Appendix A

PLANT CONTROL SYSTEMS

The gasifier control system normally operates such that the gasifier pressure is controlled by the pressure control valve at the flare controlling the gas flow. The steam and oxygen in this mode are run in flow control and are cascaded together with steam as the master.

This method of control has been used exclusively by BGC in past runs, usually operating off two flares, with one flare fixed in manual control and the other flare operating as above. For EPRI, while still retaining both cooling streams, final gas make was routed up number 4 stream only, this leading to easier definition and control of the total gas make. Also, the special requirements of a gas turbine meant that, for EPRI, the flare gas flow should be held constant in flow control. This in turn requires the steam/oxygen flows to the gasifier to be linked as normal, but to be controlled off gasifier pressure so as to maintain and hold constant the operating pressure. This arrangement is referred to as the flow control mode.

The arrangement for the pressure control mode is shown in Figure A-1, and that for the flow control in Figure A-2. Note that, for pressure control, alternative tapping points are available (PR202 and PR100H or 100G).

THE MICROPROCESSOR

It was thought necessary to have the cabability for "demand feed forward" to the steam/oxygen sets when in flow control, particularly rapid load change trials.

The flare flow set point, modified by the algorithm set up in the microprocessor, was to be added to the output of the gasifier pressure controller. The microprocessor would allow total flexibility in selecting the feed forward function as this could not be defined in advance.

In practice, demand feed forward proved unnecessary under all rates of change of flare flow and was thus not commissioned.

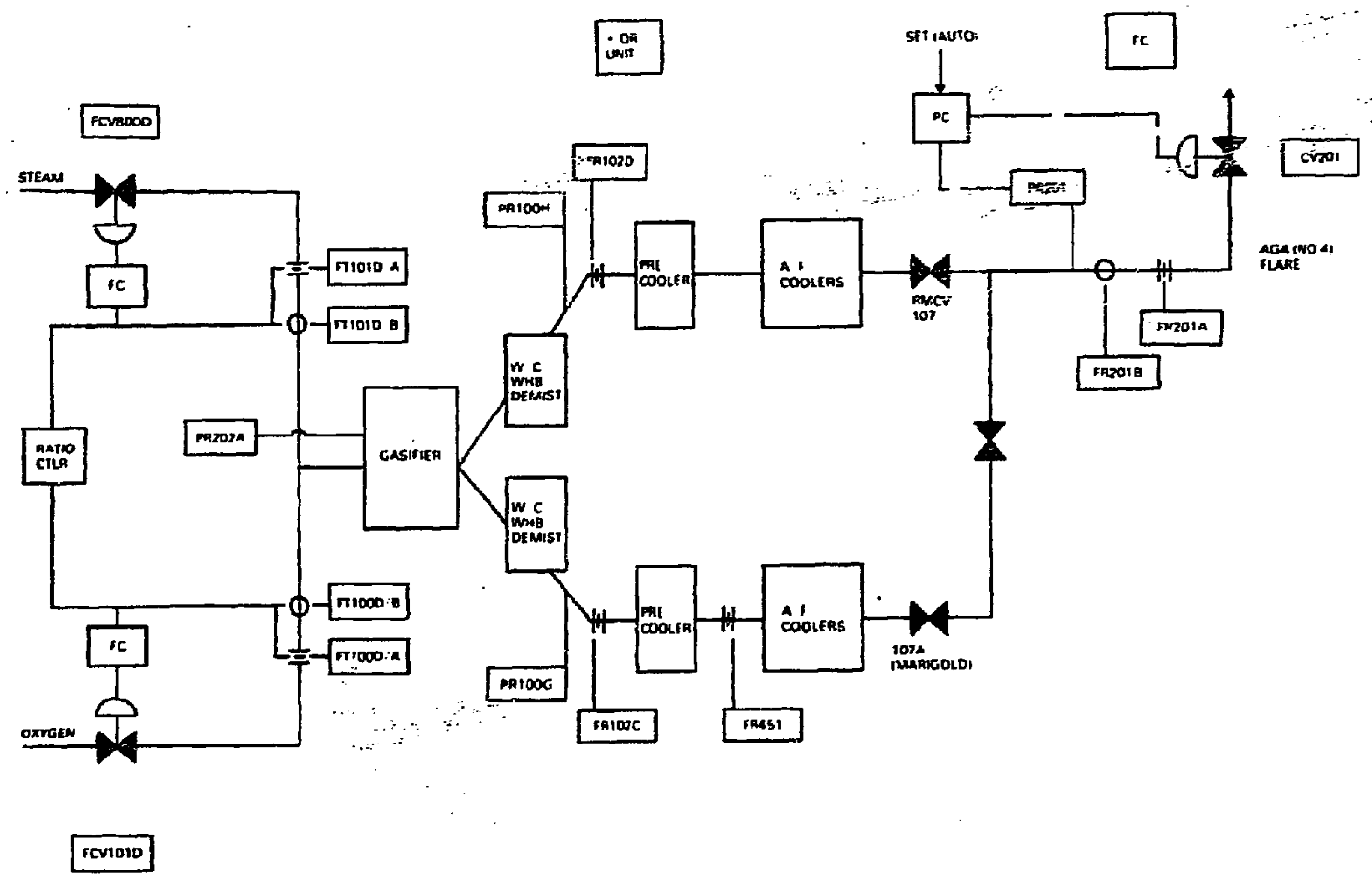


Figure A-1. Gasifier Systems in Pressure Control for EPRI - 01

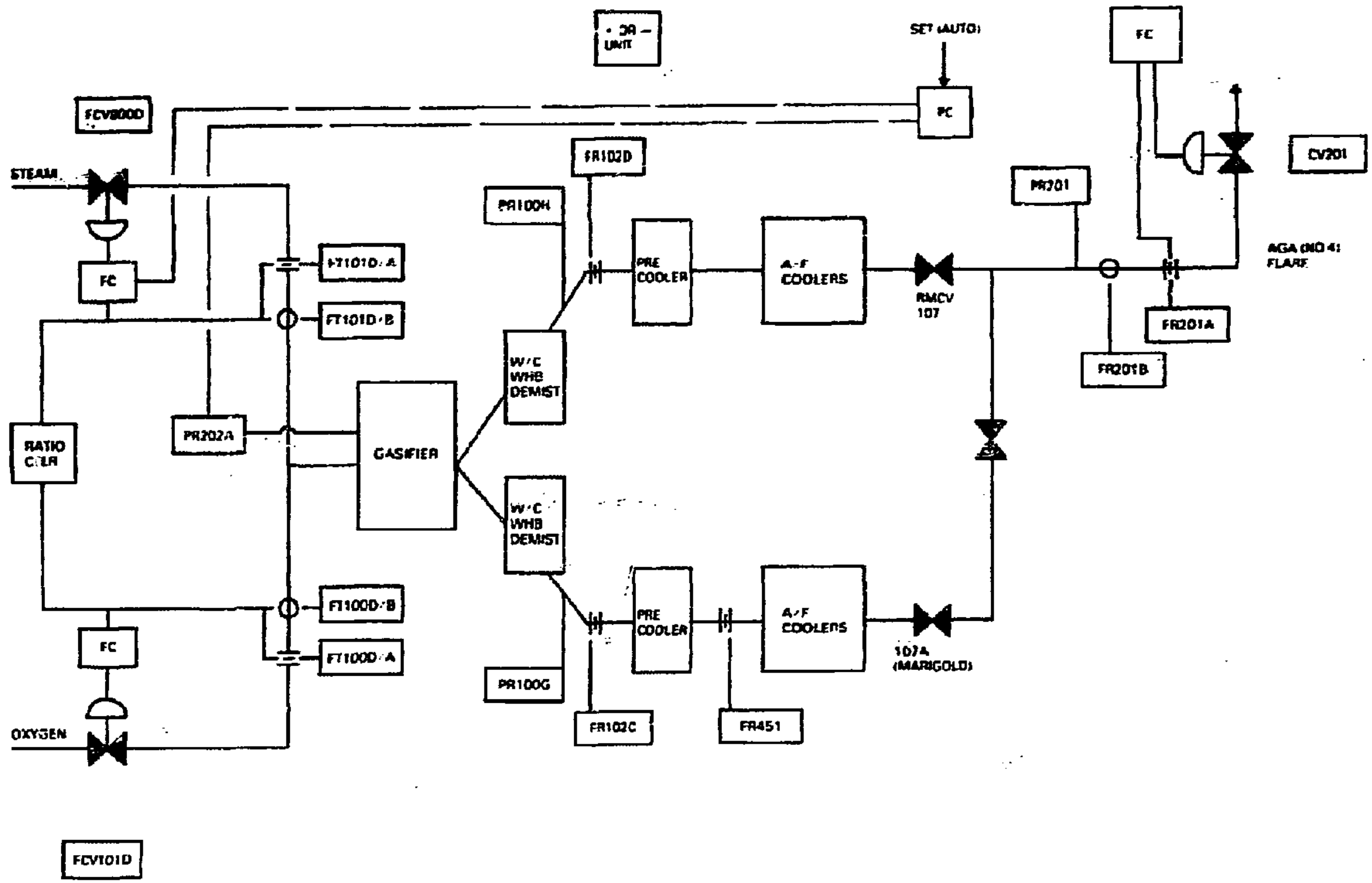


Figure A-2. Gasifier Systems in Flow Control for EPRI - 01

P & I D DESCRIPTION

The arrangements for pressure and flow control modes are shown in Figures A-1 and A-2 of the Run EPRI - 01. Further control is made with the help of switches.

CONTROL SWITCHING

Two control modes are possible with the switching as shown:

- Flow control of steam and oxygen into the gasifier and pressure control of the gasifier by modulation of the flare gas flow. This is commonly called "pressure control."
- Flow control of the flare gas and pressure control of the gasifier by modulation of the steam/oxygen flow. Commonly called "flow control."

THE SWITCH FUNCTIONS

Switch 1: Selects the flow measurements into the steam and oxygen controllers. The measurement is either from an orifice differential pressure transmitter via a damping network and a pneumatic to electric converter or from a vortex shedding flowmeter.

The orifice measurement is further selectable between high and low range transmitters to enable a wide range of flows to be controlled. This switch is omitted from the diagram for clarity.

In practice, it was not found necessary to alter the controller gains and resets when changing from "orifice" to "vortex" control.

Switch 2: Selects the setpoint for the oxygen flow controller. The signal is either from the controller itself, "local control," or from the steam flow signal via the ratio controller, "cascade control."

The steam flow is used as the master input to the ratio controller, in order that steam failure should shut off the oxygen flow. This constitutes part of the plant fail safe system.

Switch 3: Selects "pressure" or "flow" control mode.

Switch 3A: Selects the steam flow setpoint, "local" for "pressure" control or "remote," from the pressure control output via the plus-minus unit for "flow" control.

In the absence of a second input signal the plus-minus unit acts as a one-to-one relay.

Switch 3C: Selects the control signal to the flare valve, from the pressure controller in "pressure" control or the flare flow controller in "flow" control.

For the EPRI trials the pressure controller gain and reset were a compromise between the requirements of "pressure" and "flow" control to allow change over without alteration.

Switch 4: Selects the measurement set for the flare in use. Number three flare is available as a back up, but was not required during the EPRI program.

Switch 5: Selects the flow measurement into the flare flow controller. The vortex shedding flow meters on the flare lines proved unusable due to solids deposition so, in practice, the orifice plate signal was always selected.

Pneumatic Switch 6: Selects the measurement point for the "gasifier" pressure controller. The following inputs are available:

P202A	Gasifier bottom bed pressure
P100G	No. 3 stream pressure ex upper demister
P100H	No. 4 stream pressure ex upper demister
P201	No. 4 stream pressure before flare control valve.

CONTROL NOTES

Proportional Control Only

The output of a proportional controller is a fixed multiple of the measured error. This multiple is known as the controller gain Kc.

At a steady state, with proportional control only, there will be a difference between the actual level and the set point level known as an offset.

$$Kc = \text{Controller gain} = \frac{100\%}{PB}$$

PB = The proportional band

A high gain value equivalent to a low proportional band reduces the offset value and corrects any surges very rapidly, but tends to cause oscillations about the desired value.

On the gasifier a sudden increase in the gas make would probably mean that the gasifier pressure would fall to a lower value because of the increased offset required (assuming proportional control only).

Proportional Plus Reset Control

The controllers on the gasifier have proportional and reset (sometimes called integral) control action. The controller output consists of two parts, the first proportional to the error, and the second proportional to the integral of the error which means that, as long as an error exists, the output signal will change. The actual level and set point level should therefore be approximately the same.

The reset or integral time Ti is the time required for the integral portion of the controller output to become equal to the proportional portion with a constant error.

Ti can be quoted in minutes per repeat, i.e., the time in minutes required to repeat the initial proportional action change in the contoller output.

The reset on the gasifier controllers is marked in repeats per minute, i.e., $\frac{1}{Ti}$, therefore, the higher the value, the greater the effect and the faster the return to the required operating level.

Appendix B

INSTRUMENT LIST

INSTRUMENT LIST

No.	Description/Function	Signal/Characteristic	Accuracy	Calibration
FT100D-A	Steam flow orifice transmitter	Output 3 to 15 psi square root.	Transmitter ± ½% span	Prior to each run.
		EPRI 1 & 2A / EPRI 2B & 3		
	Low range Foxboro model 13.	Low span: 7,000 lbs/hr / 6,750 lbs/hr	Installation ± 1½% of reading	
	High range " " "	High span: 20,000 lbs/hr / 14,550 lbs/hr		
		Logger channel no. 20. 0 – 10 volts to Watanabe/Chan. 1 red.		
FT100D-B	Steam flow vortex meter Neptune/Eastech 3050	Output 4 to 20 ma linear Span 0 to 20,000 lb/hr.	± 0.2% span	–
FC100D	Steam flow controller Fisher Controls TL 101 Reverse acting.	Input – 4 to 20 ma from orifice transmitter via damping network and P/I converter.	Calibrated to ± 1%	Prior to project
		PB % / Reset (RPM)		
		EPRI 1: 1200 / 10		
		EPRI 2 & 3: 200 / 5		
		Output 4 to 20 ma to control valve via I/P converter.		
FCV100D	Steam flow control valve Fisher Abody 3 inch 600 lb. trim 3 inch throttle plug.	Characteristic:- modified parabolic. Cv = 107 (100%)		Checked prior to each run.

No.	Description/Function	Signal/Characteristic	Accuracy	Calibration
PA100D	Steam supply absolute pressure transmitter. Rosemount E1151	Span 4 - 20 ma = 0 to 600 psia Logger channel No. 51	± 0.25% span.	Prior to project
T100D	Steam supply temperature sensor Bare M.I. thermocouple.	Type J Logger channel No. 11		Checked prior to each run.
FR100D	Steam/oxygen ratio controller Fisher controls TL 143 direct acting.	Input - steam flow signal 1 - 5 volts Output - oxygen flow setpoint 1 - 5 volts	Calibrated to ± 1%	Prior to project
FT101D-A	Oxygen flow orifice transmitter	Output 3 to 15 psi square root.	Transmitter ± ½% span.	
		EPRI 1 & 2A — EPRI 2B & 3		
	Low range	Low span: 70,000 SCFH — 89,440 SCFH	Installation ± 2% reading.	
	High range Foxboro	High span: 200,000 SCFH — 200,000 SCFH		
		Logger channel No. :- 20. 0 - 100 to Watanabe/chan. 2 block.		
FT101D-B	Oxygen flow vortex meter. Neptune/Eastech 2150	Output 4 to 20 ma linear Span 0 to 200,000 SCFH	± 0.2% span.	-
FC101D	Oxygen flow controller Fisher controls TL101 Reverse acting	Input 4 to 20 ma from orifice transmitter via dampling network and P/I converter.	Calibrated to ± 1%	Prior to project
		PB % — Reset (RPM)		
		EPRI 1: 1500 — 10		
		EPRI 2/3: 200 — 10		
		Output 4 - 20 ma to control valve via I/P converter.		

No.	Description/Function	Signal/Characteristic	Accuracy	Calibration
FCV101D	Oxygen flow control valve Fisher A Body 3 inch 150 lb. trim. 2 inch V pup.	Characteristic equal percentage. Cv 46.7 (100%)		
PA101D	Oxygen supply absolute pressure transmitter. Rosemount E1151.	Span 4 - 20 ma ≙ 0 to 600 psia Logger channel No. 50.	± 0.25% span.	Prior to project.
T101D	Oxygen supply temperature sensor. Bare M.I. thermo-couple.	Type J Logger channel No. 10.		Checked prior to each run
AN101D	Oxygen supply purity analyser Hartmann and Braun Magnos 2T	Span 4 to 20 ma = 100 to 95% purity Logger channel No 56.	± 4% span.	Prior to runs 1 and 3.
PT202A	Gasifier bed pressure transmitter. Taylor 210T	3 - 15 psi = 0 to 600 psig. 1 - 5v to logger chan. No. 55. 1 - 5v to Watanable 1 chan. 5 blue.	± ½% span.	Prior to project.
DPT202	Overall gasifier bed diff-erential pressure transmitter Rosemount E1151	4 to 20 ma = 0 to 5 psid. Logger channel No. 25.	± 0.2% span.	Prior to project.
DPT203	Bottom bed DP transmitter. Rosemount E1151.	4 to 20 ma = 0 to 2 psid. Logger channel No. 24 0 - 10v to Watanabe 2 chan. 4 blue.	± 0.2% span.	Prior to project.
DPT204	Top bed DP transmitter Rosemount E1151	4 to 20 ma = 0 to 1 psid. Logger channel No. 23. 0 - 10v to Watanable 2 chan. 3 blue.	± 0.2% span.	Prior to project.

No.	Description/Function	Signal/Characteristic	Accuracy	Calibration
FT106D	Jacket water make up flow transmitter. Rosemount E1151.	4 to 20 ma = 0 - 30 IGPM. 1 - 5v to Watanabe 1 chan. 6 green.	Transmitter ± 0.2% span. Installation ± 5% span.	Prior to project.
T100C-1	Number 3 offtake temperature sensor. MI thermocouple in sheath.	Type J. Logger chan. No. 26. 0 - 10v to Watanabe 2 chan. 5 purple 0 - 1600°F.	Chessel ReTX. ± ½% span.	Prior to project.
T100D-1	No. 4 offtake temperature sensor. MI thermocouple in sheath.	Type J. Logger chan. No. 27 0 - 1600°F = 0 - 10 v to Watanable 2 Chan. 6 green.	Chessel ReTX. ± ½% span.	Prior to project.
T100C-3	No. 3 wash cooler exit gas temperature	Type J 0 - 1600°F	± ½% span.	Prior to project.
T100D3	No. 4 wash cooler exit gas temperature.	Type J 0 - 1600°F	± ½% span.	Prior to project.
T100C-2	No. 3 upper demister exit gas temperature.	Type J 0 - 1600°F	± ½% span.	Prior to project.
T100D-2	No. 4 upper demister exit gas temperature.	Type J 0 - 1600°F	± ½% span.	Prior to project.
PT100G	Pressure ex No. 3 upper demister transmitter. Foxboro model 44.	3 - 15 psi = 0 to 600 psig.	± ¾% span.	Prior to project.

No.	Description/Function	Signal/Characteristic	Accuracy	Calibration
PT100H	Pressure ex No. 4 upper demister transmitter. Foxboro model 44.	3 - 15 psi = 0 to 600 psig. Logger chan. No. 57	± ¾% span	Prior to project
PT201	Pressure transmitter at No. 4 flare value. Foxboro model 44.	3 - 15 psi = 0 to 600 psig.	± ¾% span	Prior to project
PA201	Absolute pressure transmitter at No. 4 flare valve. Rosemount E1151	4 - 20 ma = 0 to 600 psia. Logger chan. No. 52	± 0.25% span	Prior to project
FT201A	No. 4 flare flow orifice transmitter. Taylor 305T.	3 to 15 psi square root output. Span 1,000,000 SCFH. Logger chan. No. 22 0 - 10v to Watanabe 1 chan. 3. purple	Transmitter ± ½% span Installation ± 2.25% reading	Prior to each run
T201	Flare gas temperature sensor. Bare M.I. thermocouple.	J. type. Logger chan. No. 12		Checked prior to each run
FC201	No. 4 flare flow controller. Fisher controls TL106. Direct acting.	Input 4 to 20 ma from orifice transmitter via P/I converter. PB%: 300 Reset 2. Output 4 to 20 ma.	Calibrated to ± 1%	Prior to project
PC100	Gasifier pressure controller. Fisher controls TL106. Reverse acting.	Input 4 to 20 ma from one of four pressure transmitters via PSW6 and P/I converter. PB%: 20% Reset 0.5	Calibrated to ± 1%	Prior to project

No.	Description/Function	Signal/Characteristic	Accuracy	Calibration
P/FCV201	Flare control valve. Fisher 4" Abody. trim: 4" trim.	Characteristic equal percentage. Cv 231 (100%)		Checked prior to each run.
	Stirrer speed.	0 - 60 v AC = 0 - 10v to Watanabe 2 chan. 2 black " " logger chan. 29.	± 5% span	Prior to project
	Stirrer torque transmitter	" " " " red		Prior to project
	Flux weight transmitter. Davy Instruments. Type GP 4 - 10/EMB5 loadcell system.	0 - 10v = 0 to 1500 lbs.	-	Checked before each run. Instrument zeroed but not calibrated
	Gasifier to jacket differential pressure transmitter.	3 - 15 psi = 0 to 50 psi. 0 - 10v to logger chan. No. 41.	± ½% span	Prior to project
	Mass spectrometer. Perkin Elmer MGA1200			
	Calculated L.H.V.	4 - 20 ma = 0 to 1000 Btu/lb. 1 - 5v input to Watanabe 1. CH4 Brown " " " logger channel No. 53	± 5%	Prior to run 3.
	COS	4 - 20 ma = 0 - 1% 0 - 10v input to logger channel No. 40	Chessell re Tx. accuracy ± 0.4% span	Prior to each run

No.	Description/Function	Signal/Characteristic	Accuracy	Calibration
	CH_4	4 - 20 ma = 0 to 20% 0 - 10v input to logger chan. No. 33	Chessel re Tx. accuracy $\pm$ 0.4% span	Prior to each run
	C_2H_4	4 - 20 ma = 0 to 2% 0 - 10v input to logger chan. No. 36	" "	" " "
	C_2H_6	4 - 20 ma = 0 to 2% 0 - 10v input to logger chan. No. 35	" "	" " "
	N_2	4 - 20 ma = 0 to 10% 10 - 10v input to logger chan. No 32	" "	" " "
	CO	4 - 20 ma = 0 to 100% 0 - 10v input to logger chan. No. 37	" "	" " "
	CO_2	4 - 20 ma = 0 to 20% 0 - 10v input to logger chan. No. 38	" "	" " "
	H_2	4 - 20 ma = 0 to 100% 0 - 10v input to logger chan. No. 34	" "	" " "
	H_2S	4 - 20 ma = 0 to 2% 0 - 10v input to logger chan. No. 39	" "	" " "
FT103-C	No. 3 tar pump inlet flow flowmetering instruments Magflo 300.	4 - 20 ma = 0 - 200 IGPH input to logger chan. No. 58 This measurement was unsatisfactory	-	-
FT103-D	No. 4 tar pump inlet flow Flowmetering instrument. Magflo 300.	4 - 20 ma = 0 - 200 IGPH. input to logger chan. No. 59 This measurement was unsatisfactory	-	-

Appendix C

PARTICULATE SAMPLING - DETAILS

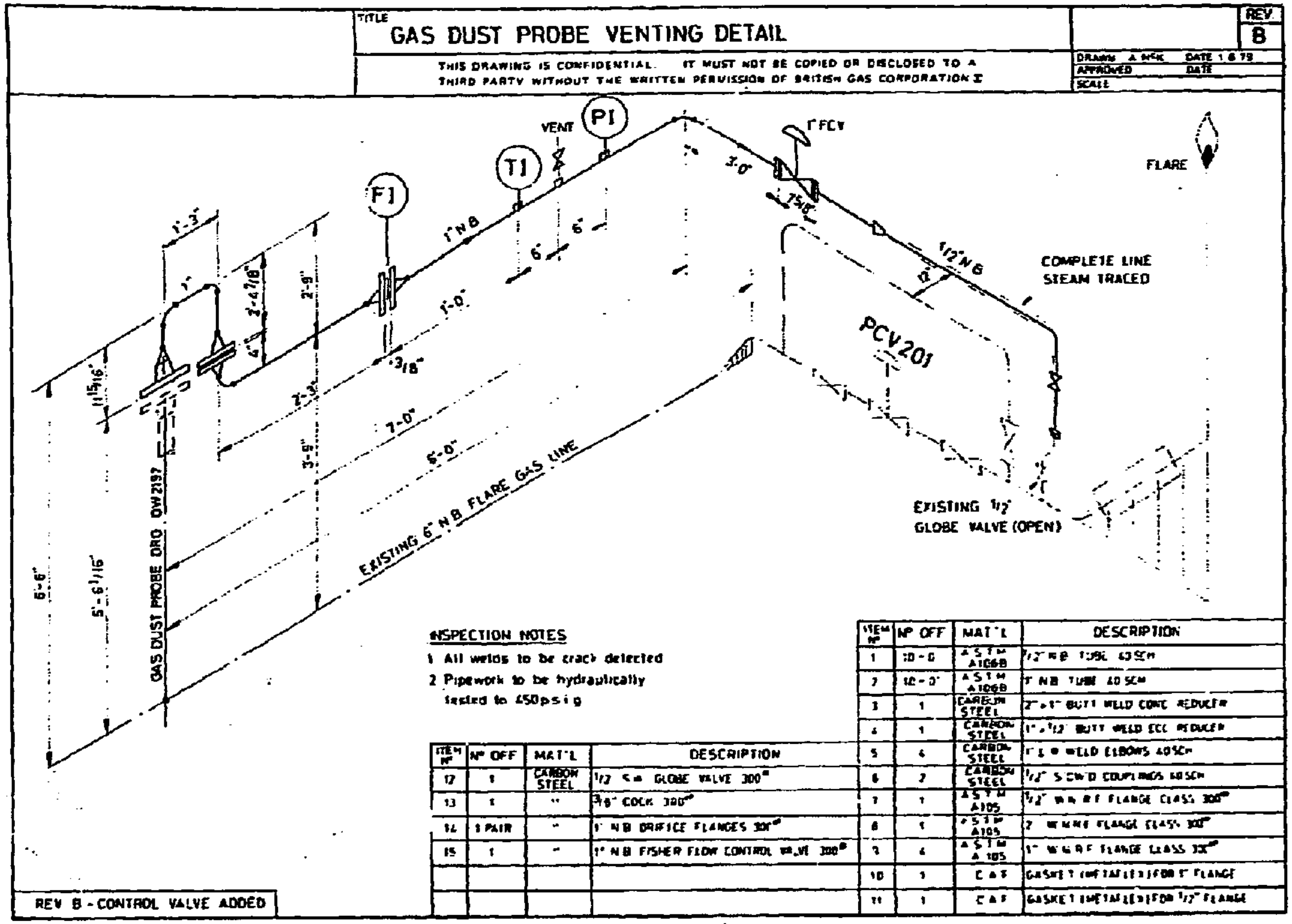


Figure c-1. Gas Dust Probe Venting Detail

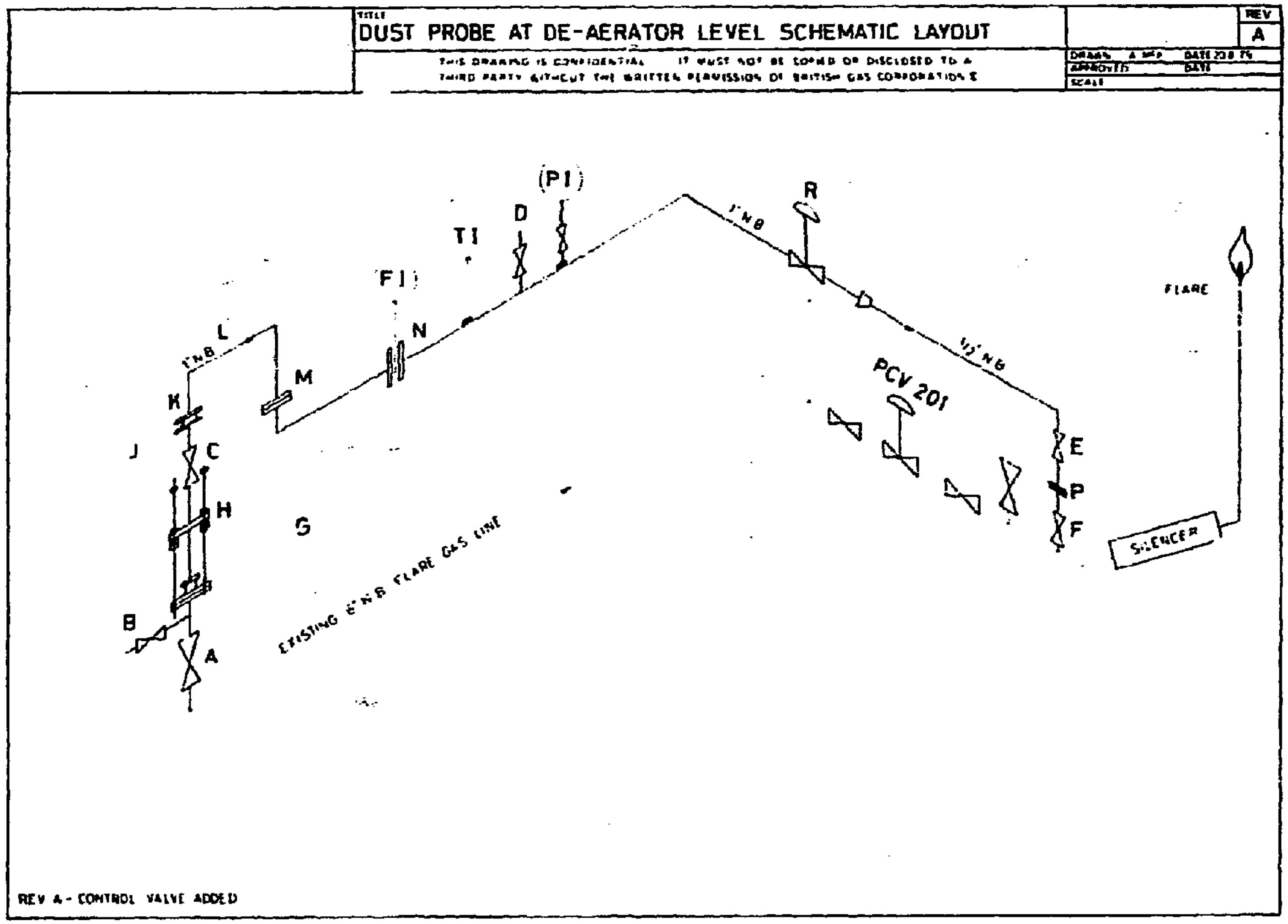


Figure C-2. Dust Probe at De-aerator Level Schematic Layout

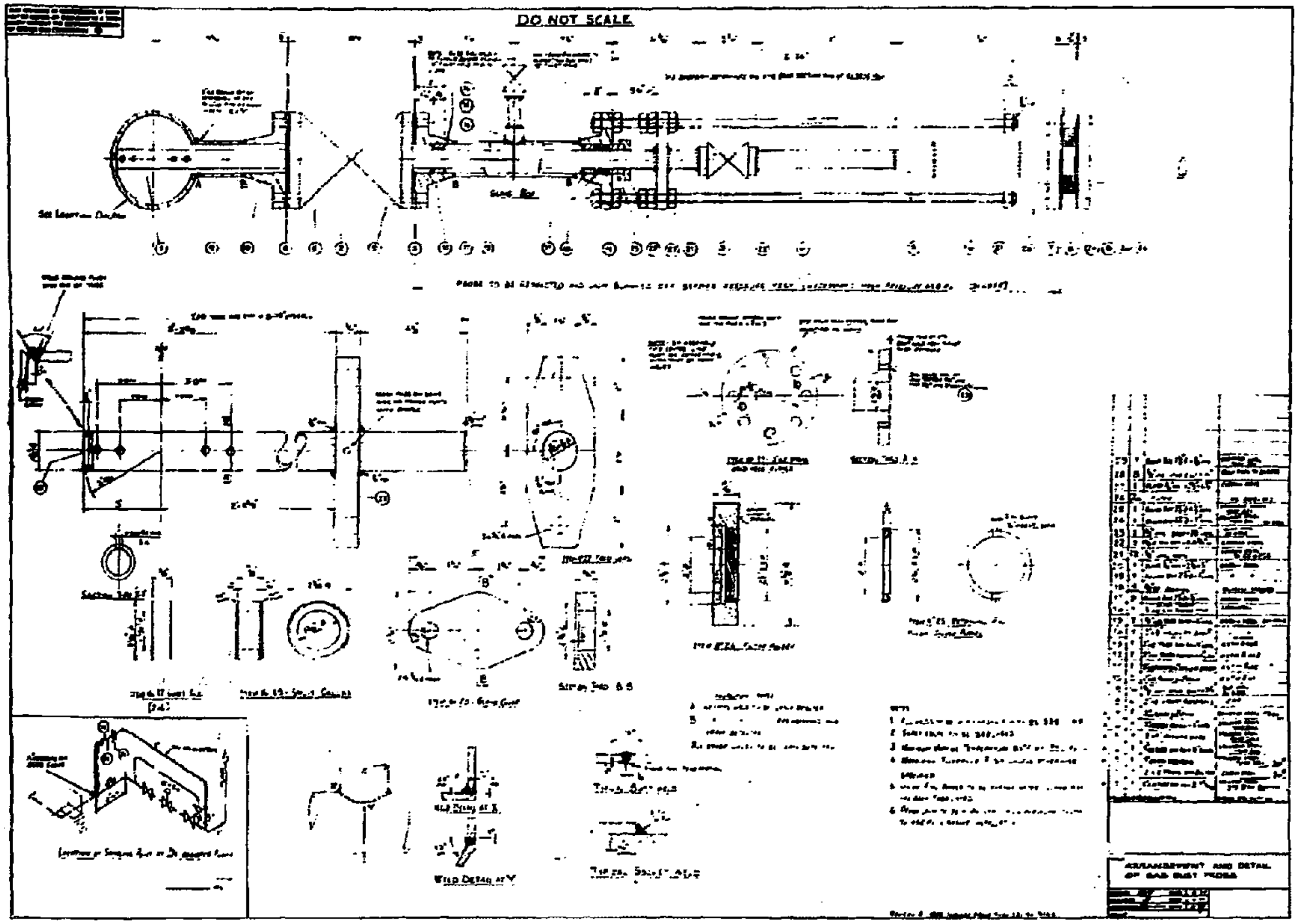


Figure C-3. Arrangement and Detail of Gas Dust Probe

Memorandum

EPRI

September 27, 1979

TO: Alan Leitch

FROM: J. McDaniel, Project Manager

RE: Dust Probe

The dust probe I am familiar with consisted of a 0.2 micron polycarbonate filter in a 47 millimeter (1.85 inch) filter holder made by Nuclepore Co., Pleasanton, California. This unit filtered about 5,000 SCF of gas with a dust loading of up to 5 micrograms per cubic meter before plugging. Finer filters quickly plugged with condensing water and the unit was probably not too well steam traced. The filter element was preweighed on a microbalance, used, placed in a drying oven for less than one hour (I'm sorry, but I didn't note the temperature), and reweighed. Such a fine filter will probably only work on our system if the ammonium carbonate can be kept vapourized and if the dust loadings are much less than your design 50-7- mg/SCSF. I would suggest we try the flow control with steam tracing and try to go finer in filter elements until the service life of the element becomes intolerably short. The polycarbonate elements are good up to 180°C, so with good steam tracing, we might be able to keep off the ammonium carbonate crystals.

John Stringer, whom you met, is preparing an accompanying memo on the particularly troublesome compounds to look for in the samples.

Memorandum

EPRI

September 27, 1979

TO: Terry Brooks

FROM: John Stringer

RE: Cleanliness of Fuel Gas for Gas Turbines

Impurities in the fuel for gas turbines can cause two types of damage to the hot components: (1) corrosion due to the deposition of molten salt layers on the metal surface, called "hot corrosion;" and (2) erosion due to impace of solid particles in the combustion gas stream.

Hot corrosion is usually attributable to the presence of alkali metal sulphates. The combination of sodium and potassium may be worse than either metal alone. The alkali metals may be present as sulphates in the fuel, or the sulphation may take place in the combustion chamber or on the metal surface. Generally, alkali metals present in strongly bonded complexes (for example, in clay minerals) will not sulphate, bot chlorides, hydroxides, oxides or carbonates will. The impurities may be present in the vapour phase, or as particulates. As a guideline, the reactive alkali metal content of the fuel should not exceed 0.5 ppm (by weight) of Na + K.

Certain elements can enhance the alkali sulphate hot corrosion markedly. These include vanadium, lead and phosphorus. The amounts of these elements combined should not exceed 2 ppm by weight.

Another form of hot corrosion may occur at lower metal temperatures (1200 - 1350 F compared to 1450 - 1750 F) and this has been attributed to the formation of complex alkali sulphates involving the transition metals, iron, cobalt and nickel. It is possible that the presence of compounds of these metals in the gas stream could be of concern, but there is insufficient experience to specify an acceptable limit.

Erosion is dependent on particle size. It is generally accepted that particles below 1μm in diameter will not cause erosion damage in turbines. Manufacturers specifications generally require no particles greater than 10 μm and a total loading no greater than 0.02 gr/scf (approximately 35 ppm). Hard angular particles are probably more erosive than soft rounded particles, and it seems likely that particles softer than 4 mohs would not be damaging, but this has not been quantified as yet.

There is extensive experience on burning gaseous fuels in gas turbines both natural gas and blast furnace gas. G.E. certainly has specification for gaseous fuels and will provide a copy; I imagine other manufacturers have something similar.

cc: J. McDaniel
Alan Leitch - please forward copy to LRS
Al Dolbec, EPRI

The probe was designed to sample 5,000 SCF/H^{-1} of gas isokinetically, assuming a flow of 8×10^5 SCF/H of raw gas up the No. 4 flare. Hence, the ratio of gas flow to flow through the probe is:

$$\frac{8 \times 10^5}{5 \times 10^3} = 160$$

for isokinetic sampling.

Sampling was considered to be isokinetic if this ratio was between 144 and 176.

Sampling was classed as "nearly isokinetic" for values in the range 128 to 192.

Whatman

LOADING CAPACITY

When loading capacities of types of high efficiency filters are compared, the fundamental differences between surface filters, (e.g. membranes) and depth filters, (e.g., glass microfibre filters), become marked. Comparison between Whatman GF/C and a membrane of equal nominal retention efficiency (1.2 µm) in filtration of precipitated milk protein shows that the flow through Whatman GF/C is maintained at a usable level long after the membrane has become largely blocked with precipitate. Fig. 5 compares flow rates when filtering river water containing 7ppm of suspended solids (inorganic, organic and microbial). It is interesting to note that thick Grade GF/B shows a very long effective life, maintaining rapid flow even after the passage of a very large volume. Even the relatively thin Grade GF/A filter remains effective much longer than the 1.2 µm membrane.

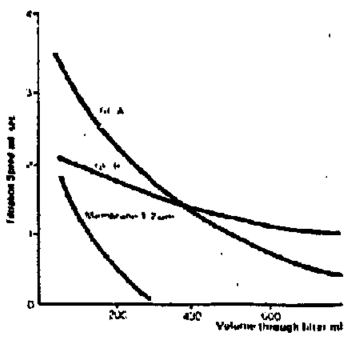


Fig. 5 Loading capacity curves - High efficiency filters (river water)

TEMPERATURE RESISTANCE

Whatman glass microfibre filters are binder-free and will withstand temperatures to 500°C. This characteristic is highly useful in filtration of hot gases. It also permits these filters to be used in gravimetric analysis, where ignition of precipitate is involved in conventional analysis with "ashless" filter paper. Here the weight of the filter remains unchanged during ignition. A typical example is the determination of inorganic matter and, by difference, the determination of volatile solids in total suspended solids collected from water samples on Whatman Grade GF/C.
On the other hand, Whatman glass microfibre filters can be used at extremely low temperatures without becoming brittle.

CHEMICAL STABILITY

The constituent glass microfibres of Whatman filters are highly resistant to chemical attack except by hydrofluoric acid and strong alkalis. Resistance to all other acids is excellent up to 5M in strength. The glass microfibre material is little affected by organic solvents; wet strengths actually increase in non-polar solvents. Whatman glass microfibre filters can be used over a wide range of chemical conditions for which other filter media would be unsuitable. Glass microfibres do not swell in either organic solvents or water.

WEIGHT STABILITY WITH HUMIDITY

Whatman glass microfibre filters will increase only very slightly in weight as a result of increased ambient relative humidity. This is of importance in gravimetric analysis. Figure 6 plots the increase in weight of grade GF/A and two Whatman cellulose filters as a function of relative humidity.

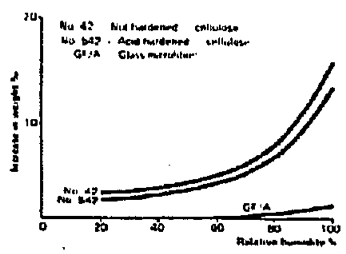


Fig. 6 Weight change of filter papers with relative humidity

THICKNESS

Glass microfibre filters are very compressible so that the thickness will reduce considerably even under a low load.
Thickness figures given below are measured under constant load (500 g/cm²).

GENERAL PROPERTIES OF GLASS MICROFIBRE FILTERS

Whatman Grade	Weight gsm	Thickness mm	Retention µm	Filtration Speed ml/sec
GF/A	53	0·25	1·6	13·0
GF/B	143	0·71	1·0	5·5
GF/C	53	0·25	1·2	10·5
GF/D	120	0·65	2·7	15·5
GF/F	75	0·44	0·7	3·0
No 42 (cellulose)	*100*	*0·20*	*2·5*	*1·5*

Technical Characteristics

STRENGTH CHARACTERISTICS

The overall strength of Whatman glass microfibre filters is difficult to specify since the term "strength" in the context is complex. It is made up of, "tear strength", "burst strength" and other parameters. Overall strength probably results from the very large number of weak bonds between the hydrated silica surface of adjacent fibres. Whatman GF grades are binder-free and hence not subject to the weakening and embrittlement due to pre-ignition (which irreversibly dehydrates these layers) which is essential where binders are used.

PAPER STRENGTH – minimum levels

WHATMAN GRADE	DRY BURST psi	DRY BURST KN/m²	WET BURST (WATER) psi	WET BURST (WATER) KN/m²	TENSILE DRY g	TENSILE WET g
GLASS MICRO-FIBRE						
GF/A	2.0	13.8	0.18	1.24	430	390
GF/B	7.0	48.3	0.32	2.21	830	765
GF/C	2.0	13.8	0.19	1.31	460	355
GF/D	7.0	62.1	0.36	2.48	500	470
GF/F	7.0	48.3	0.30	2.07	800	560

1·6 cm wide strips

STORAGE AND HANDLING

Very great care must be taken to ensure that filters do not pick up airborne or volatile impurities during storage or handling.

The commonest contaminants of this type are: chlorides, sulphates, mineral acids and ammonia — from volatile components in the atmosphere or laboratory.

sodium salts, iron or other metal oxides or salts — from airborne dust.

amino acids
— from human skin or perspiration.

Filter media must therefore always be stored in closed boxes in the laboratory and handled with forceps if used for critical trace analysis.

COLOUR AND OPTICAL PROPERTIES

Whatman glass microfibre filters are extremely white with a brightness of 96% compared with 86% for cellulose; these values are based on a value of 100% for magnesium oxide. Obviously this makes it easier to see or examine tinted or coloured precipitates. The filters reflect or transmit light efficiently and consistently. This facilitates measurement of light absorption, frequently used to determine the concentration of retained particles on, or absorbed solution in, the filters. The refractive index of borosilicate glass is 1.5097 and Whatman GF filters can be made completely transparent by immersion in a liquid of similar refractive index, such as ethyl benzoate or benzene for example:

LIGHT ABSORPTION

Whatman Grade	Transmitted* Light %	Reflected** Light %
GF/A	91.1	95.2
GF/F	96.5	96.0
No. 1 (cellulose)	80.4	86.0

*By BS 2923 method
**Based on MgO = 100% Z filter

SURFACE EXTRACTABLES FROM GLASS FIBRE PAPERS

The composition of borosilicate glass fibres is typically:—

	%		%
SiO_2	57.9	CaO	2.6
B_2O_3	10.7	MgO	0.4
Al_2O_3	5.9	BaO	5.0
Na_2O	10.1	ZnO	3.9
K_2O	2.9	F	0.6

To determine surface extractables from glass microfibre paper, pre-washed paper (5 g.) is dispersed in 200 ml. distilled water at the conditions noted below. The liquor is then filtered through an acid-washed funnel and diluted to 250 ml.

	27°C/24 hr. p.p.m. extracted	100°C/1 hr. p.p.m. extracted
sodium	1710	790
potassium	30	14
calcium	28	41
magnesium	0.8	3
zinc	9	13

TABLE

N.B. of Gas Pipe	Schedule 40 Pipework		No. of Parts in Probe	Total area of Parts /sq. ins.	Dia. of each part /in.	Distance of part centre from pipe centre/in			Minimum I.D. of probe/in.
	O.D./ inch	I.C./ inch				1	2	3	
6"	6.625	6.065	4	0.181	0.240	1.5	2.6	-	0.68"
6"	6.625	6.065	6	0.181	0.196	1.2	2.1	2.8	0.68"
8"	8.625	7.981	6	0.313	0.258	1.6	2.8	3.6	0.90"

OPERATING PROCEDURE FOR DUST IN GAS PROBE

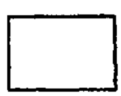
The attached pages are a draft of the operating procedures for the dust in gas probe. The operating instructions refer to the attached figure 7.11 of the test probe and related pipework. This diagram is based on Westfield drawings;—

3W 2197 (probe)

3W 2201 (pipework)

The procedures listed below are given for the operation of the probe while the gasifier is on line and the No. 4 flare is in use.

The box diagrams at the right hand edge of the operating instructions indicate the positions of the valves A to E (see Figure C-2).

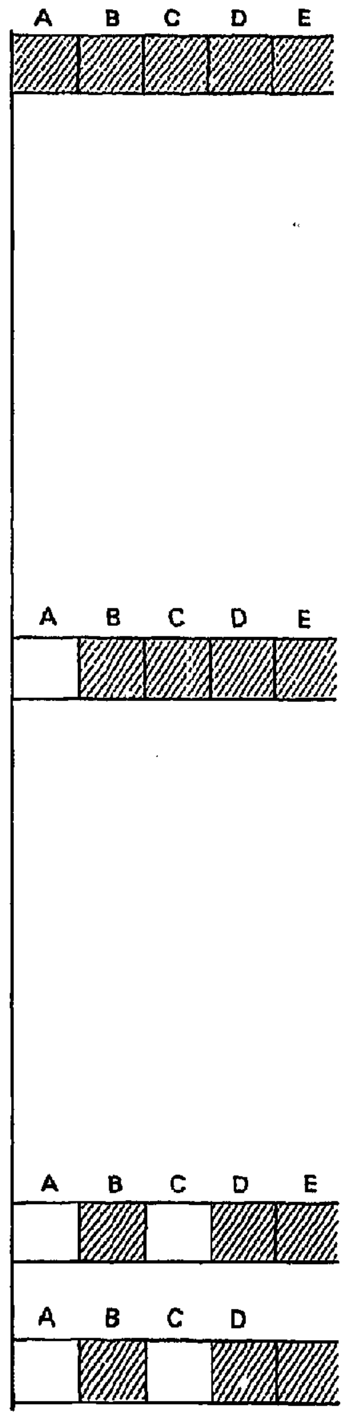
 Valve open.  Valve closed.

Valve F is inoperative and is permanently in the open position.

The attached procedures may be subject to alteration.

INSERTION OF PROBE

Initial Conditions



1. Valves A, B, C, D and E closed.
2. All pipework in position except filter assembly J and spool piece L.
3. Probe and threaded guides detached from the probe inlet.
4. Packing gland locknut G at probe inlet slack.
5. Probe in the withdrawn position relative to guides.

Procedure for Inserting Probe

1. Insert probe into packing gland locknut G.
2. Insert threaded guides into anchor plate and tighten securing nuts.
3. Tighten packing gland locknut G.
4. Slowly open ball valve A.
5. Check for gas leaks.
6. Slacken off packing gland locknut G just enough to allow the probe to be inserted.
7. Insert the probe by turning the nuts on the threaded guider to push the probe into position against the force exerted by the gas pressure.
8. Stop once the probe is in position (indicated by the 2 stop nuts on each guide). Tighten locknut G.
9. Place filter assembly J on the bottom half of flange K.
10. Position spool piece L.
11. Secure flanges K and M.
12. Open valve C slowly.
13. Check for gas leaks.
14. Begin test by opening valve E slowly to give required flow rate.

CHANGING PROBE FILTER

Initial Conditions (Test Running)

1. Valves A, C and E open. Valves B and D closed.

2. Probe and pipework fully assembled and operating.

Procedure for Changing Filter

1. Close valve C.

2. Pause till flow reaches zero.

3. Close valve E.

4. Open valve D to depressurise the line from valve C to valve E.

5. Unbolt flanges K and M.

6. Remove spool piece L and filter holder assembly J.

7. Unscrew filter retaining ring and remove stianless steel mesh support.

8. Remove used filter carefully and place in sample bottle.

9. Insert new filter.

10. Replace stainless steel mesh support and filter retaining ring.

11. Place filter assembly J on the bottom half of flange K.

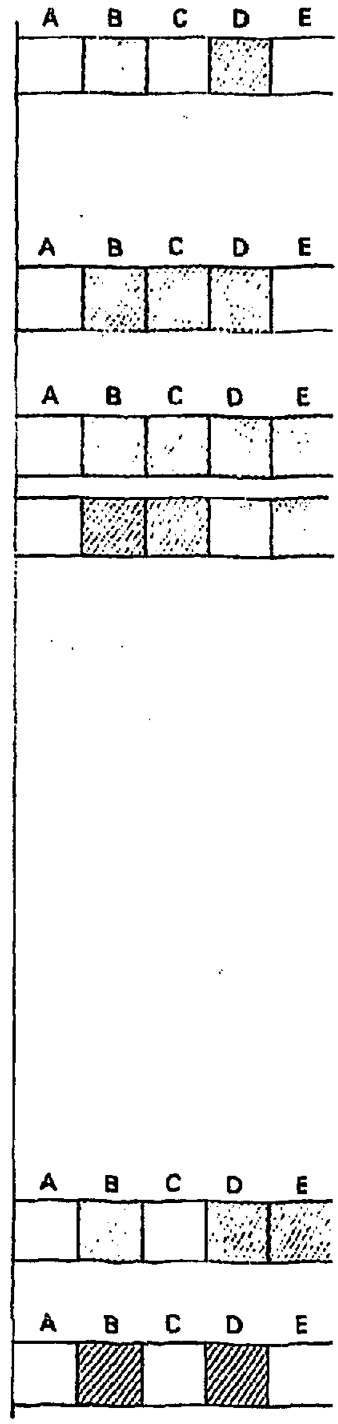
12. Position spool piece L.

13. Secure flanges K and M.

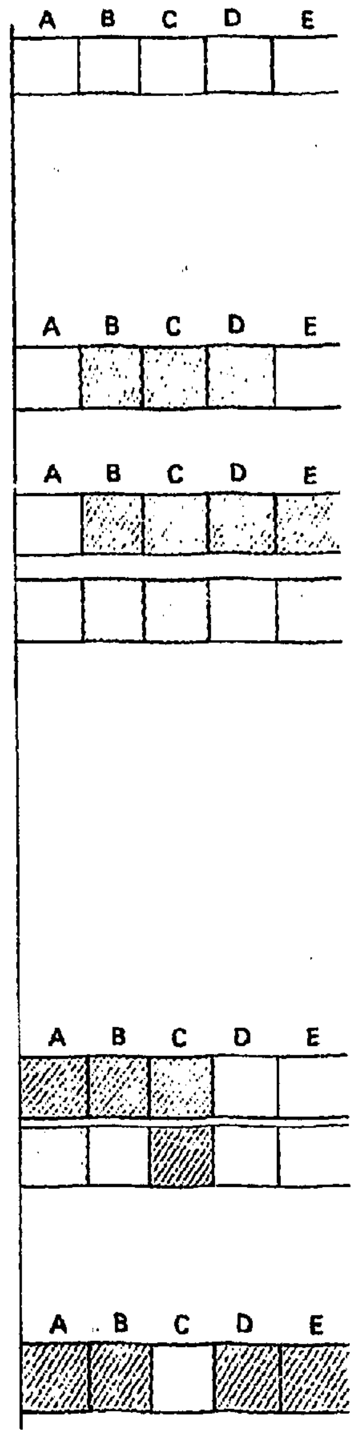
14. Open valve C slowly.

15. Check for gas leaks.

16. Begin test by opening valve E slowly to give required flow rate.



REMOVAL OF PROBE



Initial Conditions

1. Valves A, C and E open. Valves B and D closed.

2. All pipework in position as per diagram.

3. Packing gland locknut G tight and locknuts on threaded guides secure.

Procedure for Removing Probe

1. Close valve C.

2. Pause till flow reaches zero.

3. Close valve E.

4. Open valve D to depressurise the line from valve C to valve E.

5. Unbolt flanges K and M.

6. Remove spool piece L and filter assembly J.

7. Slacken off packing gland locknut G just enough to allow the probe to be removed.

8. Remove probe slowly by turning the nuts on the threaded guides. The force exerted on the probe by the gas pressure will be sufficient to push the probe out.

9. Stop when the welded stop nuts are reached (as the probe will then be clear of valve A).

10. Shut valve A.

11. Open vent valve B.

12. Remove the anchor nuts at the bottom of the threaded guides.

13. Slacken off G a bit further if necessary (but not completely) and remove the probe.

14. Close valves B and D.

BRITISH GAS CORPORATION : WESTFIELD DEVELOPMENT CENTRE

ANALYTICAL SCHEDULE FOR EPRI RUNS

No Coal, Flux or Slag samples to be taken, until steady running on Pittsburgh coal is established

		Type of Sample	Frequency	Tests Required
1. COAL	1.1	Spot Sample (to be divided into 2 samples)	2 per day	On Sample 1, Size Analysis and Bulk Density. On Sample 2, Moisture Content.
	1.2	Incremental Sample	½ hourly, outside Mass Balance periods	*Proximate and Ultimate Analysis, Calorific Value, Gray-King and Swelling Index on each daily sample. Mineral Analysis on overall sample of coal ash from screened and unscreened coal.
	1.3	Spot Sample (Split into 2 samples)	Midway through a Mass Balance period	Moisture Content on Sample 1. Bulk density on Sample 2.
	1.4	Incremental sample	½ hourly, to coincide with a Mass Balance period	Proximate and Ultimate Analysis, Calorific Value, Gray-King, Swelling Index and Mineral Analysis of the coal ash on each mass balance sample.
	1.5	Spot Sample (when running on unscreened coal)	Every 3 hours	Size Analysis
2. FLUX	2.1	Spot Sample (to be divided into 2 samples)	2 per day	On Sample 1, Size Analysis and Bulk Density. On Sample 2, Moisture Content.
	2.2	Incremental Sample	Hourly, outside Mass Balance periods	Mineral Analysis on a daily sample (if 2.3 unsatisfactory)
	2.3	Incremental Sample	Hourly, to coincide with a Mass Balance period.	Mineral Analysis on each mass balance sample.

3. **SLAG**	3.1	Incremental Sample	Hourly, outside Mass Balance periods	Make up samples as requested.
	3.2	Incremental Sample	Hourly, to coincide with a mass balance period	Make up one overall sample for each mass balance period. Selected slag samples to have mineral analysis, sulphur content, free and fixed iron and % carbon in slag.
	3.3	Slag Quench Water (Spot Sample)	Daily	
4. **OXYGEN**	4.1	Spot Sample	Every 4 hours	Oxygen Purity and impurities (Argon and Nitrogen).
	4.2	Spot Sample	Two hourly during Mass Balance periods	Oxygen purity.
5. **RECYCLE TAR** (To Distributor and Tuyeres)	5.1	Spot Sample	2 per Mass Balance period	(a) Moisture content (b) Prepare one overall dry dust free tar sample from Mass Balance periods for Ultimate and CV.
	5.2	Spot Sample	Every 3 hours, when tar injection on	Dust content (retain dust)
	5.3	Make up overall of dust from "Mass Balance" tar		Proximate and Utlimate Analysis and CV.
6. **FLARE GAS**	6.1	Spot Sample	Hourly	Analysis of major constituents + H_2 by G.L.C.
	6.2	3 Hour continuous sample	Once per Mass Balance period	Minor constituents (HCN, NH_3, Naphthalene).
	6.3	Spot Sample	3 during every Mass Balance period.	COS, CS_2, Thiophenes

		6.4 Spot Sample	On request	Determination of particulates level; collect material, dry, weigh and retain.
		6.5 Continuous sample (St Clair de Ville)	Continuous	Prepare an overall sample for Ultimate analysis CV.
		6.6 Spot Sample	On request	Determination of carbonyl concentrations.
7.	<u>FLASH GAS</u>	7.1 Spot sample at separators	Once during Mass Balance period	Major constituents, H_2 Naphthalene, NH_3.
		(No samples to be taken until 36 hours elapsed from start of the run)		
8.	<u>LIQUOR</u>	8.1 Spot sample of Tar Water	1 Sample daily (start after 36 hours)	
		8.2 Spot sample of Oil Water	1 Sample daily (" " " ")	
		Both samples to be analysed for:	T.D.S. Total Sulphur Total NH_3 Carbon as CO_3	Total Phenols Monohydric Phenols Fatty Acids Chlorine as Cl
9.	<u>SIDE-STREAM</u>	9.1 Incremental sample of Gas	Over the S/Stream period	Major constituents + H_2S
		9.2 Continuous sample on Gas Stream	Once per sidestream	Minor constituents
		9.3 Spot sample of Gas	Once per sidestream	COS, CS_2, Thiophenes
		9.4 Continuous sample (St Clair de Ville)	Once per sidestream	Prepare one overall run sample. Ultimate and CV.
		9.5 Tar/Oil/Liquor	From each sidestream	Separate into hydrocarbon and liquor fractions.

On each hydrocarbon sample; measure dust content, moisture content and on a dry dust free sample do Ultimate and CV.

On each liquor sample do tests outlined in 8.

	9.6 Spot sample of gas	On request	Major constituents + H_2S
10. <u>LOCK GAS</u>	10.1 Spot sample	On request	Major constituents (routine check on constancy).

* Analysis of these coal samples may not be necessary should there be sufficient coal samples from mass balance periods (1.4) to fully describe the coal feed over the run.

RUN EPRI 01   **MATERIAL BALANCE 1**   **COAL – ROSSINGTON + LIMESTONE FLUX**

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	26,133.46	19,966.04	1,307.29	402.74	381.04	2,031.73	127.82	1,917.80
Coal Moisture	2,521.00		282.10			2,238.90		
Steam	9,952.00		1,113.63			8,839.37		
Oxygen	14,353.73					14,353.73		
Nitrogen	2,035.24			2,035.24				
Recycle Tar	880.00	769.38	52.82	10.21	5.98	31.15	0.88	4.58
Total	55,875.43	20,735.42	2,760.84	2,452.19	387.02	27,493.88	128.70	1,917.38
Methane	2,419.62	1,811.47	608.15					
Carbon Monoxide	36,771.33	15,766.64				21,004.69		
Hydrogen	1,277.29		1,277.29					
Carbon Dioxide	1,831.23	499.72				1,331.51		
Nitrogen + Argon	1,607.65			1,607.65				
Ethylene	75.57	64.71	10.86					
Ethane	243.66	194.65	49.01					
Hydrogen Sulphide	377.89		22.40		355.49			
Ammonia	128.10		22.75	105.35				
Carbonyl Sulphide	36.70	7.34			19.59	9.77		
Carbon Disulphide	0.17	0.03			0.14			
Thiophene	0.70	0.40	0.03		0.27			
Hydrogen Cyanide	0.98	0.43	0.04	0.51				
Naphthalene	0.26	0.24	0.02					
Tar } Oil	2,380.00	2,115.82	168.98	23.80	21.18	49.27	0.95	
Naphtha	238.00	211.82	20.23	0.24	1.05	3.64	1.02	
Phenols	7.19	5.51	0.46			1.22		
Fatty Acids	5.06	3.19	0.45			1.42		
Liquor	5,658.00		633.13			5,024.87		
Minor Liquor cpds.	145.00	25.35			4.41	67.58	47.66	
Slag	1,918.61	5.76						1,912.85
Total	55,123.01	20,713.08	2,813.80	1,737.55	402.13	27,493.97	49.63	1,912.85
% Error	1.35	0.11	– 1.92	29.14	– 3.90	0	61.44	–

ENERGY BALANCE - RUN EPRI 01 M.B. 1

	Total	Potential	Latent	Therms/hr sensible
Coal	3,497.04	3,497.04		
Steam	135.33		135.33	
Oxygen	3.63			3.63
Nitrogen	0.18			0.18
Tar injection	147.50	147.31		0.19
TOTAL	3,783.68	3,644.35	135.33	4.00
Methane	594.105	578.169		15.936
Carbon Monoxide	1,682.856	1,596.906		85.957
Hydrogen	819.537	779.359		40.178
Carbon Dioxide	4.118			4.118
Nitrogen	3.734			4.734
Ethylene	16.613	16.229		0.384
Ethane	55.595	54.142		1.453
Hydrogen Sulphide	27.973	26.958		1.015
Ammonia	0.801			0.801
Tar	412.794	398.412	3.332	11.050
Liquor	83.693		59.409	24.284
Phenol	1.056	1.007	0.012	0.037
Naphtha	46.420	44.982	0.333	1.105
Fatty Acids	0.687	0.652	0.009	0.026
Slag	14.736	0.848		13.888
Heat Loss	96.351			96.351
TOTAL	3,861.069	3,497.664	63.095	300.310
% Error	- 2.05			

PERFORMANCE DATA EPRI 01. M.B. 1

Crude gas flow (inc. lock gas)	=	20.22×10^6	scfd
Steam consumption	=	3.29	lb/therm gas
Steam decomposition	=	77.13	%
Oxygen consumption	=	15,776	scf/ton DAF
Crude gas production (inc. lock gas)	=	280.95	therms/ton DAF
Fuel consumption DAF	=	256.4	tons/day
Liquor yield	=	1.87	lb/therm

EFFICIENCIES

	Gas only	incl. tar, oil, naphtha
Total crude gas therms / Coal therms	87.09	99.85
Total crude gas therms / Coal + steam	83.27	95.49
Total crude gas therms / Coal + steam @ 80% effy. + oxygen @ 2,254.36 Btu/lb.	75.94	87.07

DATA USED IN RUN NO. EPRI 01.   M.B. 1

D.A.F. Coal CV = 14,565 B.T.U./lb. (Value used)   Calculated = 14,607 B.Thu/lb.

Flux Moisture = 1.83 % w/w   Coal Moisture = 9.0 % w/w

Dry Coal Proximate Analysis: (% by weight)   Ash = 5.96   V.M. = 34.14   F.C. = 59.88

Proximate as charged, including flux (% by weight)

Moisture = 8.83   Ash = 6.70   V.M. = 31.28   F.C. = 53.19

CO_2 evolved from flux entered as Volatile Matter.

Coal Ultimate Analysis (D.A.F.) (% by weight)

C = 82.48   H = 5.32   N = 1.67   S = 1.58   Cl = 0.53   O = 8.42

CO_2 evolved from limestone flux entered under appropriate elements.

Gas Analysis (Volume %)

CH_4 = 6.77   CO = 58.97 H_2 = 28.46 CO_2 = 1.87

N_2 + Ar = 2.58 C_2H_4 = 0.12 C_2H_6 = 0.36 H_2S = 0.50

NH_3 = 0.34   COS = 0.03

Gas Offtake Temperature = 528 °C

Gasifier Pressure = 335 psig

By-Product Data

	← % By Weight →						
	CV (B.T.U./lb)	C	H	N	O	S	Cl
Tar/Oil	16,359	88.90	7.10	1.00	2.07	0.89	0.04
Naphtha	18,982	89.0	8.50	0.10	1.53	0.44	0.43
Minor Liquor Compounds	0	17.48	0	0	46.61	3.04	32.87

RUN EPRI 01 MATERIAL BALANCE 3 COAL - ROSSINGTON + LIMESTONE FLUX

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	13,629.14	10,446.61	691.16	215.48	188.82	1,086.23	62.94	935.90
Coal Moisture	1,076.02		120.41			995.61		
Steam	5,035.00		563.42			4,471.58		
Oxygen	7,822.77					7,822.77		
Nitrogen	1,745.79			1,745.79				
Recycle Tar	1,144.00	992.65	74.25	13.04	8.24	45.76	1.14	8.92
Total	30,450.72	11,439.26	1,449.24	1,974.31	197.06	14,381.95	64.08	944.82
Methane	1,190.61	891.36	299.25					
Carbon Monoxide	18,847.24	8,081.23				10,766.01		
Hydrogen	633.20		633.20					
Carbon Dioxide	1,327.90	362.37				965.53		
Nitrogen + Argon	1,387.57			1,387.57				
Ethylene	50.56	43.29	7.27					
Ethane	113.23	90.45	22.78					
Hydrogen Sulphide	193.33		11.46		181.87			
Ammonia	37.76		6.71	31.05				
Carbonyl Sulphide	45.84	9.16			24.47	12.21		
Carbon Disulphide	0.07	0.01			0.06			
Thiophene	0.32	0.18	0.02		0.12			
Hydrogen Cyanide	0.51	0.23	0.02	0.26				
Naphthalene	0.05	0.05	Trace					
Tar } Oil }	2,070.00	1,848.51	149.04	20.70	17.80	31.88	2.07	
Naphtha	114.00	102.10	10.54		1.01	0.35		
Phenols	3.30	2.53	0.21			0.56		
Fatty Acids	1.82	1.15	0.16			0.51		
Liquor	2,930.00		327.87			2,602.13		
Minor Liquor cpds.	53.00	11.79			1.51	31.43	8.27	
Slag	938.72	2.82						935.90
Total	29,939.03	11,447.23	1,468.53	1,439.58	226.84	14,410.61	10.34	935.90
% Error	1.68	- 0.07	- 1.33	27.08	- 15.11	- 0.20	83.86	0.94

ENERGY BALANCE - EPRI 01. M.B. 3

	Total	Potential	Latent	Therms/hr sensible
Coal	1,814.90	1,814.90		
Steam	69.09		69.09	
Oxygen	1.93			1.93
Nitrogen	0.08			0.08
Tar Injection	191.76	191.51		0.25
TOTAL	2,077.76	2,006.41	69.09	2.26
Methane	291.511	284.497		7.014
Carbon Monoxide	858.569	818.498		40.071
Hydrogen	404.540	386.355		18.185
Carbon Dioxide	2.696			2.696
Nitrogen	2.934			2.934
Ethylene	11.085	10.857		0.228
Ethane	25.760	25.160		0.600
Hydrogen Sulphide	14.259	13.792		0.467
Ammonia	0.211			0.211
Tar	358.200	346.518	2.898	8.784
Liquor	42.180		30.765	11.415
Phenol	0.483	0.463	0.005	0.015
Naphtha	22.190	21.546	0.160	0.484
Fatty Acids	0.246	0.235	0.003	0.008
Slag	7.209	0.415		6.794
Heat Loss	69.461			69.461
TOTAL	2,111.534	1,908.336	33.831	169.367
% Error	- 1.63			

EPRI 01 PERFORMANCE DATA M.B. 3

Crude gas flow (inc. lock gas)	=	10.49×10^6	scfd
Steam consumption	=	3.30	lb/therm gas
Steam decomposition	=	72.11	%
Oxygen consumption	=	16,477	scf/ton DAF
Crude gas production (inc. lock gas)	=	271.4	therms/ton DAF
Fuel consumption DAF	=	134.9	tons/day
Liquor Yield	=	1.90	lb/therm

EFFICIENCIES (%)

	Gas only	incl. tar, oil, naphtha
Total Crude gas therms / Coal therms	85.14	105.69
Total Crude gas therms / Coal + steam	80.96	100.50
Total Crude gas therms / Coal + steam @ 80% effy. + oxygen @ 2,254.36 Btu/lb.	73.29	90.98

DATA USED IN RUN NO. E.P.R.I. 01 M.B. 3

D.A.F. Coal CV = 14,396 B.T.U./lb. Calculated = 14,401 B.Thu/lb.

Flux Moisture = 2.25 % w/w Coal Moisture = 7.5 % w/w

Dry Coal Proximate Analysis: Ash = 5.51 V.M. = 35.35 F.C. = 59.14

* Proximate as charged, including flux (% by weight)

Moisture = 7.37 Ash = 6.41 V.M. = 32.87 F.C. = 53.35

* This analysis includes CO_2 evolved from limestone flux as volatile matter.

Ø Coal Ultimate Analysis (D.A.F.) (% by weight)

C = 82.40 H = 5.30 N = 1.68 S = 1.50 Cl = 0.50 O = 8.62

Ø This analysis includes CO_2 evolved from limestone flux under the appropriate element.

Gas Analysis (Volume %)

CH_4 = 6.43 CO = 58.25 H_2 = 27.19 CO_2 = 2.61

N_2 + Ar = 4.29 C_2H_4 = 0.16 C_2H_6 = 0.33 H_2S = 0.49

NH_3 = 0.19 COS = 0.07

Gas offtake Temperature = 485 °C

Gasifier Pressure = 335 psig

By-Product Data

	CV (B.T.U./lb)	C	H	N	O	S	Cl
		% By Weight					
Tar/Oil	16,367	89.3	7.2	1.0	1.54	0.86	0.10
Naphtha	17,905	89.55	9.25	-	-	0.89	0.43
Minor Liquor Compounds	-	22.24	-	-	59.31	2.85	15.60

RUN EPRI MATERIAL BALANCE 4 COAL - ROSSINGTON + LIMESTONE FLUX (180 lb/lock)

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	13,400.62	10,324.27	686.70	212.88	203.91	1,053.01	55.95	863.90
Coal Moisture	982.50		109.94			872.56		
Steam	5,040.00		563.98			4,476.02		
Oxygen	7,797.55					7,797.55		
Nitrogen	1,728.05			1,728.05				
Recycle Tar	660.00	575.06	42.70	7.59	4.75	24.09	0.66	5.15
Total	29,608.72	10,899.33	1,403.32	1,948.52	208.66	14,223.23	56.61	869.05
Methane	1,149.05	860.25	288.80					
Carbon Monoxide	18,673.87	8,006.90				10,666.97		
Hydrogen	611.41		611.41					
Carbon Dioxide	1,160.26	316.62				843.64		
Nitrogen + Argon	1,349.59			1,349.59				
Ethylene	46.25	39.60	6.65					
Ethane	107.28	85.70	21.58					
Hydrogen Sulphide	182.04		10.79		171.25			
Ammonia	26.72		4.75	21.97				
Carbonyl Sulphide	15.34	3.07			8.18	4.09		
Carbon Disulphide	0.08	0.01			0.07			
Thiophene	0.40	0.23	0.02		0.15			
Hydrogen Cyanide	0.28	0.12	0.01	0.15				
Naphthalene	0.05	0.05	Trace					
Tar } Oil }	1,670.00	1,476.28	120.24	18.37	15.36	39.08	0.67	
Naphtha	111.00	99.40	10.27		0.99	0.34		
Phenols	1.55	1.19	0.10			0.26		
Fatty Acids	0.65	0.41	0.06			0.18		
Liquor	2,990.00		334.58			2,655.42		
Minor Liquor cpds.	30.00	5.70			0.85	15.22	8.23	
Slag	865.54	2.60						863.94
Total	28,992.36	10,899.13	1,409.26	1,390.08	196.85	14,225.20	8.90	863.94
% Error	2.08	0.01	– 0.42	28.66	5.66	– 0.01	84.28	0.5[illegible]

ENERGY BALANCE - EPRI 01 M.B. 4

	Total	Potential	Latent	Therms/hr sensible
Coal	1,756.48	1,756.48		
Steam	68.65		68.65	
Oxygen	1.91			1.91
Nitrogen	0.08			0.08
Tar Injection	110.62	110.48		0.14
TOTAL	1,977.74	1,866.96	68.65	2.13
Methane	281.316	274.565		6.751
Carbon Monoxide	850.581	810.968		39.613
Hydrogen	390.579	373.058		17.521
Carbon Dioxide	2.350			2.350
Nitrogen	2.847			2.847
Ethylene	10.139	9.931		0.208
Ethane	24.404	23.837		0.567
Hydrogen Sulphide	13.426	12.987		0.439
Ammonia	0.149			0.149
Tar	288.967	279.558	2.338	7.071
Liquor	43.017		31.395	11.622
Phenol	0.226	0.217	0.002	0.007
Naphtha	21.604	20.979	0.155	0.470
Fatty Acids	0.088	0.084	0.001	0.003
Slag	6.655	0.383		6.272
Heat Loss	80.818			80.818
TOTAL	2,017.166	1,806.567	33.891	176.708
% Error	- 1.99			

PERFORMANCE DATA RUN EPRI 01, M.B. 4

Crude gas flow (inc. lock gas)	=	10.26×10^6	scfd
Steam consumption	=	3.38	lb/therm gas
Steam decomposition	=	68.98	%
Oxygen consumption	=	16,629	scf/ton DAF
Crude gas production (inc. lock gas)	=	268.9	therms/ton DAF
Fuel consumption DAF	=	134.2	tons/day
Liquor yield	=	2.00	lb/therm

EFFICIENCIES (%)

	Gas only	incl. tar, oil, naphtha
Total crude gas therms / Coal therms	84.16	101.11
Total crude gas therms / Coal + steam	80.01	96.13
Total crude gas therms / Coal + steam @ 80% effy. + oxygen @ 2,254.36 Btu/lb	72.85	87.52

DATA USED IN RUN NO. E.P.R.I. 01. N.B. 4

D.A.F. Coal CV = 14,422 B.T.U./lb. Calculated = 14,285 B.Thu/lb

Flux Moisture = 2.0 % w/w Coal Moisture = 7.0 % w/w

Dry Coal Proximate Analysis: Ash = 5.10 V.M. = 34.44 F.C. = 60.46
(% by weight)

* Proximate as charged, including flux (% by weight)

Moisture = 6.88 Ash = 6.05 V.M. = 32.22 F.C. = 54.85

* This analysis includes CO_2 evolved from limestone flux as volatile matter.

ø Coal Ultimate Analysis (D.A.F.) (% by weight)

C = 82.44 H = 5.33 N = 1.68 S = 1.64 Cl = 0.45 O = 8.46

ø This analysis includes CO_2 evolved from limestone flux under appropriate elements.

Gas Analysis (Volume %) – by Mass Spectrometry

CH_4 = 6.34 CO = 59.05 H_2 = 26.66 CO_2 = 2.34

N_2 = 4.27 C_2H_4 = 0.15 C_2H_6 = 0.32 H_2S = 0.47

NH_3 = 0.14 COS = 0.07

Gas Offtake Temperature = 484 °C

Gasifier Pressure = 335 psig

By-Product Data

	CV (B.T.U./lb)	C	H	N	O	S	Cl
	← % By Weight →						
Tar/Oil	16,385	88.40	7.20	1.10	2.34	0.92	0.04
Naphtha	17,905	89.55	9.25	–	–	0.89	0.43
Minor Liquor Compounds	–	19.01	–	–	50.71	2.84	27.44

RUN EPRI 01 — MATERIAL BALANCE 5 — COAL - ROSSINGTON + LIMESTONE FLUX (180 lb/lock)

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	8,398.65	6,442.87	439.86	130.07	111.95	694.65	23.93	555.30
Coal Moisture	754.00		84.37			669.63		
Steam	4,340.00		485.65			3,854.35		
Oxygen	4,873.45					4,873.45		
Nitrogen	1,603.87			1,603.87				
Recycle Tar	660.00	570.30	41.91	7.46	5.02	26.86	0.79	7.66
Total	20,629.97	7,013.17	1,051.81	1,741.40	116.97	10,118.94	24.72	562.96
Methane	752.49	563.36	189.13					
Carbon Monoxide	10,533.09	4,516.33				6,016.76		
Hydrogen	444.25		444.25					
Carbon Dioxide	2,175.14	593.57				1,581.57		
Nitrogen + Argon	1,372.51			1,372.51				
Ethylene	23.39	20.03	3.36					
Ethane	73.63	58.82	14.81					
Hydrogen Sulphide	120.85		7.16		113.69			
Ammonia	36.44		6.47	29.97				
Carbonyl Sulphide	9.60	1.92			5.12	2.56		
Carbon Disulphide	0.04	0.01			0.03			
Thiophene	0.33	0.19	0.02		0.12			
Hydrogen Cyanide	0.28	0.12	0.01	0.15				
Naphthalene	Trace	Trace	Trace					
Tar Oil	1,330.00	1,181.04	95.76	13.30	10.77	27.13	2.00	
Naphtha	74.00	66.27	6.84		0.66	0.23		
Phenols	1.49	1.14	0.10			0.25		
Fatty Acids	0.72	0.46	0.06			0.20		
Liquor	2,720.00		304.37			2,415.63		
Minor Liquor cpds.	46.00	8.77			0.86	23.38	12.99	
Slag	557.02	1.67						555.35
Total	20,271.27	7,013.70	1,072.34	1,415.93	131.25	10,067.01	14.99	555.35
% Error	1.74	- 0.01	- 1.95	18.69	- 12.21	0.51	39.36	1.35

ENERGY BALANCE - E.P.R.I. 01 NB 5

	Total	Potential	Latent	Therms/hr sensible
Coal	1,119.86	1,119.86		
Steam	58.78		58.78	
Oxygen	1.07			1.07
Nitrogen	0.04			0.04
Tar Injection	110.62	110.48		0.14
TOTAL	1,290.37	1,230.34	58.78	1.25
Methane	184.075	179.807		4.268
Carbon Monoxide	479.118	457.431		21.687
Hydrogen	283.436	271.067		12.369
Carbon Dioxide	4.265			4.265
Nitrogen	2.811			2.811
Ethylene	5.125	5.023		0.102
Ethane	16.735	16.360		0.375
Hydrogen Sulphide	8.903	8.621		0.282
Ammonia	0.196			0.196
Tar	229.976	222.642	1.862	5.472
Liquor	38.814		28.560	10.254
Phenol	0.218	0.209	0.002	0.007
Naphtha	14.394	13.986	0.104	0.304
Fatty Acids	0.097	0.093	0.001	0.003
Slag	4.278	0.246		4.032
Heat Loss	57.423			57.423
TOTAL	1,329.864	1,175.485	30.529	123.850
% Error	- 3.06			

PERFORMANCE DATA   RUN E.P.R.I. 01. M.B. 5

Crude gas flow (inc. lock gas)	=	6.82×10^6	scfd
Steam consumption	=	4.67	lb/therm gas
Steam decomposition	=	61.05	%
Oxygen consumption	=	62.25	scf/therm
		16,790	scf/ton DAF
Crude gas production (inc. lock gas)	=	269.7	therms/ton DAF
Fuel consumption DAF	=	182.7	tons/day
Liquor yield	=	2.93	lb/therm

EFFICIENCIES (%)

	Gas only	incl. tar, oil, naphtha
Total Crude gas therms / Coal therms	85.12	105.78
Total crude gas therms / Coal + steam	78.85	98.95
Total crude gas therms / Coal + steam @ 80% effy. + oxygen @ 2,254.36 Btu/lb.	71.22	89.34

DATA USED IN RUN NO. EPRI 01   M.B. 5

D.A.F. Coal CV = 14,311 B.T.U./lb.   Calculated = 14,687 B.Thu/lb.

Flux Moisture = 2.5 % w/w   Coal Moisture = 8.5 % w/w

Dry Coal Proximate Analysis: (% by weight) Ash = 5.29 V.M. = 35.64 F.C. = 59.07

* Proximate as charged, including flux (% by weight)

Moisture = 8.35 Ash = 6.15 V.M. = 32.78 F.C. = 52.72

* This analysis includes CO_2 evolved from the limestone flux as volatile matter

Ø Coal Ultimate Analysis (D.A.F.) (% by weight)

C = 82.31 H = 5.33 N = 1.62 S = 1.45 Cl = 0.31 O = 8.98

Ø This analysis includes CO_2 evolved from the limestone flux under the appropriate elements.

Gas Analysis (Volume %) - by Mass Spectrometry

CH_4 = 6.25 CO = 50.07 H_2 = 29.34 CO_2 = 6.58

N_2 = 6.53 C_2H_4 = 0.11 C_2H_6 = 0.33 H_2S = 0.47

NH_3 = 0.29 COS = 0.05

Gas Offtake Temperature = 471 °C

Gasifier Pressure = 335 psig

By-Product Data

	CV (B.T.U./lb)	C	H	N	O	S	Cl
	← % By weight →						
Tar/Oil	16,315	88.8	7.2	1.0	2.04	0.81	0.15
Naphtha	17,905	89.55	9.25	-	-	0.89	0.43
Minor Liquor Compounds	-	19.06	-	-	50.83	1.87	28.24

RUN EPRI 02 MATERIAL BALANCE 1 COAL - PITTSBURGH 8 + B.F.S. (1305 lb/lock^{-1}

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	30,848.83	19,373.23	1,343.99	382.51	473.13	1,575.15	34.62	7,666.2
Coal Moisture	1,724.15		192.93			1,531.22		
Steam	8,938.00		1,000.16			7,937.84		
Oxygen	13,604.40					13,604.40		
Nitrogen	2,042.41			2,042.41				
Recycle Tar	880.00	761.11	56.14	10.30	7.39	33.18	1.32	10.56
Total	58,037.79	20,134.34	2,593.22	2,435.22	480.52	24,681.79	35.94	7,676.76
Methane	2,390.71	1,789.83	600.88					
Carbon Monoxide	33,325.70	14,289.24				19,036.46		
Hydrogen	1,191.39		1,191.39					
Carbon Dioxide	2,745.26	749.15				1,996.11		
Nitrogen + Argon	2,490.57			2,490.57				
Oxygen	Nil							
Ethylene	47.92	41.03	6.89					
Ethane	213.05	170.20	42.85					
Hydrogen Sulphide	431.83		25.59		406.24			
Ammonia	93.34		16.58	76.76				
Carbonyl Sulphide	42.23	8.45			22.52	11.26		
Carbon Disulphide	0.18	0.03			0.15			
Thiophene	0.59	0.33	0.03		0.23			
Hydrogen Cyanide	0.26	0.12	0.01	0.13				
Naphthalene	0.04	0.04	Trace					
Tar)								
Oil)	2,400.00	2,104.00	175.20	19.20	17.76	79.20	2.88	0.96
Naphtha	761.00	686.42	65.75		5.48		2.82	0.53
Phenols	24.16	18.50	1.55			4.11		
Fatty Acids	1.86	1.16	0.16			0.52		
Liquor	3,837.00		429.36			3,407.64		
Minor liquor cpds.	77.00	15.94			1.43	42.51	17.12	
Slag	7,711.70	45.50						7,666.2
Total	57,785.77	19,920.74	2,556.24	2,586.66	453.81	24,577.81	22.82	7,667.69
% Error	0.43	1.06	1.43	- 6.22	5.56	0.42	36.51	0.12

ENERGY BALANCE - E.P.R.I. 02 MB I

	Total	Potential	Latent	Therms/hr sensible
Coal	3,470.19	3,470.199		
Steam	122.01		122.01	
Oxygen	3.52			3.52
Nitrogen	0.19			0.19
Tar Injection	147.50	147.31		0.19
TOTAL	3,743.41	3,617.50	122.01	3.90
Methane	586.528	571.260		15.268
Carbon Monoxide	1,523.146	1,447.269		75.877
Hydrogen	763.488	726.945		36.543
Carbon Dioxide	6.002			6.002
Nitrogen	5.636			5.636
Ethylene	10.526	10.291		0.235
Ethane	48.569	47.339		1.230
Hydrogen Sulphide	31.933	30.806		1.127
Ammonia	0.566			0.566
Tar	415.991	401.760	3.360	10.871
Liquor	56.321		40.288	16.033
Phenol	3.547	3.388	0.039	0.120
Naphtha	148.341	143.829	1.065	3.447
Fatty Acids	0.250	0.238	0.003	0.009
Slag	62.363	6.707		55.656
Heat Loss	103.410			103.410
TOTAL	3,766.617	3,389.832	44.755	332.030
% Error	- 0.62			

Crude gas flow (inc. lock gas)	=	19.16×10^6	scfd
Steam consumption	=	3.19	lb/therm gas
Steam decomposition	=	85.58	%
Oxygen consumption	=	57.43	scf/therm
	=	15,624	scf/ton DAF
Crude gas production (inc. lock gas)	=	272.1	therms/ton DAF
Fuel consumption DAF	=	247.29	tons/day
Liquor yield	=	1.37	lb/therm

EFFICIENCIES %

	Gas Only	incl. tar, oil naphtha
Total crude gas therms / Coal therms	81.32	97.15
Total crude gas therms / Coal + steam	78.03	93.22
Total crude gas therms / Coal + steam @ 80% effy. +oxygen @ 2254.36 Btu/lb.	71.22	85.09

DATA USED IN RUN NO. EPRI 02 M.B.1

D.A.F. Coal CV = 14,935 B.T.U./lb Calculated = 14,961 b.Thu/lb.
Flux Moisture = 7.0 % w/w Coal Moisture = 5 % w/w
Dry Coal Proximate Analysis: Ash = 11.24 V.M. = 35.90 F.C. = 52.86
(% by weight)

Proximate as charged, including flux (% by weight)
Moisture = 5.31 Ash = 23.61 V.M. = 28.75 F.C. = 42.33

Coal Ultimate Analysis (D.A.F.) (% by weight)
C = 83.62 H = 5.72 N = 1.64 S = 2.05 Cl = 0.15 O = 6.82

Gas Analysis (Volume %)
CH_4 = 7.07 CO = 56.42 H_2 = 28.02 CO_2 = 2.96
N_2 + Ar = 4.22 C_2H_4 = 0.08 C_2H_6 = 0.34 H_2S = 0.60
NH_3 = 0.26 COS = 0.03

Gas Offtake Temperature = 516°C
Gasifier Pressure = 335 psig

By-Product Data

	CV (B.T.U./lb)	C	H	N	O	S	Cl
		% By Weight					
Tar/Oil	16,350	87.7	7.30	0.80	3.30	0.74	0.12
						(Ash = 0.04)	
Naphtha	17,615	90.2	8.64	Nil	Nil	0.72	0.37
						(Ash = 0.07)	
Minor Liquor Compounds	–	20.70	Nil	Nil	55.20	1.86	22.24

RUN EPRI 02 MATERIAL BALANCE 2 COAL - PITTSBURGH 8 + B.F.S. (1305 lb/lock^{-1})

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	21,044.60	13,210.78	922.22	261.98	338.21	1,078.69	22.02	5,215.70
Coal Moisture	1,088.53		121.81			966.72		
Steam	6,241.00		698.37			5,542.63		
Oxygen	9,842.90					9,842.[illegible]		
Nitrogen	1,744.12			1,744.12				
Recycle Tar	660.00	557.77	40.59	7.52	6.07	33.92	0.86	13.27
Total	40,626.15	13,768.55	1,782.99	2,013.62	344.28	17,464.86	22.86	5,238.97
Methane	1,647.06	1,233.09	413.97					
Carbon Monoxide	22,977.93	9,852.37				13,125.56		
Hydrogen	820.40		820.40					
Carbon Dioxide	2,309.77	672.86				1,672.91		
Nitrogen + Argon	2,251.39			2,251.39				
Oxygen	Nil							
Ethylene	45.80	39.22	6.58					
Ethane	195.93	156.52	39.41					
Hydrogen Sulphide	315.06		18.67		296.39			
Ammonia	65.79		11.67	54.03				
Carbonyl Sulphide	24.87	4.97			13.27	6.63		
Carbon Disulphide	0.06	0.01	0.05					
Thiophene	0.35	0.20	0.02		0.13			
Hydrogen Cyanide	0.26	0.12	0.01	0.13				
Naphthalene	0.02	0.02	Trace					
Tar)								
Oil)	1,694.00	1,492.40	125.36	15.25	16.26	39.81	3.56	1.36
Naphtha	136.00	122.67	11.75		0.98		0.50	0.10
Phenols	21.22	16.25	1.36			3.61		
Fatty Acids	1.87	1.18	0.17			0.52		
Liquor	3,023.00		338.28			2,684.72		
Minor liquor cpds.	99.00	22.38			1.81	59.71	15.10	
Slag	5,237.16	21.46						5,215.70
Total	40,857.85	13,590.72	1,787.80	2,320.80	328.89	17,593.47	19.16	5,217.16
% Error	- 0.57	1.29	- 0.26	-15.26	4.47	- 0.74	16.26	0.23

ENERGY BALANCE – E.P.R.I. 02 MB 2

	Total	Potential	Latent	Therms/hr sensible
Coal	2,388.55	2,388.55		
Steam	84.67		84.67	
Oxygen	2.53			2.53
Nitrogen	0.09			0.09
Tar Injection	110.62	110.48		0.14
TOTAL	2,536.46	2,449.03	84.67	2.76
Methane	403.714	393.564		10.150
Carbon Monoxide	1,048.629	997.885		50.744
Hydrogen	525.019	500.581		24.438
Carbon Dioxide	4.867			4.867
Nitrogen	4.944			4.944
Ethylene	10.054	9.837		0.217
Ethane	44.624	43.536		1.088
Hydrogen Sulphide	23.271	22.476		0.795
Ammonia	0.384			0.384
Tar	293.403	283.575	2.372	7.456
Liquor	43.985		31.741	12.244
Phenol	3.112	2.976	0.034	0.102
Naphtha	26.493	25.704	0.190	0.599
Fatty Acids	0.253	0.241	0.003	0.009
Slag	41.031	3.165		37.866
Heat Loss	68.814			68.814
TOTAL	2.542.597	2,283.540	34.340	224.717
% Error	– 0.24			

E.P.R.I. 02 PERFORMANCE DATA M.R.2

Crude gas flow (inc. lock gas)	=	13.48	scfd
Steam consumption	=	3.21	lb/therm gas
Steam decomposition	=	78.01	%
Oxygen consumption	=	59.88	scf/therm
	=	16.598	scf/ton DAF

Crude gas production (inc. lock gas)	=	277.0	therms/ton DAF
Fuel consumption DAF	=	168.54	tons/day
Liquor yield	=	1.55	lb/therm

EFFICIENCIES %

	Gas Only	incl. tar, oil naphtha
Total crude gas therms / Coal therms	84.03	97.39
Total crude gas therms / Coal + steam	80.28	93.04
Total crude gas therms / Coal + steam @ 80% effy. +oxygen @ 2254.36 Btu/lb.	72.84	84.42

DATA USED IN RUN NO. EPRI 02 M.B. 2

D.A.F. Coal CV = 14,717 B.T.U./lb. Calculated = 14,929 B.Thu/lb.

Flux Moisture = 7.25 % w/w Coal Moisture = 4.5 % w/w

Dry Coal Proximate Analysis: Ash = 11.09 V.M. = 35.83 F.C. = 53.08
(% by weight)

Proximate as charged, including flux (% by weight)

Moisture = 4.94 Ash = 23.67 V.M. = 28.77 F.C. = 42.62

Coal Ultimate Analysis (D.A.F.) (% by weight)

C = 83.51 H = 5.71 N = 1.64 S = 2.15 Cl = 0.14 O = 6.85

Gas Analysis (Volume %)

CH_4 = 6.92 CO = 55.27 H_2 = 27.42 CO_2 = 3.52

N_2 + Ar = 5.42 C_2H_4 = 0.11 C_2H_6 = 0.44 H_2S = 0.62

NH_3 = 0.26 COS = 0.03

Gas Offtake Temperature = 502 °C

Gasifier Pressure = 335 psig

By-Product Data

	← % By Weight →						
	CV (B.T.U./lb)	C	H	N	O	S	Cl
Tar/Oil	16,567	88.1	7.4	0.9	2.35	0.96	0.21
					(Ash = 0.08)		
Naphtha	17,615	90.2	8.64	Nil	Nil	0.72	0.37
					(Ash = 0.07)		
Minor Liquor Compounds	-	22.61	Nil	Nil	60.31	1.83	15.25

RUN EPRI 02 MATERIAL BALANCE 3 COAL - PITTSBURGH 8 + B.F.S. (1305 lb/lock^{-1})

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	14,325.24	9,160.86	641.55	182.93	226.64	725.59	16.27	3,371.4
Coal Moisture	649.60		72.69			576.91		
Steam	4,626.00		517.65			4,108.35		
Oxygen	7,200.75					7,200.75		
Nitrogen	1,734.46			1,734.46				
Recycle Tar	494.00	422.22	32.21	5.68	4.00	24.26	0.74	4.89
Total	29,020.05	9,583.08	1,264.10	1,923.07	230.64	12,635.86	17.01	3,376.29
Methane	1,239.30	927.82	311.48					
Carbon Monoxide	16,193.29	6,943.28				9,250.01		
Hydrogen	580.52		580.52					
Carbon Dioxide	1,711.36	467.01				1,244.35		
Nitrogen + Argon	1,651.11			1,651.11				
Oxygen	Nil							
Ethylene	32.91	28.18	4.73					
Ethane	156.68	125.17	31.51					
Hydrogen Sulphide	211.05		12.51		198.54			
Ammonia	48.76		8.66	40.10				
Carbonyl Sulphide	18.80	3.76			10.03	5.01		
Carbon Disulphide	0.06	0.01			0.05			
Thiophene	0.45	0.26	0.02		0.17			
Hydrogen Cyanide	0.10	0.05	Trace	0.05				
Naphthalene	0.30	0.28	0.02					
Tar)								
Oil)	1,260.00	1,105.02	93.24	10.08	11.47	37.80	1.13	1.26
Naphtha	54.00	48.70	4.67		0.39		0.20	0.04
Phenols	7.43	5.69	0.48			1.26		
Fatty Acids	1.19	0.75	0.11			0.33		
Liquor	2,134.00		238.80			1,895.20		
Minor liquor cpds.	47.00	10.96			1.20	29.23	5.61	
Slag	3,382.90	11.50						3,371.4
Total	28,731.21	9,678.44	1,286.75	1,701.34	221.85	12,463.19	6.94	3,372.70
% Error	1.03	- 1.00	- 1.79	11.53	3.81	1.37	59.20	0.11

ENERGY BALANCE - E.P.R.I. 02 MB 3

	Total	Potential	Latent	Therms/hr sensible
Coal	1,652.33	1,652.33		
Steam	62.58		62.58	
Oxygen	1.71			1.71
Nitrogen	0.08			0.08
Tar Injection	82.81	82.70		0.11
TOTAL	1,799.51	1,735.03	62.58	1.90
Methane	303.552	296.130		7.422
Carbon Monoxide	738.152	703.242		34.910
Hydrogen	371.113	354.215		16.898
Carbon Dioxide	3.527			3.527
Nitrogen	3.540			3.540
Ethylene	7.220	7.069		0.151
Ethane	35.659	34.814		0.845
Hydrogen Sulphide	15.574	15.056		0.518
Ammonia	0.277			0.277
Tar	218.107	210.924	1.764	5.419
Liquor	30.840		22.407	8.433
Phenol	1.089	1.042	0.012	0.035
Naphtha	10.514	10.206	0.076	0.232
Fatty Acids	0.161	0.153	0.002	0.006
Slag	26.172	1.695		24.477
Heat Loss	68.272			68.272
TOTAL	1,833.769	1,634.546	24.261	174.962
% Error	- 1.90			

Crude gas flow (inc. lock gas)	=	9.60	scfd
Steam consumption	=	3.32	lb/therm gas
Steam decomposition	=	76.28	%
Oxygen consumption	=	61.14	scf/therm
	=	17 625	scf/ton DAF
Crude gas production (inc. lock gas)	=	288.3	therms/ton DAF
Fuel consumption DAF	=	116.18	tons/day
Liquor yield	=	1.52	lb/therm

EFFICIENCIES %

	Gas Only	incl. tar, oil naphtha
Total crude gas therms / Coal therms	85.75	99.34
Total crude gas therms / Coal + steam	81.37	94.27
Total crude gas therms / Coal + steam @ 80% effy. +oxygen @ 2254.36 Btu/lb.	73.59	85.25

DATA USED IN RUN NO. EPRI 02 M.B. 3

D.A.F. Coal CV = 15,007 B.T.U./lb. Calculated = 14,962 B.Thu/lb.

Flux Moisture = 7.75 % w/w Coal Moisture = 3.75 % w/w

Dry Coal Proximate Analysis: Ash = 10.38 V.M. = 36.44 F.C. = 53.18
(% by weight)

Proximate as charged, including flux (% by weight)

Moisture = 4.37 Ash = 22.68 V.M. = 29.66 F.C. = 43.29

Coal Ultimate Analysis (D.A.F.) (% by weight)

C = 83.75 H = 5.68 N = 1.65 S = 2.09 Cl = 0.15 O = 6.68

Gas Analysis (Volume %)

CH_4 = 7.31 CO = 54.70 H_2 = 27.24 CO_2 = 3.68

N_2 + Ar = 5.58 C_2H_4 = 0.11 C_2H_6 = 0.49 H_2S = 0.59

NH_3 = 0.27 COS = 0.03

Gas Offtake Temperature = 491 °C

Gasifier Pressure = 335 psig

(Estimated)

By-Product Data

	CV (B.T.U./lb)	C	H	N	O	S	Cl
	←			% By Weight			→
Tar/Oil	16,645	87.7	7.4	0.8	3.00	0.91 Ash = 0.10	0.09
Naphtha	17,615	90.2	8.64	Nil	Nil	0.72 Ash = 0.07	0.37
Minor Liquor Compounds	-	23.32	Nil	Nil	62.19	2.55	11.94

RUN EPRI 02 MATERIAL BALANCE 4 COAL - PITTSBURGH 8 + B.F.S. (1305 lb/lock^{-1})

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	10,156.57	6,380.25	453.38	128.49	170.18	507.36	14.31	2,502.60
Coal Moisture	522.47		58.46			464.01		
Steam	2,838.00		317.57			2,520.43		
Oxygen	5,040.70					5,040.70		
Nitrogen	1,692.93			1,692.93				
Recycle Tar	517.00	440.26	33.92	5.95	4.19	27.14	0.78	4.76
Total	20,767.67	6,820.51	863.33	1,827.37	174.37	8,559.64	15.09	2,507.36
Methane	857.16	641.72	215.44					
Carbon Monoxide	10,926.29	4,684.92				6,241.37		
Hydrogen	383.45		383.45					
Carbon Dioxide	1,227.50	334.97				892.53		
Nitrogen + Argon	1,608.37			1,608.37				
Oxygen	Nil							
Ethylene	10.41	8.91	1.50					
Ethane	67.39	53.84	13.55					
Hydrogen Sulphide	130.69		7.75		122.94			
Ammonia	33.20		5.90	27.30				
Carbonyl Sulphide	12.24	2.45			6.53	3.26		
Carbon Disulphide	0.03	Trace			0.03			
Thiophene	0.17	0.10	Trace		0.07			
Hydrogen Cyanide	0.04	0.02	Trace	0.02				
Naphthalene	0.03	0.03	Trace					
Tar)								
Oil)	972.00	863.15	74.84	6.80	7.48	17.59	0.97	1.17
Naphtha	205.00	184.91	17.71		1.48		0.76	0.14
Phenols	12.16	9.31	0.78			2.07		
Fatty Acids	1.17	0.74	0.10			0.33		
Liquor	1,394.00		155.99			1,238.01		
Minor liquor cpds.	32.00	7.14			0.84	19.04	4.98	
Slag	2,511.39	8.79						2,502.60
Total	20,384.69	6,801.00	877.01	1,642.49	139.37	8,414.20	6.71	2,503.91
% Error	1.84	0.29	- 1.58	10.12	20.07	1.70	55.53	0.14

ENERGY BALANCE - E.P.R.I. 02 MB 4

	Total	Potential	Latent	Therms/hr sensible
Coal	1,144.62	1,144.62		
Steam	38.04		38.04	
Oxygen	1.11			1.11
Nitrogen	0.04			0.04
Tar Injection	86.66	86.55		0.11
TOTAL	1,270.47	1,231.17	38.04	1.26
Methane	209.733	204.818		4.915
Carbon Monoxide	497.213	474.507		22.706
Hydrogen	244.740	233.968		10.772
Carbon Dioxide	2.431			2.431
Nitrogen	3.324			3.324
Ethylene	2.282	2.236		0.046
Ethane	15.321	14.973		0.348
Hydrogen Sulphide	9.631	9.323		0.308
Ammonia	0.180			0.180
Tar	168.109	162.713	1.361	4.035
Liquor	19.942		14.637	5.305
Phenol	1.708	1.706	0.019	0.055
Naphtha	39.883	38.745	0.287	0.851
Fatty Acids	0.158	0.151	0.002	0.005
Slag	19.464	1.296		18.168
Heat Loss	55.981			55.981
TOTAL	1,290.172	1,144.436	16.306	129.430
% Error	- 1.55			

F.P.P.T. 02 PERFORMANCE DATA M.B.4

Crude gas flow (inc. lock gas)	=	6.61	scfd
Steam consumption	=	3.05	lb/therm gas
Steam decomposition	=	78.77	%
Oxygen consumption	=	64.33	scf/therm
	=	17,807	scf/ton DAF
Crude gas production (inc. lock gas)	=	272.1	therms/ton DAF
Fuel consumption DAF	=	80.67	tons/day
Liquor yield	=	1.37	lb/therm

EFFICIENCIES %

	Gas Only	incl. tar, oil naphtha
Total crude gas therms / Coal therms	83.32	101.36
Total crude gas therms / Coal + steam	78.68	95.71
Total crude gas therms / Coal + steam @ 80% effy. +oxygen @ 2254.36 Btu/lb.	71.13	86.53

DATA USED IN RUN NO. EPRI 02 M.B. 4

D.A.F. Coal CV = 14,830 B.T.U./lb. Calculated = 14,889 B.Thu/lb.

Flux Moisture = 8.75 % w/w Coal Moisture = 4.25 % w/w

Dry Coal Proximate Analysis: Ash = 11.88 V.M. = 34.72 F.C. = 53.40
(% by weight)

Proximate as charged, including flux (% by weight)

Moisture = 4.95 Ash = 23.71 V.M. = 28.11 F.C. = 43.23

Coal Ultimate Analysis (D.A.F.) (% by weight)

C = 83.55 H = 5.64 N = 1.64 S = 2.26 Cl = 0.19 O = 6.72

Gas Analysis (Volume %)

CH_4 = 7.34 CO = 53.61 H_2 = 26.14 CO_2 = 3.83

N_2 + Ar = 7.89 C_2H_4 = 0.05 C_2H_6 = 0.31 H_2S = 0.53

NH_3 = 0.27 COS = 0.03

Gas Offtake Temperature = 475 °C

Gasifier Pressure = 335 psig

By-Product Data

	← % By weight →						
	CV (B.T.U./lb)	C	H	N	O	S	Cl
Tar/Oil	16,610	88.80	7.70	0.70	1.81 (Ash = 0.12)	0.77	0.10
Naphtha	17,615	90.20	8.64	Nil	Nil (Ash = 0.07)	0.72	0.37
Minor Liquor Compounds	-	22.32	Nil	Nil	59.52	2.61	15.55

RUN E.P.R.I. 03 MATERIAL BALANCE 1 COAL-PITTSBURGH 8 (Screened) + B.F.S.

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry	24,918.80	15,664.85	1,017.80	328.68	395.92	1,243.77	24.28	6,243.5
Coal Moisture	1,314.30		147.07			1,167.23		
Steam	7,227.00		808.70			6,418.30		
Oxygen	11,205.69					11,205.69		
Nitrogen	1,887.42			1,887.42				
Natural Gas	103.12	74.00		4.00		1.13		
Recycle Tar	Nil							
Total	46,655.93	15,738.85	1,997.56	2,220.10	395.92	20,035.72	24.28	6,243.5
Methane	1,787.06	1,337.90	449.16					
Carbon Monoxide	27,150.20	11,641.34				15,508.86		
Hydrogen	995.14		995.14					
Carbon Dioxide	2,532.33	691.05				1,841.28		
Nitrogen + Argon	2,036.99			2,036.99				
Ethylene	89.62	76.74	12.88					
Ethane	362.83	289.85	72.98					
Hydrogen Sulphide	363.81		21.56		342.25			
Ammonia	87.79		15.59	72.70				
Carbonyl Sulphide	31.90	6.38			17.01	8.51		
Carbon Disulphide	0.25	0.04			0.21			
Thiophene	0.25	0.15	0.01		0.09			
Hydrogen Cyanide	0.93	0.41	0.03	0.49				
Naphthalene	0.03	0.03	TRACE					
Tar } Oil }	1,039.00	903.92	76.89	11.43	4.68	41.14	0.21	0.73
Naphtha	526.00	481.08	39.50	0.58	1.00	3.31	0.21	0.32
Phenols	14.44	11.06	0.93			2.45		
Fatty Acids	3.22	2.04	0.28			0.90		
Liquor	3,120.00		349.13			2,770.87		
Minor Liquor cpds.	52.00	10.52			5.07	28.05	8.36	
Slag	6,260.98	17.48						6,243.5
Total	46,454.77	15,469.99	2,034.08	2,121.69	370.31	20,205.37	8.78	6,244.55
Error	0.43	1.71	-1.83	4.43	6.47	-0.85	63.84	-0.02

ENERGY BALANCE - RUN E.P.R.I. 03 MB1

	Total	Potential	Latent	Therms/hr sensible
Coal	2,816.36	2,816.36		
Steam	98.06		98.06	
Oxygen	2.85			2.85
Nitrogen	0.14			0.14
Tar Injection				
Total	2,917.41	2,816.36	98.06	2.99
Methane	437.630	427.018		10.612
Carbon Monoxide	1,237.193	1,179.079		58.114
Hydrogen	635.965	607.199		28.766
Carbon Dioxide	5.179			5.179
Nitrogen	4.336			4.336
Ethylene	19.656	19.248		0.408
Ethane	82.561	80.621		1.940
Hydrogen Sulphide	26.840	25.954		0.886
Ammonia	0.494			0.494
Tar	179.822	173.929	1.455	4.438
Liquor	44.999		32.760	12.239
Phenol	2.116	2.025	0.023	0.068
Naphtha	102.397	99.414	0.736	2.247
Fatty Acids	0.436	0.415	0.006	0.015
Slag	47.912	2.584		45.328
Heat Loss	73.385			73.385
TOTAL	2,900.921	2,617.486	34.980	248.455
% Error	0.57			

RUN EPRI 03 **PERFORMANCE DATA** M.B. 1

Crude gas flow (inc. lock gas)	=	15.77×10^6	scfd
Steam consumption	=	3.13	lb/therm gas
Steam decomposition	=	88.86	%
Oxygen consumption	=	57.33	scf/therm
		15.906	scf/ton DAF
Crude gas production (inc. lock gas)	=	277.5	therms/ton DAF
Fuel consumption DAF	=	200.10	tons/day
Liquor yield	=	1.35	lb/therm

EFFICIENCIES (%)

	Gas only	incl. tar, oil naphtha
Total crude gas therms / Coal therms	82.82	92.61
Total crude gas therms / Coal + steam	79.37	88.75
Total crude gas therms / Coal + steam @ 80% effy. + oxygen @ 2254.36 Btu/lb.	72.36	80.91

DATA USED IN RUN NO. E.P.R.I. 03 M.B. 1

D.A.F. Coal CV = 14,955 B.T.U./lb. Calculated = 14,830 B.Thu/lb.

Flux Moisture = 7.75 % w/w Coal Moisture = 4.5 % w/w

Dry Coal Proximate Analysis: Ash = 11.69 V.M. = 36.87 F.C. = 51.44
(% by weight)

Proximate as charged, including flux (% by weight)

Moisture = 5.01 Ash = 23.80 V.M. = 29.72 F.C. = 41.47

Coal Ultimate Analysis (D.A.F.) (% by weight)

C = 83.88 H = 5.45 N = 1.76 S = 2.12 Cl = 0.13 O = 6.66

Gas Analysis (Volume %)

CH_4 = 6.42 CO = 55.83 H_2 = 28.43 CO_2 = 3.31

N_2 + Ar = 4.19 C_2H_4 = 0.18 C_2H_6 = 0.70 H_2S = 0.62

NH_3 = 0.30 COS = 0.03

Gas Offtake Temperature = 488 °C

Gasifier Pressure = 335 psig

By-Product Data

	% By Weight							
	CV (B.T.U./lb)	C	H	N	O	S	Cl	Ash
Tar/Oil	16,329	87.0	7.4	1.1	3.96	0.45	0.02	0.07
Naphtha	18,250	91.46	7.51	0.11	0.63	0.19	0.04	0.06
Minor Liquor Compounds	-	20.23	Nil	Nil	53.94	9.75	16.08	Nil

RUN E.P.R.I. 03 MATERIAL BALANCE 2 COAL - Pittsburgh 8 (Screened) + B.F.S.

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	22,926.62	14,402.44	958.68	288.17	330.39	1,219.99	22.25	5,704.70
Coal Moisture	1,226.50		137.25			1,089.25		
Steam	7,247.00		810.94			6,436.06		
Oxygen	11,373.79					11,373.79		
Nitrogen	1,784.89			1,784.89				
Recycle Tar	800.00	673.76	50.48	8.48	5.36	46.88	0.24	14.80
Total	45,358.80	15,076.20	1,957.35	2,081.54	335.75	20,165.97	22.49	5,719.50
Methane	1,616.16	1,209.95	406.21					
Carbon Monoxide	26,971.06	11,564.53				15,406.53		
Hydrogen	1,024.66		1,024.66					
Carbon Dioxide	2,687.26	733.33				1,953.93		
Nitrogen + Argon	1,983.49			1,983.49				
Oxygen	Nil							
Ethylene	82.54	70.68	11.86					
Ethane	294.54	235.29	59.25					
Hydrogen Sulphide	317.91		18.84		299.07			
Ammonia	72.48		12.87	59.61				
Carbonyl Sulphide	33.27	6.65			17.75	8.87		
Carbon Disulphide	0.32	0.05			0.27			
Thiophene	0.48	0.28	0.02		0.18			
Hydrogen Cyanide	0.25	0.11	0. 1	0.13				
Naphthalene	0.03	0.03	TRACE					
Tar } Oil }	1,007.00	873.08	75.52	10.07	3.83	43.70	0.20	0.60
Naphtha	213.00	194.81	16.00	0.23	0.40	1.34	0.09	0.13
Phenols	15.12	11.58	0.97			2.57		
Fatty Acids	3.04	1.92	0.27			0.85		
Liquor	2,932.00		328.09			2,603.91		
Minor Liquor cpds.	52.00	10.22			8.99	27.26	5.53	
Slag	5,795.10	90.40						5,704.70
Total	45,101.71	15,002.91	1,954.57	2,053.53	330.49	20,048.96	5.82	5,705.43
Error	0.57	0.49	0.14	1.35	1.57	0.58	74.12	0.25

ENERGY BALANCE - RUN E.P.R.I. 03 M.B.2

	TOTAL	POTENTIAL	LATENT	THERMS/HR SENSIBLE
Coal	2,572.15	2,572.15		
Steam	98.28		98.28	
Oxygen	2.87			2.87
Nitrogen	0.10			0.10
Tar Injection	134.09	133.92		0.17
TOTAL	2,807.49	2,706.07	98.28	3.14
Methane	396.634	386.182		10.452
Carbon Monoxide	1,233.372	1,171.299		62.073
Hydrogen	656.966	625.211		31.755
Carbon Dioxide	5.943			5.943
Nitrogen	4.537			4.537
Ethylene	18.137	17.726		0.411
Ethane	67.171	65.448		1.723
Hydrogen Sulphide	23.519	22.680		0.839
Ammonia	0.445			0.455
Tar	174.589	168.571	1.410	4.608
Liquor	43.173		30.786	12.387
Phenol	2.220	2.120	0.024	0.076
Naphtha	41.530	40.257	0.298	0.975
Fatty Acids	0.413	0.393	0.005	0.015
Slag	54.741	13.325		41.416
Heat Loss	78.125			78.125
TOTAL	2,801,515	2,513.212	32.523	255.780
Error	0.21			

Crude gas flow (inc.lock gas)	=	15.72 x 10^6	scfd
Steam consumption	=	3.20	lb/therm gas
Steam decomposition	=	89.12	%
Oxygen consumption	=	59.40	scf/therm
		17.613	scf/ton DAF
Crude gas production (inc. lock gas)	=	296.5	therms/ton DAF
Fuel consumption DAF	=	182.42	tons/day
Liquor yield	=	1.29	lb/therm

EFFICIENCIES

	Gas only	incl. tar, oil, naphtha
Total crude gas therms / Coal therms	88.90	97.09
Total crude gas therms / Coal + steam + burner fuel	84.85	92.67
Total crude gas therms / Coal + Steam @ 80% effy. + burners + oxygen @ 2254.36 Btu/lb	76.64	83.70

DATA USED IN RUN NO. E.P.R.I. 03 M.B.2

D.A.F. Coal CV = 14.889 B.T.U./lb Calculated = 14.797 B.Thu/lb.

Flux moisture = 7.25 % w/w Coal Moisture = 4.70 % w/w

Dry Coal Proximate Analysis : Ash = 11.39 V.M. = 37.93 F.C. = 50.68
(% by weight)

Proximate as charged, including flux (% by weight)

Moisture = 5.10 Ash = 23.72 V.M. = 30.47 F.C. = 40.71

Coal Ultimate Analysis (D.A.F.) (% by weight)

C = 83.70 H = 5.46 N = 1.66 S = 1.93 Cl = 0.13 O = 7.12

Gas Analysis (Volume %)

CH_4 = 5.82 CO = 55.64 H_2 = 29.37 CO_2 = 3.53

N_2 + Ar = 4.09 C_2H_4 = 0.17 C_2H_6 = 0.57 H_2S = 0.54

NH_3 = 0.25 COs = 0.03

Gas Offtake Temperature = 521 °C
Gasifier Pressure = 335 psig

By-Product Data

	CV (B.T.U./lb)	C	H	N	O	S	Cl	Ash
		← % By Weight						→
Tar/Oil	16,434	86.7	7.5	1.0	4.34	0.38	0.02	0.06
Naphtha	18,250	91.46	7.51	0.11	0.63	0.19	0.04	0.06
Minor Liquor Compounds	–	19.66	NIL	NIL	52.42	17.28	10.64	NIL

RUN E.P.R.I. 03 MATERIAL BALANCE 3 COAL - PITTSBURGH 8 (Screened) + B.F.S.

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	22,020.98	14,144.07	932.88	281.97	319.83	1,148.24	26.79	5,167.20
Coal Moisture	1,032.50		115.54			916.96		
Steam	7,212.00		807.02			6,404.98		
Oxygen	11,292.43					11,292.43		
Nitrogen	1,894.33			1,894.33				
Recycle Tar	900.00	774.81	60.84	9.63	4.77	44.19	0.09	5.67
Total	44,352.24	14,918.88	1,916.28	2,185.93	324.60	19,806.80	26.88	5,172.87
Methane	1,568.67	1,174.40	394.27					
Carbon Monoxide	26,979.00	11,567.93				15,411.07		
Hydrogen	1,028.05		1,028.05					
Carbon Dioxide	2,684.47	732.56				1,951.91		
Nitrogen + Argon	2,053.86			2,053.86				
Ethylene	77.29	66.18	11.11					
Ethane	325.65	260.15	65.50					
Hydrogen Sulphide	302.39		17.92		284.47			
Ammonia	77.29		13.73	63.56				
Carbonyl Sulphide	33.33	6.67			17.77	8.89		
Carbon Disulphide	0.27	0.04			0.23			
Thiophene	0.26	0.15	0.01		0.10			
Hydrogen Cyanide	0.51	0.23	0.02	0.26				
Naphthalene	0.04	0.04	TRACE					
Tar }	760.00	661.20	57.76	6.08	2.66	31.31	0.55	0.46
Oil }								
Naphtha	193.00	176.51	14.49	0.21	0.37	1.22	0.08	0.12
Phenols	19.96	15.29	1.28			3.39		
Fatty Acids	2.22	1.40	0.20			0.62		
Liquor	2,815.00		315.00			2,500.00		
Minor Liquor cpds.	46.00	9.12			7.57	24.33	4.98	
Slag	5,207.84	40.62						5,167.22
Total	44,175.10	14,712.49	1,919.34	2,123.97	313.17	19,932.74	5.59	5,167.80
% Error	0.40	1.38	-0.16	2.83	3.52	-0.64	79.20	0.10

ENERGY BALANCE - Run S.P.R.I. 03 MB3

	TOTAL	POTENTIAL	LATENT	THERMS/HR SENSIBLE
Coal	2,531.33	2,531.33		
Steam	97.89		97.89	
Oxygen	2.83			2.83
Nitrogen	0.14			0.14
Tar Injection	150.85	150.66		0.19
TOTAL	2,783.04	2,681.99	97.89	3.16
Methane	385.183	374.833		10.350
Carbon Monoxide	1,234.799	1,171.644		63.155
Hydrogen	659.644	627.280		32.384
Carbon Dioxide	6.046			6.046
Nitrogen	4.777			4.777
Ethylene	16.993	16.600		0.393
Ethane	74.305	72.359		1.946
Hydrogen Sulphide	22.386	21.572		0.814
Ammonia	0.484			0.484
Tar	131.822	127.224	1.064	3.534
Liquor	41.658		29.558	12.100
Phenol	2.933	2.799	0.032	0.102
Naphtha	37.645	36.478	0.270	0.897
Fatty Acids	0.301	0.286	0.004	0.011
Slag	43.502	5.988		37.514
Heat Loss	83.004			83.004
TOTAL	2,745.502	2,457.063	30.928	257.511
% Error	1.35			

Run E.P.R.I. 03 **PERFORMANCE DATA MB 3**

Crude gas flow (inc. lock gas)	= 15.74×10^6	scfd
Steam consumption	= 3.19	lb/therm gas
Steam decomposition	= 87.72	%
Oxygen consumption	= 59.00	scf/therm
	17,883	scf/ton DAF
Crude gas production (inc. lock gas)	= 303.1	therms/ton DAF
Fuel consumption DAF	= 190.24	tons/day
Liquor yield	= 1.24	lb/therm

EFFICIENCIES %

	Gas only	inc. tar, oil, naphtha
Total crude gas therms / Coal therms	90.39	96.80
Total crude gas therms / Coal + Steam + Burner Fuel	86.18	92.29
Total crude gas therms / Coal + Steam @ 80% effy. + oxygen @ 2254.36 Btu/lb	77.77	83.28

DATA USED IN RUN NO. E.P.R.I. 03 MB 3

D.A.F. Coal CV = 14,969 B.T.U./lb   Calculated = 14,836 B.Thu/lb

Flux Moisture = 7.5 % w/w   Coal Moisture = 3.95 % w/w

Dry Coal Proximate Analysis: (% by weight) Ash = 10.01 V.M. = 37.56 F.G. = 52.43

Proximate as charged, including flux (% by weight)

Moisture = 3.95   Ash = 9.61   V.M. = 36.08   F.C. = 50.36

Coal Ultimate Analysis (D.A.F.) (%by weight)

C = 84.0)   H = 5.42   N = 1.66   S = 1.91   Cl = 0.16   O = 6.85

Gas Analysis (Volume %)

CH_4 = 5.64   CO = 55.58 H_2 = 29.43 CO_2 = 3.52

N_2 + Ar = 4.23 C_2H_4 = 0.16 C_2H_6 = 0.63 H_2S = 0.51

NH_3 = 0.26   COS = 0.03

Gas Offtake Temperature = 529 °C

Gasifier Pressure = 335 psig

By-Product Data

	CV (B.T.U./lb)	C	H	N	O	S	Cl	Ash
	← % By weight →							
Tar/Oil	16,527	87.0	7.6	0.8	4.12	0.35	0.07	0.06
Naphtha	18,250	91.46	7.51	0.11	0.63	0.19	0.04	0.06
Minor Liquor Compounds		19.83	NIL	NIL	52.89	16.46	10.82	NIL

RUN E.P.R.I. 03 MATERIAL BALANCE 4 COAL - PITTSBURGH 8 (Run of Mines) + B.F.S

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	23,872.12	15,191.18	1,002.31	318.72	332.70	1,213.24	28.77	5,785.20
Coal Moisture	1,167.00		130.59			1,036.41		
Steam	7,345.00		821.91			6,523.09		
Oxygen	11,771.25					11,771.25		
Nitrogen	1,517.22			1,517.22				
Recycle Tar	807.00	694.34	56.62	8.72	4.76	36.96	0.16	9.44
Total	46,479.59	15,885.52	2,007.43	1,844.66	337.46	20,580.95	20.93	5,794.64
Methane	1,709.62	1,279.92	429.70					
Carbon Monoxide	28,063.40	12,032.90				16,030.50		
Hydrogen	955.90		955.90					
Carbon Dioxide	2,642.15	721.02				1,921.13		
Nitrogen + Argon	1,723.63			1,723.63				
Ethylene	75.73	64.84	10.89					
Ethane	265.90	212.41	53.49					
Hydrogen Sulphide	329.07		19.50		309.57			
Ammonia	78.37		13.92	64.45				
Carbonyl Sulphide	33.43	6.69			17.82	8.92		
Carbon Disulphide	0.38	0.06			0.32			
Thiophene	0.34	0.19	0.02		0.13			
Hydrogen Cyanide	0.25	0.11	0.01	0.13				
Naphthalene	0.02	0.02	Trace					
Tar }- Oil	1,449.00	1,276.57	105.78	11.59	4.35	49.12	0.72	0.87
Naphtha	231.00	211.27	17.35	0.25	0.44	1.46	0.09	0.14
Phenols	15.05	11.52	0.97			2.56		
Fatty Acids	3.12	1.97	0.28			0.87		
Liquor	3,360.00		375.99			2,984.01		
Minor Liquor cpds.	59.00	10.17			15.65	27.13	6.05	
Slag	5,800.81	15.61						5,785.20
Total	46,796.17	15,845.27	1,983.80	1,800.05	348.28	21,025.70	6.86	5,786.21
% Error	- 0.68	0.25	1.18	2.42	- 3.21	- 2.16	76.29	0.15

ENERGY BALANCE - EPRI Run 3 MB 4

	Total	Potential	Latent	Therms/hr sensible
Coal	2,694.22	2,694.22		
Steam	99.61		99.61	
Oxygen	3.00			3.00
Nitrogen	0.01			0.01
Tar Injection	135.26	135.09		0.17
TOTAL	2,932.10	2,829.31	99.61	3.18
Methane	419.129	408.514		10.615
Carbon Monoxide	1,281.113	1,218.738		62.375
Hydrogen	611.906	583.255		28.651
Carbon Dioxide	5.628			5.628
Nitrogen	3.809			3.809
Ethylene	16.626	16.265		0.361
Ethane	60.573	59.084		1.489
Hydrogen Sulphide	24.312	23.476		0.836
Ammonia	0.461			0.461
Tar	251.007	242.562	2.029	6.416
Liquor	48.979		35.280	13.699
Phenol	2.208	2.111	0.024	0.073
Naphtha	45.005	43.659	0.323	1.023
Fatty Acids	0.423	0.403	0.005	0.015
Slag	44.309	2.309		42.000
Heat Loss	92.842			92.842
TOTAL	2,908.330	2,600.376	37.661	270.293
% Error	0.81			

Run EPRI 03 PERFORMANCE DATA MB 4 (R.O.M. Pitts. 8/BFS)

Crude gas flow (inc. lock gas)	=	15.72×10^6	scfd
Steam consumption	=	3.22	lb/therm gas
Steam decomposition	=	83.26	%
Oxygen consumption	=	60.94	scf/therm
		17,350	scf/ton DAF
Crude gas production (inc. lock gas)	=	284.7	therms/ton DAF
Fuel consumption DAF	=	192.66	tons/day
Liquor yield	=	1.47	lb/therm

EFFICIENCIES (%)

	Gas only	inc. tar, oil, naphtha
Total crude gas therms / Coal therms	85.58	96.30
Total crude gas therms / Coal + steam	81.12	92.06
Total crude gas therms / Coal + steam @ 80% effy. + oxygen @ 2,254.36 Btu/lb	73.99	83.25

DAT USED IN RUN NO. E.P.R.I. 03 W.B. 4

D.A.F. Coal CV = 14,852 B.T.U./lb Calculated = 14,863 B.Thu/lb

Flux Moisture = 7.75 % w/w Coal Moisture = 4.12 % w/w

Dry Coal Proximate Analysis: Ash = 11.11 V.M. = 37.22 F.C. = 51.67
(% by weight)

Proximate as charged, including flux (% by weight)

Moisture = 4.68 Ash = 23.20 V.M. = 30.20 F.C. = 41.92

Coal Ultimate Analysis (D.A.F.)(% by weight)

C = 84.06 H = 5.44 N = 1.75 S = 1.85 Cl = 0.16 O = 6.74

Gas Analysis (Volume %)

CH_4 = 6.16 CO = 57.89 H_2 = 27.40 CO_2 = 3.47

N_2 + Ar = 3.56 C_2H_4 = 0.16 C_2H_6 = 0.51 H_2S = 0.56

NH_3 = 0.27 COS = 0.03

Gas Offtake Temperature = 505 °C
Gasifier Pressure = 335 psig

By Product Data

	CV (B.T.U./lb)	C	H	N	O	S	Cl	Ash
	← % By weight →							
Tar/Oil	16,302	88.1	7.3	0.8	3.39	0.30	0.05	0.06
Naphtha	18,250	91.46	7.51	0.11	0.63	0.19	0.04	0.06
Minor Liquor Compounds.	-	17.24	NIL	NIL	45.98	25.52	10.26	NIL

RUN E.P.R.I. 03 MATERIAL BALANCE 5 COAL - Pittsburgh 8 (Run of Mines) + Limestone

COMPONENT	RATE LB/HR	CARBON	HYDROGEN	NITROGEN	SULPHUR	OXYGEN	CHLORINE	ASH
Coal (Dry)	21,051.29	15,063.04	986.07	309.41	330.27	1,153.52	15.98	3,193.00
Coal Moisture	1,116.50		124.94			991.56		
Steam	7,511.00		840.48			6,670.52		
Oxygen	11,116.09					11,116.09		
Nitrogen	1,843.33			1,843.33				
Recycle Tar	928.00	786.56	61.99	9.84	5.20	55.22	0.19	9.00
Total	43,566.21	15,849.60	2,013.48	2,162.58	335.47	19,986.91	16.17	3,202.00
Methane	1,674.76	1,253.83	420.93					
Carbon Monoxide	27,463.88	11,775.84				15,688.04		
Hydrogen	949.30		949.30					
Carbon Dioxide	3,080.87	840.75				2,240.12		
Nitrogen + Argon	2,325.51			2,325.51				
Ethylene	67.18	57.52	9.66					
Ethane	259.33	207.17	52.16					
Hydrogen Sulphide	286.29		16.97		269.32			
Ammonia	111.08		19.73	19.35	91.35			
Carbonyl Sulphide	31.65	6.33			16.88	8.44		
Carbon Disulphide	0.27	0.04			0.23			
Thiophene	0.34	0.19	0.02		0.13			
Hydrogen Cyanide	0.14	0.06	0.01	0.07				
Naphthalene	0.02	0.02	Trace					
Tar } Oil }	1,653.00	1,449.68	123.97	13.22	4.30	59.18	1.49	1.16
Naphtha	215.00	196.63	16.15	0.24	0.41	1.35	0.09	0.13
Phenols	27.09	20.74	1.74			4.61		
Fatty Acids	4.71	2.97	0.42			1.32		
Liquor	3,465.00		387.74			3,077.26		
Minor Liquor cpds.	70.00	13.40			11.14	35.73	9.73	
Slag	3,208.67	15.67						3,193.00
Total	44,894.09	15,840.84	1,998.80	2,430.39	302.41	21,116.05	11.31	3,194.29
% Error	- 3.05	0.06	0.73	- 12.38	9.85	- 5.65	30.06	0.24

ENERGY BALANCE - E.P.R.I. Run 3 MB 5

	Total	Potential	Latent	Therms/hr sensible
Coal	2,539.43	2,539.43		
Steam	101.91		101.91	
Oxygen	2.81			2.81
Nitrogen	0.12			0.12
Tar Injection	155.55	155.35		0.20
TOTAL	2,799.82	2,694.78	101.91	3.13
Methane	410.528	400.183		10.345
Carbon Monoxide	1,253.474	1,192.702		60.772
Hydrogen	607.565	579.232		28.333
Carbon Dioxide	6.531			6.531
Nitrogen	5.117			5.117
Ethylene	14.746	14.428		0.318
Ethane	59.066	57.622		1.444
Hydrogen Sulphide	21.148	20.424		0.724
Ammonia	0.651			0.651
Tar	286.315	276.712	2.314	7.289
Liquor	50.445		36.382	14.063
Phenol	3.973	3.799	0.043	0.131
Naphtha	41.884	40.635	0.301	0.948
Fatty Acids	0.638	0.607	0.008	0.023
Slag	25.498	2.317		23.181
Heat Loss	77.452			77.452
TOTAL	2,865.031	2,588.661	39.048	237.322
% Error	- 2.33			

Run: EPRI 03 PERFORMANCE DATA MB 5 (R.O.M. Pitts. 8/Limestone)

Crude gas flow (inc. lock gas)	=	15.76×10^6	scfd
Steam consumption	=	3.35	lb/therm gas
Steam decomposition	=	81.40	%
Oxygen consumption	=	58.62	scf/therm
		16,595	scf/ton/DAF
Crude gas production (inc. lock gas)	=	283.1	therms/ton DAF
Fuel consumption DAF	=	190.24	tons/day
Liquor yield	=	1.54	lb/therm

EFFICIENCIES (%)

	Gas only	inc. tar, oil, naphtha
Total crude gas therms / Coal therms	89.18	101.79
Total crude gas therms / Coal + steam	84.96	96.98
Total crude gas therms / Coal + steam @ 80% effy. + oxygen @ 2,254.36 Btu/lb	76.79	87.65

DATA USED IN RUN NO. E.P.R.I. 03 M.B. 5

D.A.F. Coal CV. = 14,953 B.T.U./lb Caluclated = 14,930 B.Thu/lb

Flux Moisture = 6.5 % w/w Coal Moisture = 4.88 % w/w

Dry Coal Proximate Analysis: Ash = 10.06 V.M. = 38.05 F.C. = 51.89
(% by weight)

Proximate as charged, including flux (% by weight)

Moisture = 5.06 Ash = 14.47 V.M. = 36.47 F.C. = 44.00

Coal Ultimate Analysis (D.A.F.) (% by weight)

C = 84.42 H = 5.42 N = 1.72 S = 1.86 Cl = 0.09 O = 6.49

Gas Analysis (Volume %)

CH_4 = 6.02 CO = 56.90 H_2 = 27.14 CO_2 = 4.03

N_2 + Ar = 4.79 C_2H_4 = 0.14 C_2H_6 = 0.50 H_2S = 0.49

NH_3 = 0.38 COS = 0.03

Gas Offtake Temperature = 503 °C
Gasifier Pressure = 335 psig

By Product Data ← % By Weight →

	CV (B.T.U./lb)	C	H	N	O	S	Cl	Ash
Tar/Oil	16,427	87.7	7.5	0.8	3.58	0.26	0.09	0.07
Naphtha	18,250	91.46	7.51	0.11	0.63	0.19	0.04	0.06
Minor Liquor Compounds	-	19.14	Nil	Nil	51.05	15.91	13.90	Nil