Revision 0

PyGas™ GASIFIER

PRESSURE VESSEL

STRUCTURAL DESIGN CRITERIA

Prepared by ______________________________ Date __________

Approved by ______________________________ Date __________

Approved by ______________________________ Date __________

January, 1995

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PyGas™ GASIFIER VESSEL
STRUCTURAL INTEGRITY

MECHANICAL DESIGN

PROCESS DESIGN

FABRICATION & INSTALLATION

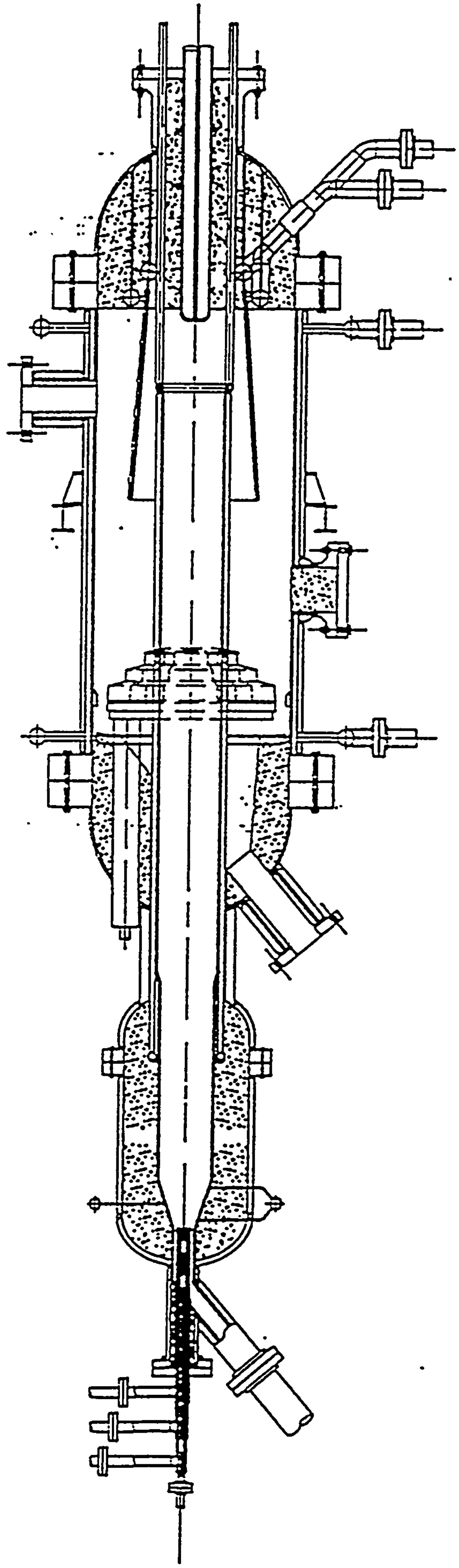
INSPECTION

HYDROTEST

INSTRUMENTATION & CONTROL

OPERATION & MAINTENANCE

PRESSURE RELIEF



GPIF

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GPIF PROJECT PyGas™ GASIFIER VESSEL
APPLICABLE ASME BOILER CODE SECTION

SECTION I VS. SECTION VIII, DIV. 1

- SECTION I APPLIES TO POWER BOILERS; PyGas™ VESSEL IS PRIMARILY A PROCESS VESSEL
- SECTION VIII INCLUDES PROVISIONS FOR UNFIRED STEAM BOILERS
- SECTION VIII, DIV. 1 USED AS DESIGN BASIS FOR PROCESS REACTOR VESSELS; SOME ARE USED TO CONTAIN COMBUSTION
    - PFB SYSTEM
- BOLTED CLOSURE RULES INCLUDED IN SECTION VIII, DIV. 1
- OTHER GASIFIER VESSELS CONSTRUCTED IN ACCORDANCE WITH SECTION VIII, DIV. 1
    - GREAT PLAINS GASIFICATION PROJECT
    - PIÑON PINES
- FOR PRESSURE RELIEF, SECTION I IS APPLICABLE TO BOILERS
- MORE STRINGENT HYDROSTATIC TEST REQUIREMENTS PER SECTION VIII, DIV. 1
- FULL RADIOGRAPHY REQUIRED FOR BUTT WELDS PER SECTION VIII, DIV. 1 FOR VESSELS CONTAINING LETHAL GAS

SECTION 2

2.0 SCOPE

Structural design of the PyGas™ vessel includes the following items.

2.1 PRESSURE BOUNDARY COMPONENTS

- Intermediate water-cooled outer shell
- Upper head and air inlet
- Lower head
- Coal inlet shell assembly
- Bolted closures
- Removable coal/air nozzles
- Gas product outlet
- Access penetration
- Other nozzles and penetrations including reinforcement
- Vessel shell support attachments

2.2 INTERNALS REQUIRING STRUCTURAL DESIGN

- Pyrolyzer tube including cooling system
- Water-cooled upper shroud
- Shell cooling system inner wall
- Shell cooling system headers
- Shroud cooling system headers
- Pyrolyzer cooling system headers
- Support of grate
- Grate drive shaft penetration

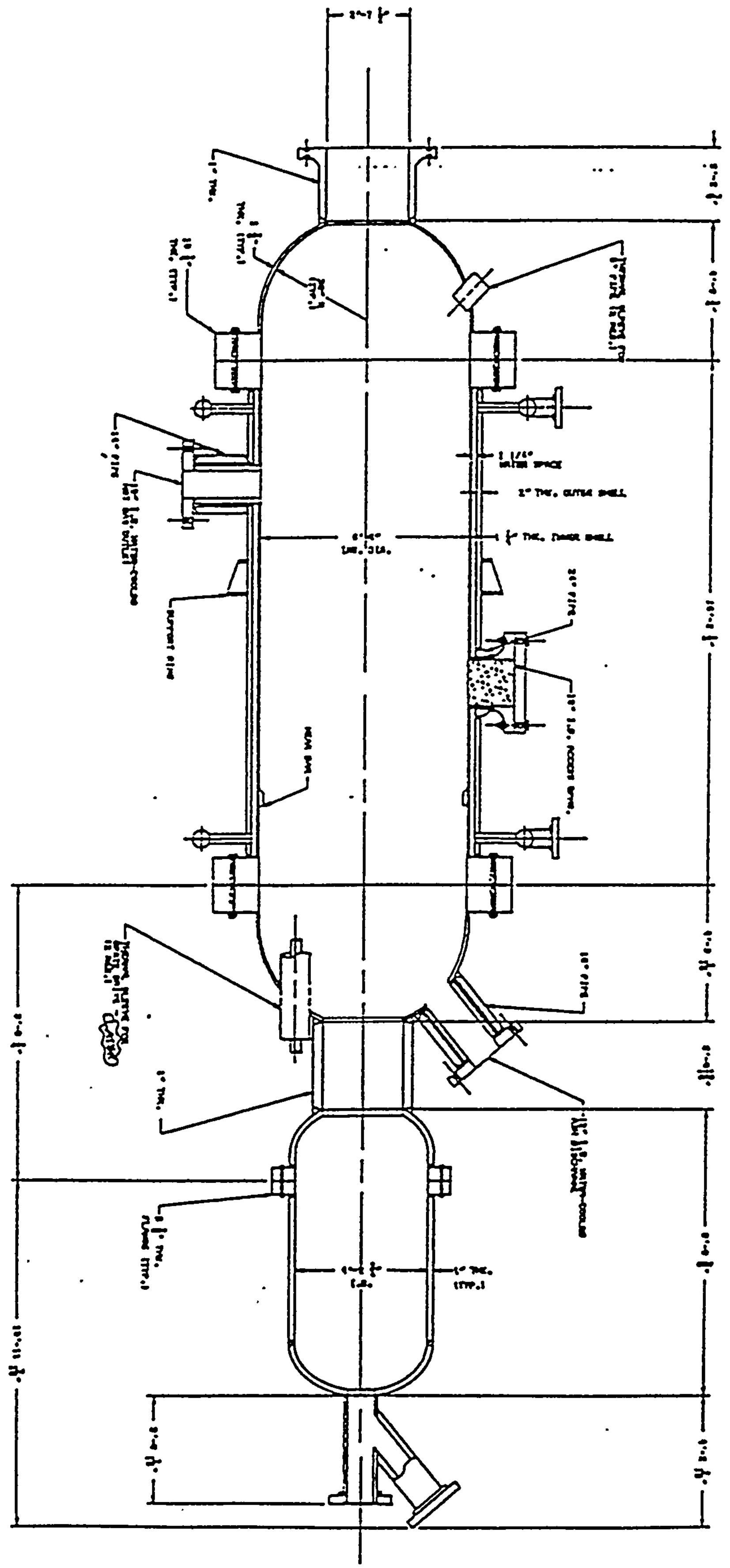
DESIGN INPUTS REQUIRED FOR

STRUCTURAL DESIGN

- DESIGN PRESSURE
  - MAXIMUM ALLOWABLE WORKING PRESSURE
  - MARGIN
  - DIFFERENTIAL PRESSURE
- DESIGN TEMPERATURE
  - METAL TEMPERATURE
- OPERATIONAL CYCLES
  - PRESSURE TIME HISTORY
  - TEMPERATURE TIME HISTORY
- ABNORMAL PROCESS REACTIONS
  - EXPLOSIONS
- SEISMIC LOADING
  - BOCA 1990

PRESSURE BOUNDARY DESIGN CONDITIONS

- PROCESS CHAMBER
  - 510 PSIG
- COOLING JACKET OUTER SHELL
  - 660 PSIG
- COOLING JACKET INNER SHELL
  - 150 PSID
- DESIGN TEMPERATURE
  - 700°F (METAL TEMP)



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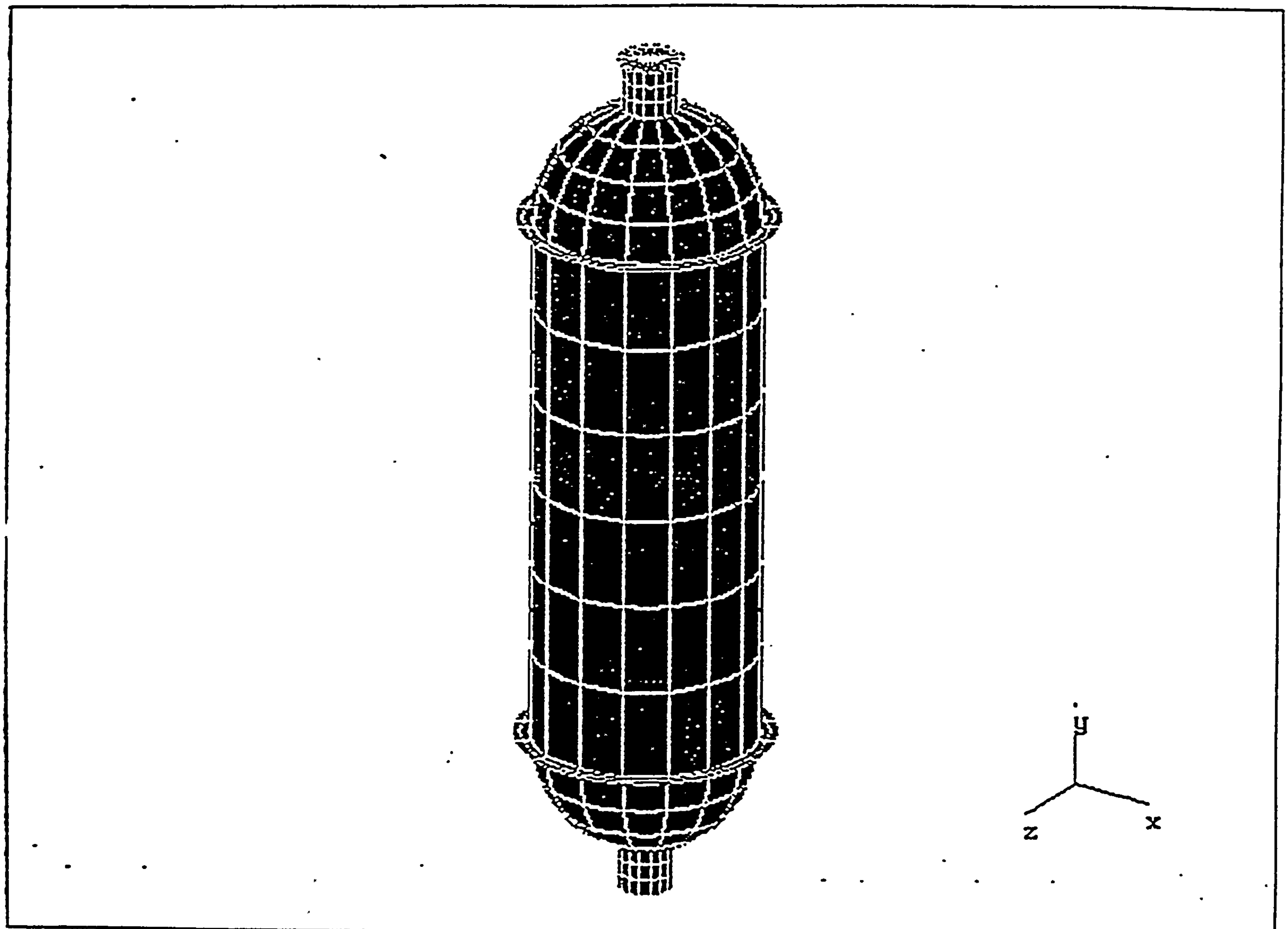

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PRESSURE RELIEF DEVICES

- REQUIRED BY CODE

- LIMITS MAX PRESSURE IN VESSEL OR CHAMBER
  - 110% P_{DES} - SINGLE DEVICE
  - 116% P_{DES} - MULTIPLE DEVICES

- HOW DO WE MEET CODE?
  - SELECT DEVICE SIZE
  - SELECT LOCATION
  - ANALYZE PROCESS TO SHOW PRESSURE LIMITS ARE NOT EXCEEDED
    - INCLUDE EFFECTS OF RELIEF DEVICE, VESSEL CONFIGURATION AND VENT PIPING (LOSSES)

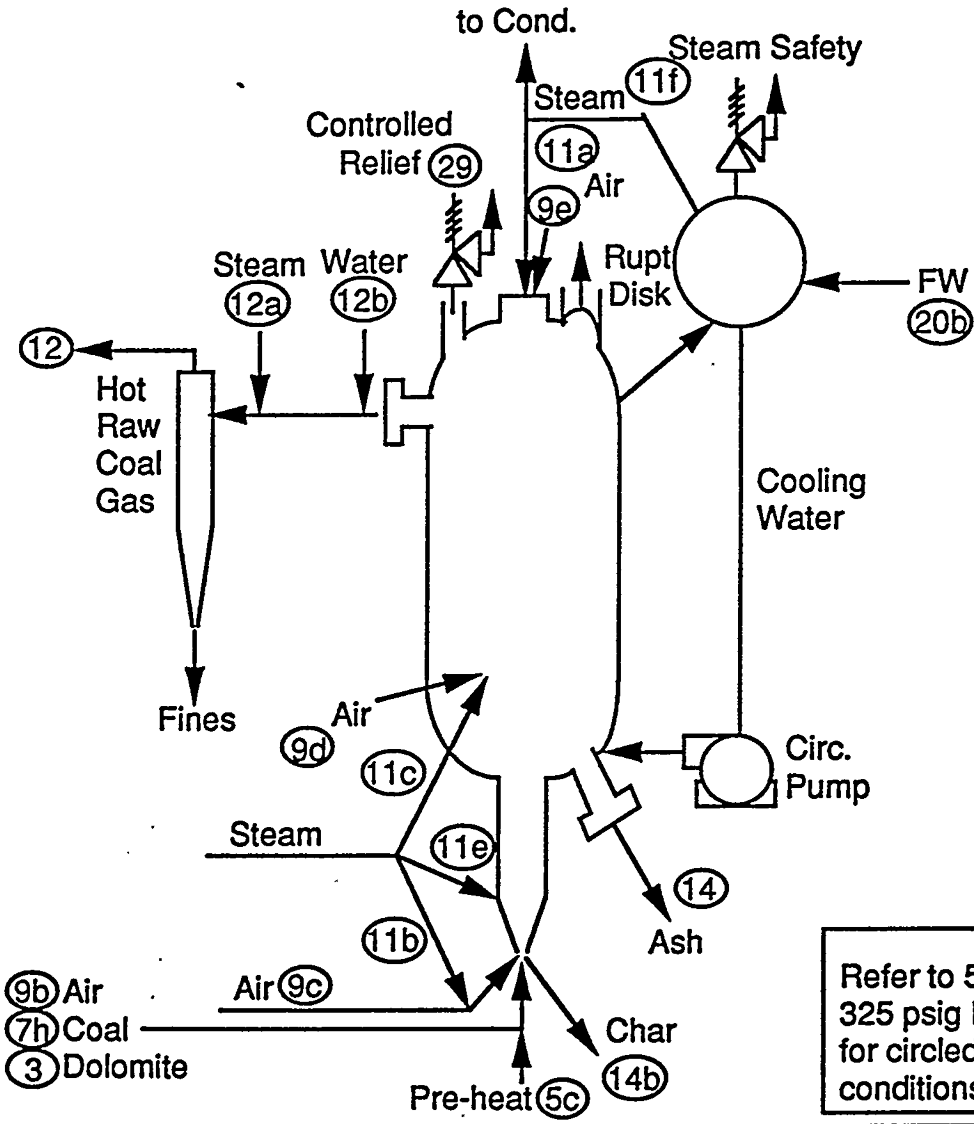
- SET PRESSURE LIMITED TO P_{DES} IN GENERAL

- CERTIFICATION AND STAMPING REQUIRED

SYSTEM PROCESS DESIGN BASIS

PDB No. 40-1AA-1

Equipment Name: PyGas™ Coal Gasifier
Equipment No. 1AA-RPV-1
System Name: Coal Gasifier Island
Flowsheet No. 16N25706-40-F-1AA-001



Refer to 5/31/95, ◯ 325 psig Mass Balance for circled number conditions.

SYSTEM EQUIPMENT SPECIFICS

1. Gasifier & system to be designed per U.S. Patents 5,133,780, & 5,145,490.
2. Provisions for coal, air & steam injection per mass balances columns 7, 9 & 11.
3. Gasifier to operate at 325 psig at pyrolyzer inlet nozzle.
4. Pyrolyzer operating temperature range is 1300°F to 2000°F.
5. Top gas & fixed-bed operating range 1500°F to 2200°F (peak 2300°F).

REV. 1

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Gasifier Load Sheet
Gasifier Flows, Pressures, & Temperatures

	C. System Dry	D. Ready For Ignition	E. Pyrolyzer In Service (Start-up)	F. Fixed-bed Ignited (Start-up)	G. DualBeds In Service 30 psig	H. Steady State 325 psig	H. Steady State Hot Hold (Min Flows)	H. Steady State Future Top Air/Steam
Pyrolyzer Nozzle:								
Coal Convey Line:								
Air Flow (lb/hr) (9b):	-	397	3,175	3,175	3,175	3,969	3,175	3,969
Air Viscosity (Cp):	-	0.04	0.002	0.002	0.024	0.024	0.024	0.024
Kinematic Visc., (cs)	-	13.21	2.45	2.45	1.72	0.84	0.84	0.84
Coke Flow (lb/hr) (8):	-	-	3,969	3,969	-	-	-	-
Coal Flow (lb/hr) (7g):	-	-	-	-	400	4,000	1,774	4,000
Limestone Flow (lb/hr) (7h):	-	-	0	0	0	0	0	0
Air Pressure (psig) (10):	-	30	30	30	30	325	325	325
Air/Coke/Coal Temp. (°F) (10):	-	-	125	125	125	125	125	125
Fluidization Annulus:								
Air Flow (lb/hr) (9c):	-	292	441	441	573	2,919	1,264	2,919
Air Pressure (psig) (9c):	-	-	30	30	30	325	325	325
Air Temp. (°F) (9c):	-	-	400	400	400	400	400	400
Steam Flow (lb/hr):	-	-	-	-	-	-	-	-
Steam Pressure (psig):	-	-	353	353	353	353	353	353
Steam Temperature (°F):	-	-	530	530	530	530	530	530
Outer Char Sampling Annulus:								
Air Flow (lb/hr):	-	750	-	-	-	-	-	-
Air Pressure (psig):	-	30	-	-	-	-	-	-
Air Temp. (°F):	-	400	-	-	-	-	-	-
Steam Flow (lb/hr) (11b):	-	62	62	100	33	417	46	417
Steam Pressure (psig) (11b):	-	-	353	353	353	353	353	353
Steam Temperature (°F) (11b):	-	-	530	530	530	530	530	530
Cone Sweep Steam:								
Steam Flow (lb/hr) (11b):	-	62	62	100	100	250	250	250
Steam Pressure (psig) (11b):	-	-	353	353	353	353	353	353
Steam Temperature (°F) (11b):	-	-	530	530	530	530	530	530
Pyroyzer Superficial Velocity (fps) (10a):	-	5.44	14.90	8.27	4.55	4.54	2.00	4.54
Top Air/Steam Nozzle:								
Air Flow (lb/hr) (9e):	-	-	-	-	-	-	-	2,200
Air Pressure (psig) (9e):	-	-	-	-	-	-	-	332
Air Temp. (°F) (9e):	-	-	-	-	-	-	-	400
Steam Flow (lb/hr) (11a):	-	-	-	-	-	-	-	778
Steam Pressure (psig) (11a):	-	-	-	-	-	-	-	332
Steam Temperature (°F) (11a):	-	-	-	-	-	-	-	530
Undergrate Blast:								
Air Flow (lb/hr) (9d):	5,193	415	415	1,072	763	5,238	1,596	1,721
Air Pressure (psig) (9d):	30	30	30	30	30	328	328	328
Air Temp. (°F) (9d):	400	400	400	400	400	400	400	400
Steam Flow (lb/hr) (11c):	-	1,662	1,662	482	298	2,032	603	640
Steam Pressure (psig) (11c):	-	31	31	31	31	332	332	332
Steam Temperature (°F) (11c):	-	530	530	530	530	530	530	530
Jacket Heat-up WHB Steam:								
Steam Flow (lb/hr):	5,640	5,640	5,076	4,568	-	-	-	-
Steam Pressure (psig):	353	353	353	353	-	-	-	-
Steam Temperature (°F):	353 (Tsat=435)	530	530	530	-	-	-	-
Excess Jacket Steam Condensed:								
Steam Flow (lb/hr):	-	-	-	-	932	2,330	2,330	2,330
Steam Pressure (psig):	-	-	-	-	353	353	353	353
Steam Temperature (°F):	-	-	-	-	274	274	274	274
Raw Coal Gas Output :								
Coal Gas Flow (lb/hr) (10h):	-	-	-	5,371	6,274	21,155	11,037	19,224
Coal Gas Pressure (psig) (10h):	-	-	-	28	25	319	319	319
Coal Gas Temp. (°F) (10h):	-	-	-	1083	1083	1083	975	1083
Coal Gas HHV (Btu/dscf) (10h):	-	-	-	113	150	149	150	140
Gas Cooling Water Spray:								
Steam & Water Flow (lb/hr) (12a,12b):	-	-	-	0	0	0	0	0
Water Pressure (psig) (12a,12b):	-	-	-	35	35	334	334	334
Water Temp. (°F) (12a,12b):	-	-	-	170	170	170	227	227
Cooled Coal Gas Output :								
Coal Gas Flow (lb/hr) (12):	-	-	-	5,371	6,274	21,155	11,037	19,224
Coal Gas Pressure (psig) (12):	-	-	-	27	27	319	319	319
Coal Gas Temp. (°F) (12):	-	-	-	1083	1083	1083	1083	1083
Coal Gas HHV (Btu/dscf) (12):	-	-	80	91	150	149	150	140

400 Psig DESIGN

PYROLIZER DESIGN SUMMARY				A/C = 1.72	
Low Load vs Pressure Relation	Design	W = kP		W = kP^n	
Load, %	100	76	52	87	72
DESIGN PARAMETERS					
Coal flow rate, lb/hr	8000	6071	4142	6969	5756
Limestone flow rate, lb/hr	1884	1430	975	1641	1356
Total Solids Flow, lb/hr	9884	7501	5117	8610	7112
Pressure Scale Down Index, n	–	1.0	1.0	0.5	0.5
Pyrolizer Bed Pressure, psig (linear W/ % load)	400	300	200	300	200
Pyrolizer Bed Pressure, psia (linear W/ % load)	415	315	215	315	215
Pyrolizer Bed Temperature, °F	1600	1600	1600	1600	1600
Total Pyrolizer Air/ Coal Ratio (From Mass Bal. Sheets)	1.72	1.72	1.72	1.72	1.72
Total Pyrolizer Air/ Coal Ratio (Calc. For Heat Reqd.)	1.71	1.82	2.14	1.78	1.90
Total Pyrolizer Air/Solids Ratio	1.39	1.39	1.39	1.39	1.39
Transport Air/Solids Flow Ratio	0.8000	0.8000	0.8000	0.6969	0.5764

SOLID PARTICLE SIZE					
Solid Particle Diameter For Design, mm	3.00	3.00	3.00	3.00	3.00
Solid Particle Maximum Diameter, mm	6.35	6.35	6.35	6.35	6.35
Solid Particle Minimum Diameter, mm	1.00	1.00	1.00	1.00	1.00
Sphericity for Bituminous Coal	0.86	0.86	0.86	0.86	0.86
Sphericity* Coal Particle Design Diameter, mm	2.58	2.58	2.58	2.58	2.58
Sphericity* Coal Particle Maximum Diameter, mm	5.46	5.46	5.46	5.46	5.46
Sphericity* Coal Particle Minimum Diameter, mm	0.86	0.86	0.86	0.86	0.86

FLUIDIZATION VELOCITIES					
Char Density(Assumed), lbm/ft^3	60	60	60	60	60
Voidage @ Minimum Fludization Condition	0.44	0.44	0.44	0.44	0.44
Minimum Fluid'n Vel. For Design Particle Dia., ft/sec	1.06	1.20	1.40	1.20	1.40
Minimum Fluid'n Vel. For Max. Particle Dia., ft/sec	3.56	4.07	4.88	4.07	4.88
Minimum Fluid'n Vel. For Min. Particle Dia., ft/sec	0.37	0.39	0.42	0.39	0.42
Terminal Velocity For Design Particle Dia., ft/sec	8.89	10.07	11.94	10.07	11.94
Terminal Velocity For Max. Particle Dia., ft/sec	14.14	16.12	19.29	16.12	19.29
Terminal Velocity For Min. Particle Dia., ft/sec	3.95	4.40	5.07	4.40	5.07
Jetting Region Bed Voidage(Rihardson & Zaki)	0.68	0.65	0.61	0.68	0.69
Jetting Region Bed Voidage(Linear Fn(Umf, Ucf & Emf)	0.60	0.57	0.54	0.60	0.61
Fluidiz'n Vel. @ Jet Rgion Flows & Linear fn. Void, ft/sec	3.24	3.24	3.25	3.72	4.52
Bubbling Region Bed Voidage(Richardson & Zaki)	0.73	0.70	0.66	0.74	0.75
Bubbling Region Bed Voidage(Linear Fn(Umf, Ucf & Emf	0.65	0.62	0.58	0.65	0.66
Fluidiz'n Vel. @ Linear fn. void & Py. Flows, ft/sec	3.96	3.98	4.01	4.56	5.58
Bubbling Region Bed Voidage(Jovanavic–Fast Bubble)	0.68	0.68	0.68	0.71	0.74
Fluidiz'n Vel. @ Jovanavic Void & Py. Flows, ft/sec	4.48	5.06	5.98	5.40	6.97

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400 Psig Design Pr.

PYROLIZER DESIGN SUMMARY				A/C = 1.72	
Low Load vs Pressure Relation	Design	W = kP		W = kP^n	
Load, %	100	76	52	87	72
INNER JET					
Solids Transport Air (Inner Jet) Flow, lb/hr	7907	6000	4094	6000	4099
Solids Transport Air Pr. @ Injection pt., psig	400	300	200	300	200
Solids Transport Air Temp. @ Injection pt., °F	125	125	125	125	125
Solids Transport Air (Inner Jet) Flow, ft^3/sec	1.152	1.152	1.152	1.152	1.154
Solids Transport Pipe(2-1/2"Sch.160) ID, in.	2.125	2.125	2.125	2.125	2.125
Air Vel. @ Solids Transport Pipe Exit (Vi), ft/sec	46.8	46.8	46.8	46.8	46.8

OUTER JET					
Total Outer Jet Air Flow, lb/hr	5868	4453	3038	6000	5812
Air Temperature @ Injection pt., °F	400	400	400	400	400
Total Outer Jet Air flow, ft^3/sec	1.257	1.257	1.257	1.693	2.405
Outer Jet Air Annulus Gap, in.	0.4755	0.4755	0.4755	0.475	0.475
Outer Jet Air Pipe (4" Sch.80) ID, in.	3.826	3.826	3.826	3.826	3.826
Outer Jet Air Superficial Vel. in Annulus, ft/sec(Vo)	36.2	36.2	36.2	48.7	69.2

CHAR REMOVAL ANNULUS					
Total Fluidizing Steam Flow, lb/hr	1334	1012	691	1162	960
Steam Pressure @ Injection pt. °F	400	300	200	300	200
Steam Temperature @ Injection pt., °F	610	610	610	610	610
Total Fluidizing Steam flow, ft^3/sec	0.57	0.57	0.57	0.66	0.79
% Of Total Fluidizing Steam Through Annulus	70	70	70	70	70
Steam Flow Through The Char Removal Annulus, lb/hr	934	709	483	813	672
Char Removal Annulus Gap, in.	1.25	1.25	1.25	1.25	1.25
Char Removal Annulus Outer Pipe ID, in.	8.063	8.063	8.063	8.063	8.063
Superficial Velocity in Char Removal Annulus, ft/sec(Va)	1.64	1.64	1.64	1.88	2.27
Multiplying factor of Umf for Va	1.54	1.37	1.16	1.57	1.62

SPARGER #1					
Design Steam Flow For Each Sparger 1 & 2, lb/hr	560	425	290	488	403
Design Steam Flow For Each Sparger 1 & 2, ft^3/sec	0.240	0.240	0.240	0.275	0.333
Sparger annulus 1 outer pipe(5"sch80) ID, in.	4.813	4.813	4.813	4.813	4.813
Sparger annulus 1 gap, in.	0.1565	0.1565	0.1565	0.156	0.156
Velocity in the Sparger Annulus 1, ft/sec	15.1	15.1	15.1	17.3	21.0
Number Of Orifices In Sparger 1	12	12	12	12	12
Diameter Of Each Orifice Of Sparger 1, in.	0.22	0.22	0.22	0.22	0.22
Steam Velocity @ Each Orifice Of Sparger 1, ft/sec	73.7	73.7	73.7	84.6	102.4

SPARGER #2					
Sparger Annulus 2 (6"sch80) ID, in.	5.761	5.761	5.761	5.761	5.761
Sparger Annulus 2 gap, in	0.099	0.099	0.099	0.099	0.099
Velocity in the Sparger Annulus 2, ft/sec	19.6	19.6	19.6	22.5	27.2
Number of Orifices In Sparger 2	12	12	12	12	12
Diameter Of Each Orifice Of Sparger 2, in.	0.25	0.25	0.25	0.25	0.25
Steam Velocity @ Each Orifice Of Sparger 2, ft/sec	58.6	58.6	58.6	67.3	81.4

GPIF

400 Psig Design Pr Coke

PYROLIZER DESIGN SUMMARY					A/C = 1.72
Low Load vs Pressure Relation	Design	W = kP		W = kP^n	
Load, %	100	76	52	87	72
CONICAL GRID					
Steam Flow For Conical Grid, lb/hr	400	304	207	349	288
Steam Flow For Conical Grid, ft^3/sec	0.17	0.17	0.17	0.20	0.24
Total Number Of Tubes In The Cone	12	12	12	12	12
ID of Each Tube, in.	0.213	0.213	0.213	0.213	0.213
Velocity @ The Exit Of Each Tube, ft/sec	57.4	57.4	57.4	57.4	57.4
JET HEIGHT CALCULATION(YANG'S CORRELATION)					
ID of support air annulus outer pipe*7.65, ft	2.439	2.439	2.439	2.439	2.439
Area corresponding to ID of air annulus out. pipe, ft^2	0.0798	0.0798	0.0798	0.0798	0.0798
(Ucf)atmospheric/(Ucf)pressurized Ratio	3.88	3.39	2.82	3.43	2.91
1/(particle density−gas density), ft^3/lb	0.0111	0.0111	0.0111	0.0111	0.0111
1/(gravity(32.174)*ID of air annul out. pipe),(sec/ft)^2	0.0975	0.0975	0.0975	0.0975	0.0975
Flow area of transport Noz. & air annulus, ft^2	0.0594	0.0594	0.0594	0.0594	0.0594
Equivalent Diameter for flow area, ft	0.2750	0.2750	0.2750	0.2750	0.2750
Jet Momentum based on ID of Annulus, lb/ft−sec^2					
Jet Momentum Due To Transport Air, lb/ft−sec^2	1287	977	666	976	668
Jet Momentum Due To Solids, lb/ft−sec^2	1303	958	620	1100	863
Jet Momentum Due to Support Air, lb/ft−sec^2	738	560	382	1017	1399
Total Jet Momentum, lb/ft−sec^2	3328	2495	1669	3093	2931
Overall Jet Ht. based on ID of Air Annulus, ft.	8.5	6.9	5.3	7.7	7.0
Overall Jet Ht. based on equiv. ID of flow area, ft.	8.4	6.9	5.2	7.7	6.9
JET BUBBLE SIZE & JET HALF ANGLE					
Total air through jet nozzle, lb/hr	13775	10453	7132	12000	9912
Pyrolizer Bed Pressure, psig	400	300	200	300	200
Pyrolizer Bed Temperature, °F	1600	1600	1600	1600	1600
Air Density @ Bed Pr. & Temp., lb/ft^3	0.5433	0.4123	0.2813	0.412	0.281
Total Jet Air Volumetric flow, ft^3/sec	7.042	7.042	7.042	8.084	9.787
Bubble Dia. based on Bosev et al(1969), in.	17	17	17	18	19
Bubble Dia. based on Davidson & Harrison, in.	17	17	17	18	19
Max. Bubble Dia. based on volume of Jet air & Umf , in	25	23	21	25	25
Bubble Vol. based on Bosev et al(1969), in.	1.54	1.54	1.54	1.80	2.24
Bubble Vol. based on Davidson & Harrison, in.	1.49	1.49	1.49	1.76	2.21
Max. Bubble Vol. based on Max. bubble Dia., in	4.55	3.80	2.99	4.68	4.89
Jet half Angle based on Bosev et al., deg	3.6	4.4	5.7	4.2	5.1
Jet Half Angle based on Davidson & Harrison, in.	3.5	4.3	5.7	4.2	5.1
Jet half Angle based on Max. bubble Dia., deg	5.7	6.4	7.6	6.3	7.1
Bubble Rise Vel., ub, ft/sec (Eqn 12.6−Davidson)	4.80	4.80	4.80	4.94	5.13

400 Psig Design Pr. Case.

PYROLIZER DESIGN SUMMARY					A/C = 1.72
Low Load vs Pressure Relation	Design	W = kP		W = kP^n	
Load, %	100	76	52	87	72
CHECK ON SOLIDS RESIDENCE TIME ABOVE THE JET TOP FOR 100% DEVOLATALIZATION					
Avg. Solids Residence Time Above the Jet, min.	7.75	12.02	20.86	9.10	11.13
Time Reqd. For 100% Devolatalization (Pillai, 1981)	Coal Analysis Used		Ft.Martin	Ft.Martin	Ft.Martin
Coal Type	In Mass Bal. A-8		Mapco#2	Metiki#2	Consol#2
Free Swelling Index(FSI) of the Coal	Assume <6	Assume >6	3.5	9	7.5
Coal Volatiles, % (dry ash free)	36.4	36.4	41.0	21.6	40.0
Average Bed Temperature, °F	1600	1600	1600	1600	1600
Design Particle Size With Sphericity, mm	2.58	2.58	2.58	2.58	2.58
Time for 100% Devolatilization, tv–press.., min.	0.23	0.62	0.22	0.54	0.59
Maximum Particle Size With Sphericity, mm	5.46	5.46	5.46	5.46	5.46
Time for 100% Devolatilization, tv–press.., min.	0.44	1.18	0.39	0.91	1.09
Minimum Particle Size With Sphericity, mm	0.86	0.86	0.86	0.86	0.86
Time for 100% Devolatilization, tv–press.., min.	0.09	0.24	0.09	0.25	0.25
Conclusion: There is enough Residence Time Above The Jet Top For 100% Devolatalization					

FLOW VELOCITY ALONG THE JET AXIS					
Distance Downstream of Jet Entry, x, ft	25	25	25	25	25
Average Jet Inj. Vel @ Noz. Exit, ft/sec	44.1	44.1	44.1	47.3	54.5
Overall Bed Density, lb/ft^3	21.5	23.3	25.4	21.1	20.5
Flow Velocity @ x along the Jet Axis(Slip Vel.)	1.10	0.92	0.73	1.07	1.06
Terminal Velocity For Min. Particle Dia., ft/sec	3.95	4.40	5.07	4.40	5.07
Terminal Velocity For Design Particle Dia., ft/sec	8.89	10.07	11.94	10.07	11.94
(Jet Flow Vel. + Comp. Fluid Vel.), ft/sec	4.33	4.16	3.98	4.79	5.58
CHAR TO COAL CONCENTRATION ALONG THE JET HEIGHT					
Coal Concentration @ x, lb/ft^3	0.22	0.20	0.17	0.20	0.17
Diff. bet. Char Conc. in Bed & Jet Axis, lb/ft^3	12.24	15.96	22.16	14.19	16.93
Char Concentration @ x, lb/ft^3	8.94	7.12	3.11	6.66	3.35
Distance from jet nozzle on Jet Axis @ 0.5 sec, ft	5.2	4.8	4.3	5.2	5.1
Char./Coal Conc. @ time = 0.5 sec	–35	–57	–102	–50	–77
Distance from jet nozzle on Jet Axis @ 1 sec, ft	7.4	6.8	6.0	7.3	7.3
Char./Coal Conc. @ time = 1 sec	–27	–48	–92	–41	–66
Time To Reach Top of Jet Height, sec	1.3	1.1	0.8	1.1	0.9
Char./Coal Conc. @ Top of jet	32	32	30	32	34
Time To Reach Top of Pyrolizer, sec	14	17	21	14	14
Char./Coal Conc. @ Top of Pyrolizer	37	28	2	27	7
Along the Jet Axis, Residence Time Above Jet Top, sec	12.64	15.63	20.32	13.01	13.35

SUPERFICIAL GAS VELOCITY PROFILE					
Gas Flow @ Pyrolizer Bottom, lb/hr	15109	11466	7822	13162	10871
Gas Temperature @ Pyrolizer Bottom, °F	1600	1600	1600	1600	1600
Gas Velocity in Pyrolizer(21"Dia) ft/sec	3.24	3.24	3.25	3.72	4.52
Pyrolizer Product Gas Flow, lb/hr	19496	14795	10094	16984	14028
Pyrolizer Product Gas Temperature @ Its Outlet, °F	1637	1637	1637	1637	1637
Gas Velocity in Pyrolizer(24"Dia) ft/sec	3.96	3.98	4.01	4.56	5.58
Gas Superficial Vel., Inlet to the inner annulus, ft/sec	5.51	5.33	5.01	6.12	6.96
(Gas+Fines) Velocity, inlet to the inner annulus, ft/sec	7.32	7.08	6.66	8.13	9.25
Gas Superficial Vel., Outlet of the inner annulus, ft/sec	3.11	3.01	2.83	3.45	3.93
(Gas+Fines) Vel., Outlet of the inner annulus, ft/sec	4.12	3.98	3.74	4.57	5.20
Gas Velocity, Fixed Bed Exit, ft/sec	0.44	0.45	0.45	0.51	0.63
Gas Vel. – Outer Annulus @ Shroud Bot., ft/sec	1.07	1.06	1.08	1.22	1.50

GPIF

PyGas™ COAL GASIFIER
PDB No. 40-1AA-1

MAJOR PHILOSOPHY FOR SAFE OPERATION (HAZOPS CREDO)

1. The incinerator/WHB is the primary disposal method of the coal gas.
2. The most environmentally friendly way of consuming coal gas is in the incinerator/WHB.
3. Coal gas produced from the gasifier will normally flow to the incinerator/WHB.
4. Only in an emergency will coal gas be diverted to the flare.
5. The gasifier outlet rupture disk is the code compliant gas pressure relief safety.
6. Venting to the flare is an emergency shut-down operation for equipment & personnel protection.
7. Gasifier testing should only proceed if the incinerator/WHB is in service.
8. The coal preparation system shall be operated as a direct fired system per NFPA.
9. The oxygen concentration leaving the pyrolyzer tube should not be allowed to exceed 1% vol when either the pyrolyzer or the fixed-bed are generating coal gas.
10. The oxygen concentration leaving the fixed-bed should not be allowed to exceed 4% vol whenever either the pyrolyzer or the fixed-bed are generating coal gas.

NORMAL START-UP, NORMAL SHUT-DOWN, EMERGENCY SHUT-DOWN TO INCINERATOR/WHB, EMERGENCY SHUT-DOWN TO FLARE, UNCONTROLLED EMERGENCY SHUTDOWN

The following reflects the conceptualized normal start-up procedure assuming "cold" start-up conditions. It should be anticipated that all safety related interlocks and permissives to include all fail-safe equipment design considerations will be integrated into this plan as the detailed design process continues.

NORMAL START-UP

(Verify all cooling water systems are filled and in operation)

1. START INCINERATOR/WHB AND BRING TO OPERATING CONDITION

2. PROVE GASIFIER WATER JACKET COOLING CIRCULATION

3. NITROGEN PURGE THE GASIFIER INTO THE INCINERATOR/WHB

4. PRE-HEAT GASIFIER JACKET COOLING SYSTEM WITH STEAM (flow and rate of temperature rise per mechanical design requirements) WHEN GASIFIER DRUM TEMPERATURE EXCEEDS SATURATION, STEAM WILL VENT THROUGH THE GRATE PREVENTING PREMATURE IGNITION OF FIXED-BED. MAINTAIN MINIMUM STEAM FLOW.

5. START AIR COMPRESSOR AND BUILD PRESSURE (within mechanical stress limit constraints) TO START-UP PRESSURE (approximately 30 psi gas side pressure) (air flows into INCINERATOR/WHB); PROVE INCINERATOR/WHB COAL GAS FLAME SCANNER SEES STABILIZATION FLAME, AND EMERGENCY FLARE READY PERMISSIVE IS MET

6. PREHEAT PYROLYZER CONE WITH NATURAL GAS (Direct Combustion in Fluidized Cone) (flow and rate of temperature rise per mechanical design requirements) UNTIL TEMPERATURE REACHES 1000°F (anticipate several hours)

7. ADJUST PYROLYZER AIR AND STEAM FLOW TO MINIMUM FLUIDIZATION FLOW RATE (at proper ratio for startup; air flow to reach set point pyrolyzer operating temperature and steam flow will be required in both the coal conveying and pyrolyzer fluidization streams) BYPASS BALANCE OF COMPRESSOR AIR TO ATMOSPHERE (if necessary)

8. ADD COKE, CHAR OR LOW VOLATILE NON-CAKING COAL TO PYROLYZER AT MINIMUM FLOW RATE (approximately one tenth of maximum rotary feeder speed)

9. RAISE PYROLYZER TEMPERATURE TO SET POINT (approx. 1600°F), THEN SHUT DOWN DIRECT PRE-HEATING (will likely take several minutes), AND BUILD SOLIDS BED IN PYROLYZER.

10. SWITCH TO TEST COAL WHEN PYROLYZER LEVEL INDICATOR/MONITOR INDICATES PYROLYZER SOLIDS OVERFLOW (prevents caking before bed can accept increased coal flow)

11. AS COAL RATE IS INCREASED, ADJUST PYROLYZER AIR FLOW TO MAINTAIN SET POINT TEMPERATURE, AND DECREASE STEAM FLOW WHILE MAINTAINING ABOVE MINIMUM FLUIDIZATION FLOW (may be automatically controlled)

12. WHEN INDICATOR/MONITOR INDICATES PROPER FIXED-BED SOLIDS LEVEL, TURN ON GRATE AIR AND INCREASE GRATE STEAM TO MAINTAIN SET POINT PEAK BED TEMPERATURE (approximately 2300°F; may be automatically or manually controlled)

13. GRATE ROTATION IS INITIATED WHEN INDICATOR/MONITOR INDICATES HIGH SOLIDS LEVEL

14 GRATE SPEED IS PROPORTIONED BY COAL FEED RATE AND TRIMMED BY ABOVE GRATE TEMPERATURE SET POINT (decreases speed as temperature increases, and the reverse)

15. HIGH INNER ANNULUS DELTA PRESSURE OVERRIDES TEMPERATURE CONTROL OF GRATE SPEED AND INCREASES GRATE SPEED UNTIL INDICATOR/MONITOR INDICATES LOSS OF BED LEVEL. HIGH ABOVE GRATE TEMPERATURE INCREASES GRATE STEAM FLOW.

NORMAL SHUT-DOWN

1. RAMP OPERATING PRESSURE TO 30 PSI.
(rate of temperature decline per mechanical design requirements)

2. REDUCE COAL FEED TO MINUMUM FEED RATE (Approximately 10%).

3. STOP COAL FEED.

4. PURGE PYROLYZER INVENTORY; CONTROL PYROLYZER OPERATING TO 1500°F TO PREVENT AGGLOMERATION

5. START DIRECT PRE-HEAT NATURAL GAS BURNER TO CONTROL RATE OF PYROLYZER CONE TEMPERATURE DECLINE IF NECESSARY
(rate of temperature decline per mechanical design requirements)

6. STOP AIR FLOW TO PYROLYZER. AS PYROLYZER TEMPERATURE DECREASES, REDUCE STEAM FLOW (may be automatic)

7. ALLOW FIXED-BED TO BURN-OUT CONTROLLING PEAK BED TEMPERATURE AT SETPOINT

8. STOP ALL AIR FLOW & INDIRECT HEATER & CONTINUE REDUCING STEAM FLOW THROUGH PYROLYZER & GRATE UNTIL ITS TEMPERATURE IS CLOSE TO WATER JACKET (rate of temperature decline per mechanical design requirements); THEN STOP STEAM FLOW & PURGE WITH NITROGEN.

9. REMOVE REMAINING SOLIDS FROM FIXED-BED VIA THE GRATE AND PRESSURE LOCKS

10. CONTINUE NITROGEN FLOW THROUGH GRATE UNTIL ITS TEMPERATURE IS CLOSE TO WATER JACKET; THEN STOP NITROGEN FLOW

11. INERT WITH NITROGEN, AND ISOLATE WITH A NITROGEN BLANKET TO PROTECT AGAINST FIRES AND CORROSION
(important note: bypass this step if personnel expect to enter system within 2 days)

12. SHUT DOWN THE INCINERATOR/WHB

13. CLOSE FLUE GAS ISOLATION DAMPER TO FT MARTIN

14. SHUT DOWN ALL WATER COOLING CIRCUITS

15. NITROGEN BLANKET ALL WATER CIRCUITS TO PROTECT AGAINST CORROSION
(important note: bypass this step if personnel expect to enter system within 2 days)

16. WHEN COOL, AIR PURGE SYSTEM THROUGH THE INCINERATOR/WHB PRIOR TO ALLOWING ANY PERSONNEL ENTRY INTO THE SYSTEM.

CONTROLLED EMERGENCY SHUTDOWN TO INCINERATOR/WHB

INITIATED AUTOMATICALLY OR BY OPERATOR

COVERS THE FOLLOWING CASES:

1. LOSS OF COAL FEED
2. WATER LEAK INTO SHELL
3. HIGH TEMPERATURE ALARM ON GASIFIER OUTLET

PROCEDURE:

1. STOP COAL AND AIR COMPRESSOR
2. DEPRESSURIZE SYSTEM TO INCINERATOR/WHB AT A CONTROLLED RATE USING STEAM
   (rate of pressure decline per mechanical design requirements)
3. REDUCE STEAM TO PYROLYZER & GASIFIER TO MINIMUM
4. CLOSE FLUE GAS ISOLATION DAMPER TO FT MARTIN
5. DRAIN PYROLYZER CHAR THROUGH ASH LOCK SYSTEM
6. INERT WITH NITROGEN
   (important note: bypass this step if personnel expect to enter system within 2 days)
7. EITHER CONTINUE SHUT-DOWN FOLLOWING NORMAL SHUT-DOWN PROCEDURES, OR LEAVE SYSTEM BLANKETED UNTIL READY FOR RESTART (OPERATOR DECISION)

CONTROLLED EMERGENCY SHUTDOWN TO FLARE (OR INCINERATOR/WHB STUB STACK)

INITIATED AUTOMATICALLY OR BY OPERATOR

COVERS THE FOLLOWING CASES:

1. LOSS OF ELECTRIC POWER
2. INCINERATOR/WHB GOES DOWN
3. FORT MARTIN GOES DOWN

ITEMS IN THE PROCEDURE ARE LISTED SEQUENTIALLY, HOWEVER, EVENTS 1 THRU 4 ARE SIMULTANEOUS (by control system)

PROCEDURE:

1. TRIP AIR COMPRESSOR
2. STOP COAL AND AIR TO GASIFIER
3. OPEN FLARE (OR INCINERATOR/WHB STUB STACK) CONTROL VALVE AND DEPRESSURIZE SYSTEM AT A CONTROLLED RATE
   (rate of pressure decline per mechanical design requirements)
4. DEPRESSURIZE SYSTEM TO INCINERATOR/WHB AT A CONTROLLED RATE USING STEAM (rate of pressure decline per mechanical design requirements)
5. REDUCE STEAM TO PYROLYZER & GASIFIER TO MINIMUM
6. TRIP VENT SYSTEM
7. CLOSE FLUE GAS ISOLATION DAMPER TO FT MARTIN
8. DRAIN PYROLYZER CHAR THROUGH ASH LOCK SYSTEM
9. INERT WITH NITROGEN
   (important note: bypass this step if personnel expect to enter system within 2 days)
10. CLOSE FLARE (OR INCINERATOR/WHB) CONTROL VALVE AND LEAVE SYSTEM UNDER NITROGEN BLANKET
    (important note: bypass this step if personnel expect to enter system within 2 days)
11. EITHER CONTINUE SHUT-DOWN FOLLOWING NORMAL SHUT-DOWN PROCEDURES, OR LEAVE SYSTEM BLANKETED UNTIL READY FOR RESTART (OPERATOR DECISION)

UNCONTROLLED EMERGENCY SHUTDOWN

INITIATED AUTOMATICALLY

COVERS THE FOLLOWING CASES:

1. PRESSURE RELIEF THROUGH RUPTURE DISK

ITEMS IN THE PROCEDURE ARE LISTED SEQUENTIALLY, HOWEVER, EVENTS 1 THROUGH 6 ARE SIMULTANEOUS (by control system)

PROCEDURE:

1. TRIP AIR COMPRESSOR
2. STOP COAL AND AIR TO GASIFIER
3. TRIP INCINERATOR/WHB
4. CLOSE FLUE GAS ISOLATION DAMPER TO FT MARTIN
5. INERT GASIFIER WITH STEAM
6. INERT WITH NITROGEN
7. CONTINUE SHUT-DOWN FOLLOWING NORMAL SHUT-DOWN PROCEDURES

STATES /Sub-states (TRANSITIONS)	SUBSYSTEM STATUS	CONSTRAINTS
Locked Out (Inerted/Idle)	All systems locked out.	Warning alarm permissive.
A Ready for Start-up	All systems ready.	All permissives met.
System Purged (Idle/Purge)	Incinerator/WHB then gasifier are air purged using induced draft fan.	Prerequisite to personnel entry. O2 test must prove air present. Flue gas isolation damper to Ft. Martin then closed. ID fan then tripped & proven shut down.
Precharged (Purge/Pre-Charge)	Fixed-bed is manually loaded with startup materials.	Breathing air introduced into gasifier. Other gasifier systems locked-out.
Nitrogen Purged (Pre-Charge/Inerted)	Nitrogen system on with continuous flow through gasifier out flare stack until O2 < 5%.	This step not necessary if startup is imminent (within one day).
Water Filled (Inerted/Water Filled)	WHB water drum level proven. Gasifier water drum level proven.	Condensate water (110°F max) used to fill both WHB circuits & gasifier jacket prior to start-up.
Water Circulating (Water Full/Circ.)	WHB circulating water pump on. Gasifier circulating water pump on.	Proven water circulation is a WHB & gasifier start-up permissive.
B WHB in Service	Generating Steam at 353 psig/530°F	WHB prerequisite to Gasifier opn.
Incinerator Spt Fuel Burn (Idle/WHB In Service)	Incinerator firing on support fuel.	Boiler drum water temperature rise rate during start-up of 100°F/hour.
Start-up System : Cold Stand-by (Circ./Ready)	Air compressor on and receiver at minimum pressure (in venting mode).	Gasifier purging and drying-out with compressed air decompressing through system to Incinerator/WHB.
Steam Pre-heat Method (Ready/Pre-heat)	Jacket water heater and pump is in service. Steam the cooling circuit to pre-heat water.	Water jacket and gasifier water cooled internals always at slightly higher pressure than gasifier gas side (well within maximum full load differential pressure). Rate of gasifier drum water temperature rise limit is 100°F per hour.

STATES /Sub-states (TRANSITIONS)	SUBSYSTEM STATUS	CONSTRAINTS
Alternate Start-up System Gas Pre-heat Method **(Ready/Pre-heat)**	Unheated jacket water (approx. 110°F). Indirect natural gas pre-heat burner in service. 1200°F heated compressed air entering pyrolyzer.	WHB must be in service. Heat water until rate of gasifier drum temperature rise becomes less than 100°F per hour. Then add "shot of solid fuel" to pyrolyzer. When pyrolyzer temperature starts to rise, set solid fuel feed rate to minimum. Raise gasifier cooling water temperature at 100°F per hour until steam pressure exceeds air pressure.
C System Dry	Pre-heat in Service.	530°F Superheated Steam available.
Cone Air Pre-heat **(Ready/Cone Pre-heat)**	Introduce pre-heated air into pyrolyzer and steam & nitrogen into fixed-bed. Use jacket.auxiliary indirect air pre-heater & sand to heat pyrolyzer refractory.	Pressure balance maintained between jacket & gasifier. Also between nitrogen and air flows. Flow and pressure dependent upon pressure letdown system. Steam/nitrogen maintained below minimum fluidization velocity in fixed-bed. Preheater output. Materials thermal stress constraints. Maintain steam/nitrogen purge in the fixed-bed to prevent premature ignition and moisture condensation. Pressure ramp limited by gasifier steam condensation temperature. Gasifier train through WHB must be above condensation temperature.
D Ready for Ignition	Pre-heat system in operation.	1000°F cone temperature reached by burning natural gas in fluidized cone.
Coke Pre-heat **(Cone PH/Coke PH)**	Conveying coke with hot air and sustain substoichiometric air to heat the pyrolyzer.	Maintain velocities below the point of solid fuel feed carryover during building of pyrolyzer solids inventory. Maintain maximum combustion temperatures below ash fusion temperatures by introducing annular steam flow when necessary. Maintain minimum fluidization of solids.

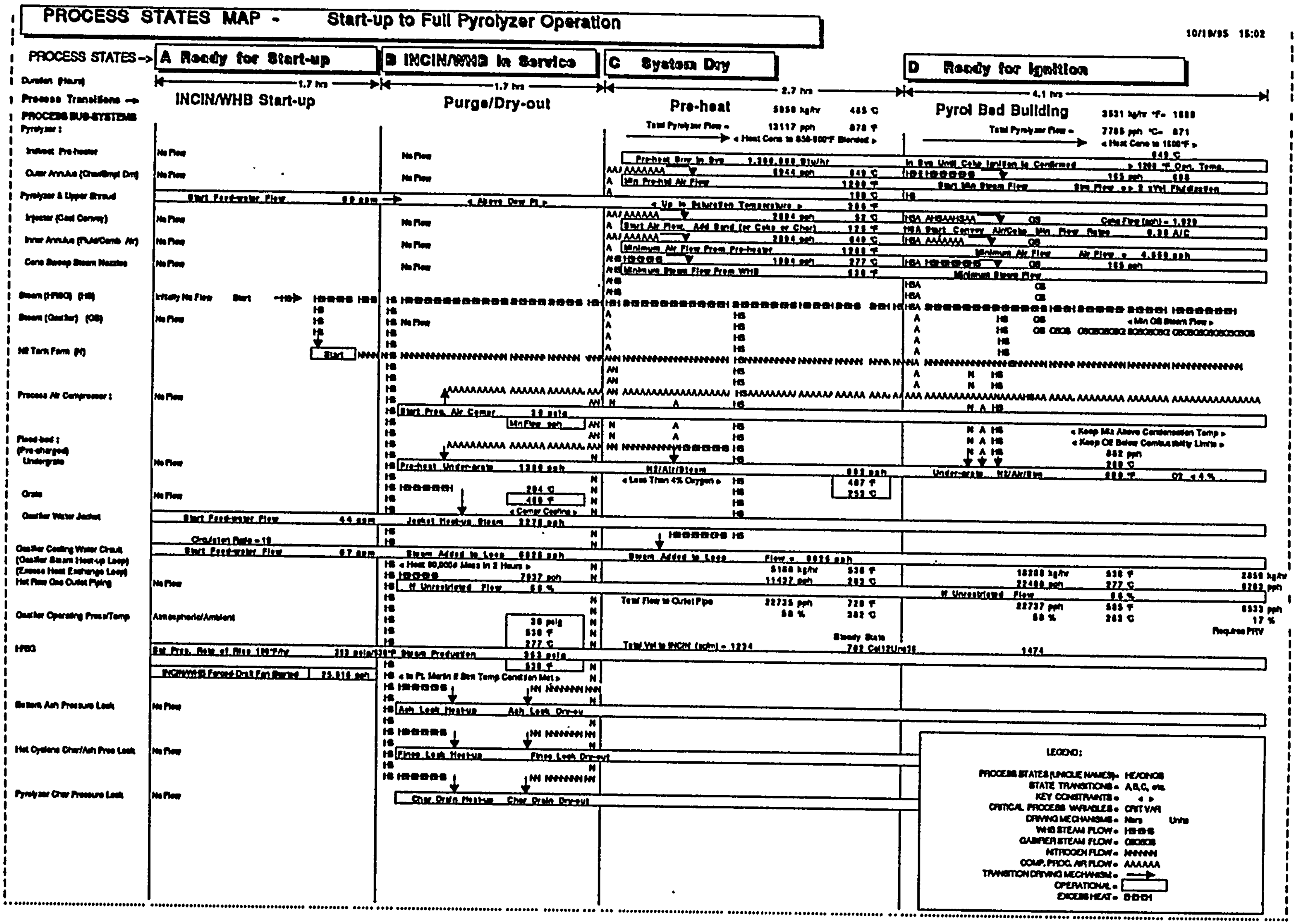
STATES /Sub-states (TRANSITIONS)	SUBSYSTEM STATUS	CONSTRAINTS
Bed-building **(Coke PH/Bed Bldg)**	Build coke bed in pyrolyzer sufficient to obtain coke ignition while continuing to pre-heat the pyrolyzer.Continue conveying coal/coke to completely fill the pyrolyzer. Shut down pyrolyzer cone pre-heater.	Coke feed rate. Solids entrainment velocity. Minimum fluidization velocity. Coke bed level below the water walls to minimize heat losses until ignition is achieved. Maintain sufficient oxygen to offset increased heat losses due to water walls. Maintain velocities below the point of jet penetration through the bed to prevent hot char carryover. Maintain temperatures above dew-point of sulfur when feeding coal.
E Pyrolyzer in Service	Char/Air/Steam feed to pyrolyzer.	Char inventory built.
Direct Grate Heating Hot Char **(Bed-Bldg/Grate Ign)**	Allow hot pyrolyzer char to overflow the pyrolyzer and fall onto the grate below. Operate grate for at least one revolution.	Pyrolyzer temperature >1200°F. Grate Oxygen concentration <4%. Assure hot char distribution.
F Fixed-bed Ignited	Char/Air/Steam feed to fixed-bed.	Several feet of hot char (at 1600°F) inventory built on fixed-bed.
Fixed-bed Building **(Grate Ign/Bed Bldg)**	Ignite fixed-bed. Start flow of air and steam under the grate. Pyrolyzer char overflowing.	Adjust air flow to retain the combustion zone within the bed (ie no oxygen breakthrough). Adjust steam to keep peak temperature below ash fusion temperature. Maintain grate rotation to ensure uniform solids bed temperature profile.

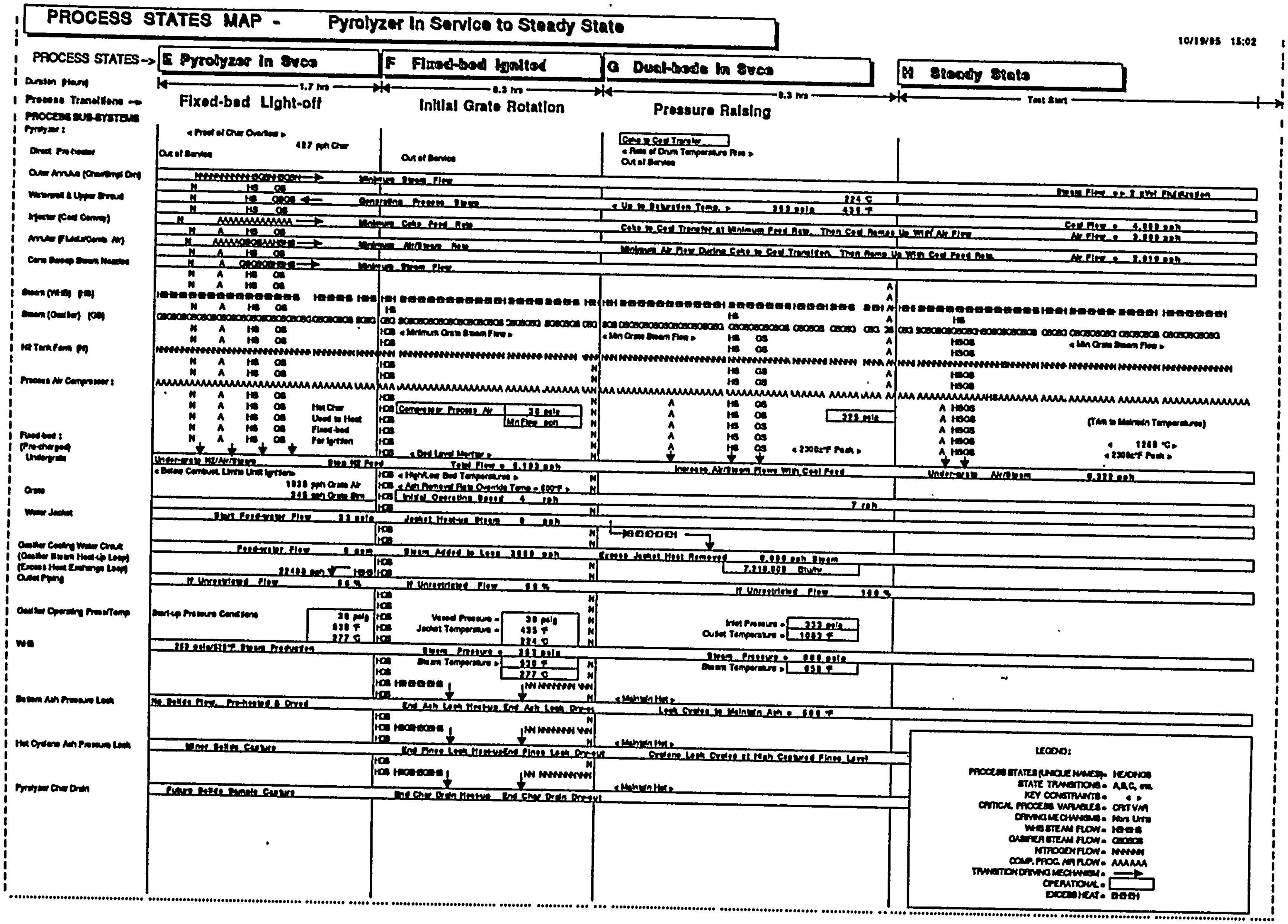
STATES /Sub-states **(TRANSITIONS)**	SUBSYSTEM STATUS	CONSTRAINTS
G Dual-beds in Service	Char/Air/Steam feed to pyrolyzer and fixed-bed.	Oxygen at outlet < 4% vol.
Pressure Ramp **(Bed Bldg/Pres Ramp)**	Incrementally increase the pressure by increasing throughput.	Fluidization air flow in fluid-bed. Stay below fines entrainment velocity. Avoid channeling in fixed-bed by maintaining sufficient grate steam flow to maintain peak fixed-bed temperatures below ash fusion temperature. Maintain water jacket and gasifier pressure balance. Adjust air flows in fixed-bed and air/coke ratio in pyrolyzer to compensate for higher wall temperatures and lower heat losses at lower pressures by maintaining set-point temperatures. coke feed ramp. Balance input flows in fixed-bed to prevent gases from penetrating the fixed-bed.
Coal Feed **(Pres Ramp/Coal Feed)**	Switching from coke to coal feed.	Adjust the coal/coke, air and steam flows in the nozzle to maintain desired reaction temperature. Maintain fluidization and sub-entrainment velocity in the pyrolyzer. Maintain desired pyrolyzer jet penetration momentum by operating at appropriate coal/air/steam flows.
H Steady State	All test load required systems in service.	No transients.
Gasification **(Coal Feed/Gasification)**	Low sulfur bituminous coal.	Adjust the grate speed to keep the bed level from raising above the shroud (high bed level) during tests which do not call for inner annulus solids inventory (initial tests). Adjust the grate air flow to consume carbon laden ash. Adjust grate steam flow to control peak fixed-bed temperature below the ash fusion temperature. Increase low solids bed-level by reducing grate speed. Raise peak fixed-bed temperature elevation by increasing grate air/steam flow. Lower peak fixed-bed temperature elevation by reducing grate air/steam flow (within ash carbon loss limitations).

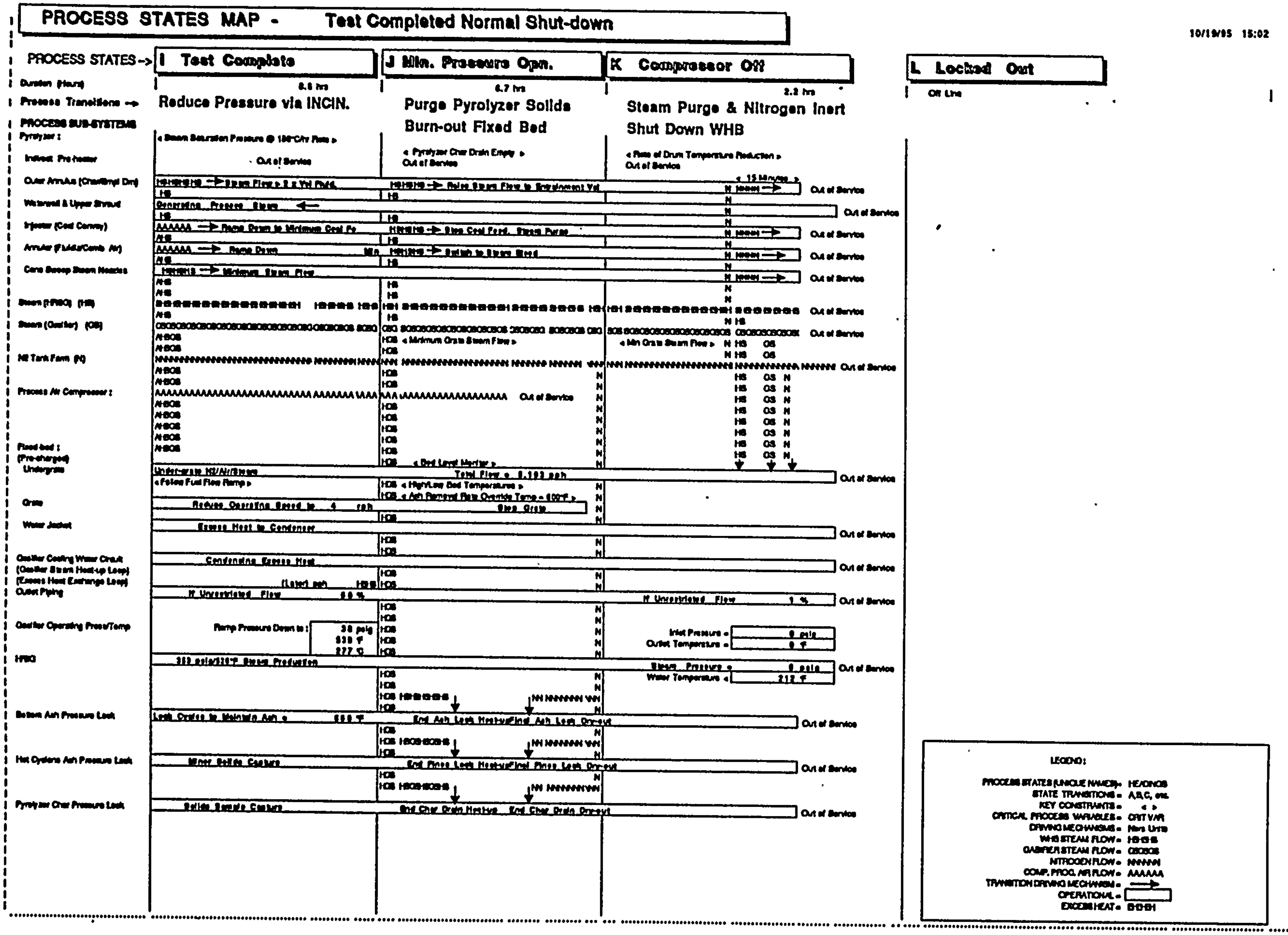
STATES /Sub-states (TRANSITIONS)	SUBSYSTEM STATUS	CONSTRAINTS
Hot Hold **(Stdy State/Min Opn)**	Minimum pyrolyzer coal feed & fluidization. Pyrolyzer air flow at minimum operating temperature. Minimized fixed-bed air, steam, & bottom ash (grate speed) flows.	Coal caking characteristics will affect minimum pyrolyzer velocities and operating temperature. When fixed-bed combustion zone moves up-ward to top of bed and temperature cannnot be maintained, stop under-grate air & steam flows. When fixed-bed temperature becomes reduced to below 800°F, abort test and stut-down.
Co-flow Bed Building **(Gasif/CF Bed Bldg)**	Adjust the grate speed to raise the fixed-bed level above the shroud.	Avoid high pressure drop in the inner annulus. Avoid filling outer annulus with solids to gasifier outlet gas nozzle.
Sub-bituminous Coal Gasification **(CF Bed Bldg/Sub-bit Gasif)**	Switching from coke to sub-bituminous coal.	Adjust the coal/coke, air and steam flows in the nozzle to maintain desired reaction temperature. Maintain fluidization and sub-entrainment velocity in the pyrolyzer. Maintain desired pyrolyzer jet penetration momentum by operating at appropriate coal/air/steam flows.
High Sulfur Bituminous Gasification **(CF Bed Bldg/Bit Coal Gasif)**	Switching from coke to high sulfur bituminous coal	Not an option unless previous testing with limestone proves sufficient sulfur capture, or previous testing with Phase II HGCU provided sufficient sulfur capture. Adjust the coal/coke, air and steam Coal flows in the nozzle to maintain desired reaction temperature. Maintain fluidization and sub-entrainment velocity in the pyrolyzer. Maintain desired pyrolyzer jet penetration momentum by operating at appropriate coal/air/steam flows.
Coal Plus Limestone Gasification **(Coal Gasif/Sorb Feed)**	Co-feeding of pressure lock with coke and limestone.	Wall temperatures above lime hydration temperature. Do not feed limestone at flow rates which produce low temperature eutectics when combined with coal ash (prior ash analysis information required).
Top Injection **(Sorb Feed/Top Air Injection)**	Introduce Air and/or steam into top injector.	Max. temperature below ash fusion temperature. Materials temperature constraint. Insure top air/steam injector has been added to system.

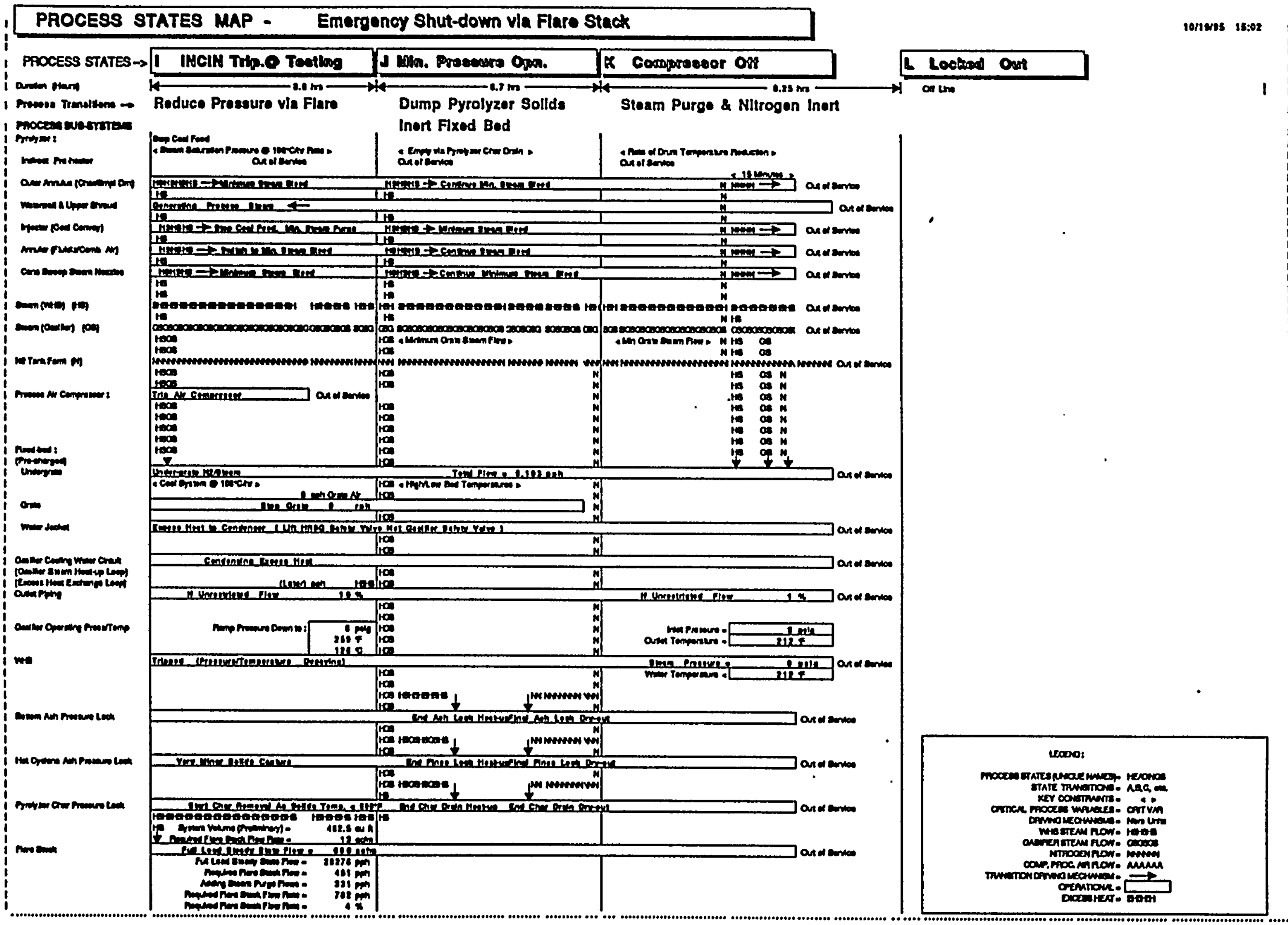
STATES /Sub-states (TRANSITIONS)	SUBSYSTEM STATUS	CONSTRAINTS
I Test Complete	All test load required systems in service.	No transients.
J Minimum Pressure Opn	Ramp down complete.	30 psig pressure.
Bed Burnout **(TA Inject/Bed Burn)**	Purge fluid-bed & burn-out fixed-bed. Produce a benign ash.	Low pressure operation similar to start-up sequence. Preclude mixing of reducing and oxidizing gases. Avoid entrainment of solids.
Controlled Shut-down General	Gradually reduce pressure and temperature by decreasing throughput.	Steam from gasifier drum used to balance pressure. Follow bed-burnout.
K Compresor Off	Coal feed also off.	Use superheated steam to gasifier outlet to maintain system pressure under controlled pressure ramp-down.
L Locked Out	All systems off.	Nitrogen inerted unless personnel entry is anticipated. System cooled to 150°F.
Controlled Emergency Shut-down via WHB **(Opn/Cntr Shut-dn WHB)**	Loss of Coal Feed	Follow NORMAL SHUT-DOWN procedure. Extend the process while attempting to reestablish coal feed.If cause is found and corrected, follow NORMAL START-UP procedure from appropriate STATUS STATE.
	Water Leak Into Gasifier Vessel	Follow NORMAL SHUT-DOWN procedure with HRSG incineration.
	High Gasifier Exit Gas Temperature Increasing steam flow has failed.	Follow NORMAL SHUT-DOWN procedure. Accelerate the process to reduce operating pressure to a safe level. If cause is found and corrected, follow NORMAL START-UP procedure from point of pressure raising.
	Loss of Gasifier Water Cooling	Follow NORMAL SHUT-DOWM procedure. Accelerate the process. If cause is found and corrected, follow NORMAL START-UP procedure from appropriate STATUS STATE.

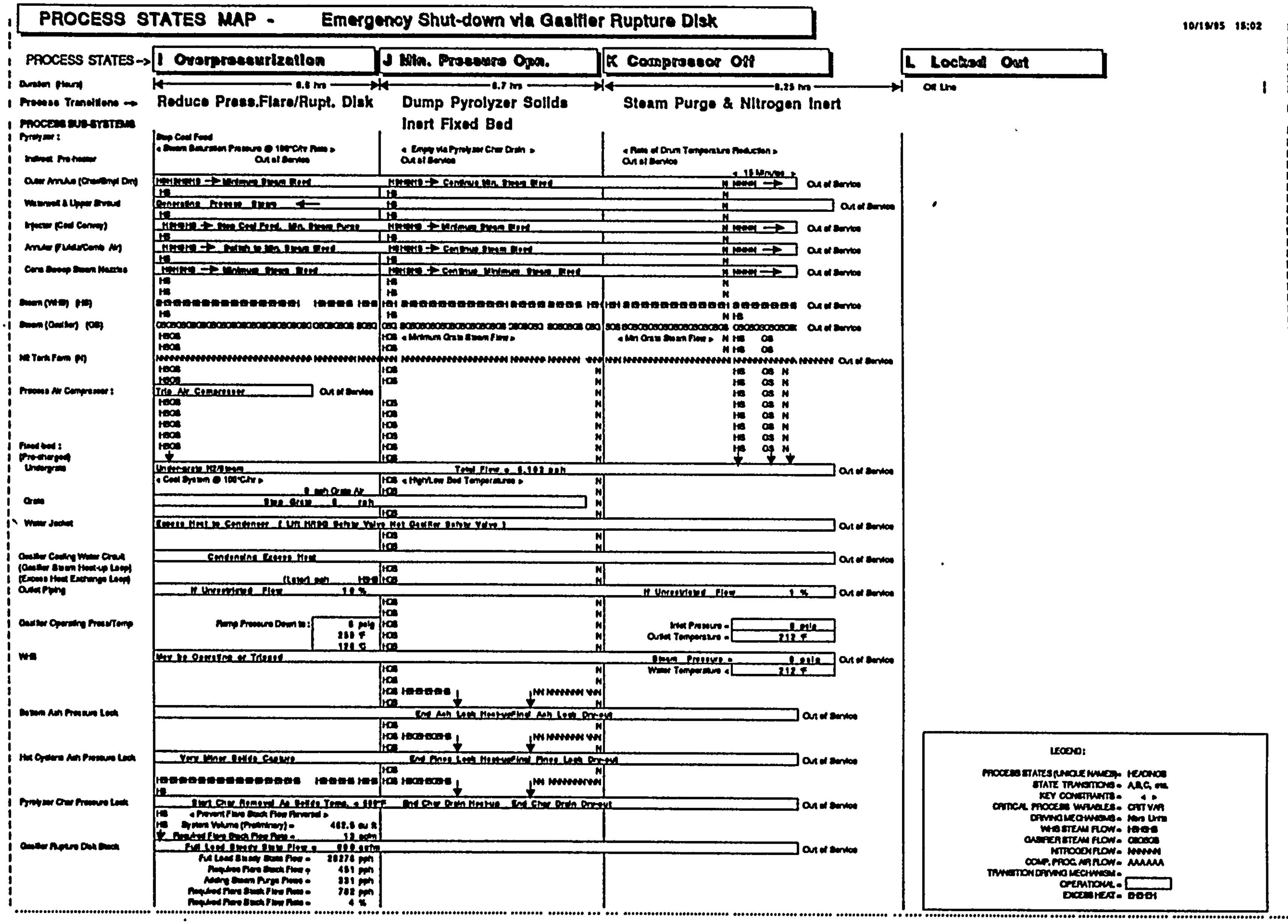
STATES /Sub-states (TRANSITIONS)	SUBSYSTEM STATUS	CONSTRAINTS
I WHB Trip	Could be anywhere in start-up.	Controlled emergency shutdown required. No further testing allowed.
Controlled Emergency Shut-down to Flare or Incinerator Dump Stack **(Opn/Cntr Shut-dn Flare)**	Ft. Martin Trip	Trip WHB. Trip air compressor. Follow NORMAL SHUT-DOWN procedure. Accelerate the process. If cause is found and corrected, follow NORMAL START-UP procedure from appropriate STATUS STATE.
	Loss of Ft. Martin Condensate	Trip Incin. Trip air compressor. Follow NORMAL SHUT-DOWN procedure. Accelerate the process. If cause is found and corrected, follow NORMAL START-UP procedure from appropriate STATUS STATE.
	Incinerator/WHB - Trip	Incinerator/WHB has tripped. Trip air compressor. Follow NORMAL SHUT-DOWN procedure. Accelerate the process. If cause is found and corrected, follow NORMAL START-UP procedure from appropriate STATUS STATE.
	Loss of Electric Power	Incinerator/WHB has tripped. Uninterruptable power source (UPS) backup system employed. Accelerate the process. If cause is found and corrected, follow NORMAL START-UP procedure from appropriate STATUS STATE.
I Overpressurization	Gasifier rupture disk has relieved. Flare stack control valve (or Incinerator stub stack) has opened, and flare stack (or incinerator stub stack) is in service.	Vent steam to gasifier to control pressure let-down ramp to 180°F per hour. Isolate and trip air compressor. Stop coal feed. Inert with nitrogen.


PROCESS STATES MAP - Start-up to Full Pyrolyzer Operation
10/19/95 15:02
PROCESS STATES->
A Ready for Start-up
B INCIN/WHB In Service
C System Dry
D Ready for Ignition
Duration (Hours)
1.7 hrs
1.7 hrs
2.7 hrs
4.1 hrs
Process Transitions ->
INCIN/WHB Start-up
Purge/Dry-out
Pre-heat
Pyrol Bed Building
PROCESS SUB-SYSTEMS
Pyrolyzer:
Indirect Pre-heater
Outer Annulus (Char/Empt Drn)
Pyrolyzer & Upper Shroud
Injector (Coal Convey)
Inner Annulus (Fluid/Comb Air)
Cone Sweep Steam Nozzles
Steam (HRSG) (HS)
Steam (Gasifier) (GS)
N2 Tank Farm (N)
Process Air Compressor:
Fluid bed:
(Pre-charged)
Undergrate
Grate
Gasifier Water Jacket
Gasifier Cooling Water Circuit
(Gasifier Steam Heat-up Loop)
(Excess Heat Exchange Loop)
Hot Raw Gas Outlet Piping
Gasifier Operating Press/Temp
HRSG
Bottom Ash Pressure Lock
Hot Cyclone Char/Ash Press Lock
Pyrolyzer Char Pressure Lock
No Flow
Atmospheric/Ambient
Start Feed-water Flow
Start Pres. Air Compr
Pre-heat Undergrate
Jacket Heat-up Steam
Steam Added to Loop
Ash Lock Heat-up
Ash Lock Dry-out
Fines Lock Heat-up
Fines Lock Dry-out
Char Drain Heat-up
Char Drain Dry-out
Total Flow to Outlet Pipe
Steady State
Requires PRV
LEGEND:
PROCESS STATES (UNIQUE NAMES) = HEADINGS
STATE TRANSITIONS = A,B,C, etc.
KEY CONSTRAINTS = < >
CRITICAL PROCESS VARIABLES = CRIT VAR
DRIVING MECHANISMS = Nars Units
WHB STEAM FLOW = HSHS
GASIFIER STEAM FLOW = GSGS
NITROGEN FLOW = NNNN
COMP. PROC. AIR FLOW = AAAAA
TRANSITION DRIVING MECHANISM =
OPERATIONAL =
EXCESS HEAT = SHSH


PROCESS STATES MAP - Pyrolyzer In Service to Steady State
10/19/95 15:02
PROCESS STATES->
E Pyrolyzer In Svce
F Fixed-bed Ignited
G Dual-beds In Svce
H Steady State
Duration (Hours)
Process Transitions ->
Fixed-bed Light-off
Initial Grate Rotation
Pressure Raising
Test Start
PROCESS SUB-SYSTEMS
Pyrolyzer :
Direct Pre-heater
Outer Annulus (Char/Emp! Drn)
Waterwall & Upper Shroud
Injector (Coal Convey)
Annular (Fluidiz/Comb Air)
Cone Sweep Steam Nozzles
Steam (WHB) (HS)
Steam (Gasifier) (GS)
N2 Tank Farm (N)
Process Air Compressor :
Fixed-bed : (Pre-charged) Undergrate
Grate
Water Jacket
Gasifier Cooling Water Circuit (Gasifier Steam Heat-Up Loop) (Excess Heat Exchange Loop) Outlet Piping
Gasifier Operating Press/Temp
WHB
Bottom Ash Pressure Lock
Hot Cyclone Ash Pressure Lock
Pyrolyzer Char Drain
Out of Service
Hot Char Used to Heat Fixed-bed For Ignition
Compressor Process Air
Start-up Pressure Conditions
Vessel Pressure =
Jacket Temperature =
Inlet Pressure =
Outlet Temperature =
Steam Pressure =
Steam Temperature =
Increase Air/Steam Flows With Coal Feed
LEGEND:
PROCESS STATES (UNIQUE NAMES)= HEADINGS
STATE TRANSITIONS= A,B,C, etc.
KEY CONSTRAINTS= < >
CRITICAL PROCESS VARIABLES= CRIT VAR
DRIVING MECHANISMS= Non Units
WHB STEAM FLOW= HSHSHS
GASIFIER STEAM FLOW= GSGSGS
NITROGEN FLOW= NNNNNN
COMP. PROC. AIR FLOW= AAAAAA
TRANSITION DRIVING MECHANISM=
OPERATIONAL=
EXCESS HEAT= EHEHEH


PROCESS STATES MAP - Test Completed Normal Shut-down
10/19/95 15:02
PROCESS STATES->
I Test Complete
J Min. Pressure Opn.
K Compressor Off
L Locked Out
Duration (Hours)
Process Transitions ->
PROCESS SUB-SYSTEMS
Reduce Pressure via INCIN.
Purge Pyrolyzer Solids
Burn-out Fixed Bed
Steam Purge & Nitrogen Inert
Shut Down WHB
Off Line
Pyrolyzer :
Indirect Pre-heater
Outer Annulus (Char/Smpl Drn)
Waterwall & Upper Shroud
Injector (Coal Convey)
Annular (Fluidiz/Comb Air)
Core Sweep Steam Nozzles
Steam (HRSG) (HS)
Steam (Gasifier) (GS)
N2 Tank Farm (N)
Process Air Compressor :
Fixed-bed :
(Pre-charged)
Undergrate
Grate
Water Jacket
Gasifier Cooling Water Circuit
(Gasifier Steam Heat-up Loop)
(Excess Heat Exchange Loop)
Outlet Piping
Gasifier Operating Press/Temp
HRSG
Bottom Ash Pressure Lock
Hot Cyclone Ash Pressure Lock
Pyrolyzer Char Pressure Lock
Out of Service
Generating Process Steam
Ramp Down to Minimum Coal Fe
Ramp Down
Minimum Steam Flow
Undergrate N2/Air/Steam
Reduce Operating Speed to 4 rph
Excess Heat to Condenser
Condensing Excess Heat
N Unrestricted Flow
Ramp Pressure Down to
Steam Production
Minor Solids Capture
Solids Sample Capture
Slow Coal Feed, Steam Purge
Switch to Steam Bleed
Minimum Grate Steam Flow
Bed Level Monitor
Total Flow
High/Low Bed Temperatures
Ash Removal Rate Override Temp
Slow Grate
End Ash Lock Heat-up/Final Ash Lock Dry-out
End Fines Lock Heat-up/Final Fines Lock Dry-out
End Char Drain Heat-up
End Char Drain Dry-out
Min Grate Steam Flow
15 Minutes
Inlet Pressure =
Outlet Temperature =
Steam Pressure =
Water Temperature =
LEGEND:
PROCESS STATES (UNIQUE NAMES) = HEADINGS
STATE TRANSITIONS = A,B,C, etc.
KEY CONSTRAINTS = < >
CRITICAL PROCESS VARIABLES = CRIT VAR
DRIVING MECHANISMS = Fwd Units
WHB STEAM FLOW = HSHS
GASIFIER STEAM FLOW = GSGSGS
NITROGEN FLOW = NNNNN
COMP. PROC. AIR FLOW = AAAAAA
TRANSITION DRIVING MECHANISM =
OPERATIONAL =
EXCESS HEAT = EHEH

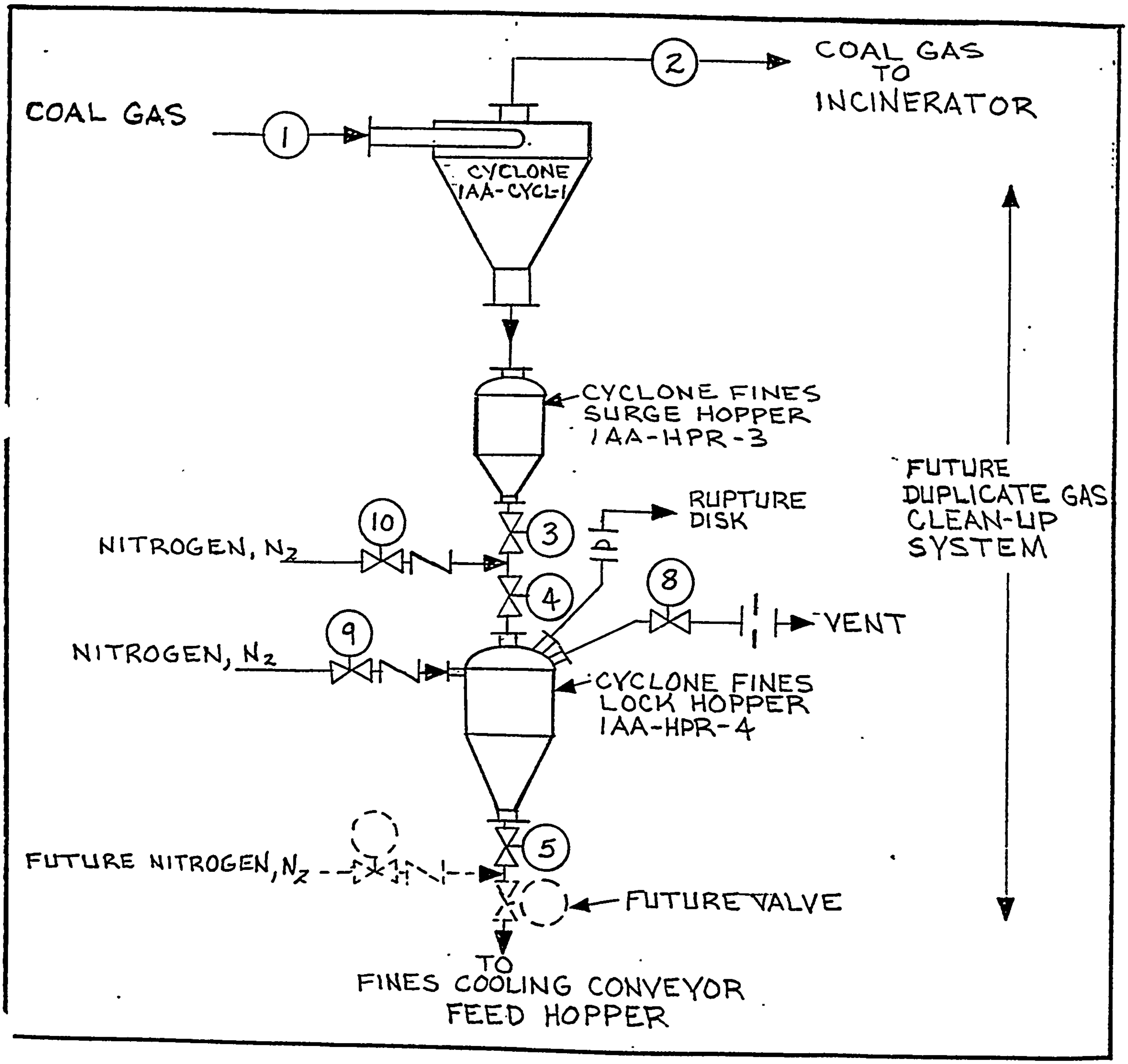

PROCESS STATES MAP - Emergency Shut-down via Flare Stack
10/19/95 15:02
PROCESS STATES
I INCIN Trip.@ Testing
J Min. Pressure Opn.
K Compressor Off
L Locked Out
Duration (Hours)
Off Line
Process Transitions
Reduce Pressure via Flare
Dump Pyrolyzer Solids
Inert Fixed Bed
Steam Purge & Nitrogen Inert
PROCESS SUB-SYSTEMS
Out of Service
Total Flow
Excess Heat to Condenser
Condensing Excess Heat
Ramp Pressure Down to:
Inlet Pressure
Outlet Temperature
Water Temperature
End Ash Lock Heatup/Final Ash Lock Dry-out
LEGEND:
PROCESS STATES (UNIQUE NAMES)
STATE TRANSITIONS
KEY CONSTRAINTS
CRITICAL PROCESS VARIABLES
DRIVING MECHANISMS
OPERATIONAL
EXCESS HEAT


PROCESS STATES MAP - Emergency Shut-down via Gasifier Rupture Disk
10/19/95 15:02
PROCESS STATES ->
I Overpressurization
J Min. Pressure Opn.
K Compressor Off
L Locked Out
Duration (Hours)
Off Line
Process Transitions ->
Reduce Press.Flare/Rupt. Disk
Dump Pyrolyzer Solids Inert Fixed Bed
Steam Purge & Nitrogen Inert
PROCESS SUB-SYSTEMS
Pyrolyzer :
Indirect Pre-heater
Outer Annulus (Char/Ppl Drn)
Waterwall & Upper Shroud
Injector (Coal Convey)
Annular (Fluidiz/Comb Air)
Cone Sweep Steam Nozzles
Steam (WHB) (HS)
Steam (Gasifier) (GS)
N2 Tank Farm (N)
Process Air Compressor :
Fixed bed :
(Pre-charged)
Undergrate
Grate
Water Jacket
Gasifier Cooling Water Circuit
(Gasifier Steam Heat-up Loop)
(Excess Heat Exchange Loop)
Outlet Piping
Gasifier Operating Press/Temp
WHB
Bottom Ash Pressure Lock
Hot Cyclone Ash Pressure Lock
Pyrolyzer Char Pressure Lock
Gasifier Rupture Disk Stack
Stop Coal Feed
Out of Service
Trip Air Compressor
Condensing Excess Heat
Ramp Pressure Down to :
Inlet Pressure =
Outlet Temperature =
Water Temperature <
Very Minor Solids Capture
Full Load Steady State Flow =
Required Flare Stack Flow =
Adding Steam Purge Flow =
LEGEND:
PROCESS STATES (UNIQUE NAMES) = HEADINGS
STATE TRANSITIONS = A,B,C, etc.
KEY CONSTRAINTS = < >
CRITICAL PROCESS VARIABLES = CRIT VAR
DRIVING MECHANISMS = Non Units
WHB STEAM FLOW = HSHSHS
GASIFIER STEAM FLOW = GSGSGS
NITROGEN FLOW = NNNNNN
COMP. PROC. AIR FLOW = AAAAAA
TRANSITION DRIVING MECHANISM =
OPERATIONAL =
EXCESS HEAT = EHEHEH

SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1AA-2

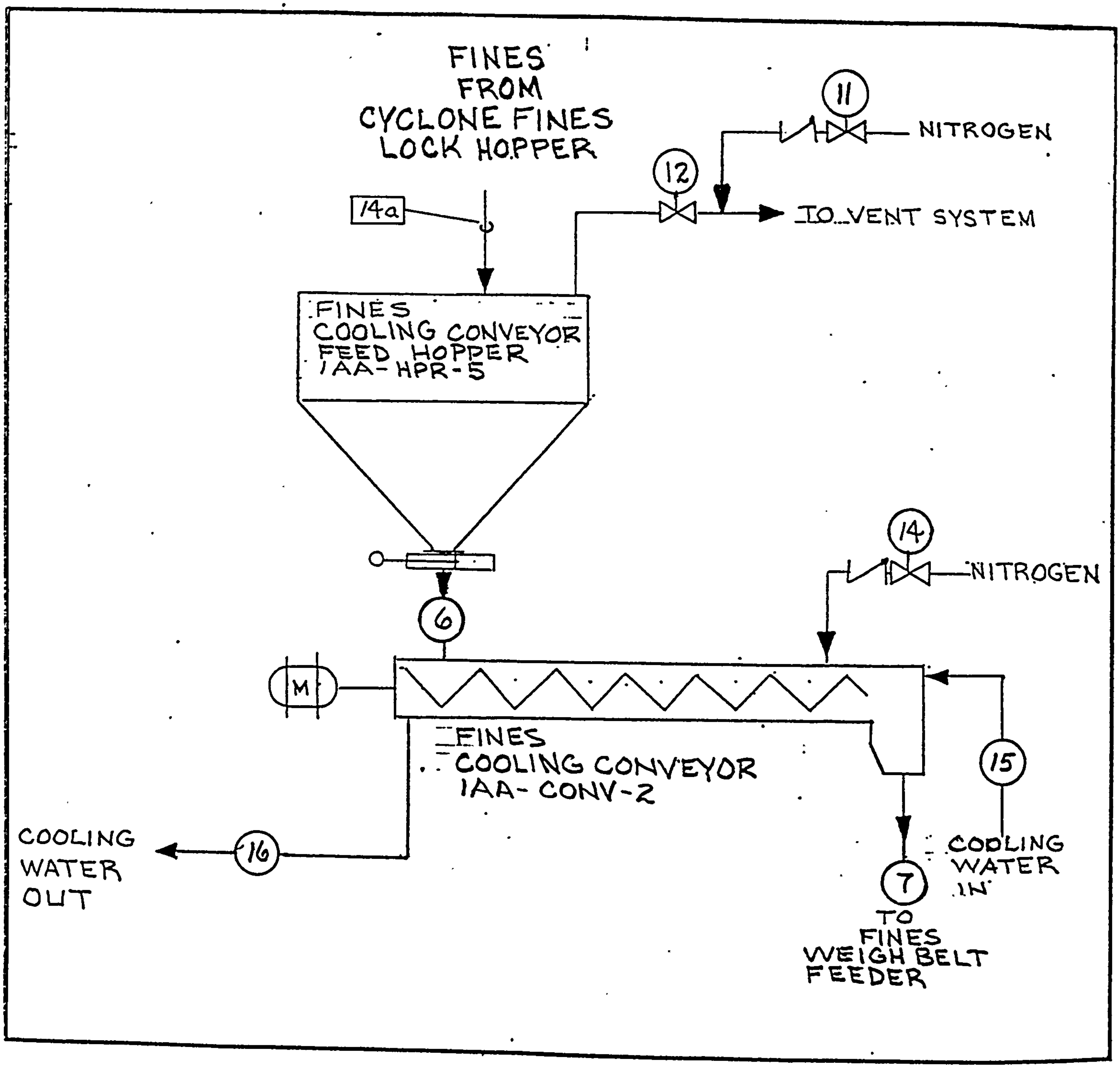
System Name Gas Clean Up System
Flowsheet No. 16N25706-40-F-1AA-002



SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1AA-2

System Name Gas Clean Up System
Flowsheet No. 16N25706-40-F-1AA-002



SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-2

System Name: Gas Clean-Up System
Flowsheet No.: 16N25706-40-F-1AA-002

I. DESIGN PHILOSOPHY

1. The purpose of the Gas Clean-Up System is to remove gasifier char fines from the coal gas stream. The fines are removed from the gas stream by a cyclone prior to the gas entering the incinerator.

2. Space for a future backup cyclone system has been saved in the building.

3. Each cyclone is designed to the following specifications:

a.	Coal Gas Flow Rate	=	18,878 Lbs./Hr.	(19,822 Lbs./Hr. Maximum. See Note 9 Under Design Notes)
b.	Fines Flow Rate to Cyclone	=	83 Lbs./Hr. 500 Lbs./Hr.	(Normal) (Maximum)
c.	Total Gas and Fines	=	18,961 Lbs./Hr. 20,322 Lbs./Hr.	(Normal) (Maximum)
d.	Actual Cubic Feet Per Minute	=	665 ACFM @ 18,878 lbs/hr	
e.	Temperatures:			
	Normal	=	1023°F	
	Maximum	=	1100°F	
f.	Pressure: To Cyclone			
	Normal	=	324 PSIG	
	Maximum	=	420 PSIG	
g.	Fines Removal Efficiency (Actual will be Based on Vendor Selection)	=	90%	

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-2

System Name: Gas Clean-Up System
Flowsheet No.: 16N25706-40-F-1AA-002

h. Fines Particle Size Distribution

Diameter MM	Microns	Weight % Less Than
0.180	180	100
0.150	150	91
0.125	125	84
0.106	106	80
0.073	73	67
0.043	43	53
0.010	10	31

i. Solids Particle Density = 60 Lb./Ft.^{3}

j. Gas Composition

	Inlet Gas Wt %
CO	25.41
H_2	1.39
CO_2	10.48
H_2O	11.23
CH_4	0.50
H_2S	0.64
N_2	48.97
AR	1.10
NH_3	0.28
	100.00

k. Gas Molecular Weight = 23.25

l. Materials of Construction:

Shell - Carbon Steel

Lining (Approximate) - 3" refractory layer for insulation and 3" refractory layer for abrasion (assuming a cyclone outside metal surface temperature of less than 270°F)

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-2

System Name: Gas Clean-Up System
Flowsheet No.: 16N25706-40-F-1AA-002

Outlet Tube -	Stainless Steel
Inlet Nozzle -	Refractory lined transition, round to rectangular

The exact material thicknesses will be determined by vendor.

m. Pressure drop across the cyclone will be determined by vendor at time of purchase.

4. Gasifier char fines that discharge from the bottom of the cyclone are collected in a Cyclone Fines Lock Hopper. Fines from the lock hopper fall into a Fines Cooling Conveyor Feed Hopper where they are fed to and cooled by the Fines Cooling Conveyor. Cooled fines discharge onto a Cyclone Fines Weigh Belt Feeder for weighing and conveying into the Ash Bucket Elevator. Samples of the fines are also taken from the weigh belt feeder.

   The Ash Bucket Elevator delivers a mixture of fines and bottom ash to an Ash Silo. The fines/ash mixture flows through a dustless rotary conditioner and falls into a truck for delivery to a landfill.

   This process design basis document ends at the outlet of the Fines Cooling Conveyor as shown on pages 1 and 2. (See Process Design Basis 40-1AA-4 for weight belt feeder, bucket elevator an aisle silo.)

5. The following is a description of the Gas Clean-Up System Operation.

   a. Cyclone Fines Collecting System

      1) Start fines cooling conveyor. Open cooling water supply valve(s) to conveyor (line 15 on sketch, page 2).

      2) The initial starting of the Cyclone Fines Lock Hopper requires a hopper warm-up sequence that brings the hopper's internal temperature to a temperature approaching that of the hot nitrogen. All valves surrounding the lock hopper are closed except the nitrogen fill Valve 9 and the lock hopper vent Valve 8. This allows hot nitrogen to pass through the lock hopper for vessel warming.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-2

System Name: Gas Clean-Up System
Flowsheet No.: 16N25706-40-F-1AA-002

3) After initial hopper warm-up the vent Valve 8 is closed while the nitrogen Valve 9 remains open to fill the hopper to its required internal pressure. This pressure will be 2 PSI to 10 PSI below the cyclone operating pressure to induce fines flow to the lock hopper and minimize fines re-entrainment when gas is displaced by solids. Once pressure is reached nitrogen Valve 9 is closed.

4) Positive pressure sealing inlet Valve 4 is opened then inlet Valve 3 is opened to allow cyclone fines to fall into the lock hopper.

5) When hopper level has reached its desired height of 70% full, inlet Valve 3 is closed followed by positive pressure sealing inlet Valve 4. Lock hopper filling time is based on percent of rated load of gasifier and lock hopper volume and will vary with cyclone particulate loading. (See Note 4).

6) After Valves 3 and 4 are closed and the lock hopper is going through its normal fines removal cycle, fines are collecting in the cyclone fines surge hopper located between the cyclone and lock hopper inlet Valve 3.

7) The cyclone fines surge hopper collects cyclone fines during the lock hopper's depressurizing and dumping cycle. The surge hopper will have the capacity to store as a minimum the quantity of fines that collect during one lock hopper dump cycle. Re-entrainment of fines by the cyclone's vortex action is also prevented by having the surge hopper located below the cyclone fines outlet. Fines re-entrainment is prevented due to the fact that a cyclone vortex is broken and unable to reach down into the surge hopper.

8) Open vent Valve 8 to vent remaining nitrogen/coal gas mixture to vent system. Vent Valve 8 remains open while the lock hopper's internal pressure is reduced to 2 psig or less.

9) After pressure constraint is met, open positive sealing dump Valve 5 allowing fines to drop into Fines Cooling Conveyor Feed Hopper. Space has been allocated for a future sealing valve located downstream of Valve 5 as shown on drawing on page 1.

10) When the lock hopper is indicated as empty, close dump Valve 5.

SYSTEM PROCESS DESIGN BASIS
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System Name Gas Clean-Up System
Flowsheet No. 16N25706-40-F-1AA-002

11) The lock hopper cycle time that is required to size the Cyclone Fines Surge Hopper will initially be established by approximation calculations on the lock hopper's vent line. An orifice in the vent line can be field modified based on actual operating tests to increase or decrease lock hopper venting time, therefore minimizing fines carryover to the vent system.

12) Open nitrogen fill Valve 9 allowing the lock hopper and vent line to purge for 5 to 10 seconds.

13) Close vent Valve 8 and allow the cyclone fines lock hopper to repressurize starting the cycle over.

14) The cyclone lock hopper and surge hopper will be designed for the same maximum pressure and temperature as the gasifier.

15) At this time fines have been deposited into the low pressure, Fines Cooling Conveyor Feed Hopper. This hopper will be sized to hold 1.5 times the volumetric capacity of the fines lock hopper. The equipment above the feed hopper is going through another cycle. The feed hopper is equipped with a vent Valve 12. If a plug occurs, nitrogen Valve 13 can be opened after Valve 12 is opened to facilitate unplugging hopper. If cracked open Valves 12 and 13 can also be used to cool the fines before they are delivered to the cooling conveyor. Care must be taken to prevent excessive nitrogen flow because of potential fines re-entrainment and carryover to the vent system.

16) Fines are removed from the feed hopper by a water cooled, screw type fines cooling conveyor. Fines will be removed at a maximum rate of 500 lbs./hr. and will be cooled from 1100°F maximum to 200°F before being discharged to a weigh belt feeder. Cooling water at a flow determined after equipment purchase will be used to cool the conveyor's screw and outer jacket. The fines cooling conveyor is driven by a variable speed drive.

b. Interlocks

Interlocks are provided to help prevent inadvertent sequencing of the cyclone fines lock hopper valves. The interlocks are as follows:

1) The lock hopper fines dump Valve 5 cannot open until pressure in lock hopper is less than 2 psig.

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PDB No. 40-1AA-2

System Name Gas Clean-Up System
Flowsheet No. 16N25706-40-F-1AA-002

2) Lock hopper fines dump Valve 5 cannot open if nitrogen fill Valve 9 is open.

3) Lock hopper fines dump Valve 5 cannot open unless vent Valve 8 is open.

4) Lock hopper fines dump Valve 5 and lock hopper fines inlet Valves 3 and 4 cannot be open at the same time.

5) Lock hopper fines inlet Valves 3 and 4 cannot open if nitrogen fill Valve 9 is open.

6) Lock hopper fines inlet Valves 3 and 4 and lock hopper vent Valve 8 cannot be opened at the same time.

7) The nitrogen fill Valve 9 cannot be opened if the lock hopper fines inlet Valve 4 or the lock hopper fines dump Valve 5 is open.

8) Lock hopper fines inlet Valve 3 cannot be opened until lock hopper fines positive sealing Valve 4 has been opened.

9) Dump Valve 5 cannot be opened if water (Line 15) is not proven to fines cooling conveyor screw and conveyor motor is not operating (screw is not turning).

10) Dump Valve 5 cannot be opened if low pressure nitrogen Valve 14 is closed.

11) The weigh belt feeder and bucket elevator motors will be interlocked to start when fines cooling conveyor motor starts.

12) Loss of electricity or instrument air pressure will cause the cyclone fines lock hopper to depressurize by opening vent Valve 8.

c. Miscellaneous

1) Nitrogen Valves 10 and 11 are used to purge or unplug fine lines or valves.

2) The operator should use caution when using these valves.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-2

System Name Gas Clean-Up System
Flowsheet No. 16N25706-40-F-1AA-002

II. DESIGN CRITERIA

ITEM	GAS CLEAN-UP SYSTEM - NORMAL 400# GASIFIER OPERATION									
Item No.	Process Stream	Maximum Flow		Normal Flow		Minimum Flow		Maximum Temp °F	Normal Temp. °F	Maximum Pressure PSIG	Normal Pressure PSIG
		Gas	Fines	Gas	Fines	Gas	Fines				
1	Coal Gas to Cyclone	* 20.32 M Note 9	500 Lb/Hr	*18.878 M	83 Lb/Hr	* M Note 3	Note 3	1100 Note 1	1023	440	324 Note 10
2	Coal Gas to Incinerator	* 20.32 M Note 9	150 Lb/Hr Note 8	*18.878 M	8 Lb/Hr Note 7	Note 3	Note 3	1100 Note 1	1023	440	321 Note 11
3	Cycl. Fines L.H. Inlet	500 Lb/Hr Note 4		75 Lb/Hr		____ Lb/Hr		1100 Note 1	1023	440	321
4	Cycl. Fines L.H. Inlet	500 Lb/Hr Note 4		75 Lb/Hr		____ Lb/Hr		1100 Note 1	1023	440	321
5	Cycl. Fines L.H. Dump	500 Lb/Hr Note 4		75 Lb/Hr		____ Lb/Hr		1100 Note 1	1023	Note 2	0
6	Cycl. Fines to Cooling Conveyor	500 Lb/Hr Note 4		75 Lb/Hr		____ Lb/Hr		1100 Note 1	1023	10	0
7	Cycl. Fines to Weigh Belt Feeder	500 Lb/Hr Note 4		75 Lb/Hr				220	200	10	0
8	Cycl. Fines L.H. Vent	Note 5		Note 5				1100 Note 1	1023	440	322 Note 13
9	Cycl. Fines L.H. Nitrogen Fill	Note 6		Note 6				465	Hold	374	324
10	Nitrogen Purge - HP	Note 6		Note 6				465	Hold	374	324
11	Nitrogen Purge - LP	Note 6		Note 6				100	Hold	10	2
12	Fines Cooling Conv. F.H. Vent	Hold		Hold		Hold		1100	1023	10	2
13	Nitrogen Purge - LP	Note 6		Note 6				100	Hold	10	2
14	Nitrogen Purge - LP	Note 6		Note 6				100	Hold	10	2
15	Cooling Water In	Note 12		Note 12		Note 12		Hold	Hold	100	Hold
16	Cooling Water Out	Note 12		Note 12		Note 12		Hold	Hold	100	Hold

* M = 1000 Lb/hr

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-2

System Name: Gas Clean-Up System
Flowsheet No.: 16N25706-40-F-1AA-002

II. DESIGN CRITERIA - Continued

The fines lock hopper system is designed to the following design criteria:

1. Fines Particles:

   Fines Particle Density = 60 Lb/Ft^3
   Fines Bed Density = 25 Lb/Ft^3

   Note: Particle and bed density is assumed. 25 Lb/Ft^3 is based on an assumed voidage of 0.58.

2. Lock hopper and surge hopper will be fabricated from refractory lined carbon steel or non-refractory lined stainless steel per most economical design. If refractory is used the lock hopper's skin temperature will not exceed 240°F. Interconnecting piping will be made of stainless steel.

3. The lock hopper and surge hopper outlet cones will have an angle of 70° from horizontal to help ash flow.

4. Ash Composition:

   "Later"

5. Expected composition at expected normal output.

C	52 Lb/Hr
CaO	0 Lb/Hr
Inerts	23 Lbs/Hr
Total Solids	75 Lb/Hr

   Composition at normal output taken from 325 psig mass balance dated 5-31-95, stream 14a.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-2

System Name Gas Clean-Up System
Flowsheet No. 16N25706-40-F-1AA-002

III. DESIGN NOTES

1. 1100°F is based on maximum upset temperature from gasifier.

2. Cyclone fines lock hopper dump valve must hold against maximum pressure in cyclone which is 440 psig. The valve will open normally against 2 psig or less after lock hopper is vented.

3. From 200 psig mass balance. Note: This column does not show minimums at 200 psig operation.

4. 500 Lb./Hr. of fines is the anticipated maximum flow from the cyclone to the lock hopper. 75 Lb./Hr. is the anticipated normal flow to the lock hopper based on the May 31, 1995 mass balance. The lock hopper will be designed for three dump cycles per hour at the 500 Lb./Hr. flow rate. This equates to 167 Lb./Hr. per cycle, at a normal level of 70% full in the lock hopper. The calculated lock hopper size (based on 500 Lb./Hr.) will yield 2.2 hours between cycles at the normal flow rate of 75 Lb./Hr. Operating experience based on actual fines flow will show the optimum cycle time for the lock hopper. It is anticipated that one dump cycle per hour or 167 Lb./Hr. of fines would be optimum for fines removal and minimal valve cycle time.

5. The vent time for a dump cycle will be calculated based on a 1/4" orifice located in the vent pipe adjacent to the lock hopper. The orifice will set the depressurization time and the dump cycle time.

6. Nitrogen fill time of lock hopper will be based on 1/2" pipe and valve(s). Nitrogen purge will be accomplished with 1/2" pipe and valve(s). Pipe and valve size will be re-evaluated based on line loss due to routing.

7. 8 Lb./Hr. based on 90% efficiency from cyclone. Actual efficiency and mass carryover from cyclone will be determined during cyclone purchase.

8. 150 Lb./Hr. based on assumed derated cyclone efficiency of 70%.

9. 20,320 Lb./Hr. includes a 5% margin for equipment sizing on normal coal gas flow of 18,878 Lb./Hr. (stream 12 on mass balance dated June 1, 1995 plus 500 Lb./Hr. of fines in gas, i.e., 1.05 x 18,878 = 19,822 + 500 = 20,320.

10. 324 psig taken from mass balance dated May 31, 1995, Stream No. 10L.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-2

System Name: Gas Clean-Up System
Flowsheet No.: 16N25706-40-F-1AA-002

11. Assuming 3 psi pressure drop across the Cyclone (324 psig-3 psig = 321 psig).

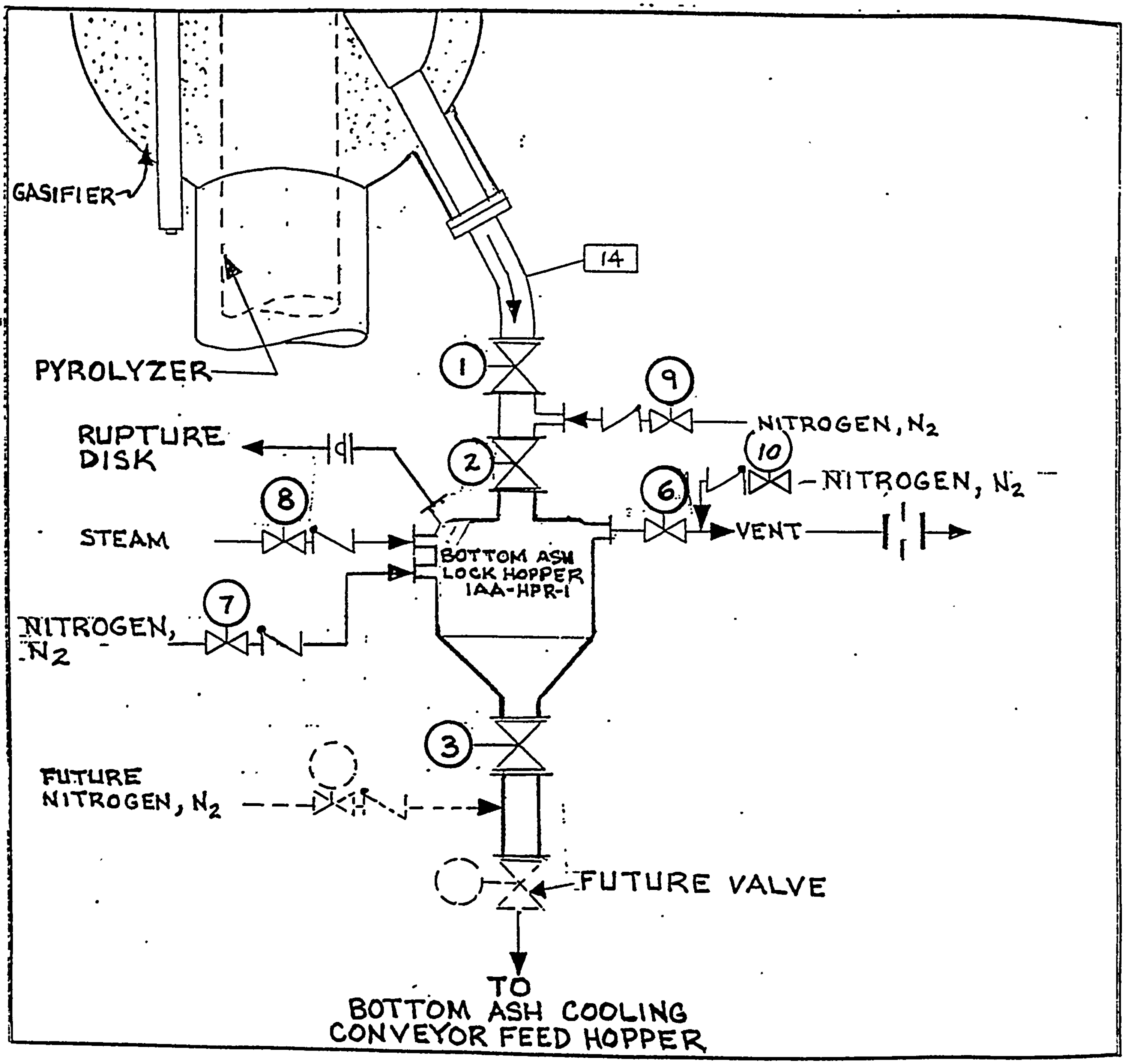
12. Flow requirements after equipment purchase.

13. Pressure in lock hopper is normally 2 to 10 psig (field adjustable) below cyclone pressure.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1AA-3

System Name Gasifier Ash Handling (Botton Ash Lock Hopper,Bottom Ash Cooling Conveyor Feed Hopper, and Bottom Ash Cooling Conveyor)

Flowsheet No. 16N25706-40-F-1AA-004

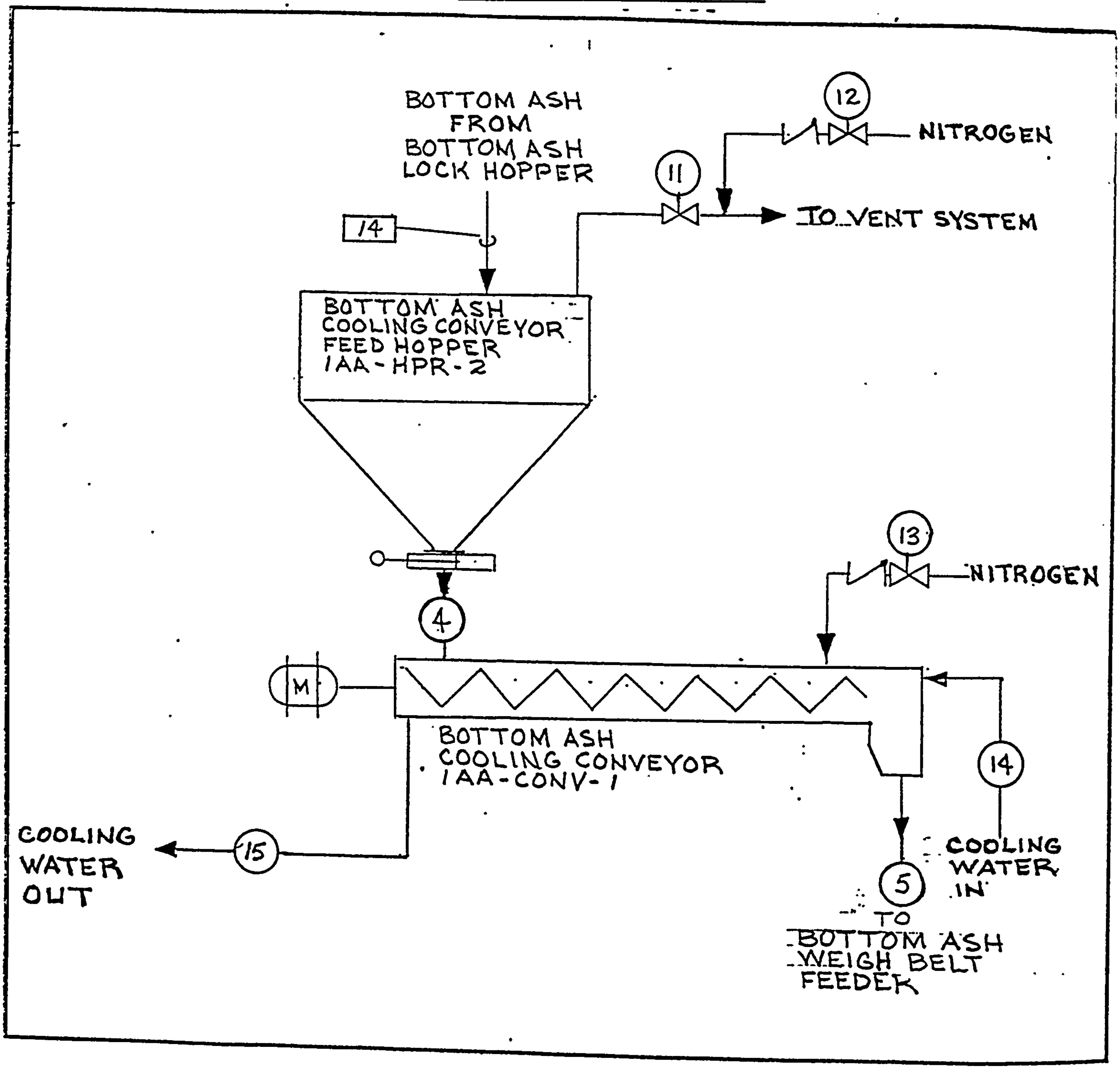


SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1AA-3

System Name Gasifier Ash Handling (Botton Ash Lock Hopper,Bottom Ash Cooling Conveyor Feed Hopper, and Bottom Ash Cooling Conveyor)

Flowsheet No. 16N25706-40-F-1AA-004



SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-3

System Name: Gasifier Ash Handing (Bottom Ash Lock Hopper, Bottom Ash Cooling Conveyor Feed Hopper, and Bottom Ash Cooling Conveyor)

Flowsheet No.: 16N25706-40-F-1AA-004

I. DESIGN PHILOSOPHY

1. The Gasifier Ash Handling System is made-up of several key pieces of equipment which are as follows:

   a. Bottom Ash Lock Hopper
   b. Bottom Ash Cooling Conveyor Feed Hopper
   c. Bottom Ash Cooling Conveyor
   d. Weigh Belt Feeder
   e. Ash Bucket Elevator
   f. Ash Silo/Ash Dustless Unloader

   Gasifier ash that discharges from the undergrate area of the gasifier is collected in a bottom ash lock hopper. Ash from the lock hopper falls into a bottom ash cooling conveyor feed hopper where it is fed to and cooled by the bottom ash cooling conveyor. Cooled ash discharges onto a bottom ash weigh belt feeder for weighing and conveying into the ash bucket elevator. Samples of the ash are also taken from the weigh belt feeder.

   The ash bucket elevator delivers a mixture of ash and fines to an ash silo. The ash/fines mixture flows through a dustless rotary conditioner and falls into a truck for delivery to a landfill.

   This System Process Design Basis addresses a. bottom ash lock hopper, b. bottom ash cooling conveyor feed hopper, and c. the bottom ash cooling conveyor only. Other PDB's address the remaining key equipment.

2. The following is a description of the bottom ash collecting system operation.

   a. Bottom Ash Collecting System:

      1) Start Bottom Ash Cooling Conveyor. Open cooling water supply valve(s) to conveyor (Line 14 on sketch, page 2).

      2) The initial starting of the Bottom Ash Lock Hopper requires a hopper warm-up sequence that brings the hopper's internal temperature to the temperature approaching that of the super-heated steam. All valves surrounding the lock hopper are closed except the steam fill Valve 8 and the lock hopper vent Valve 6. This allows superheated steam to pass through the lock hopper for warming.

      3) Once the hopper temperature has reached a temperature that closely approaches the superheated steam temperature, shut steam Valve 8 and open nitrogen Valve 7. Nitrogen flow through the lock hopper is for dry out purposes. Dry vessel for 3 to 5 minutes.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-3

System Name: Gasifier Ash Handing (Bottom Ash Lock Hopper, Bottom Ash Cooling Conveyor Feed Hopper, and Bottom Ash Cooling Conveyor)

Flowsheet No.: 16N25706-40-F-1AA-004

4) After initial warm-up and dry-out, close the nitrogen Valve 7 and vent Valve 6. Open steam fill Valve 8 to fill the hopper to its required internal pressure. This pressure will be 2 psi above the gasifier undergrate pressure to minimize coal gas migration and to prevent ash impaction. Once internal hopper pressure is reached, steam Valve 8 is closed.

5) Positive sealing inlet Valve 2 is opened, then inlet Valve 1 is opened to allow bottom ash to fall into the Bottom Ash Lock Hopper. Valve 1 blocks ash flow so that Valve 2 can provide positive without having ash on the valve. Lock hopper pressure will then equalize with gasifier pressure.

6) When hopper level has reached its desired height of 70% full, inlet Valve 1 is closed followed by positive sealing inlet Valve 2. Hopper filling time is based on rated load of gasifier and lock hopper volume. A gain Valve 1 blocks ash from Valve 2.

7) After Valves 1 and 2 are closed and the lock hopper is going through its normal cycle, bottom ash is collecting in the pipe line between the gasifier and the lock hopper's inlet Valve 1. One cycle of fines therefore collect in the pipe.

8) Open vent Valve 6 to vent remaining steam/coal gas mixture to vent system. Vent Valve 6 remains open while the lock hopper's internal pressure is reduced to 2 PSIG or less.

9) After pressure constraint is met, open positive sealing dump Valve 3 allowing ash to drop into the bottom ash cooling conveyor feed hopper. Space has been allocated for a future sealing valve located downstream of Valve 3 as shown on sketch on page 1.

10) When the hopper is indicated empty close dump Valve 3 and vent Valve 6.

11) The lock hopper cycle time that is required to size the bottom ash connecting pipeline, i.e., between the gasifier outlet flange and the lock hopper inlet flange, will initially be established by approximation calculations on the lock hopper's vent line. An orifice in the vent line can be field modified based on actual operating tests to increase or decrease lock hopper venting time, therefore minimizing fines carryover to the vent system. The interconnecting pipe will be 10" I.D. stainless steel.

12) Open nitrogen purge Valve 10 and allow the vent line to purge for 3 to 4 seconds. Close purge Valve 10.

13) Open steam Valve 8 and allow the Bottom Ash Lock Hopper to repressurize, starting the cycle over.

b. Interlocks

Interlocks are provided to help prevent inadvertent sequencing of the Bottom Ash Lock Hopper valves. The interlocks are as follows:

1) The lock hopper ash dump Valve 3 cannot open until pressure in lock hopper is less than 2 psig.

2) Lock hopper ash dump Valve 3 cannot open if nitrogen fill Valve 7 or steam fill Valve 8 is open.

3) Lock hopper ash dump Valve 3 cannot open unless vent Valve 6 is open.

4) Lock hopper ash dump Valve 3 and lock hopper ash inlet Valves 1 and 2 cannot be open at the same time.

5) Lock hopper ash inlet Valves 1 and 2 cannot open if steam fill Valve 8 or nitrogen fill Valve 7 is open.

6) Lock hopper ash inlet Valves 1 and 2 and lock hopper vent Valve 6 cannot be opened at the same time.

7) The steam fill Valve 8 or the nitrogen fill Valve 7 cannot be opened if the lock hopper ash inlet Valve 2 or the lock hopper ash dump Valve 3 is open.

8) Lock hopper ash inlet Valve 1 cannot be opened until lock hopper ash positive sealing Valve 2 has been opened. Lock hopper inlet Valve 2 cannot be closed until inlet valve 1 is closed.

9) Dump Valve 3 cannot be opened if water (Line 14) is not proven to bottom ash cooling screw and conveyor motor is not operating (screw is not turning).

10) Dump Valve 3 cannot be opened if low pressure nitrogen Valve 13 is closed.

11) The weigh belt feeder and bucket elevator motors will be interlocked to start when bottom ash cooling conveyor motor starts.

12) Loss of electricity or instrument air pressure will cause the bottom ash lock hopper to depressurize by opening vent Valve 6. Inlet valves 1 and 2 will also close.

SYSTEM PROCESS DESIGN BASIS

System Name: Gasifier Ash Handing (Bottom Ash Lock Hopper, Bottom Ash Cooling Conveyor Feed Hopper, and Bottom Ash Cooling Conveyor)

Flowsheet No.: 16N25706-40-F-1AA-004

c. Miscellaneous

1) Nitrogen Valves 9 and 12 are used to purge or unplug ash lines or valves and the vent line.

2) The operator should use caution when using nitrogen purge valves.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-3

System Name: Gasifier Ash Handing (Bottom Ash Lock Hopper, Bottom Ash Cooling Conveyor Feed Hopper, and Bottom Ash Cooling Conveyor)

Flowsheet No.: 16N25706-40-F-1AA-004

II. DESIGN CRITERIA

ITEM	PROCESS STREAM	MAX FLOW	NORM FLOW	MIN. FLOW	MAX. TEMP. °F	NORM TEMP. °F	MAX. PRESS. PSIG	NORM PRESS. PSIG
1	BOTTOM ASH L.H. INLET	1000 LB/HR NOTE 2 AND 4	832 LB/HR NOTE 1 AND 4	NOTE 3 AND 4	750	560 NOTE 10	440	324 NOTE 7
2	BOTTOM ASH L.H. INLET	1000 LB/HR NOTE 2 AND 4	832 LB/HR NOTE 1 AND 4	NOTE 3 AND 4	750	560 NOTE 10	440	324 NOTE 7
3	BOTTOM ASH L.H. DUMP	1000 LB/HR NOTE 2 AND 4	832 LB/HR NOTE 1 AND 4	NOTE 3 AND 4	750	560 NOTE 10	NOTE 8	2
4	BOTTOM ASH TO BOTTOM ASH COOLING CONVEYOR	1000 LB/HR NOTE 2 AND 4	832 LB/HR NOTE 1 AND 4	NOTE 3 AND 4	750	560 NOTE 10	10	2
5	BOTTOM ASH TO WEIGH BELT FEEDER	1000 LB/HR	832 LB/HR	NOTE 3	220	200	10	2
6	BOTTOM ASH L.H. VENT	NOTE 5	NOTE 5	NOTE 5	750	560 NOTE 10	NOTE 5	326 NOTE 7
7	BOTTOM ASH L.H. NITROGEN FILL	NOTE 6	NOTE 6	NOTE 6	465	HOLD	374	324
8	BOTTOM ASH L.H. STEAM FILL	NOTE 6	NOTE 6	NOTE 6	560	600	374 PSIG	HOLD
9	NITROGEN PURGE - HP	NOTE 6	NOTE 6	NOTE 6	465	HOLD	374	324
10	NITROGEN PURGE - HP	NOTE 6	NOTE 6	NOTE 6	465	HOLD	374	324
11	BOTTOM ASH COOLING CONV. FEED HOPPER VENT	HOLD	HOLD	HOLD	750	560 NOTE 10	10	0
12	NITROGEN PURGE - LP	NOTE 6	NOTE 6	NOTE 6	100	HOLD	10	2
13	NITROGEN PURGE - LP	NOTE 6	NOTE 6	NOTE 6	100	HOLD	10	2
14	COOLING WATER IN	NOTE 9	NOTE 9	NOTE 9	HOLD	HOLD	100	HOLD
15	COOLING WATER OUT	NOTE 9	NOTE 9	NOTE 9	HOLD	HOLD	100	HOLD

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-3

System Name: Gasifier Ash Handing (Bottom Ash Lock Hopper, Bottom Ash Cooling Conveyor Feed Hopper, and Bottom Ash Cooling Conveyor)

Flowsheet No.: 16N25706-40-F-1AA-004

II. DESIGN CRITERIA - Continued

The Bottom Ash Lock Hopper System is designed to the following design criteria:

1. Ash particles

   Ash Particle Density = 60 Lb/Ft^3
   Ash Bed Density = 40 Lb/Ft^3

   Note: Particle and bed density is assumed. 40 Lb/Ft^3 is based on an assumed voidage of 0.33.

2. Lock hopper will be fabricated from refractory lined carbon steel or non-refractory lined stainless steel per most economical design. If refractory is used the lock hopper's skin temperature will not exceed 240°F Interconnecting piping will be made of stainless steel.

3. The lock hopper outlet cone will have an angle of 70° from horizontal to help ash flow.

4. Ash Composition: Expected composition as an oxide.

   SiO_3
   AL_2O_3
   FE_2O_3
   TiO_2
   MgO "LATER"
   MnO
   P_2O_5
   K_2O
   CaO

5. Expected composition at normal output.

C	19	Lb/Hr
CaO	100	Lb/Hr
Inerts	713	Lb/Hr
Total Solids	832	Lb/Hr

Composition at normal output taken from 325 psig mass balance dated 5-31-95, Stream 14.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA-3

System Name: Gasifier Ash Handing (Bottom Ash Lock Hopper, Bottom Ash Cooling Conveyor Feed Hopper, and Bottom Ash Cooling Conveyor)

Flowsheet No.: 16N25706-40-F-1AA-004

III. DESIGN NOTES

1. 832 Lb/Hr of bottom ash taken from 325 psi mass balance, Rev. 0 dated 5-31-95.

2. Maximum ash flow of 1000 Lb/Hr is 20% higher than mass balance ash flow for safety margin.

3. Minimum bottom ash flow is taken from 200 psi mass balance. Absolute minimum will be a function of gasifier turndown at 200 psig operation.

4. The lock hopper will be designed for one dump cycle per hour at 1000 Lb/Hr flow rate. The hopper will go into a dump cycle when the lock hopper level reaches 70% full. Operating experience based on actual ash flow will show the optimum cycle time for the lock hopper.

5. The vent time for a dump cycle will be based on a 1/4" orifice located in the vent pipe line adjacent to the lock hopper. The orifice will set the depressurization time and the dump cycle time.

6. Nitrogen and steam fill time of lock hopper will be based on 1/2" pipe and valve(s). Nitrogen purge will be accomplished with 1/2" pipe and valve(s). Pipe and valve size will be re-evaluated based on line loss due to routing.

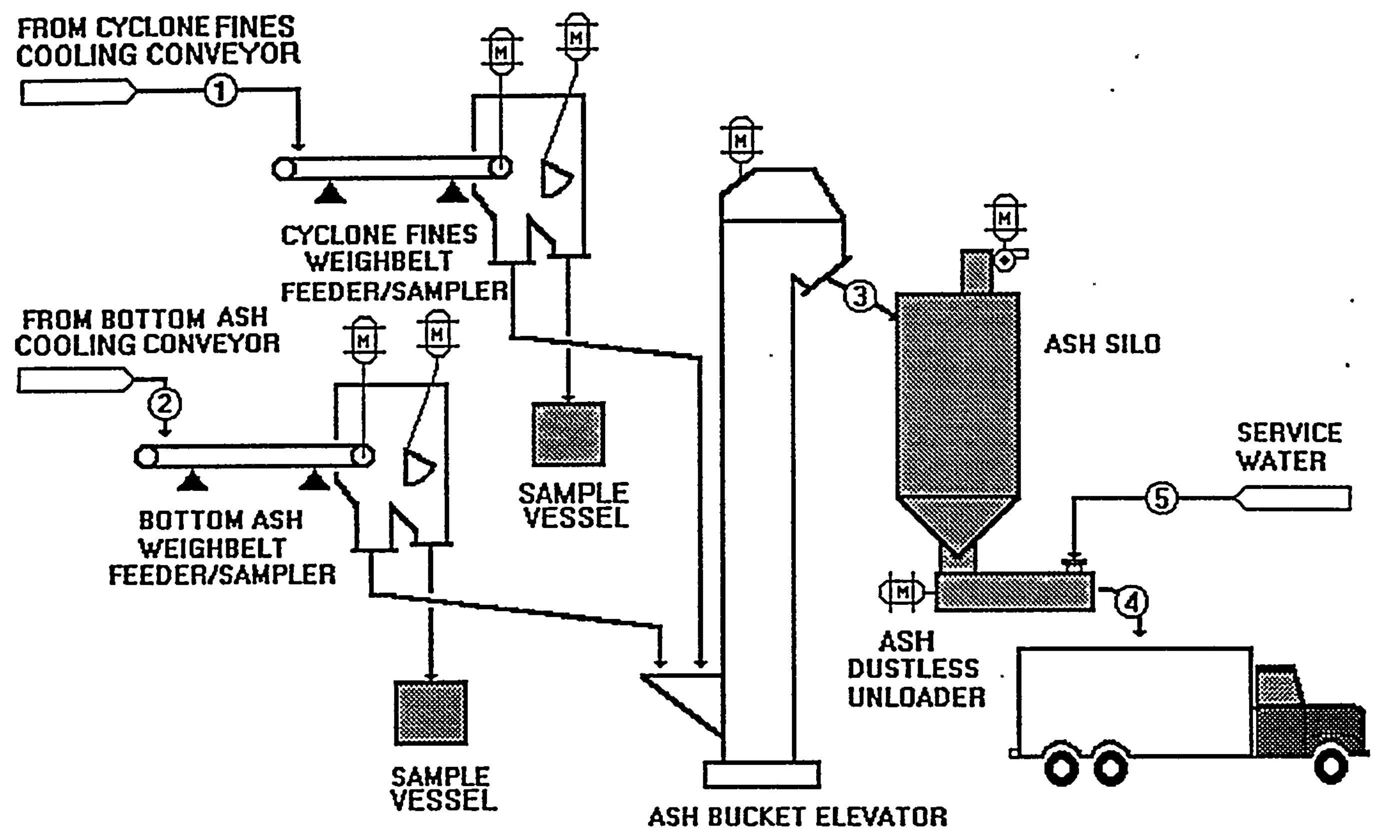
7. Internal pressure of bottom ash lock hopper will be approximately 2 psi higher or 326 psig.

8. Bottom ash lock hopper dump valves must hold against maximum pressure in gasifier which is 440 psig. The valves will open normally against 2 psig or less after lock hopper is vented.

9. Flow requirements after equipment purchase.

10. Per Riley.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA - 4
System Name Solid Waste Disposal System
Flowsheet No. 16N25706-40-F-1AA-005



EQUIPMENT

Cyclone Fines Weighbelt Feeder (Eq. No. 1AA-FDR-1)
Bottom Ash Weighbelt Feeder (Eq. No. 1AA-FDR-2)
Fines Sample Container (Eq. No. 1AA-VSL-1)
Bottom Ash Sample Vessel (Eq. No. 1AA-VSL-2)
Fines Sampler (Eq. No. 1AA-SMX-1)
Bottom Ash Sampler (Eq. No. 1AA-SMX-2)
Ash Bucket Elevator (Eq. No. 1AA-ELEV-1)
Ash Silo (Eq. No. 1AA-SILO-1)
Ash Dustless Unloader (Eq. No. 1AA-COND-1)
Ash Silo Dust Collector (Eq.No. 1AA-DCOL-1)

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA - 4
System Name Solid Waste Disposal System
Flowsheet No. 16N25706-40-F-1AA-005

I. DESIGN PHILOSOPHY

1. The primary functions of the Solid Waste Disposal System is to weigh, collect and provide a means of disposing the process gas cyclone fines and gasifier bottom ash.

2. The bottom ash and cyclone fines are continuously transferred (individually) to the weighbelt feeders by the cyclone fines and bottom ash conveyors.

3. The weighbelt feeders weigh and record the "throughput" of cyclone fines and bottom ash.

4. Samplers on the ends of the weighbelt feeders provide a means of sampling fines and ash by diverting a portion of the fines/ash to sample bins.

5. Fines and ash discharged from the weighbelt feeders are directed to the inlet of the bucket elevator.

6. The bucket elevator lifts the combined fines and ash and discharges the mixture into the ash silo. A filter in the silo vent prevents fines from escaping to the atomosphere.

7. An unloader mounted at the bottom of the ash silo discharges the stored ash/fines into an ash removal truck.

8. Service water is injected into the unloader to reduce the dust emissions during the unloading process.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1AA - 4
System Name Solid Waste Disposal System
Flowsheet No. 16N25706-40-F-1AA-005

II. DESIGN CRITERIA

ITEM	PROCESS STREAM	MAXIMUM FLOW #/HR (or as noted)	NORMAL FLOW #/HR (or as noted)	MINIMUM FLOW #/HR (or as noted)	MAXIMUM TEMP. °F	NORMAL TEMP. °F	MAXIMUM PRESS. PSIG	NORMAL PRESS. PSIG
1	Cyclone Fines from Conveyor	500	(See Mass Balance)	(See Mass Balance)	200	(See Mass Balance)	2	(See Mass Balance)
2	Bottom Ash from Conveyor	1,000	(See Mass Balance)	(See Mass Balance)	750	(See Mass Balance)	10	(See Mass Balance)
3	Combined Ash from Bucket Elevator	1,500	Hold	Hold	Hold	Hold	atmos.	atmos.
4	Ash Discharged from Unloader	1,500	(See Mass Balance)	(See Mass Balance)	Hold	(See Mass Balance)	atmos.	atmos.
5	Service Water	Hold	(See Mass Balance)	(See Mass Balance)	Hold	(See Mass Balance)	Hold	(See Mass Balance)

SYSTEM PROCESS DESIGN BASIS

PDB No. 40-1AA - 4

System Name Solid Waste Disposal System

Flowsheet No. 16N25706-40-F-1AA-005

III. DESIGN NOTES

1. Current design is based on the Mass Balance dated 5/31/95.

2. Cyclone fines bulk density is assumed to be 25 #/ft^3.

3. Cyclone fines size distribution is assumed to be : 50% less than 30 microns.
   50% greater than 30 microns.

4. Bottom ash bulk density is assumed to be 50 #/ft^3.

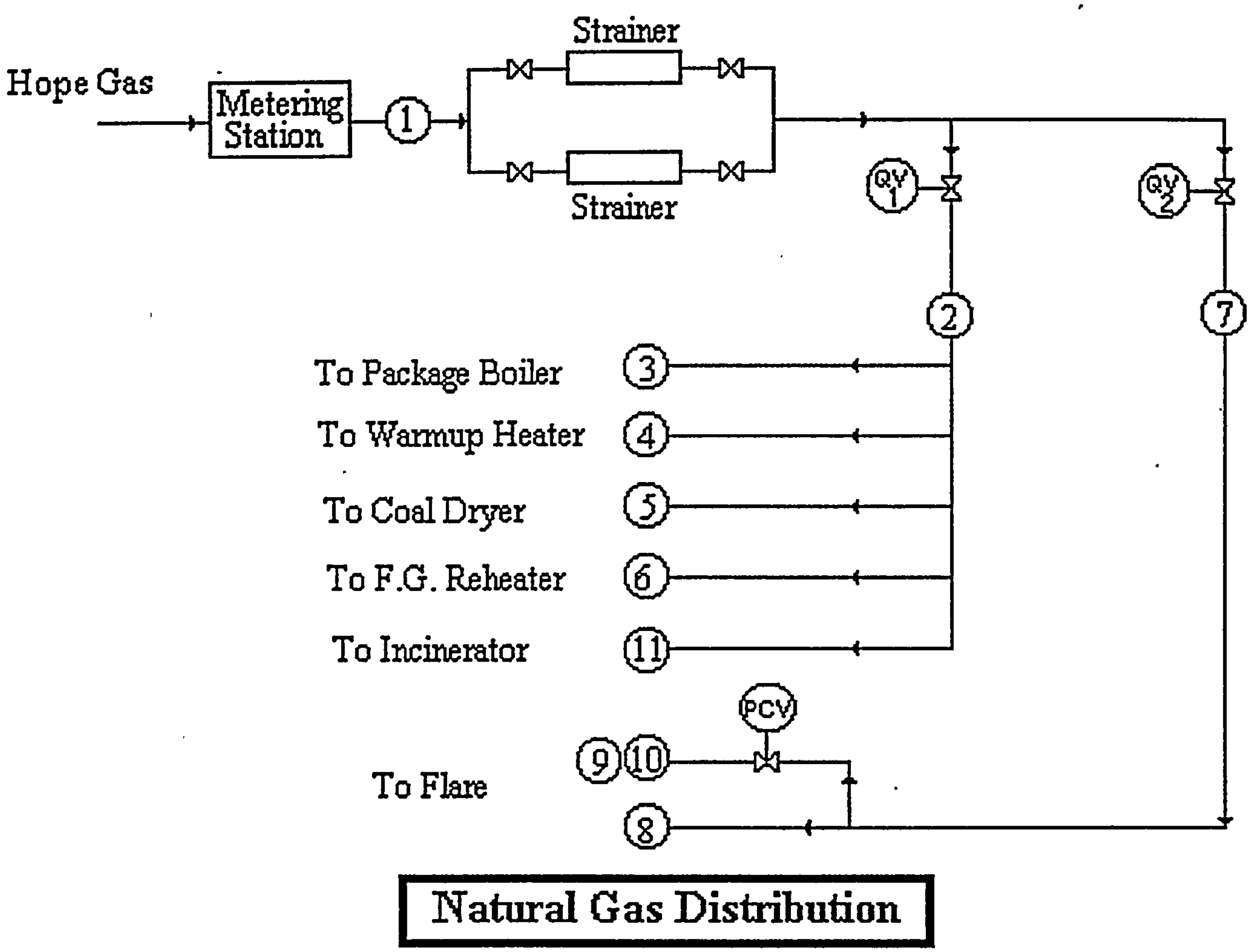
5. The ash silo is sized to allow for 45 hours of continuous bucket elevator discharge at maximum design conditions. (LATER #/hr of fines/ash) 45 hours of storage is based on the ash removal schedule as defined in the Site Access Agreement. With normal ash hauling hours being from 7:00 a.m. to 2:30 p.m. Monday through Friday and from 7:00 a.m. to 12:00 noon Saturdays, the longest period of time when no ash is removed is 43 hours. (From 2:30 p.m. on Saturday to 7:00 a.m. on Monday) To be conservative, an additional hour was added to the beginning and the end of the 43 hour time period to allow for minor deviations from the hauling schedule.

6. A temperature drop of **LATER** °F is assumed across the weighbelt feeders.

7. A temperature drop of **LATER** °F is assumed across the ash bucket elevator.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1DG - 1

System Name: Natural Gas Distribution
Flowsheet No.: 16N25706-40-F-1DG-001



SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1DG - 1

System Name: Natural Gas Distribution
Flowsheet No.: 16N25706-40-F-1DG-001

I. DESIGN PHILOSOPHY

1) Hope Gas acquires any permits required for running the pipeline to the facility. Hope Gas provides a natural gas metering station that measures the gas consumption and regulates the gas pressure. Jacobs-Sirrine is responsible for the piping design downstream of the metering station.

2) Allegheny Power grants Hope Gas an easement for Hope Gas to establish a meter site on Allegheny Power property. The approximate size of the station is 20' x 20'.

3) Natural gas supply to the facility is uninterruptable. A firm gas supply is required in order to start up, operate, and shut down the facility.

4) Gas piping is designed for the maximum pressure attainable from the Hope metering station. No safety valve is required.

5) A duplex strainer removes any foreign matter entrained within the gas.

6) The main shutoff valve (QV-1) and the flare shutoff valve (QV-2) are located downstream of the strainer. Each is interlocked to automatically close under emergency low pressure conditions (fire, explosion, etc.). Two separate lines are provided in order to always have a natural gas supply to safely incinerate coal gas. If a low pressure occurs at the coal dryer, for example, QV-1 shuts down the main gas line, but the flare is still available. Likewise, if QV-2 shuts down the flare gas supply, the HRSG is still available. Each gas line has a different routing so that an emergency condition in one part of the facility does not take down both lines.

7) Natural gas is not used for building heating. Electric unit heaters will be used.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1DG - 1

System Name Natural Gas Distribution
Flowsheet No. 16N25706-40-F-1DG-001

II. DESIGN CRITERIA

1) Stream Data (Note 1)

ITEM	PROCESS STREAM	MAX FLOW MMBTU /HR	NORM FLOW MMBTU /HR	MAX FLOW SCFM	NORM FLOW SCFM	MAX PRESS PSIG	NORM PRESS PSIG
1	Natural Gas Supply	Note 3	34.00	Note 3	529.00	Note 4	40
2	Main Supply Line	Note 3	33.80	Note 3	525.90	Note 4	40
3	Package Boiler	8.00	3.00	124.0	46.7	Note 2	Note 2
4	Gas to Warm Up Heater	1.00	0.00	31.1	0.0	Note 2	Note 2
5	Gas to Coal Dryer	3.00	3.00	46.7	46.7	Note 2	Note 2
6	Gas to F.G. Reheater	12.00	12.00	186.7	186.7	Note 2	Note 2
7	Flare Supply Line	15.35	0.20	238.8	3.1	Note 4	40
8	Flare Assist Gas	15.0	0.00	233.4	0.0	Note 4	40
9	Flare Ignitor Gas	0.15	0.00	2.3	0.0	15	10
10	Flare Pilot Gas	0.20	0.20	3.1	3.1	15	10
11	Incinerator	Note 2	Note 2	Note 2	Note 2	Note 4	Note 2

2) Composition

CONSTITUENT	FORMULA	MASS %	VOL %
Methane	CH4	81.20	90.42
Ethane	C2H6	9.22	5.48
Propane	C3H8	3.46	1.40
Isobutane	C4H10	2.42	0.74
Nitrogen	N2	1.98	1.26
Carbon Dioxide	CO2	1.72	070
Total		100.00	100.00

3) Molecular Weight - 17.86

4) Lower Heating Value - LHV 967 BTU/SCF
20,503 BTU/LB

5) Higher Heating Value - HHV 1,071 BTU/SCF
22,711 BTU/LB

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1DG - 1

System Name: Natural Gas Distribution
Flowsheet No.: 16N25706-40-F-1DG-001

III. DESIGN NOTES

1) Standard conditions for natural gas are 60 deg F and 30" Hg (14.73 psia). The specific volume of Hope gas is 21.2 scf/lb.

2) Per Vendor.

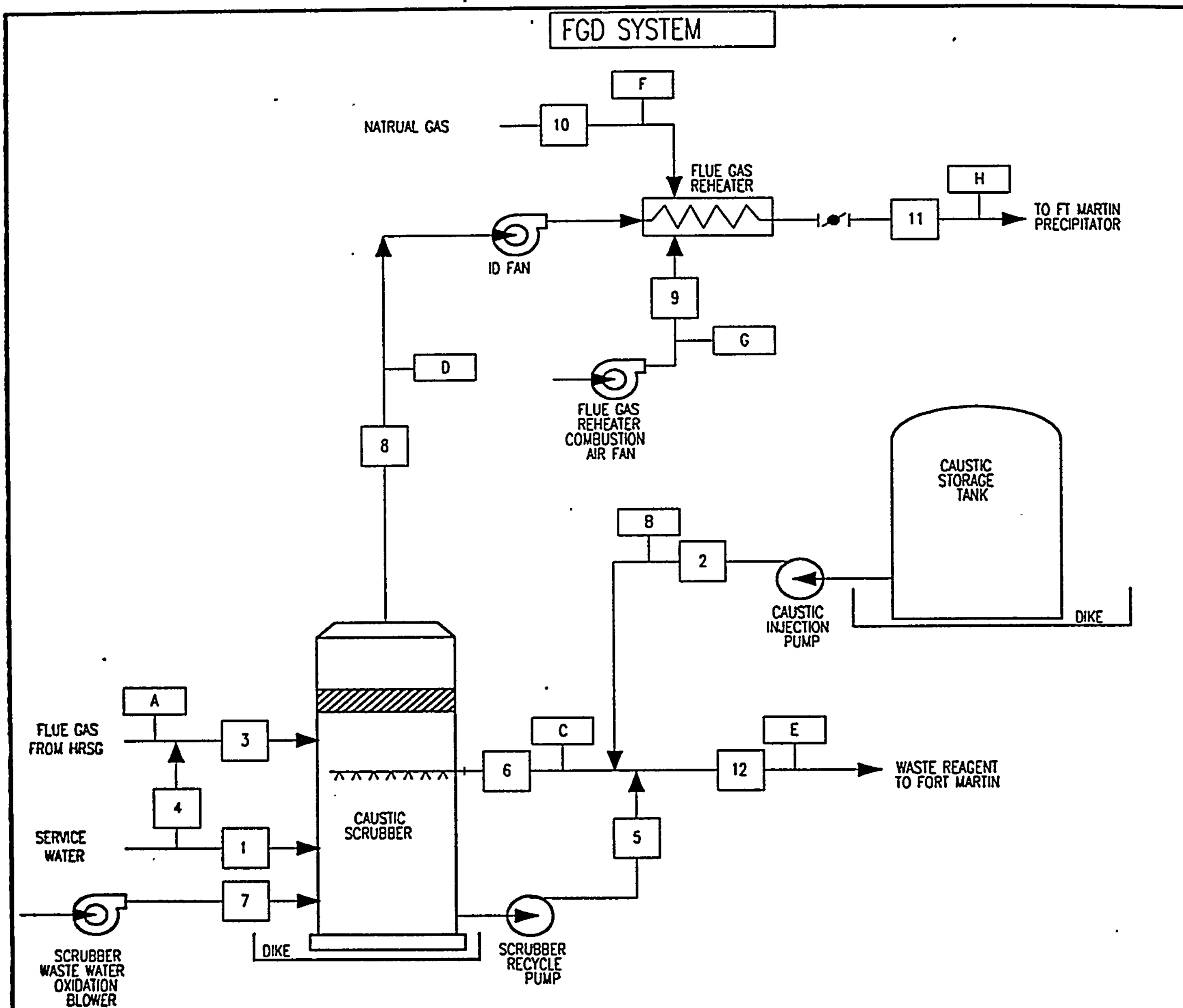
3) Later.

4) Per Hope Gas.

5) The gas system is designed per NFPA requirements for Seismic Zone 1.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1GA-1

System Name FGD System
Flowsheet No. 16N25706-40-F-1GA-001



EQUIPMENT

Caustic Scrubber (Eq. no. 1GA-SCG-1)
Caustic Storage Tank (Eq. No. 1GA-TK-!)
Caustic Injection Pump (Eq. No. 1GA-P-2)
Scrubber Recycle Pump (Eq. No. 1GA-P-1)
Flue Gas Reheater (Eq. No. 1GA-CHTR-1)
I. D. Fan (Eq. No. 1GA-FAN-1)
Caustic Heater (Eq. No. 1GA-HTR-1)
Scrubber Waste Water Oxidation Blower (Eq. No. 1GA-BLO-1)
Knife Gate Damper (Eq. No. 1GA-DMP-1)
Flue Gas Reheater Combustion Air Fan (Eq. No. 1GA-BLO-1)

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1GA-1

System Name FGD System
Flowsheet No. 16N25706-40-F-1GA-001

I. **DESIGN PHILOSOPHY**

1. The purpose of the FGD System (Flue Gas Desulfurization System) is to remove sulfur dioxide (SO_2) from the HRSG flue gas to assure that permit conditions are met at all times.

2. A caustic soda-based wet scrubbing system is used for ease of operation and low capital cost.

3. The scrubber is designed to achieve up to 90% removal of SO_2.

4. Reagent is injected into a caustic scrubber spray tower reactor where the solution absorbs the SO_2. The reagent reacts to form a solution of sodium sulfate and sodium sulfite.

5. Reagent is recirculated through the reactor and fresh reagent is added to maintain a pH setpoint necessary to meet the SO_2 emission limit. Spent reagent is bled from the system to the sewer to Fort Martin.

6. Reagent is aerated in the scrubber reactor basin with an air sparge to oxidize sulfites to sulfates prior to discharge to the Fort Martin wastewater treatment system. The spent solution contains up to 15% dissolved solids, primarily sodium sulfate, after oxidation.

7. Flue gas entering the scrubber is quenched with a water quench prior to entering the spray tower. Flue gas leaving the scrubber passes through a demister into exit ductwork saturated with moisture at 182 F.

8. The treated flue gas passes through an I.D. fan, is reheated to 250 F, and discharged to the duct running to the Fort Martin precipitator inlet breeching. The FGD system and reheater are isolated from the duct with a knife gate damper.

9. The FGD system is designed for outdoor operation, to accommodate widely varying operating conditions and for intermittent operation. The components are equipped to be flushed at the completion of and operating run to minimize corrosion and prevent solids deposits setting up between runs.

10. The system design life is five years. The materials of construction for the reactor is carbon steel with two coats of high temperature coal tar epoxy coating. Spray piping and nozzles are 304 stainless steel.

11. External piping, recycle pump and valves are FRP construction.

12. Pressure drop through the FGD system is approximately 6" WG at full load.

13. The caustic truck unloading station is curbed to prevent release of caustic in case of a spill. The caustic storage tank and scrubber tower are also diked to provide secondary containment.

14. Service water is added to the reactor basin to maintain level, replacing evaporation and spent reagent volume. Service water is also used as required to quench incoming flue gas from 1800 F to below 500 F.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1GA-1

System Name FGD System
Flowsheet No. 16N25706-40-F-1GA-001

II. DESIGN CRITERIA

Strm No.	Process Stream	Max Flow (#/hr) or as noted	Max Flow (acfm)	Temperature (°F)	Pressure (psig)	Consitiuent as noted
1	Service Water Make-up	16 gpm	-	80	80	-
2	50 % Caustic Solution	0.67 gpm	-	25	55	256 lbs/hr NaOH
3	Flue Gas From Burner	67,863	66,683	1800	-0.36	237 lb/hr SO_2
4	Service Water Quench	48 gpm	-	60	80	-
5	Reagent Recycle	1,006 gpm	-	180	55	-
6	Reagent Feed	1,000 gpm	-	180	40	-
7	Oxidation Air	2,700	600	80	10	-
8	Flue Gas to I.D. Fan	93,682	26,111	182	-0.58	22.9lb/hr SO_2
9	Reheater Com-bustion Air	2,555	568	80	0.36	
10	Natural Gas to Reheater	135	2	80	20	
11	Flue Gas to Fort Martin	96,372	28,636	250	0.36	8 lb/hr solids
12	Waste Reagent	5.8 gpm	-	180	5	15% TDS

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1GA-1

System Name FGD System
Flowsheet No. 16N25706-40-F-1GA-001

III. DESIGN NOTES

1. Current design is based on the Revision 1 of the Base Case, 2 TPH, Mass and Energy Balance, dated 8/24/95 for 325 psig operation.

2. Current design is based on using caustic soda as the reagent. The caustic tank is designed to hold 6,000 gallons of 50% caustic soda solution, commercial grade. The tank is insulated and heated with an electric heater to maintain the caustic in liquid form.

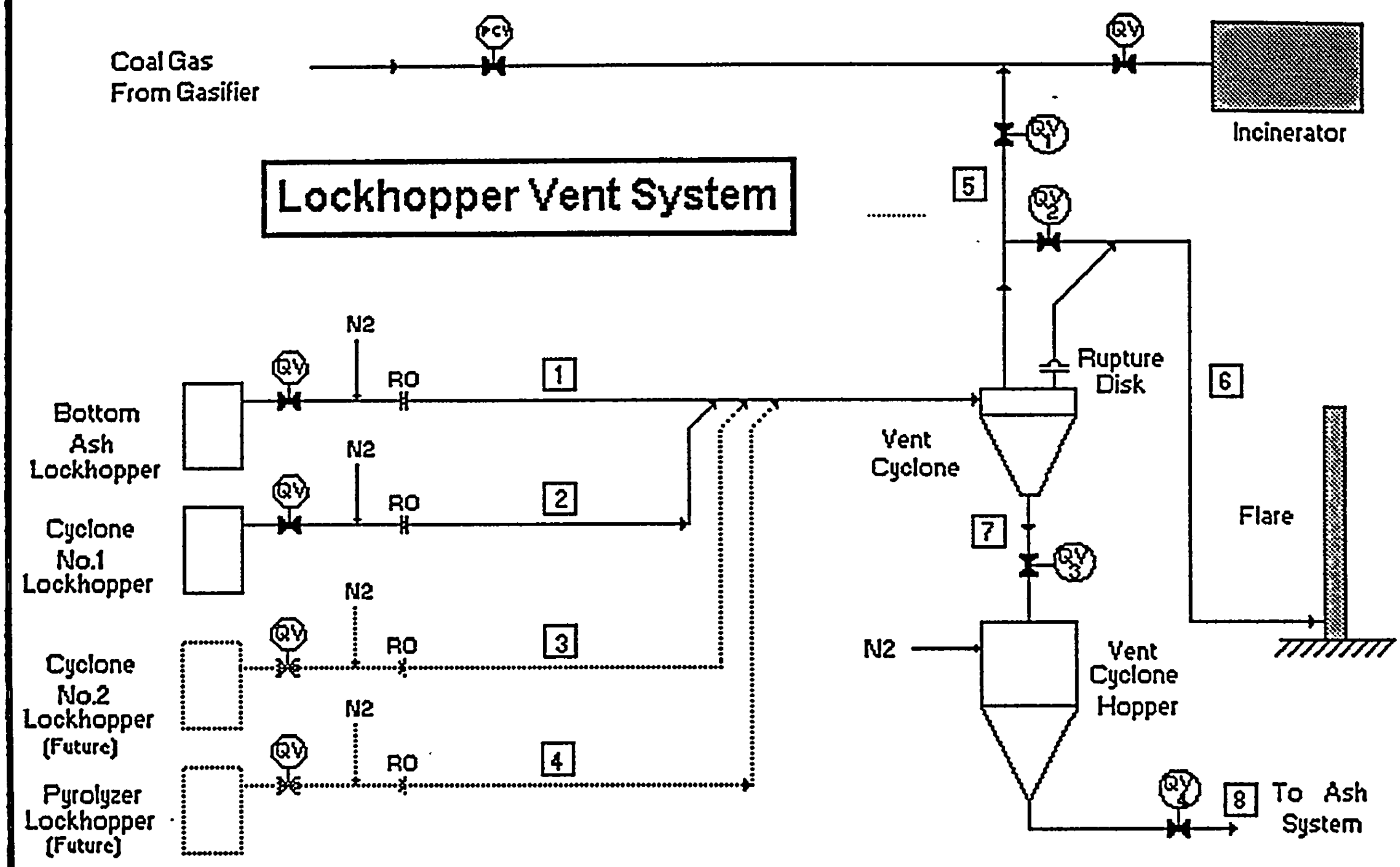
3. Current design is based on flue gas reheat to 250 F. Although this is the minimum delivery temperature allowed under the Site Access Agreement with Fort Martin, the parties have concluded that the quantity of flue gas involved is so small relative to that at the existing Fort Martin unit, that this temperature is adequate.

4. The caustic scrubber reactor tower is approximately 42 feet high and 8 feet in diameter.

5. Current design is to oxidize reagent in the scrubber basin using an air sparge. The bleed stream off of the recycle line will be about 15% sodium sulfate solution, and discharged to the Fort Martin sewer.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 1

System Name Lockhopper Vent System
Flowsheet No. 16N25706-40-F-GG-001



EQUIPMENT:

Vent Cyclone - 1GG-CYCL-1
Vent Cyclone Hopper - 1GG-HPR-1

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 1

System Name **Lockhopper Vent System**
Flowsheet No. **16N25706-40-F-GG-001**

I. DESIGN PHILOSOPHY

1) The lockhopper vent system vents coal gas from the lockhoppers to the incinerator. Under normal conditions the oxygen concentration of the gas within the system is below the limiting oxidant concentration, and the gas within the system (by itself) is noncombustible. However, if the coal gas is exposed to oxygen, it has the potential to autoignite due to its high temperature.

2) A lockhopper is depressurized by opening its vent valve. A stellite orifice in the vent line sets the vent flowrate. The depressurization rate is not precisely controlled, but it is kept within a given range. If the vessel depressurizes too quickly, then there is excessive particulate carryover. Conversely, if the vessel depressurizes too slowly, then the lockhopper emptying cycle time is excessive. The time to depressurize depends on the amount of ash / fines in the lockhopper and the amount of coal gas above the ash / fines. After the vessel depressurizes, the lockhopper is drained.

3) The lockhopper vent valves are interlocked so that only one lockhopper can be vented at a time. Each lockhopper has a separate vent line (there is not a main header) in order to minimize particulate fallout. In addition, each vent line has a nitrogen purge connection.

4) The Vent System allows the lockhoppers to depressurize to 2 psig.

5) A vent cyclone is located downstream of the lockhoppers. It removes entrained particulate that carries over into the vent system. A rupture disk on the cyclone is set at 150 psig.

6) A vent cyclone hopper beneath the vent cyclone stores the fly ash particulate that falls out in the cyclone. This hopper empties intermittently by gravity. During normal system operation QV-3 is open and QV-4 is closed. During an emptying cycle QV-3 closes and QV-4 opens. If a plug develops in the ash line, then QV-4 also closes, and the hopper is pressurized with heated nitrogen. QV-4 reopens and the plug is blown free.

7) Vent flow is diverted to the flare if the incinerator trips. QV-1 and QV-2 are interlocked. Under normal conditions QV-1 is open and QV-2 is closed. If the incinerator trips then QV-1 closes and QV-2 opens.

8) All lines and equipment within the system are insulated and heat traced in order the prevent the condensation of any vapor (condensate and particulate form mud in the system).

9) All lines within the vent system are purged with heated nitrogen on a regular basis in order to prevent the accumulation of particulate within the lines.

10) Before gasifier startup the vent system is purged of air (with nitrogen) into the incinerator. After a gasifier shutdown, the vent system is purged of coal gas (with nitrogen) into the incinerator.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 1

System Name Lockhopper Vent System
Flowsheet No. 16N25706-40-F-GG-001

II. DESIGN CRITERIA

ITEM	PROCESS STREAM	MAX FLOW LB/HR	NORM FLOW LB/HR	MAX TEMP DEG F	NORM TEMP DEG F	MAX PRESS PSIG	NORM PRESS PSIG	MIN PRESS PSIG
1	Gasifier LH Vent	3000	0	1100	560	420	2	0
2	No.1 Cycl. LH Vent	1500	0	1100	1086	420	2	0
3	No.2 Cycl. LH Vent	1500	0	1100	1086	420	2	0
4	Pyrolyzer LH Vent	500	0	1100	650	420	2	0
5	Vent to Incin	3000	0	1100	400	150	-1	0
6	Vent to Flare	3000	0	1100	400	150	0	0
7	Vent Cyclone Ash	Note 1	0	1100	400	150	0	0
8	Cyclone Hopper Ash	Note 1	0	1100	400	150	2	0

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 1

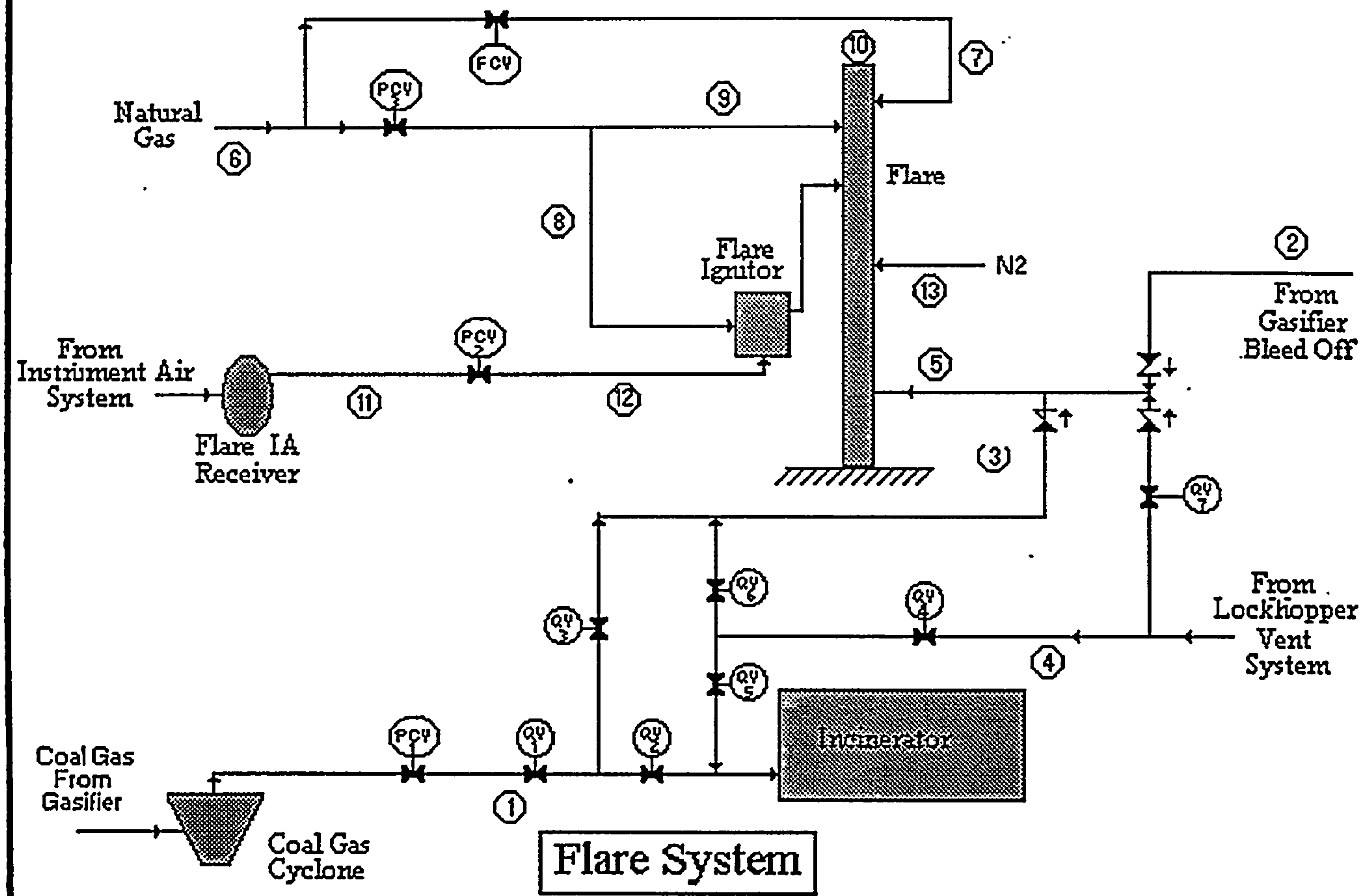
System Name Lockhopper Vent System
Flowsheet No. 16N25706-40-F-GG-001

III. DESIGN NOTES

1) Later

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 2

System Name **Flare System**
Flowsheet No. **16N25706-40-F-GG-001**



Flare System

EQUIPMENT:

Flare - 1GG-STK-1
Instrument Air Receiver - 1GG-RCV-1

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 2

System Name **Flare System**
Flowsheet No. 16N25706-40-F-GG-001

I. DESIGN PHILOSOPHY

1) The flare incinerates coal gas during emergency conditions when the incinerator goes down. Whenever the incinerator is operating, coal gas is burned in the incinerator even during gasifier startup and shutdown. If the incinerator shuts down, the gasifier is interlocked to immediately trip.

2) The following streams divert to the flare if the incinerator goes down:
   a) gasifier bleed
   b) lockhopper vent system bleed
   c) incinerator bleed

3) The flare is designed for 10% of the gasifier coal gas outlet design flow and the maximum lockhopper vent system flow (both flows simultaneously).

4) The flare tip is designed for a maximum exit velocity of 60 ft/sec.

5) Assist gas (natural gas) is added to the flare tip in order to maintain a combined gas heating value of 200 Btu/scf. This heating value is needed to ensure complete combustion of the coal gas. The natural gas flow rate is adjusted based on the coal gas flow and heating value. The combined gas at the flare tip always has minimum heating value of 200 Btu/scf.

6) The flare is located on the roof of the reactor tower.

7) The flare height is based on a maximum radiation rate at the base of the stack of 1500 Btu/hr/sq ft. At this radiation rate the exposure time necessary to reach the pain threshold is 16 seconds (Note 1). Personnel wearing appropriate clothing may perform emergency action lasting several minutes. Equipment on the roof, and the roofing construction material must be capable of withstanding a heat density of 1500 Btu/hr/sq ft.

8) The minimum flare height available is 30 feet. At low tip velocities the flame may be drawn to the low pressure area on the downwind side of the stack, down along the stack. A minimum height of 30 feet ensures that the flame is always a safe distance above the roof. Low tip velocity can occur as the gasifier's pressure decays after an emergency shutdown.

9) The flare stack is constructed of stainless steel or refractory lined carbon steel. The flare stack is not insulated. Vent piping to the flare is insulated where needed for personnel protection. Coal gas flare systems that are in continuous operation are normally insulted to prevent line plugging due to condensation and particulate. Since the GPIF flare is not normally in operation, it is not insulated. When the GPIF flare system is used, the flare burner and all lines within the flare system must be purged before the flare can be brought on-line for the next test run.

10) Before each test run the entire flare vent system is purged with nitrogen. If there is oxygen in the flare system, a flashback and deflagration may occur within the flare system.

11) An integral fluidic seal (velocity seal) is incorporated into the flare tip. It is continuously purged with nitrogen to ensure that air does not enter into the flare stack. Nitrogen connections are provide on each vent line to the flare to allow continuous purging of each line if required.

12) Several pilot burners are located in the flare tip. The pilots are lit before the gasifier operation starts. Each pilot has its own thermocouple to monitor ignition and normal operation. If for some reason the pilots go out during operation, they automatically reignite. Oxygen for the continuos pilot is supplied from ambient air at the pilot.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 2

System Name **Flare System**
Flowsheet No. **16N25706-40-F-GG-001**

13) A flame front generator ignites the pilots. Compressed air and natural gas are mixed outside the base of the stack to form a combustible mixture. An ignition panel at the base of the stack generates a spark, and the resulting flame front ignites the pilots. The instrument air system supplies the compressed air to the ignition system until the pilot ignites. An air receiver is located in the supply line to the flare to ensure that an adequate air supply is always available.

14) During the bid period an enclosed flare (incinerator) will be evaluated as an option.

15) During the bid period an insulated flare stack will be evaluated as an option.

16) Flare Startup

a) Nitrogen purge vent lines and flare stack.

b) Nitrogen seal the flare tip.

c) Ignite pilots. (The pilots are ignited after the system is nitrogen purged. During a shutdown oxygen and coal gas can form a combustible mixture within the vent system. This mixture can ignite when exposed to a flame (if a pilot were lit) and cause a flashback within the stack).

17) Flare Standby Operation

a) Continuously seal the flare tip with nitrogen. (The vent system may also be continuously sealed/purged with nitrogen based on recommendations from the flare vendor).

b) Continuously seal the flare vent piping with nitrogen (if flare manufacturer recommends).

c) Continuously burn flare pilots.

18) Flare Operation (Incinerator Trips)

a) QV-1, QV-2, and QV-3 are interlocked. QV-1 and QV-2 close, and QV-3 opens. Coal gas diverts to the flare.

b) QV-4, QV-5, QV-6, and QV-7 are interlocked. QV-4 and QV-5 close ,and QV-6 and QV-7 open. Lockhopper vent gas diverts to the flare.

c) Continuously monitor flowrate and heating value of the gas flow to the flare. Automatically adjust the natural gas assist flow (FCV) to maintain a combined gas heating value of greater than 200 Btu/scf.

d) Depressurize coal gas system to the flare.

e) Nitrogen purge the coal gas system to the flare.

f) Lock up coal gas system under nitrogen blanket. Shut down flare.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 2

System Name **Flare System**
Flowsheet No. **16N25706-40-F-GG-001**

II. DESIGN CRITERIA

A) Process Streams

1) Operating Conditions

		Flare in Standby Mode (Incinerator Running)			Flare in Operation (Incinerator Down)		
ITEM	PROCESS STREAM	NORM FLOW LB/HR	NORM PRESS PSIG	NORM TEMP DEG F	NORM FLOW LB/HR	NORM PRESS PSIG	NORM TEMP DEG F
1	Coal Gas to Incin	18,878	30	1217	0	30	1217
2	Coal Gas to Flare	0	30	1217	5000	30	1217
3	C.G. at Flare Inlet	0	0	60	5000	2	1217
4	L.H. Vent to Ejector	3000	0	400	0	0	400
5	L.H. Vent to Flare	0	0	60	3000	10	400
6	Natural Gas Supply	8.8	40	60	676	40	60
7	N.G. Assist Gas	0	0	60	660	10	60
8	N.G. Ignitor Gas	0	10	60	0	10	60
9	N.G. Pilot Gas	8..8	10	60	8.8	10	60
10	Gas to Flare Tip	21.7	0	60	11,452	1	800
11	Air from Receiver	0	100	60	0	100	60
12	Air to Ignitor	0	20	60	0	20	60
13	N2 Tip Seal	21.7	30	60	21.7	30	60
14	N2 Main Purge	0	30	60	0	30	60
15	N2 L.H. Purge	0	30	60	0	30	60
16	N2 QV-1,2 Purge	0	30	60	0	30	60

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 2

System Name Flare System
Flowsheet No. 16N25706-40-F-GG-001

2) Design Conditions (Notes 2,3,4,5)

ITEM	PROCESS STREAM	MAX FLOW LB/HR	MAX FLOW SCFM	MAX PRESS PSIG	MAX TEMP DEG F
1	Coal Gas to Incin	18,878	5213	660	1500
2	Coal Gas to Flare	7770	2146	660	1500
3	C.G. at Flare Inlet	7770	2146	10	1500
4	L.H. Vent to Ejector	3000	829	150	1500
5	L.H. Vent to Flare	3000	829	150	1500
6	Natural Gas Supply	676	239	Note 8	90
7	N.G. Assist Gas	660	233	Note 8	90
8	N.G. Ignitor Gas	6.5	2.3	15	90
9	N.G. Pilot Gas	8.8	3.1	15	90
10	Gas to Flare Tip	11,452	4046	40	90
11	Air from Receiver	137	30	125	90
12	Air to Ignitor	137	30	30	90
13	N2 Tip Seal	21.7	5	50	90
14	N2 Main Purge	1519	350	50	90
15	N2 L.H. Purge	1519	350	50	90
16	N2 QV-1,2 Purge	434	100	50	90

B) Coal Gas Data (Note 6)

1) Composition

CONSTITUENT	FORMULA	MASS %	VOL %
Carbon Monoxide	CO	25.46	21.13
Hydrogen	H2	1.38	15.91
Carbon Dioxide	CO2	10.57	5.58
Water	H2O	11.41	14.73
Methane	CH4	0.49	0.71
Hydrogen Sulfide	H2S	0.17	0.12
Nitrogen	N2	49.15	40.80
Argon	Ar	1.09	0.64
Ammonia	NH3	0.28	0.38
Total		100.00	100.00

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 2

System Name **Flare System**
Flowsheet No. **16N25706-40-F-GG-001**

2) Coal Gas Properties

Molecular Weight	23.25
Lower Heating Value - Btu/SCF	118
Higher Heating Value - Btu/SCF	127
Lower Heating Value - Btu/lb	1958
Higher Heating Value - Btu/lb	2106

C) **Natural Gas Data** (Note 7)

1) Composition

CONSTITUENT	FORMULA	MASS %	VOL %
Methane	CH4	81.20	90.42
Ethane	C2H6	9.22	5.48
Propane	C3H8	3.46	1.40
Isobutane	C4H10	2.42	0.74
Nitrogen	N2	1.98	1.26
Carbon Dioxide	CO2	1.72	070
Total		100.00	100.00

2) Natural Gas Properties (Note 2)

Molecular Weight	17.86
Lower Heating Value - Btu/SCF	967
Higher Heating Value - Btu/SCF	1,071
Lower Heating Value - Btu/lb	20,503
Higher Heating Value - Btu/lb	22,711

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1GG - 2

System Name **Flare System**
Flowsheet No. **16N25706-40-F-GG-001**

III. DESIGN NOTES

1) Per API 521, p 35.

2) Standard conditions for natural gas are 30" Hg (14.73 psia) and 60 deg F. The specific volume of Hope gas is 21.2 scf/lb.

3) Standard conditions for nitrogen are 14.7 psia and 70 deg F. The specific volume of nitrogen is 13.8 scf/lb.

4) Standard conditions for instrument air are 14.7 psia, 59 deg F, and 36% RH. The specific volume of standard air is 13.16 scf/lb.

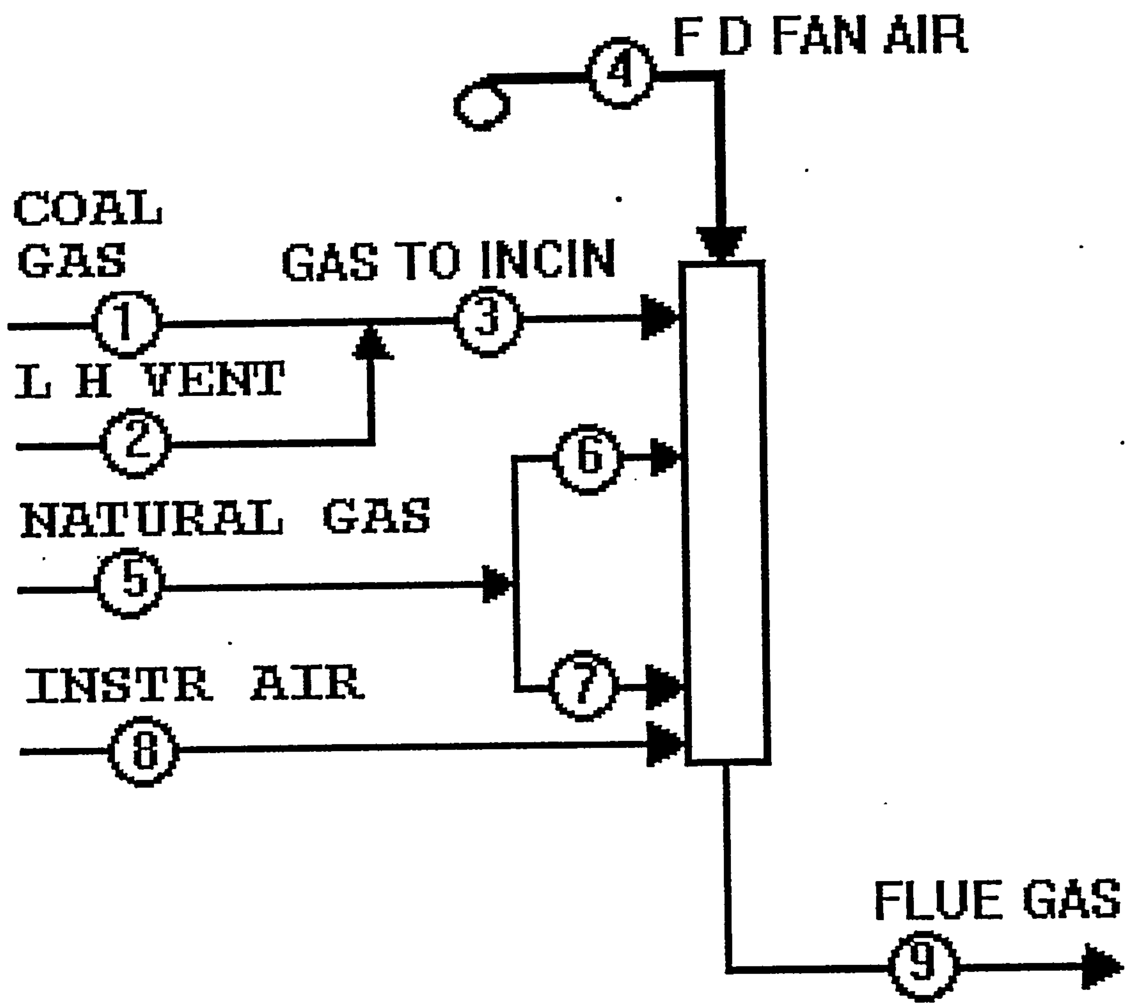
5) Standard conditions for waste gas (coal gas) to a flare are 14.7 psia and 68 deg F per 40 CFR 60.18. The specific volume of the design coal gas to the flare is 16.57 scf/lb.

6) Per Mass Balance - 3/22/95.

7) Per Natural Gas Distribution Process Design Basis.

8) Per Hope Gas.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1GH-1
System Name Incineration System
Flowsheet No. 16N25706-40-F-GH-001



EQUIPMENT:

Incinerator - 1GH-INCN-1
FD Fan - 1GH-FAN-1

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1GH-1
System Name Incineration System
Flowsheet No. 16N25706-40-F-GH-001

I. DESIGN PHILOSOPHY

1) The incinerator burns the coal gas so that it can be safely released to the atmosphere. The residence time in the coal gas within the incinerator is one second.

2) The temperature within the incinerator is controlled to 2000 deg F. The heating loop is controlled by the natural gas fuel control valve. The cooling loop is controlled by the FD fan VFD.

3) The coal gas enters the incinerator through a stainless steel burner.

4) The forced draft fan supplies the combustion air (and quench air) to the incinerator . A variable frequency drive (VFD) controls the speed of the fan motor.

5) The incinerator is a vertical, cylindrical, down-fired unit constructed of refractory lined carbon steel. It is approximately nine feet in diameter and twenty-five feet tall. The coal gas inlet to the incinerator is approximately the same elevation as the coal gas outlet from the cyclone.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1GH-1
System Name Incineration System
Flowsheet No. 16N25706-40-F-GH-001

II. DESIGN CRITERIA

A) **Process Streams** (Notes 1,2,3)

ITEM	PROCESS STREAM	MAX FLOW LB/HR	MAX FLOW SCFM	MAX PRESS PSIG	MAX TEMP DEG F
1	Gasifier Coal Gas	18,878	5213	30	1150
2	LH Vents	3000	829	30	1150
3	Coal Gas to Incin.	21,878	6042	30	1150
4	FD Fan Air	Note 4	Note 4	1	100
5	Natural Gas Supply	Note 4	Note 4	60	100
6	N.G. Burner Gas	Note 4	Note 4	60	100
7	N.G. Ignitor Gas	Note 4	Note 4	60	100
8	Inst. Air to Ignitor	Note 4	Note 4	120	100
9	Flue Gas	Note 4	Note 4	1	2100

B) **Coal Gas Data** (Note 5)

1) Coal Gas Composition

CONSTITUENT	FORMULA	MASS %	VOL %
Carbon Monoxide	CO	25.40	21.08
Hydrogen	H2	1.39	16.04
Carbon Dioxide	CO2	10.48	5.54
Water	H2O	11.23	14.49
Methane	CH4	0.50	0.73
Hydrogen Sulfide	H2S	0.64	0.44
Nitrogen	N2	48.98	40.65
Argon	Ar	1.10	0.64
Ammonia	NH3	0.28	0.39
Total		100.00	100.00

2) Coal Gas Properties

Molecular Weight	23.25
Higher Heating Value - Btu/scf	127

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SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1GH-1
System Name Incineration System
Flowsheet No. 16N25706-40-F-GH-001

Higher Heating Value - Btu/lb	2147

C) **Particulate Data** (Particulate in coal gas going to the incinerator)

1) Max Particulate - 125 lb/hr (Note 6)

2) Particulate Composition - Wt% (Note 5)

Carbon	70
Ash	30

3) Ash Composition - (Note 7)

CONSTITUENT	FORMULA	MASS %
Silica	SiO2	55.19
Alumina	Al2O3	31.11
Iron (III) Oxide	Fe2O3	7.08
Titania	TiO2	1.49
Magnesia	MgO	1.22
Manganese Oxide	MnO	0.08
Phosphorus (V) Oxide	P2O5	0.27
Potassium Oxide	K2O	2.66
Calcium Oxide	CaO	0.90
Total		100.00

4) Ash Fusion Temp - 2200 Deg F. (Note 7)

5) Particulate Size Distribution - It is anticipated that 95% of the particulate is between 1-5 micron (Note 8).

D) **Natural Gas Data** (Note 9)

1) Natural Gas Composition

CONSTITUENT	FORMULA	MASS %	VOL %
Methane	CH4	81.20	90.42
Ethane	C2H6	9.22	5.48
Propane	C3H8	3.46	1.40
Isobutane	C4H10	2.42	0.74
Nitrogen	N2	1.98	1.26
Carbon Dioxide	CO2	1.72	070
Total		100.00	100.00

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1GH-1
System Name Incineration System
Flowsheet No. 16N25706-40-F-GH-001

2) Natural Gas Properties

Molecular Weight	17.86
Higher Heating Value - Btu/SCF	1,071
Higher Heating Value - Btu/lb	22,711

SYSTEM PROCESS DESIGN BASIS
PDB No. 40-1GH-1
System Name Incineration System
Flowsheet No. 16N25706-40-F-GH-001

III. DESIGN NOTES

1) Standard conditions for waste gas (coal gas) are 14.7 psia and 68 deg F per 40 CFR 60.18. The specific volume of the design coal
gas is 16.57 scf/lb.

2) Standard conditions for natural gas are 30" Hg (14.73 psia) and 60 deg F. The specific volume of Hope gas is 21.2 scf/lb.

3) Standard conditions for instrument air are 14.7 psia, 59 deg F, and 36% RH. The specific volume of standard air is 13.16 scf/lb.

4) Per Vendor

5) Per Mass Balance - 5/31/95.

6) Per cyclone Process Design Basis.

7) Per Task IV report.

8) Based on correlating the Bacho particulate curve with the cyclone efficiency curve.

9) Per Natural Gas Distribution Process Design Basis.

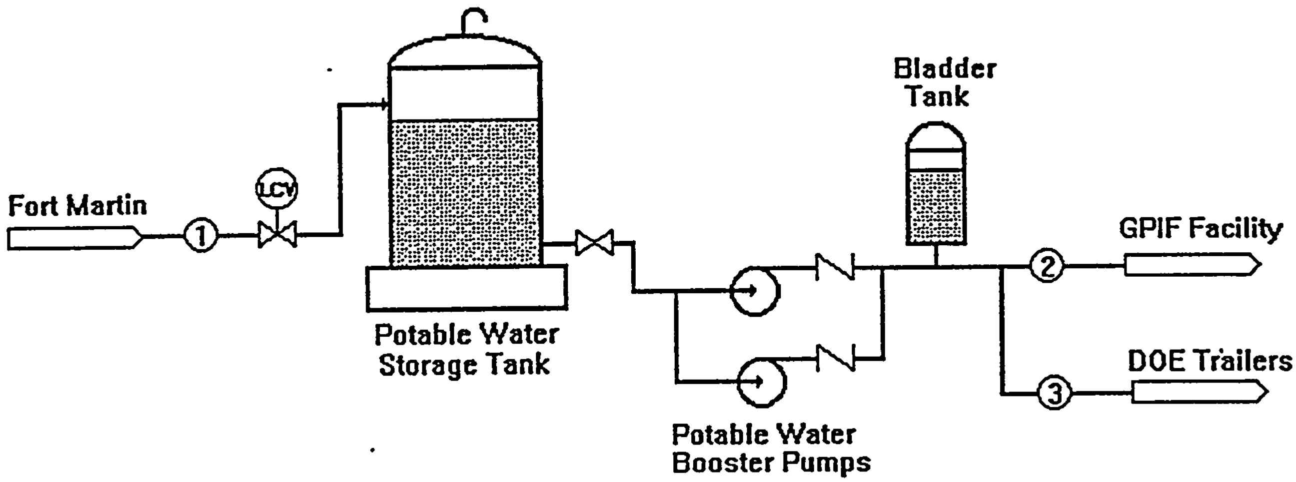
10) Incinerator will be arranged vertical with flow down, per manufacturer recommendation when particulate is present in fuel.

SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1KK - 1

System Name Potable Water Sytem

Flowsheet No. 16N25706-40-F-1KK-001



EQUIPMENT

Potable Water Storage Tank (Eq. No. 1KK-TK-1)
Potable Water Booster Pumps (Eq. Nos. 1KK-P-1, 1KK-P-2)

SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1KK - 1

System Name Potable Water Sytem

Flowsheet No. 16N25706-40-F-1KK-001

I. DESIGN PHILOSOPHY

1. The function of the Potable Water System is to receive and store potable water from the Fort Martin Station and forward the water to the various GPIF users.

2. Potable water is received at 1 gpm and stored in 500 gallon capacity storage tank. With only 1 gpm of makeup flow being available, the potable water must be stored for peak use periods.

3. The Potable Water Booster Pumps take suction directly from the storage tank. The potable water is forwarded to the GPIFdistribution header and in turn, available to the users. Potable water is also forwarded to the Department of Energy (DOE) trailers.

4. A bladder tank located downstream of the pumps maintains constant pressure on the distribution header at all flow conditions. This tank monitors system pressure regulates pump operation based on increases and decreases in system pressure.

5. This system provides water for the plants safety showers, and domestic plumbing needs. (Toilets, showers, sinks, etc.)

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1KK - 1
System Name Potable Water Sytem
Flowsheet No. 16N25706-40-F-1KK-001

II. DESIGN CRITERIA

ITEM NO.	PROCESS STREAM	MAXIMUM FLOW GPM	NORMAL FLOW GPM	MINIMUM FLOW GPM	MAXIMUM TEMP. °F	MINIMUM TEMP. °F	MAXIMUM PRESS. PSIG	MINIMUM PRESS. PSIG
1	Potable Water from Ft. Martin	Hold	1	1	55	55	150	150
2	Potable Water to GPIF	Hold	65	65	Ambient	Ambient	30	30
3	Potable Water to DOE Trailers	Hold	Hold	Hold	Ambient	Ambient	30	30

SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1KK - 1

System Name Potable Water Sytem

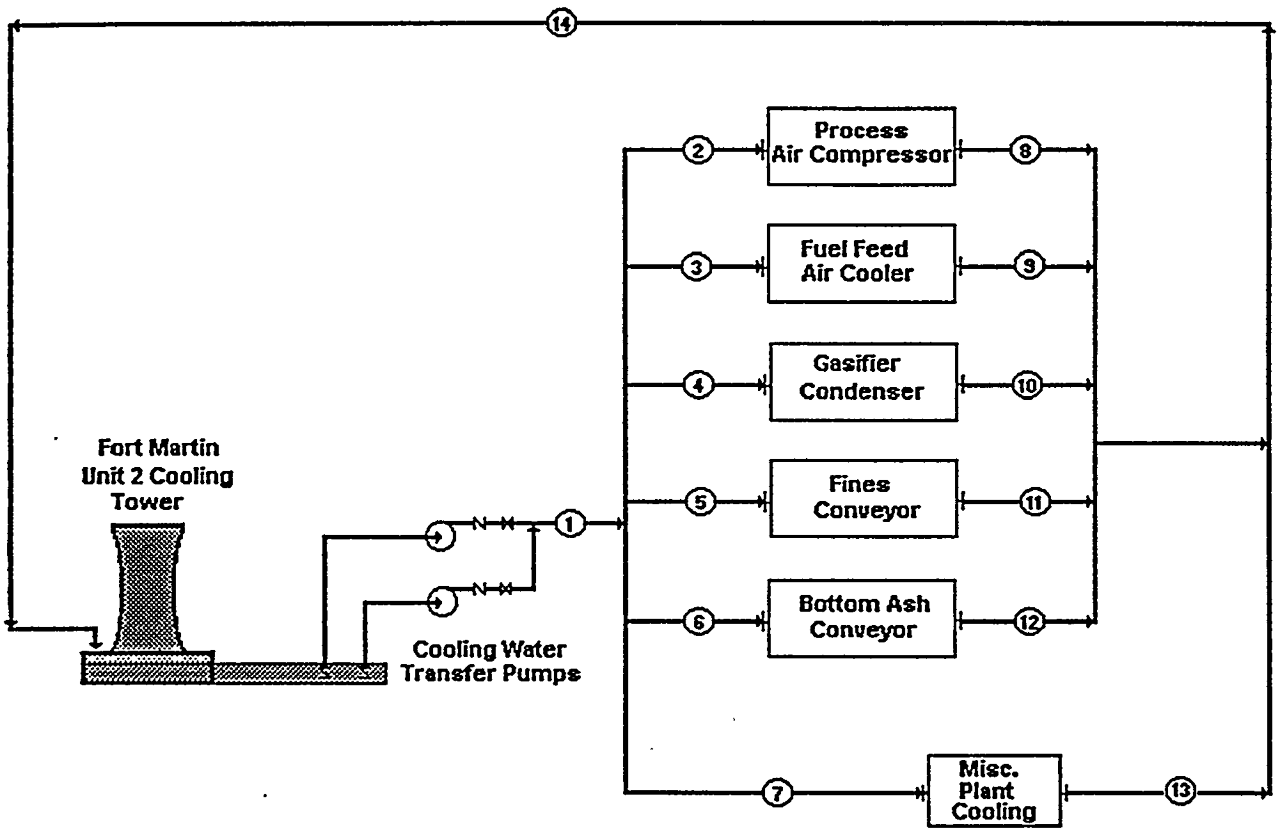
Flowsheet No. 16N25706-40-F-1KK-001

III. DESIGN NOTES

1. Potable water design flow rates will be determined once the plant layout and potable water users are finalized.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1KV - 1

System Name Auxiliary Water Distribution (Cooling Water)
Flowsheet No. 16N25706-40-F-KV-001



EQUIPMENT

Cooling Water Transfer Pumps (Eq. Nos. 1KV-P-1, 1KV-P-2)

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1KV - 1

System Name Auxiliary Water Distribution (Cooling Water)
Flowsheet No. 16N25706-40-F-KV-001

I. DESIGN PHILOSOPHY

1. The function of Cooling Water System is to provide cooling water to the Process Air Compressor, Fuel Feed Air Cooler, Gasifier Condenser, Fines Conveyor, Bottom Ash Conveyor and other miscellaneous plant components that require cooling water.

2. The two 50% capacity Cooling Water Transfer Pumps take suction from the existing Fort Martin Station Unit No. 2 Cooling Tower Basin and forward cooling water to the Gasification Product Improvement Facility (GPIF).

3. During normal or emergency plant shut down, only one of the two Cooling Water Transfer Pumps is required to be operational in order to provide cooling water for shutdown.

4. The Cooling Water Transer Pumps are self priming, centrifugal horizontal type pumps. Foot valves are installed on the cooling water suction line inlet to maintain prime during GPIF and system shutdown.

5. After passing through the cooling heat exchangers the cooling water is returned back to the Fort Martin cooling tower.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1KV - 1

System Name Auxiliary Water Distribution (Cooling Water)
Flowsheet No. 16N25706-40-F-KV-001

II. DESIGN CRITERIA

ITEM NO.	PROCESS STREAM	MAX. FLOW (gpm)	MIN. FLOW (gpm)	NORMAL FLOW (gpm)	MAX. TEMP. (°F)	MIN. TEMP. (°F)	MAX. PRESS. (psig)	MIN. PRESS. (psig)
1	Cooling Water Transfer Pump Discharge	Hold	Hold	Hold	150	Hold	100	30
2	Inlet to Process Air Compressor	Hold	Hold	Hold	150	Hold	100	30
3	Inlet to Fuel Feed Air Cooler	50	35	10	150	85	100	40
4	Inlet to Gasifier Condenser	Hold	Hold	Hold	150	85	100	40
5	Inlet to Fines Conveyor	Hold	Hold	Hold	150	85	100	40
6	Inlet to Bottom Ash Conveyor	Hold	Hold	Hold	150	85	100	40
7	Header to Miscellaneous Plant Cooling	Hold	Hold	Hold	150	85	100	40
8	Outlet from Process Air Compressor	Hold	Hold	Hold	150	105	100	30
9	Outlet from Fuel Feed Air Cooler	Hold	Hold	Hold	150	105	100	30
10	Outlet from Gasifier Condenser	Hold	Hold	Hold	150	105	100	30
11	Outlet from Fines Conveyor	Hold	Hold	Hold	Hold	Hold	100	30
12	Outlet from Bottom Ash Conveyor	Hold	Hold	Hold	Hold	Hold	100	30
13	Header from Miscellaneous Plant Cooling	Hold	Hold	Hold	150	Hold	100	30
14	Return to Fort Martin Cooling Tower	Hold	Hold	Hold	150	Hold	100	30

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1KV - 1

System Name Auxiliary Water Distribution (Cooling Water)
Flowsheet No. 16N25706-40-F-KV-001

III. DESIGN NOTES

1. Current design is based on the Mass Balance dated (later).

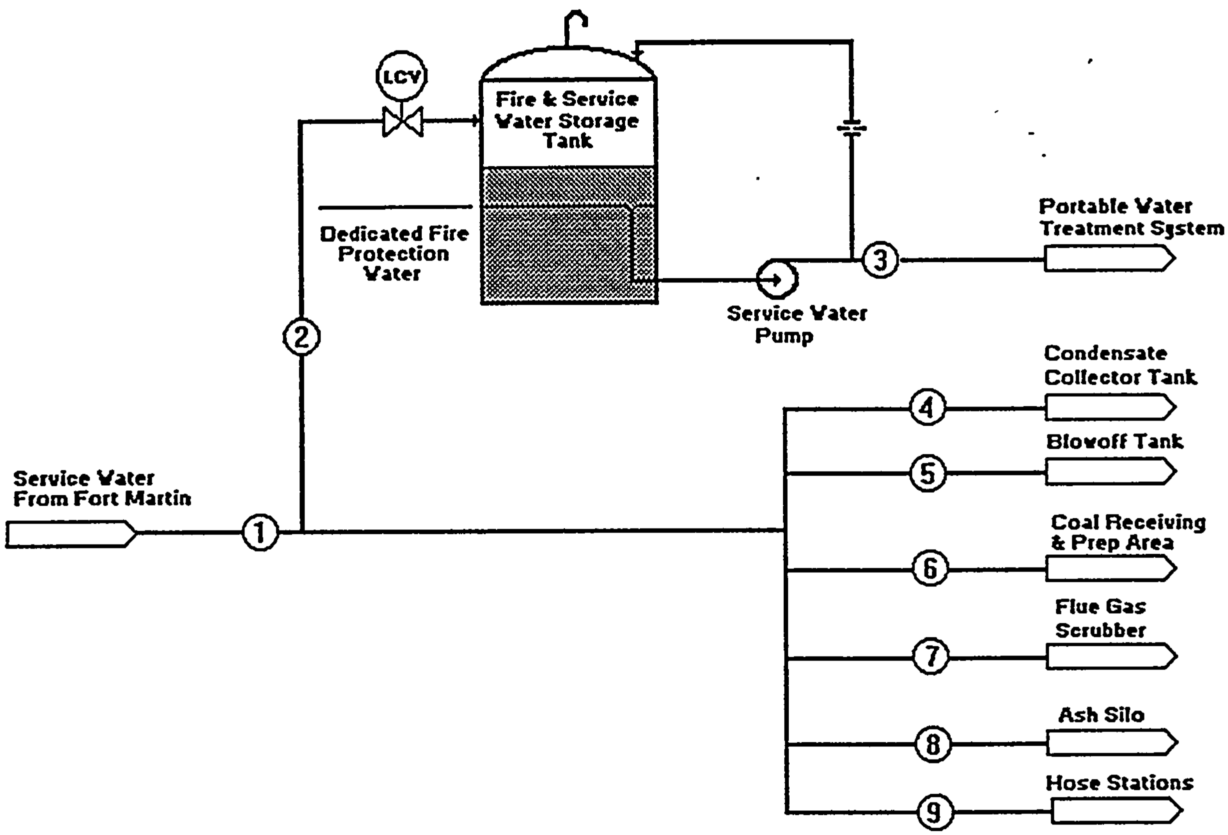
2. Design criteria will be finalized when equipment design and selection is completed.

SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1KW - 1

System Name Service Water System

Flowsheet No. 16N25706-40-F-1KW-001



EQUIPMENT

Fire & Service Water Storage Tank (Eq. No. 1KW-TK-1)
Service Water Pump (Eq. No. 1KW-P-1)

SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1KW - 1

System Name Service Water System

Flowsheet No. 16N25706-40-F-1KW-001

I. DESIGN PHILOSOPHY

1. The function of the Service Water System is to receive, store and distribute service water from Fort Martin station to the various GPIF users.

2. The Fire & Service Water Storage Tank receives and collects service water from Fort Martin. The tank provides an inventory of both fire protection water and pretreated boiler feedwater.

3. A level control valve, located at the inlet to the storage tank, maintains tank level by modulating service water inlet flow.

4. The Service Water Pump takes suction from the storage tank and forwards the water to the inlet to the portable water treatment skid. The inlet to the Service Water pump suction line is located at a tank level above the dedicated fire protection water level.

5. Required minimum flow is maintained for the Service Water Pump by continuously recirculating a portion of pump discharge flow back to the storage tank.

6. Sevice water to the Condensate Collector Tank, Blowoff Tank, coal receiving and prep area, Flue Gas Scrubber, the Ash Silo and the plant hose stations is pipe directly from the Fort Martin service water supply header. Pressure to these users is adequate as provided by the Fort Martin service water pumps.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1KW - 1
System Name Service Water System
Flowsheet No. 16N25706-40-F-1KW-001

II. DESIGN CRITERIA

ITEM NO.	PROCESS STEAM	MAXIMUM FLOW GPM	NORMAL FLOW GPM	MINIMUM FLOW GPM	MAXIMUM TEMP. °F	MINIMUM TEMP. °F	MAXIMUM PRESS. PSIG	MINIMUM PRESS. PSIG
1	Service Water from Ft. Martin	Hold	Hold	Hold	90	60	100	75
2	Service Water to Storage Tank	Hold	Hold	Hold	90	60	100	75
3	Service Water to Portable Water Treatment System	Hold	Hold	Hold	90	60	100	70
4	Service Water to Condensate Collector Tank	Hold	Hold	Hold	90	60	80	40
5	Service Water to Blowoff Tank	Hold	Hold	0	90	60	80	40
6	Service Water to Coal Prep and Receiving Area	Hold	Hold	0	90	60	80	40
7	Service Water to Flue Gas Scrubber	Hold	Hold	0	90	60	80	40
8	Service Water to Ash Silo	Hold	(See Mass Balance)	(See Mass Balance)	(See Mass Balance)	(See Mass Balance)	(See Mass Balance)	(See Mass Balance)
9	Service Water to Hose Stations	Hold	0	0	90	60	80	40

SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1KW - 1

System Name Service Water System

Flowsheet No. 16N25706-40-F-1KW-001

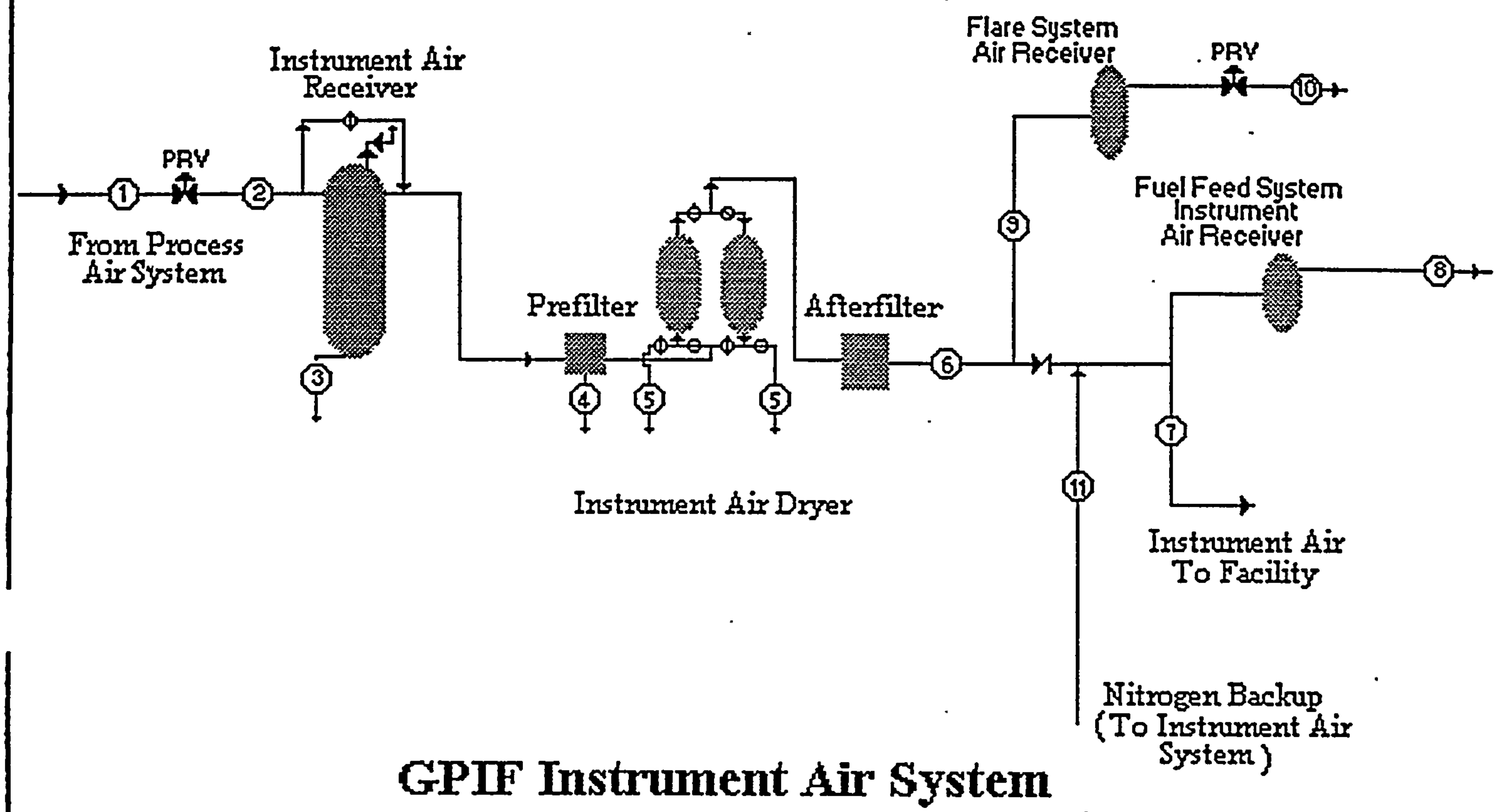
III. DESIGN NOTES

1. Current design is based on Mass Balance dated (later).

2. This document does not describe the Fire Protection System.

3. The capacity of the Fire & Service Water Storage Tank is (later) gallons. This is based on (later) gallons of fire protection water and (later) gallons of service water.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LD - 1
System Name **Plant and Instrument Air Systems**
Flow sheet No. **16N25706-40-F-1LD-001**



EQUIPMENT

Dryer Prefilter (Eq. No. 1LD-FLT-1)
Instrument Air Dryer (Eq. No. 1LD-DRY-1)
Dryer Afterfilter (Eq. No. 1LD-FLT-2)
Instrument Air Receiver (Eq. No. 1LD-TK-1)
Fuel Feed System Instrument Air Receiver (1LD-TK-2)
Flare System Air Receiver (Eq. No. 1GG-TK-1)

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LD - 1
System Name Plant and Instrument Air Systems
Flow sheet No. 16N25706-40-F-1LD-001

DESIGN PHILOSOPHY

1. The Instrument Air System shall be designed to provide instrument quality air (-40 °F pressure dew point) to users in the GPIF facility.

2. While the GPIF will operate on a schedule of two weeks operating and down for six weeks, the Instrument Air System shall be designed to operate continuously.

3. Instrument Air shall be provided from an interface with the Process Air System A pressure reducing value shall be used to reduce Process Air pressure to approximately 100 psig for use in the Instrument Air System.

4. The design pressure of the Instrument Air System shall be 125 psig. All piping, vessels, and equipment shall have an ASME pressure rating of this value.

5 The capacity of the **Instrument Air Dryer** shall be determined, in part, by the purge flow technology used by the dryer ultimately selected. Instrument Air System Vendors will recommend a system configuration based upon specified system requirements and economic parameters agreed to by JSE, R/S, and the DOE.

6. The **Instrument Air Receiver** volume in cubic feet shall equal **30 seconds** (.5 minutes) of additional flow at a rate of **100 scfm**.. This flow shall be adequate for meeting the anticipated flow surges in the Instrument Air System.

7. The **Instrument Air Dryer** shall be a dual tower desiccant-type dryer. This dryer shall be designed to deliver **350 SCFM** to the facility's Instrument Air System. During normal operation, one tower will be in service while the other is undergoing regeneration. Regeneration shall be controlled on either a timed cycle or by monitoring the exit humidity of the regenerating bed.. The dried compressed air will have a pressure dew point of at least **-40 °F**.

8. The maximum pressure drop across the instrument air dryer shall be **5 psi** at rated flow and pressure.

9. The dryer prefilter shall be designed to capture all liquid and solid particles greater than **0.9 microns** in size. The maximum pressure drop associated with a saturated filter at rated flow and pressure shall be **2 psi**.

10. The dryer afterfilter shall be designed to capture all desiccant particles greater than **0.9 microns** in size that may escape from the desiccant towers. The maximum pressure drop associated with a completely saturated afterfilter shall be **3 psi**.

11. The Instrument Air System will supply the instrument air needs of the Coal Preparation Facility. The interface with this facility shall be the **Fuel Feed System Instrument Air Receiver Tank** sized to handle the intermittent air flows associated with the air cannons and dustbins on the coal silo. The current estimate for size of this receiver is 14.5 ft^3.

12. Instrument Air will also be supplied to the Flare System. Instrument air will be required for the flame front ignitors. The interface with this system will also be an air receiver (**Flare System Air Receiver**) tank sized to handle the air requirements of the Flare System. It is currently estimated that this receiver will be approximately 8 ft^3. Air for this purpose will come off the Instrument Air System at a location upstream of the interface between the Instrument Air and Nitrogen Backup System. A check valve will prevent nitrogen from getting into the Flare System's ignitors.

13. Because the Instrument Air System will not be on emergency power, the backup system for instruments shall be nitrogen from the nitrogen distribution system. At least one nitrogen pump shall be on standby power so that nitrogen will always be available for critical uses.

14. The conversion between SCF and lbs. for this document is 0.076 lbs/ft^3.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LD - 1
System Name **Plant and Instrument Air Systems**
Flow sheet No. **16N25706-40-F-1LD-001**

Instrument Air System Profile

Stream No.	Process Stream	Normal Flow (PPH)	Maximum Flow ** (PPH)	Normal Temp. (°F)	Maximum Temp. (°F)	Normal Pressure (psig)	Maximum Pressure (psig)
1	Process Air	1,058	1,603	70	100	487	550
2	Process Air	1,058	1,603	70	100	105	125
3	Condensate	0	25	70	100	105	125
4	Condensate	0	5	70	100	103	125
5	Dryer Purge	80	80	70	100	10	125
6	Instrument Air	978	1,493	70	100	95	125
7	Instrument Air To Facility	932	1,219	70	100	93	125
8	Instrument Air To Fuel Feed	46	274	70	100	93	125
9	Instrument Air To Flare	0	90	70	100	93	125
10	Instrument Air To Flare	0	90	70	100	20	25
11	Nitrogen To Instrument Air	0	1,493	60	90	95	125

DESIGN NOTES

1. ** The following is the basis for Instrument Air System component sizing: These flow are the basis for system design (see Average Useage column below). Note that individual flows are not necessarily cumulative

GPIF Instrument Air Estimates (PPH)

	(a) Minimum Usage During Shutdown	(b) Minimum Usage During Normal Operation	(c) Average Usage During Normal Operation (Assumes 60% Utilization)	(d) Maximum Air Demand (100 % Utilization)
Instrument Air To Facility	18	18	1089	1796
Instrument Air To MH	23	91	274	456
Instrument Air To Flare	--	--	--	--
Losses (5 % Dryer Purge)	2.35	6	80	131
(10% Leakage)	5	13	160	265
Total	47	128	1603	2649

[a] These figures represent the facility's instrument requirement when the GPIF is down during the six week data evaluation period. Because the process air compressors will not be operating during this time, this flowrate also represents the base nitrogen demand by the Instrument Air System.

[b] These figures represent the estimated minimum instrument air demand during normal GPIF operation.

[c] Normal instrument air demand is based upon a conservative estimate of equipment utilization of 60% of system maximum demand.

[d] These figures represent all instrumentation and other users in operation concurrently.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LD - 1
System Name **Plant and Instrument Air Systems**
Flow sheet No. **16N25706-40-F-1LD-001**

2. Instrument air requirements were estimated by summarizing all instruments loops and the air requirements of each type.

3. An Instrument Air Dryer size of 350 SCFM is recommended based upon the estimate air requirements of the facility. This unit sizing reflects very little contingency when compared to the normal usage figure. However, the utilization figure used to estimate normal usage is very conservative and therefore has contingency already included. In addition, the Instrument Air System will have a nitrogen backup that will supplement the system to maintain optimum system operating pressure.

4. Plant Air shall be provided by a separate compressor / receiver / dryer designed to provide air for less critcal uses . The capacity of this system shall be 100 SCFM. Compressed air from this system shall be used for pneumatic tools and housekeeping. The following is an estimate of anticipated plant air users and their consumption.

Estimated Plant Air Usage

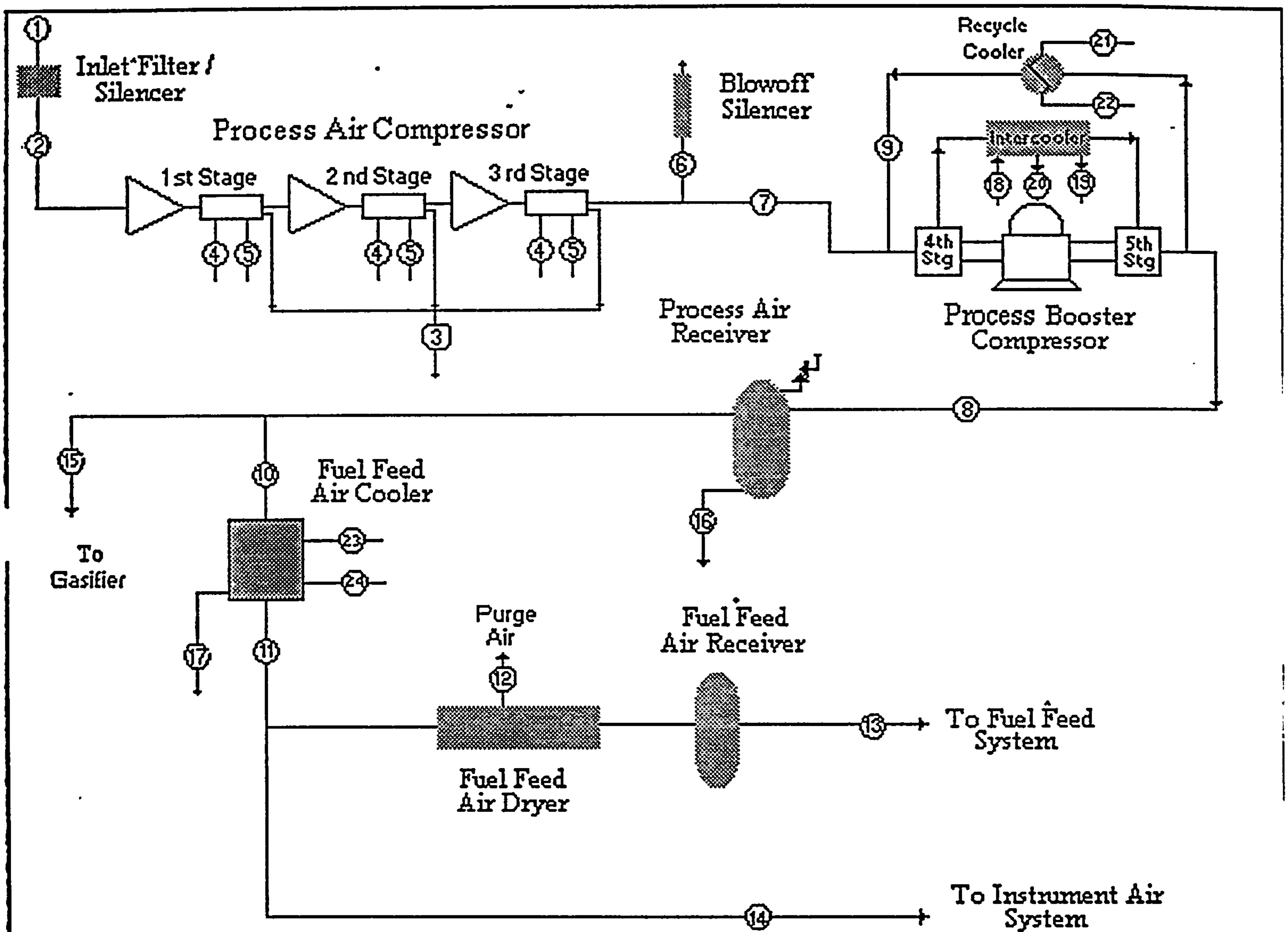
Pneumatic Tools

Tool	No.	Air Requirement (SCFM) Per Tool	Total
Drills	2	35	70
Grinders	2	50	100
Sm. Screw Driver	3	12	36
Lrg.. Screw Driver	2	30	60
Riveters	1	35	35
Hoist	3	35	105
Sub-Total =			406
Tool Utilization Factor (15%)			61

Total Plant Air Usage	SCFM
Pneumatic Tools	61
Hose Stations (Cleaning)	20
Leakage (15%)	14
Total =	95

SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1LF - 1
System Name Process Air System
Flow sheet No. 16N25706-40-F-1LF-001



EQUIPMENT

Inlet Filter / Silencer (Eq. No. 1LF-FLT-1)
Process Air Compressor (Eq. No. 1LF-CMP-1)
Process Booster Compressor (Eq. No. 1LF-CMP-2)
1st Stage Intercooler (Eq. No. 1LF-HX-1)
2nd Stage Intercooler (Eq. No. 1LF-HX-2)
3rd Stage Intercooler (Eq. No. 1LF-HX-3)
th Stage Intercooler (Eq. No. 1LF-HX-4)
Recycle Cooler (Eq. No. 1LF-HX-5)

Blowoff Silencer (Eq. No. 1LF-SIL-1)
Process Air Receiver (Eq. No. 1LF-TK-1)
Fuel Air Cooler (Eq. No. 1LF-HX-7)
Fuel Feed Air Dryer (Eq. No. 1LF-DRY-1)
Fuel Feed Air Receiver (Eq. No. 1LF-Tk-2)

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LF - 1
System Name **Process Air System**
Flow sheet No. **16N25706-40-F-1LF-001**

DESIGN PHILOSOPHY

1. The process air compressors provide high pressure compressed air to the pyrolizer coal feed system , the Pygas Gasifier, and the Instrument Air System.

2. The process air compressors shall be a multi-stage centrifugal compressor followed by a two stage, balanced-opposed, reciprocating booster compressor designed to take atmospheric air and compress it to varying operating pressures. While the "design" discharge of the final stage of this system shall be 500 psig, the system shall be designed to operate from pressures near atmospheric up to the design pressure.

3. The varying flow and pressure requirements of the process shall be regulated by the operation of the air compressors' inlet guide vanes, blow-off system, recycle system and process pressure / flow control valves. The two compressors shall be designed to operate independently of each other. Capacity control of the reciprocating compressor shall be achieved by a pressure/flow controller sensing the process requirements and regulating a bypass valve that will direct the compressor's discharge to either the process or recycle it back to the compressor's suction. The recycled flow shall be cooled in the recycle cooler to prevent overheating of the compressor. The centrifugal compressor's capacity control system will also sense the changing flow/pressure requirements simultaneously and will regulate its inlet guide vanes and blowoff valve as necessary to maintain process conditions and prevent compressor surging.

4. Each air compressor shall be a complete, self contained units with all necessary controls for continuous, multi-pressure operation, and unit protection.

5. The air compressors shall be designed to support the facility schedule of two weeks operating and down for six weeks throughout the year.

6. The compressor shall be equipped with intercoolers between each stage of compression to cool inlet air and eliminate moisture. Each cooler shall be equipped with automatic condensate drainage traps.

7. The Process Air System will be designed to allow the discharge temperature from the final stage compression to vary from a low temperature of approximately 150 °F to a maximum temperature of approximately 400 °F. The discharge temperature will be adjusted by the regulation of cooling water flow to the intercoolers of the centrifugal and reciprocating compressors. The final temperature will be limited only by the site requirement that no single motor can exceed 2000 HP.

8. The high temperature, high pressure, compressed air leaving the air compressors is anticipated to have less than a 3 % degree of saturation due to intercooling between stages.

9. Compressor Design Ambient Conditions:

Dry Bulb:	0 °F	Winter
	90 °F	Summer
Humidity:	49 %	RH

10. The air compressors shall be shop assembled. Due to the anticipated size of these units, some disassembly maybe necessary to get them into the building.

11. The air compressors shall be designed for indoor operation.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LF - 1
System Name Process Air System
Flow sheet No. 16N25706-40-F-1LF-001

12. The Process Air Receiving Tank will act as a dampener for process flow transients. The receiver shall be designed to supply the intermittent air requirements of process users to minimize compressor capacity. Current estimates of system receiver capacity are ~300 ft^3. This volume is equivalent to approximately 100 SCFM of additional capacity assuming a 10 psi drop in system operating pressure over two minutes. Any moisture accumulating in the receiver shall be removed with automatic condensate traps. The air receiving tank shall be a carbon steel, ASME coded vessel. It shall be equipped with a safety valve set at 10% above compressor design pressure.

13. The Fuel Feed Air Cooler will reduce the hot process and instrument air temperature to approximately 100 °F to allow desiccant air drying. This cooler shall be a water cooled shell and tube heat exchanger designed for high pressure air applications Air will flow in the tubes and water on the shell-side of this exchanger. A relief valve shall be installed on the shell-side to prevent over-pressurization due to thermal expansion. The cooler shall be equipped with moisture separating equipment to allow the removal of condensation. Moisture accumulating in the air cooler shall be removed with moisture traps. The Fuel Feed Air Cooler sizing shall be based upon the final capacity of the Fuel Feed Air Dryer and the air requirements of the Instrument Air System (see Design Note (1) below).

14. The Fuel Feed Air Dryer shall be designed to dry the saturated, high pressure compressed air from approximately 100 °F to a pressure dew point of -40 °F. This air quality is necessary to prevent instrumentation freeze-up and the "caking" of the crushed coal in the pneumatic convey system. The dryer shall be a dual tower type with one desiccant bed undergoing regeneration at all times. The anticipated purge flow will be ~ 5% of dryer throughput. Final dryer sizing shall be based upon the dryer technology selected and the dryer's actual purge requirements (see Design Note (1) below).

15. The Fuel Feed Air Receiving Tank shall be designed to accommodate the transient flows associated with the fuel feed system. On the basis of the latest information from the fuel feed conveyor vendor, the flow rate due to lock vessel pressurization/depressurization is estimated to be 39 SCFM. Based upon a repressurization time of 130 seconds, the air receiver will have a volume of 60 ft^3. The air receiver shall be an ASME coded vessel designed for the maximum system operating pressure. Since this system will be design for instrument quality air, no condensate traps shall be installed on the receiver. However, the receiver shall be equipped with drain plugs.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LF - 1
System Name Process Air System
Flow sheet No. 16N25706-40-F-1LF-001

Design Criteria
325 Psig Gasifier Operation

Steam No.	Process Stream	Normal Flow (#/hr) Appx. A-8	Maximum Flow (#/hr) (Design *)	Normal Temp. (°F)	Maximum. Temp. (°F)	Normal Pressure (psig)	Maximum Pressure (psig)
1	Inlet Air	16,277	19,212	70	90	14.52 **	14.6 **
2	Inlet Air	16,277	19,212	70	90	14.21**	14.3 **
3	Condensate	300	360	-	-	-	-
4	C.W. Supply	23,725	28,000	85	85	40	60
5	C.W. Return	23,725	28,000	105	105	30	60
6	Compressor Blowoff	0	0	105	105	120	138
7	Centrifugal Discharge	15,977	18,852	105	105	120	138 ❖
8	Recip. Discharge	15,893	18,752	350	400	500	550
9	Recip. Recycle	0	0	105	105	120	138
10	Air Cooler Inlet	5,837	7,551	350	400	492	550
11	Air Cooler Outlet	5,812	7,521	70	100	487	550
12	Dryer Purge	247 ****	296 ****	70	100	484	550
13	Air To Fuel Feed	4,492 ***	5,622	70	100	474	550
14	Air To Instr. Air System	1,058	1,603	70	100	487	550
15	Air To Gasifier	9,506	11,407	350	400	492	550-
16	Condensate	5	6	350	400	500	550
17	Condensate	25	30	350	400	492	550
18	C.W. Supply	11,860	14,000	85	95	40	60
19	C.W. Return	11,860	14,000	105	115	30	60
20	Condensate	84	100	200	215	500	550
21	C.W. Supply	0	14,000	85	95	40	60
22	C.W. Return	0	14,000	105	115	30	60
23	C.W. Supply	17,500	22,650	85	95	40	60
24	C.W. Return	17,500	22,650	105	115	30	60

* This data reflects a 20 % contingency added to " normal " flow (process flow only) requirements @ 325 psig gasifier operation.
** Units for these data are psia.
*** These flows will occasionally be increased by ~ 39 SCFM when the charge and transfer hoppers in the fuel conveying system undergo pressure equalization.
**** Actual dryer purge flow will depend upon the dryer technology eventually chosen. Compressor sizing calculations have assumed a 5% purge flowrate.
❖ Assumes that the rise to surge pressure is 15% above design pressure.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LF - 1
System Name Process Air System
Flow sheet No. 16N25706-40-F-1LF-001

DESIGN NOTES:

1) The following is the basis for process air compressors, air cooler, and air dryer sizing.

Estimated Based Upon 5/31/95 Mass Balance
Unless Otherwise Noted.

Process		Air Flowrate	
Pyrolyzer	(Stream No. [9c])	3,579	lb/hr
Gasifier	(Steam No. [9d])	5,927	lb/hr
Coal Conveying ([9b])		4,492 *	lb/hr
	Sub-total =	14,013	lb/hr
Air Receiver Losses		5	lb/hr
Fuel Feed Air Dryer Purge		247	lb/hr
Pass Loss From Fuel Feed Air Cooler		25	lb/hr
Compressor Losses		384	lb/hr
	Sub-total =	661	lb/hr
	Total =	14,674	lb/hr
Instrument Air Requirement		1,603	lb/hr

Fuel Feed Air Dryer Capacity		
To Process	5,622 **	lb/hr
Purge	296	lb/hr
Total	5,918	lb/hr
(Includes 20% Contingency)		

Fuel Feed Air Cooler Capacity		
To Air Dryer	5,918	lb/hr
To P & I Air	1,603	lb/hr
Condensate Losses	5	lb/hr
Total =	7,526	lb/hr

	Sub-total Inlet Air Flow =	16,277	lb/hr	(Without Contingency)
Design Basis	Total Inlet Air Flow =	19,212	lb/hr	(Value includes a 20% contingency for process air requirements only)
	Delivered Air Flow =	18,750	lb/hr	

* Data from the 5/31/95 Rich Sadowski Mass Balance estimates this value to be 3309 lbs/hr, however Clyde Pneumatic Conveying's estimate is 4492 lbs/hr (985.4 SCFM) per 6/9/95 memo to Joe Bushek.

** This value includes an additional 178 lbs/hr (39 SCFM) of air losses from lock vessels.(per Clyde memo dated 6/9/95 to Joe Bushek)

2) The "Design" discharge pressure of the air compressor is 500 psig. This pressure was defined as follows:

Minimum pressure to fuel delivery system:	441 psig
Line loss between fuel feed dryer and convey system	8 psi
Fuel Feed Dryer and Filter Δ P	10 psi
Line loss between fuel feed air dryer and air cooler	3 psi
Fuel Feed Cooler Δ P	5 psi
Line loss between fuel feed air cooler and receiver	3 psi
Air Receiver Δ P	2.5 psi
Line loss between receiver and compressor discharge	2.5 psi
Contingency	25 psi
Total =	500 psig.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LF - 1
System Name **Process Air System**
Flow sheet No. **16N25706-40-F-1LF-001**

** All line loss values include at least a 30% contingency on equivalent length values.

3) A 20 % contingency has been added to the flow data. Process flow data is from Mass Balance for 325 psig Base Operation dated 5/31/95..

4) Minimum compressor flow is based on a 60 % turndown capability in air compressor throughput before encountering compressor surge limitations.

5) Normal operation assumes process operating as illustrated in Design Note (1) without miscellaneous conveyor system losses.

6) The periodic instantaneous air requirements of the miscellaneous conveyor system users and other non-continuous users have not been added to the air compressor capacity. This requirement is being designed into the Process and Fuel Feed Air Receiving Tanks' capacity.

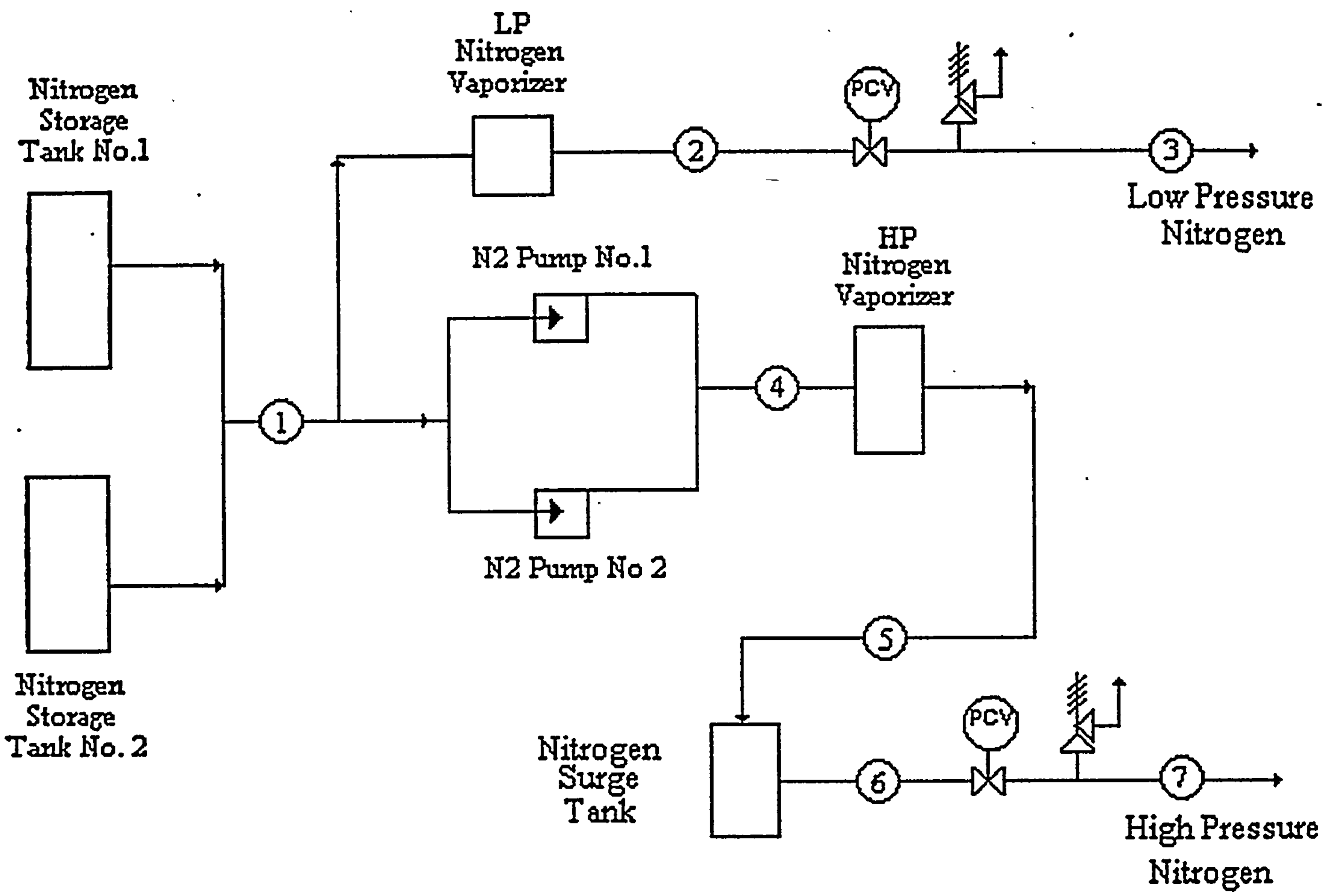
7) Compressor mass losses are estimated to be approximately 2%. These losses are those associated with moisture/air removal in the intercoolers between stages of compression.

8) The maximum system pressure is based upon a compressor / system safety valve setting of 110 % of the compressor design pressure of 500 psig (i.e. safety valve setting of 550 psig).

SYSTEM PROCESS DESIGN BASIS

PDB No. 40 - 1LK - 1

System Name: Nitrogen Storage & Distribution
Flowsheet No.: 16N25706-40-F-LK-001



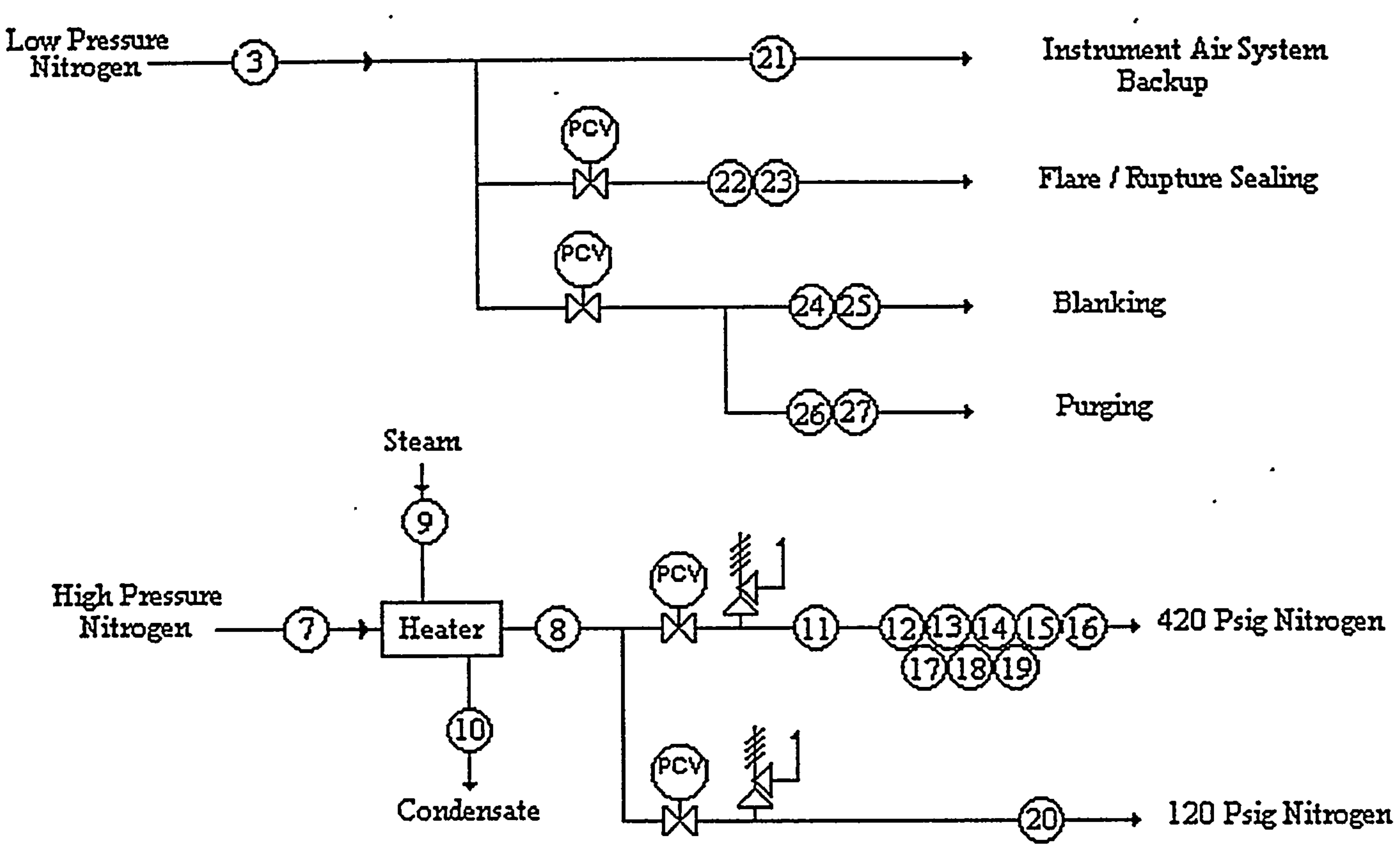
Nitrogen Storage and Distribution

EQUIPMENT:

Nitrogen Storage Tank No. 1 - 1LK-TK-1
Nitrogen Storage Tank No. 2 - 1LK-TK-2
Low Pressure Nitrogen Vaporizer - 1LK-VAP-1
High Pressure Nitrogen Vaporizer - 1LK-VAP-2
Nitrogen Pump No. 1 - 1LK-P-1
Nitrogen Pump No. 2 - 1LK-P-2
High Pressure Nitrogen Surge Tank - 1LK-TK-1
Nitrogen Heater - 1LK-HX-1

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LK - 1

System Name Nitrogen Storage & Distribution
Flowsheet No. 16N25706-40-F-LK-001



Nitrogen Storage and Distribution

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LK - 1

System Name Nitrogen Storage & Distribution
Flowsheet No. 16N25706-40-F-LK-001

I. DESIGN PHILOSOPHY

1) The facility requires nitrogen during four time periods; normal operation, gasifier transition, facility downtime, and utilities upset. Nitrogen use during these periods is as follows:

A) Normal Operation

a) Inert Cyclone Lockhoppers - Depressurize lockhopper to vent system. Dump ash. Pressurize lockhopper with nitrogen.

b) Inert Pyrolyzer Lockhopper - Depressurize lockhopper to vent system. Dump ash. Pressurize lockhopper with nitrogen.

c) Seal Flare Tip - Continuously supply nitrogen to the flare tip to prevent air from entering into the flare vent system (the flare vent system is an inert atmosphere).

d) Seal Rupture Disk Stack - Continuously supply nitrogen to the rupture disk stack tip to prevent air from entering into rupture disk stack vent system.

e) Purge Lockhopper Vent System - Intermittently purge lockhopper vent system in order to prevent plugging from coal and ash particles.

f) Purge Pressure Transmitters - Continuously seal pressure transmitter tubing in order to keep clear of coal and ash particles.

g) Seal/Cool Equipment - Nitrogen seal and/or cool equipment in contact with coal gas (ash/fines conveyor, gasifier rupture disk, high temperature valves, etc.)

B) Gasifier Transition (Note 4)

1) Startup

a) Pressure Test - Pressurize the gasifier system with nitrogen and monitor the leak rate.

b) Vent Purge - Purge the flare vent piping and the rupture disk stack vent piping with nitrogen.

c) Purge/Dry-out - Heat lockhoppers and lockhopper vent system with steam. Dry-out lockhoppers and vent system with nitrogen.

d) Pyrolyzer Bed Building - Feed coke to pyrolyzer to build the pyrolyzer bed. Add nitrogen and steam to the fixed bed to maintain the oxygen concentration below the combustion limit.

2) Hot Hold - *No nitrogen required* (Note 5).

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LK - 1

System Name Nitrogen Storage & Distribution
Flowsheet No. 16N25706-40-F-LK-001

3) **Normal Shutdown**

a) Purge Pyrolyzer Solids - Stop coal flow. Purge pyrolyzer solids with steam. *No nitrogen required.*

b) Burn-out Fixed Bed - Air and steam to fixed bed. *No nitrogen flow to fixed bed.* Nitrogen inert lockhoppers and vent system.

c) Purge and Inert - Steam purge gasifier system. Nitrogen to pyrolyzer and fixed bed for 15 minutes to dry out entire system. Lock up system under a nitrogen blanket unless personnel entry is anticipated.

4) **Emergency Shutdown via Flare Stack**

a) Reduce pressure via Flare - Depressurize system to 6 psig through the gasifier bleed control valve. *No nitrogen required.*

b) Dump Pyrolyzer Solids / Inert Fixed Bed - Minimum steam flow to pyrolyzer and fixed bed. *No nitrogen flow to gasifier.* Nitrogen inert lockhoppers and vent system.

c) Inert - Nitrogen to pyrolyzer and fixed bed for 15 minutes to inert and dry out the gasifier. Lock up system under a nitrogen blanket unless personnel entry is anticipated.

5) **Emergency Shutdown via Rupture Disk**

a) Reduce pressure via Rupture Disk - Depressurize system to 6 psig through the gasifier rupture disk. Add steam to pyrolyzer and fixed bed to control the rate of pressure decay. *No nitrogen required.*

b) Dump Pyrolyzer Solids / Inert Fixed Bed - Minimum steam flow to pyrolyzer and fixed bed. *No nitrogen flow to gasifier.* Nitrogen inert lockhoppers and vent system.

c) Inert - Nitrogen to pyrolyzer and fixed bed for 15 minutes to inert and dry out the gasifier. Replace rupture disk. Nitrogen purge and blanket coal gas system unless personnel entry is anticipated.

C) **Facility Downtime** - Nitrogen is used during plant downtime to blanket the following systems for corrosion protection (unless personnel entry is anticipated):

a) water side of gasifier
b) gas side of gasifier
c) cooling water system

D) **Utilities Upset**

a) Nitrogen is used as the backup fluid for the instrument air system if the instrument air compressor fails.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LK - 1

System Name Nitrogen Storage & Distribution
Flowsheet No. 16N25706-40-F-LK-001

2) The system (except for the heater) is leased from a nitrogen supplier. The initial lease duration is seven years.

3) Liquid nitrogen is shipped to the facility and is stored in two cryogenic nitrogen storage tanks.

4) A low pressure ambient vaporizer gasifies the liquid nitrogen. A PCV downstream of the vaporizer maintains the low pressure nitrogen system at 120 psig. The low pressure nitrogen system is used for instrument air backup, flare and rupture disk stack purging and sealing, and equipment blanketing. During the bid period the low pressure system is evaluated to determine its cost effectiveness (Depending on the lease cost of the low pressure vaporizer, it may be more economical to take everything from the high pressure system, and eliminate the low pressure system).

5) Two full size, cryogenic, rotary, positive displacement pumps are located downstream of the liquid storage tank. One pump cycles on and off based on the nitrogen demand. The other pump serves as a backup. Pump discharge pressure is approximately 2350 psig.

6) A high pressure ambient vaporizer gasifies the high pressure liquid nitrogen. The vaporizer is sized so that it can handle the total flow from both pumps running simultaneously.

7) High pressure nitrogen storage tubes are located downstream of the vaporizer. The tubes have enough storage capacity to handle peak nitrogen requirements. (One high pressure nitrogen storage tank may be more economical than high pressure storage tubes. This option is evaluated during the bid period). A PCV downstream of the storage tubes maintains the high pressure nitrogen system at 420 psig. A safety valve is locate downstream of the PCV and is set at 460 psig.

8) High pressure steam heats the nitrogen to 400 deg F (the same as process air) in a carbon steel shell and tube heat exchanger. The nitrogen is heated so that it does not condense any vapors when admitted into the system. Steam supply to the heater is from the 400 psig steam header. In addition, natural gas and electric heaters are evaluated during the bid period.

9) A PCV maintains the 420# header at 420 psig. A safety valve downstream of the PCV is set at 460 psig. The 420# header supplies nitrogen to the gasifier, lockhoppers, lockhopper vent system, and transmitter purge header.

10) A PCV maintains the 120# header at 120 psig. A safety valve downstream of the PCV is set at 150 psig. The 120# header supplies nitrogen to the vent system hoppers.

11) Nitrogen Purging:
   a) Purging is accomplished by mixing (dilution purging), and requires ten volumes to assure that the vessel is completely purged.

   b) When purging a vessel into service (air to nitrogen to coal gas) the goal is to reduce the oxygen level to less than 25% of the LOC (limiting oxidant concentration) of the coal gas. Proper instrumentation is required to ensure that purging requirements are met.

   c) When purging a vessel out of service (coal gas to nitrogen to air) the goal is to reduce the fuel concentration to less than 25% of the LEL (lower explosive limit) of the coal gas. Proper instrumentation is required to ensure that purging requirements are met.

   d) NFPA 325M (Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids) states that at high temperatures the LEL of a fuel is lowered and NFPA 69 (Explosion Prevention Systems) states that at high temperatures the LOC of a fuel is lowered. However, no published data exist quantifying by how much these limits are reduced. To account for this uncertainty, the purge system is designed to reduce both the LOC and the LEL to 25% of their values at standard conditions.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LK - 1

System Name Nitrogen Storage & Distribution
Flowsheet No. 16N25706-40-F-LK-001

II. DESIGN CRITERIA

ITEM	PROCESS STREAM	MAX FLOW SCFM	NORM FLOW SCFM (Note 6)	AVG FLOW SCFM (Note 7)	NORM PRESS PSIG	NORM TEMP DEG F
1	Liquid Nitrogen	Note 2	Note 2	Note 2	150	-270
2	From LP Vaporizer	Note 2	Note 2	Note 2	150	50
3	LP Nitrogen	400	10	10	120	50
4	From Cryogenic Pumps	Note 2	Note 2	Note 2	2350	-250
5	From HP Vaporizer	Note 2	Note 2	Note 2	2300	50
6	From Surge Tank	Note 3	Note 3	Note 3	2300	60
7	HP Nitrogen	Note 3	Note 3	Note 3	700	60
8	From N2 Heater	Note 3	Note 3	Note 3	700	400
9	HP Steam	Note 2	Note 2	Note 2	400	475
10	Condensate	Note 2	Note 2	Note 2	400	475
11	420# Nitrogen	Note 3	Note 3	Note 3	420	400
12	To Pyrolyzer	Note 3	0	0	420	400
13	To Pyro Fluid Nozzles	Note 3	0	0	420	400
14	To Grate	Note 3	0	0	420	400
15	Pyrolyzer LH	300	0	1	420	400
16	Bottom Ash LH Vent	5000	0	92	420	400
17	No. 1 Cyclone LH	3000	0	14	420	400
18	No. 2 Cyclone LH	3000	0	7	420	400
19	Transmit Purge Hdr.	Note 3	Note 3	Note 3	420	400
20	Vent Cycl. Hopper	100	0	0	120	400
21	Instrument Air Backup	350	0	0	120	50
22	To Flare Seal	5	5	5	30	50
23	To Rupture Disk Stack	5	5	5	30	50
24	Deaerator Blanket	350	0	0	30	50
25	Cooling Jacket Blanket	350	0	0	30	50
26	To Flare Vent Piping	350	0	0	30	50
27	To Rupture Vent Piping	350	0	0	30	50
28	120# Nitrogen	3000	18	18	120	400
29	No. 1 Cycl. LH Vent	3000	0	25	420	400
30	No. 2 Cycl. LH Vent	3000	0	13	420	400
31	Pyrolyzer LH Vent	300	0	1	420	400

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1LK - 1

System Name Nitrogen Storage & Distribution
Flowsheet No. 16N25706-40-F-LK-001

III. DESIGN NOTES

1) Standard conditions for nitrogen are 14.7 psia and 70 deg F. The specific volume of nitrogen is 13.8 scf/lb.

2) Per Vendor.

3) Later.

4) Per Process States Map in Rev. "0" Gasifier Process Design Basis. All of the process transition states are not listed. Only those transition states that relate to nitrogen usage are listed in this document. For a complete list of process transitions, refer to the Process States Map.

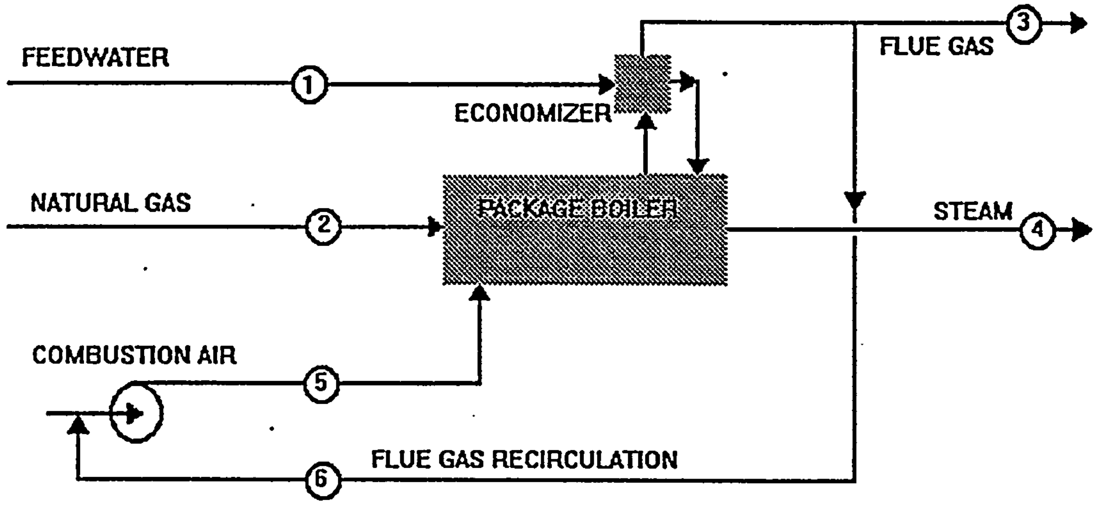
5) Per "Hot Hold" Mass Balance, 3/22/95.

6) "Normal Flow" is the typical stream flow rate during normal GPIF operation. A normal flow of zero implies that the stream is not normally in operation.

7) "Average Flow" is the average stream flow rate during normal GPIF operation.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1SB - 1

System Name Package Boiler Sytem
Flowsheet No. 16N25706-40-F-1SB-001



EQUIPMENT

Package Boiler (Equipment No. 1SJ-BLR-001)

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1SB - 1

System Name Package Boiler Sytem
Flowsheet No. 16N25706-40-F-1SB-001

I. DESIGN PHILOSOPHY

1. Product gas to be burned in an incinerator without heat recovery, and steam generation.

2. Export no steam to Fort Martin host.

3. Utilize a small package boiler to provide steam for the gasifier process, and for utilities.

4. Package boiler outlet steam conditions will match gasifier requirements rather than any "host" requirements.

5. Use natural gas as fuel for the package boiler.

6. Exhaust package boiler flue gas directly to the atmosphere withou;t any enviromental treatmen

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1SB - 1

System Name Package Boiler Sytem
Flowsheet No. 16N25706-40-F-1SB-001

II. DESIGN CRITERIA

ITEM	PROCESS STREAM	MAXIMUM FLOW #/HR(or as noted)	NORMAL FLOW #/HR(or as noted)	MINIMUM FLOW #/HR(or as noted	MAXIMUM TEMP. F	NORMAL TEMP. F	MAXIMUM PRESSURE PSIG	MIMIMUM PRESSURE PRIG
1	FEEDWATE R	6000	(See mass balance)	LATER	212	212	LATER VENDOR	LATER VENDOR
2	NATURAL GAS	LATER VENDOR	LATER VENDOR	LATER	Ambient	Ambient	40	LATER
3	FLUE GAS	LATER VENDOR	LATER VENDOR	LATER	300	250	LATER VENDOR	LATER VENDOR
4	STEAM	6000	(See mass balance)	LATER	560	550	500	400
5	COMBUST. AIR	LATER VENDOR	LATER VENDOR	LATER VENDOR	100	80(normal)	LATER VENDOR	LATER VENDOR
6	FLUE GAS RECIRC.	LATER VENDOR	LATER VENDOR	LATER VENDOR	300	250	LATER VENDOR	LATER VENDOR

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1SB - 1

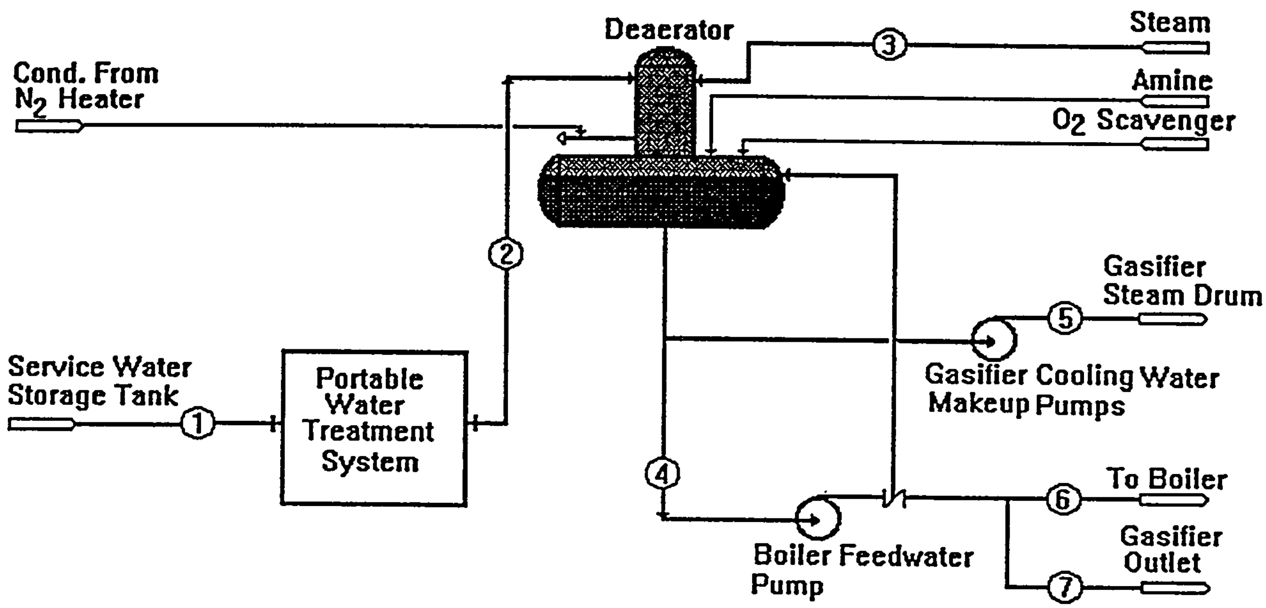
System Name Package Boiler Sytem
Flowsheet No. 16N25706-40-F-1SB-001

III. DESIGN NOTES

1. Some package boiler manufacturers will require a separate, natural gas fired superheater, to provide superheated steam.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1SJ - 1

System Name Condensate/Deaerator/Feedwater
Flowsheet No. 16N25706-40-F-1SJ-001



EQUIPMENT

Deaerator (Eq. No. 1SJ-DEA-1)
Boiler Feedwater Pump (Eq. No. 1SJ-P-1)
Gasifier Cooling Water Pumps 1 and 2 (Eq. Nos. 1SJ-P-2, 1SJ-P-3)

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1SJ - 1

System Name Condensate/Deaerator/Feedwater
Flowsheet No. 16N25706-40-F-1SJ-001

I. DESIGN PHILOSOPHY

1. The function of the Deaerator/Feedwater System is to provide deaerated feedwater to the boiler steam drum. Deaerated feedwater is also utilized for makeup to the gasifier cooling water system, and for gasifier outlet temperature control during upset conditions.

2. Fort Martin service water is utilized as the raw water supply for the feedwater system.

3. The service water is forwarded from the Service & Fire Water Storage tank to the inlet to the Portable Water Treatment System. The treated water is then forwarded to Deaerator.

4. Boiler steam, in conjunction with the deaerator internals, reduces the levels of dissolved gases in the treated water. The expunged gases are vented to atmosphere. The deaerated water is then stored in the storage tank section of the deaerator unit for use as feedwater.

5. An oxygen scavenger is injected into the feedwater storage tank to further reduce the oxygen content. A neutralizing amine is added for pH control.

6. The Boiler Feedwater Pump takes suction from the storage tank. The feedwater pump suction line also provides water to the two Gasifier Cooling Water Makeup Pumps.

7. The boiler feedwater pump discharge line is piped to the economizer section of the Package Boiler.

8. A branch of the boiler feedwater provides high pressure water to the gasifier out for temperature control. Spray water to the gasifier outlet is not required during normal conditions.

9. An ARC valve is located downstream of the feedwater pump discharge in order to maintain minimum flow requirements at all plant conditions. The ARC valve recirculates all or a portion of feedwater pump flow back to the feedwater storage tank.. A backpressure regulator located in the recirculation line at the deaerator, provides constant backpressure on the ARC valve and prevents steam flashing in the recirculation line.

10. The Portable Water Treatment system is a "once-through" system..

11. Elevation of Deaerator/Feedwater Storage Tank will be based on required net positive suction head of the boiler feedwater pump at deaerator operating pressure with a minimum 10% margin of safety added.

12. The storage capacity of the deaerator is sized to provide 15 minutes of feedwater and gasifier cooling water makeup flows with zero condensate makeup flow. Normal level in the storage tank will be 2/3 of the tank diameter above the tank bottom. The storage tank is equipped with a high level dump line that discharges to the Blowoff Tank.

13. The operating pressure of the Deaerator is 5 psig. This produces a feedwater temperature of 227 °F.

14. The feedwater pump flow is based on requirements to the boiler. A margin of 10% was added to the calculated value in determining this value. The feedwater pumps total head is based on system losses, static head and drum pressure. A margin of 25% was added to the calculated pressure drop in determining this number.

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1SJ - 1

System Name Condensate/Deaerator/Feedwater
Flowsheet No. 16N25706-40-F-1SJ-001

II. DESIGN CRITERIA

ITEM	PROCESS STREAM	MAXIMUM FLOW #/HR (or as noted)	NORMAL FLOW #/HR (or as noted)	MINIMUM FLOW #/HR (or as noted)	MAXIMUM TEMP. °F	MINIMUM TEMP. °F	MAXIMUM PRESS.. PSIG	MINIMUM PRESS. PSIG
1	Service Water from Storage Tank	Hold	Hold	Hold	90	70	100	(See Mass Balance)
2	Treated Water from Water Treatment System	Hold	(See Mass Balance)	(See Mass Balance)	90	(See Mass Balance)	100	(See Mass Balance)
3	Steam	Hold	(See Mass Balance)	(See Mass Balance)	250	(See Mass Balance)	10	(See Mass Balance)
4	FW Pump Suction	Hold	(See Mass Balance)	(See Mass Balance)	250	(See Mass Balance)	10	(See Mass Balance)
5	FW from Gasifier Cooling Water Pumps	10	(See Mass Balance)	(See Mass Balance)	250	(See Mass Balance)	Hold	(See Mass Balance)
6	FW to Boiler	Hold	(See Mass Balance)	(See Mass Balance)	250	(See Mass Balance)	Hold	(See Mass Balance)
7	FW to Gasifier Outlet	Hold	0	0	250	227	Hold	Hold

SYSTEM PROCESS DESIGN BASIS
PDB No. 40 - 1SJ - 1

System Name Condensate/Deaerator/Feedwater
Flowsheet No. 16N25706-40-F-1SJ-001

III. DESIGN NOTES

1. Current design is as based on Mass Balance dated (later). Design will be finalized when detailed information on the boiler is received from the manufacturer.

2. Steam flow to the Deaerator was estimated at 5% of the feedwater outlet flow. The actual amount will be finalized once design on the feedwater system is complete.

3. The elevation of the Deaerator normal water level is estimated at 20 feet above grade.

4. Conductivity of the drum water will be controlled by continuously blowing down the steam drum. A blowdown of 1% of steam outlet flow has been assumed.

5. Steam produced by the Gasifier Cooling Water System is independent from steam generated in the boiler. Steam generated in the gasifier cooling water system is used strictly condensed, except for a very small flow into the gasifier..