LARGE PILOT PLANT ALTERNATIVES FOR SCALEUP OF THE CATALYTIC COAL GASIFICATION PROCESS

APPENDIX I

DETAILS OF STUDY DESIGN FOR GRASS ROOTS CASE

APPENDIX I

DETAILS OF STUDY DESIGN FOR GRASS ROOTS LARGE PILOT PLANT

APPENDIX I (Cont'd.)

APPENDIX I-A

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY - GRASS ROOTS CASE

ONSITE FACILITIES

This specification covers the onsite facilities for a study design of a Large Pilot Plant for the Catalytic Coal Gasification Process. The study design is based on locating the Large Pilot Plant adjacent to a large gulf coast refinery. A site adjacent to the Exxon Baytown Refinery in Baytown, Texas was selected for the study design to represent a typical site.

Major areas covered by the specification are: coal feeding system, gasifier and cyclones, char withdrawal system, gasifier fines recovery system, high temperature heat recovery facilities, wet scrubbers, NH_3 scrubber, methane recovery facilities, preheat furnace, steam reformer, sour slurry stripper and catalyst recovery section.

Design Basis

In the grass roots the Large Pilot Plant is designed to gasify 92 ST/SD of as-received Illinois No. 6 bituminous coal and produce pipeline quality SNG.

Process Description

Pretreated gasifier feed coal is fed via a lock hopper system to a fluidized bed gasifier which operates at approximately 1300°F and 500 psia. Gasification of the coal occurs with a mixture of steam and recycled synthesis gas producing CH_4, CO_2, CO, H_2 and unconverted steam as the gasifier effluent. The effluent gas is sent to primary and secondary cyclones where unconverted coal fines and ash are separated and sent back to the gasifier.

The effluent gas enters a gas-gas exchanger where it is cooled to approximately 1050°F. Further cooling of the gas is achieved in a high-pressure waste heat boiler where 600 psig steam is generated. The gas leaves the boiler at approximately 520°F. After leaving the waste heat boiler, the gas is sent to a tertiary cyclone to recover as many of the overhead fines as possible.

A fines scrubbing system is provided to remove particulate solids from the gas prior to further treating. The raw product gas from the tertiary cyclone is fed to the bottom of a cyclonic fines scrubber where it is contacted counter currently with cold feed water. The saturated gas is then fed to a venturi scrubber where it is contacted and scrubbed with saturator bottoms slurry. The water slurry leaving the venturi knockout drum, which contains NH_3, H_2S, CO_2 and dissolved catalyst in addition to the particulate solids and water, is fed to a sour slurry stripper for further treating. The gas from the venturi knockout drum is cooled to 110°F in a product gas cooler and fed to an NH_3 scrubber where final NH_3 cleanup is accomplished. The gas

from the NH_3 scrubber is then fed to the acid gas removal system which employs a two-stage heavy glycol process consisting primarily of two absorption and two stripping towers. Removal of H_2S, CO_2, COS and other sulfur compounds takes place by counter currently contacting the feed gas with a process solvent (Dimethyl ether of polyethylene glycol) in two conventional absorption towers. The rich solvent is regenerated by the stripping towers and the lean solvent is returned to the absorbers.

Downstream of the acid gas removal system, molecular sieve purifiers are provided to assure complete removal of the CO_2, H_2S and to absorb other impurities which could freeze in the downstream cryogenic facilities. Leaving the purifiers, the gas is fed to the cryogenic methane recovery facilities where synthesis gas (H_2 + CO) is separated from the product methane. The recycled synthesis gas plus makeup from the reformer is compressed, mixed with 600 psig steam and heated in the preheat furnace. This gas is fed to the gasifier and provides the heat input for the gasification reactor.

Ash and char residue from the gasification step and overhead fines from the fines slurry drum are sent to a catalyst recovery unit. Semi-rich catalyst solution from the recovery unit is used to slurry each of the feed solids streams separately. A large fraction of the catalyst is leached from the residue and fines using counter current water washing. The recovered catalyst solution is concentrated, mixed with fresh makeup catalyst and is used to impregnate the coal to complete the catalyst recovery loop.

Duty Specification for Acid Gas Removal

This duty specification covers a grass roots heavy glycol acid gas removal section. Major items include: H_2S removal stage, CO_2 removal stage, solvent dehydration, and refrigeration. The process flow plan is shown in Figure I-A-8.

The heavy glycol acid gas removal process is a chilled-solvent absorption process for H_2S and CO_2 removal from process gas streams. The process envisioned for use in the catalytic gasification process is a selective system composed of a first stage for H_2S removal and a second stage for CO_2 removal. Gas enters the bottom of the H_2S absorber where it is contacted with chilled solvent. The liquid bottoms is flashed and regenerated in the H_2S stripper and an H_2S-rich stream from the top of the stripper is sent to the refinery's Claus plant. The absorber overhead is then introduced into the bottom of the CO_2 absorber where it is again contacted with chilled solvent. The liquid bottoms is flashed and regenerated in the CO_2 stripper using air as the stripping medium, with the CO_2-rich overhead stream being vented. The purified gas containing 0.1 mole% CO_2 and 1 ppm total sulfur is sent to the molecular sieves for trace CO_2 removal.

A Freon refrigeration system of conventional design is used to provide the solvent chilling duty.

TABLE I-A-1

DUTY SPECIFICATION FOR ACID GAS REMOVAL

- Feed Gas

Rate, moles/hr	812
Pressure, psig	440
Temperature, °F	110

Composition, mole%

CO	8.1
CO_2	17.5
H_2	41.6
H_2O	0.28
CH_4	31.6
C_2H_6	50 vppm
C_6H_6	100 vppm
H_2S	0.9
COS	60 vppm

- Specificatons

Effluent Gas:	$\angle$0.1 mole % CO_2
	$\angle$2 vppm S
H_2S Rich Stream:	Suitable as feed to a refinery Claus Plant.
CO_2 Vent Stream:	Vented to atmosphere
Methane Losses:	Not critical

- Utilities Requirements

Cooling Water	350 GPM
Steam (125 psig, 360°F)	3300 lbs/hr
Electric Power	500 kw

TABLE I-A-2

ONSITE UTILITIES AND CHEMICAL REQUIREMENTS

Cooling Water

Requirements, GPM		Normal	Maximum
E-103	Product Gas Cooler	258	1120*
E-104	Slurry Stripper O'Hd Cond.	242	242*
E-105	Slurry Stripper Btm's Cooler	423	423*
E-113	MRT R 12 Condenser	15	15*
E-114	MRT Methane Comp After Cooler	25	25*
E-118	Reformer Effluent Trim Cooler	82	105*
E-119	Cat Recovery Slurry Cooler	9	33*
E-120	Evaporator O'hd Condenser	100	100*
E-121	Reactivation Gas Cooler	55	55*
E-123	MRT Methane Comp. Int. Cooler	24	24*
C-102	MRT Methane Comp Jacket Cooling	47	47*
		1280	2189
	Simultaneous Maximum		2189

Boiler Feed Water

Requirements, GPM		Normal	Maximum
E-102	Gasifier Waste Heat Boiler	17	24*
E-116	Reformer Waste Heat Boiler	5	36*
		22	60
	Simultaneous Maximum		60

Industrial Water

Requirements, GPM		Normal	Maximum
D-113	Char Quench Drum	1	2*
D-121N	Hydroclone Mix Drum	6	17*
T-101	Ammonia Scrubber	50	50*
		57	69
	Simultaneous Maximum		69

Steam

Steam - 600

Requirements, #/hr		Normal	Maximum
E-111	Reactivation Gas Heater	5500	5500*
R-101	Gasifier	12430	12430*
F-102	Reformer	1473	11340*
D-113	Char Quench Drum	7220	7220*
		26623	36,490
	Simultaneous Maximum		36,490

Steam - 125

Requirements, #/hr		Normal	Maximum
E-122	Slurry Stripper Reboiler	5711	8705*
J-101	Evaporator Ejector	2110	2110*
F-101	Preheat Furnace	0	3000*
F-102	Reformer	0	3000*
	CO_2 Vaporizer	0	700
			17515
	Simultaneous Maximum		16815

Steam - 600

Production, #/hr		Normal	Maximum
E-102	Gasifier Waste Heat Boiler	7870	11160*
E-116	Reformer Waste Heat Boiler	970	7950*
F-102	Reformer Convection Section	0	8143*
		8840	27253
	Simultaneous Maximum		27253

Electric Power

Requirements, kW		Service	Operating Load	Reacceleration
E-117	Ref Effluent Cooler	N	11*	A
C-101A	Recycle Gas Compressor	N	250*	A
B	Recycle Gas Compressor	S	250	A
C-102A	MRT Methane Compressor	N	370*	A
B	MRT Methane Compressor	S	370	A
C-103A	MRT Ethylene Compressor	N	54*	A
B	MRT Ethylene Compressor	S	54	A
C-104A	MRT R-12 Compressor	N	64*	A
B	MRT R-12 Compressor	S	64	A

TABLE I-A-2 (cont'd)

Requirements, kW		Service	Operating Load	Reaccel-eration
P-101A	Ref. WH Boiler Circul. Pump	N	24*	A
P-101B	Ref. WH Boiler Circul. Pump	S	24	A
P-102A	Cyclonic Scrubber Btm Pump	N	4*	A
P-102B	Cyclonic Scrubber Btm Pump	S	4	A
P-103A	Ammonia Scrubber Btm Pump	N	8*	A
P-103B	Ammonia Scrubber Btm Pump	S	8	A
P-104A	Slurry Stripper Reflux Pump	N	1*	A
P-104B	Slurry Stripper Reflux Pump	S	1	A
P-105	Sulfuric Acid Metering Pump	N	0.5*	B
P-106A	Neutralization Circul. Pump	N	2*	A
P-106B	Neutralization Circul. Pump	S	2	A
P-107A	MRT Reflux Pump	N	0.5*	A
P-107B	MRT Reflux Pump	S	0.5	A
P-108A	MRT Bottoms Pump	N	0.5*	A
P-108B	MRT Bottoms Pump	S	0.5	A
P-109A	Char Slurry Pump	N	22*	A
P-109B	Char Slurry Pump	S	22	A
P-110A	Cat Solution Surge Pump	N	7*	A
P-110B	Cat Solution Surge Pump	S	7	A
P-111A	Slurry Feed Pump	N	2.3*	A
P-111B	Slurry Feed Pump	S	2.3	A
P-112A	Recycle Cat Solution Pump	N	1.5*	A
P-112B	Recycle Cat Solution Pump	S	1.5	A
P-113A	Spent Char & Ash Pump	N	1.5*	A
P-113B	Spent Char & Ash Pump	S	1.5	A
P-114A	Hydroclone Pump	N	2.3*	A
P-114B	Hydroclone Pump	N	2.3*	A
P-114C	Hydroclone Pump	N	2.3*	A
P-114D	Hydroclone Pump	N	2.3*	A
P-114E	Hydroclone Pump	N	2.3*	A
P-114F	Hydroclone Pump	N	2.3*	A
P-114G	Hydroclone Pump	N	2.3*	A
P-114H	Hydroclone Pump	N	2.3*	A
P-114I	Hydroclone Pump	N	2.3*	A
P-114J	Hydroclone Pump	N	2.3*	A
P-114K	Hydroclone Pump	N	2.3*	A
P-114L	Hydroclone Pump	N	2.3*	A
P-114M	Hydroclone Pump	N	2.3*	A
P-114N	Hydroclone Pump	N	2.3*	A
P-115A	Evaporator Circ. Pump	N	11*	A
P-115B	Evaporator Circ. Pump	S	11	A
P-116A	Concentrated Solution Pump	N	0.3*	A
P-116B	Concentrated Solution Pump	S	0.3	A
P-117A	Makeup Water Booster Pump	N	0.7*	A
P-117B	Makeup Water Booster Pump	S	0.7	A

TABLE I-A-2 (cont'd)

Requirements, kW		Service	Operating Load	Reacceleration
P-118A	MRT HP Flash Btm's Pump	N	0.5*	A
P-118B	MRT HP Flash Btm's Pump	S	0.5	A
P-119A	Scrubbing Water Booster Pump	N	34.6*	A
P-119B	Scrubbing Water Booster Pump	S	34.6	A
P-120	Dimethyl Sulfide Metering Pump	N	0.1	C
M-101	Neutralization Mix Drum Mixer	N	1*	A
M-102	Char Slurry Drum Mixer	N	4*	A
M-103	Fines Slurry Drum Mixer	N	4*	A
M-104	Slurry Feed Drum Mixer	N	1*	A
M-105	Recycle Cat Solution Drum Mixer	N	1*	A
M-106A	Hydroclone Mix Drum Mixer	N	1*	A
M-106B	Hydroclone Mix Drum Mixer	N	1*	A
M-106C	Hydroclone Mix Drum Mixer	N	1*	A
M-106D	Hydroclone Mix Drum Mixer	N	1*	A
M-106E	Hydroclone Mix Drum Mixer	N	1*	A
M-106F	Hydroclone Mix Drum Mixer	N	1*	A
M-106G	Hydroclone Mix Drum Mixer	N	1*	A
M-106H	Hydroclone Mix Drum Mixer	N	1*	A
M-106I	Hydroclone Mix Drum Mixer	N	1*	A
M-106J	Hydroclone Mix Drum Mixer	N	1*	A
M-106K	Hydroclone Mix Drum Mixer	N	1*	A
M-106L	Hydroclone Mix Drum Mixer	N	1*	A
M-106M	Hydroclone Mix Drum Mixer	N	1*	A
M-106N	Hydroclone Mix Drum Mixer	N	1*	A
			928.2	

Fuel System

Fuel Gas

Requirement, MBtu/hr		Normal	Maximum
F-101	Preheat Furnace	11.0	15.0*
F-102	Reformer	3.3	34.5*
		14.3	49.5
	Simultaneous Maximum		49.5

Pilot Gas

Requirement, MBtu/hr		Normal	Maximum
F-101	Preheat Furnace	1.0	1.0*
F-102	Reformer	0.2	1.4*
		1.2	2.4
	Simultaneous Maximum		2.4

TABLE I-A-2 (cont'd)

Air System

Instrument Air

Requirement, SCFM

Estimated 200

Utility Air

Requirement, SCFM

Estimated 100

Nitrogen - 125

Requirement, SCFM

Estimated 400

Catalyst and Chemicals

Methane

Requirement, SCFM		Normal	Maximum
F-102	Reformer	100	1150

Sulfuric Acid - 98% H_2SO_4

Requirement, #/hr

D-107	Neutralization Mix Drum	950	950

Carbon Dioxide (Liquid)

Requirement, #/hr

	CO_2 Vaporizer (Instrument Purge Backup)	0	1875

Dimethyl Sulfide

Requirement, #/hr

P-120

HYDROFINING Catalyst

3200 lbs of Ni-Mo catalyst, 1/16" extrudate

ZnO Absorbent

3200 lbs of Adsorbent 1/8" - 3/16" spheres

TABLE I-A-2 (Cont'd)

Mol Sieve Adsorbent

30,000 lbs of 1/16" molecular sieve

Activated Carbon

3000 lbs of activated carbon

Reformer Catalyst

75 ft^3 of 5/8" x 5/8" x 1/4" nickel on alumina gas reforming rasching rings. 52-54 lbs/ft^3 bulk density

TABLE I-A-3

ONSITES EQUIPMENT LISTS - HEAT EXCHANGERS

- Shell and Tube Exchangers

Equipment No.	Service	Duty, MBtu/hr	Total Surface, Ft^2	No. Shells
E-101	Gas-Gas Exchanger	3.5	326	1
E-102	Gasifier W. H. Boiler	11.3	722	1
E-103 A and B	Product Gas Cooler	24.1	2460	2
E-104	Slurry Stripper O'H Condenser	5.2	430	1
E-105 A and B	Slurry Stripper Bottoms Cooler	8.6	1160	2
E-111	Reactivation Gas Heater	1.22	200	1
E-113	MRT Condenser	0.32	130	1
E-114 A and B	MRT Methane Comp. After Cool	0.54	340	2
E-115	H/F Feed Preheater	1.2	165	1
E-116	Reformer W. H. Boiler	8.2	620	1
E-118	Ref. Effluent Trim Cooler	1.2	517	1
E-119	Cat. Recovery Slurry Cooler	0.7	40	1
E-120	Evaporator O'H Condenser	2.1	110	1
E-121	Reactivation Gas Cooler	1.2	300	1
E-122	Slurry Stripper Reboiler	7.6	2660	1
E-123 A and B	Methane Comp. Intercooler	0.51	350	2

TABLE I-A-3 (cont'd)

- Shell and Tube Exchangers

Equipment No.	Service	Duty MBtu/hr	Total Surface, Ft^2	No. Shells
E-124	Evaporator Heater	2.9	300	1
• Air Fin Exchangers				
E-117	Ref. Effluent Cooler	10.7	975	0
• Plate Fin Exchangers				
E-106 A & B	MRT Feed Cooler	1.8	11,400	0
E-107	MRT Feed Chiller	0.44	1,100	0
E-108	MRT Feed Condenser	0.11	240	0
E-109	MRT Auxiliary Cooler	0.94	300	0
E-110	MRT O'H Condenser	0.71	3,000	0
E-112	MRT Ethylene Condenser	0.19	450	0

TABLE I-A-4

ONSITES EQUIPMENT LIST - PUMPS

Equipment No.	Service	Type	Capacity, GPM	ΔP, Psi	BHP
P-101 A and B	Ref. WH Boiler Circulating Pump	Centrifugal	580	60	28
P-102 A and B	Cyclonic Scrubber Bottoms Pump	Centrifugal	65	55	5
P-103 A and B	Ammonia Scrubber Bottoms Pump	Centrifugal	50	115	10
P-104 A and B	Slurry Stripper Reflux Pump	Centrifugal	15	25	1
P-105	Sulfuric Acid Metering Pump	Metering	0.1	110	0.5
P-106 A and B	Neutralization Circulating Pump	Centrifugal	90	20	2
P-107 A and B	MRT Reflux Pump	Centrifugal	16	10	1
P-108 A and B	MRT Bottoms Pump	Centrifugal	16	10	0.5
P-109 A and B	Char Slurry Pump	Centrifugal	350	40	30.0
P-110 A and B	Cat Solution Surge Pump	Reciprocal	18	480	7.5
P-111 A and B	Slurry Feed Pump	Centrifugal	21	50	2.5
P-112 A and B	Recycle Cat Solution Pump	Centrifugal	10	65	2.0
P-113 A and B	Spent Char and Ash Pump	Centrifugal	10	70	2.0
P-114 A and N	Hydroclone Pump	Centrifugal	30	45	2.5
P-115 A and B	Evaporator Circulating Pump	Centrifugal	880	5	15.0
P-116 A and B	Concentrated Solution Pump	Centrifugal	5	50	1

TABLE I-A-4 (cont'd)

Equipment No.	Service	Type	Capacity, GPM	ΔP, Psi	GPM
P-117 A and B	Makeup Water Booster Pump	Centrifugal	11	50	2.0
P-118 A and B	MRT H. P. Flash BTM's Pump	Centrifugal	23	10	0.75
P-119 A and B	Scrubbing Water Booster Pump	Centrifugal	60	570	50
P-120	Dimethyl Sulfide Metering Pump	Metering	0.004	625	0.1

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TABLE I-A-5

ONSITES EQUIPMENT LIST - COMPRESSORS

Equipment No.	Service	Type	No. Stages	Suction Flow, ACFM	BHP
C-101 A and B	Recycle Gas Compressor	Recip.	1	240	330
C-102 A and B	MRT Methane Compressor	Recip.	2	1,400	500
C-103 A and B	MRT Ethylene Compressor	Recip.	2	112	75
C-104 A and B	MRT K-12 Compressor	Recip.	2	227	100

TABLE I-A-6

ONSITES EQUIPMENT LIST - PRESSURE VESSELS

Equipment No.	Service	Diameter, Ft.	Length, Ft.	Position
R-101	Gasifier	3'6"	150'0"	Vertical
R-102	Hydrofiner	3'0"	12'0"	Vertical
T-101	Ammonia Scrubber	2'0"	31'0"	Vertical
T-102	Slurry Stripper	2'6"	62'0"	Vertical
T-103	Methane Recovery Tower	1'6"	36'0"	Vertical
D-101	Gasifier Steam Drum	3'0"	13'0"	Vertical
D-102	Gasifier Steam Blowdown Drum	1'0"	5'0"	Vertical
D-103	Cyclonic Fines Scrubber	4'0"	15'0"	Vertical
D-104	Venturi Fines Scrubber	1'6"	5'6"	Vertical
D-105	Product Gas KO Drum	4'0"	16'0"	Horizontal
D-106	Stripper Distillate Drum	3'0"	9'0"	Horizontal
D-107	Neutralization Mix Drum	3'0"	9'0"	Vertical
D-108	MRT Distillate Drum	3'0"	9'0"	Horizontal
D-109	MRT Bottoms Flash Drum	3'0"	9'0"	Vertical
D-110	Reformer Steam Drum	3'6"	14'0"	Vertical

TABLE I-A-6 (cont'd)

Equipment No.	Service	Diameter, Ft.	Length, Ft.	Position
D-111	Reformer Steam Blowdown Drum	1'0"	5'0"	Vertical
D-112	Reformer Effluent KO Drum	2'6"	10'0"	Vertical
D-113	Char Quench Drum	2'6"	30'0"	Vertical
D-114	Char Slurry Drum	4'0"	6'0"	Vertical
D-115	Fines Hoppers	2'6"	7'0"	Vertical
D-116	Fines Slurry Drum	4'6"	7'6"	Vertical
D-117	Slurry Feed Drum	3'0"	6'0"	Vertical
D-118	Recycle Cat Solution Drum	2'0"	6'0"	Vertical
D-119	Spent Char and Ash Drum	2'0"	4'0"	Vertical
D-120	Cat Solution Surge Drum	2'6"	7'6"	Vertical
D-121 A and N	Hydroclone Mix Drum	3'6"	6'0"	Vertical
D-122	Zno Bed	3'0"	6'0"	Vertical
D-123 A and C	Mol Sieve Adsorber	4'6"	16'6"	Vertical
D-124	MRT Ethylene Compressor KO Drum	1'6"	4'6"	Vertical
D-125	MRT R-12 Compressor KO Drum	1'6"	5'0"	Vertical
D-126	Product SNG KO Drum	1'6"	6'0"	Vertical

TABLE I-A-6 (cont'd)

Equipment No.	Service	Diameter, Ft.	Length, Ft.	Position
D-127	MRT Pressure Flash Drum	3'0"	10'0"	Vertical
D-128	Evaporator	4'6"	7'0"	Vertical
D-129	Condensate Surge Drum	2'6"	8'0"	Horizontal
BN-101	Low Pressure Feed Hopper	4'6"	3'8"	Vertical
BN-102 A and B	Lock Hopper	4'6"	1'6"	Vertical
BN-103	Continuous Feed Hopper	4'6"	3'8"	Vertical
CYC-101	Primary Gasifier Cyclone	1'7"	6'1"	Vertical
CYC-102	Secondary Gasifier Cyclone	1'6"	5'7"	Vertical
CYC-103	Tertiary Gasifier Cyclone	1'1"	4'1"	Vertical
CYC-104	Char Quench Drum Cyclone	8"	2'0"	Vertical
CYC-105	Feed Hopper Cyclone	2'0"	5'0"	Vertical

TABLE I-A-7

ONSITE EQUIPMENT LIST - FURNACES

Furnaces

Equipment No.	F-101	F-102
Service	Steam/Recycle Gas Preheat Furnace	Steam Reformer Furnace
Type	Vertical Tube Box Furnace with Horizontal Convection Section	Vertical Tube Box Furnace with Horizontal Convection Section
Duty, MBtu/Hr	11.6	18.8 Radiant/10.7 Conv.
Efficiency, %	75.3	83.8
Excess Air, %	20	15

TABLE I-A-8

ONSITE EQUIPMENT LIST - SPECIAL EQUIPMENT

Special Equipment

SCRN - 101 A and B	Screens to remove particles larger than 1000 micron from slurry feed to D-117 Slurry feed tank Sweco
STR - 101 A and B	Char slurry strainers, screen type to remove particles larger than 3/16", screen area in 40 $in.^2$.
J - 101	Steam jet ejector. Suction pressure 10 in. Hg back pressure 40 in. Hg, 886.6 lb/hr saturated steam.

TABLE I-A-9

ONSITES EQUIPMENT LIST - ANALYZERS

Item	Stream	Type	Components
A-101 R	Ammonia Scrubber Overhead	GC	H_2, CO, CO_2, CH_4
A-102 R	Ammonia Scrubber Overhead	GC	H_2S, NH_3, C_2+
A-103 R	Sour Slurry Stripper Bottoms	pH	
A-104 R	Feed to MRT Cooler	H_2O Dew Point	0 to -140 °F
A-105 R	Feed to MRT Cooler	CO_2 (ppm)	
A-106 R	Synthetic Product Gas	GC	H_2, CO, CO_2, CH_4
A-107 R	Steam Reformer Feed	H_2S	0-2 ppm
A-108 R	Preheat Furnace Feed	GC	H_2, CO, CO_2, CH_4
A-109 R	Preheat Furnace Effluent	H_2S	0-2 ppm

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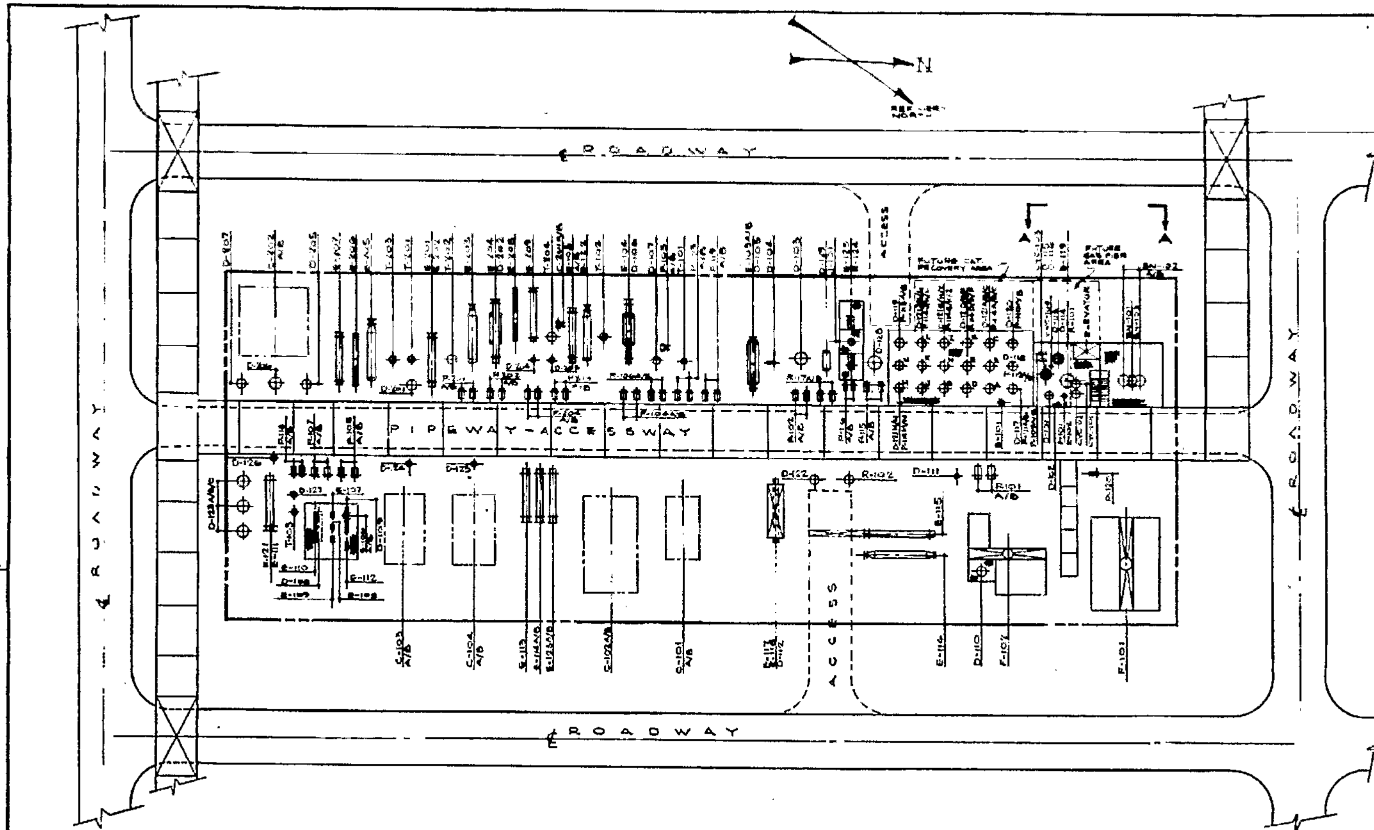
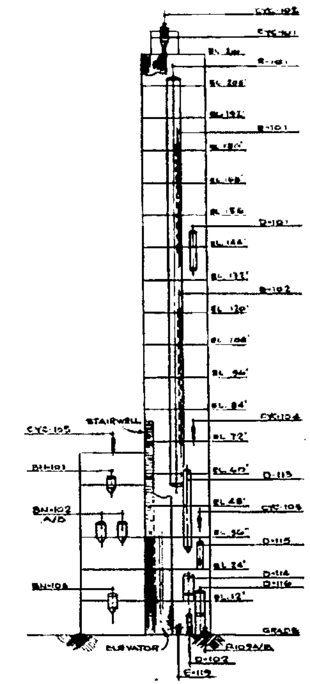




ELEVATION VIEW A-A

EQUIPMENT LISTING

NO	DESCRIPTION
	TOWERS
T-101	AMMONIA SCRUBBER
T-102	SLURRY STRIPPER
T-103	METHANE RECOVERY
	DRUMS
D-101	GASIFIER STEAM
D-102	GASIFIER STEAM BLOWDOWN
D-103	CYCLONIC FINES SCRUBBER
D-104	VENTURI FINES SCRUBBER
D-105	PRODUCT GAS K.O.
D-106	STRIPPER DISTILLATE
D-107	NEUTRALIZATION MIX
D-108	MRT DISTILLATE
D-109	MRT BOTTOMS FLASH
D-110	REFORMER STEAM
D-111	REFORMER STEAM BLOWDOWN
D-112	REFORMER EFFLUENT K.O.
D-113	CHAR QUENCH
D-114	CHAR SLURRY
D-115	FINES HOPPER
D-116	FINES SLURRY
D-117	SLURRY FEED
D-118	RECYCLE CAT SOLUTION
D-119	SPENT CHAR AND ASH
D-120	CAT SOLUTION SURGE
D-121	HYDROCLONE MIX
A-N	
D-122	ZnO BED
D-123	MOL SIEVE ADSORBER
A-C	
D-124	MRT ETHYLENE COMPRESSOR K.O.
D-125	R-12 COMPRESSOR K.O.
D-126	PRODUCT SNG K.O.
D-127	MRT H.P. FLASH
D-128	EVAPORATOR
D-129	CONDENSATE SURGE

NO	DESCRIPTION
	EXCHANGERS
E-101	GAS-GAS
E-102	GASIFIER WASTE HEAT BOILER
E-103A/B	PRODUCT GAS COOLER
E-104	SLURRY STRIPPER OVH'D CONDENSER
E-105A/B	SLURRY STRIPPER BOTTOMS COOLER
E-106A/B	MRT FEED COOLER
E-107	MRT FEED CHILLER
E-108	MRT FEED CONDENSER
E-109	MRT AUXILIARY COOLER
E-110	MRT OVH'D. CONDENSER
E-111	REACTIVATION GAS HEATER
E-112	MRT ETHYLENE CONDENSER
E-113	MRT R-12 CONDENSER
E-114A/B	MRT METHANE COMPR. AFTERCOOLER
E-115	HYDROFINER FEED PREHEATER
E-116	REFORMER WASTE HEAT BOILER
E-117	REFORMER EFFLUENT COOLER
E-118	REFORMER EFFLUENT TRIM COOLER
E-119	CAT RECOVERY SLURRY COOLER
E-121	REACTIVATION GAS COOLER
E-122	SLURRY STRIPPER REBOILER
E-123A/B	1ST STAGE INTERCOOLER
E-124	EVAPORATOR HEATER
E-125	EVAPORATOR OVH'D. CONDENSER
	PUMPS
P-101A/B	REFORMER W.H. BOILER CIRCULATING
P-102A/B	CYCLONIC SCRUBBER BOTTOMS
P-103A/B	AMMONIA SCRUBBER BOTTOMS
P-104A/B	SLURRY STRIPPER REFLUX
P-105	SULFURIC ACID METERING
P-106A/B	NEUTRALIZATION CIRCULATING
P-107A/B	MRT REFLUX
P-108A/B	MRT BOTTOMS
P-109A/B	CHAR SLURRY
P-110A/B	CAT. SOLUTION SURGE
P-111A/B	SLURRY FEED
P-112A/B	RECYCLE CAT. SOLUTION
P-113A/B	SPENT CHAR AND ASH
P-114A-H	HYDROCLONE
P-115A/B	EVAPORATOR CIRCULATING
P-116A/B	CONCENTRATED SOLUTION
P-117A/B	MAKEUP WATER BOOSTER

NO	DESCRIPTION
	PUMPS (CONT'D.)
P-118A/B	MRT H.P. FLASH BOTTOMS
P-119A/B	SCRUBBING WATER BOOSTER
P-120A/B	DIMETHYL SULFIDE METERING
	FURNACES
F-101	PREHEAT
F-102	STEAM REFORMER
	COMPRESSORS
C-101A/B	RECYCLE GAS
C-102A/B	MRT METHANE
C-103A/B	MRT ETHYLENE
C-104A/B	MRT R-12
	HOPPERS
BH-101	LOW PRESSURE FEED
BH-102A/B	LOCK
BH-103	CONTINUOUS FEED
	CYCLONES
CYC-101	PRIMARY
CYC-102	SECONDARY
CYC-103	TERTIARY
CYC-104	CHAR QUENCH
CYC-105	FEED HOPPER
	REACTORS
R-101	GASIFIER
R-102	HYDROFINER
	MISCELLANEOUS
J-101	STEAM JET EJECTOR
S-101	SEPARATOR

SELEXOL UNIT

NO	DESCRIPTION
	TOWERS
T-201	H_2S ABSORBER
T-202	H_2S STRIPPER
T-203	CO_2 ABSORBER
T-204	CO_2 STRIPPER
	DRUMS
D-201	CO_2 ABSORBER ENTRAINMENT SEP
D-202	H_2S STRIPPER CONDENSATE
D-203	CO_2 STRIPPER ENTRAINMENT SEPARATOR
D-204	DEHYDRATION SYSTEM FLASH
D-205	REFRIGERANT COMPR. SUCTION K.O.
D-206	REFRIGERANT LIQUID SURGE
D-207	REFRIGERANT FLASH
	EXCHANGERS
E-201	HEAVY GLYCOL GAS-GAS
E-202	H_2S REMOVAL SECTION
E-203	H_2S STRIPPER REBOILER
E-204	H_2S STRIPPER OVHD CONDENSER
E-205	H_2S SECTION SOLVENT CHILLER
E-206	CO_2 SECTION SOLVENT CHILLER
E-207	REFRIGERANT CONDENSER
E-208	DEHYDRATION SYSTEM HEATER
E-209	DEHYDRATION SYS. INTERCHANGER
	PUMPS
P-201A/B	H_2S REMOVAL SOLVENT CIRCULATION
P-202A/B	H_2S STRIPPER REFLUX
P-203A/B	CO_2 REMOVAL SOLVENT CIRCULATION
P-204A/B	DEHYDRATION SYSTEM RETURN
C-201A/B	AIR BLOWER
C-202A/B	REFRIGERANT COMPRESSOR

103

103-A

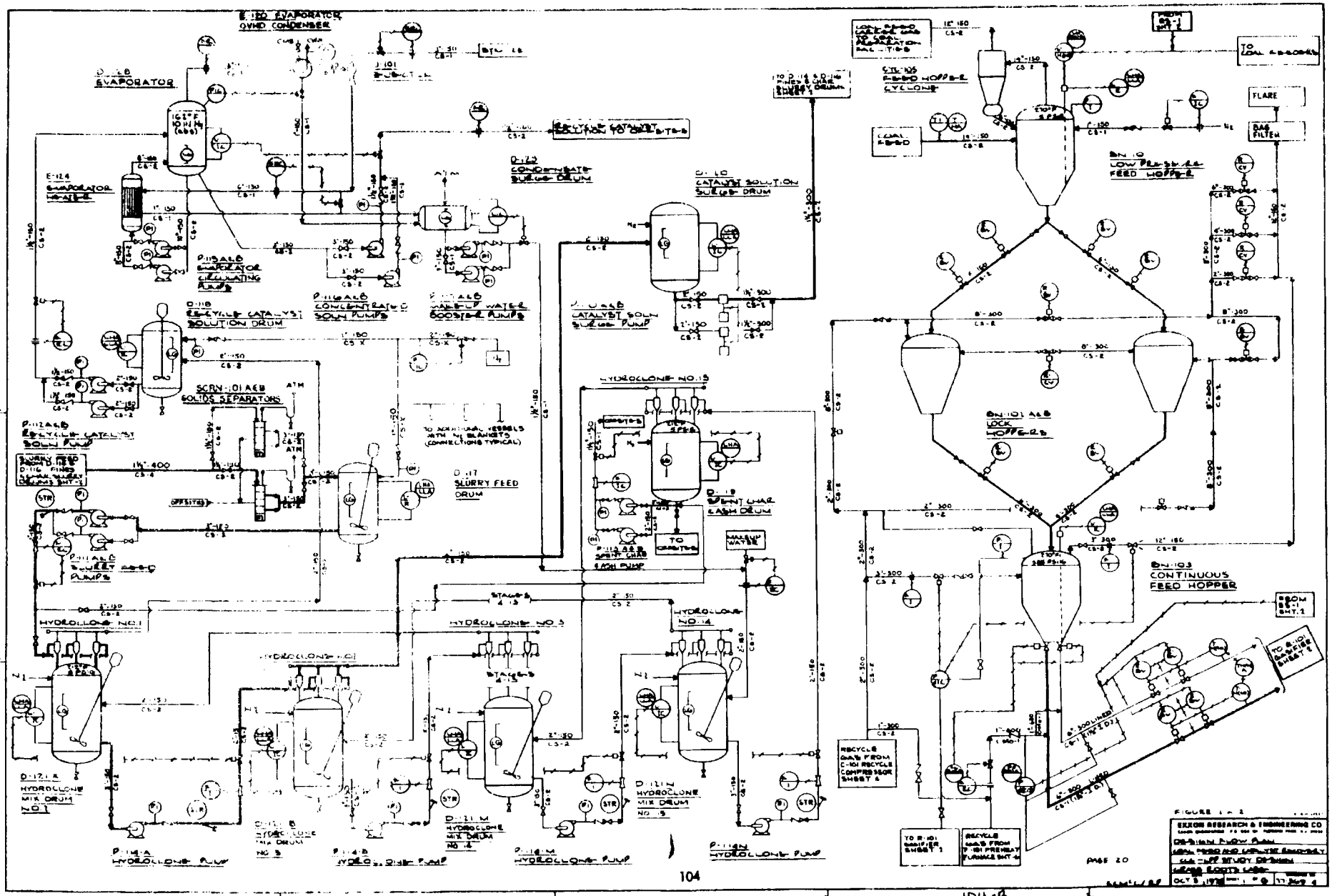
10 0 10 20 30 40 50
— SCALE IN FEET —

FIGURE I-A-1

EXXON RESEARCH & ENGINEERING CO
PLOT PLAN
CCG—LPP STUDY DESIGN
GRASS ROOTS CASE
BAYTOWN, TEXAS
DATE OCT 3, 1978 — SHEET OF — DRAWING NO. PP-1289-4

TN/OP

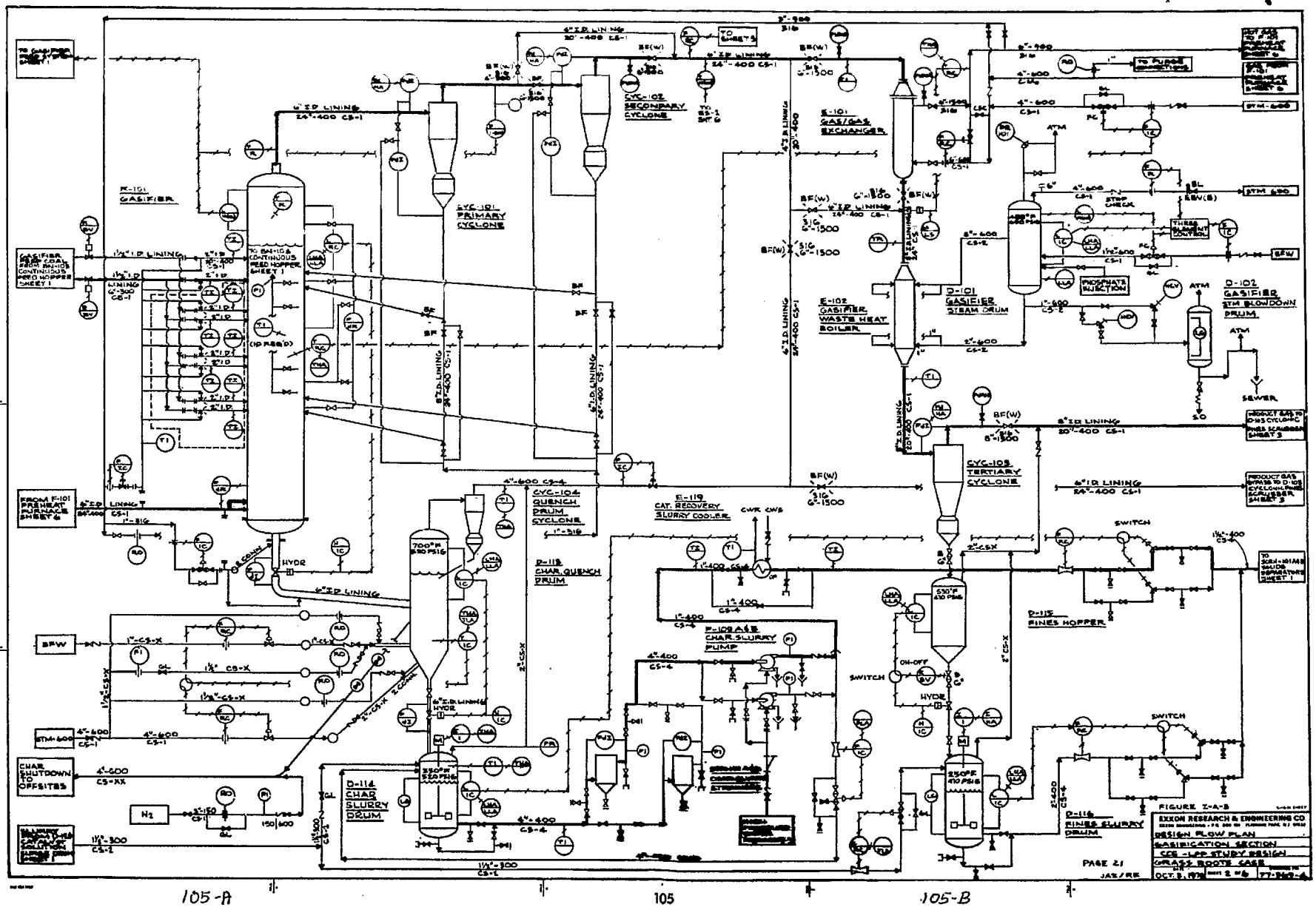
103-B



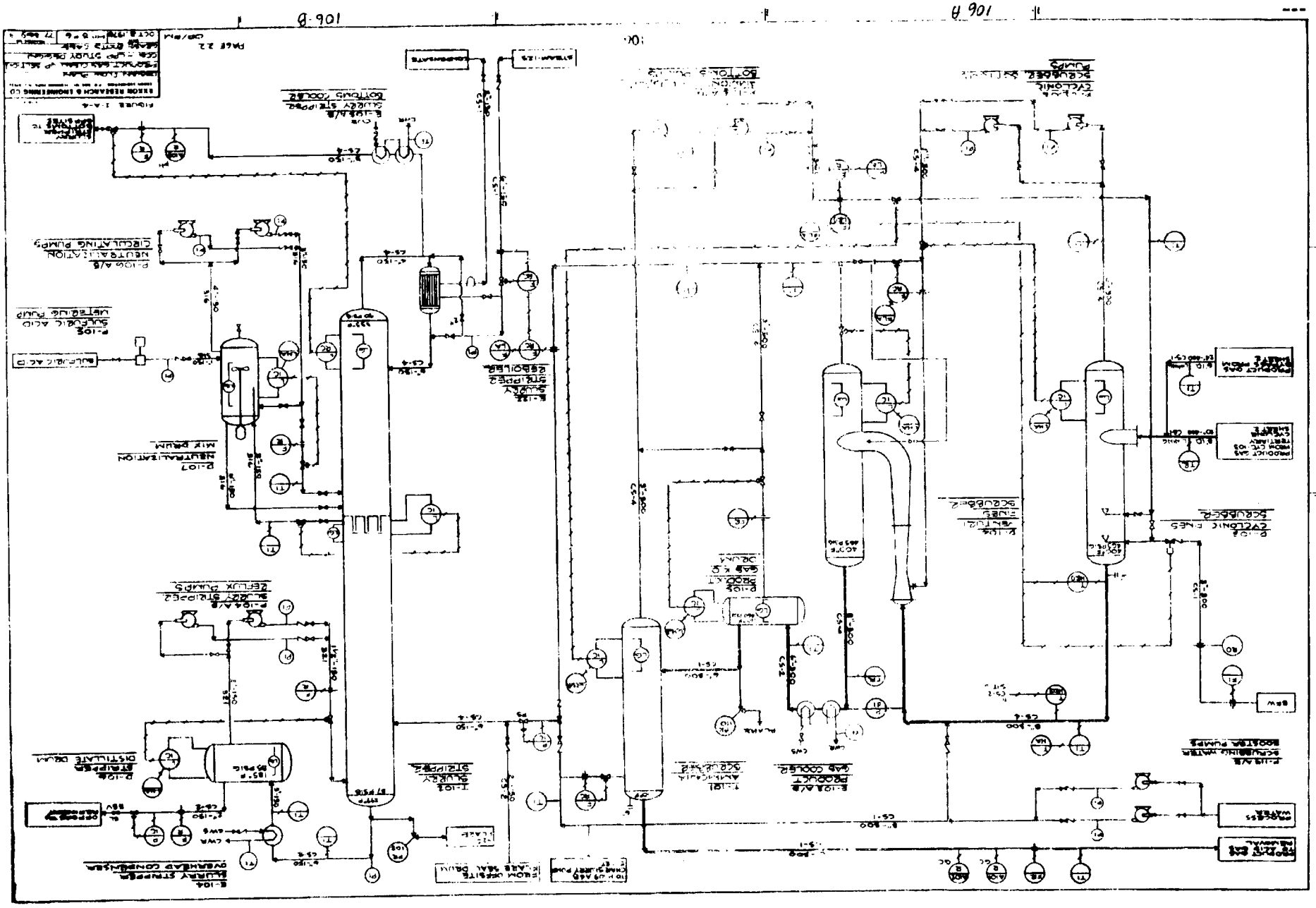
104

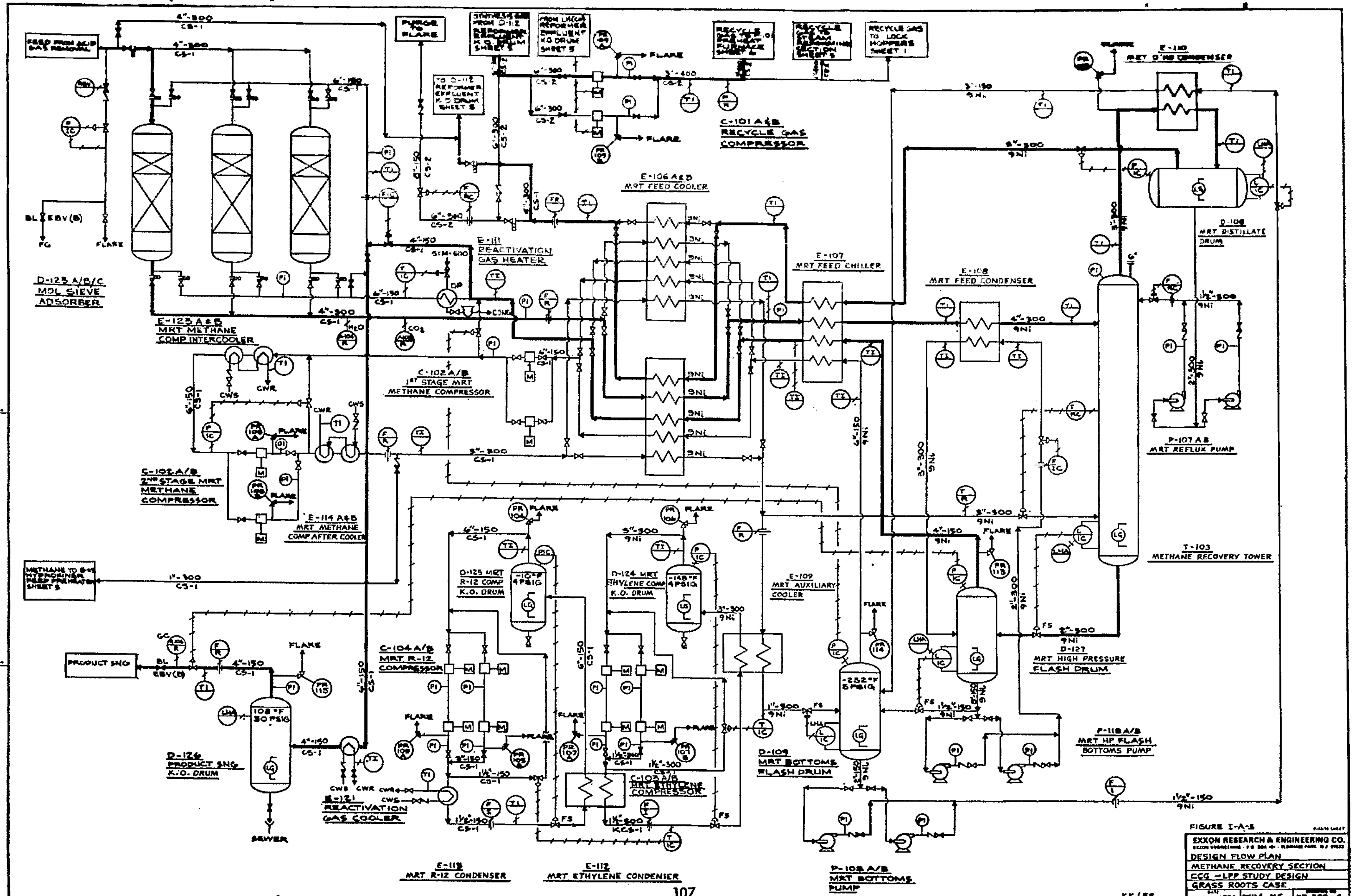
104-A

104-B



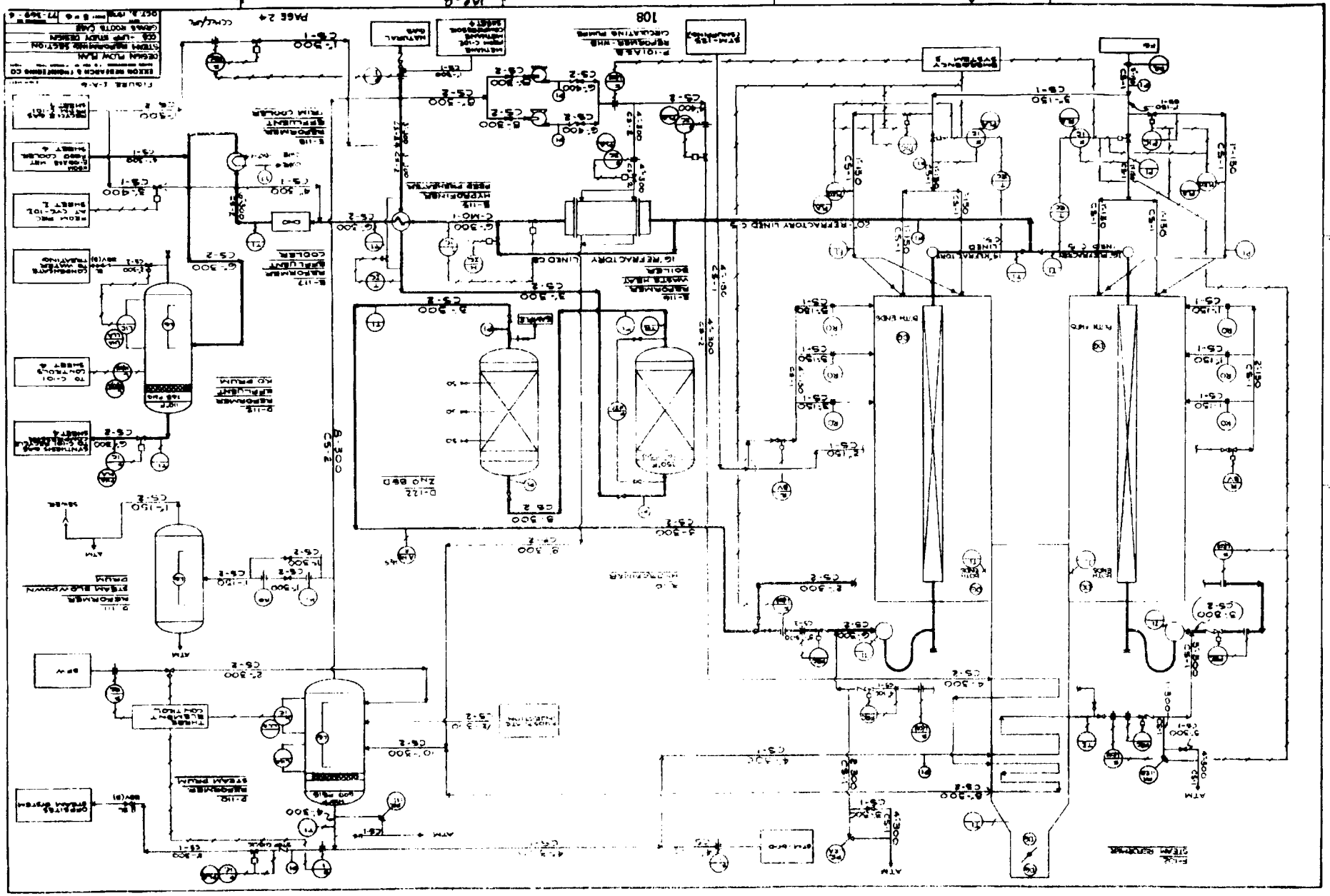
105-A 105 105-B




FEED FROM ACID GAS REMOVAL
PURGE TO FLARE
SYNTHESIS GAS FROM D-112 REFORMER EFFLUENT K.O. DRUM SHEET 5
FROM LPG REFORMER EFFLUENT K.O. DRUM SHEET 5
TO D-112 REFORMER EFFLUENT K.O. DRUM SHEET 5
RECYCLE GAS TO LOCK HOPPERS SHEET 1
C-101 A&B RECYCLE GAS COMPRESSOR
E-110 MRT O'HD CONDENSER
D-108 MRT DISTILLATE DRUM
D-123 A/B/C MOL SIEVE ADSORBER
E-106 A&B MRT FEED COOLER
E-111 REACTIVATION GAS HEATER
E-107 MRT FEED CHILLER
E-108 MRT FEED CONDENSER
E-123 A&B MRT METHANE COMP INTERCOOLER
C-102 A/B 1ST STAGE MRT METHANE COMPRESSOR
C-102 A/B 2ND STAGE MRT METHANE COMPRESSOR
E-114 A&B MRT METHANE COMP AFTER COOLER
P-107 A B MRT REFLUX PUMP
METHANE TO B-4 HYDROFINER FEED PREHEATER SHEET 5
D-125 MRT R-12 COMP K.O. DRUM
D-124 MRT ETHYLENE COMP K.O. DRUM
E-109 MRT AUXILIARY COOLER
T-103 METHANE RECOVERY TOWER
D-127 MRT HIGH PRESSURE FLASH DRUM
PRODUCT SNG
C-104 A/B MRT R-12 COMPRESSOR
C-103 A/B MRT ETHYLENE COMPRESSOR
D-126 PRODUCT SNG K.O. DRUM
E-121 REACTIVATION GAS COOLER
D-109 MRT BOTTOMS FLASH DRUM
P-118 A/B MRT HP FLASH BOTTOMS PUMP
E-113 MRT R-12 CONDENSER
E-112 MRT ETHYLENE CONDENSER
P-108 A/B MRT BOTTOMS PUMP
SEWER
107
FIGURE I-A-5
EXXON RESEARCH & ENGINEERING CO.
DESIGN FLOW PLAN
METHANE RECOVERY SECTION
CCG -LPP STUDY DESIGN
GRASS ROOTS CASE
OCT. 5, 1978
77-369-4
KK/FS

107-A

107-B



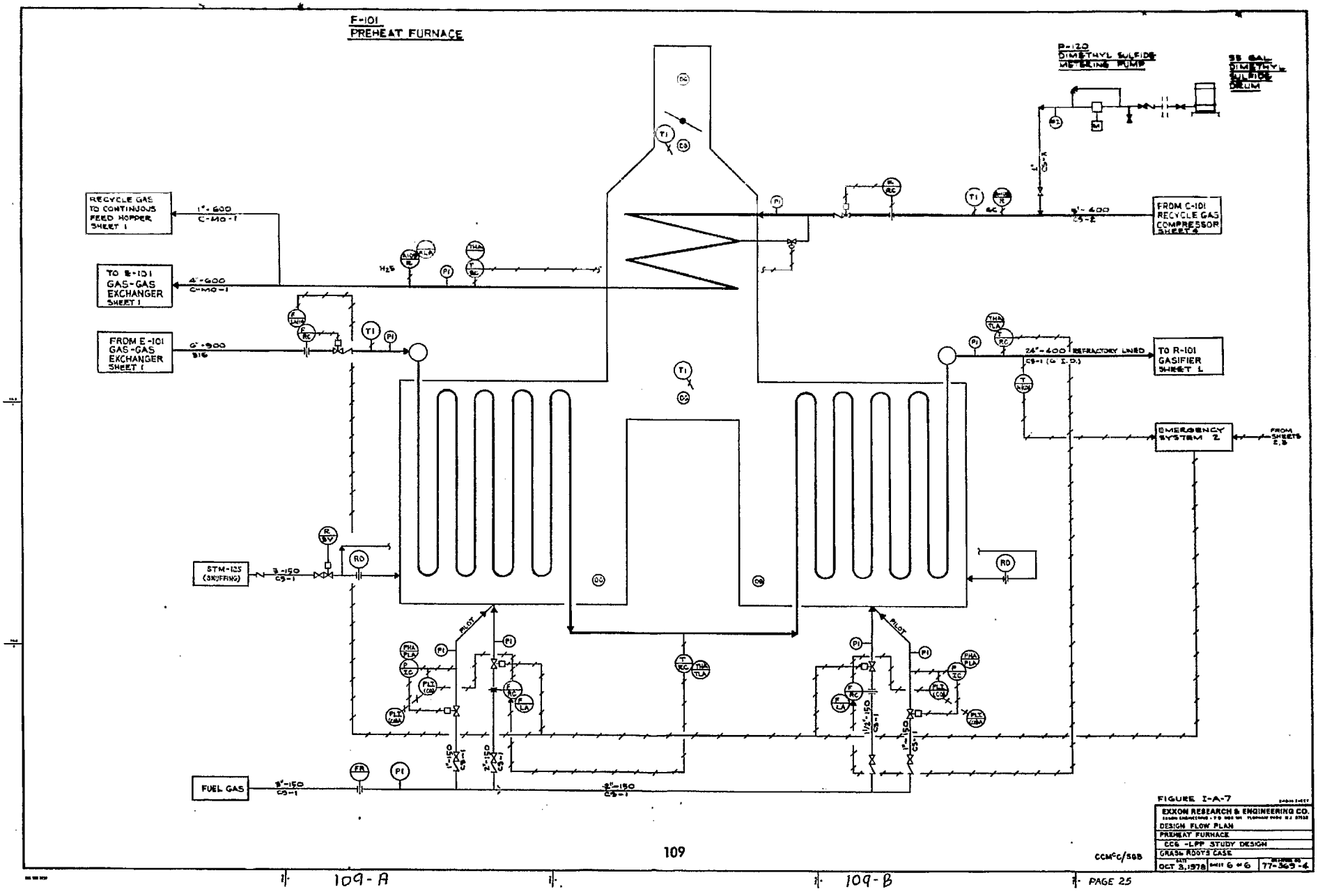
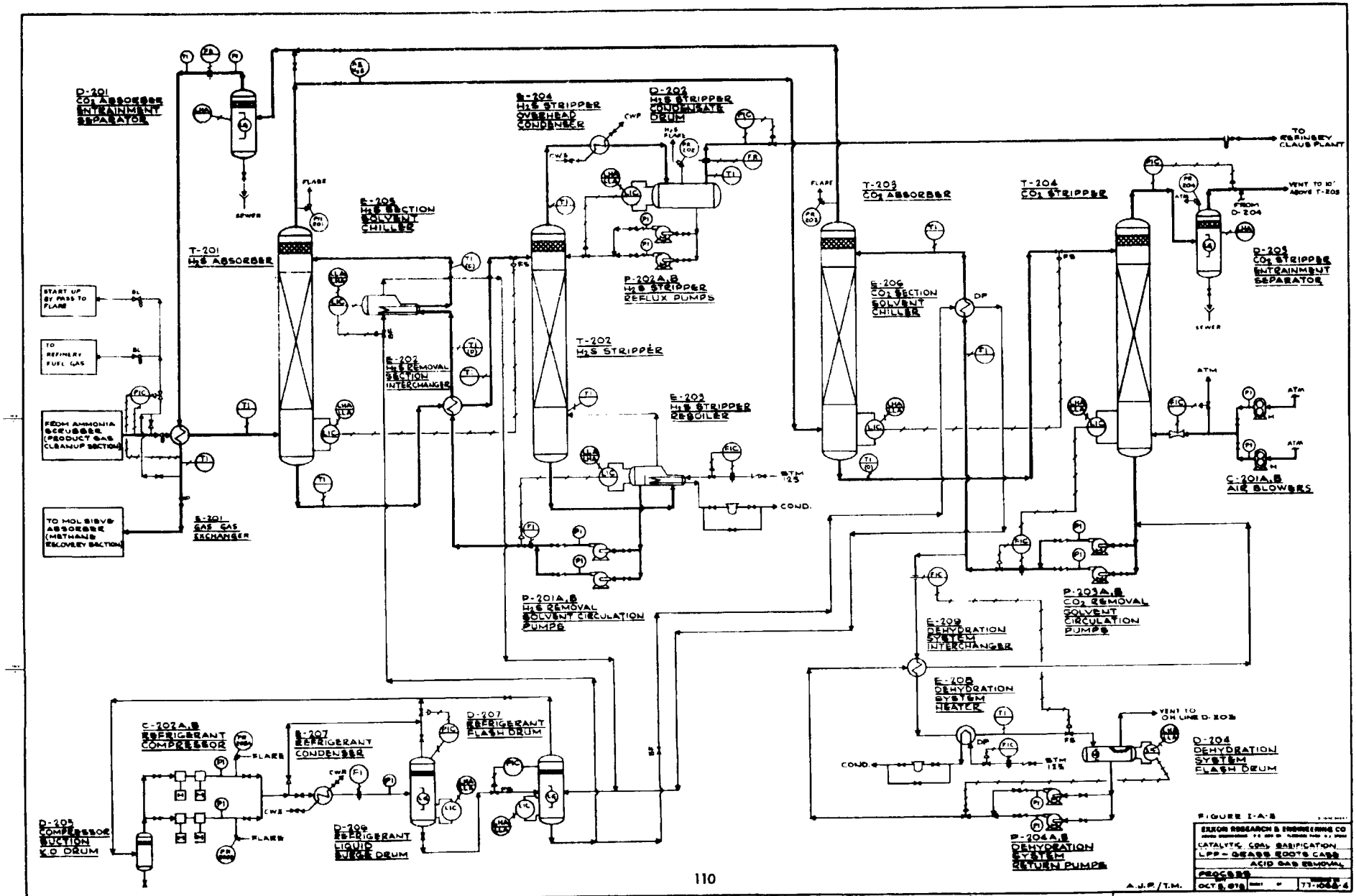


FIGURE I-A-7

EXXON RESEARCH & ENGINEERING CO.	
DESIGN FLOW PLAN	
PREHEAT FURNACE	
CCG -LPP STUDY DESIGN	
GRASS ROOTS CASE	
OCT 3, 1978	SHEET 6 OF 6 — 77-369-4

CCM°C/56B


D-201 CO2 ABSORBER ENTRAINMENT SEPARATOR
E-204 H2S STRIPPER OVERHEAD CONDENSER
D-202 H2S STRIPPER CONDENSATE DRUM
TO REFINERY CLAUS PLANT
E-205 H2S SECTION SOLVENT CHILLER
T-201 H2S ABSORBER
P-202A,B H2S STRIPPER REFLUX PUMPS
T-203 CO2 ABSORBER
T-204 CO2 STRIPPER
VENT TO 10' Above T-205
FROM D-204
D-203 CO2 STRIPPER ENTRAINMENT SEPARATOR
START UP BY PASS TO FLARE
TO REFINERY FUEL GAS
FROM AMMONIA SCRUBBER (PRODUCT GAS CLEANUP SECTION)
T-202 H2S STRIPPER
E-207 H2S REMOVAL SECTION INTERCHANGER
E-206 CO2 SECTION SOLVENT CHILLER
E-203 H2S STRIPPER REBOILER
C-201A,B AIR BLOWERS
TO MOL SIEVE ABSORBER (METHANE RECOVERY SECTION)
E-201 GAS GAS EXCHANGER
COND.
P-201A,B H2S REMOVAL SOLVENT CIRCULATION PUMPS
P-203A,B CO2 REMOVAL SOLVENT CIRCULATION PUMPS
E-209 DEHYDRATION SYSTEM INTERCHANGER
E-208 DEHYDRATION SYSTEM HEATER
C-202A,B REFRIGERANT COMPRESSOR
E-210 REFRIGERANT CONDENSER
D-207 REFRIGERANT FLASH DRUM
VENT TO ON LINE D-205
D-204 DEHYDRATION SYSTEM FLASH DRUM
D-205 COMPRESSOR SUCTION K.O. DRUM
D-206 REFRIGERANT LIQUID SURGE DRUM
P-204A,B DEHYDRATION SYSTEM RETURN PUMPS
FIGURE I-A-8
EXXON RESEARCH & ENGINEERING CO
CATALYTIC COAL GASIFICATION
LPG - GEGAS COOTS CASE
ACID GAS REMOVAL
PROCESS
OCT 8, 1976
77-1044-4
A.J.P./T.M.

APPENDIX I-B

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY - GRASS ROOTS CASE

COAL RECEIPT AND STORAGE

This section of the Study Design covers the Coal Receipt and Storage Facilities for the Catalytic Coal Gasification Pilot Plant. These facilities consist of equipment in that area of the coal handling system beginning with the undertrack rail dump hopper and ending with the raw coal storage reclaim feeders. The major components are a 110 ton track hopper, a 570 foot raw coal conveyor, and a 2000 ton raw coal silo.

DESIGN BASIS

- General

  The coal receipt and storage facilities have been sized based on past planning work done for a similar project rather than a detailed transportation study involving optimum coal train size and advance/delay factors.

- Coal type and properties

  The plant will process Illinois No. 6 bituminous coal. A summary of the major physical properties for the coal is as follows:

  - Moisture content

    + Total, % wt. 16.6
    + Surface, % wt. 3.6

  - Bulk density, lb/ft^3 45-50
  - Hardgrove index 56
  - As-received angle of repose 40
  - As-received particle size distribution: see page 3

  All equipment shall be designed for a maximum as-received particle size of three inches.

- Maximum process coal consumption
  - Moisture free, ST/SD 77
  - As-received, ST/SD 92

- Coal receipt

  Coal will be shipped in covered 100 ton, bottom-dump rail cars and received in a below grade track hopper. Eleven rail cars using regular freight service to Illinois will satisfy the coal demand. The round trip time to Illinois will be eleven days including time for loading and unloading. The unloading rate of 125 TPH will permit unloading the eleven rail cars in nine hours. Should plant production and rail freight delays result in low silo inventory, additional rail cars will be required.

- Storage

  A single 2000 ton raw coal storage silo will be provided. If different feed coals are to be run, they can be processed sequentially, eliminating the need for storing more than one coal at a time. The silo will be inerted to minimize coal degradation and fire potential.

- Dust suppression

  A water spray system shall be provided to suppress airborne dust at the rail hopper and at the feeder/conveyor transfer points. Dust collection shall be provided at the silo inlet, reclaim feeder outlets, and at the transfers near the silo to minimize dusting in these areas. Forced ventilation shall also be provided in the track hopper pit.

TABLE I-B-1

UTILITIES AND CHEMICALS

Electric Power

Requirements (KW)

Symbol	Service	Duty	Load	
			Operating	Connected
C-1001	Track Hopper Collection Conveyor	I	2.2	2.8
C-1002	Raw Coal Transport Conveyor	I	28.0	33.5
FE-1001A	Track Hopper Reclaim Feeder	I	1.0	1.0
FE-1001B	Track Hopper Reclaim Feeder	I	1.0	1.0
FE-1001C	Track Hopper Reclaim Feeder	I	1.0	1.0
FE-1001D	Track Hopper Reclaim Feeder	I	1.0	1.0
FE-1002A	Silo Reclaim Feeder	N	0.7	1.0
FE-1002B	Silo Reclaim Feeder	N	0.7	1.0
P-1001	Sump Pump	I	1.9	2.8
M-1001	Tramp Iron Magnet	I	By Contractor	
SS-1001	Dust Suppression Spray	I	20.0	20.0
B-1001	Dust Collector Fan	N	9.0	9.0
B-1002	Track Hopper Pit Ventilation Fan	N	1.5	1.9
	Control Booth Ventilation and Air Conditioning	N	By Contractor	
	Instruments	N	By Contractor	
	Lighting	N	By Contractor	

TABLE I-B-1 (cont'd)

Industrial Water

Requirements, GPM	Normal	Maximum
Dust Suppression Sprays	0	25

Compressed Air

Requirements, SCFM	Normal	Maximum
Instrument	10	10
Utility (Rail Car Unloading)	0	50

Nitrogen

Requirements, SCFM	Normal	Maximum
Raw Coal Storage Silo Purge	50	200

Chemicals

Requirements	Normal	Maximum
Dust Suppression Spray System Wetting Agent (gallons per rail delivery)	0	10

TABLE I-B-2

EQUIPMENT LISTS - COAL PREPARATION AND STORAGE

Pumps

Equipment No.	P-1001
Service	Track Hopper Sump Pump
Type	Vertical Sump
Capacity, gpm	50
ΔP, psi	30
Driver	Electric Motor

Compressors

Equipment No.	B-1001	B-1002
Service	Dust Collection Fan	Track Hopper Pit Ventilation Fan
Flow Rate, SCFM	2500	1100
Fan ΔP (1W)		
Inlet Temperature, °F	Ambient	By Contractor
Gas	Air/Nitrogen	Air

Bins

Equipment No.	BN-1001	BN-1002
Service	Track Hopper	Raw Coal Storage Silo
Shape	Rectangular	Cylindrical
Dimensions, ft	50 x 11 x 9.9 ft. ht.	40 ft. diam. x 125 ft. ht
Net Capacity, tons	110	2000
Max. Outlet Rate, STPH	125	
Special Features		Concrete silo with 1/2" CS inserts, Silo shall be closed and inerted.

Conveyors

Equipment No.	CO-1001	CO-1002
Service	Track Hopper Coll.	Raw Coal Transport
Type	Belt	Belt
Length, Ft.	65	565
Rise, ft.	0	155
Width, in.	24	18
Capacity, STPH	125	125

TABLE I-B-2 (cont'd)

Feeders

Equipment No.	FE-1001 A-D	FE-1002 A/B
Service	Track Hopper Reclaim	Silo Reclaim
Type	Vibrating Pan	Flat Belt
Length, Ft.	7	9.5
Width, In.	24	18
Capacity/Feeder, STPH	32	5.5

Excavations

- Rail Dump Hopper Pit (see page 1001)
  - Pit shall be large enough to accommodate the track hopper and all associated equipment. Approximate dimensions are 65' long x 20' wide x 25' deep, with a low area at one end. Approximate low area dimensions are 18' long x 20' wide x 7' deep. (Maximum depth of pit 32'.) Low area will form the beginning of the raw coal transport conveyor tunnel (see below) and will contain the tail pulley end of the transport conveyor, and the pit sump pump.
- Transport Conveyor Tunnel
  - Tunnel shall accommodate CO-1002 and associated equipment. Inclined tunnel dimensions shall be approximately 8 ft wide x 8 ft high x 130 ft long.

M-1001 TRAMP IRON MAGNET

• Service:	Remove tramp iron from coal stream on CO-1001
• Type:	Electromagnet
• Remarks:	- Provide hoist for magnet to permit cleaning - Locate at discharge end of CO-1001 - Provide on/off switch locally at magnet

SS-1001 DUST SUPPRESSION SYSTEM

• Type:	Water spray with chemical wetting agent package unit.
• Sprays:	- Along sides of track hopper BN-1001 - FE-1001A-D transfer points - CO-1001/CO-1002 transfer point
• Remarks:	- Dust suppression system shall be provided as a package system. Owner's engineer shall determine location of associated board mounted instruments.

TABLE I-B-2 (cont'd)

DUST COLLECTOR
DC-1001 DUST COLLECTION BAG FILTER

- Type: Continuous self-cleaning

- Collection Points and Design Rates

Location	ACFM
- Silo Filling Purge	100
- Silo Purge Max.	200
- CO-1002/Silo Transfer	750
- FE-1002A/B Purge	200
- Feed to CO-1101/1102	1100
	2350
- Contingency	150
	2500

- Gas: Air/Nitrogen
- Design Volume (ACFM): 2500
- Net Bag Area (ft^2): 850
- Remarks:
  - To be located at grade near raw coal storage silo BN-1002.
  - Provide slide valve gates on all ducts leading to the bag filters.
  - Shall be high enough above grade to permit dumping of dust in "tote bin" or equivalent.

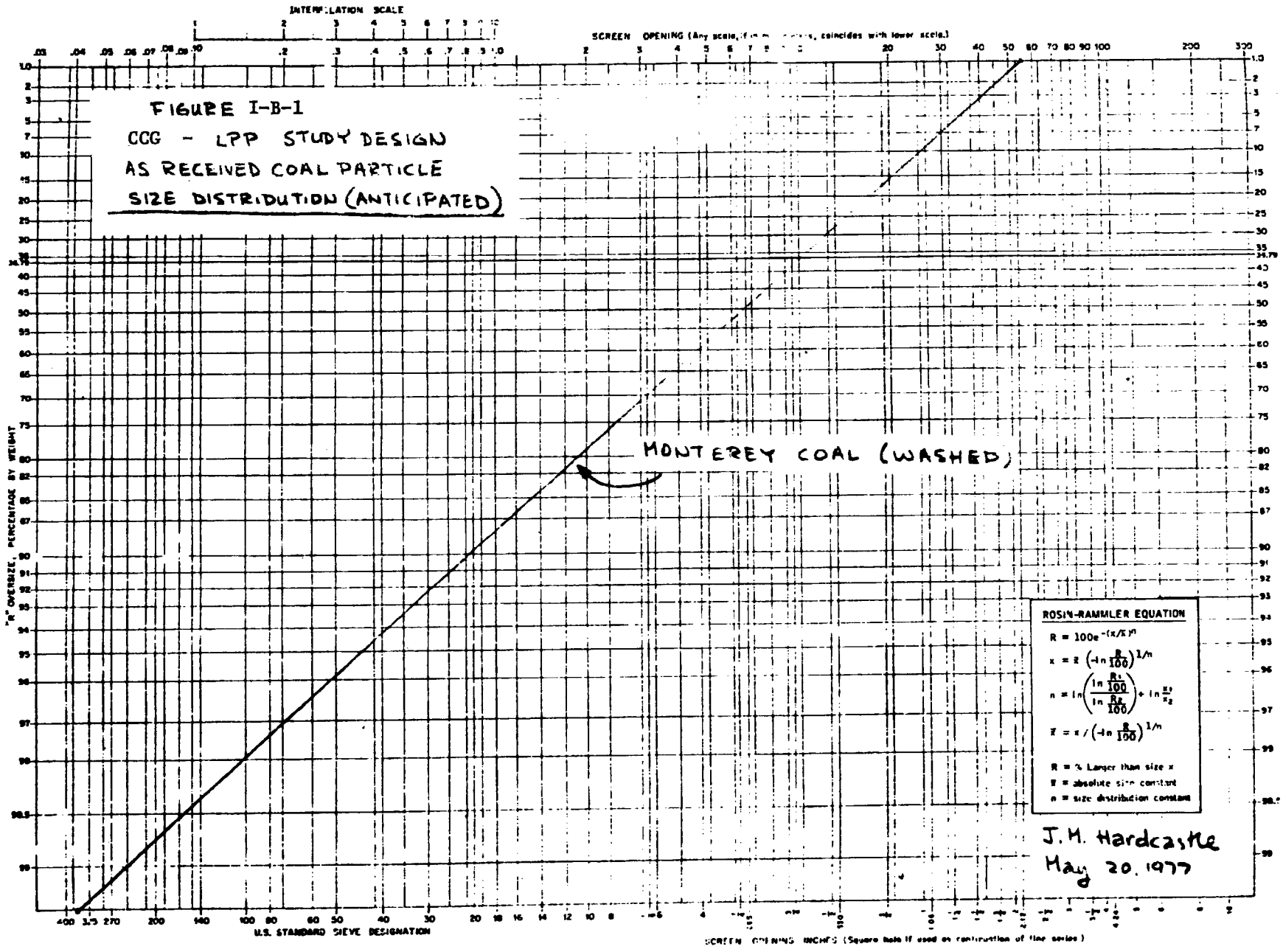
RAIL CAR UNLOADING FACILITIES

- A rail car unloading system shall be provided to permit semi-automatic unloading of the rail cars (activated by a pushbutton located in the track hopper control room). This system shall be designed according to Specification 500-500 of the Ortner Freight Car Company and shall include:
  - A "third rail" for engaging the car pickup shoe.
  - A 24-32 volt DC power supply for operation of the pneumatic solenoid operated valve.
  - Control equipment to permit remote unloading activation from the track hopper control room.
- Provide a flexible hose and the necessary connections to provide air to the rail car door operating mechanism.

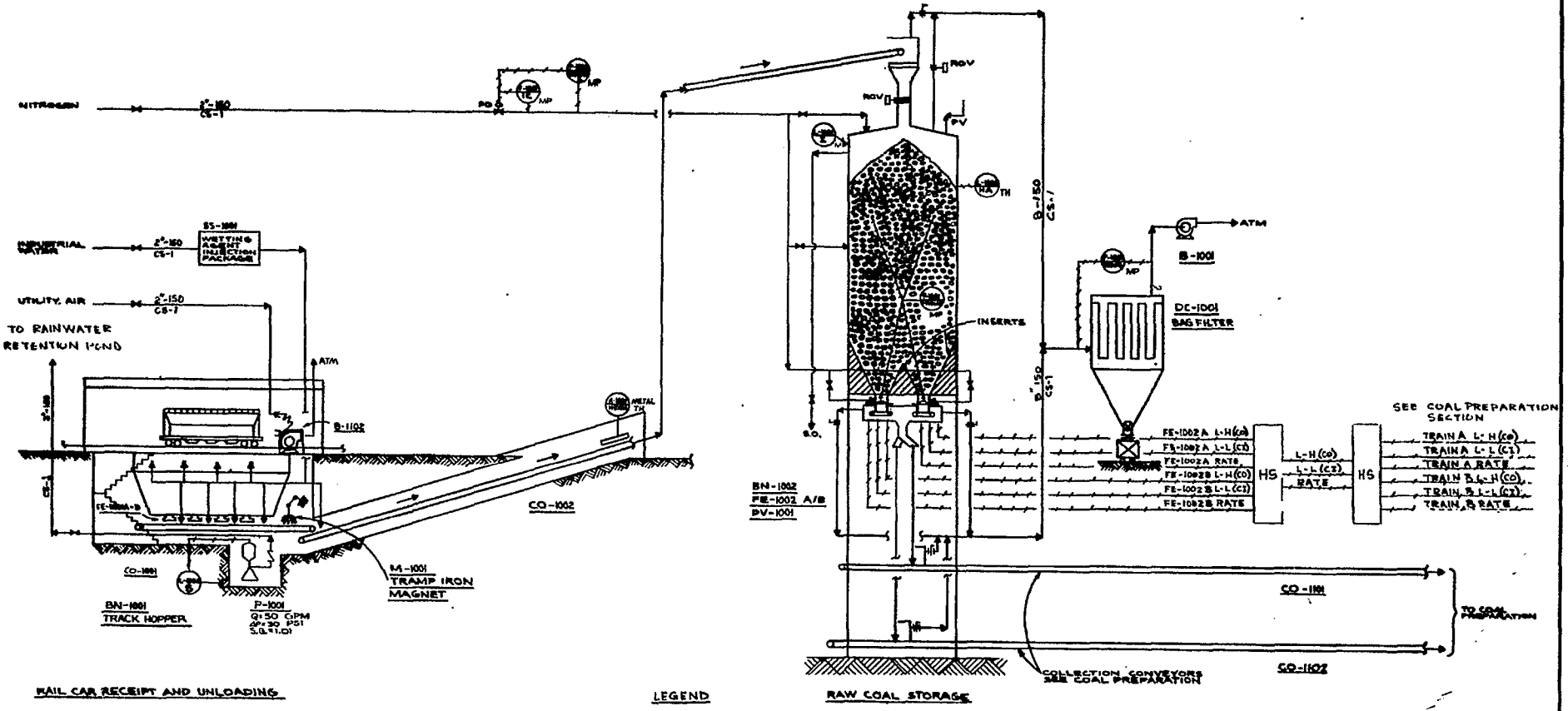
TABLE I-B-2 (cont'd)

Shelters

- Track Hopper Shelter
  - Shall cover track hopper dump area.
  - Approximate size: 65' x 25' x 25' high.
  - Minimum internal clearance: 17' wide centered on rails x 23' high.
  - Unheated.
  - Shelter shall be of economical construction using fireproof material.
  - Provide paving between rail tracks from one end of track hopper to nearest roadway to permit entry of trucks to dump into track hopper.
  - Provide a track side control for a local control panel and operators. Control room shall be air-conditioned and sound and dust insulated according to OSHA requirements.
- Conveyor Tunnel Shelter
  - A minimal shelter shall be provided at the CO-1002 tunnel outlet at grade to control access to the tunnel and prevent rainwater entry.
  - The shelter shall be provided with a gate and lock.



GRAPHICAL FORM FOR REPRESENTING DISTRIBUTION OF SIZE OF BROKEN COAL



LEGEND

- INSTRUMENT MOUNTED LOCALLY ONLY.
- INSTRUMENT MOUNTED ON COAL PREPARATION CONTROL PANEL ONLY.
- INSTRUMENT MOUNTED ON BOTH COAL PREPARATION PANEL AND CONTROL HOUSE PANEL. (MP)
- INSTRUMENT MOUNTED ON TRACK HOPPER CONTROL PANEL ONLY. (TH)
- —|[|— SLIDE VALVE USED FOR PRESSURE BALANCE
- HS HAND SWITCH

FIGURE I-B-2 NOTE: EQUIPMENT NOT TO SCALE

EXXON RESEARCH & ENGINEERING CO.		
EXXON ENGINEERING - P.O. BOX 101 - FLORHAM PARK, N.J. 07932		
COAL RECEIPT AND STORAGE FLOW PLAN		
CCG—LPP STUDY DESIGN		
GRASS ROOTS CASE		
DATE OCT. 5, 1978	SHEET OF	DRAWING NO. 77-786-3

JMH/AL

APPENDIX I-C

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY-GRASS ROOTS CASE

COAL PREPARATION FACILITIES

This section of the Study Design covers the design of the coal preparation facilities for the Catalytic Coal Gasification Large Pilot Plant. The Coal Preparation Plant will be located in its own equipment block along with the raw coal storage silo and adjacent to the onsite equipment block. The Coal Preparation Plant consists of two parallel equipment trains which begin at the point of collection of the raw coal from the raw coal storage silo feeders and end with the delivery of the prepared coal to the lock hopper feed system. Each train is designed to accomplish three processing steps: (1) crushing and drying of the raw coal, (2) adding catalyst, and (3) final drying. Also included in this section are an inerted prepared coal storage bin, an inerted coke/char storage bin, an inert gas dust collector and recycle system, a coal preparation equipment shelter, and a dilute phase lift blower and feeder.

DESIGN BASIS

The Coal Preparation trains process as received, minus 3 inch Illinois No. 6 or Wyoming coal so that the prepared coal is 98% less than 8 mesh or 16 mesh, contains 20 wt% catalyst, and has 4 wt% total moisture. The Coal Preparation trains are designed to minimize fines (i.e., particles smaller than 325 mesh) production since the small particles tend to be entrained out of the fluid bed gasifier before being gasified.

The maximum gasification process flow rates are as follows:

	Design Rates (#/hr)
+ Moisture Free Coal	6,420
+ Dried Coal (4 wt% moisture)	6,690
+ As-Received Coal	
- Illinois No. 6 (16.6 wt% moisture)	7,700
- Wyoming (30 wt% moisture)	9,170
+ Catalyst (maximum)	1,290

The coal preparation plant (per train) flow rates are as follows:

	Design Rates (#/hr)
+ Moisture Free Coal	7,700
+ As-Received Coal	
- Illinois No. 6 (16.6 wt% moisture)	9,230
- Wyoming (30 wt% moisture)	11,000
+ Dried Coal (4 wt% moisture)	8,020
+ Catalyst (maximum)	1,550

The preparation plant operating schedules are as follows:

+ 7 days/week, 20 hrs/day with the reactor at maximum rate

+ 5 days/week, 14 hrs/day with the reactor at 50% maximum rate

Two parallel 100% capacity trains have been specified to reduce the possibility of a low service factor in this area and seriously interrupt the operations of the plant. Both Train A and Train B begin with a belt type conveyor which receives raw coal from the raw coal storage silo feeders.

In Train A, the raw coal is fed to a closed circuit, controlled oxygen, hot-gas swept, venturi-impact mill. This mill accomplishes the first processing step of crushing and drying by passing recycled gas together with hot combustion gas from a furnace through the crusher. The crushed coal is swept from the crusher by the hot gas which dries and conveys the coal through an integral pneumatic classifier above the crusher to an elevated cyclone separator. Oversized material reaching the classifier is directed back into the crusher. The cyclone feeds the dried coal onto a screen and the hot gas is directed back to the crusher and a gas scrubber. A portion of the clean gas from the scrubber is recycled back to the furnace as tempering gas and the remainder is vented. The second processing step, catalyst addition, is accomplished by spraying a 40 wt% solution of the catalyst on the coal and mixing the two in a ribbon blender. The final drying step utilizes a flash dryer. The flash dryer system is integrated with the gas-swept mill. Both systems use a common furnace and gas scrubber. The flash dryer operates in the same way as the gas-swept mill with the exception of not crushing and sizing the coal. The cyclone separator feeds the dried catalyzed coal into the prepared coal storage bin.

In Train B, the coal is processed in more conventional equipment than in Train A. The raw coal is first crushed to 1/4 x 0 so that it can pass through the minimum clearances of the first steam dryer. The dryer utilizes low level heat and a long residence time to remove the majority of the coal's moisture. This is in contrast to the hot gas dryers of Train A, the gas swept mill and flash dryer, in that the hot gas dryers use high level heat and a very short residence time. The 1/4 x 0 dried

coal is then elevated and screened at the desired product size. The oversized is crushed in a cage-type impact mill. The cage-type impact mill was specified because it produces a minimum of fines. The crusher product is then recycled to the screen. The undersize from the screen goes to the blender where the catalyst solution is added in the same manner as Train A. The wet catalyzed coal then enters a second steam dryer where the moisture content is reduced to 4 wt%. The dried, catalyzed coal is then elevated and put into the prepared coal storage bin.

The capacity of the inerted prepared coal storage bin which serves both Train A and B is 125 tons. This bin will permit operating the preparation plant 5 days/week, 14 hours/day with a two hour contingency when the reactor is at 50% maximum rate. This bin will also provide 30 hours of prepared coal storage at the maximum reactor coal consumption rate. A weigh feeder delivers catalyzed coal from this bin to a gate lock which feeds a rotating vane feeder. The rotating vane feeder and gate lock deliver coal to a dilute phase pneumatic lift system.

An inerted 40 ton bin is also provided for start-up coke or recycled char. Char will be dumped from the process reactor in the event of a reactor shutdown and will be recycled to the reactor during the subsequent start-up. A line is provided to deliver initial start-up coke from a pneumatic unloading truck. The truck's unloading equipment will be used during this operation. A weigh feeder is provided on this bin to deliver the coke/char to the dilute phase lift system gate lock.

TABLE I-C-1

UTILITIES AND CHEMICALS

ELECTRIC POWER

Requirements, KW

Symbol	Service	Duty	Load Operating	Load Connected
B-1101	Gas-Swept Mill Fan	S	112.0	123.0
B-1102	Gas Heater Furnace Fan	S	30.0	33.5
B-1103	Scrubber Discharge Fan	S	143.0	161.0
B-1104	Flash Dryer Fan	S	56.0	62.1
B-1105	Inert Gas Dust Collector Fan	N	10.6	13.0
B-1106	Nitrogen Recycle Fan	N	41.9	49.7
CO-1101	Raw Coal Feed To Train A	S	2.3	2.8
CO-1102	Raw Coal Feed To Train B	N	2.3	2.8
CO-1103	Bucket Elevator No. 1	N	1.3	1.9
CO-1104	Bucket Elevator No. 2	N	1.8	1.9
CR-1101	Gas-Swept Impact Mill	S	33.5	33.5
CR-1102	Primary Crusher	N	17.0	17.0
CR-1103	Secondary Crusher	N	21.0	21.0
D-1102	No. 1 Steam Dryer	N	33.5	33.5
D-1103	No. 2 Steam Dryer	N	33.5	33.5
FE-1101	Gas-Swept Mill Feeder	S	1.5	1.9
FE-1102	Vibrating Screen S-1101 Feeder	S	1.4	1.4
FE-1103	Intermediate Storage Bin Weigh Feeder	S	0.7	1.0
FE-1104	Flash Dryer Feeder	S	1.5	1.9
FE-1105	Prepared Coal Bin Feeder	N	1.4	1.4
FE-1106	Vibrating Screen S-1102 Feeder	N	0.4	0.4
FE-1107	D-1102 Feeder	N	3.2	4.4
FE-1108	Bucket Elevator Feeder	N	1.2	1.4
FE-1109	Bucket Elevator Feeder	N	1.3	1.9
FE-1110	D-1103 Feeder	N	1.4	1.4
FE-1111	Bucket Elevator Feeder	N	1.2	1.4
FE-1112	Coke and Char Storage Bin Feeder	I	1.4	1.4
FE-1113	Prepared Coal Weigh Feeder	N	1.0	1.0
FE-1114	Coke and Char Weigh Feeder	S	1.0	1.0
FE-1115	Dilute Phase Lift Feeder	N	1.4	1.4
GL-1101	Gate Lock	N	1.4	1.4
M-1101A	Mixer	S	6.6	6.6
M-1101B	Mixer	N	6.6	6.6
P-1101A	Scrubber Water Recirculation Pump	S	96	102
S-1101	Vibrating Screen	S	1.0	1.0
S-1102	Vibrating Screen	N	2.8	2.8
S-1103	Vibrating Screen	N	1.0	1.0
	Control Room Ventilation & A/C	N	By Contractor	
	Instruments		By Contractor	
	Lighting		By Contractor	
	Simultaneous Maximum		479	

TABLE I-C-1 (Cont'd)

STEAM - 125 PSIG (Saturated)

Requirements, lb/hr

• D-1102	5300
• D-1103	4000
• Stream Tracing of DC-1102 and Associated Ducts	100
	9400

LP CONDENSATE

Production, lb/hr

• D-1102	5300
• D-1103	4000
• Steam Tracing	100
	9400

PROCESS WATER

Requirements, GPM

• Venturi Scrubber	132

COMPRESSED AIR

Requirements, SCFM

• Instrument	50
• Utilitiy	50

NITROGEN - 125 PSIG

Requirements, SCFM	1000

FUEL (Natural Gas)

Requirements, 10^6 Btu/hr HHV

Symbol	Service	Duty	Load
F-1101	Gas Heater Furnace	N	9.0

TABLE I-C-2

EQUIPMENT LIST - COAL PREPARATION SECTION

D-1101 Flash Dryer System

The flash dryer system will be used to dry the catalyst/coal mixture and to convey it to the prepared coal storage bin. The system will consist of a closed gas circuit containing a dispersion sling, cyclone separator, and ducts as shown in Figure I-C-1. Also associated with the flash dryer is a gas heater furnace, secondary gas cleaner (scrubber), and fans. The dryer shall have the capability to dry the catalyst/coal mixture from 22 wt% moisture to 4 wt% moisture.

CY-1102 Flash Dryer Cyclone

- Gas Flow (SCFM) 8750
- Design Solids Flow Rate (STPH) 4.9
- Operating Temperature (°F) 225
- Maximum Diameter (ft) 3

- Include 1" external insulation.
- Cyclone shall be designed to maximize solids recovery.

Ducts

- Total length (ft estimated): 350
- Provide 1" of external insulation on all ductwork in the coal preparation plant with the exception of the furnace discharge duct which is covered in Section 7.
- Include explosion hatch protection.

D-1102 No. 1 Steam Dryer

Service	Reduce the total moisture in the coal from 30 wt% moisture to 4 wt% moisture.
Type	Indirect Steam Dryer
Design Capacity (STPH)	5.5
Product Moisture Content (wt%)	4

TABLE I-C-2 (Cont'd)

D-1103 No. 2 Steam Dryer

Service	Reduce the total moisture in the coal/ catalyst mixture from 22 wt% moisture to 4 wt% moisture.
Type	Indirect Steam Dryer
Design Capacity	
• Coal (STPH)	4.0 (includes 4 wt% moisture)
• Catalyst (GPM)	5.1
Product Moisture Content (wt%)	4

TABLE I-C-2 (Cont'd)

Compressors

Equipment No.	B-1101	B-1102	B-1103	B-1104	B-1105	B-1106
Service	Mill Fan	Gas Heater Furnace Fan	Scrubber Discharge Fan	Flash Dryer Fan	Inert Gas Dust Collector Fan	N_2 Recycle Fan
Flow Rate, SCFM	7000	1417	11,200	8750	3300	1800
Gas Mol. Wt.	22.2	29	22.2	22.2	28-29	28
Fan ΔP, in H_2O	51	74	75	38	13	86
Inlet Temp., °F	225	Ambient	193	225	Ambient to 300	Ambient to 300
Inlet Press., in H_2O	-6	Ambient	-27	7	By Contractor	24
Fan Type	Centrif.	Centrif.	Centrif.	Centrif.	Centrif.	Centrif.

Pumps

Equipment No.	P-1101
Service	Scrubber Water Recirculation
Type	Centrif.
Capacity, gpm	132
ΔP, psi	552

Furnaces

Equipment No.	F-1101
Service	Gas Heater Furnace
Duty, MBtu/hr	9.0
Fuel	Natural Gas

Process Vessels

Equipment No.	D-1101/D-1102
Service	Venturi Scrubber and Separator
Normal Gas Rate, SCFM	11,200
Inlet Dust Loading, lbs/hr	320
Scrubbing Liquid	Water

TABLE I-C-2 (Cont'd)

Equipment No.	BN-1101	BN-1102	BN-1103	BN-1109	BN-1105
Service	"A" Feed Bin	"A" Coal Storage Bin	"B" Feed Bin	Prepared Coal Storage Bin	Coke and Char Storage Bin
Type	Circular, Conical Outlet				
Diameter, ft.	4.5	4.0	4.4	16	10
Straight Side ht., ft.	6.5	7.0	5.7	27.5	24
Tape Height, ft.	4.0	4.4	3.8	12	16
Capacity, tons	2.2	2.0	1.9	125	40

Conveyors

Equipment No.	CO-1101	CO-1102	CO-1103	CO-1104
Service	Raw Coal to "A"	Raw Coal to "B"	Bucket Elevator Number 1	Bucket Elevator Number 2
Length, ft.	130	130	35	100
Rise, ft.	35	35	35	100
Width, in.	14	14	-	-
Capacity, STPH	5.5	5.5	6.1	4.9

130

TABLE I-C-2 (Cont'd)

Coal Crushers

Equipment No.	CR-1102	CR-1103
Service	Primary Crusher	Secondary Crusher
Type	Hammermill	Cage Type Impactor
Capacity, STPH	3.8	2.1
Product Size	98% 1/4"	80% 8 mesh

Dust Collectors

Equipment No.	DC-1101	DC-1102	DC-1103
Service	Dust Collection Bag Filter	Steam Dryer Dust Collector	Dustor Collector
Type	Continuous, Self-Cleaning	Continuous Self-Cleaning	Continuous Self-Cleaning
Gas Rate, SCFM	3,000	2,700	1,300
Bag Area, ft^2	1,000	1,000	440

Coal Feeders

Equipment No.	FE-1101	FE-1102	FE-1103
Service	Gas Swept Mill Feeder	Vibrating Screen Feeder	Intermediate Storage Bin Weigh Feeder
Type	Screw	Rotating Vane	Flat Belt
Length, Ft.	15	-	4.5
Diam. (width), in	12	-	18
Capacity, STPH	6.5	5.0	4.0

Equipment No.	FE-1104	FE-1105	FE-1106
Service	Flash Dryer Feeder	Prepared Coal Bin Feeder	Vibrating Screen Feeder
Type	Screw	Rotating Vane	Vibrating Pan
Length, ft.	15	-	4
Diam. (width), in	12	-	12
Capacity, STPH	6.0	4.9	5.5

Equipment No.	FE-1107	FE-1108	FE-1109	FE-1110
Service	D-1102 Feeder	Bucket Elevator Feeder	Bucket Elevator Feeder	D-1103 Feeder
Type	Screw Lock	Screw	Screw	Rotating Vane
Length, ft.	15	5	20	-
Diam. (width), in.	9	9	6	-
Capacity, STPH	5.5	4.0	2.1	6.0

TABLE I-C-2 (Cont'd)

Equipment No.	FE-1111	FE-1112	FE-1113	FE-1114	FE-1115
Service	Bucket Elevator Feeder	Coke & Char Storage Bin Feeder	Prepared Coal Weigh Feeder	Coke & Char Weigh Feeder	Dilute Phase Lift Feeder
Type	Screw	Rotating Vane	Flat Belt	Flat Belt	Rotating Vane
Length, ft.	5	-	4.5	4.5	-
Diam. (width), in	9	-	18	18	-
Capacity, STPH	4.9	-	4.1	4.1	4.1

Screens

Equipment No.	S-1101	S-1102	S-1103
Service	Remove Particles 8 Mesh From Gas Swept Mill Product	Remove Particles 1/4" From Primary Crusher	Remove Particles 8 Mesh
Capacity, STPH	5.0	5.5	6.1
Operation	Continuous	Continuous	Continuous

Coal Preparation Equipment Shelter

To shelter coal preparation trains A and B and local control panel.

- 6000 sq. ft., 30 ft. height, semi-open sides.

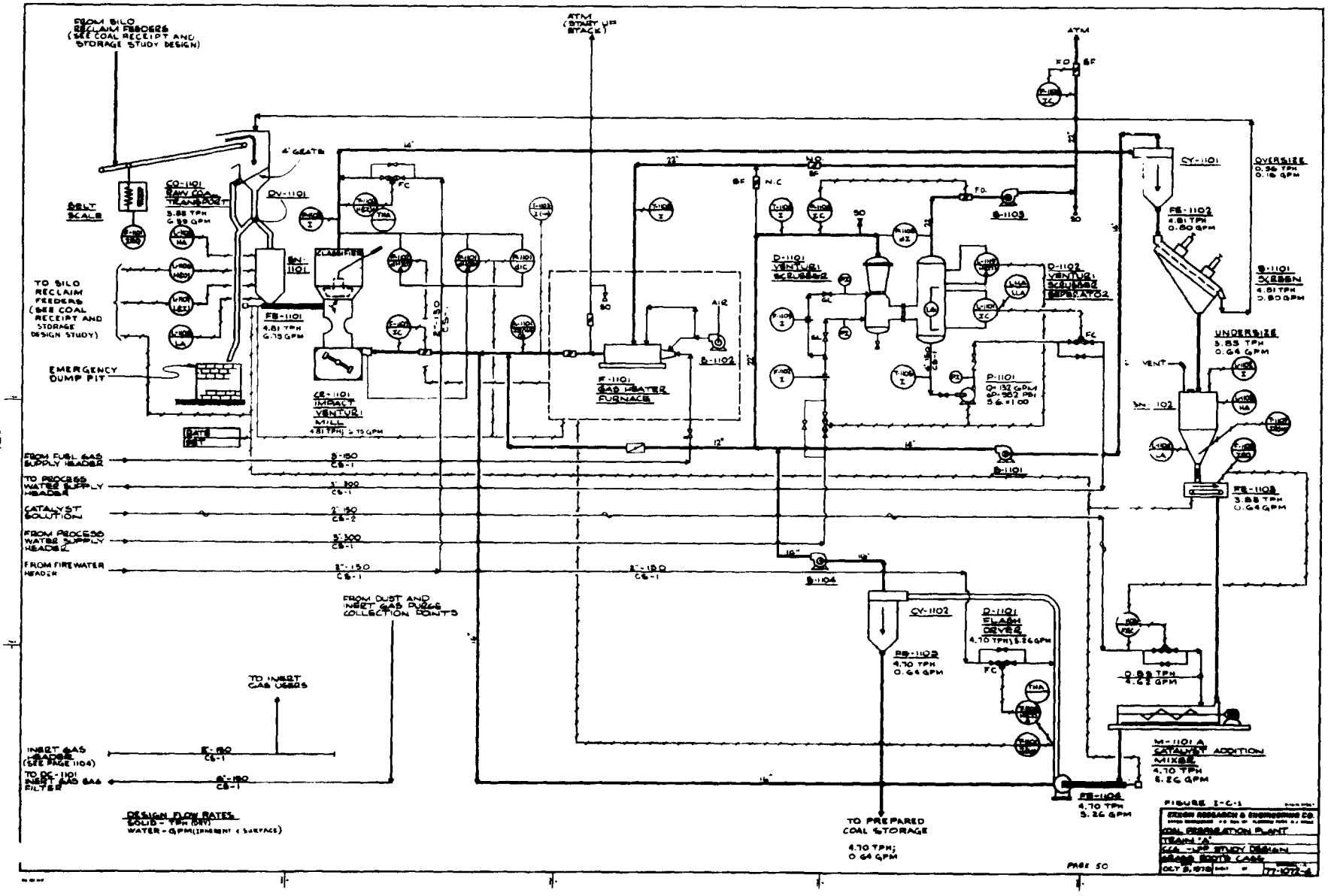
TABLE I-C-4

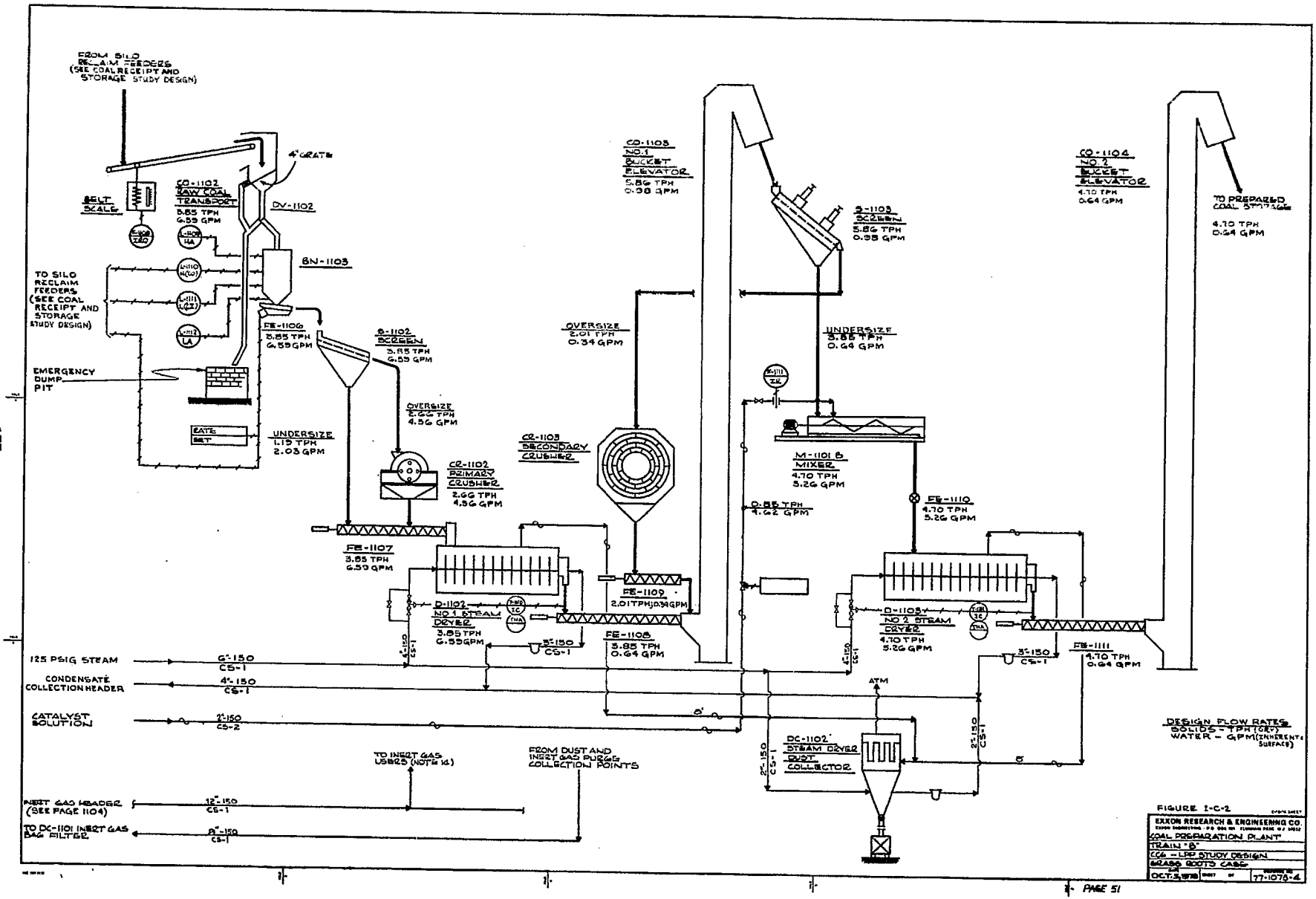
M-1101 A/B Catalyst Addition Mixer

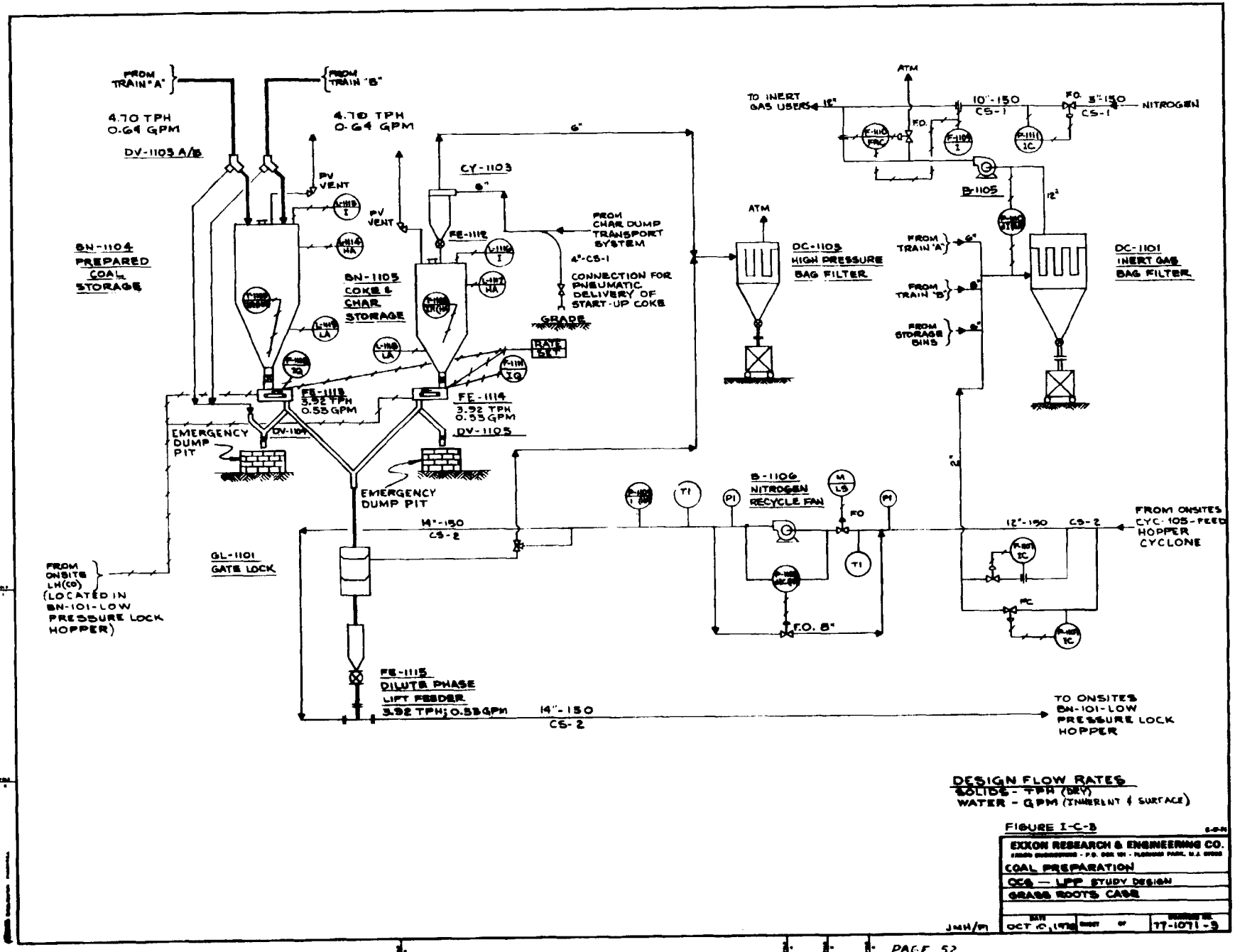
Service	Mix coal and catalyst solution
Type	Ribbon Blender
Design Capacity	
Coal (STPH)	4.1
Catalyst Solution (GPM)	5.1
Material Being Handled	
• Coal	
• Catalyst Solution	40 wt% aqueous solution of K_2CO_3
Operation	Continuous

Remarks:

(1) Mixer shall be designed to permit blanketing with nitrogen.


FROM SILO RECLAIM FEEDERS (SEE COAL RECEIPT AND STORAGE STUDY DESIGN)
ATM (START UP STACK)
ATM
4" GRATE
BELT SCALE
CO-1101 RAW COAL TRANSPORT
5.88 TPH 0.39 GPM
CV-1101
SN-1101
CLASSIFIER
TO SILO RECLAIM FEEDERS (SEE COAL RECEIPT AND STORAGE DESIGN STUDY)
FE-1101 4.81 TPH 0.79 GPM
EMERGENCY DUMP PIT
CE-1101 IMPACT VENTURI MILL 4.81 TPH 0.79 GPM
F-1101 GAS HEATER FURNACE
B-1102
D-1101 VENTURI SCRUBBER
D-1102 VENTURI SCRUBBER SEPARATOR
P-1101 90 132 GPM 50-352 PSI 5.6 HP 1.00
B-1103
CV-1101
OVERSIZE 0.96 TPH 0.16 GPM
FE-1102 4.81 TPH 0.80 GPM
B-1101 SCREEN 4.81 TPH 0.80 GPM
UNDERSIZE 3.85 TPH 0.64 GPM
VENT
SN-102
FE-1103 3.85 TPH 0.64 GPM
FROM FUEL GAS SUPPLY HEADER
TO PROCESS WATER SUPPLY HEADER
CATALYST SOLUTION
FROM PROCESS WATER SUPPLY HEADER
FROM FIRE WATER HEADER
FROM DUST AND INERT GAS PURGE COLLECTION POINTS
B-1104
CV-1102
D-1101 FLASH DRYER 4.70 TPH 5.26 GPM
FE-1102 4.70 TPH 0.64 GPM
0.89 TPH 4.62 GPM
M-1101A CATALYST ADDITION MIXER 4.70 TPH 5.26 GPM
TO INERT GAS USERS
INERT GAS HEADER (SEE PAGE 1104)
TO DC-1101 INERT GAS FILTER
FE-1104 4.70 TPH 5.26 GPM
TO PREPARED COAL STORAGE 4.70 TPH; 0.64 GPM
DESIGN FLOW RATES SOLID - TPH (DRY) WATER - GPM (IMMENT SURFACE)
PAGE 50
FIGURE I-C-1
COAL PREPARATION PLANT
TRAIN 'A'
GAS-UP STUDY DESIGN
OCT 5, 1978


FROM SILO RECLAIM FEEDERS (SEE COAL RECEIPT AND STORAGE STUDY DESIGN)
4" GRATE
BELT SCALE
CO-1102 RAW COAL TRANSPORT
3.85 TPH
6.59 GPM
DV-1102
8N-1103
TO SILO RECLAIM FEEDERS (SEE COAL RECEIPT AND STORAGE STUDY DESIGN)
EMERGENCY DUMP PIT
FE-1106
3.85 TPH
6.59GPM
S-1102 SCREEN
3.85 TPH
6.59 GPM
OVERSIZE
2.66 TPH
4.56 GPM
UNDERSIZE
1.19 TPH
2.03 GPM
CR-1102 PRIMARY CRUSHER
2.66 TPH
4.56 GPM
FE-1107
3.85 TPH
6.59 GPM
CO-1103 NO.1 BUCKET ELEVATOR
5.86 TPH
0.98 GPM
OVERSIZE
2.01 TPH
0.34 GPM
CR-1103 SECONDARY CRUSHER
FE-1109
2.01TPH|0.34GPM
D-1102 NO.1 STEAM DRYER
3.85 TPH
6.59GPM
FE-1108
3.85 TPH
0.64 GPM
S-1103 SCREEN
5.86 TPH
0.98 GPM
UNDERSIZE
3.85 TPH
0.64 GPM
M-1101 B MIXER
4.70 TPH
5.26 GPM
0.85 TPH
4.02 GPM
FE-1110
4.70 TPH
5.26 GPM
D-1103 NO.2 STEAM DRYER
4.70 TPH
5.26 GPM
FE-1111
4.70 TPH
0.64 GPM
CO-1104 NO.2 BUCKET ELEVATOR
4.70 TPH
0.64 GPM
TO PREPARED COAL STORAGE
4.70 TPH
0.64 GPM
125 PSIG STEAM
6"-150 CS-1
CONDENSATE COLLECTION HEADER
4"-150 CS-1
CATALYST SOLUTION
2"-150 CS-2
TO INERT GAS USAGES (NOTE 16)
FROM DUST AND INERT GAS PURGE COLLECTION POINTS
INERT GAS HEADER (SEE PAGE 1104)
12"-150 CS-1
TO DC-1101 INERT GAS BAG FILTER
8"-150 CS-1
DC-1102 STEAM DRYER DUST COLLECTOR
ATM
DESIGN FLOW RATES SOLIDS - TPH (DRY) WATER - GPM (CONVERENT SURFACE)
FIGURE I-C-2
EXXON RESEARCH & ENGINEERING CO.
COAL PREPARATION PLANT
TRAIN "B"
EDS - LPG STUDY DESIGN
BASIS: BOOTS CASE
OCT. 5, 1976
77-1076-4



DESIGN FLOW RATES
SOLIDS - TPH (DRY)
WATER - GPM (INHERENT & SURFACE)

FIGURE I-C-3

EXXON RESEARCH & ENGINEERING CO.
COAL PREPARATION
CCG — LPP STUDY DESIGN
GRASS ROOTS CASE

DATE OCT 10, 1978 | SHEET OF | DRAWING NO. 77-1071-9

JMH/PI

APPENDIX I-D

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY - GRASS ROOTS CASE

UTILITIES

This section covers the study design for the facilities required to provide the general utilities within plant battery limits for the grass roots case of the Catalytic Coal Gasification Large Pilot Plant (LPP) Study. The utilities covered in this study design include: Domestic Water, Industrial Water, Boiler Feed Water, Cooling Water, Steam, Compressed Air, Nitrogen, and Natural Gas. Electric Power, Waste Handling, and Fire Water are covered in their respective study designs.

DESIGN BASIS

In general, the study design assumes that the utilities are available from the Refinery and will be provided to the LPP site via new interplant transfer lines. The facilities provided are therefore primarily for distribution of the utilities within the LPP site. The exceptions are the new facilities required for cooling water and compressed air. Product gas from the LPP will be compressed so that it may be fed into the refinery fuel gas system. The details of the new interplant transfer lines and the respective tie-ins are covered in the study design covering interconnecting lines.

Cooling Water

Cooling water shall be provided at the site via a new recirculating cooling water system consisting of a multicell induced draft cooling tower, onsites and offsites distribution and return systems, and chemical addition facilities.

The cooling water system is designed to supply 4325 GPM of 87°F cooling water to the LPP consumers.

Make-up water for the cooling tower shall be obtained from the industrial water system.

Compressed Air

Air will be compressed in the utility block and distributed to the consumer battery limits. Minimum pressure of 80 psig for instrument air and 90 psig for industrial air is required at the most remote locations in the process blocks.

Two new 1500 SCFM centrifugal compressors will be added to satisfy demands of the LPP project. One compressor will be steam turbine driven, and the other will be electric motor driven. Air will be discharged from the compressors at 110 psig.

Steam

High pressure steam (600 psig) demand at the LPP site will be satisfied via import from the refinery steam network. Medium pressure (125 psig) steam for process and offsite consumption will be produced by the back pressure turbine driver of the air compressor and the 600/125 psig letdown stations.

Boiler Feedwater (BFW) and Condensate

Boiler feedwater will be imported from the refinery high pressure BFW system for process wasteheat steam generation plus offsite 125 psig steam desuperheaters. A condensate collection system shall be provided to recover clean process and offsite steam condensate in order to reduce BFW import requirements.

TABLE I-D-1

UTILITIES SECTION - UTILITIES AND CHEMICAL REQUIREMENTS

Electrical Power (KW)

Item	Service	Duty	Reacceleration	Operating Load
C-1160 B	Air Compressor	S	A	305.0*
C-1161	Product Gas Compressor	N	A	30.0*
P-1170 A	Recirc. Cooling Water	N	A	100.0*
P-1170 B	Recirc. Cooling Water	N	A	100.0*
P-1171 A	Inhibitor Injection	I	C	0.5*
P-1171 B	Inhibitor Injection	S	C	0.5
P-1172 A	Acid Injection	I	C	0.5*
P-1172 B	Acid Injection	S	C	0.5
P-1173	Deleted			
P-1174 A	Condensate	N	A	66.0*
P-1174 B	Condensate	S	A	66.0
P-1175 A	Morpholine	N	C	0.5*
P-1175 B	Morpholine	S	C	0.5
Heater for DR-1160 (2)		I		20.0
MR-1100 Mixer		I	C	0.5*
Cooling Tower Fans		N	B	70.0*
	*Maximum Simultaneous Load			673*

Steam (lb/hr) - 600 psig Consumer	Service	Normal	Maximum
C-1160A	Air Compressor	14,200	15,600

Steam (lb/hr) - 125 psig Consumer	Service	Normal	Maximum
P-1170 C	Cooling Water Pump (4)	5,740	6,310
Producer			
C-1160 A	Air Compressor	14,200	15,600

Industrial Water (GPM)	Service	Normal	Maximum
Cooling Tower	Makeup Water	160	280

Cooling Water (GPM)	Service	Normal	Maximum
C-1160 A, B (5)	Air Compressors	200	400
DR-1160	Inst. Air Dryer	10	10

TABLE I-D-1 (cont'd)

Compressed Air (SCFM)	Normal	Maximum
Instrument Air	30	30
Chemicals	**Normal**	**Maximum**
Sulfuric Acid (98 wt%)	10 gal/24 hrs	17 gal/24 hrs
Chromate Inhibitor	4 gal/24 hrs	7 gal/24 hrs
Chlorine Gas	26 lbs/48 hrs	21 lbs/24 hrs
Morpholine (40 wt%)	270 lbs/mo.	2700 lbs/mo.

Notes:

(1) Deleted.

(2) Instrument air dryer DR-1160 shall be heat regenerative using electric heater(s).

(3) Deleted.

(4) Spare pump.

(5) Cooling water requirements include water for intercoolers and after-coolers.

TABLE I-D-2

UTILITIES SECTION - EQUIPMENT LIST

Cooling Tower

The contractor shall provide an induced draft, counterflow, multi-cell box type cooling tower. The cooling tower shall have two 50% cells.

Design Conditions

Total Circulating Water Rate	4325 GPM
Design Wet Bulb Temperature	80°F
Design Dry Bulb Temperature	95°F
Approach	7°F
On Tower Temperature	122°F
Off Tower Temperature	87°F
Range	35°F

Compressor Aftercoolers
E-1160 A and B

The compressor vendor shall provide aftercoolers on the discharge on air compressors C-1160 A and B. The aftercoolers shall be compatible with the final selected compressors; cooling water shall be used as the cooling medium.

TABLE I-D-2 (cont'd)

Pumps

Equipment No.	Service	Capacity, GPM	ΔP, PSI
P-1170 A,B,C	Cooling Water Recirculation Pumps	2170	75
P-1171 A&B	Inhibitor Injection Pumps	.6 GPH	25
P-1172 A&B	Sulfuric Acid Injection Pumps	0.7	25
P-1174 A&B	Condensate Transfer Pumps	53	900
P-1175 A&B	Morpholine Injection Pumps	0.5 GPH	10

Compressors

Equipment No.	Service	Type	No. Stages	Suction FLow	BHP
C-1160 A & B	Air Compressors	Centrifugal	2	1500	418
C-1161	Product Gas Compressor	Reciprocating	1	1350	40

TABLE I-D-2 (cont'd)

Vessels

Equipment No.	Service	Size Dia. x L	Net Capacity Gal.
D-1140	Natural Gas	2'0" x 6'-6"	-
TK-1150			
D-1151			
D-1152			
D-1171	CrO_4 (35 wt%)	By Contractor	500
D-1172	H_2SO_4 (98 wt%)	By Contractor	500
D-1160	Air Receiver	6'-0" - 10'-0"	-
D-1130	Steam K.O.	3'0" x 8'0"	-
D-1131	Condensate	2'6" x 7'0"	(10)
D-1132	Morpholine	Vendor	100

TABLE I-D-2 (cont'd)

Other Equipment

Equipment Number	DR-1160
Service	Instrument Air Dryer
Type	Dual Tower Dessicant
Capacity, SCFM	600

Equipment Number	DSH-1100	DSH-1101	DSH-1102
Service	Desuperheat Letdown Steam	600/125 psig	Desuperheat 125 psig Turbine Outlet Steam
Inlet Steam Rate, lbs/hr	40,000	10,000	22,000

TABLE I-D-2 (cont'd)

Analyzers

Automatic Water Analyzer/Controller

To maintain proper water treating control of tower recirculation water an automatic analyzer/controller shall be utilized.

Whenever corrosion rate exceeds predetermined values, the controller unit will OVERRIDE all other system controls to correct corrosion problem. Unit shall also record pH, corrosion and conductivity levels and activate alarms when preset values are exceeded. Two pH sensors shall be provided with the unit. If the two sensors indicate pH values that differ by more than an amount pre-determined by the vendor, an alarm shall sound.

The analyzers' sensing devices shall be located in the immediate vicinity of the cooling tower; analyzer unit's instrumentation (i.e., controllers, recorders, etc.) shall be installed in the main control house.

Symbol	Function	Recorder Range
A-1170-RC/HA	Conductivity controller/recorder - controls level of TDS by increasing makeup rate	0-5000/micromhos
A-1171-RC/HA	Corrosivity controller/recorder - corrosion OVERRIDE	0-10 absolute units
A-1172-RC/HA/LA	pH Controller/recorder - activates acid injection pumps	0-14 pH units
A-1173-RC	Chromate inhibitor controller/recorder - activates inhibitor injection pumps	0-100 ppm
A-1174-R	Residual chlorine recorder	0-10 ppm

NOTES:

- THE CONTRACTOR SHALL PROVIDE BATTERY LIMIT ISOLATION VALVES ON ALL UTILITY LINES AT THE PLOT BATTERY LIMIT FOR EACH USER LOCATION.
- UNLESS OTHERWISE NOTED ALL LINES ARE CS-1 WITH 150 PSIG FLANGE RATING. ALL PIPING IS ABOVE GROUND.

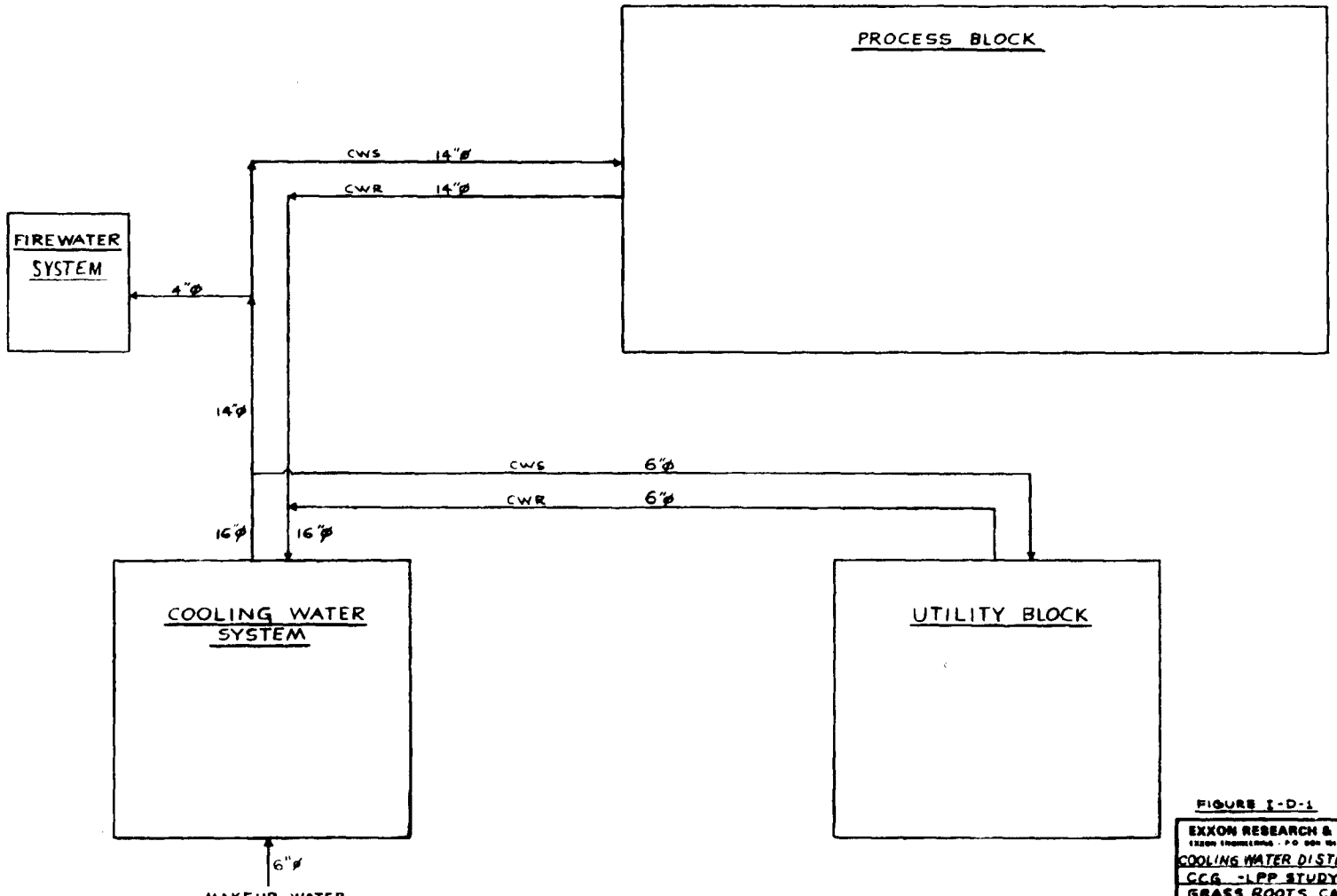
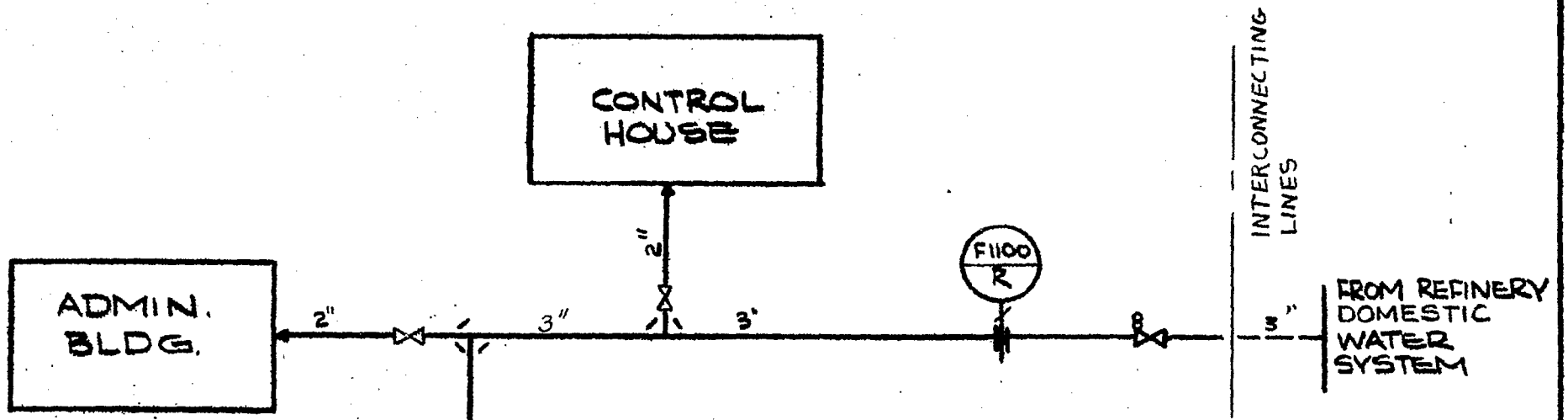


FIGURE I-D-1

EXXON RESEARCH & ENGINEERING CO.	
COOLING WATER DISTRIBUTION PLAN	
CCG - LPP STUDY DESIGN	
GRASS ROOTS CASE	
BAYTOWN, TEXAS	
DATE OCT. 5 1978	DRAWING NO. 77-1163-B



147

NOTES:

- DISTRIBUTION TO SAFETY SHOWERS, EYE WASHES AND DRINKING FOUNTAINS SHALL BE PROVIDED.
- THE CONTRACTOR SHALL PROVIDE BATTERY LIMIT ISOLATION VALVES ON ALL UTILITY LINES AT THE PLOT BATTERY LIMIT FOR EACH USER.
- UNLESS OTHERWISE NOTED ALL LINES ARE CS-1 WITH 150 PSIG FLANGE RATING.
- DOMESTIC WATER SYSTEM SHALL BE BURIED FOR FROST PROTECTION

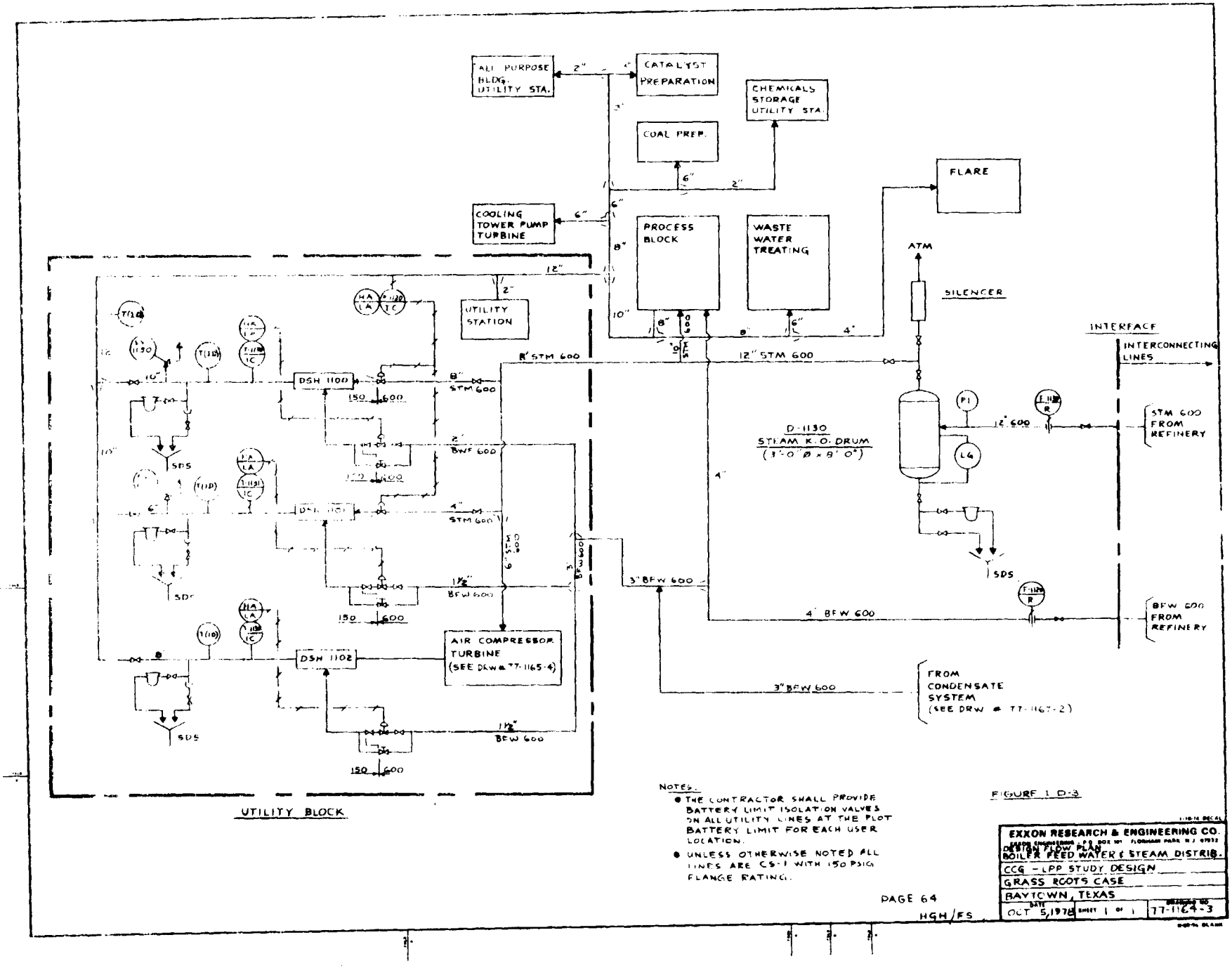
FIGURE I-D-2

E-19-74 REV. A.

EXXON RESEARCH & ENGINEERING CO.			
EXXON ENGINEERING - P.O. BOX 101 - FLORHAM PARK, N.J. 07932			
DESIGN FLOW PLAN			
DOMESTIC WATER DIST. SYSTEM			
CCG -LPP STUDY DESIGN			
GRASS ROOTS CASE			
DATE: OCT. 5, 1978	SHEET 1 OF 1	DRAWING NO. 77-1170-1	

PAGE 18

SEW/FS

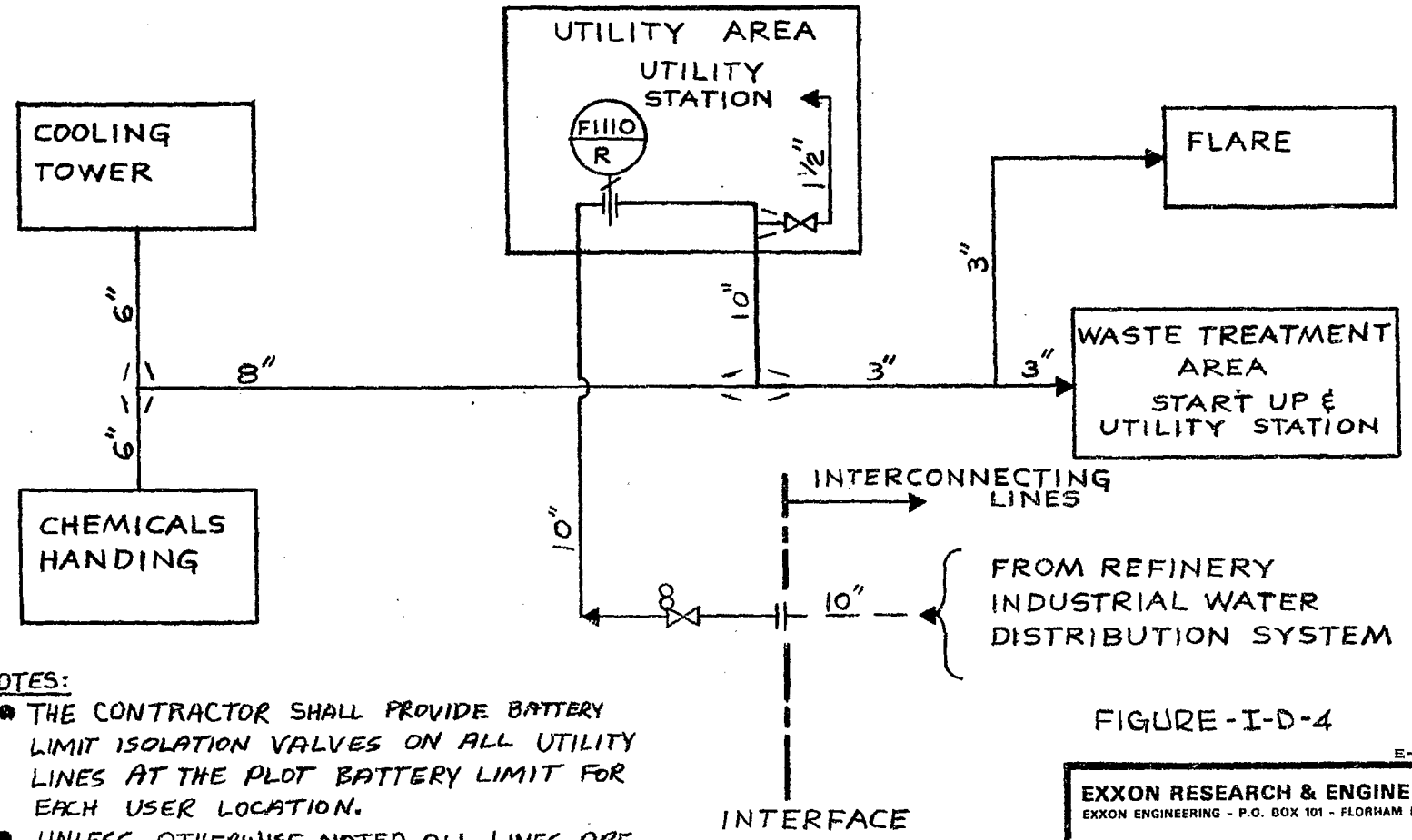


NOTES:

- THE CONTRACTOR SHALL PROVIDE BATTERY LIMIT ISOLATION VALVES ON ALL UTILITY LINES AT THE PLOT BATTERY LIMIT FOR EACH USER LOCATION.
- UNLESS OTHERWISE NOTED ALL LINES ARE CS-1 WITH 150 PSIG FLANGE RATING.

FIGURE 1 D-3

EXXON RESEARCH & ENGINEERING CO.
DESIGN FLOW PLAN
BOILER FEED WATER & STEAM DISTRIB.
CCG - LPP STUDY DESIGN
GRASS ROOTS CASE
BAYTOWN, TEXAS
DATE OCT 5, 1978 SHEET 1 OF 1
DRAWING NO. 77-1164-3



NOTES:

- THE CONTRACTOR SHALL PROVIDE BATTERY LIMIT ISOLATION VALVES ON ALL UTILITY LINES AT THE PLOT BATTERY LIMIT FOR EACH USER LOCATION.
- UNLESS OTHERWISE NOTED ALL LINES ARE CS-1 WITH 150 PSIG FLANGE RATING.

FIGURE-I-D-4

E-43-74 DECAL

EXXON RESEARCH & ENGINEERING CO.
EXXON ENGINEERING - P.O. BOX 101 - FLORHAM PARK, N.J. 07932

OCT 11, 1978

DESIGN FLOW PLAN

INDUST WATER DIST. SYSTEM

CCG-LPP STUDY DESIGN

GRn., ROOTS CASE

SPW/FS NO. 77-1169-1

PAGE 65

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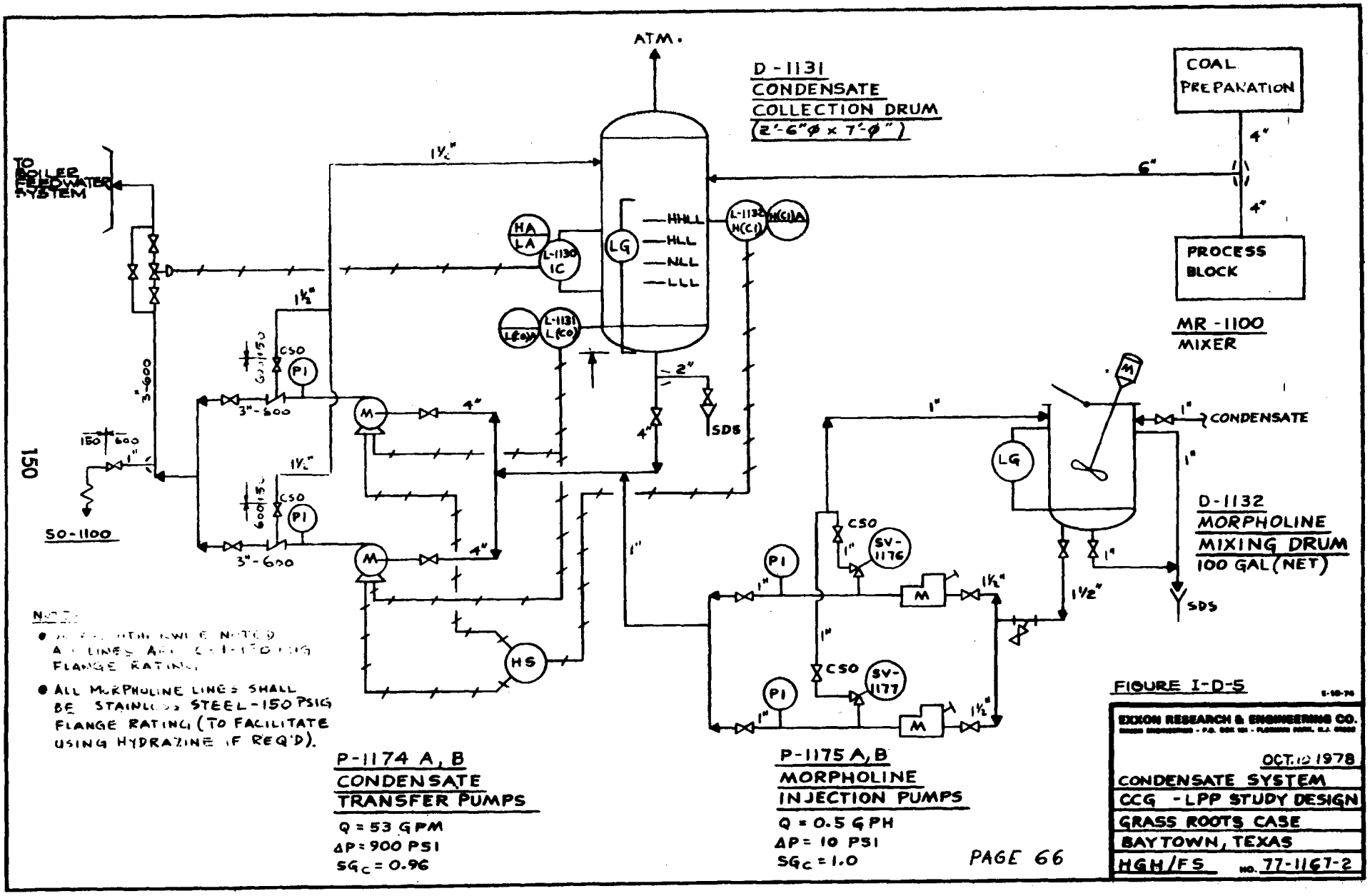
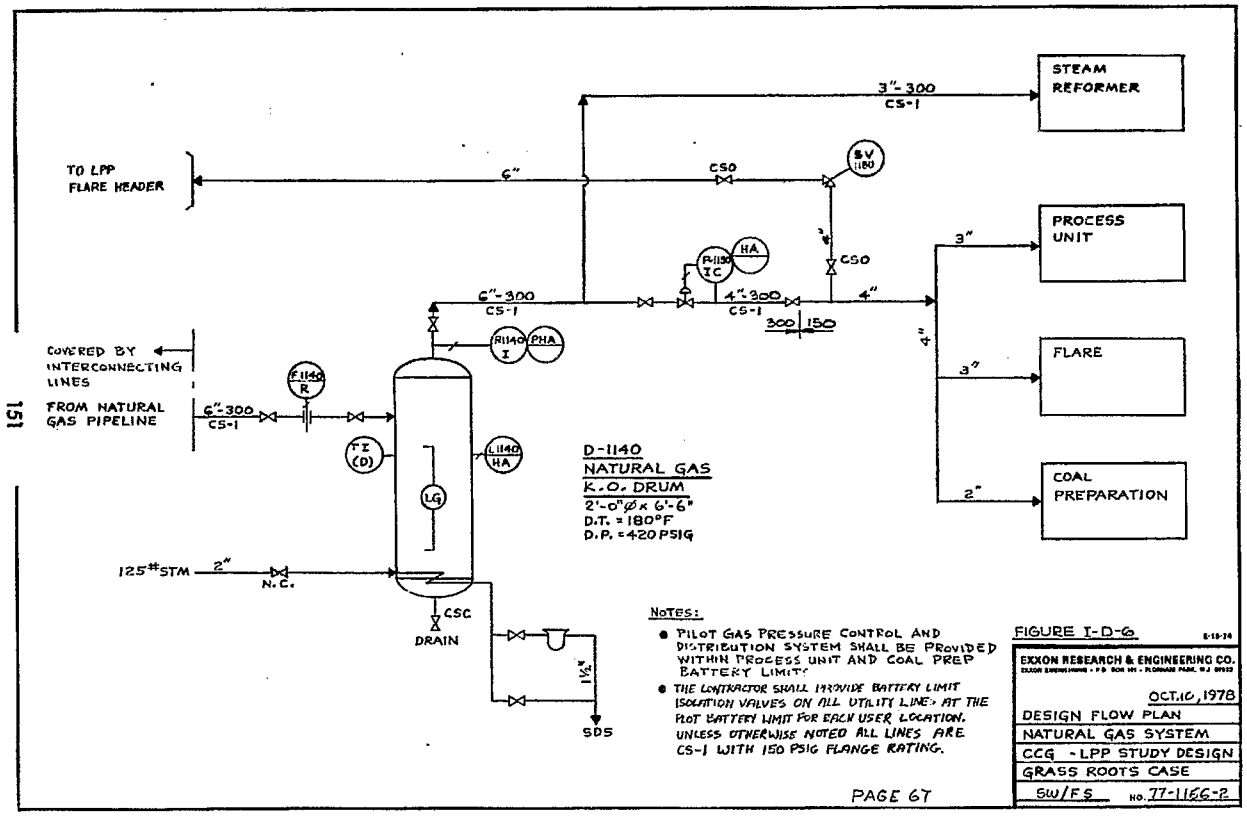


FIGURE I-D-5

EXXON RESEARCH & ENGINEERING CO.

OCT. 10 1978

CONDENSATE SYSTEM
CCG - LPP STUDY DESIGN
GRASS ROOTS CASE
BAYTOWN, TEXAS
HGH/FS NO. 77-1167-2


STEAM REFORMER
3"-300 CS-1
TO LPP FLARE HEADER
6"
CSO
SV 1180
PROCESS UNIT
3"
4"
CSO
R-1139 TC
HA
6"-300 CS-1
4"-300 CS-1
4"
300 150
4"
COVERED BY INTERCONNECTING LINES
FROM NATURAL GAS PIPELINE
6"-300 CS-1
R1140 I
PHA
F1140 R
FLARE
3"
TI (D)
L1140 HA
LG
2"
COAL PREPARATION
D-1140
NATURAL GAS
K.O. DRUM
2'-0"ø x 6'-6"
D.T. = 180°F
D.P. = 420 PSIG
125#STM
2"
N.C.
CSC
DRAIN
1½"
SDS
NOTES:
• PILOT GAS PRESSURE CONTROL AND DISTRIBUTION SYSTEM SHALL BE PROVIDED WITHIN PROCESS UNIT AND COAL PREP BATTERY LIMITS
• THE CONTRACTOR SHALL PROVIDE BATTERY LIMIT ISOLATION VALVES ON ALL UTILITY LINES AT THE PLOT BATTERY LIMIT FOR EACH USER LOCATION. UNLESS OTHERWISE NOTED ALL LINES ARE CS-1 WITH 150 PSIG FLANGE RATING.
FIGURE I-D-6
EXXON RESEARCH & ENGINEERING CO.
OCT. 10, 1978
DESIGN FLOW PLAN
NATURAL GAS SYSTEM
CCG - LPP STUDY DESIGN
GRASS ROOTS CASE
SW/FS
NO. 77-1166-2

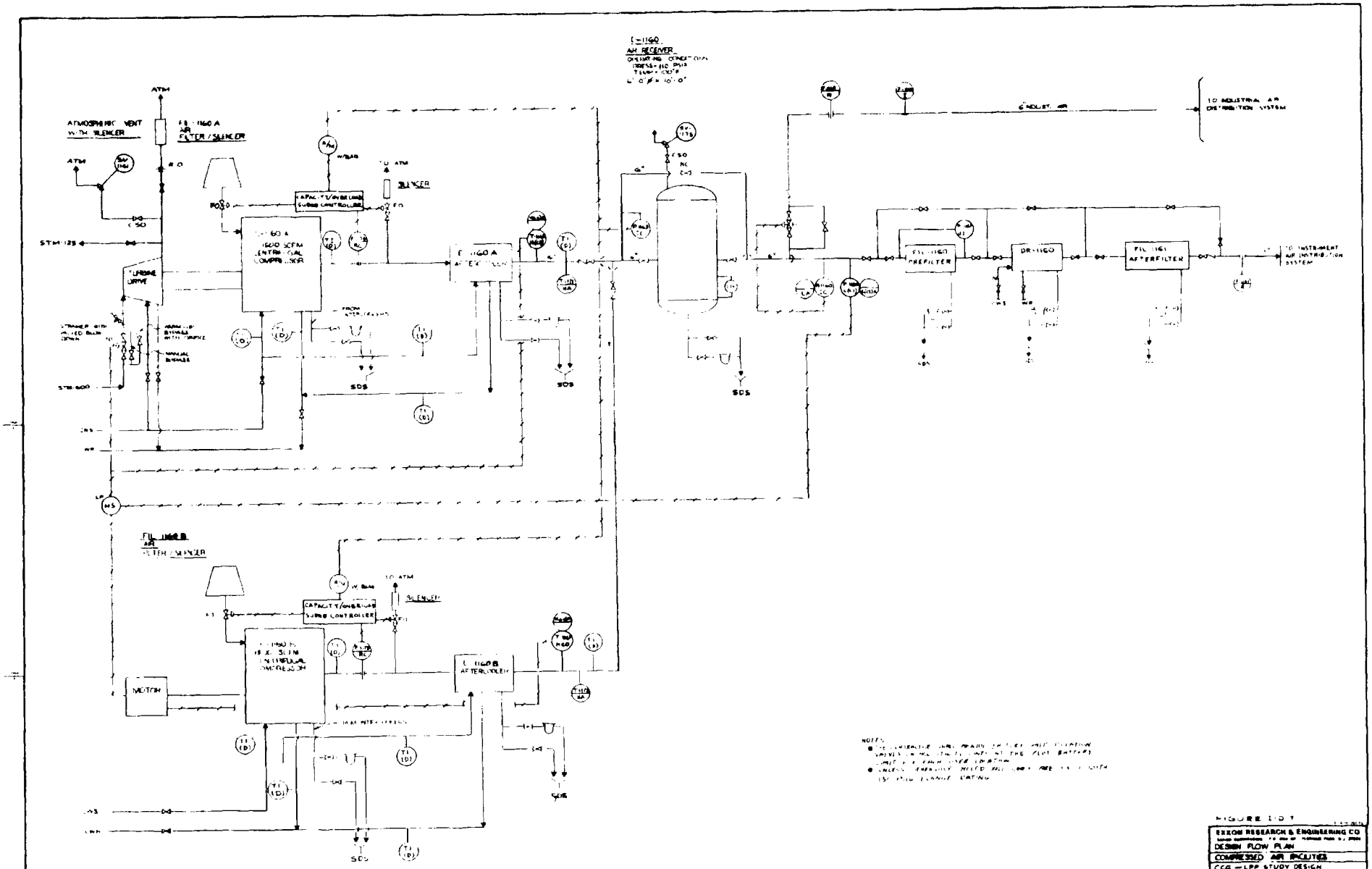
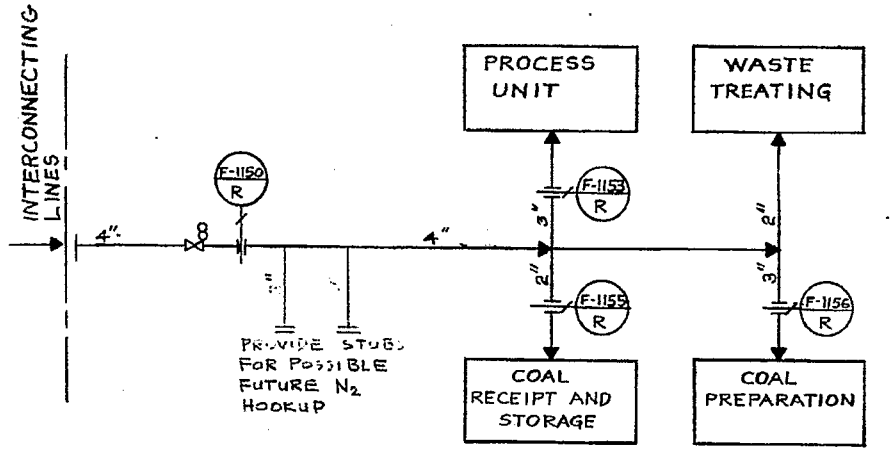


FIGURE I-D 7

EXXON RESEARCH & ENGINEERING CO	
DESIGN FLOW PLAN	
COMPRESSED AIR FACILITIES	
CCG — LPP STUDY DESIGN	
GRASS ROOTS CASE	
OCT 3 [illegible] 2ND Q	5-4



NOTES:

- THE CONTRACTOR SHALL PROVIDE BATTERY LIMIT ISOLATION VALVES ON ALL UTILITY LINES AT THE PLOT BATTERY LIMIT FOR EACH USER LOCATION
- UNLESS OTHERWISE NOTED ALL LINES ARE CS-1 WITH 150 PSIG FLANGE RATING.

FIGURE I-D-8 E-43-74 DECAL

EXXON RESEARCH & ENGINEERING CO.
EXXON ENGINEERING - P.O. BOX 101 - FLORHAM PARK, N.J. 07932

OCT. 5, 1978

NITROGEN SYSTEM
CCG -LPP STUDY DESIGN
GRASS ROOTS CASE

SPW/FS NO. 77-1168-1

PAGE 69

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OGILVIE PRESS

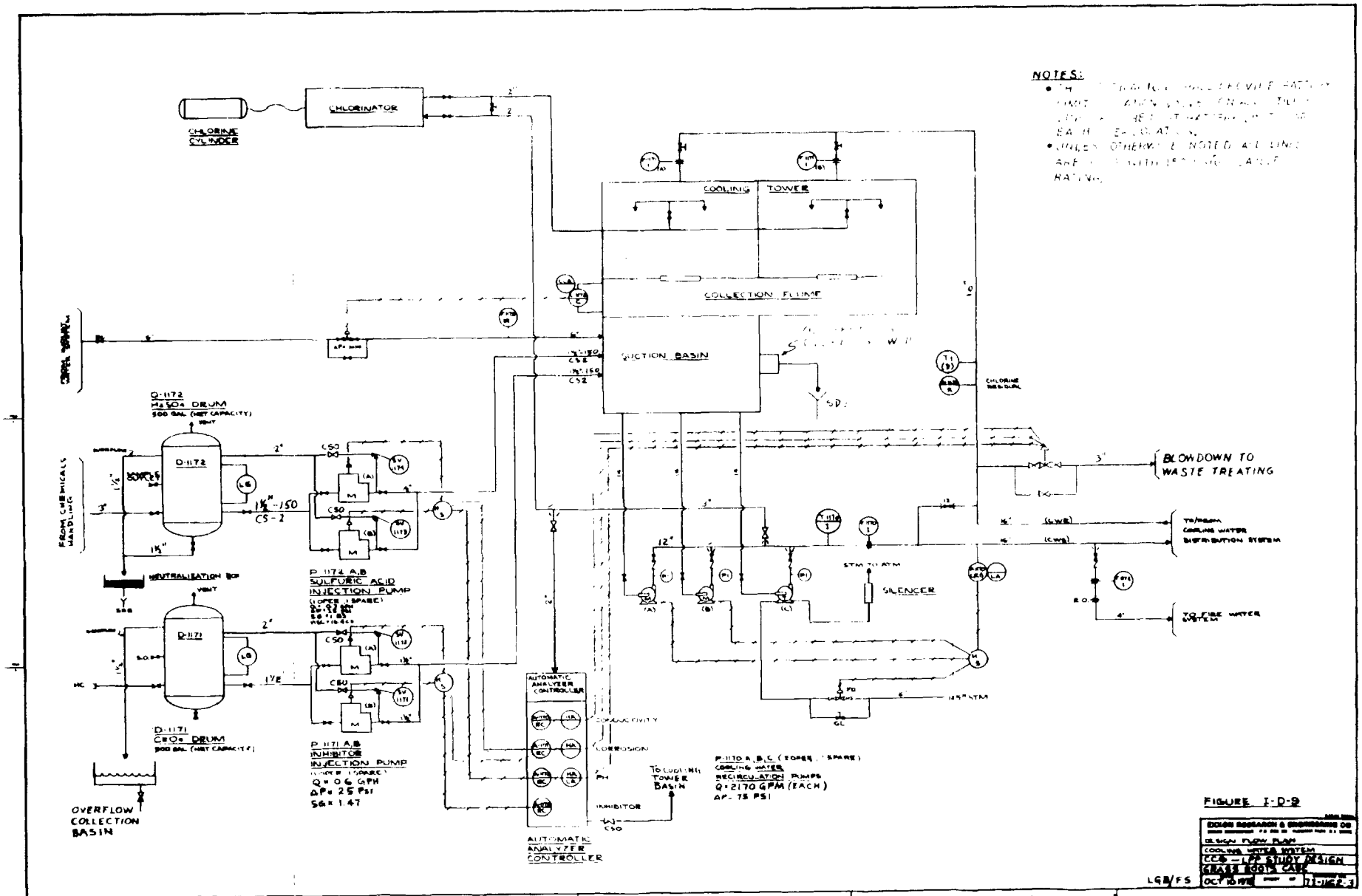


FIGURE I-D-9

DESIGN FLOW PLAN	
COOLING WATER SYSTEM	
CCS — LPP STUDY DESIGN	
GRASS ROOTS CASE	
OCT 1978	II-DEF-3

LGB/FS

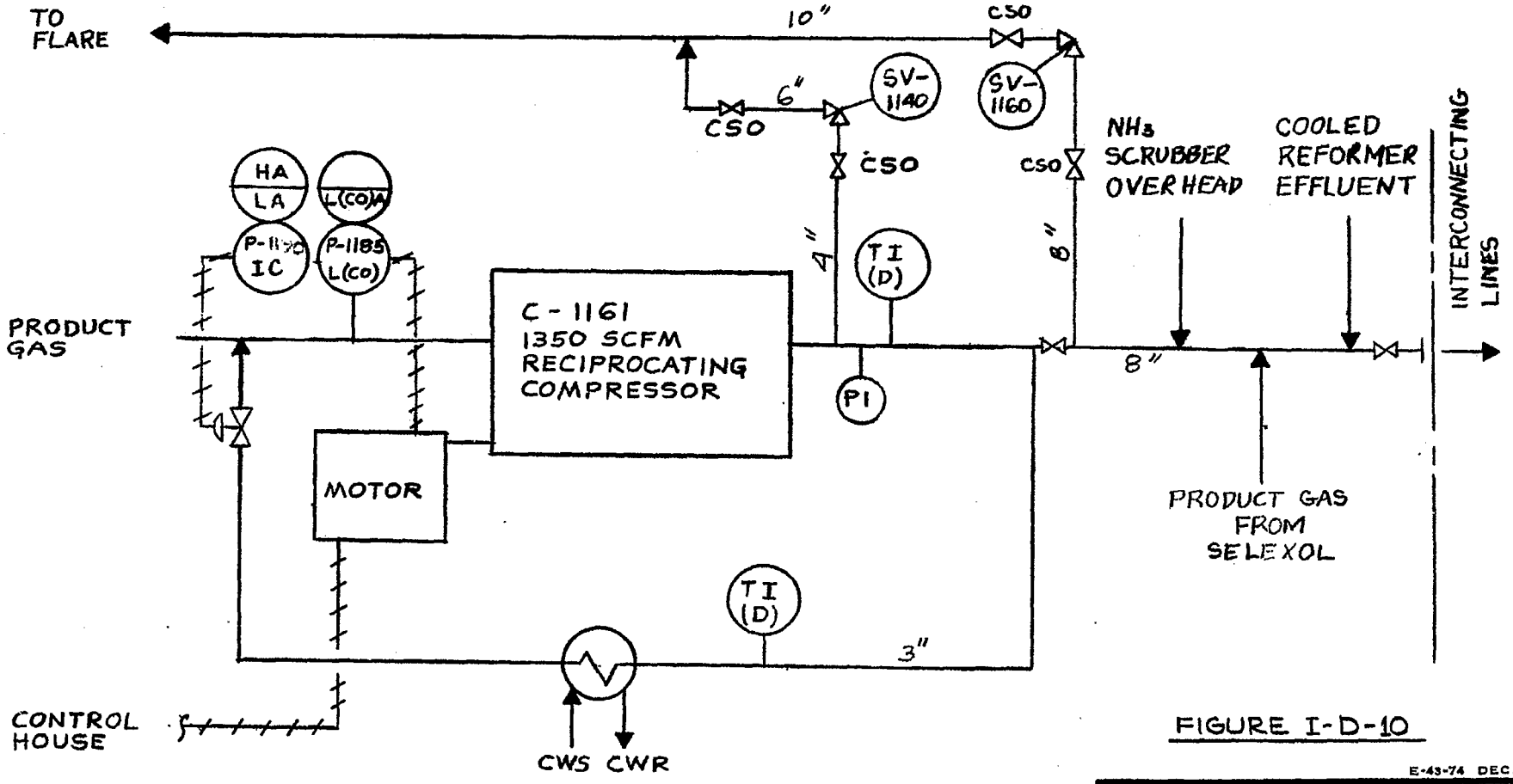


FIGURE I-D-10

E-43-74 DECAL

NOTES:

- COMPRESSOR TO BE LOCATED IN PROCESS UNIT.
- THE CONTRACTOR SHALL PROVIDE BATTERY LIMIT ISOLATION VALVES ON ALL UTILITY LINES AT THE PLOT BATTERY LIMIT FOR EACH USER LOCATION.
- UNLESS OTHERWISE NOTED ALL LINES ARE CS-1 WITH 150 PSIG FLANGE RATING.

EXXON RESEARCH & ENGINEERING CO.	
EXXON ENGINEERING - P.O BOX 101 - FLORHAM PARK, N.J. 07932	
OCT. 10, 1978	
DESIGN FLOW PLAN	
PRODUCT GAS COMPRESSION	
FACILITIES	
CCG - LPP STUDY DESIGN GRASS ROOTS CASE	
JULY 1, 1977	NO. 77-1198-1

PAGE 71 SPW/FS

APPENDIX I-E

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT GRASS ROOTS CASE

ELECTRIC POWER SYSTEM

This section of the Study Design covers the electrical power supply and distribution system for the Catalytic Coal Gasification - Large Pilot Plant (CCG-LPP).

Design Basis

Power for the Coal Gasification Large Pilot Plant is assumed to be purchased at 138 kV from HL&P (Houston Lighting and Power Company). The design of the 138 kV circuit connecting CCG-LPP to the HL&P system assumes that the CCG-LPP will be the only facility installed at the location.

Power shall be distributed radially from two 4160V substations and from three 480V substations.

The estimated maximum simultaneous demand for the CCG-LPP is approximately 4.1 MW, including contingencies. The loads are summarized by distribution center in Table I-E-1.

No planned pre-investment for future expansion shall be included in the electrical distribution system.

Power Source -

138 kV Supply

Power for the Coal Gasification Large Pilot Plant shall be supplied at 138 kV, 3 phase, 60 Hz by HL&P (Houston Lighting and Power Company) by looping an existing 138 kV transmission line, located approximately 500 feet away from the eastern edge of the site, to and away from the dead end structure supplied by the contractor at the 138 kV switchyard. This will provide two incoming 138 kV lines. See layout Drawing PP-1290-4 for 138 kV switchyard location.

The Owner will pay HL&P for the design, supply and installation of the feed facility and also for the removal of the same facility at the completion of the useful life of the project.

The basis for equipment design at the 138 kV level shall be 15,000 MVA maximum symmetrical for bolted 3 phase faults.

The contractor's responsibilities shall include, but are not limited to:

- Provide a 138 kV dead end structure with necessary switches, bussing insulators, and related equipment for termination of the HL&P 138 kV incoming lines. Design and installation to conform with HL&P Standards, and drawing HD-24574.

- Supply and install the feeder from the utility company incoming lines, to the new 138 kV, 2000 AMP, 15,000 MVA oil circuit breaker at the 138 kV switchyard.

- Provide shutdown schedules required to complete the job to Owner's Engineer for submission to HL&P.

- Submit to Owner's Engineer, for HL&P approval, all specifications and drawings dealing with the 138 kV equipment and main transformer. No equipment purchase or installation at the 138 kV interface may proceed without HL&P approval.

- Terminate the required 2" conduit runs from the instrument transformers to a 12"x12" junction box located below the meter boxes to be located in Substation 1. HL&P will complete the meter connections.

System Voltage Levels

The distribution voltage level will be 4.16 kV. For utilization, the medium voltage loads will be supplied at 4.16 kV and the low voltage loads will be supplied at 480 V.

Distribution System

Substations are identified by a number which refers to a building or area where one or several voltage busses are located, and by a letter which refers to the individual bus voltage levels, A (4160V) or B (480V).

At substation 1A, two overhead 138 kV feeders shall supply the plant 138-4.16 kV incoming transformer.

Substations 1B, 2A, and 2B shall be fed radially from S/S 1A via direct buried cable. Substation 3B shall be fed radially from S/S 2A, also via direct buried cable.

All substations shall be elevated, indoor design with the exception of S/S 3B which shall be outdoor metal-clad switchgear.

The 138 kV switchyard and Substations 1A and 1B shall be located at the eastern end of the site (see Layout Dwg. PP-1290-4). Substations 2A and 2B shall be located next to the Control House, and Substation 3B shall be located next to the Administration Building. All indoor substations shall be air conditioned.

System Grounding

The 138-4.16 kV transformer at S/S 1A shall have delta connected primary windings and wye connected secondary windings with a low resistance grounded neutral (1.5-2 ohms).

All 4160-480 V transformers shall have delta connected primary windings and wye connected secondary windings, with a solidly grounded neutral.

Turnaround Power Center

Turnaround power centers for lighting and other similar services requiring supply during shutdowns shall be provided at both Substation 1B and Substation 2B. Each center shall consist of a standardized wall mounted enclosure with grouped fuses disconnect switches.

COMMUNICATIONS

The communication system for this project is not the responsibility of the contractor; however, there are several interface requirements to be completed for the installation of communication equipment.

The contractor shall provide raceways and sleeves as required for the installation of a switched dial telephone network and a two-way radio system.

The telephone system, with a manual/automatic switchboard, shall have telephones located in the general purpose building, main control house, administration building, substations and main gate guard house.

The contractor shall contact the Owner's Engineer for additional information.

TABLE I-E-1

DISTRIBUTION CENTER LOAD SUMMARY

Distrib. Center	Load Area	Oper. kW[1]	Equiv. kVA[2]	Transformer Size kVA, OA/FA
Substation 1A (4160v)	Waste H_2O Treat	192	216	
	Firewater	195	219	
	S/S 2A	2036	2298	
	S/S 1B	350	411	
	S/S 2B	1368	1609	
		4141	4753	5000/6200[1]
Substation 1B (480v)	Coal Receipt & Stor.	99	116	
	Waste H_2O Treat.	244	287	
	Safety Syst.	7	8	
		350	411	500/575
Substation 2A (4160v)	Onsites	1320	1483	
	Utilities	330	371	
	Coal Prep.	186	209	
	S/S 3B	200	235	
		2036	2298	(3)
Substation 2B (480v)	Onsites	491	578	
	Coal Prep	520	612	
	Chem. Handling	6	7	
	Utilities	337	396	
	Cat. Recpt. & Stor.	14	16	
		1368	1609	1500/1725
Substation 3B (480v)	Admin. Bldg. & Gate House	200	235	300

NOTES:

(1) Additional allowance has been included.
(2) Assumed power factors are 0.89 for medium voltage loads, 0.85 for low voltage loads.
(3) Loads fed directly at 4160v.

General

The estimated maximum simultaneous demand for the Catalytic Coal Gasification Large Pilot Plant, including contingencies, is approximately 4100 kW. The loads are summarized by distribution center in Table 1. The contractor is responsible for finalizing all loads and for assuring compatibility of all equipment throughout the system.

PROTECTION AND CONTROL

Metering

Houston Lighting and Power will provide all the revenue metering at the primary of the S/S 1A 138-4. 16 kV transformer, including the necessary CTs and PTs.

The 138 kV dead end structure shall include the required CT and PT supports.

The transformer secondary shall be equipped with:

- An indicating watthour meter with a demand register.
- One single phase indicating ammeter with selector switch for three phases.
- Voltmeter with selector switch for three phases.

Protection

The protection of Substation 1A 138-4. 16 kV transformer shall include overcurrent, differential, fault pressure, and ground fault relays. The relays shall be energized from current transformers located on or in the primary bushings or cable ends, and shall be arranged to transfer trip the main power circuit breaker throught a lockout relay. Type and settings of relays must be approved by HL&P.

Emergency deenergization of the main bus at all low voltage substations shall be provided by manual initiation of a transfer trip lockout relay, tripping the substation feeder breaker.

Manual transfer tripping of the substation feeder breaker shall be provided at S/S 2A.

Protection for each 4.16 kV distribution feeder shall include phase overcurrent relays, and a ground fault relay supplied from a zero sequence CT. Protection for each 4.16 kV motor feeder shall include a ground fault relay supplied from a zero sequence CT.

INSTRUMENT POWER SUPPLY

The contractor shall provide an IPS (instrument power supply) in the main control house, for supplying power to instruments and other essential services during power outages. Figure 5.1 is a simplified IPS one-line diagram.

A standby generator and storage batteries shall be provided with the IPS. The batteries shall be sized for 1/2 hour operation without charger.

The a-c loads to be served by the IPS shall be classified as shown in Table 5.1, based on the tolerable time of transfer between normal and standby supplies.

INSTRUMENT LOAD CLASSIFICATION

Tolerable Transfer Time (seconds)	Class
0.005	I
0.2	II
0.2-20	III
Transfer to standby not required	not classified

Transfer switches for a-c loads shall operate immediately upon drop of voltage below lower tolerable limit of loads served. A solid state transfer switch shall be provided for Class I loads and electromechanical transfer switches shall be provided for Class II and Class III loads.

Classification of d-c instrument loads shall be by specification of tolerable outage time for each load.

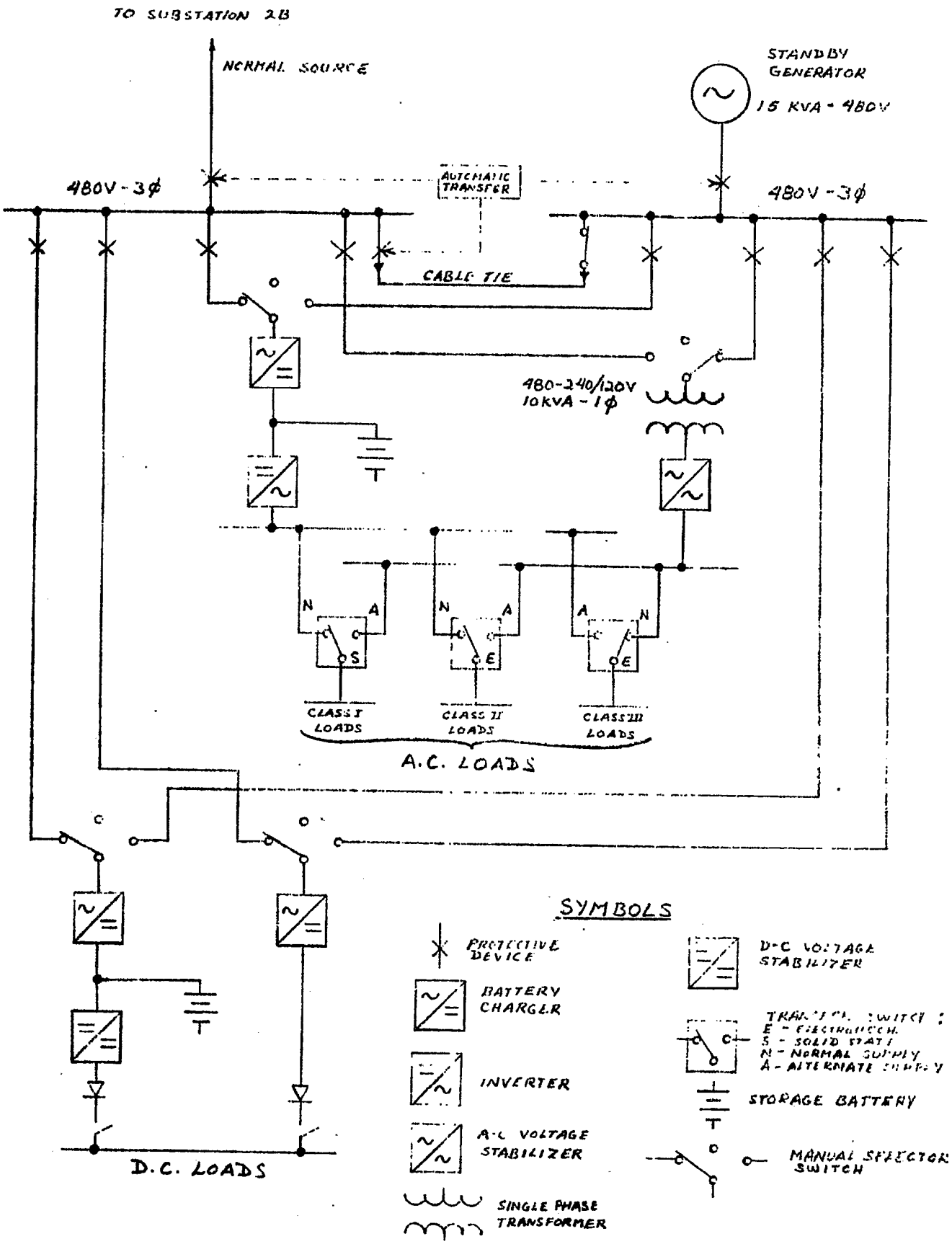
The instrument power distribution panels shall be standardized metal enclosures with grouped fused disconnect switches.

The contractor's responsibilities shall include, but are not limited to:

- Selection and sizing of equipment for the IPS system based on the latest instrument power requirements.
- Grouping of instrument loads by priority classes as indicated above.
- Complete coordination of switching and tripping elements.

FIGURE I-E-1

IPS ONE-LINE DIAGRAM



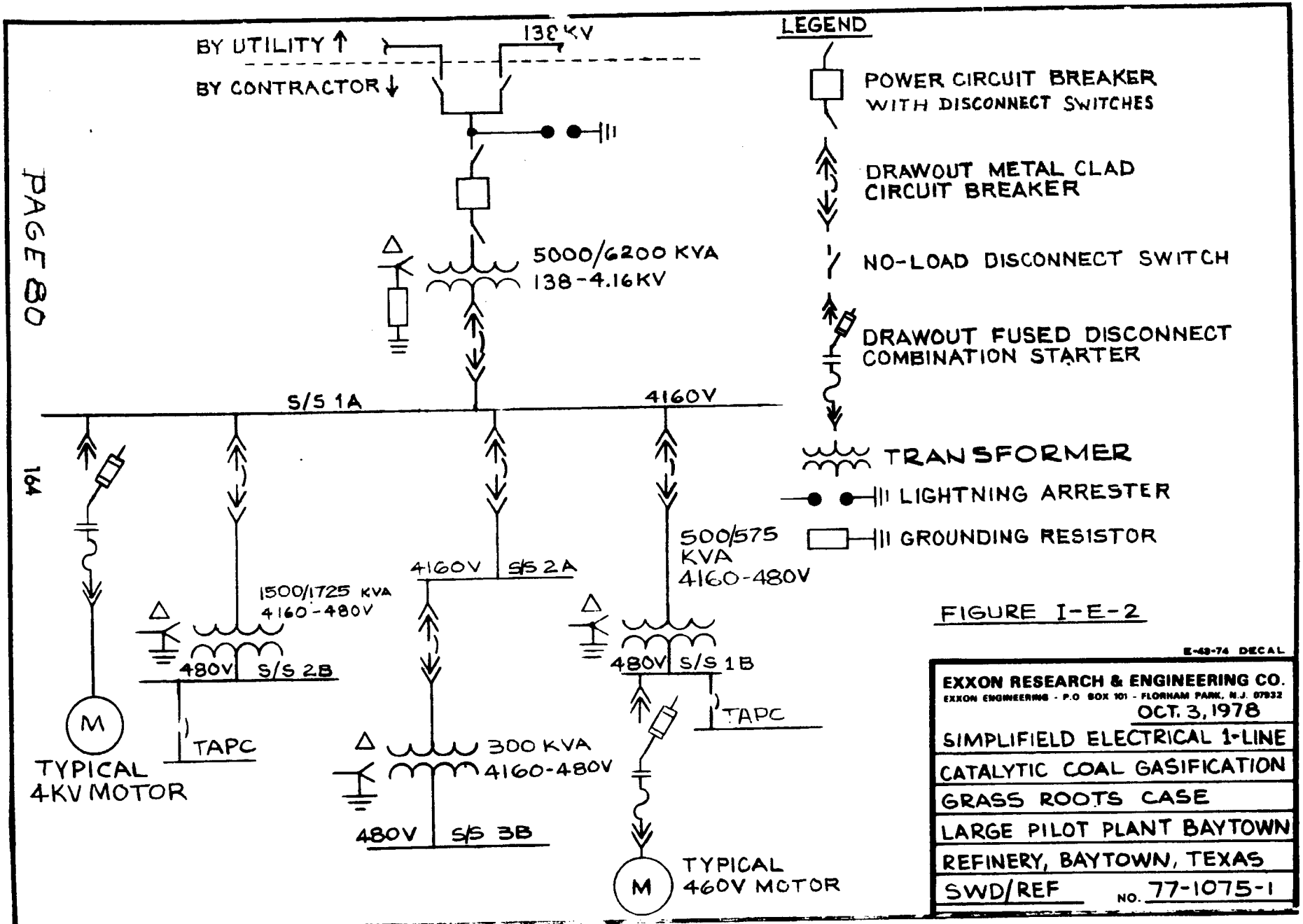


FIGURE I-E-2

E-49-74 DECAL

EXXON RESEARCH & ENGINEERING CO.
EXXON ENGINEERING - P.O. BOX 101 - FLORHAM PARK, N.J. 07932
OCT. 3, 1978
SIMPLIFIED ELECTRICAL 1-LINE
CATALYTIC COAL GASIFICATION
GRASS ROOTS CASE
LARGE PILOT PLANT BAYTOWN
REFINERY, BAYTOWN, TEXAS
SWD/REF NO. 77-1075-1

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OGILVIE PRESS

APPENDIX I-F

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY-GRASS ROOTS CASE

CATALYST HANDLING FACILITIES

This section covers the Gasification Process Catalyst handling facilities for the Catalytic Coal Gasification Large Pilot Plant. The Catalyst Handling Facilities will be located adjacent to the Coal Preparation Plant. Major equipment covered in this section includes receipt and storage facilities for the catalysts K_2CO_3, a batch tank for making an aqueous slurry of the Na_2CO_3, transfer pumps to transfer the catalyst solutions at a predetermined ratio to one of two day tanks, and feed pumps which deliver the catalyst to the catalyst/coal blending facilities.

DESIGN BASIS

The Catalyst Handling Facilities have the flexibility to add up to 20 wt% (on dry coal) of either K_2CO_3, or a 50/50 mixture of K_2CO_3 and Na_2CO_3. The catalyst receipt and storage facilities have been designed to receive and store the two catalysts separately. Both catalysts will be received by truck. Hose connections will be provided to transfer the catalyst to storage. This operation utilizes the unloading equipment of the trucks.

K_2CO_3 will be received as a 47 wt% aqueous solution. Na_2CO_3 will be received as a dry solid, since it is not available commercially as a solution. The liquid K_2CO_3 storage tank and the solid Na_2CO_3 storage bin have been sized to store 4 days of catalyst at the respective maximum usage rates. The maximum usage rates occur when the catalyst recovery unit is not operating. The maximum usage rate of the 47 wt% K_2CO_3 solution is 5200 gallons/day and the maximum usage rate of the solid Na_2CO_3 is 7.7 short tons/day. The liquid K_2CO_3 tank will be provided with a mixer.

A batch tank will be provided for mixing the solid Na_2CO_3 with industrial water to form a 40 wt% slurry solution. The batch tank is sized to make a one day batch of the solution. This tank will be provided with a mixer. The solid Na_2CO_3 storage will be elevated above the tank to allow for the easy transfer of the solid into the top of the tank. The solids feeder is sized to feed the Na_2CO_3 to the tank in 4 hours.

Transfer pumps will be provided to transfer the catalyst solutions using a flow ratio controller to one of the two day tanks at a predetermined ratio. The two catalyst solutions will be combined with the recovered catalyst stream and go through a static mixing column before entering the tank. This transfer will take a maximum of 4 hours.

Two day tanks equipped with mixers will be provided to allow for sampling and checking before the catalyst is added to the coal. Each of the tanks has a connection for industrial water and a connection to the sewer.

TABLE I-F-1

UTILITIES AND CHEMICALS

ELECTRIC POWER

Requirements, KW

Symbol	Service	Duty	Load	
			Operating	Connected
P-1300	K_2CO_3 Transfer Pump	I	0.7	1.0
P-1301	Na_2CO_3 Transfer Pump	I	0.9	1.0
P-1302A	Catalyst Feed Pump	N	0.5	1.0
P-1302B	Catalyst Feed Pump	S	0.5	1.0
FE-1300	Na_2CO_3 Screw Feeder	I	1.4	1.4
MA-1300	TK-1300 Tank Mixer	N	1.9	1.9
MA-1301	TK-1301 Tank Mixer	N	1.9	1.9
MA-1302A	TK-1302A Tank Mixer	N	1.9	1.9
MA-1302B	TK-1302B Tank Mixer	N	1.9	1.9

COMPRESSED AIR

Requirements, SCFM

	Normal	Maximum
Self-cleaning Filter on BN-1300	0	By Contractor

INDUSTRIAL WATER

Requirements, GPM

	Normal	Maximum
Preparing Na_2CO_3 Solution	0	3

CHEMICALS

	Normal	Maximum
K_2CO_3 (47 wt% solution)	1200 GPD	5200 GPD
Na_2CO_3 (Solid)	0 STPD	7.7 STPD

STEAM - 125 PSIG

Requirements, lb/hr

Tank TK-1301 Heating	110
Tank TK-1302A Heating	130
Tank TK-1302B Heating	130
Steam Tracing	130
	500

TABLE I-F-2

EQUIPMENT LIST

Pumps

Equipment No.	P-1300	P-1301	P-1302 A&B
Service	K_2CO_3 Transfer Pump	N_2CO_3 Transfer Pump	Catalyst Feed Pump
Type	Centrifugal	Centrifugal	Centrifugal
Capacity, gpm	28	38.5	5.5
ΔP, PSI	14	16	25

Bins

Equipment No.	BN-1300
Service	Solid Na_2CO_3 Storage
Type	Circular, Conical Outlet
Diameter, ft	12
Straight Side Height, ft.	15.3
Taper Height, ft.	10.2
Capacity, tons	31

Filters

Equipment No.	DC-1300
Service	Bag Filter
Gas Rate, ACFM	400
Bag Area, ft^2	100

Feeders

Equipment No.	FE-1300
Service	Solid Na_2CO_3 Feeder
Type	Screw
Length, ft.	10
Diameter, in.	9
Capacity, STPH	1.9

TABLE I-F-3

PROCESS VESSELS

Tank No.	Service	Type	Size Dia.(ft)	Size Ht.(ft)	Insul.	Heaters	Temp.(°F)	Mixers
TK-1300	K_2CO_3 Solution Storage	CR(1)	15	18	No	No	Ambient	Yes(2)
TK-1301	Na_2CO_3 Batch Tank	CR(1)	7.5	12	No	Yes(5)	110	Yes(2)
TK-1302 A&B	Day Tanks	CR(1)	10.5	12	No	Yes(5)	110	Yes(2)

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Notes:

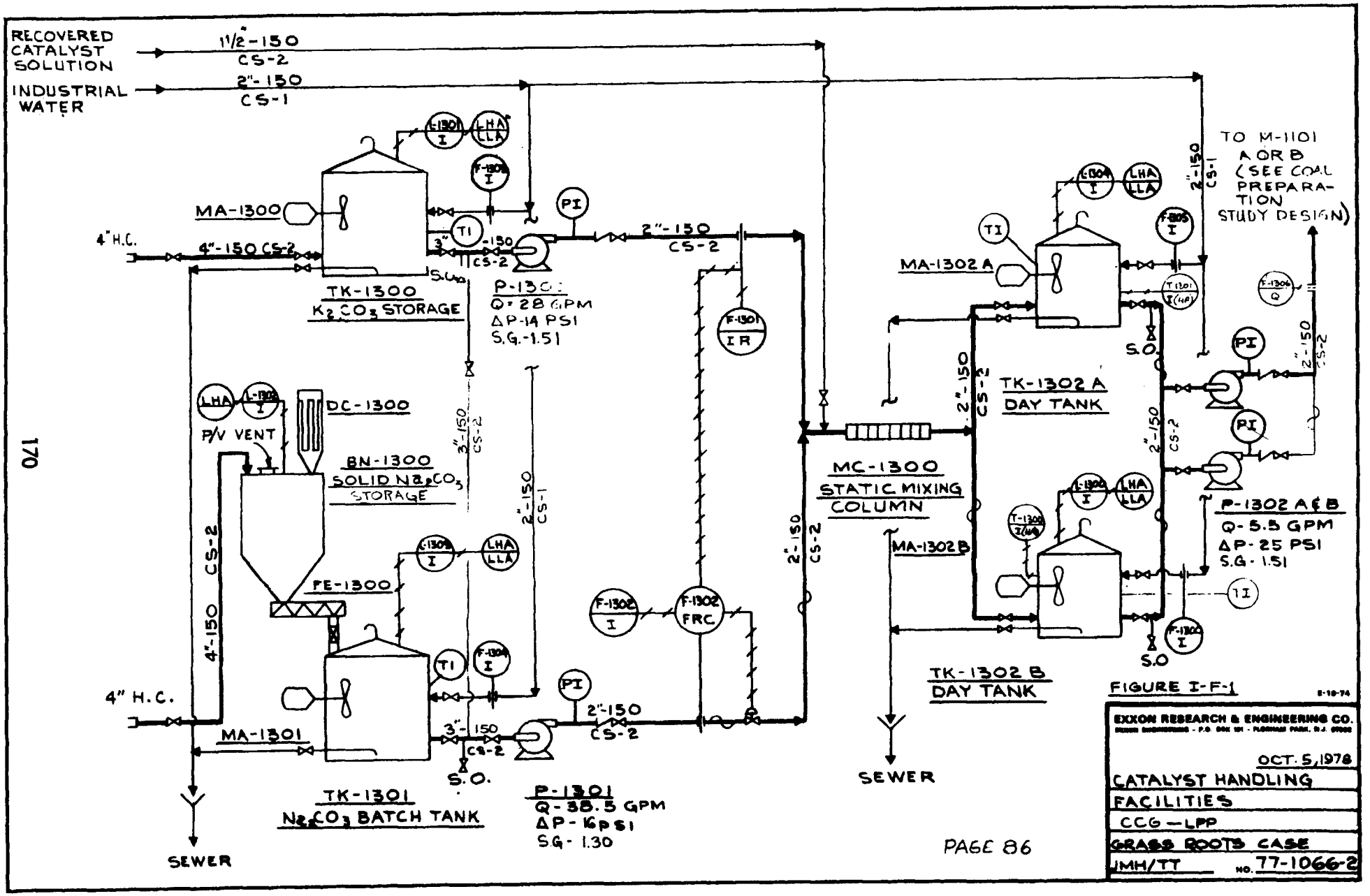
(1) Cone roof tanks with cone bottom, apex down.

(2) A 2 HP mechanical agitator shall be provided.

(3) For instrumentation see flow plan.

(4) Each tank shall be provided with a water/bottoms drawoff connection, gage hatch, and a manway for possible maintenance requirements.

(5) Tank shall be equipped with steam heater and automatic temperature control. Steam pressure = 125 psig.


RECOVERED CATALYST SOLUTION
11/2"-150 CS-2
INDUSTRIAL WATER
2"-150 CS-1
MA-1300
4" H.C.
4"-150 CS-2
TK-1300
K2CO3 STORAGE
P-1300
Q=28 GPM
ΔP-14 PSI
S.G.-1.51
2"-150 CS-2
TO M-1101 A OR B (SEE COAL PREPARATION STUDY DESIGN)
MA-1302 A
TK-1302 A DAY TANK
P-1302 A&B
Q-5.5 GPM
ΔP-25 PSI
S.G-1.51
DC-1300
P/V VENT
BN-1300
SOLID Na2CO3 STORAGE
MC-1300
STATIC MIXING COLUMN
MA-1302 B
TK-1302 B DAY TANK
FE-1300
4"-150 CS-2
3"-150 CS-2
2"-150 CS-1
2"-150 CS-2
4" H.C.
MA-1301
TK-1301
Na2CO3 BATCH TANK
P-1301
Q-38.5 GPM
ΔP-16 PSI
S.G-1.30
SEWER
SEWER
S.O.
S.O
S.O
PAGE 86
FIGURE I-F-1
EXXON RESEARCH & ENGINEERING CO.
OCT. 5, 1978
CATALYST HANDLING
FACILITIES
CCG—LPP
GRASS ROOTS CASE
JMH/TT
NO. 77-1066-2

APPENDIX I-G

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY-GRASS ROOTS CASE

WASTE TREATING FACILITIES

This section covers the handling, treating, and disposition of waste streams for the grass roots case of the Catalytic Coal Gasification large pilot plant study design. These include:

- Coal Gasification Process Waste Water
- Coal Drier Scrubber Water
- Contaminated Rainwater Runoff
- Heavy Glycol Scrubbing Unit Purge
- Catalyst Concentrator Condensate
- Cooling Towers Blowdown (not treated)
- Waste Heat Boiler Blowdown
- Steam Reformer Effluent Condensate
- Sanitary Waste
- Char/Ash Slurry Streams

Site drainage is covered in the Study Design covering site development.

DESIGN BASIS

Coal gasification process waste water will be thickened, filtered, treated biologically in an activated sludge unit and then recycled to the coal preparation and process scrubbers. After biological treatment, excess water will be pumped to the adjacent refinery sewer system.

The activated sludge unit is designed to reduce the concentration of phenol from 50 ppm at the inlet to less than 1 ppm in the effluent.

Vacuum filtration facilities will be operated 24 hours/day, 7 days/week at maximum coal feed rate. These facilities have been designed to remove 2800 lbm/day char, ash and fines from the char and ash slurry and the thickened slurry.

Filter cake (30 wt% solids) will be loaded directly into truck mounted disposal bins. Flexibility has been provided to divert filter cake to a sheltered storage pit to accommodate minor interruptions in the truck loading operation. Reclaim from this area will be accomplished with a front end loader. Depending upon the solids content of slurry from the catalyst recovery area, these fines will be either pumped to the thickener/ filters or dumped into a disposal bin in the catalyst recovery area.

During normal operations, coal drier scrubber water will be obtained from and returned to the process water supply header. Flexibility has been provided to permit sending coal drier scrubber effluent water directly to the thickener during periods when the gasification process is shut down. Similarly, scrubber water can be supplied directly to the process area when the coal preparation unit is not in operation.

Rainwater runoff will be collected from the following areas and pumped into the rainwater impounding basin:

- CCG Process Block
- Heavy Glycol Scrubbing Unit Block
- Coal Storage and Preparation Block
- Waste Water Treating Block
- Coal Receipt Area

Design 24 hour rainfall is 10 inches. Design rainfall intensity is 3.5 inches/hour. Impounded rainwater collected during the design 24 hour storm will be pumped to the activated sludge unit over a 7 day period.

Cooling tower blowdown will be pumped to the adjacent refinery sewer system.

All other waste streams will be sent to the activated sludge unit.

TABLE I-G-1

UTILITIES AND CHEMICALS

Electric Power Consumption (KW)

Symbol	Service	Duty	Reacceleration Required	Operating Load
P-1400	Slurry from TK 1400	I	A	6.0
P-1401A	Thickener Underflow	N	C	1.1*
P-1401B	Thickener Underflow	N	C	1.1*
P-1401C	Thickener Underflow	S	C	1.1*
P-1402A	Thickener Overflow	N	A	5.4*
P-1402B	Thickener Overflow	S	A	5.4
P-1403A	Aeration Basin Overflow	N	B	7.5*
P-1403B	Aeration Basin Overflow	S	B	7.5
P-1404B	Scrubber Water Supply	N	A	148*
P-1405A	Filtrate from Vacuum Filters	N	C	1.1*
P-1405B	Filtrate from Vacuum Filters	S	C	1.1
P-1406	Deleted			
P-1407A	Metering $H_3 PO_4$	N	C	By Contractor
P-1407B	Metering $H_3 PO_4$	S	C	By Contractor
P-1408A	Metering $H_2 SO_4$	N	C	By Contractor
P-1408B	Metering $H_2 SO_4$	S	C	By Contractor
P-1409A	Metering Na OH	N	C	By Contractor
P-1409B	Metering Na OH	S	C	By Contractor
P-1410A	Nutrient Injection	N	C	By Contractor
P-1410B	Nutrient Injection	S	C	By Contractor
P-1411A	Rainwater Lift	I	A	12*
P-1411B	Rainwater Lift	I	A	12*
P-1411C	Rainwater Lift	I	A	12*
P-1412	Rainwater Lift	I	C	4
P-1413A	Rainwater Discharge	I	C	3*
P-1413B	Deleted			
P-1414A	Sludge Recycle	N	C	1.2*
P-1414B	Sludge Recycle	S	C	1.2*
C-1400A	Vacuum Pump	N	C	17.3*
C-1400B	Vacuum Pump	S	C	17.3*
F-1400A	Vacuum Filter	N	C	2.5*
F-1400B	Vacuum Filter	N	C	2.5*

TABLE I-G-1 (Cont'd)

Electric Power Consumption (KW)

Symbol	Service	Duty	Reacceleration Required	Operating Load
MA-1400A,B	Mixers for TK-1400	I	C	6 each*
MA-1402	Mixer for TK-1402	N	C	16*
MA-1403	Mixer for TK-1403	N	C	6*
MA-1404	Mixer for TK-1404	N	C	15*
MA-1405A	Surface Aerator	N	C	11.2*
MA-1405B	Surface Aerator	N	C	11.2*
MA-1405C	Surface Aerator	S	C	11.2
CO-1400A	Filter Cake Conveyor	N	C	1.5*
CO-1400B	Filter Cake Conveyor	N	C	1.5*
CO-1401A	Filter Cake Conveyor	N	C	1.5*
CO-1401B	Filter Cake Conveyor	N	C	1.5*

* Max Simultaneous = 323.7

TABLE I-G-1 (Cont'd)

125 PSIG Steam Consumption (lb/hr)		
Consumers	Normal	Maximum
p-1404A Scrubber Water Supply Pump	0	9129
Compressed Air Requirements (SCFM)		
Instrument Air	Normal	Maximum
Instruments and Controls	20	20
Utility Air		
VF 1400 A&B	190	190
Industrial Water (GPM)	Normal	Maximum
C-1400 A&B Seal Makeup	By Contractor	By Contractor
Aerated Lagoon Startup	0	50
Chemicals (GPH)	Normal	Maximum
75 wt% H_3PO_4	0.4	0.4
98 wt% H_2SO_4	2.5	60.0
15° Be NaOH	10.0	10.0
Phenol	0	10.0
Nitrogen (LP) SCFM	Normal	Maximum
TK-1400 Blanketing	0	150

TABLE I-G-2

EQUIPMENT LIST - WASTE TREATING FACILITIES

Equipment List

Pumps

Equipment No.	Service	Capacity, GMP	ΔP, PSI
P-1400	Slurry From TK 1400	40	23
P-1401 A,B,C	Thickener Underflow	40	23
P-1402 A&B	Thickener Overflow	355	23
P-1403 A&B	Aearated Lagoon Overflow	380	31
P-1404 A&B	Scrubber Water Supply	380	515
P-1405 A&B	Filtrate From Vac. Filter	37	25
P-1407 A&B	Metering $H_3 PO_4$	1.1	100
P-1408 A&B	Metering H_2SO_4	0.5	100
P-1409 A&B	Metering NaOH	20	100
P-1410 A&B	Metering Nutrient	10	100
P-1411 A,B,C	Rainwater Lift	4000	
P-1412	Rainwater Lift	180	25
P-1413 A	Rainwater Discharge	180	20
P-1414 A&B	Sludge Recycle	190	10
C-1400 A&B	Vacuum Pump	320 CFM	5-30 in Hg Inlet Pressure

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TABLE I-G-2 (Cont'd)

TANKAGE LIST

Tank No.	Service(6)	Roof Type	Bottom Type(1)	Ht x Dia Feet	Gross Capacity Bbl	Max. Inlet Rate GPM(3)	Max. Outlet Rate GPM(3)	Mixer Type(2)
1400	Slurry Holdup	Dome	CBD	28 x 28	3,071	88	44	MA
1402	Equalization Tank	Cone	CBD	36 x 36	6,526	355	355	MA
1403	Process Water Storage	Cone	CBD	42 x 47	12,978	380	380	MA
1404	Neutralization	Cone	CBD	10 x 10	140	355	350	MA
D-1400	Filtrate Receiver	Drum		10 x 3				

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Notes:

(1) Bottom Type: CBD = Cone Bottom Apex Down
(2) Mixer Type: MA = Motor Driven Mechanical Agitator. Two agitators shall be provided in TK-1400.
(3) Tank Roof Vents shall be compatible with indicated maximum inlet and outlet rates.

TABLE I-G-2 (Cont'd)

Vacuum Filters

Equipment Symbol:	VF 1400 A&B.
Number of Filters Required:	2
Type:	Rotary Drum.
Filtration Area:	80 sq. ft. per filter
Discharge:	Scraper type suitable for future conversion to belt type.
Feed Composition:	(per filter) - 40 GPM containing 12 wt% solids. - Dry solids rate 2832 lb/hr.
Discharge Composition:	Filter Cake, 30 wt% solids.
Filter Cloth:	Continuous monofilament yarn. Pressure drop not to exceed 1.5 in wg @ 1.33 CFM/FT^2.
Accessories:	- Pan Agitator. - Provision to backflush cloth with air. - Variable speed drive on pan agitator and on drum. Drum speed shall be adjustable from 1/2 to 5 minutes per revolution.

TABLE I-G-2 (Cont'd)

Belt Conveyors

Symbol	Approximate Length-Feet
CO 1400A	45
CO 1400B	45
CO 1401A	11
CO 1401B	11

The following applies to all conveyors above:

- Belt Speed: 36 FPM.
- Idler trough Angle: 20 Degrees.
- Belt Width: 18".
- Conveyors Shall Be Reversible
- Capacity: 5 Tons/Hour.
- Belt Cleaners: Provide at both ends.
- Material Characteristics: Surcharge Angle - 0 Degrees.
  Bulk Density - 60 Lb/Ft^3
- Conveyor Length subject to detailed layout by the Contractor

TABLE I-G-2 (Cont'd)

Slurry Thickener

Equipment Symbol:	TH-1401
Service:	Fines Slurry Thickening.
Feed:	- Flow Rate. - Slurry Concentration. - Temperature: 120°F.
Overflow Clarity:	100 wppm Solids Maximum.
Minimum Diameter:	50 Feet.
Side Wall Depth:	By vendor. Allowance shall be made for 15 tons (dry basis) of char fines storage to permit stopping underflow withdrawal for up to 12 hours.
Freeboard:	1 foot, minimum.
Tank Materials:	Carbon Steel, 1/8"CA.
Underflow Pump Location:	Directly under Discharge Cone.
Accessories:	- Local and remote torque indicator. - Torque overload alarm (set at 115% of maximum rated operating torque) to be located in Central Control Room. - Rake lifting device to automatically raise rakes up to 2 feet during torque overload condition while rakes are turning. Reset to Low Position shall be manually controlled. - Surface skimmer, scum baffle, and scum collection box. Surface skimmer to be driven independently of rake. - Design shall be consistent with future addition of a cover.

TABLE I-G-2 (Cont'd)

Activated Sludge Unit

- Aeration Basin

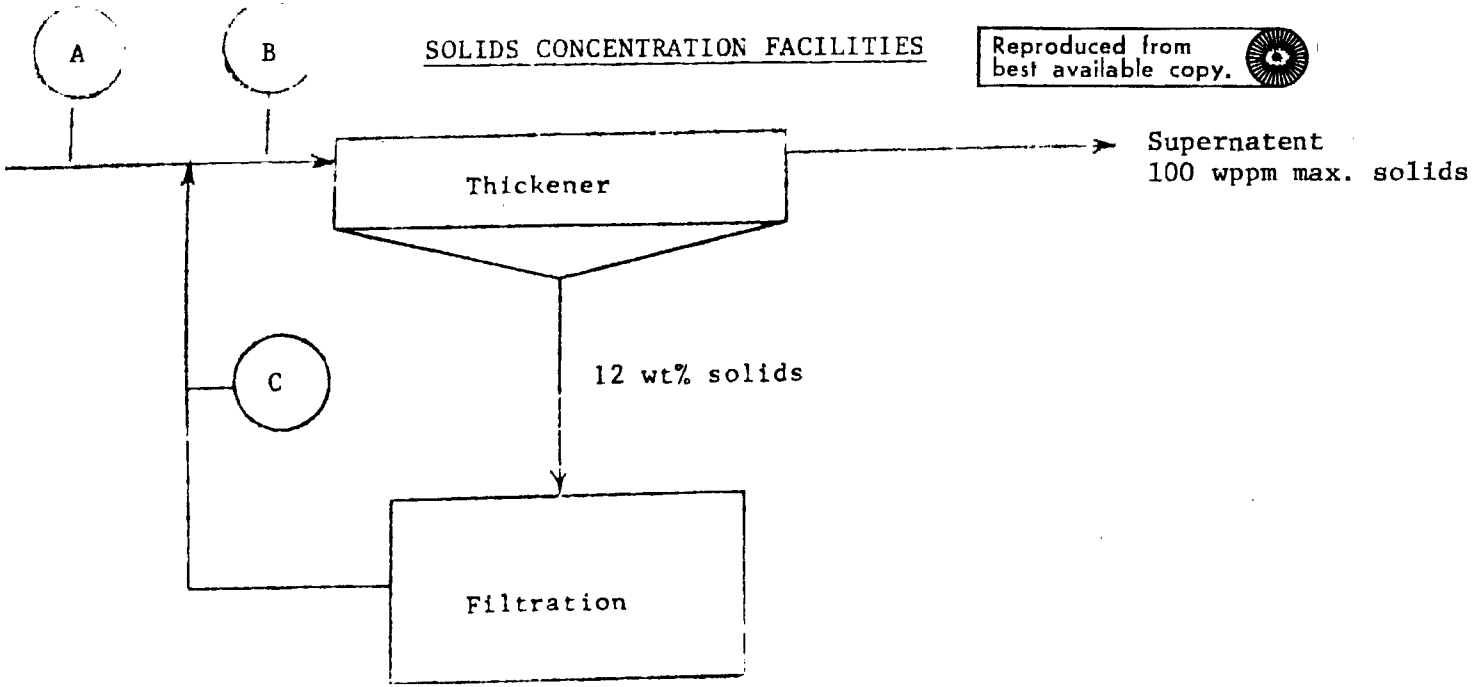
Equipment Symbol	AB-1405
Design Capacity, GPM	380 Max.
Type Unit	Circular, Activated Sludge Process
Retention Time, hr.	8
Diameter, ft.	55
Height (including 2 ft. freeboard) ft.	12
Aerators	Three 15 hp aerators

- Clarifier

Equipment Symbol	CL-1406
Type	Circular
Maximum Rise Rate, GPM/ft^2	0.25
Retention Time, hr.	4
Diameter, ft.	44
Height (including 2 ft. freeboard), ft.	10
Miscellaneous	Provide oil skimming and sludge scraping facilities. Sludge scraper motor shall be protected by overload trip switch. Inlet distributor(s) shall be provided for even influent dispersion.

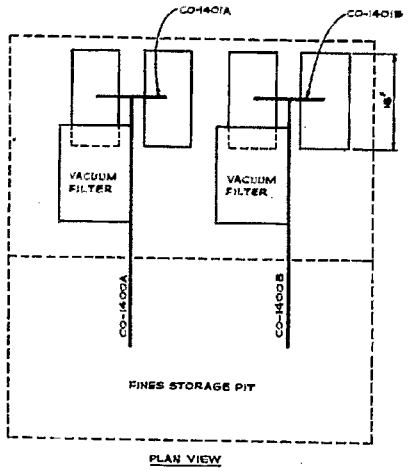
FIGURE I-G-1

SOLIDS CONCENTRATION FACILITIES

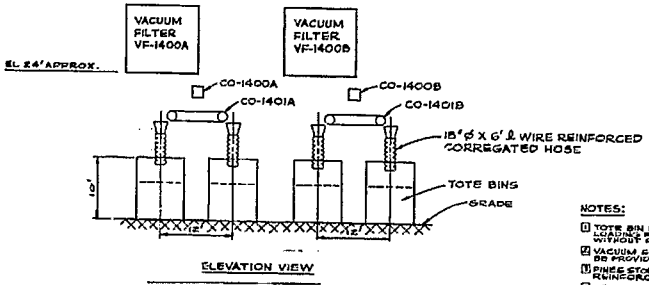


Stream	Case 1		Case 2	
	Liquid GPM	Wt.% Solids	Liquid GPM	Wt.% Solids
A	189	2.5	361	1.3
B	223	2.4	395	1.4
C	34	1.9	34	1.9

Note: Case 2 includes rainwater, Case 1 is dry weather flow (process units only).

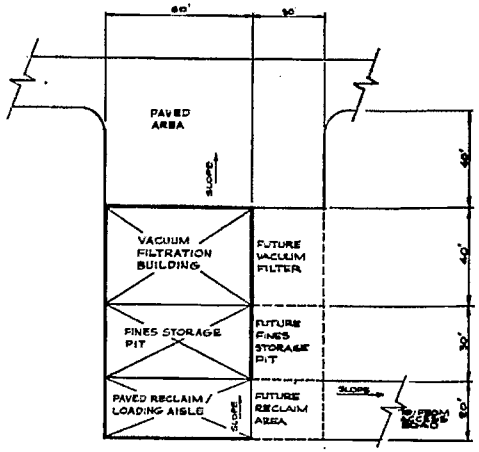


PLAN VIEW



ELEVATION VIEW

GENERAL ARRANGEMENT
VACUUM FILTRATION BUILDING/
LOADING FACILITIES



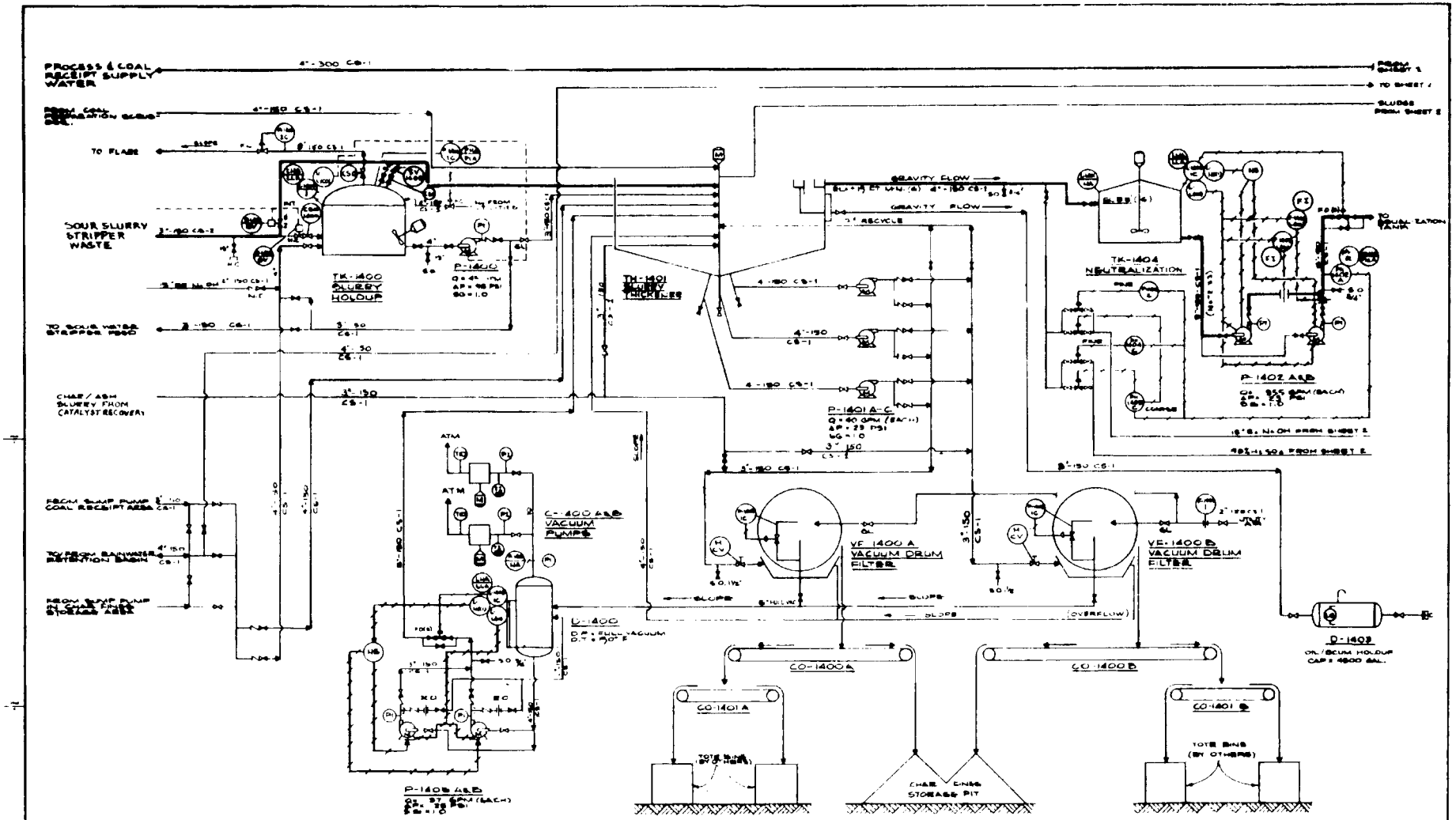
VACUUM FILTRATION AREA
PLAN VIEW

NOTES:

1. TOTE BIN DIMENSIONS ARE 8'W X 10'-6" X 5'-6"H. LOADING FACILITIES SHALL PROVIDE FOR EASE OF FILLING BINS WITHOUT REMOVING BIN FROM TRUCK.
2. VACUUM FILTRATION AREA/ FINES STORAGE PIT SHALL BE PROVIDED WITH A ROOF.
3. FINES STORAGE PIT SHALL BE PROVIDED WITH 4' HIGH REINFORCED CONCRETE RETAINING WALLS ON 3 SIDES.
4. DETAILED LAYOUT OF EQUIPMENT / BUILDING SHALL BE DEVELOPED BY THE CONTRACTOR AND SUBMITTED TO THE OWNER'S ENGINEER FOR APPROVAL.
5. PROVIDE A COVERED SUMP AND PUMP IN FINES STORAGE PIT TO HANDLE WATER SEEPAGE FROM FILTER CAKE.
6. TOTE BIN LOADING AREA SHALL DRAIN TO THE FINES STORAGE PIT SUMP.

FIGURE I-6-2

EXXON RESEARCH & ENGINEERING CO.	
LAYOUT & GENERAL ARRANGEMENT	
VACUUM FILTRATION & TRUCK LOADING FACILITIES	
CCG — LPF STUDY DESIGN	
BRAUN BOOTS CASE	
DATE OCT 3, 1978	SHEET 1 OF 1 — 77-956-4


PROCESS & COAL RECEIPT SUPPLY WATER
SOUR SLURRY STRIPPER WASTE
TO FLARE
TO SOUR WATER STRIPPER FEED
CHAR / ASH SLURRY FROM CATALYST RECOVERY
TK-1400 SLURRY HOLDUP
P-1400
TH-1401 SLURRY THICKENER
P-1401 A-C
TK-1404 NEUTRALIZATION
P-1402 A&B
TO SOUR WATER STRIPPER
TO FLUID EATION
GRAVITY FLOW
3" RECYCLE
ATM
C-1400 A&B VACUUM PUMPS
VF-1400 A VACUUM DRUM FILTER
VF-1400 B VACUUM DRUM FILTER
V-1400
D-1402
OIL/BCUM HOLDUP
CAP = 4000 BBL
CO-1400 A
CO-1400 B
CO-1401 A
CO-1401 B
TOTE BINS (BY OTHERS)
CHAR BINS STORAGE PIT
P-1408 A&B
FIGURE I-G-3
EXXON RESEARCH & ENGINEERING CO
LIQUEFACTION PLANT PROCESS FLOW PLAN
WASTE TREATMENT FACILITIES
CCG - LPP STUDY DESIGN
SINGLE BOOTS CASE
OCT 8, 1976
77-920-3

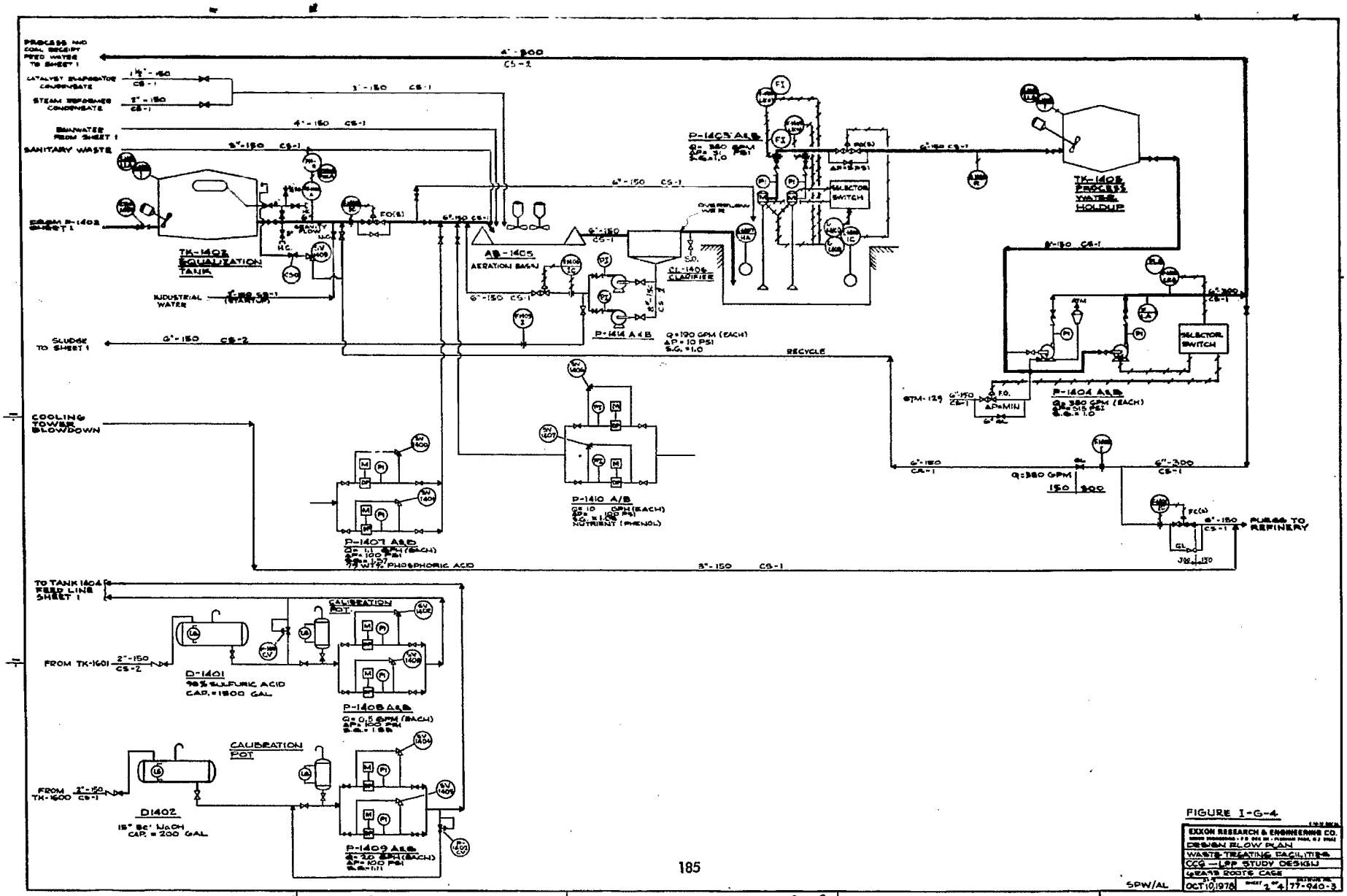


FIGURE I-G-4.

EXXON RESEARCH & ENGINEERING CO.	
DESIGN FLOW PLAN	
WASTE TREATING FACILITIES	
CCG — LPP STUDY DESIGN	
4GEAR ROOTS CAGE	
OCT 10 1978	77-940-3

SPW/AL

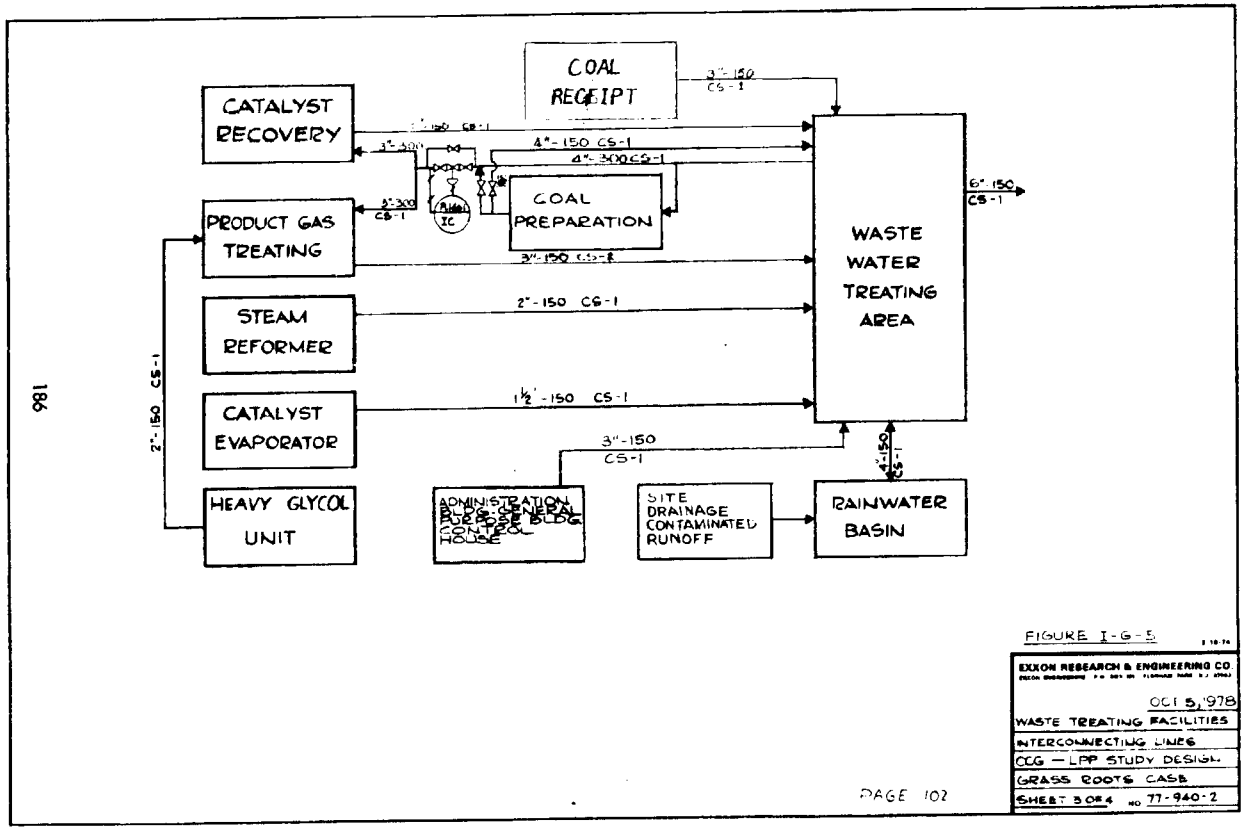


FIGURE I-G-5

EXXON RESEARCH & ENGINEERING CO.

OCT 5, 1978

WASTE TREATING FACILITIES

INTERCONNECTING LINES

CCG — LPP STUDY DESIGN

GRASS ROOTS CASE

SHEET 3 OF 4 NO. 77-940-2

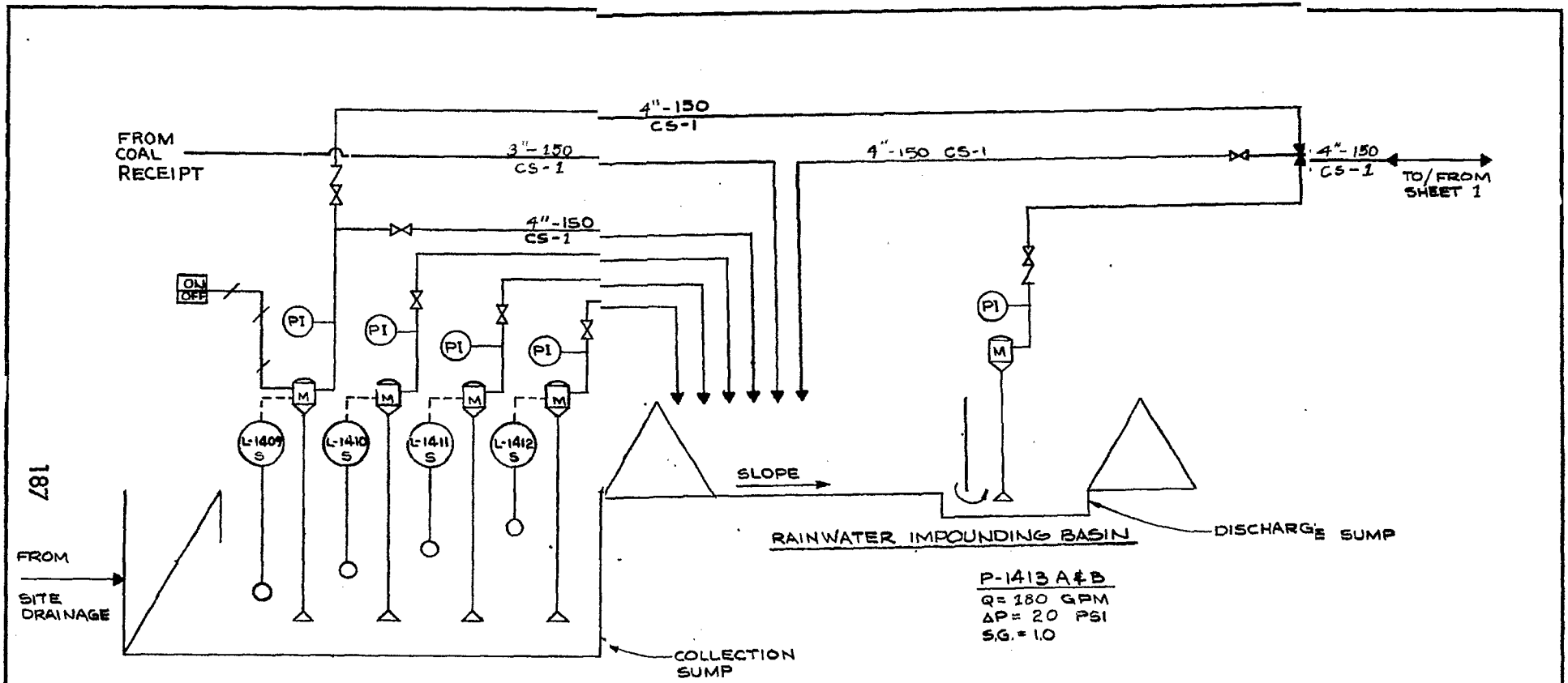


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FIGURE I-G-6

EXXON RESEARCH & ENGINEERING CO.
EXXON ENGINEERING - P.O. BOX 101 - FLORHAM PARK N.J. 07932

OCT. 5, 1978

DESIGN FLOW PLAN
WASTE TREATING FACILITIES
RAINWATER RETENTION BASIN
CCG -LPP STUDY DESIGN
GRASS ROOTS CASE
SHEET 4 OF 4 NO. 77-940-2

SPW/AL

APPENDIX I-H

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY-GRASS ROOTS CASE

CHEMICAL HANDLING FACILITIES

This section covers chemicals receipt, dilution, storage, and distribution facilities for the Catalytic Coal Gasification Large Pilot Plant Study Design. In addition to the storage facilities described herein, additional chemical storage vessels are specified in the individual unit designs. All chemical requirements are summarized in Table 1.

DESIGN BASIS

Caustic soda and sulfuric acid will be received in 4000-5000 gallon trucks. Only partial shipments of caustic will be taken to fit tank capacity. The caustic soda is received as a 50 weight percent solution. Line dilution facilities shall be provided to mix as-received caustic with industrial water during the unloading operation to form a 15° Be' solution. Sulfuric acid will be stored as-received. The storage drums at the individual unit consumers will be filled periodically from the centralized storage facilities described herein.

TABLE I-H-1

UTILITIES AND CHEMICALS

Electric Power Consumption (KW)

Symbol	Service	Duty	Reacceleration Required	Operating Load
P-1600	Caustic Dilution	I	C	2.2
P-1601	Caustic Distribution	I	C	1.2
P-1602	Sulfuric Acid Unloading	I	C	.7
P-1603	Sulfuric Acid Distribution	I	C	.8

Industrial Water (GPM) (Note 1)

	Normal	Maximum
Caustic Dilution	0	235

Instrument Air (SCFM)

	Normal	Maximum
Instruments and Controls	0	5

125 PSIG Steam Consumption (lb/hr)

	Normal	Maximum
TK-1600	0	By Contractor
Steam tracing of caustic lines	0	By Contractor

Note:

(1) Industrial water is required only during caustic unloading.

TABLE I-H-2

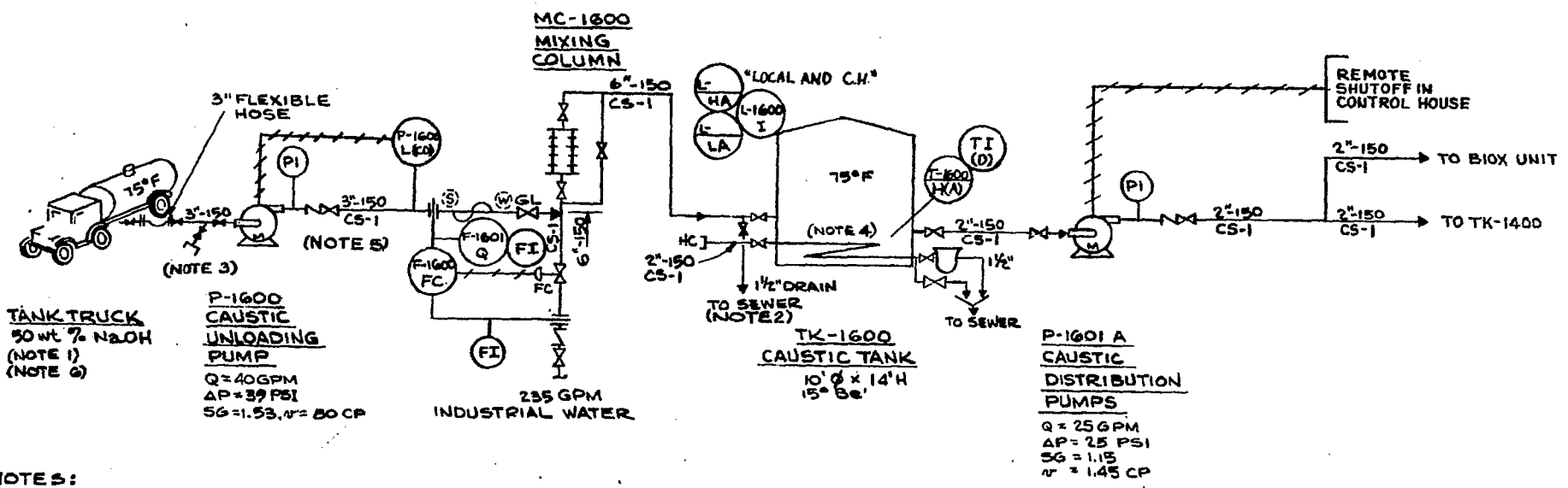
CHEMICALS HANDLING SUMMARY

Chemical	User	Form	Manner	Delivery Time Lag	Daily Req't @ Design Rate	Gross Storage Provided
Caustic(1)	Biox Unit TK-1400	50 wt% NaOH	Tank Trucks	readily available	261 g/d	196 Bbl (30 days holdup)
Sulfuric Acid	Cooling Tower Biox Unit Sour Slurry Stripper	98% H_2SO_4	Tank Trucks	readily available	1592 g/d	168 Bbl (4 days holdup)
Chlorine	Cooling Tower	Liquid	1-ton Cylinders	readily available	.55 lb/hr	1 cylinder in Cooling Tower area 1 cylinder in storage
Phenol	Biox Unit		Drums	readily available	-	-
Chromate Inhibitor	Cooling Tower	CrO_4	Tank Trucks	readily available	4.0 g/d	500 gallon drum in Cooling Tower area
H_3PO_4	Biox Unit	75 wt%	Drums	readily available	6.6 g/d	2 drums onsite 8 drums in storage

Notes:

(1) Caustic is received as a 50 wt% solution (6.38 # NaOH/gal) and will be delivered to consumers at 15° Be' caustic (0.96 # NaOH/gal).

(2) Space provided within general purpose building for storage of chemicals and catalyst not specifically mentioned herein.



NOTES:

1. PROVIDE UTILITY STATION WITH STEAM, AIR & WATER AT THE TRUCK UNLOADING AREA.
2. CONCRETE PADS (EXTENDING 6" BEYOND EQUIPMENT SERVED) SHALL BE PROVIDED AROUND CAUSTIC UNLOADING FACILITIES, STORAGE TANK AND DISTRIBUTION PUMPS. PADS TO SLOPE TO CATCH BASINS DISCHARGING TO SEWER. SEWER SHALL DRAIN TO THE RAINWATER IMPOUNDING BASIN.
3. EMERGENCY SHOWER AND EYE BATH TO BE PROVIDED IN UNLOADING/TANKAGE AREA.
4. PROVIDE HEATING COIL-BROWN FINTUBE FR-11 OR EQUIVALENT.
5. STEAM TRACE AND INSULATE CAUSTIC LINES UP TO MIXING POINT. STEAM TRACED PIPE TO BE STRESS RELIEVED

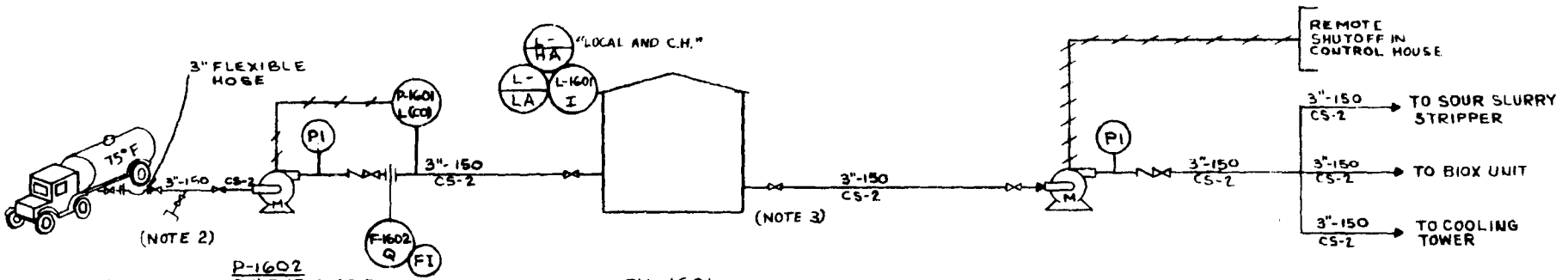
FIGURE I-H-1

E-43-74 DECAL

EXXON RESEARCH & ENGINEERING CO.
EXXON ENGINEERING - P.O. BOX 101 - FLORHAM PARK, N.J. 07932

OCT. 3, 1978

CAUSTIC RECEIPT AND
DISTRIBUTION FACILITIES
CCG -LPP STUDY DESIGN
GRASS ROOTS CASE
S.P.W./O.P.H. NO. 77-1011-2



NOTES:

1. PROVIDE UTILITY STATION WITH STEAM, AIR & WATER AT THE TRUCK UNLOADING AREA.
2. EMERGENCY SHOWER AND EYE BATH TO BE PROVIDED IN UNLOADING/TANKAGE AREA.
3. ALL VALVES SHALL BE C-20SS.

FIGURE I-H-2

8-16-74

EXXON RESEARCH & ENGINEERING CO.

OCT 3, 1978

SULFURIC ACID RECEIPT AND DISTRIBUTION FACILITIES

CCG - LPP STUDY DESIGN

GRASS ROOTS CASE

S.P.W./O.P.H. NO. 77-1012-2

APPENDIX I-I

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY-GRASS ROOTS CASE

INTERCONNECTING LINES

This section covers the design of the interplant lines and associated facilities which will connect the Large Pilot Plant with the adjacent Refinery for the transhipment of utilities and other streams between the two sites. Natural gas is assumed to be obtained directly from a public utility. The following facilities are covered in this specification:

- All interplant lines and pipe routings
- All tie-in connections into the refinery piping
- LPP product gas KO facilities
- Natural gas pipeline and associated tie-in

DESIGN BASIS

The interplant lines shall provide the Catalytic Coal Gasification Large Pilot Plant with selected utilities and will provide for disposal of selected products/by-products. Lines covered in this specification shall interface with existing Refinery/Chemical Plant lines at the respective tie-in points and shall terminate at the interface with the following study designs:

- Utilities
- Product Handling
- Waste Treatment

TABLE I-I-1

TIE-IN POINT SUMMARY

Identification Number	Service	Line Sizes New	Line Sizes Existing	Existing Stream Conditions at Tie-In Location P(PSIG)	Existing Stream Conditions at Tie-In Location T(°F)	Location
1A	Industrial Water to LPP	10"	10"	85-105	75	Flanged "T" connection on Discharge Line of "High Lift Pump P-35".
1B	Industrial Water to LPP	10"	20"	85-105	75	Discharge line of "High Lift Pump P-31".
2	Sour Slurry Stripper and Overhead	10"	-	8	-	Claus Plant (located north of Bean St. and West of Baytown Ave.).
3	Natural Gas to LPP	6"	-	380	-	Natural gas line located at north battery limits of LPP site.
4	Nitrogen to LPP	4"	8"	150	Ambient	Flanged connection on Nitrogen Header just outside TK-768 tanklot along West Ave.
5A,B	600# STM to LPP	12"	12"/12"	630	750	Two 12" 600 psig steam lines along West Ave. between Houston and Crocket Streets.
6	Boiler Feed Water to LPP	4"	12"	900	250	BFW distribution header (to Boiler 61-64) located at Boiler House No. 6.
7	Safety Valve Release to Flare	8"	20"	10 Max.	Ambient	Along Bastrop Street in vicinity of Lube HYDROFINING Unit.
8A	Spiked Product Gas to Refinery	10"	16"(F-9-16")	55	90	No. 1 Manifold Header in Blend Gas Manifold located at Humble Street and Crosby Street near TK-386.
8B	(Same as No. 8A)	10"	16"(F-10-16")	55	90	No. 2 Manifold Header in Blend Gas Manifold. Blend Gas Manifold same as for 8A above.
8C	(Same as No. 8A)	6"	6" (Torch Line)	Zero 1.0(max.)	Ambient	Torch line (connected also with 12" Natural Gas from #20 station) from No. 1 and No. 2 Manifold Headers in Blend Gas Manifold. Blend Gas Manifold same as for 8A above.
9	Spike fromLEFU unit to Product Gas K.O. Drum	6"	-	85	130	LEFU column 2 overhead.
10	Sour Water from Product Gas K.O. Drum to H_2S Removal Facilities	1-1/2"	3"	40	-	Along west side of Victoria Street in vicinity of Product Gas K.O. Drum.
11	Domestic Water to LPP Site	3"	14"	40	Ambient	At location of refinery Water Well No. 30, located near southeast corner of Marbon property.
12	Treated Waste Water from LPP Site to Exxon Chemical Plant's Gravity Sewer	6"	30" Sewer	Atmospheric	-	At manhole located on east side of Milam Street near TK-1123.

Notes:
1. Stream conditions are typical pipeline flow conditions for existing lines at locations of tie-ins and are applicable only at these respective locations.

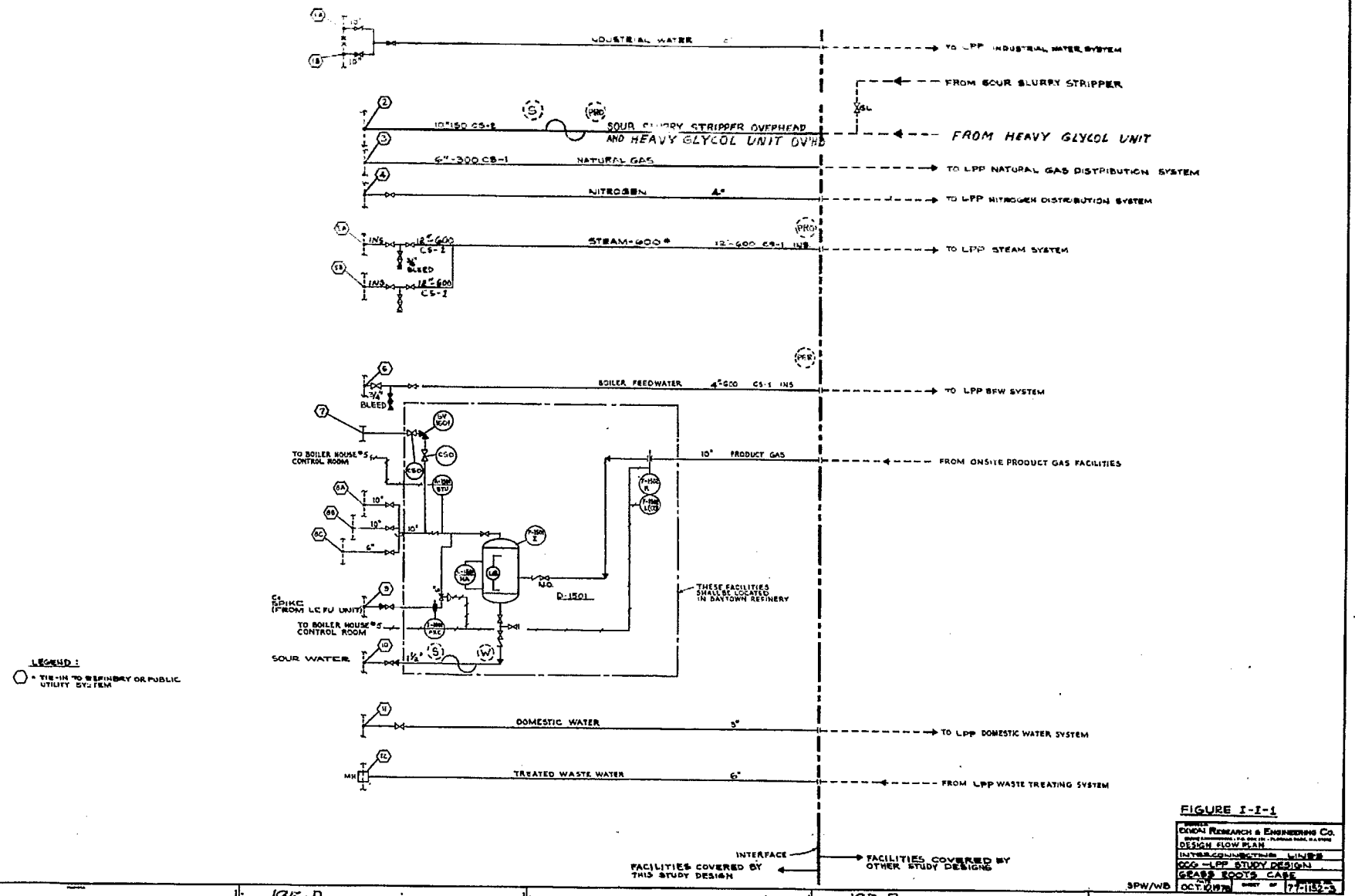


FIGURE I-I-1

EXXON RESEARCH & ENGINEERING CO.
DESIGN FLOW PLAN
INTERCONNECTING LINES
OCC - LPP STUDY DESIGN
GEARED ROOTS CASE
SPW/WB OCT. 1977 77-1152-3

APPENDIX I-J

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY - GRASS ROOTS CASE

FIRE PROTECTION

This section covers the fire protection facilities for the grass roots case of the Catalytic Gasification Large Pilot Plant Study design.

DESIGN BASIS

Two 2000 gpm pumps shall be used to obtain firewater from the San Jacinto River Canal. One pump shall be electric motor driven and one shall be diesel engine driven.

A looped firewater distribution network shall be provided. Valving and lines are arranged to permit isolating a ruptured line within the looped system, and if a fire emergency should occur, to supply firewater to a fire emergency area at a minimum pressure of 80 psig.

The firewater system shall provide a minimum pressure of 80 psig at each hydrant and monitor with a pump discharge pressure of 125 psig. The firewater system has been designed to provide 3000 GPM to the LPP Process Unit.

Mobile fire fighting equipment; pumpers, foam trucks, and equipment trucks will be furnished by the refinery. Therefore, no fire station for mobile equipment will be provided at the LPP site.

TABLE I-J-1

UTILITIES AND CHEMICALS

ELECTRIC POWER

User	Service	Duty	Load KW (1)	Reacceleration Classification
P-1800A	Firewater Pump	Intermittent	152	A

DIESEL FUEL

User	Service	Duty	Consumption, U.S. gal/hr (1)
P-1800B	Firewater Pump	Intermittent	12

INSTRUMENT AIR

Item	Normal Consumption SCFM (1)
Instruments	3

Note:

1. Consumption rates shall be confirmed by Contractor.

TABLE I-J-2

EQUIPMENT LIST - FIRE PROTECTION

Fire Extinguishers

Fire extinguishers shall be provided as shown in the following list. The final number and location of extinguishers shall be developed by the Contractor and reviewed by the Owner's Engineer.

Location	Quantity	Type
Main Substation	2	CO_2 (20 lb.)
Switch House at Control House	2	CO_2 (20 lb.)
Vacuum Filters	2	27 lb. dry chemical extinguishers
Fines Bin	1	27 lbs dry chemical extinguishers
Coal Preparation Crush/Dry Building (none at Silos)	6	27 lb dry chemical extinguishers
Control House	2	27 lb dry chemical extinguishers
Laboratory	2	27 lb dry chemical extinguishers
Process Block	6	27 lb dry chemical extinguishers
Process Block Furnace Area	3	27 lb dry chemical extinguishers
Process Block Main Structure	8	27 lb dry chemical extinguishers
Administration Building	7	27 lb dry chemical extinguishers

TABLE I-J-2 (cont'd)

Location	Quantity	Type
General Purposes Building		
3 - Main Shop 2 - Second Floor Hall 1 - At Outside of Change House	6	27 lb dry chemical extinguishers
Chemical Storage Building	2	27 lb dry chemical extinguishers
Firewater Pumps	1	27 lb dry chemical extinguishers
Coal Unloading Hopper	2	27 lb dry chemical extinguishers
Gate House	1	27 lb dry chemical extinguishers
Process Block		
North Area	1	125 lb dry chemical extinguishers
South Area	1	125 lb dry chemical extinguishers

Fire Whistle

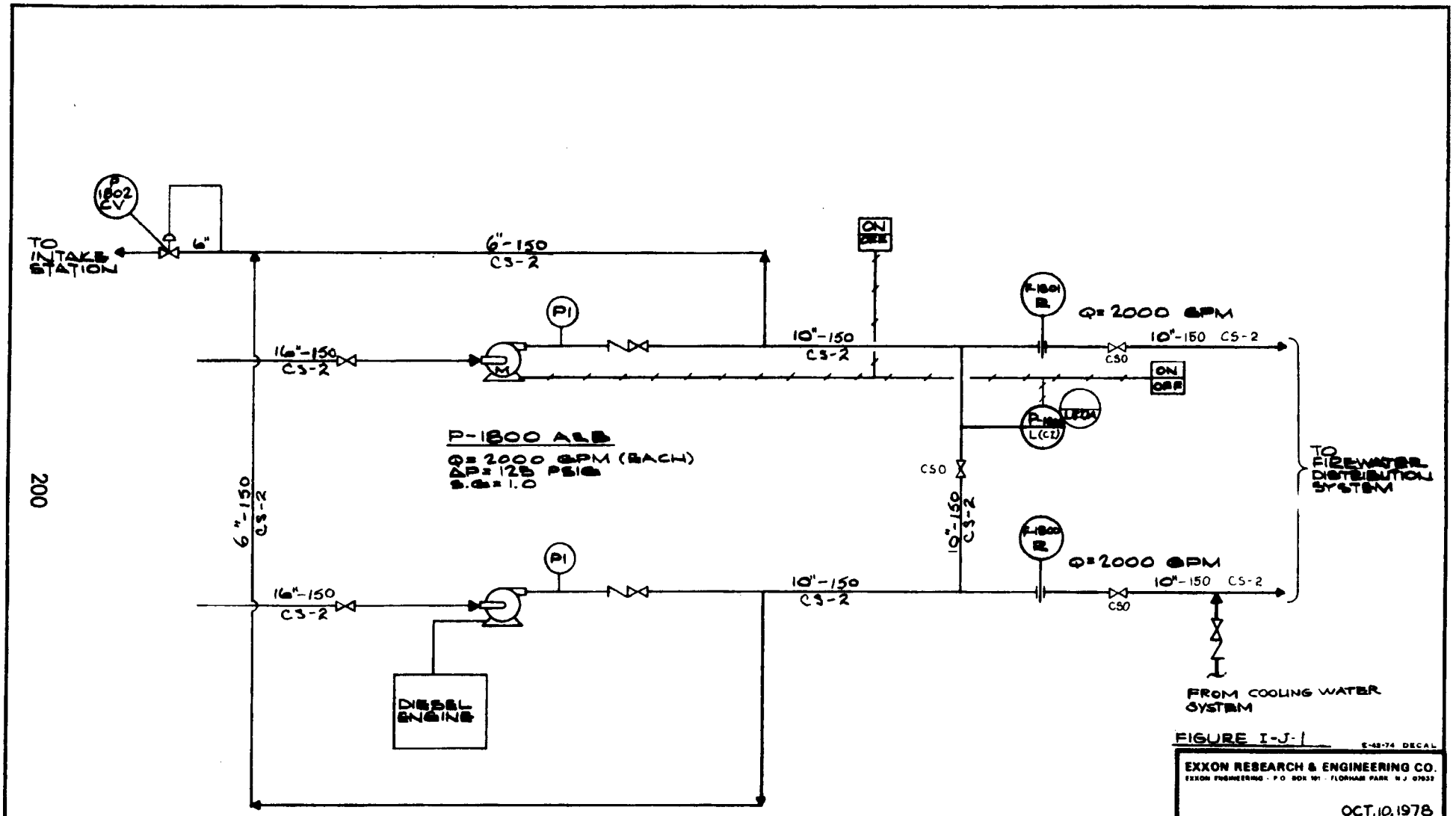
A steam or air operated fire whistle shall be provided mounted on top of and controlled from the control house.

Fire Protection Telephone and Alarm

A red fire alarm telephone shall be provided in the control house. This red fire alarm telephone shall be linked to the Refinery's Fire Protection Communication Network.

Intake Station

The Intake Station shall be located in the south bank of the San Jacinto River Canal. The contractor shall investigate the feasibility of this location paying special attention to the following: sufficient hydraulic depth and minimum accumulation of silt at the intake side of the structure. The Intake Station shall be designed according to Hydraulic Institute Standards and pump vendor recommendations.



200

FIGURE I-J-1

E-48-74 DECAL

EXXON RESEARCH & ENGINEERING CO.
EXXON ENGINEERING - P.O. BOX 101 - FLORHAM PARK N.J. 07932
OCT. 10, 1978
FIREWATER PUMPING FACILITIES
CCG — LPP STUDY DESIGN
GRASS ROOTS CASE
BAYTOWN, TEXAS
SPW NO. 77-1248-2

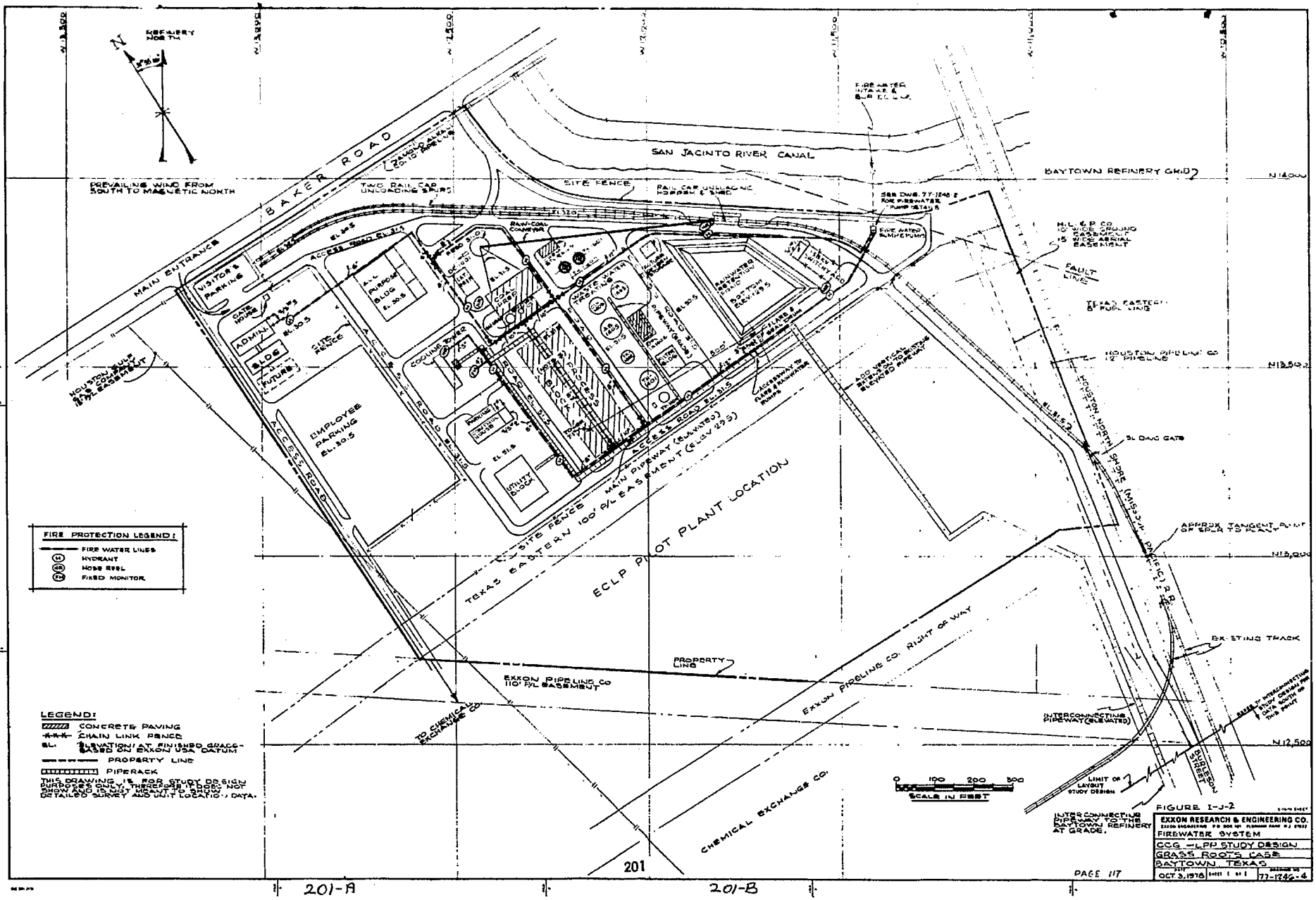


FIGURE I-J-2

EXXON RESEARCH & ENGINEERING CO.	
FIREWATER SYSTEM	
CCG - LPP STUDY DESIGN	
GRASS ROOTS CASE	
BAYTOWN, TEXAS	
OCT 3, 1978	77-1242-4

APPENDIX I-K

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY-GRASS ROOTS CASE

SAFETY FACILITIES

This section covers the study design for the safety facilities serving the onsite and offsite systems of the Catalytic Coal Gasification Large Pilot Plant.

Equipment is provided to safely collect the vapor releases from the plant and burn them in the elevated flare.

DESIGN BASIS

The flare system is designed to handle simultaneously the largest releases from the process area plus an overpressure situation in the natural gas fuel system.

The following have been provided:

- An onsite/offsite flare gas collection header
- A separate H_2S collection header
- A flare seal drum with associated seal water facilities
- An elevated flare with pilots and steam injection facilities

A continuous flow of seal drum water is taken from the industrial water system and is backed up by tie-in to the firewater network.

The potentially sour sealing water from the seal drum is pumped to the sour water stripper for clean-up. Provision is also made to route the used seal water to waste water treating.

Steam injection into the center of the flare tip aids smokeless burning and provides a seal on the stack during periods of no flaring. Provision has also been made to add natural gas directly to the stack in order to achieve complete combustion when flaring H_2S gases only.

TABLE I-K-1

UTILITIES - SAFETY FACILITIES

STEAM

125 psig Requirements, lbs/hr		Normal	Maximum
P-2100B	Sealing Water Disposal Pump (spare)	-	460*
D-2100	Flare Seal Drum Steam Coil	-	100*
E-2100	Flare Gas Heater	-	1730*
FLT-2100	Flare Tip	(1)	1220*
	Total Normal Requirements	(1)	-
	*Simultaneous Maximum	-	3510*

ELECTRIC POWER

Requirements, kw		Service	Operating Load	Reacceleration
P-2100A	Sealing Water Disposal Pump	C	6.4	A
FLT-2100	Flare Pilot Ignitor	I	(2)	-

INDUSTRIAL WATER

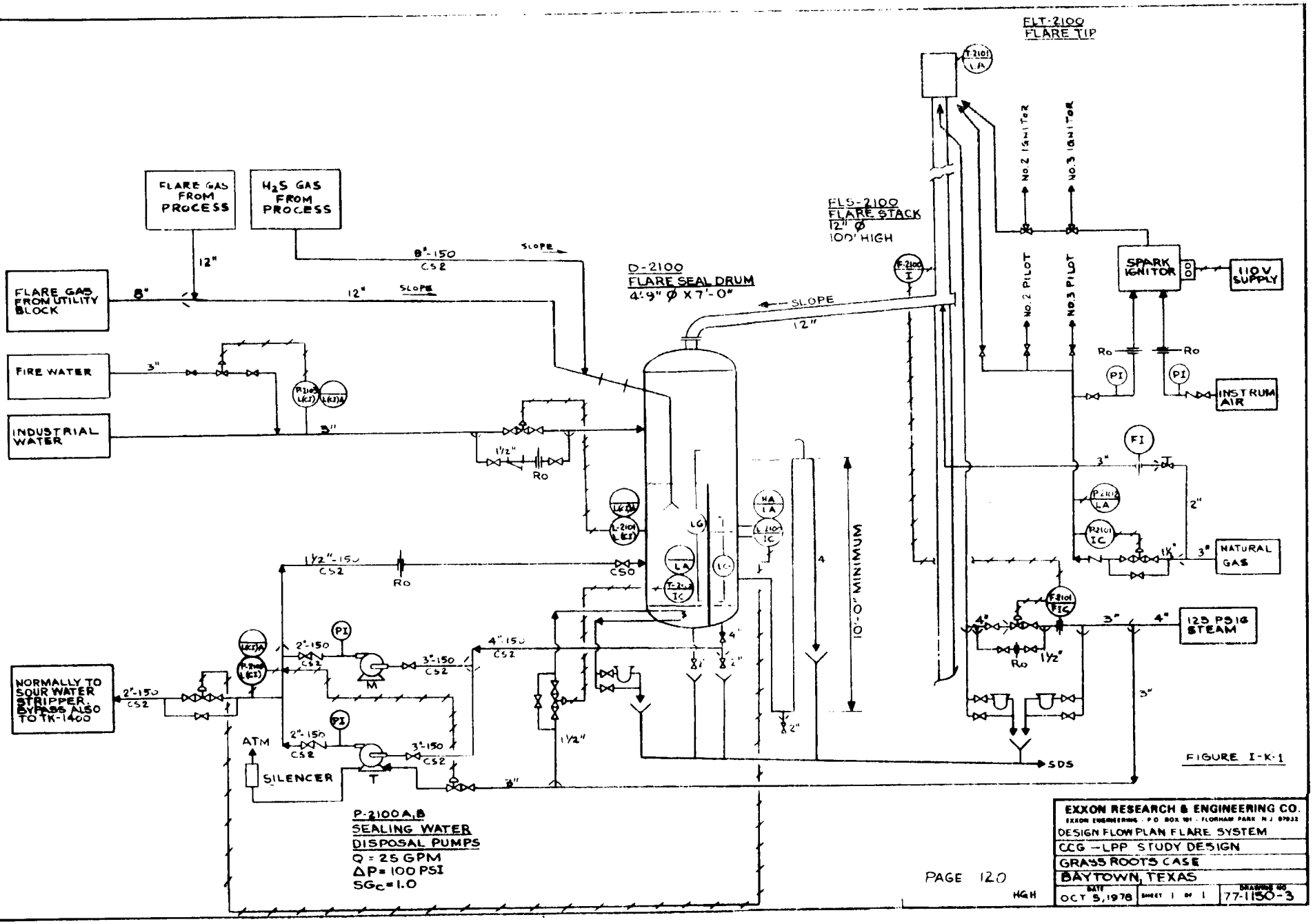
Requirements, GPM		Normal	Maximum
D-2100	Flare Seal Drum	20	50

INSTRUMENT AIR

Requirements, SCFM		Normal	Maximum
FLT-2100	Flare Pilot Ignitor	-	145*
Instruments		16	16*
	Total Normal Requirements	16	-
	*Simultaneous Maximum	-	161*

FUEL GAS (Natural Gas)

Requirements, MBtu/hr		Normal	Maximum
FLT-2100	Flare Pilots	1.2	1.2*
FLT-2100	H_2S Combustion	-	5.5*
	Total Normal Requirements	1.2	-
	*Simultaneous Maximum	-	6.7*


FLT-2100
FLARE TIP
FLARE GAS FROM PROCESS
H2S GAS FROM PROCESS
FLARE GAS FROM UTILITY BLOCK
FIRE WATER
INDUSTRIAL WATER
FLS-2100
FLARE STACK
12" Ø
100' HIGH
D-2100
FLARE SEAL DRUM
4'-9" Ø X 7'-0"
SLOPE
12"
8"-150 CS2
NO.2 IGNITOR
NO.3 IGNITOR
NO.2 PILOT
NO.3 PILOT
SPARK IGNITOR
110V SUPPLY
INSTRUM AIR
NATURAL GAS
125 PSIG STEAM
10'-0" MINIMUM
1½"-150 CS2
4"-150 CS2
3"-150 CS2
2"-150 CS2
NORMALLY TO SOUR WATER STRIPPER. BYPASS ALSO TO TK-1400
ATM
SILENCER
SDS
P-2100 A,B
SEALING WATER
DISPOSAL PUMPS
Q = 25 GPM
ΔP = 100 PSI
SGc = 1.0
FIGURE I-K-1
EXXON RESEARCH & ENGINEERING CO.
DESIGN FLOW PLAN FLARE SYSTEM
CCG - LPP STUDY DESIGN
GRASS ROOTS CASE
BAYTOWN, TEXAS
OCT 5, 1978
77-1150-3

HGH

APPENDIX I-L

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY-GRASS ROOTS CASE

PLANT LAYOUT

This section covers the overall layout of the Catalytic Coal Gasification Large Pilot Plant including coal receipt and preparation, overall process area, utilities, wastewater treatment facilities, roads, interconnecting pipeways, and other major facilities. The detailed layout of the process units is covered in the onsite study design.

DESIGN BASIS

The conceptual "Grass Roots Case" has been developed to provide a basis for comparison with the "Revamped Existing Pilot Plant Case." The "Grass Roots Case" is assumed to be constructed on open land adjacent to a large operating Gulf Coast refinery to make use of some existing utility systems, offsite facilities, outlets for products and waste, and a pool of experienced operators and maintenance personnel. No specific site has been chosen or offered for this pilot plant. However, a great deal of project basis and design information was available from the design of the Exxon Coal Liquefaction Large Pilot Plant, which is being constructed on the Baker Road Site at the Exxon Baytown Refinery. Therefore, in view of the availability of this design basis information, the Baker Road site was chosen as being representative of a location adjacent to a large gulf coast refinery.

SITE DESCRIPTION

The site for the study design is located approximately 5,000 feet north of the Exxon Chemical Butadiene Unit at Baytown, Texas. The site is bounded by a public road (Baker Road) on the north, by undeveloped Exxon property on the west, by the Texas Eastern Transmission Company's pipeline easement to the south, by the San Jacinto River canal on the northeast, and by the Missouri Pacific Railroad on the east.

The site is traversed by several pipeline right-of-ways, as shown in Figure I-L-1. Although it is permitted to cross these right-of-ways with railroads, roads, pipeways, and conveyors, no equipment may be located in these areas.

A fault line exists in the northeast corner of the site. Its approximate location is shown on the layout drawing.

The site is essentially level, sloping slightly from the northwest corner to the southeast. On the layout drawing, the existing site grade has been considered level at 29.5 feet elevation.

A shell surfaced road exists along the northeastern and eastern site boundary. It permits access to the Chemical Exchange Company property and joins Burleson Street (a back access road to the Baytown Refinery). A portion of this shell surfaced road shall be abandoned. A new (primary) access road to the Chemical Exchange shall be provided just west of the site.

All coordinates refer to a grid system previously established for the Baytown Refinery. Bench marks for horizontal and vertical control have been established at or near the site.

All elevations shown are nominal high point of finished grade elevations based on Exxon Company, USA, Baytown Refinery datum. Final grades within each area shall slope to the area drains.

CONTRACTOR STAGING AREA

At present the site leased from the Baytown Refinery is not large enough to include a contractor staging area and a contractor parking area. For the purpose of this study design only, it is assumed that the unoccupied area to the west would be used for staging.

RAILROAD FACILITIES

A rail spur, for the receipt of raw coal, is specified as shown in Figure I-L-1. The hopper unloading and car storage spurs shall parallel the northern property line. The spur lengths shall be as indicated in the layout. All interconnecting curved trackage shall be of minimum allowable curvatures, (R= 460 feet), joining the straight run trackage tangentially.

Rail spur elevations shown on the layout are top of embankment levels, before ballast and trackage has been laid.

The rail car unloading hopper shall be located in the straight run of track along the northeastern site boundary. It shall have a minimum approach of 100 feet of straight track in either direction.

The layout inter-relationship between rail car unloading hopper and raw coal storage silos shall be such as to provide for a straight conveyor run between the two facilities. A minimum horizontal distance of 550 feet is required.

EQUIPMENT SPACING

Since all tanks except TK-1600 and TK-1601 are water vessels nominal maintenance clearances only are required.

An eighteen inch toewall shall be provided around the caustic tank, TK-1600 and the sulfuric acid tank, TK-1601. Due to the high site water table, the bottom of the Rainwater Retention Pond is specified at natural grade, i.e., 29.5 foot elevation. Construction shall be as indicated in the Site Development, Soils, and Foundations Study Design.

PIPEWAYS

This study design covers the pipeways to a point just southeast of the Chemical Exchange property. The extension of the interconnecting lines from this point to the Baytown Refinery is covered in the Interconnecting Lines Study Design.

Except for the flare header, offsite pipeways after they have crossed plant roads shall be at grade on concrete sleepers. Pipeways within the process block and at road crossings shall be elevated.

All pipeways crossing rail tracks shall have a 23 foot minimum clearance above top of rail. Pipe rack clearance above plant roads and accessways shall be 22 feet.

ROADS AND PARKING AREAS

Roads, accessways and paved parking areas are shown on Figure I-L-1. Accessways within the process block are covered in the onsite study design layout.

All site access roads shall be 20 feet wide. Onsite access roads, the administration parking lot and off-road loading and unloading areas shall be asphalt paved in accordance with the access road cross sections noted in Figure I-M-1 in the Site Development, Soils, and Foundations Study Design.

Accessways shall be 12 feet wide. Accessways and the large parking lot south of the administration building shall be of crushed stone construction.

PAVING AND SURFACING

Onsite and Offsite paving shall be concrete as noted in Figure I-L-1.

The balance of the areas, as noted below, shall be surfaced with 4 inches of crushed stone or gravel (1 1/2" maximum size).

- Utility block
- Waste treatment area
- Substations areas
- Under pipeways
- Cooling tower area
- Control house area
- Catalyst preparation area

SECURITY FENCING AND LIGHTING

A galvanized steel fence shall be installed as shown in Figure I-L-1. The fence shall enclose the entire site along the site boundary with approximate gates as shown. The administration building and parking lot is external to the site fence to permit access to these areas without entering the site proper.

Security lighting shall be provided.

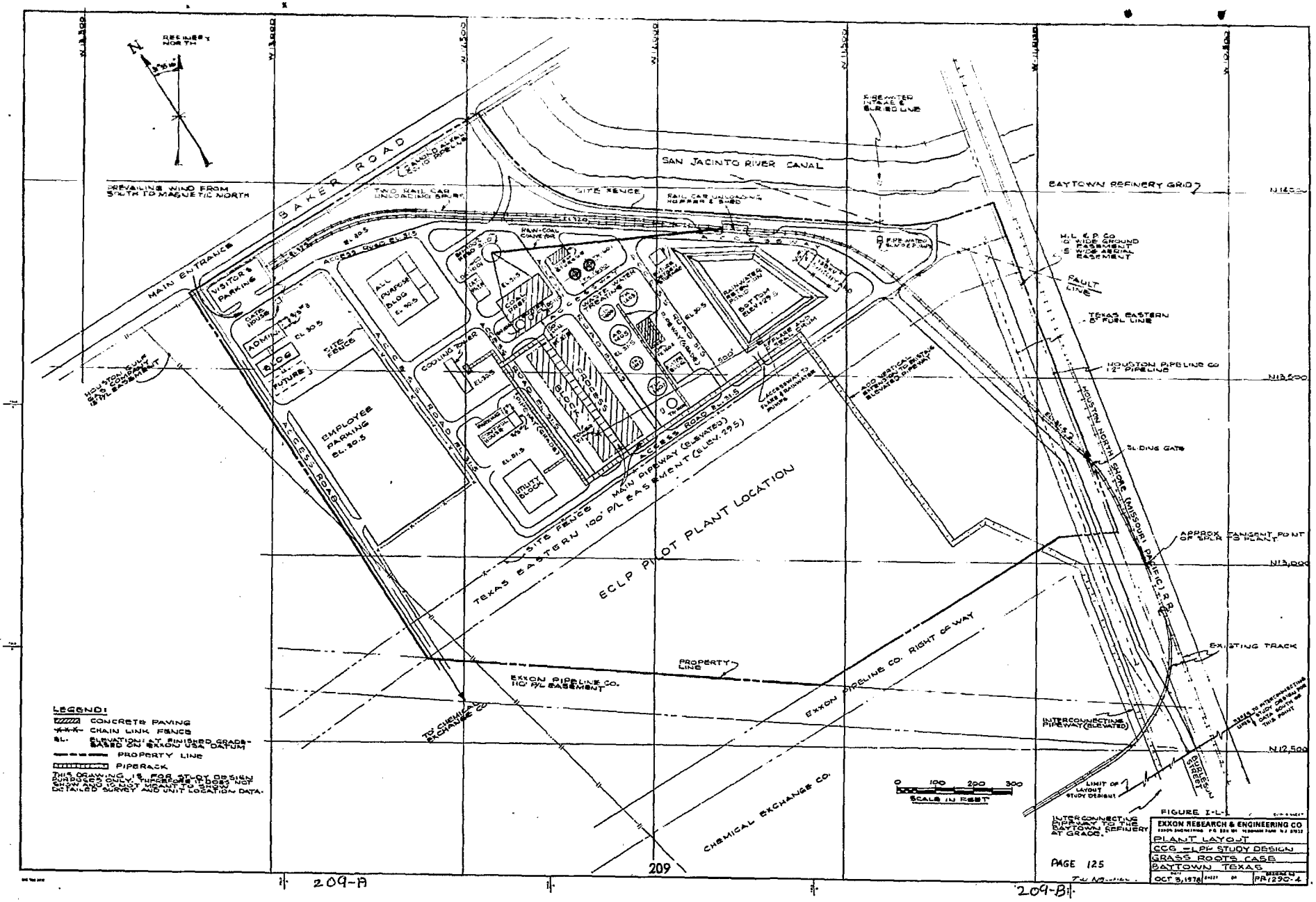


FIGURE I-L-1

EXXON RESEARCH & ENGINEERING CO
PLANT LAYOUT
CCG - ECLP STUDY DESIGN
GRASS ROOTS CASE
BAYTOWN TEXAS
OCT 3, 1978 PR/290-4

APPENDIX I-M

CATALYTIC COAL GASIFICATION
LARGE PILOT PLANT STUDY-GRASS ROOTS CASE

SITE DEVELOPMENT, SOILS AND FOUNDATIONS

This section contains requirements for site preparation as well as foundation design and construction for the Catalytic Coal Gasification Large Pilot Plant Project. Major areas of work covered by this specification are:

- Site preparation
- Foundations
- Coal unloading facilities
- Drainage
- Roads
- Impounding basins

SITE DESCRIPTION

The site for the study design is located approximately 5,000 feet north of the Exxon Chemical Butadiene Unit at Baytown, Texas. The site is bounded by a public road (Baker Road) on the north, by undeveloped land on the west, by the Texas Eastern Transmission Company's pipeline easement to the south, by the San Jacinto River Canal on the northeast, and by the Missouri Pacific Railroad on the east.

The site is nearly level at approximate elevation +29.5 feet. There is a slight (less than 1%) slope to the southeast corner of the site. Natural drainage is poor and standing water is common in periods of moderate rainfall.

Vegetation consists of grass and low bushes; no trees are growing on the site.

All elevations in this study design are given in feet and refer to Exxon U.S.A. Baytown Refinery Datum.

All coordinates refer to a grid system previously established for the Baytown Refinery. Bench marks for horizontal and vertical control have been established at or near the site.

SITE PREPARATION

After clearing and grubbing of the site, a 6 inch layer of sand shall be spread and compacted. Site fill soil shall be placed on this sand blanket to elevations shown on Plant Layout drawing (found in Layout Study Design). If clay or clayey soils are chosen for site fill, the moisture content shall be at least 2% greater than the optimum as determined by ASTM D-1557. These soils shall be compacted to 95% of the maximum dry density as determined by ASTM D-1557. Non-cohesive soils shall be compacted to 70% relative density.

A minimum of one density check per 3500 square yards per layer shall be made during site filling operations.

A railroad embankment is required and shall be constructed according to the cross section shown in Figure I-M-1. Location of this embankment is shown in the Layout Study Design.

Site preparation, as defined here, refers only to those areas of the site required for the installation of coal gasification pilot plant facilities, including coal receipts and overall site fencing and access.

SOILS

For purposes of this study design, data from past soils investigations of the general site will be used. The data used is for convenience of this study only and is not meant to represent data suitable for design or construction.

STRUCTURES AND FOUNDATIONS

- Shallow Spread Footings

Spread footings at or near the surface shall be designed in accordance with the curves shown in Figure I-M-2. The bottom of all footings shall be at least 18 inches below grade. The net allowable bearing pressures may be increased by 25% when short duration loads (wind) are applied. It is expected that light-weight facilities can be supported in this fashion.

- Deep Spread Footings, Belled Caissons At Elevation + 20 feet

Facilities of intermediate weight may be founded on spread footings or drilled-in caissons at elevation + 20 feet in accordance with the curves given in Figure I-M-3.

Concrete for the caissons shall not be placed while water is in the excavation. Each hole shall be free of loose cuttings and inspected prior to concrete placement.

The net allowable bearing capacity for deep spread footings or drilled-in caissons may be increased by 25% when wind loads are applied.

- Piling

It is anticipated that heavy loads will need to be supported by deep piling extending into the dense sand layer approximately 60 feet below ground level. The tip elevation shall be as required to attain a given pile capacity but not higher than elevation - 45 feet.

The allowable skin friction values for clay soils against the surface of driven piles shall be as follows:

steel	375 psf
concrete	440 psf

For the portion of the pile penetrating the dense sand layer, the allowable skin friction values are:

steel	450 + 7.5 H psf
concrete	540 + 9 H psf

where H is the penetration, in feet, of the pile into the dense sand layer.

The allowable end bearing in the dense sand is 440 Z psf where Z is the distance from the ground surface to the pile tip.

The allowable uplift capacity shall be equal to the skin friction component of the downward capacity.

Timber piles and uncased, cast-in-place displacement type piles are not permitted.

The capacity of pile groups shall be reduced in accordance with the following:

Pile Spacing	Group Efficiency
3 x pile diameter	75%
8 x pile diameter	100%

Intermediate values may be obtained by linear interpolation.

- Tankage

Tank 1601 shall have an elevated foundation as shown in Figure I-M-4. Other tanks on the site do not require special foundations.

- Coal Unloading Facilities

The coal unloading hoppers at the northern edge of the site require a large box structure to be built below grade. The inside dimensions of this structure are 65 ft by 20 ft by 30 ft deep.

As the ground water level is very near the surface, the design of these facilities must either include hydrostatic forces or provide for permanent relief of hydrostatic pressures.

The lateral forces on the sides and ends of the hopper are also a function of the construction technique used to build the structure. However for the purpose of this study only, the contractor shall slope the sides of the excavation to avoid the necessity of bracing the sides. It will be necessary to backfill around the structure with noncohesive soils after construction is complete. Backfill shall be compacted to 60 percent relative density. Lateral pressures for design will be a function of wall stiffness, lateral support system, water level, etc. The contractors assessment and evaluation of wall pressures shall be reviewed by the Owner's Engineer.

- Resistance to Horizontal Forces

The allowable passive resistance to horizontal forces shall be computed using the following data:

- A coefficient of friction of 0.3 at the base of spread footings or belled caissons.
- If clay fill is used, the allowable resistance shall be equal to 600+ 30 H psf where H is the depth to the bottom of the footing.
- If sand fill is used, the allowable resistance shall be equal to 190 H psf where H is the depth to the bottom of the footing.
- For footings at elevation +20, the allowable resistance shall be equal to 1200 psf.

No passive resistance shall be allowed for the first foot of depth below grade.

- For piling, a uniform soil modulus of 70,000 psf shall be used when determining horizontal resistance. For piles spaced at 3 diameters, this value shall be reduced to 17,500 psf.

- Construction Considerations

Excavation for footings may be cut neat and concrete poured directly against the soil where feasible. However, any footing excavation remaining open for more than 24 hours shall have a layer of lean concrete placed to cover the bottom of the excavation. This concrete shall not be considered a part of the foundation.

Type 1 cement shall be used in concrete for foundations.

- Machinery Foundations

Grade level foundations for heavy machinery or vibrating equipmetn shall be designed using the following shear moduli:

Depth Below Grade, ft	Shear Moduli, psi
11	10,200 to 17,000
16	11,100 to 18,500
22	13,800 to 23,000

DRAINAGE

All drainage ditches and culverts shall be designed using a rainfall intensity of 3.5 inches per hour. Ditches shall be unlined. Culverts under roadways shall be capable of supporting single axle AASHO-H20 highway loadings. In addition, culverts under main roads shall be capable of sustaining the load imposed by a tandem-axle bogie load of 50 tons. Clean runoff from the administration, cooling tower, control house, and utility areas shall drain via ditches to the southeast portion of the site for discharge to existing ditches (which is the present disposition of runoff from the site). Potentially contaminated runoff from the process, coal preparation, waste treating, and coal handling areas shall discharge to the rainwater impounding basin specified in the Waste Treating Study Design.

Headwalls shall be designed and installed at the inlet and outlet of all culverts.

ROADS

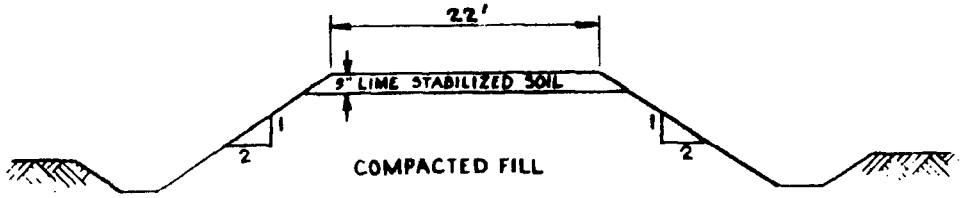
Roads shall be constructed in accordance with the cross sections shown in Figure I-M-1.

The maximum slope on any road shall be 6 percent. Road curves at main intersections shall have a minimum inside turning radius of 30 feet.

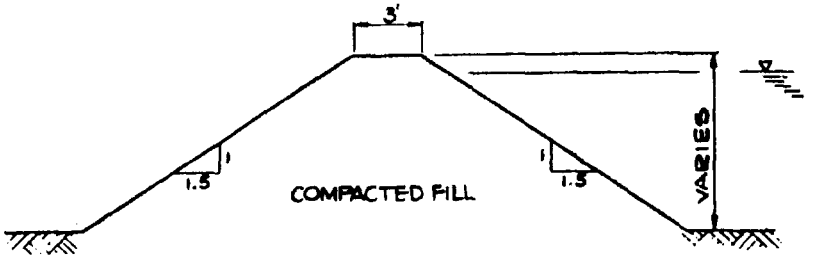
The wearing surface shall be placed after construction. The limestone surface construction roads shall be relevelled and rolled prior to placement of the wearing course.

IMPOUNDING BASINS

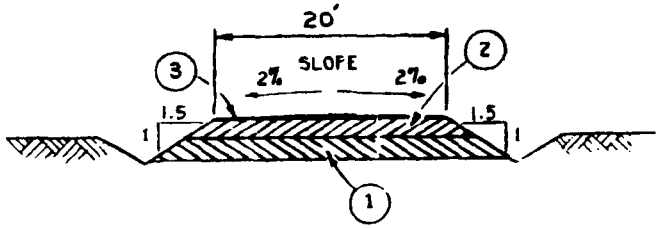
A rainwater impounding basin shall be constructed at the location shown on the Plant Layout drawing (see Layout Study Design). Soil dikes shall be compacted to 95 percent of the maximum dry density as determined by ASTM D-1557. Cross sections of the dikes shall be according to Figure I-M-1 The rainwater retention pond does not require a liner, but the bottom shall be rolled prior to dike construction.



RAILROAD EMBANKMENT



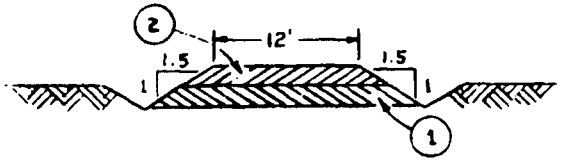
IMPOUNDING DIKES



COMPACTED SITE FILL

① 8" LIME STABILIZED SUBSOIL
② 12" CRUSHED LIMESTONE (COMPACTED)
③ 2" HOT MIX ASPHALT (TO BE APPLIED AFTER CONSTRUCTION)

ACCESS ROADS



COMPACTED SITE FILL

① 6" LIME STABILIZED SUBSOIL
② 10" CRUSHED LIMESTONE (COMPACTED)

ACCESS WAY

FIGURE I-M-1

5-10-74 REVISED

EXXON RESEARCH & ENGINEERING CO.
EXXON ENGINEERING - P.O. BOX 101 - FLORHAM PARK, N.J. 07932

OCT. 3, 1978

TYPICAL CROSS SECTIONS

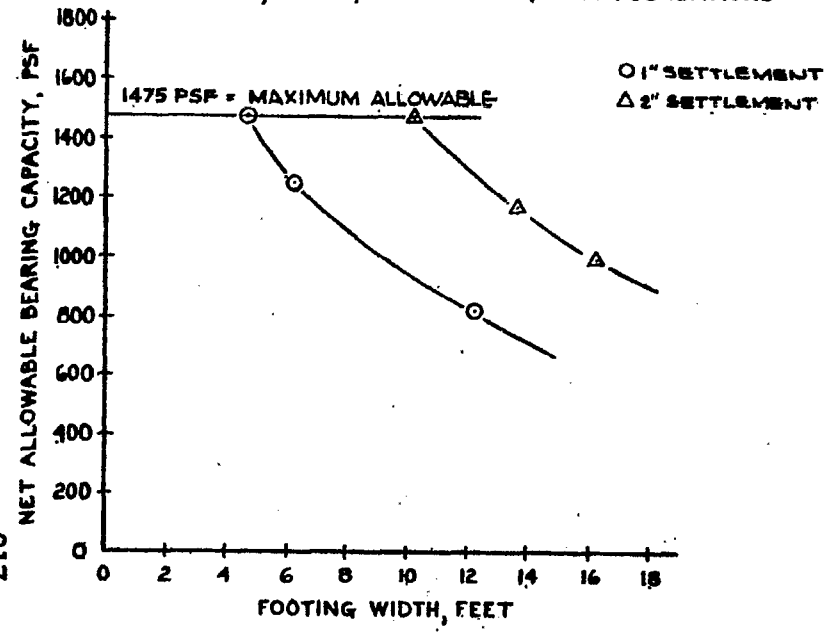
CCG — LPP STUDY DESIGN

GRASS ROOTS CASE

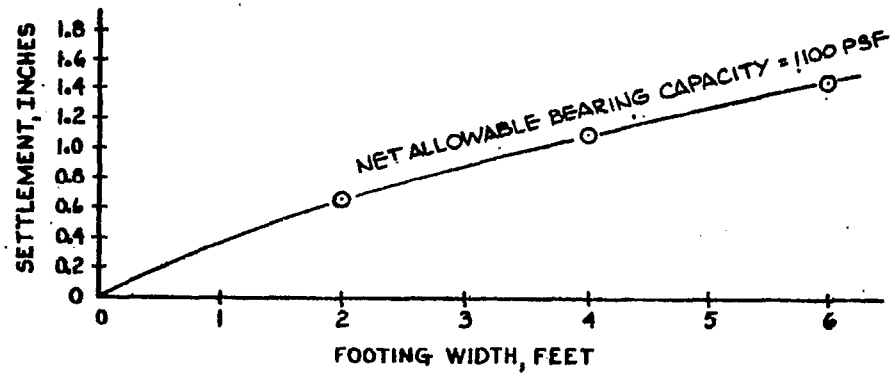
BAYTOWN, TEXAS

J.M.H./T.M. NO. 77-877-2

SQUARE, ROUND, OR NEARLY SQUARE FOUNDATIONS



STRIP FOOTINGS



NOTES:

1. NET ALLOWABLE BEARING PRESSURE IS DEFINED AS THE DIFFERENCE BETWEEN THE GROSS BEARING PRESSURE ACTING ON THE BASE OF THE FOOTING AND THE SOIL PRESSURE EXISTING AT THAT ELEVATION PRIOR TO FOUNDATION EXCAVATION.
2. THE NET ALLOWABLE BEARING PRESSURE MAY BE INCREASED BY 25% WHEN WIND LOADS ARE BEING CONSIDERED.
3. THE EFFECT OF OVERLAPPING SOIL PRESSURE BULBS FROM ADJACENT FOOTINGS SHALL BE CONSIDERED AND SOIL BEARING PRESSURES ADJUSTED AS NECESSARY.
4. FOR RECTANGULAR FOOTINGS, THE FOLLOWING REDUCTION FACTOR SHALL BE APPLIED TO BEARING CAPACITY ABOVE:

LENGTH TO WIDTH RATIO	REDUCTION FACTOR
2	90%
5	84%

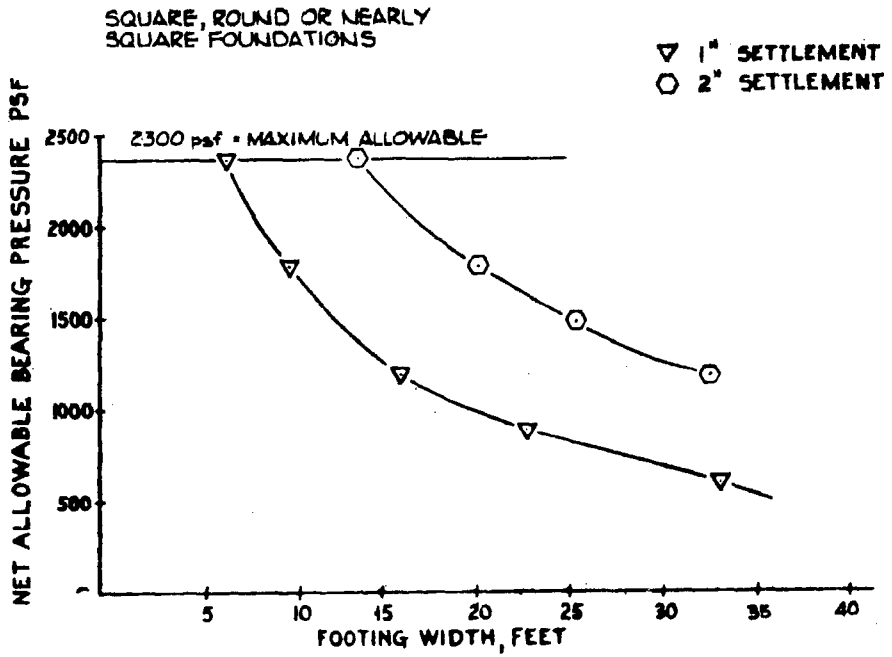
FIGURE I-M-2.

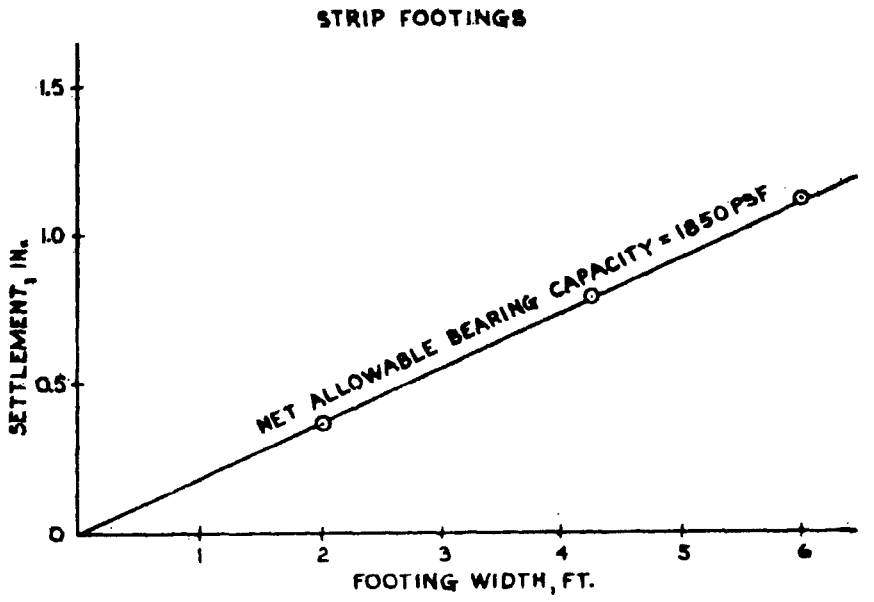
E-48-74 DECAL

EXXON RESEARCH & ENGINEERING CO.
EXXON ENGINEERING - P.O. BOX 101 - FLORHAM PARK, N.J. 07932

OCT. 3, 1978

SHALLOW SPREAD FOOTINGS
CCG — LPP STUDY DESIGN
GRASS ROOTS CASE
BAYTOWN, TEXAS
J.M.H./T.M. NO. 77-875-2





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NOTES:

1. NET ALLOWABLE BEARING PRESSURE IS DEFINED AS THE DIFFERENCE BETWEEN THE GROSS BEARING PRESSURE ACTING ON THE BASE OF THE FOOTING AND THE SOIL PRESSURE EXISTING AT THAT ELEVATION PRIOR TO FOUNDATION EXCAVATION.
2. THE NET ALLOWABLE BEARING PRESSURE MAY BE INCREASED BY 25% WHEN WIND LOADS ARE BEING CONSIDERED.
3. THE EFFECT OF OVERLAPPING SOIL PRESSURE BULBS FROM ADJACENT FOOTINGS SHALL BE CONSIDERED AND SOIL BEARING PRESSURES ADJUSTED AS NECESSARY.
4. FOR RECTANGULAR FOOTINGS, THE FOLLOWING REDUCTION FACTOR SHALL BE APPLIED TO BEARING CAPACITY ABOVE:

LENGTH TO WIDTH RATIO	REDUCTION FACTOR
2	90%
5	84%

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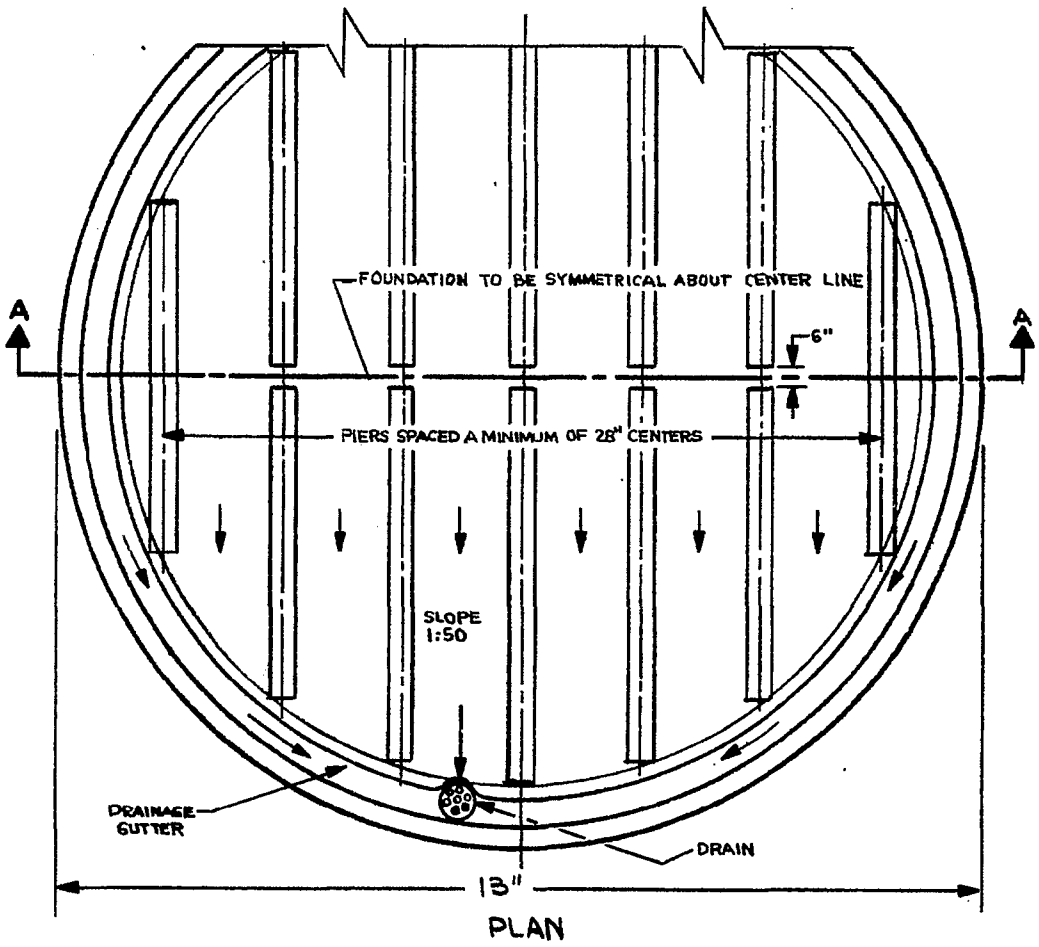
FIGURE I-M-3

E-49-74 DECAL

EXXON RESEARCH & ENGINEERING CO.
EXXON ENGINEERING · P O BOX 101 FLORHAM PARK N J 07932

OCT. 3, 1978
DEEP SPREAD FOOTINGS
CCG - LPP STUDY DESIGN
GRASS ROOTS CASE
BAYTOWN, TEXAS
J.M.H./T.M. NO. 77-876-2



PLAN

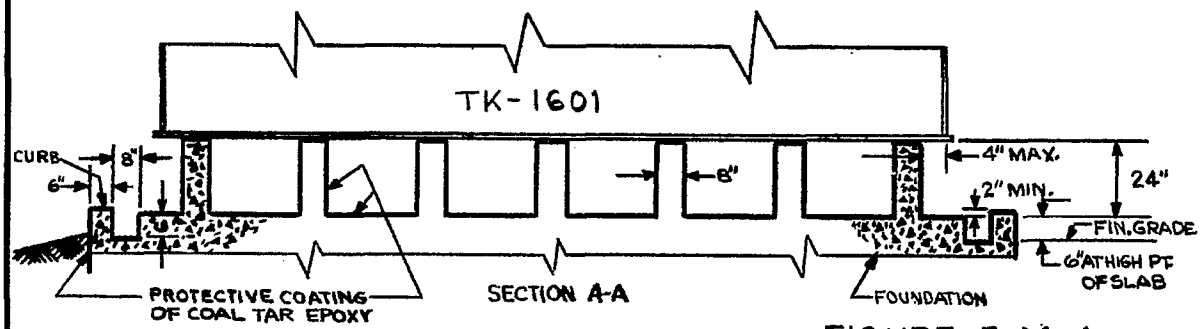


FIGURE I-M-4

E-11-74

EXXON RESEARCH & ENGINEERING CO.
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OCT. 3, 1978

H_2SO_4 TANK FOUNDATION

CCG-LPP STUDY DESIGN

GRASS ROOTS CASE

BAYTOWN, TEXAS.

JMH/W.B. NO. 77-114-1

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