ln \frac{R}{100} \right)^{1/n}$$

$$n = \ln \left(\frac{\ln \frac{R_1}{100}}{\ln \frac{R_2}{100}} \right) + \ln \frac{x_1}{x_2}$$

$$\bar{x} = x / \left(-\ln \frac{R}{100} \right)^{1/n}$$

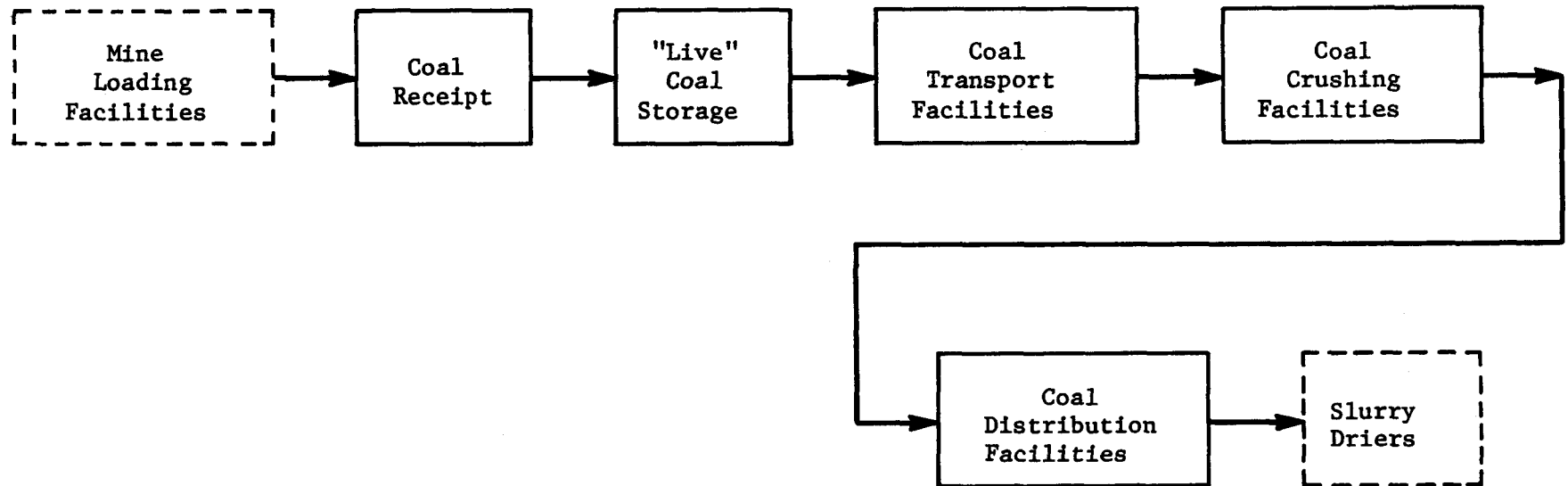
R = % Larger than size x
 \bar{x} = absolute size constant
n = size distribution constant

GRAPHICAL FORM FOR REPRESENTING DISTRIBUTION OF SIZE OF BROKEN COAL

SCREEN OPENING INCHES (Square hole if used as continuation of fine series.)

FIGURE 3

EDS COMMERCIAL PLANT STUDY DESIGN UPDATE
OFFSITE DESIGN BASIS-WYOMING COAL CASE
COAL STORAGE AND HANDLING FACILITIES



Note: Dashed lines indicate facilities not located in the EDS plant offsites.

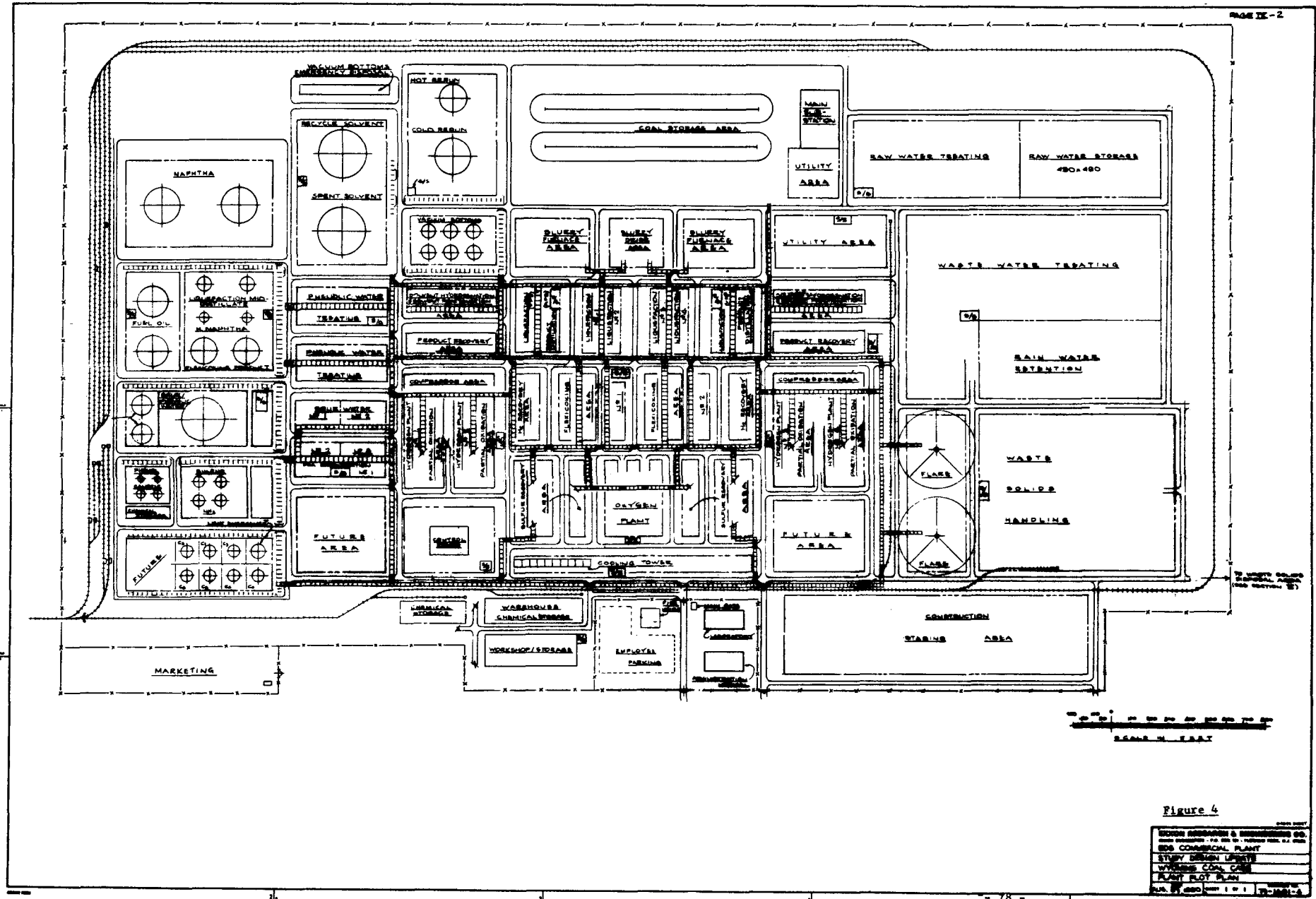


Figure 4

DESIGNED BY	EDS COMMERCIAL PLANT
DRAWN BY	EDS COMMERCIAL PLANT
CHECKED BY	EDS COMMERCIAL PLANT
DATE	10/1/78
PROJECT NO.	100-100-100

LIST OF ABBREVIATIONS

APS	Atmospheric Pipestill
B	Barrel
BHP	Brake Horsepower
Btms	Bottoms
Btu	British Thermal Unit
Cond.	Conditions
D	Day
EDS	Exxon Donor Solvent
EOR	End-of-Run
HBG	High Btu Gas
k	Thousand
LBG	Low Btu Gas
LPG	Liquified Petroleum Gas
M	Million
max	Maximum
min	Minimum
MW	Molecular Weight
RVP	Reid Vapor Pressure
SCF	Standard Cubic Feet
SCFM	Standard Cubic Feet Per Minute
SD	Stream Day
SDU	Study Design Update
SOR	Start-of-Run
ST	Short Ton
S/U	Startup

LIST OF ABBREVIATIONS (cont'd)

T	Ton
T/A	Turnaround
VGO	Vacuum Gas Oil
VPPM	Volume Parts Per Million
VPS	Vacuum Pipestill
w/o	Without
wppm	Weight Parts Per Million
ρ	Density