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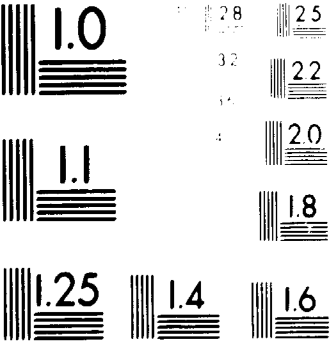

MICROCOPY RESOLUTION TEST CHART

13555

India.

OPERATING AND MAINTENANCE
MANUAL
GASIFICATION PILOT PLANT
HYDERABAD / INDIA

OCT/DEC. 1983

DP/IND/80/004

LURGI

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Daily Reports

Oct. 18, 1983 Arrival of Dr. Gummel in Hyderabad. After visit to plant started commissioning of plant based on extended RRLH/LURGI PI-DIAGRAM. A complete check of process and utilities line will be finished this week and will be commented and completed with a P & I brought to 'as build' conditions. Lists of alarm-and SV-settings are in progress. Start up of steam plant to heat up H.P steam header is planned for end of next week followed by S/U of O2-plant.

Oct. 19, 1983 Discussion on P &IScheme of Unit 400

Comment: Some modifications to be done after general plant shut down.

A. HP & LP Steam lines:

1. To separate the drain lines from WHB and gasifier jacket;

2. To incorporate PIACO in the P & I scheme. (oxygen shut off by low steam pressure).

3. To instal a by pass line at steam isolation valve for the use of initial start up and to have a constant minimum flow of steam during start up. RRL provide later.

4. To remove the insulation from valve DH 414 in order to change the position of figure 8 blind.

5. To indicate correctly in the P & I scheme the position of pressure gauge in HP steam header between jacket and flange steam connections.

6. To fix a blind in water line from ash lock condensate line.

   Comment: Ref: Cooling water for flushing condensate line.

7. To tighten up or remove the pressure gauge fixed on duplex pump G 444.

8. To fix the blind in oxygen line at F 001 as soon as the pneumatic tests are over.

9. To change the position of oxygen line leading to mixing tube F 407 before start up. The oxygen line may be installed above the HP steam line or at least from the side of it.

   Comment: O_2-line enters from bottom. Deposition of tar condensation is possible.

   To be discussed: (1) Cleaning permanently before S/U (2) Steam and O_2-line through hose connection.

B. HP & LP Feed Water lines:

1. To prepare a list of all instrument alarms and safety valves, their set points and their testing according to IBR.

2. All non-return valves are to be checked for the direction of flow.

3. To set the pressure of feed water tank at 0.4 kg/Cm^2 (gauge).

4. To discuss the possibility of disconnecting HP feed water line permanently leading to waste heat boiler and after cooler. The connection between gas liquor injection pipe and H.P. BFW will be used only as standby. Connection from BFW-supply to after cooler is blinded.

5. To find the velocity of crude gas coming out of after cooler E 437 in order to check up the size of the pipe line. O.K. appr. 12 m/sec.

C. Liquor, oil and gas lines:

1. Raw gas safety valve on WHB to be provided on the high pressure side with H.P. STM purge.

2. To remove the wheel of valve GR 411 fixed in outlet of gas line from after cooler, after opening it fully to ensure its open position during normal operation.

3. To study the possibility of mixing jacket steam into HP steam leading to mixing tube, and to discuss the differential pressure in jacket and gasifier. Design ΔP (Max) = 2.5 bar.

4. To instal a sight glass in overflow line of expansion vessel F 423.

5. The coal lock gas inlet valve to be raised a little for operational convenience.

6. To provide tapping of gas samples from gas lines at the top of the line instead of bottom.

Oct. 20, 1983 Comments/recommendations made by Dr. Gummel during discussions on 20.10.1983

In continuation of discussions of 19 October, 1983 the P & I scheme of the section 800 (TANK FARM) was discussed and inspected.

1. Installation of flow orifices in Tar line/Gas liquor lines in order to avoid errosion problems due to pressure release in the expansion vessels. To be provided later if necessary.

2. Provision of a hose connection below the tanks F 811, F 812 and F 814 for flushing drain lives and down stream transport.

3. To check the area for the disposal of the drains from F 811, F 812 and F 814.

4. To avoid atmospheric pollution provision of a tie in to the existing flare for the burning of the gas vapours released from the expansion vessels F 801 and F 802, since the gases contain NH_3, phenolics and H_2S.

5. The control panel was also inspected.

Following pre-commissioning tests were done:

5.1 The high pressure gas liquor pump was started and the after cooler sump and the sump of waste heat boiler were filled.

5.2 The local indicators of the sumps were checked.

Comment: It is suggested that high and low level alarms be also provided for the level indicators in the A.cooler and and W.H. boiler.

5.3 The gas liquor recirculation pump was started and operated.

Comment: The local level indicator gauge position of WHB may be changed to a place below where the operator can see and regulate the manual control.

5.4 Boiler feed water pump was started and the gasifier jacket was filled to the required level with B.F.water.

Oct. 21, 1983 1. Written procedure for the estimation of O_2, CO_2 from the exit gas from gasifier to be made.

2. Alarm to be provided while the coal tub is going up and coming down.

3. Sample collectors i.e. foot ball bladders with valves to be provided.

4. Gasifier is taken to a press of 7 bar and level controllers of After cooler, and W.H. boiler adjusted with control valves. The High pressure Gas liquor pumps were operated and water was injected into above. The return flow of excess water from the sumps was checked. The controllers range was adjusted for 40 and 60%. The operation of ash grate and W.H.B. recirculation pump were checked under pressure.

5. The list of high and low levels alarm for different level controlers was prepared.

6. The list of safety valves in gasification section was made and their set blow off pressure noted.

7. The log-sheet prepared earlier by RRL for shift operation record was discussed.

8. The operation philosophy of the ash lock chamber was explained.

9. The following programme of work was planned for next Monday.

9.1 Provision of high pressure steam to heat up the feed water and gasifier jacket water and check the operation of level controller.

9.2 Operation of the ash lock to be demonstrated and training of operators.

9.3 The philosoohy of operation of coal lock is to be explainec and training of operators.

Oct. 24, 1983 Arrival of Mr. Kuepfer in Hyderabad.

1. Items 1, 2, 3 of 21 October, 1983 are to be done again on 25 October, 1983.
2. Provide a blind in the steam line to BHEL and check for leakage.
3. The non-return valve for oxygen to be changed to a SS valve. The existing one is forged steel valve. Replaced by washing O_2-line and non return valve with CTC.
4. An rpm - vs position of PIV indicator with calibration is to be provided.
5. All drains at different levels of the plant to be diverted to an outside area:

   Steam vents
   Level controls
   Safety valves outlets.
6. The level gauges are to be cleaned.
7. Indicator for steam drum level and crude gas pressure are not connected to the control room. The PVC nuts are to be replaced with brass nuts. This must be taken up at the earliest.
8. Cleaning of oxygen line to gasifier with CTC (on Saturday or Sunday).

Oct. 25, 1983

1. To remove air bypass line connecting air compressor and oxygen compressor for safety reasons. A separate air line from air compressor is to be laid from air compressor to the mixing tube.
2. All steam traps to be checked for their operation (HP & LP).
3. The flange connection before heating coil to ash lock to be tightened.

4. Zero points on O_2 and steam lines to be checked with actual signals at flow levels. Zero check can be done by instruments people with pressure equalation line.

5. To prepare correction charts for air and oxygen and steam.

6. Level indicator 4403 (W.H.Boiler) is indicating 10% error in control room. Local indicator is indicating correctly.

7. Gas liquor recirculation pump may be provided with an Amper meter (preferably in control room).

8. New orifice plates to be placed in gas liquor injection lines to restrict and adjust the flow into WHB and after cooler.

9. P 4108 on the gas liquor recirculation pump to be rotated by 180° so that it is visible from steam header.

10. To provide a parallel pressure gauge indicating gasifier pressure at coal lock and ash lock.

11. To put two more rings in the stuffing box in the operating lever of the ash lock.

Programme for October 26, 1983

1. H.P. and L.P. steam to be made available.
2. Repeat operation of ash lock with other.
3. Operation of coal lock to be demonstrated.

Oct. 26, 1983

1. Ash lock lever and coal lock lever to be provided with indication (visual) for open and closed positions.

2. Restriction orifice to be provided in crude gas pressurising line to coal lock. Orifice dia may be 3mm/4mm. This orifice may be provided in valve GS 431.

3. Standby power to be provided for: (extended by note 27 October 1983; point 3).

   HP feed water pump;
   Gas liquor recirculation pump and
   High press. gas liquor injection pump.

4. Communication system between all floors to be provided. RRL provide later.

5. To modify the depressurising system of ash lock to insure that the depressurisation is complete.

Programme for October 27, 1983

1. Low pressure steam line in 800 section (Tank farm) to be commissioned.

2. Support or propping to the ash lock lever.

3. Jacket water level controller to be tested again.

Oct. 27, 1983

1. Accessability to the gas liquor injection valves to be provided on WHB and after cooler.

2. Provide valve in the condensate line going into the gas liquor tank (Normally closed).

3. Standby diesel power to be provided.

   HP feed water pump,
   Gas liquor recirculation pump,
   High pressure gas liquor injection pumps,
   Lights and (v) pannel board.

4. Gas liquor tank to be provided with level indicators like dip-stick/floating stick.

5. Additional support to be provided for steam line.

6. Multipoint temperature recorder 4201 to be checked.

7. Charts of Recorders to be checked for the rotation.

8. Near the ash lock electrical cables to be sheilded (G.I. sheet).
9. Stuffing box of coal lock bottom cone to be tightened.
10. Provision of drain lines to the impulse lines from the coal lock and gasifier. RRL will provide later steam purge.
11. Bolts on the gland on the scrapper to be changed. The leaking gland to be made good.
12. Provide a bypass to the overflow line of expansion vessel.

Programme for October 29, 1983

1. Repeat of training of operation in case of power failure.
2. Supports for ash lock bottom & top cone levers.
3. Checking the function of solenoid valve.

Oct. 31, 1983

1. The flow of oxygen and steam through the orifice were checked (by calculation) against the pressure drop.
2. The flow of steam through the steam pipe and its indication in flow indicator was checked.
3. The gasifier was pressurised at 10 bar with air and steam.

Nov. 1, 1983

1. Mass flow of O_2, steam through the orifice calculations have been continued and flows at 25 bar and 10 bar were calculated. Graphs were prepared for each of the gasifying agents i.e. steam and oxygen.
2. High pressure steam and air were admitted into gasifier, and gasifier jacket for heating up. The gasifier was pressurised to 10 bar. The functioning of the temperature recorder, the flow indicators and ratio regulators were tested.
3. Gas sampling lines and collection of samples were tested.

Nov. 2, 1983

1. Heating of feed water tank with HP steam was started at 10.30 A.M. operation of gasifier at 10 bar tried.
2. Working of instruments checked.
3. Charts for flow of O_2, HP steam air and crude gas at 10 bar and 25 bar were prepared.
4. Emergency power from diesel generator was provided for pumps and lighting.

Nov. 3, 1983

1. Operation of boiler at 20 bar and take maximum output of steam and operate gasifier at 10 bar and check its working of all instruments especially steam flow. Air flow and Air/Oxygen Cut off if steam fails, was tried.

2. Time required to heat up coal to the ignition temperature using H.P. steam.

3. Collection of coal sample (from boiler feed) for analysis

Nov. 7, 1983

1. Preparation of flow charts for air, oxygen and steam at different pressures was continued.

2. The gasifier system comprising gasifier, waste heat boiler and after cooler, was pressurised to 10 bar, with all level controllers and spray cooler recirculation pump in operation.

3. The gasifier and jacket were steam heated.

4. The gasifier was stopped for maintenance, as there was a minor leakage in boiler and steam was not available.

Nov. 8, 1983

1. The gasifier system was pressurised to 10 bar with all the pumps in circuits and level controllers in operation.

2. As there was no steam available, the drain pipe on the boiler was rearranged for controlling the HP steam supply to gasification unit.

3. The checklist for the start up of gasifier was discussed.

4. The boiler was started.

Nov. 9, 1983

1. The oxygen cut out for low steam pressures was checked; the response appeared to be slow.

2. Three coal locks full of coal was charged into the gasifier. It was heated with steam and ignited by admission of air and steam. The CO_2 and O_2 content in gas were estimated.

3. The gasifier was emptied and the coal discharged was observed.

Nov. 10, 1983

1. The gasifier was charged with fresh coal and using superheated steam and air. Temperature of gasifier outlet, CO_2 and O_2 content of exit gas were observed. At CO_2 levels of 18-20% and oxygen less than 0.4%. Filling of the gasifier with coal was started.
2. Difficulty was experienced in charging coal to gasifier through the coal lock as there was some blockage for free flow of coal from bunker. This was rectified and gasifier filled with coal at a pressure of 1 bar.
3. The sumps of waste heat boiler and after cooler were discharged under a pressure of 3 bar and the process was repeated for three times.
4. The gasifier was shut down due to lack of steam under pressure.

Nov. 11, 1983

1. With the same charge of coal, the gasifier was lighted again and the system was pressurised to 5 bar with air operation, taking into consideration the CO_2 and O_2 contents of exit gas. However the gasifier system was depressurised due to non-availability of steam.
2. The gasifier was shut down for maintenance.

Nov. 14, 1983

1. Coal was charged into the gasifier. After the availability of H.P. steam the gasifier is pre-heated for 3 hours. Ignition of coal was made by admission of compressed air.
2. The gasifier was filled with coal and operation of gasifier was continued at 5 bar. After the stabilisation of the plant the flare stack was lighted. The gas was burning with a blue flame.
3. Operation of the plant at 5 bar was continued.

Nov. 15, 1983 After 24 hours satisfactory operation of the plant at 5 bar the plant, following maintenance works were done:

The welding joint in the line of W.H.B. liquor recirculation pump was leaking. By isolating the pump from the circuit and adjusting the gas outlet temperature through regulation of high pressure liquor spray, the connecting piece was removed leakage at the welding rectified. The piece was hydraulically tested and replaced. The circuit was again brought into operation and temperatures controlled.

The packing at the steam injection cooler (LP-steam system) got burst. The gasifier was depressurised and the packing replaced. The gasifier was again brought back to a pressure of 5 bar and operated.

Nov. 16, 1983

1. Due to fluctuation in voltage the motor of the forced draught fan coil got burnt. The motor was replaced and fan again started (Boiler house).
2. There was power shut down, from 8.45 A.M. to 11.30 P.M.
3. The plant was started again and gasifier operated at 10 bar.

Nov. 17, 1983

1. The plant was continuously operated at a pressure of 10 bar and the personnel were trained.
2. Operational conditions were adjusted so that no clinker formation in the ash was observed.

Nov. 18, 1983

1. The plant operation was continued at 10 bar with air and steam.
2. The operating pressure was increased to 15 bar.

3. The plant was operated for 24 hours at 15 bar with air and steam.

4. Arrangements were made to switch over to oxygen but this could not be done due to unexpected trouble in the expansion turbine of the oxygen plant.

Nov. 19, 1983

1. Operation of the gasifier at 15 bar, with air and oxygen was continued.

2. At 4.30 P.M. the plant was taken for a shut down for maintenance works.

Nov. 21, 1983

1. There was power tripping off from APSEB four times. The maximum period at one time was about 2 hours. Hence the Oxygen plant that was stabilised, could not be taken for production of oxygen. Steady power supply was available from 4 P.M.

2. The steam flow controller which was taken for maintenance and the pressure transmitter were available in service at about 4 P.M.

3. From about 4.30 P.M. the plant was started and operated on air-steam at 10 bar. Operation was continued overnight.

Nov. 22, 1983

1. The operation of the gasifier overnight at 10 bar with air and steam was continued. It was considered to operate the plant at 15 bar for a period 7 to 8 hours before oxygen was admitted.

2. At about 4 P.M. oxygen was admitted at gasifier pressure of 5 bar and oxygen steam operation was continued for 4 hours.

3. The gasifier was brought back to air-steam operation and operated overnight at 15 bar.

Nov. 23, 1983

1. The gasifier operating at 15 bar on air + steam was brought down to 5 bar and oxygen was admitted at 10.30 A.M.
2. Gasifier pressure was brought to 10 bar and maintained for about 2 hours.
3. When the pressure was increased to 12 bar, water hammering was observed in the line from steam injection cooler, steam collection drum and feed water tank.
4. Feed water pump was not able to pump water to steam collection drum as well as boiler at the desired pressure.
5. The gasifier pressure was brought down 5 bar and switched over to air steam, to sort out the problem.

Nov. 24, 1983

1. The gasifier was maintained overnight on air-steam gasification.
2. The feed water tank operating conditions were examined and set for a temp of 100-105°C and 0.2 bar.
3. The gasifier was switched over to oxygen steam operation and at 12 bar attempts were made to regulate the steam collection drum pressure, and water level and also the feed water tank conditions.
4. When the level in feed water tank was maintained feed water to boiler was not sufficient and pressure went down.
5. The motor of ash discharge grate of the gasifier tripped and no ash was coming out. The plant was depressurised and switched over to air steam and shut down.
6. Attempts were made to disturb the gasifier bed and discharge the ash.

Nov. 25, 1983	1.	Small quantity of clinkers were observed during the discharge of ash.
	2.	The grate was operated and ash continuously discharged till all the ash was discharged and coal started coming out.
	3.	The plant was taken for maintenance on November 26, 1983.
Nov. 27, 1983	1.	The plant was taken for remaining maintenance work.
	2.	Air steam gasification was started following the normal procedures followed so far.
Nov. 28, 1983	1.	The plant was brought on to oxygen steam operation using the usual procedure and pressure brought up to 12 bar and operated at 12-13 bar.
	2.	Difficulty was experienced in supply of water to steam injection cooler-steam collection drum and waste heat boiler circuit as well as feed water to the boiler. The level in the steam collection drum could not be maintained. When more water was supplied to the steam collection drum, the boiler feed water was getting effected.
	3.	The gasifier was depressurised and operated on air-steam to provide necessary arrangement for supply of additional water to steam injection cooler.
Nov. 29, 1983	1.	The plant was operated again on oxygen + steam from 10^{50} am to 1^{15} pm. It was observed that the gland packing of the valve for the low pressure steam from the steam injection cooler was badly leaking and needs replacement. The coal lock top cone was also found leaking. The H.P. feed water was not able to be pumped even though H.P. feed water pump steam driven duplex pump were operated.
	2.	The plant was shut down for the above works and the works were completed.

Nov. 30, 1983

1. The boiler feed water pump was repaired to develop the necessary pressure and capacity.
2. The gasifier was operated with oxygen steam and attempts were made to go to higher pressures up to 16 or 17 bar.

The problem of supply of necessary water to maintain the level in steam collection drum at pressures higher than 12 bar still remained unsolved.

Dec. 1, 1983

1. The feed water line to the steam injection cooler was isolated and a separate low pressure pump was installed to supply water to this circuit.
2. The gasifier was operated at 10 to 12 bar and attempts were made to maintain the system.
3. The maintenance of water level in the steam collection drum and supply of water to the circuit - steam injection cooler - steam collection drum and waste heat boiler - was not possible even with this New LP-water supply system.

Dec. 2, 1983

1. The plant was operated with oxygen and steam at 10 bar.
2. The feed water was supplied through the BFW level controller as well as by pass line but the level could not be maintained.
3. The inlet pressure of water at the L.P. feed water pump and at the level controller was checked. A ΔP of 4 to 5 bar was maintained and water supplied. But the level could not be maintained.

Dec. 3, 1983

1. A separate connection for feeding water directly into the steam collection drum was made removing the level controller and the flow controller from the circuit. Feed water was supplied to the steam collection drum directly and water level brought up.

2. After obtaining the required level and normally adjusting the feed water, the gasifier pressure could be maintained and the system was brought under balance and the pressure in the steam collection drum could be maintained at 2.5 to 2.8 bar.

3. The gasifier pressure could be gradually increased from 10 to 24 bar at the rate of 1 bar every 10 minutes, steadily controlling the CO_2 and O_2 content in the crude gas. At 20 bar the bolts of the gasifier top were tightened and the plant was observed for any leakages. The system was found to be in order. It was maintained at that pressure for 45 minutes. The plant was taken for a shut down for maintenance works.

Dec. 5, 1983 Following check lists were discussed for the operation of the plant.

(a) Planned shut down of a gasifier.

(b) Emptying and cooling of a gasifier before blanks can be installed.

(c) Preparation for installation of blinds after emptying the gasifier and cooling.

(d) Installation of blinds after emptying and cooling gasifier and emptying.

(e) Precautions to be taken before entering the gasifier after blinds are installed.

(f) Preparation and removal of blinds from a gasifier after an internal inspection or a major maintenance before the gasifier can be started up.

(g) The start up of a gasifier with high pressure steam and air.

(h) The switching over of a gasifier from air to oxygen.

At the plant maintenance works and modifications of the water connections between feed water to steam injection cooler and steam collection drum were started.

Dec. 6, 1983 The modifications to the feed water line to the steam injection cooler and steam collection drum were continued and completed.

Other aspects of operational manual were also prepared and discussed.

Discussions were held with operational staff on following aspects of operation:

(i) Heating up the gasifier. (ii) Start up with air. (iii) Switching over to oxygen. (iv) control of CO_2 and O_2 in crude gas. (v) Control of temperatures. (vi) Increasing and decreasing of gasifier load and pressure. (vii) Preparation of gasifier for start up. (viii) Prepautions, safety etc. (ix) Routine maintenance.

Dec. 7, 1983 The gasifier was started with air-steam operation and after 5 to 6 hours of operation and stabilisation of the system, operation was switched over to oxygen steam. The pressure of the gasifier was gradually brought up to 24 bar and maintained. The load was increased to 68% (about 1000 m^3N of raw gasifier/h). After operation at this pressure and load for same time, operation was changed over to air-steam at 5 bar and plant handed over for operation by RRL-H staff.

Dec. 8, 1983 The plant was taken over for operation by RRL-H and the operation was switched over to oxygen steam at 10^{30} hours. Following the usual procedures the pressure was brought up to 21 bar at 14^{00} hours. The plant was operated at this pressure and at 85% to 90% load.

Dec. 9, 1983 The pressure was brought up to 24 bar at 5.30 hrs. and operated at that pressure. The load was maintained and some times increased stagewise up to 95%. The CO_2 content of crude gas was regulated between 29 to 31% and the oxygen less than 0.8 to 1.0% but mean value was 0.3 to 0.4%. At about 11^{00} the gland packings in the ash lock top cone and at the grate were found leaking. The gasifier pressure was brought down by depressurising following normal procedures.

Dec. 1[illegible], 1983 The gasifier was shut down for replacement of gland packings and other maintenance worked. The ash was discharged and ash lock and grate were operated till coal came out and the gasifier was locked.

Dec. 12 & 13 1983 The functioning of different equipment in the gasification section and gas liquor separation section were discussed with the operational staff. Precautions to be taken and operation of different controls were also discussed. The safety aspects in the operation of the plant were generally explained.

Dec. 14, 1983 Departure from Hyderabad.

2) Piping and Instrumentation drawing

(As Build Status)

3) List of orifices with details

		FRC 4301 Steam	FRRC 4302/1 O_2	FR 4303/1 Crude gas
1.	D.P. range	4900 mmwel	2500 mm wel	2500 mm wel
2.	Design press/ Working press	34/31	31/30	31/23.4
3.	Design temp./ Working temp.	400/350	+50/+40	+60/+40
4.	Max. Rate	1700 kg/h	250 NM^3/h	1650 NM^3/h
5.	Normal Rate	1500 kg/h	230 NM^3/h	1050 NM^3/h
6.	$(d/D)^2$	0.5095	0.2807	0.2416
7.	d	30.767	13.246	26.780
8.	Co.efficient	0.7136	0.6458	0.6314
9.	Flange to flange distance	65 mm	900 mm	65 mm

COAL Divn
RRLH: 21.10.198?

5) **SAFETY VALVE LISTING**

UNIT 400

	Valve No.	Location	Set Pressure
1.	S.V. 431	Waste Heat Boiler	27 bar
2.	S.V. 435	Steam drum	3.4 bar
3.	S.V. 441	Feed Water Tank	0.34 bar Hold 0.4
4.	S.V. 444	Steam pump discharge line	43.0 bar Hold 40.0
5.	S.V. 448	Instrument-Air Receiver	14.0 bar
6.	S.V.Discharge side	Oxygen compressor	35 bar

Coal Divn
RRLH: 21.10.1983

6) Instrument Alarm List

1. Oxygen pressure alarm high and low
   PRA-HL 4103 A-H set of 30 bar
   A.L set of 27 bar

2. Oxygen safety system alarm low and very low
   PIA-L-CO 4101 A-L set at 29.0 bar
   CO set at 28.0 bar

3. Jacket level Alarm High and low
   LICA-HL-4401 A-H set at 80%
   A-L set at 20%

4. Instrument Air low alarm
   PIA-L-4131 A-L set at 1.7 bar

7) Operating Pressures

Gasifier - O.P.	24 bar
Gasifier - design pressures	30 bar
Oxygen-Header O.P.	29 bar
Steam header O.P.	30 bar
Low Pressure Steam O.P.	2.8 bar (140 $^{\circ}$ C)
Instrument Air O.P.	4.0 to 5.0 bar

8) Operating data

8.1) Log sheets

8.2) Recording charts

8.1) Log sheets

(2)

7/11/83/11

GASIFICATION (SECTION 400) SHEET 1 (CONTROL ROOM)

TIME	STEAM FLOW (FRC 4301) kg/h	STEAM FLOW kg/h	OXYGEN FLOW Nm³/h	RATIO kg/Nm³	STEAM PRESS kg/cm² PR 4101	OXYGEN PRESS PA 4103	CRUDE/PURE GAS PRESSURE PR 4110	CRUDE/PURE GAS FLOW Nm³/h	TEMP. RECORDER (TR 4201): 1. GAS TO F 403 (MIXING ZONE) °C	2. MIXING VESSEL F4103 °C	3. ASH LOCK F4A1 °C	4. CRUDE GAS FROM GASIFIER C401 °C	5. CRUDE GAS TO A COOLER E 4?? °C	6. H.P. STEAM °C	TEMP. RECORDER (TR 4208): CRUDE GAS TO D601 °C	LYE FROM D601 °C	3. REGEN. D 602 °C	4. GASIFIER TOP (TRC 4204)	5. PURE GAS °C	6. CRUDE GAS TO 13 603	Remarks
1.15	3.8	4.7	4.9		28.0	29.6	25.0	5.7	26.0	4.0	211	324	147.0	380.0	40.0			175.0		✓	Steam flow off at 1.25 due to low steam ...
1.30	3.8	4.1	4.7		28.6	30.0	17.8	2.8	26.0	310	203	348	145.0	360.0	40.0			170.0			... 1.30 hrs
1.45	4.7	4.7	6.0		28.0	30.0	23.5	7.7	27.0	305	211	344	155.0	320.0	40.0			186.0			
2.00	4.5	4.8	5.8		28.2	29.3	23.5	7.7	27.0	325	215	355	160.0	340.0	40.0			156.0			
2.15	4.5	4.7	5.5		28.0	29.2	23.5	7.1	38.0	330	213	358	160.0	370.0	40.0			156.0			
2.30	4.4	4.2	4.4		29.0	30.0	21.0	7.8	32.0	330	211	358	120.0	370.0	40.0			186.0			
2.45	2.0	2.2	—		29.0	10.5	12.0	2.0	26.0	330	187	325	152.0	358.0	42.0			186.0	✓		O_2 cut off at 2.35 Steam at 3
3.00	—	—	—		21.5	—	8.2	1.3	25.0	305	180	298	160.0	348.0	44.0			183.0			
3.15	-		—		28.0	—	2.8	1.0	25.0	277	177	240	135.0	325.0	42.0			168.0			Total Steam cut off at 2.55 hrs
3.30	-	—	—		21.0	—	1.8	1.0	23.0	265	170	187	120.0	290.0	36.0			160.0			
5.10	1.2	1.7	9.0		24.0	13.0	1.5	2.1	22.0	111.0	158	182	104.0	272.0	36.0			136.0			Air steam started from 5.00 hrs
5.30	1.2	1.6	9.0		26.5	1[illegible]	1.5	9.1	22.0	155.0	155	187	102.0	298.0	34.0			13[illegible]			
5.41	1.2	1.3	9.0		25.0	13.0	1.5	9.2	25.0	138.0	155	187	102.0	284.0	34.0			133.0			
6.00	min	min	9.0		24.0	12.0	2.2	1.75	24.0	230	155	187	102.0	286.0	35.0			131.0			
6.30	min	min	9.0		[illegible]	12.2	4.3	1.75	[illegible]	134	155	198	103.0	258.0	35.0			130.0			
7.00	min	min	9.0		25.2	10.5	5.6	2.1	26.0	140	152	205	103.0	282.0	35.0			128.0			
7.30	min	min	9.0		26.0	13.4	5.8	2.7	26.0	138	153	210	103.0	280.0	35.0			105.0			
8.00	min	min	1.0		26.0	13[illegible]	6.0	3.[illegible]	28.0	141	147	201	102.0	278.0	35.0			115.0			

DATE 7.12.83

SHIFT A (from 1 hrs)

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12.83

GASIFICATION (SECTION 400) SHEET 1 (CONTROL ROOM)

TIME	STEAM FLOW (FRC 4301) kg/h	STEAM FLOW kg/h (FRC 4302)	OXYGEN FLOW m³/h (FRC 4302)	RATIO kg/m³	STEAM M PRESS kg/cm² PR 4101	OXYGEN PRESS PR 4103	CRUDE / PURE GAS PRESSURE PR 4110	CRUDE/PURE GAS FLOW m³/h	TEMP. RECORDER (TR 4301) 1. GAS TO F 407 (MIXING) °C	2. MIXING VESSEL FLANGE °C	3. ASH LOCK FA41 °C	4. CRUDE GAS FROM GASIFIER C401 °C	5. CRUDE GAS TO ... COOLER E 4301 °C	6. H.P. STEAM °C	TEMP. RECORDER (TR 4208) 1. CRUDE GAS TO D601 °C	2. LYE FROM D601 °C	3. REGEN. ... D602 °C	4. GASIFIER ... (TRC 4204)	5. PURE GAS °C	6. CRUDE GAS TO 13 603	Remarks
8.30 (1)	--	--	11.0		24.[illegible]	13.0	5.0	3.5	30	145	155	206	100	301	33			115		✓	
9.00	1.5	1.6	8.6		28.0	13.0	5.0	4.2	30	162	150	200	100	300	35			115			
9.30 (2)	1.0	1.0	8.0		27.0	12.0	5.0	3.8	31	208	157	232	138	335	38			132			
10.00	—	—	9.0		28.5	12.0	5.0	2.4	31	189	157	236	135	348	41			134			O2/Steam [illegible] 10.30
10.30 (3)	4	4.4	4.2		24.0	10.0	2.5	2.0	31	220	157	216	146	350	33			128			
[illegible]	4	4.3	4.[illegible]		[illegible]	10.2	[illegible]	4.9	31	232	151	240	145	[illegible]	41			124			
10.50 (4)	4	4.2	4.2		26.0	10.5	5.0	4.0	31	210	165	242	145	362	42			132	✓		St/O2 [illegible]
11.00	3.9	4.1	4.2		28.5	10.0	[illegible]	4.0	31	280	[illegible]	[illegible]	146	375	41			124			[illegible]
11.10 (5)	4	4.1	4.2		29	12.5	5.4	6.0	32	310	167	258	148	395	42			137			[illegible]
11.30	4.0	4.1	4.2		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	390	[illegible]			140			St/O2 [illegible]
[illegible] (6)	4.0	4.1	4.4		27	[illegible]	[illegible]	5.0	31	[illegible]	[illegible]	250	141	382	42			136			[illegible]
12.00	4.0	4.1	4.4		[illegible]	13.0	[illegible]	[illegible]	31	[illegible]	157	260	151	375	44			141			Flow [illegible]
[illegible] (7)	4.0	[illegible]	4.4		[illegible]	[illegible]	[illegible]	[illegible]	31	295	162	270	166	375	43			144			[illegible]
[illegible]	4.0	4.1	4.4		[illegible]	12.[illegible]	[illegible]	[illegible]	31	[illegible]	[illegible]	260	[illegible]	381	44			146			[illegible]
[illegible] (8)	4.0	4.2	4.4		27	12.5	10.0	6.3	31	[illegible]	[illegible]	270	[illegible]	[illegible]	44			148			[illegible]
[illegible]	4.0	[illegible]	4.4		[illegible]	[illegible]	[illegible]	[illegible]	31	[illegible]	182	278	161	[illegible]	45			150			[illegible]
[illegible] (9)	4.0	4.2	4.4		28	18.0	12.0	5.4	31	310	189	214	160	385	43			153			[illegible]
[illegible]	[illegible]	4.9	[illegible]		29	18.0	12.5	6.5	32	316	190	290	157	380	44			155			

DATE [illegible]

SHIFT 1 ([illegible]) K. Kaleikimal Signature 8.12.83
Shift coordinator

[signature] Signature 8/12/83
Control pannel operator

P.T.O

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GASIFICATION (SECTION 400) SHEET 1 (CONTROL ROOM)

TIME	Steam flow (FRC 4301) kg/h	Steam flow kg/h (FRRC 4302)	Oxygen flow m³/h	Ratio kg/kg	Steam press kg/cm² PR 4101	Oxygen press PR 4103	Crude/pure gas pressure PR 4110	Crude/pure gas flow m³/h PR 4115	1. [illegible] F 407 (mixing) °C	2. Mixing vessel F402 °C	3. Ash lock F421 °C	4. Crude gas from gasifier C401 °C	5. Crude gas to cooler E 432 °C	6. H.P. steam °C	1. Crude gas to E601 °C	2. Lye from D 601 °C	3. Regen. tower D 602 °C	4. Gasifier top (TRC 4201) °C	5. Pure gas °C	6. Crude gas to D 603	Remarks
1 10	[illegible]	4.25	4.4		29	22	[illegible]	6.8	55	305	195	292	156	362	46			160		✓	1.45 Ash discharge
1 20	[illegible]	4.25	4.3		28	22	6.2	6.0	55	300	172	305	169	360	42			155			Gravels observed to C-D
2	4.1	4.0	4.4		28.5	26	16.5	6.4	36	300	167	296	156	369	43			158			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		29.0	26	17.0	6.3	36	305	202	294	160	372	43			156			Grate [illegible]
3	4.0	4.1	4.4		28.5	[illegible]	18.0	5.9	36	310	202	292	166	375	43			172			P1 ↑ 618 [illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	19.5	6.3	35	315	204	300	155	385	42			175			[illegible] 614 [illegible]
4	4.0	4.2	4.4		28.5	26	20.0	6.2	35	320	204	300	165	378	43			181	✓		P1 ↑ 620 [illegible] 2.00 PM
[illegible]	[illegible]	[illegible]	4.4		28.0	26	20.0	6.1	35	310	204	310	165	378	44			185			
5	4.0	4.2	4.4		28.5	26.0	20.0	6.0	35	305	182	358	165	352	46			192			
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	35	320	[illegible]	[illegible]	165	382	43			202			
3.00 6	4.0	4.2	4.4		28.5	27.0	20.0	6.1	32	318	208	332	165	380	43			210			
3.10	4.0	4.2	4.4		29.5	27.0	20.0	5.6	32	320	209	339	162	380	42			216			
3.20 7	4.0	4.2	4.4		29.0	26.0	20.0	6.0	32	315	188	330	155	380	42			205			
3.30	4.0	4.2	4.4		28.5	26	20.0	5.5	32	315	186	330	152	378	42			198			
3.40 8	4.0	4.2	4.4		29.0	26.0	20.0	5.5	32	315	207	340	155	365	42			172			
3.50	4.0	4.2	4.4		29.0	26	20	5.8	34	315	215	340	162	315	42			177			
4.00 9	4.0	4.2	4.4		29.0	27.5	20.0	5.8	34	312	216	335	162	375	42			158			

DATE 8.12.83

SHIFT I (HAMBURG)

K Khaleekmal

Signature 8.12.83

Shift coordinator

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Signature

Control pannel operator

P.T.O

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GASIFICATION (SECTION 400) SHEET 1 (CONTROL ROOM)

TIME	STEAM FLOW (FRC 4301) kg/h	STEAM FLOW kg/h (FRC 4302)	OXYGEN FLOW m³/h (FRC 4302)	RATIO kg/h / m³/h (FRC 4302)	STEAM PRESS kg/cm² PR 4101	OXYGEN PRESS PR 4103	CRUDE / PURE GAS PRESSURE PR 4110	CRUDE/PURE GAS FLOW m³/h FR 4116	TEMP RECORDER (TR 4201) 1. GAS TO F 407 (MIXING) °C	TEMP RECORDER (TR 4201) 2. MIXING VESSEL F4103 °C	TEMP RECORDER (TR 4201) 3. ASH LOCK F401 °C	TEMP RECORDER (TR 4201) 4. CRUDE GAS FROM GASIFIER C401 °C	TEMP RECORDER (TR 4201) 5. CRUDE GAS TO COOLER E 4?? °C	TEMP RECORDER (TR 4201) 6. H.P. STEAM °C	TEMP. RECORDER (TR 6208) 1. CRUDE GAS TO D601 °C	TEMP. RECORDER (TR 6208) 2. LYE FROM D601 °C	TEMP. RECORDER (TR 6208) 3. REGEN TOWER D602 °C	TEMP. RECORDER (TR 6208) 4. GASIFIER (TAL 4281) °C	TEMP. RECORDER (TR 6208) 5. PURE GAS °C	6. CRUDE GAS TO D603	Remarks
1 (4.15)	5.0	[illegible]	5.9		[illegible]	21.0	20.6	[illegible]	30	330	186	348	163	378	42			181		✓	[illegible] 5/[illegible] at 4.25 hrs
4.45	5.0	[illegible]	5.9		2.9	26.0	20.8	7.8	32	322	210	360	162	388	42			182			
2 (5.00)	5.0	[illegible]	5.9		2.85	26.0	20.5	8.1	32	320	207	360	163	370	42			183			Ratio [illegible] 5/[illegible] at 5.15 hrs
5.15	[illegible]	[illegible]	7.0		2.80	25.0	21.0	[illegible]	31	340	208	[illegible]	[illegible]	400	42			163			
3 (5.30)	[illegible]	[illegible]	7.0		2.80	26.0	21.0	9.4	31	325	192	360	160	378	[illegible]			190			[illegible] 5 [illegible]
5.50	5.8	5.0	6.0		2.90	26.0	21.3	8.8	31	330	212	363	164	380	42			183			
4 (6.30)	[illegible]	[illegible]	[illegible]		2.85	26.0	21.5	7.0	32	[illegible]	205	480	163	390	43			[illegible]	✓		DM [illegible] 3 m³/h
7.00	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	32	330	214	[illegible]	163	[illegible]	43			210			
7.30	[illegible]	[illegible]	[illegible]		29.0	26.0	20.5	7.0	30	315	208	390	110	378	43			223			Ratio [illegible] 6.8/[illegible] at 5 [illegible]
5	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	31	[illegible]	224	[illegible]	108	[illegible]	43			187			Ratio [illegible]
6																					[illegible]
7																					Ratio [illegible] at 6.15 hrs
8																					[illegible] 6.35 [illegible] 7.20
9																					

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SHIFT I ([illegible])

K. Kaleekumar
Signature 8.12.83
Shift coordinator

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Signature
Control pannel operator

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GASIFICATION (SECTION 400) SHEET 1 (CONTROL ROOM)

TIME	STEAM FLOW (FRC 4301) kg/h	FRRC 4302 STEAM FLOW kg/h	OXYGEN FLOW Nm³/h	RATIO kg/Nm³	STEAM PRESS kg/cm² PR 4101	OXYGEN PRESS PR 4103	CRUDE/PURE GAS PRESSURE PR 4110	CRUDE/PURE GAS FLOW Nm³/h FR 4116	TEMP. RECORDER (TR 4201) 1. C4 F403 (MIXING) °C	2. MIXING VESSEL F403 °C	3. ASH LOCK F461 °C	4. CRUDE GAS FROM GASIFIER C401 °C	5. CRUDE GAS TO ... E 4301 °C	6. H.P. STEAM °C	TEMP. RECORDER (TR 4202) 1. CRUDE GAS TO D601 °C	2. LYE FROM D601 °C	3. Regen ... D602 °C	4. GASIFIER ... (TRL 4201) °C	5. PURE GAS °C	6. CRUDE GAS TO IB 603	Remarks
20 30	[illegible]	6.3	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	3[illegible]	343	218	440	165	40[illegible]	44			19[illegible]		✓	changes in inputs 6.4/[illegible]
21 00	6.6	6.7	6.9		[illegible]	23.5	[illegible]	[illegible]	3[illegible]	347	215	402	163	420	43			19[illegible]			6.[illegible]
21 30 (2)	6.[illegible]	6.7	7.0		[illegible]	26.3	[illegible]	6.8	32	310	217	455	162	380	44			18[illegible]			6.5/7 [illegible]
22 00	6.5	6.7	7.0		[illegible]	[illegible]	[illegible]	7.8	3[illegible]	328	225	407	160	370	44			[illegible]			6.0/6.2 at 23.00
22 30 (3)	6.[illegible]	6.7	7.0		[illegible]	26	215	9.2	32	312	233	41[illegible]	164	370	43			186			6.1/6.[illegible] [illegible]
23 00	6.0	[illegible]	[illegible]		27[illegible]	26	[illegible]	7.6	3[illegible]	302	235	370	162	370	43			185			
23 30 (4)	[illegible]	[illegible]	[illegible]		28[illegible]	26	21[illegible]	8.4	3[illegible]	310	23[illegible]	380	165	[illegible]	43			184	✓		6.3/6.7 at 3 AM
00 00	[illegible]	6.[illegible]	6.[illegible]		28[illegible]	26.5	21[illegible]	1.9	3[illegible]	310	23[illegible]	430	16[illegible]	385	42			178			
00 30 (5)	6.[illegible]	6.2	6.5		27	[illegible]	21[illegible]	8.6	3[illegible]	31[illegible]	230	375	16[illegible]	375	4[illegible]			182			6.4/6.7 at 4 AM
01 00	6.4	6.3	6.5		2[illegible]	270	21[illegible]	8.5	32	32[illegible]	22[illegible]	390	165	370	4[illegible]			175			6.3/6.6 at 5 AM
01 30 (6)	6.1	6.3	6.5		[illegible]	[illegible]	21[illegible]	8.0	32	315	22[illegible]	420	164	400	4[illegible]			18[illegible]			Readings of
02 00	[illegible]	[illegible]	[illegible]		2[illegible]	[illegible]	21[illegible]	8.1	3[illegible]	310	22[illegible]	410	165	[illegible]	4[illegible]			1[illegible]			2 all are taken
02 30 (7)	6.1	6.3	6.5		[illegible]	[illegible]	[illegible]	[illegible]	3[illegible]	[illegible]	22[illegible]	380	164	[illegible]	4[illegible]			18[illegible]			from ...
03 00	[illegible]	6.5	6.5		[illegible]	[illegible]	21[illegible]	7.6	3[illegible]	30[illegible]	[illegible]	460	160	385	44			18[illegible]			correction ...
03 30 (8)	[illegible]	6.[illegible]	6.7		27[illegible]	[illegible]	[illegible]	8.3	32	310	224	405	164	400	4[illegible]			183			taken ...
04 00	[illegible]	[illegible]	6.7		[illegible]	[illegible]	[illegible]	9.1	3[illegible]	[illegible]	[illegible]	390	165	[illegible]	[illegible]			184			
04 30 (9)	6.4	6.6	6.7		[illegible]	[illegible]	[illegible]	[illegible]	32	310	22[illegible]	430	165	33[illegible]	4[illegible]			1[illegible]			
05 00	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	3[illegible]	320	[illegible]	[illegible]	163	[illegible]	4[illegible]			1[illegible]			

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Shift coordinator

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control pannel operator

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GASIFICATION (SECTION 400) SHEET 1 (CONTROL ROOM)

TIME	STEAM FLOW (FRC 4301) kg/h	FRRC 4302 STEAM FLOW kg/h	FRRC 4302 OXYGEN FLOW m^3_N/h	FRRC 4302 RATIO kg/h / m^3_N/h	STEAM PRESS kg/cm² PR 4101	OXYGEN PRESS PR 4103	CRUDE / PURE GAS PRESSURE PR 4110	CRUDE/PURE GAS FLOW m^3_N/h FR 4115	TEMP RECORDER (TR 4201) 1. GAS to F 407 (MIXING TUBE) °C	TEMP RECORDER (TR 4201) 2. MIXING VESSEL F 408 °C	TEMP RECORDER (TR 4201) 3. ASH LOCK F 441 °C	TEMP RECORDER (TR 4201) 4. CRUDE GAS from GASIFIER C 401 °C	TEMP RECORDER (TR 4201) 5. CRUDE GAS to cooler E 435 °C	TEMP RECORDER (TR 4201) 6. H.P. STEAM °C	TEMP RECORDER (TR 6208) 1. CRUDE GAS to D 601 °C	TEMP RECORDER (TR 6208) 2. LYE FROM D 601 °C	TEMP RECORDER (TR 6208) 3. Regen Tower D 602 °C	TEMP RECORDER (TR 6208) 4. GASIFIER TOP °C (TR 4201)	TEMP RECORDER (TR 6208) 5. PURE GAS °C	TEMP RECORDER (TR 6208) 6. CRUDE GAS TO ID 603	Remarks
1 0530	6.3	6.5	6.6		[illegible]	30.0	[illegible]	[illegible]	32	340	[illegible]	[illegible]	165	420	42			181		✓	6.5/6.6 [illegible]
0600	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	32	340	250	[illegible]	165	[illegible]	42			180			
2 0630	6.5	6.7	6.6		29	[illegible]	[illegible]	[illegible]	32	330	221	460	165	310	42			184			Readings [illegible]
0700	6.2	6.4	6.3		[illegible]	[illegible]	[illegible]	7.5	31	345	228	420	160	400	[illegible]			174			
3 0730	6.5	6.7	6.6		[illegible]	310	[illegible]	9.2	31	345	235	400	162	340	42			170			[illegible] 42 [illegible]
0800	6.5	6.7	6.6		28	[illegible]	[illegible]	8.5	32	330	230	410	164	400	42			192			
4																			✓		[illegible] which correction
5																					factor are to be applied.
6																					[illegible]
7																					
8																					
9																					

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Shift coordinator

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GASIFICATION (SECTION 400) SHEET 1 (CONTROL ROOM)

TIME	STEAM FLOW (FRC 4301) kg/h	STEAM FLOW kg/h (FRC 4302)	OXYGEN Nm³/h (FRC 4302)	KaCC kg/h / m³/h	STEAM PRESS kg/cm² PR 4101	OXYGEN PRESS PR 4103	CRUDE / PURE GAS PRESSURE PR 4110	CRUDE/PURE GAS FLOW Nm³/h FR 4115	1. Gas to F 407 (MIXING TANK) °C	2. MIXING VESSEL F 403 °C	3. ASH LOCK F 441 °C	4. CRUDE GAS FROM GASIFIER C 401 °C	5. CRUDE GAS TO A. COOLER E 433 °C	6. H.P. STEAM °C	1. CRUDE GAS TO D 601 °C	2. LYE FROM D 601 °C	3. REGEN TOWER D 602 °C	4. GASIFIER TOP °C (TR 4208)	5. PURE GAS °C	6. CRUDE GAS TO D 603	REMARKS
[illegible]	6.5	6.7	6.1		28.3	[illegible]	24.7	[illegible]	34.0	[illegible]	[illegible]	420.0	165.0	415.0	43.0			137.0			
7.00 AM 1	[illegible]	6.7	6.6		[illegible]	27.0	[illegible]	7.0	34.0	34.10	[illegible]	383	165.0	400	[illegible]			[illegible]			[illegible]
[illegible] 2	6.3	6.5	6.4		[illegible]	27.1	25.0	8.6	35.0	[illegible]	225.0	370.0	165.0	355	[illegible]			174.0			[illegible]
[illegible]	6.6	6.7	6.5		[illegible]	27.5	26.7	8.2	33.0	[illegible]	[illegible]	378.0	[illegible]	[illegible]	[illegible]			175.0			[illegible]
[illegible] 3	6.6	[illegible]	[illegible]		29.0	28.0	24.0	[illegible]	34.0	350.0	228.0	403.0	164.0	410.0	44.0			192.0			at 10 AM [illegible]
11 [illegible]	6.6	[illegible]	[illegible]		28.5	28.0	24.0	8.4	34.0	340.0	410.0	408.0	165	312.0	44.0			191.0			[illegible]
11 [illegible] 4	6.6	[illegible]	[illegible]		28.5	29.0	24.0	8.5	36.0	335.0	222	342	166	342	44			187			
[illegible]	[illegible]	[illegible]	6.5		28.5	29.0	25.0	9.7	36.0	352	222	[illegible]	164	[illegible]	46.0			161.0			
12 [illegible]	[illegible]	6.7	6.5		22.2	[illegible]	24.5	8.3	[illegible]	[illegible]	217	[illegible]	166	[illegible]	[illegible]			160.0			
5																					
[illegible]	[illegible]	[illegible]	[illegible]		21.0	21.0	24	8.5	35	340	208	420	166	315	44			176			
[illegible] 6	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	2.4	8.6	35	388	241	410	164	400	44			179			
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	22	24	[illegible]	35	331	208	425	161	400	44			181			
[illegible] 7	6.6	[illegible]	6.5		28.6	26	24	8.0	37	342	212	411	162	310	44			182			
[illegible]	[illegible]	6.7	[illegible]		22.2	26.2	24	8.4	37	[illegible]	201	413	160	310	46			190			Load ↑ [illegible]
[illegible] 8	[illegible]	[illegible]	[illegible]		22.4	22	24	8.8	37	350	228	[illegible]	161	400	44			190			at 4 PM [illegible]
[illegible]	6.7	[illegible]	[illegible]		27.6	27	24	8	37	[illegible]	[illegible]	[illegible]	162	310	45			183			[illegible] ↑ [illegible]
[illegible] 9	6.9	7.0	6.7		28.5	27	24	10	37	[illegible]	[illegible]	421	166	310	[illegible]			183			[illegible]
[illegible]	[illegible]	[illegible]	6.8		28.5	27	24	8.7	[illegible]	340	[illegible]	[illegible]	167	314	[illegible]			184			Load ↑ [illegible]

DATE 1/12/[illegible]

SHIFT I ([illegible])

Khaleek mal

Signature 9.12.63

Shift coordinator

[illegible signature]

Signature
control pannel operator

P.T.O.

7

GASIFICATION (SECTION 400) SHEET 1 (CONTROL ROOM)

TIME	STEAM FLOW (FRC 4301) kg/h	STEAM FLOW kg/h	OXYGEN FLOW m^3/h	Ratio kg/m^3	STEAM PRESS kg/cm² BR A101	OXYGEN PRESS PR 4103	CAUSE / PURE GAS PRESSURE PR 4110	CRUDE/PURE GAS FLOW m^3/h	1. GAS TO F 407 (MIXING) °C	2. MIXING VESSEL F408 °C	3. ASH LOCK F401 °C	4. CRUDE GAS FROM GASIFIER C401 °C	5. CRUDE GAS TO A. COOLER E 431 °C	6. H.P. STEAM °C	1. CRUDE GAS TO D601 °C	2. LYE FROM D601 °C	3. Regen. D602 °C	4. GASIFIER TP (TRC 4301)	5. PURGE °C	6. CRUDE GAS TO D603	Remarks
17.30 (1)	7.2	7.4	7.0		28.5	[illegible]	21.0	[illegible]	35.0	355.0	222	450.0	163	402	440			191.0		✓	C.R. changed 7.2/7.0 [illegible]
18.00	7.2	7.4	7.0		24.1	27.2	24.0	7.1	35.0	365.0	210	466.0	165	422	440			191.0			
18.30 (2)	7.2	7.4	7.0		28.5	27.8	24.0	8.7	35.0	360.0	222	458.0	165	412	440			191.0			Gasifier [illegible]
19.00	7.5	7.5	7.1		28.4	[illegible]	24.0	[illegible]	35.0	360.0	214	458.0	165	410	440			127.0			
19.30 (3)	7.5	7.7	7.3		28.0	26.6	24.0	8.5	35.0	356.0	227	468.0	165	410	450			163.0			C.R. changed 7.3/7.1 [illegible]
20.00 (4)	7.0	7.2	6.9		28.0	27.0	24.0	8.4	34.0	355.0	220.0	465.0	165.0	415	450			190.0	✓		C.R. changed to 7.5 [illegible]
20.30	6.6	6.8	6.5		28.5	28.0	24.0	8.2	35	355	235	440.0	163.0	410	[illegible]			142.0			
5																					[illegible]
6																					[illegible]
7																					[illegible]
8																					[illegible]
9																					

DATE 9/12/82

SHIFT 2 (8AM - 4PM) Signature [signature] 9.82.13 — Shift coordinator

Signature [signature] — control pannel operator

P.T.O

8

GASIFICATION (SECTION 400) SHEET 1 (CONTROL ROOM)

TIME	STEAM FLOW (FRC 4302) kg/h	STEAM FLOW kg/h	OXYGEN FLOW Nm^3/h	RATIO kg/Nm^3	STEAM PRESS kg/cm^2 PR 4101	OXYGEN PRESS PR 4103	CRUDE/PURGE GAS PRESSURE PR 4110	CRUDE/PURGE GAS FLOW Nm^3/h FR 4115	TEMP. RECORDER (TR 4201) 1. Gas to F 407 (mixing) °C	2. Mixing vessel F 403 °C	3. Ash lock F 401 °C	4. Crude gas from gasifier C 401 °C	5. Crude gas to cooler E 4... °C	6. H.P. steam °C	TEMP. RECORDER (TR 4208) 1. Crude gas to D 601 °C	2. Lye from D 601 °C	3. Regeneration D 602 °C	4. Gasifier top (TRI 4204)	5. Purge °C	6. Crude gas to D 603	Remarks
1	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	7.8	34	[illegible]	[illegible]	450	162	415	45			178		✓	
	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	34	[illegible]	245	400	164	430	45			188			
2	[illegible]	[illegible]	[illegible]		27	270	260	[illegible]	34	350	235	410	164	415	44			185			[illegible]
	[illegible]	[illegible]	[illegible]		29	280	[illegible]	[illegible]	34	355	[illegible]	338	164	415	45			185			[illegible]
3	[illegible]	[illegible]	[illegible]		270	280	240	65	34	355	245	378	164	420	44			180			[illegible]
	4.5	[illegible]	[illegible]		270	280	270	[illegible]	[illegible]	315	240	315	162	375	44			142			[illegible]
4	4.4	4.6	4.3		[illegible]	285	[illegible]	[illegible]	34	370	240	380	164	370	45			192	✓		[illegible]
	-	-	-		285	-	[illegible]	[illegible]	34	280	235	190	140	280	72			175			[illegible]
5	-	-	-		280	-	-	-	34	245	215	100	115	~~240~~	78			158			[illegible]
6	[illegible]	[illegible]	9.5		210	9.0			24	150	184	146	93	220	35			123			[illegible]
	do	do	9.4		[illegible]	[illegible]		1.0	34	120	180	151	95	224	35			120			[illegible]
7	[illegible]	[illegible]	9.5		[illegible]	9.0		2.5	[illegible]	[illegible]	[illegible]	178	100	[illegible]	35			117			[illegible]
	[illegible]	[illegible]	9.5		280	9.0	[illegible]	2.5	[illegible]	[illegible]	174	176	100	310	35			115			[illegible]
8	do	do	9.6		265	9.0	5.0	3.0	28	165	193	[illegible]	165	300	36			112			[illegible]
	do	do	9.4		[illegible]	[illegible]	4.5	2.0	[illegible]	150	194	184	165	300	35			106			[illegible]
9	do	do	9.5		28	[illegible]	35	1.0	28	160	180	120	100	300	37			112			[illegible]
	do	do	[illegible]		29	[illegible]	[illegible]	[illegible]	28	130	[illegible]	[illegible]	[illegible]	275	37			115			[illegible] 6.45 AM

DATE [illegible]

SHIFT [illegible]

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Shift coordinator

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control pannel operator

P.T.O

GAS COMPOSITION

7.12.85 (II)

		CRUDE GAS (RAWGAS)						PURE GAS						
		CO_2	C_nH_m	O_2	CO	H_2	CH_4	CO_2	C_nH_m	O_2	CO	H_2	CH_4	H_2S
							Time							
1.05	1	31.6		0.4			6.10	21.2		0.6				
10.10		25.2		2.6			6.25	20.4		2.0				
1.15	2	28.4		0.4			6.35	21.6		0.4				
1.25		30.0		1.0			6.40	21.4		0.8				
							7.00	21.0		[illegible]				
1.30	3	22.0		0.4			7.15	19.8		1.2				
1.35		30.4		1.4			7.30	~~21.0~~ 19.0		2.0				
1.45	4	32.8		0.8			7.40	18.0		[illegible]				
1.50		32.2		0.4			7.50	[illegible]		2.0				
1.55	5	30.0		0.6			8.00	18.0		1.2				
2.00		31.0		0.6										
2.10	6	26.6		1.4										
2.20		30.2		0.4										
2.30	7	28.1		1.4										
[illegible]		25.0		1.0										
[illegible]	8	25.2		1.0										
Start [illegible] 5.05	9	9.6		1.0										
[illegible]		16.4		1.6										
5.30		17.2		1.0										
5.35		~~17.~~		1.0										
5.45		18.0		0.8										
5.50		15.3		1.4										
6.05		20.2		0.0										

1

GAS COMPOSITION

8 12·83 (I)

CRUDE GAS (RAWGAS)

Note	Time	Sample	CO_2	C_nH_m	O_2	CO	H_2	CH_4
Air/[illegible]	[illegible]	1	17·[illegible]		1·4			
	[illegible]		16·[illegible]		[illegible]			
	[illegible]		17·2		[illegible]			
	[illegible]·40	2	16·6		1·6			
	[illegible]		16·2		1·6			
	[illegible]	3	21·4		[illegible]			
	9·10		21·4		1·[illegible]			
	9·3[illegible]	4	[illegible]		[illegible]			
	9·[illegible]		[illegible]		[illegible]			
	[illegible]	5	[illegible]		[illegible]			
	10·[illegible]		22·[illegible]		[illegible]			
[illegible]	10·16	6	[illegible]		1·[illegible]			
	10·[illegible]		[illegible]		2·4			
	10·40	7	43·4		1·2			
	10·4[illegible]		37·0		1·0			
	10·50		[illegible]		1·[illegible]			
	11·[illegible]	8	37·0		1·6			
	11·05		35·[illegible]		0·6			
	11·10	9	33·0		1·6			
	11·15		34·0		1·6			
	11·20		33·0		1·2			
	11·25		33·4		0·6			
	11·[illegible]		[illegible]0·8		1·8			
	11·35		33·0		0·4			
	11·40		[illegible]		[illegible]			
	11·45		31·[illegible]		[illegible]			
	11·55		29·4		[illegible]			
	12·[illegible]		30·6		[illegible]			
	12·[illegible]		[illegible]·4		1·[illegible]	Grate stopped		
	12·15		30·6		[illegible]			

~~PURE~~ CRUDE GAS

Time	CO_2	C_nH_m	O_2	CO	H_2	CH_4	H_2S	Note
12:20	28·6		1·4					
12·25	31·4		[illegible]					
12·30	31·2		[illegible]					
12·35	31·0		[illegible]					
12·40	30·[illegible]		[illegible]					
12·45	31·4		0·4					
12·55	31·2		0·4					
13·00	–		–					Grate changed to C-D
13·10	37·0		0·4					13[15] Grate stopped
13·20	31·4		[illegible]					
13·30	31·6		0·4					
13·40	31·6		0·4					
13:50	31·2		0·6					

2

GAS COMPOSITION

8/12/83 (I)

	CRUDE GAS (RawGAS)						PURE GAS						
	CO_2	C_nH_m	O_2	CO	H_2	CH_4	CO_2	C_nH_m	O_2	CO	H_2	CH_4	H_2S
14.20	31.6		0.6										
14.30	32.0		0.6										
14.40	31.8		0.6										
14.42	31.2		0.8										
15.00	32.0		0.8										
15.13	31.6		0.8										
15.[illegible]	[illegible]		[illegible]										
15.30	[illegible]		[illegible]										
15.44	[illegible]		[illegible]										
15.50	30.4		0.4										
16.00 5	31.4		1.0										
6													
7													
8													
9													

8.12.83 (1)

GAS COMPOSITION

	CRUDE GAS (RAW GAS)						PURE GAS						
	CO_2	C_nH_m	O_2	CO	H_2	CH_4	CO_2	C_nH_m	O_2	CO	H_2	CH_4	H_2S
16.25 1	32.2		0.8										
16.35	29.8		0.6										
16.45	29.8		0.6										
16.55 2	29.8		0.8										
17.05	29.4		0.4										
17.10 3	29.4		0.4										
17.25	29.2		0.6										
	~~[illegible]~~		~~[illegible]~~										
17.35 4	28.0		0.8										
17.45	28.0		0.8										
17.55	29.4		0.4										
[illegible] 5	[illegible]		[illegible]										
18.2[illegible]	[illegible]		[illegible]										
18.36 6	[illegible]		[illegible]										
[illegible]	29[illegible]		[illegible]										
19 7	22.4		1.2										
19.15	29.6		0.4										
8	[illegible]		[illegible]										
19.[illegible]	[illegible]		[illegible]										
9	[illegible]		[illegible]										

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GAS COMPOSITION

		CRUDE GAS (RAW GAS)						PURE GAS						
Time	No.	CO_2	C_nH_m	O_2	CO	H_2	CH_4	CO_2	C_nH_m	O_2	CO	H_2	CH_4	H_2S
[illegible]	1	[illegible]		[illegible]										
2045		28		[illegible]										
2100	2	30.0		0.6										
2130	3	28.8		0.8										
[illegible]		27.4		0.6										
2215	4	30.0		0.6										
2240		29.8		0.8										
[illegible]	5	[illegible]		[illegible]										
2315		29.8		0.4										
[illegible]	6	27.0		0.6										
2345		30.4		0.2										
[illegible]	7	29.4		[illegible]										
[illegible]		28.0		0.8	19.6	36	[illegible]							
[illegible]	8	[illegible]		0.6										
1 30	9	[illegible]		0.4										
2 00		30.0		0.6										
2 30		30.2		0.4										
3 00		30.4		0.6										
3 30		[illegible]		0.4										
4 00		29.6		0.4										
4 30		30.0		0.4										
[illegible]		27.8		0.2										

8.12.83 (II)

GAS COMPOSITION

		CRUDE GAS (RAWGAS)						PURE GAS						
		CO_2	C_nH_m	O_2	CO	H_2	CH_4	CO_2	C_nH_m	O_2	CO	H_2	CH_4	H_2S
[illegible]	1	[illegible]		0.4										
5.45		30.[illegible]		[illegible]										
[illegible]	2	30.[illegible]		[illegible]										
6.15	3	30.4		[illegible]										
6.30		30.6		0.4										
[illegible]	4	30.0		[illegible]										
7.30	5	29.0		0.8										
7.45		29.6		0.4										
[illegible]	6	[illegible]		[illegible]										
	7													
	8													
	9													

9.12.83 ([illegible])

GAS COMPOSITION

	CRUDE GAS (RAWGAS)						PURE GAS						
	CO_2	C_nH_m	O_2	CO	H_2	CH_4	CO_2	C_nH_m	O_2	CO	H_2	CH_4	H_2S
						16.40	30.8		0.4	4.4			
						[illegible]	[illegible]		[illegible]				
						17.00	30.0		0.0				
						17.40	29.0		0.2				
1	[illegible]	[illegible]	[illegible]										
	[illegible]	30.0	[illegible]										
2	[illegible]	[illegible]	[illegible]										
	[illegible]	[illegible]	[illegible]										
3	[illegible]	29.4	[illegible]										
	[illegible]	[illegible]	[illegible]										
	[illegible]	[illegible]	0.4										
4	[illegible]	30.0	[illegible]										
	[illegible]	[illegible]	[illegible]										
	[illegible]	[illegible]	[illegible]										
5	[illegible]	30.6	[illegible]										
	[illegible]	[illegible]	[illegible]										
6	[illegible]	[illegible]	[illegible]										
	[illegible]	[illegible]	[illegible]										
7	11.45	[illegible]	[illegible]										
	[illegible]	[illegible]	[illegible]										
	12.15	30.4	[illegible]										
8	[illegible]	[illegible]	[illegible]										
	12.30	31.0	0.2										
	12.45	30.2	0.2										
9	13.00	27.0	0.4										
	13.15	30.8	0.2										
	13.30	30.0	0.2										
	13.45	[illegible]	0.4										
	14.00	29.0	[illegible]										
	14.15	29.4	0.4										
	[illegible]	[illegible]	[illegible]										
	15.20	29.4	0.4										
	15.40	29.4	0.4										
	[illegible]	[illegible]	[illegible]										
	[illegible]	[illegible]	[illegible]										

CO = 16.2
CH_4 = 12.85
[illegible]

10784

7

9.12.83(?)

GAS COMPOSITION

	CRUDE GAS (RAWGAS)						PURE GAS						
	CO_2	C_nH_m	O_2	CO	H_2	CH_4	CO_2	C_nH_m	O_2	CO	H_2	CH_4	H_2S
17.20 / 1	[illegible]	31.6	0.2										
[illegible]		30.6	0.6										
11.3? / 2		27.6	0.6										
[illegible]		[illegible]	4										
3		29.6	0.4										
19.? / 4		28.6	0.4										
19.?		29.4	0.2										
11.4? / 5		29.0	0.2										
[illegible]		29.8	0.4										
6													
7													
8													
9													

41283 (4)

GAS COMPOSITION

		CRUDE GAS (RAW GAS)						PURE GAS						
		CO_2	C_nH_m	O_2	CO	H_2	CH_4	CO_2	C_nH_m	O_2	CO	H_2	CH_4	H_2S
20.30	1	27.5		[illegible]										
21.50		30.4		[illegible]										
21.10	2	29.8		0.6										
[illegible]	3	[illegible]		[illegible]										
21.50		29.8		0.6										
22.15	4	29.6		0.4										
22.30		29.8		0.2										
22.45	5	30.6		0.2										
23.00	6	31.8		0.4										
23.[illegible]		33.0		0.4										
[illegible]	7	33.[illegible]		[illegible]										
[illegible]	8	11.6		3.4										
[illegible]		[illegible]		[illegible]										
[illegible]	9	20.4		0.8										
[illegible]		[illegible]		[illegible]										
[illegible]		[illegible]		[illegible]										
[illegible]		[illegible]		[illegible]										

9

8.2) Recording charts

Chart reading for air/oxygen and steam

December 8, 1983

S/U Air and Steam
S/U Oxygen and Steam
24 bar with oxygen
and steam

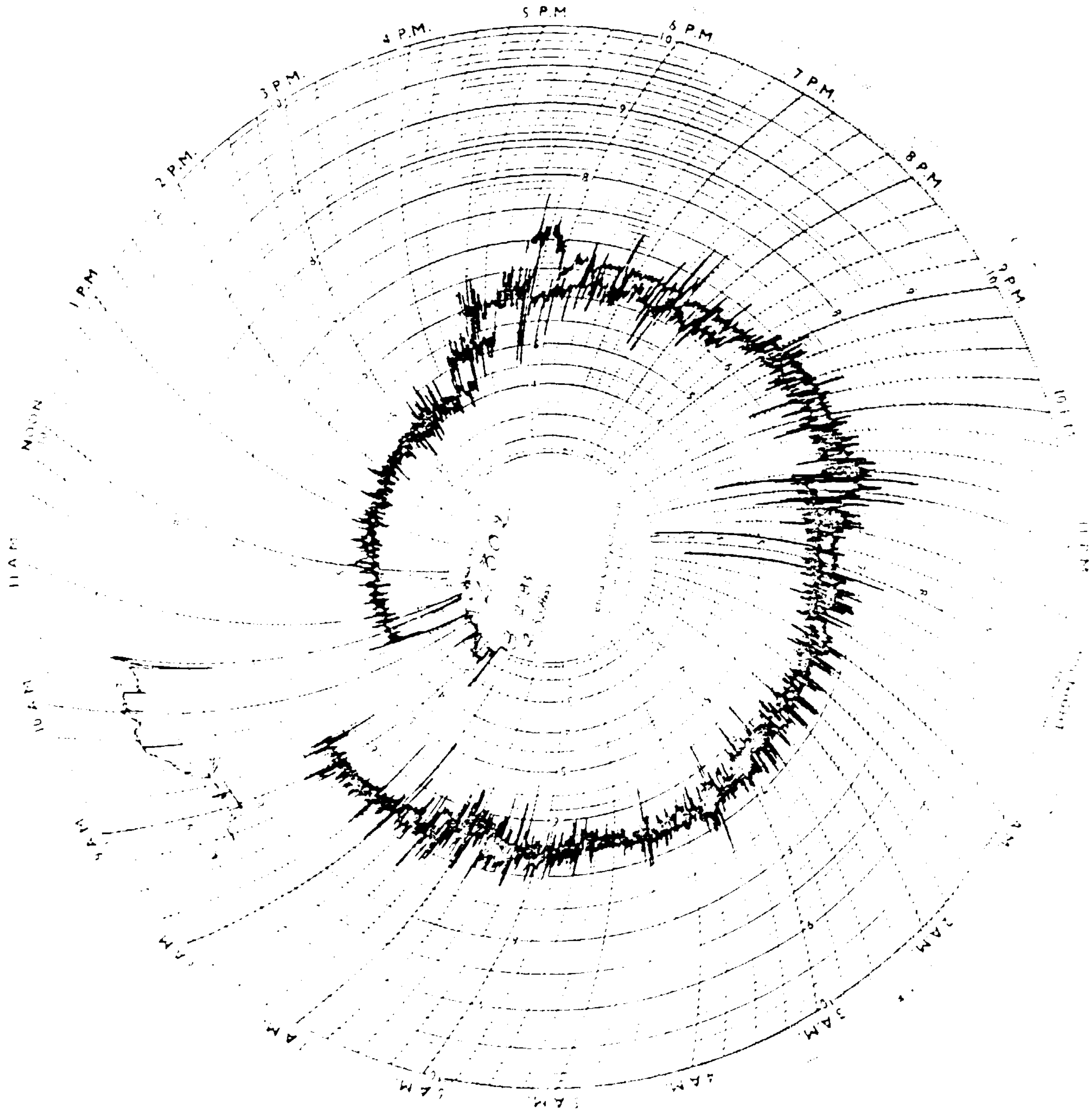


Chart reading for air/oxygen and steam, continued on December 9, 1983

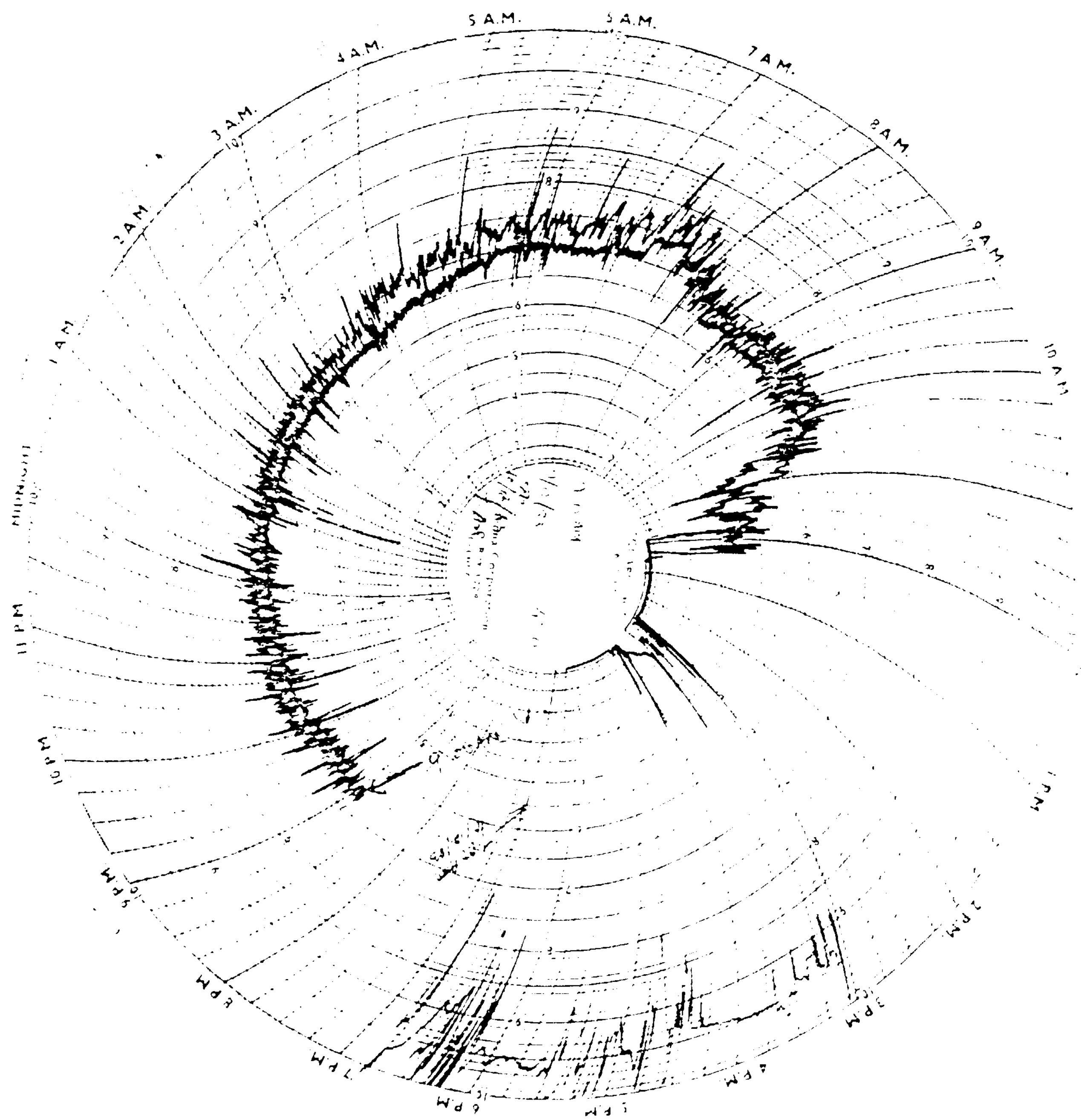


Chart reading for raw gas-flow and pressure

December 8, 1983

S/U Air and Steam
S/U Oxygen and Steam
24 bar with oxygen
and steam

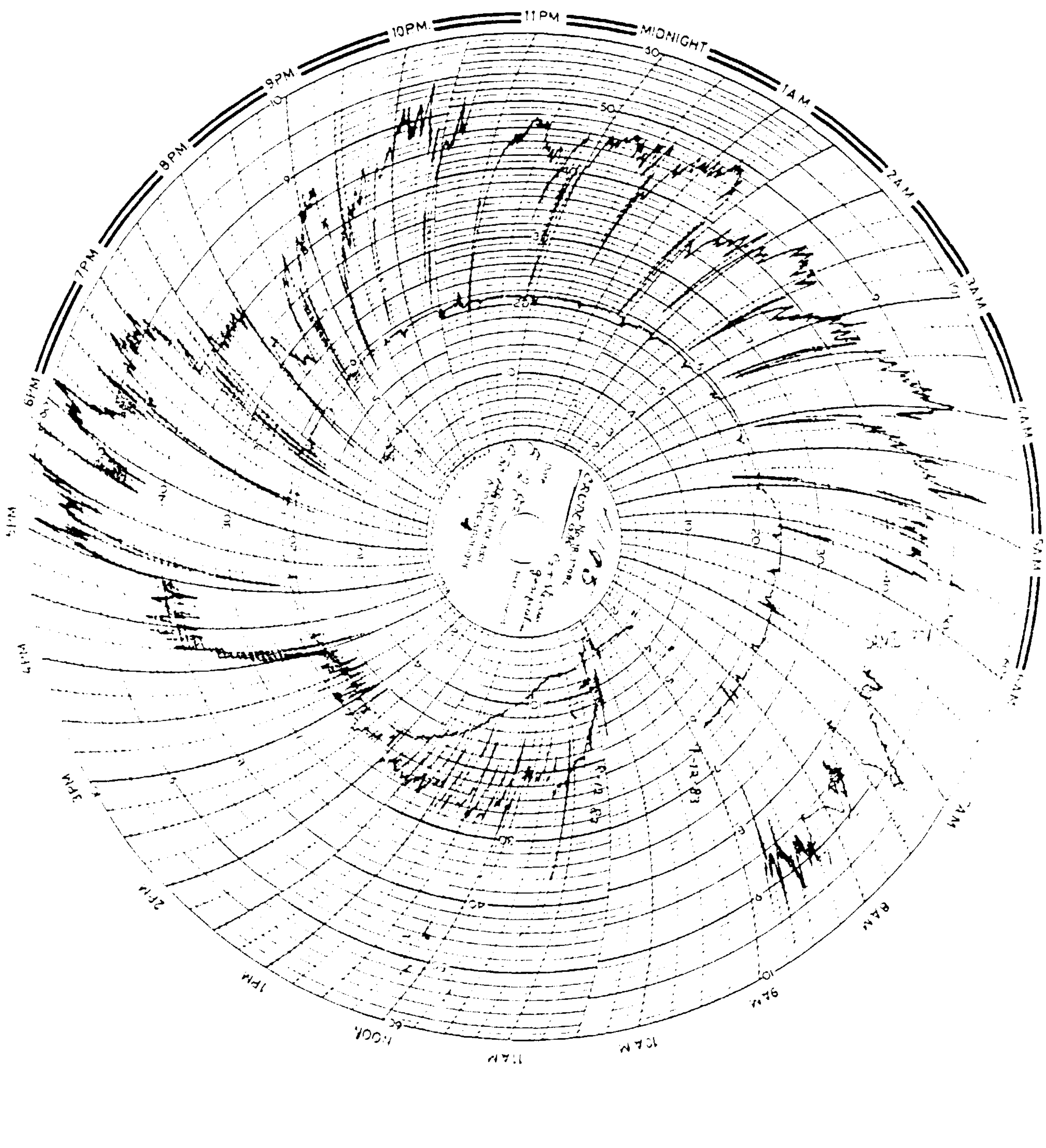
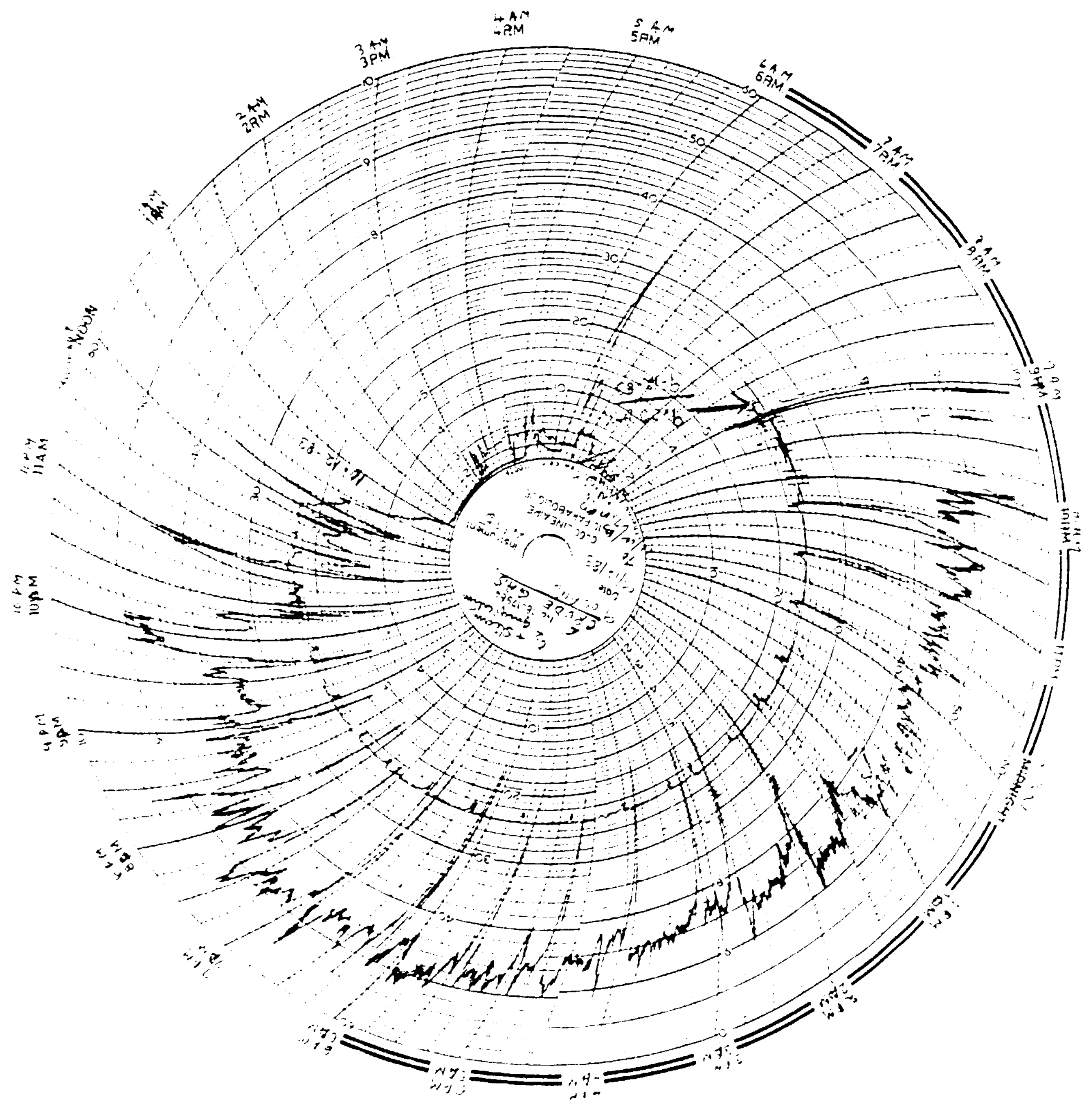
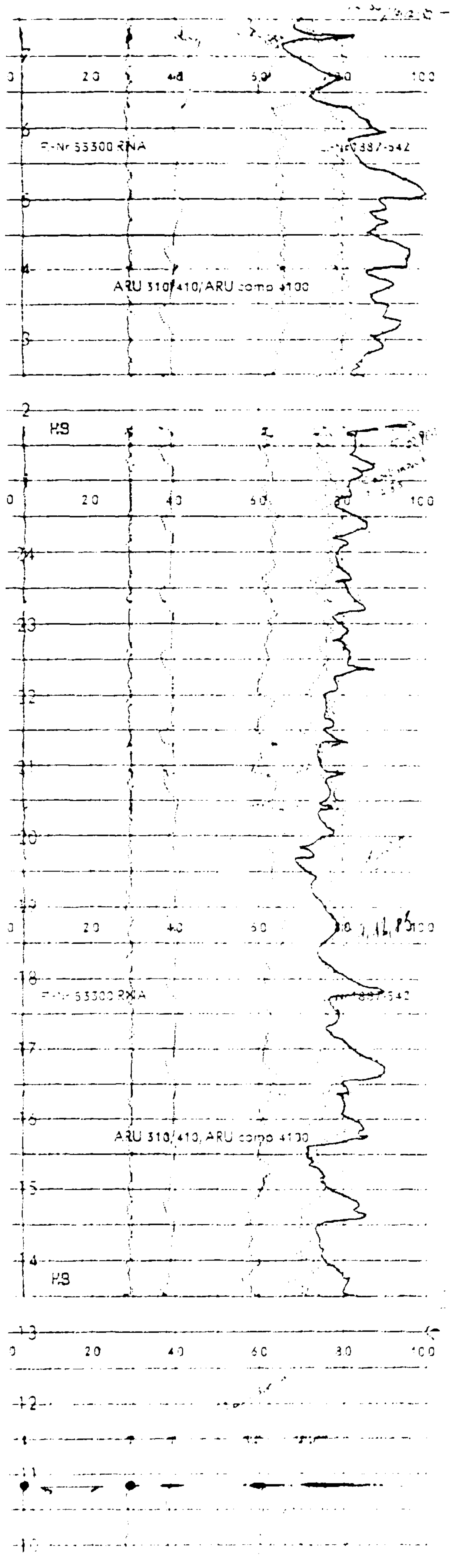


Chart reading for raw gas-
flow and pressure

continued December 9, 1983





December 8 / 9, 1983

Chart reading for temperatur[illegible]
of:

a) Raw gas from gasifier

b) H.P. Steam to mixing tube

c) Agent (steam and oxygen)

d) Raw gas after waste heat
boiler

e) Ash lock

f) oxygen

(from right to left)

100% chart reading ≙ 500 °C

9) <u>Coal Properties</u>

1) Type of coal

Coal is received from GODAVAR/KHANI area of the Godaveri Valley Coal fields.

2) Size of coal

>25 mm	2.9 %
25 to 13 mm	53.5 %
13 to 6 mm	34.3 %
<6 mm	9.3 %
Total	100.0 %

3) Bulk density 773 kg/m^3

4) Proximate analysis

Ash	26.3 %
Moisture	5.2 %
Volatile matter	27.3 %
Fixed Carbon	41.2 %

5) Grayting analysis for 100 g dry coal

Coke	77.87 %
Tar	6.48 %
Gas liquor	7.49 %
Gas	8.26 % (0.00833 m^3n)

6) Elementar Analysis

C	53.8 %
H	3.53 %
O	9.68 %
N	1.18 %
S	0.32 %
Moisture	5.16 %
Ash	26.33 %

9) Coal Properties (cont'd)

7) Fusion point (mildy reducing atmosphere)

Initial deformation	1275
Hemispherical point	1345
Flow point	1400

8) Ash composition

	wt%
SiO_2	54.63
Al_2O_3	25.03
Fe_2O_3	9.93
CAO	6.12
MgO	nil
loss on ignition	0.53
Potassium (as K_2O)	0.44
Sulphur (as SO_3)	2.97

10) GASIFICATION

10.1) Description

The object of this Chapter is to familiarise you with the following:

1) What a gasifier consists of
2) The purpose of each part of a gasifier
3) How jacket steam is formed
4) The purpose of jacket feed water
5) The description of the grate
6) The purpose of the grate
7) The gasifying of coal
8) The gasifying process
9) The purpose and working of the wash cooler
10) The purpose and working of the waste heat boiler
11) Safety valves on the waste heat boiler drum
12) Flows, levels and pressures in a gasifier
13) Manualy operated valves on a gasifier
14) General.

The Gasifier

The gasifier consists of an inner and an outer shell, the space between them being called the jacket. The gasifier has two flanges on both ends ; one at the top through which coal is fed from the coal lock into the gasifier and the other at the bottom through which ash is turned out by the grate into the ash lock.

The Inner Shell

The inner shell can withstand a maximum pressure of 2,5 bar. If the pressure is too high the shell can fracture.

The Outer Shell

The outer shell is designed to withstand the total pressure of 30 bar. The outer shell is insulated with glass wool to prevent heat loss and for personnel protection.

Jacket

This is a space between the two shells. This space is filled with high pressure feed water at 33 bar from the high pressure pump and the level is controlled by a controller and control valve. The heat transmitted by the inner shell is absorbed by the water, thus keeping the shells cool. Should the level in the jacket is lost the shells will be overheated. The gasifier has to be shut down immediately to avoid that.

Due to the heat transmitted by the inner shell the water boils and gives off steam. This is called jacket steam.

Jacket Steam:

The temperature of jacket steam is determined by the gasifier pressure. The pressure in the jacket is close to the pressure of the gasifier. The jacket steam flows into the wash cooler. A safety valve fitted to the wash cooler at raw-gas flow side will open if the pressure exceeds 27 bar.

Jacket Feed Water

The jacket level is maintained by a controller and control valve. This is also fitted with a by-pass line and valve to enable the level to be maintained manually in the event of the controller being inoperable.

The Gasifier Grate

Without the grate it would not be possible to operate the gasifier. It is therefore important to know how the grate fits into the process and how it works.

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Description

The grate is fitted into the bottom of the gasifier. It is round and is made of two shells which are fitted together. These layers form a cone and have holes through which the gasifying agent flows. One opening is provided in the outer ring of the grate to turn out the ash into the ash lock. The grate is driven by a motor, whose speed can be adjusted and controlled.

Purpose

The rotating grate is used to control the ash bed. A well formed ash bed is very necessary and as the grate turns the gasifying agent is evenly distributed, ensuring even burning in the oxidation zone. The grate also keeps the firebed moving so as to prevent the formation of channels. These are usually formed when the grate has been stationary for long periods.

Skirt in the Gasifier

Situated at the top of the gasifier is a skirt which prevents carry over of fine coal with the raw gas. This prevents blockages which cause production loss.

The Gasifying of Coal

Coal is burned under controlled pressures and temperatures to produce gas for later use. Other products are tar, ammonia, oil, phenols etc..

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The Gasifying process - Combustion Zone

A continuous gasifying process takes place when 99 % pure oxygen from the oxygen plant and high pressure steam from the steam boiler are sent into the gasifier. The oxygen and high pressure steam are first mixed and forced into the gasifier, under the grate. This is then evenly distributed through the holes in the shells of the grate.
The oxygen makes contact with the hot coal, a chemical process takes place and carbon dioxide is formed. Temperatures of about 1.400 °C are achieved. Due to the high heat a further reaction occurs with steam with the formation of carbon monoxide. The high pressure steam controls the temperature in the combustion zone.

Heat and temperature play an important role in the combustion zone. When the temperature rises, due to unsufficient high pressure steam supply the CO_2 decreases while the CO-content increases. This can cause problems, including the formation of clinkers. By adding more steam the CO_2 percentage will rise. If the supply of high pressure steam is too high, the temperature in the Combustion zone drops and the CO_2 percentage will rise too high. If this occurs oxygen reaction can be reduced. The danger here is that all the oxygen will not react with the coal but some will pass through with the raw gas to form an explosive mixture. Cut the steam flow and the temperature will rise, CO_2 will drop,

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and the oxidation zone will again react normally. If either of the above problems occur regular CO_2 analyses must be performed.

Minimum CO_2 Percentage

The lowest allowable CO_2 percentage is 27.5 (this may vary with the type of coal, If the percentage drops lower than this, this is the indication that the temperature in the oxidation zone has risen. Add steam and do a CO_2 analysis during the following 15 minutes (at least 3 analysis).

Maximum CO_2 percentage

It sometimes happens that the CO_2 percentage is too high, possibly as much as 32%. This can be caused by a loss of heat in the Combustion zone. IN normal circumstances we would cut back on the steam flow.

If the CO_2 percentage continues to rise the gasifier has to be shutdown, depressurised, and brought back into commission as normal. When a gasifier is changed from air to oxygen it can happen that the CO_2 can be as high as 45%. A series of quick analyses must be done and if the percentage does not drop quickly it will indicate that the firebed is not burning, the oxygen is not taking part in any reaction, and the gasifier must be shut down immediately.

Short Description of the Various Zones

1) Ash Zone: This is the bottom zone in the gasifier . It is important that this is well formed thus assisting even distribution of the gasifying agent.

2) Combustion Zone:

It has been stated that high pressure steam is used for no purpose other than to control the temperature in the oxidation zone. With upward flow CO_2, CO and Hydrogen and high pressure steam, it makes contact with hot coal in this zone. Chemical reactions take place and hydrogen and carbon dioxide are formed.

3) Gasification of Coal with:

a) High pressure steam:

$H_2O + C = H_2 + CO$

b) Carbon Dioxide

$CO_2 + C = 2CO$

c) Hydrogen shift reaction

$H_2O + CO = H_2 + CO_2$

d) A decomposition of steam (of about 35% to 40%) of the steam takes place.

4) Reduction Zone

The decomposition of steam is stopped.

The coal is heated up by the upward flow of the hot gas and tar is cracked to lighter oils.
Methane is formed here when the temperature is lower than 1100°C .
$C+2H_2 = CH_4$

5. Devolatilisation Zone:

In this zone all the volatiles (tar, oil, water) are removed from the coal. These volatiles pass out of the gasifier with the raw gas.

Gasifier - Gas outlet

With the high gas loads it happens that coal dust and even sometimes coal will be forced out of the gasifier with the raw gas. This can cause blockages. A manually operated scraper is fitted to keep the gas outlet clean and is to be operated every two hours. Raw gas leaves the gasifier, normally, at 400 °C.

The Washcooler

The wash cooler is coupled to the gas outlet and it is here where the gas is washed and partially cooled by gas liquor which is injected into the top of the cooler. This gas liquor is pumped by the wash cooler circulation pump which gets its suction from the waste heat boiler sump.

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A second gas liquor line, from the gas liquor separation plant, is also connected to the wash cooler supplying a continuous flow. This is to ensure gas liquor supply to wash cooler when wash cooler pump fails.

The Waste Heat Boiler

This is a tube cooler where the raw gas passes through the tubes which are surrounded by boiler feed water with 105 °C. As the gas passes through the tubes the water is heated and steam is formed. The water level is controlled by a controller and control valve at the L.P. steam drum. The low pressure steam is supplied to the L.P. steam header and to the B.F.W. heating system, also to gas cleaning and tank farm sections.
The condensable matter in the gas are cooled and forms gas liquor which flows to the bottom of the WHB together with the gas liquor from the wash cooler.

A certain amount of this gas liquor is circulated by the wash cooler pump. The level of the WHB sump is controlled by a level controller. The heavy gas liquor is routed to the expansion drum located in the gas liquor separation plant. The raw gas flows from the top of the WHB to the after cooler.

Safety Valves on Low Pressure Steam

Low pressure steam has a pressure of 2.8 bar (gauge).

One safety valve is connected to the steam drum. It will open at 3.4 bar (gauge). If this opens the process-coordinator is to be informed. The feedwater level is to be checked as it is possible that water has been carried over. The opening of the safety valve can be caused by a tube rupture in the WHB. If this occurs shut down gasifier immediately.

Flows on the Gasifier Panel

The following flows are seen on the panel:

1) Oxygen and start up air.
2) High pressure Steam:
3) Raw Gas Flow

Pressures on the Gasifier Panel

1) Gasifier pressure:
2) Oxygen header press ure
3) Steam header pressure

Levels on the Gasifier Panel

1) Jacket Level
2) WHB Gas liquor sump level:
3) After cooler gas liquor sump level
4) Steam drum level

Flow of Oxygen and HP Steam

1) Oxygen: This comes from the oxygen Plant and flows

through a isolation valve, control valve, measuring orifice, manual control valve, non-return valve into the mixing vessel and gasifier.

2) __HP Steam__ flows from the steam boiler through isolation valve, control valve, measuring orifice, manual control valve, non-return valve into the mixing tube and gasifier.

10.2 Gasifier operation instructions

The object of this chapter is to familiarise you with the following:

1) All temperature points on a gasifier
2) The operating temperatures
3) The description of temperatures
4) Guide lines for temperature control
5) Guide lines for flow control
6) Guide lines for pressure control
7) Guide lines for level control

10.2.1 Gasifier operations

10.2.1.1 Introduction

The gasifying of coal with oxygen and HP steam uncer high pressures and temperatures is a chemical process. A gasifier is designed to operate with maximum safety and various safety devices have been included. If operating instructions are followed a gasifier is a safe piece of equipment to operate. If the gasifier is not full of coal the complete oxygen reaction will not take place, and oxygen will then mix with the raw gas to form a highly explosive mixture. If temperatures are not controlled it will lead to equipment damage.

10.2.1.2 Control of a Gasifier

The most important points to watch an operating gasifier are temperatures, grate speed and CO_2 analyses of produced gas. Other control points are pressure and level readings, coal and gas analyses, melting point of ash, coal sizing, steam/oxygen ratio and gas load. All these factors have an influence on the safe operation of a gasifier.

10.2.1.3 Temperatures

Temperatures are measured at seven points and are recorded. These points are as follows:

TR1 Oxygen

TR2 Agent

TR3 Ash lock

TR4 Gas outlet on gasifier

TR5 Crude gas to aftercooler

TR6 H.P.steam to mixing tube

TR7 Gasifier top temperature

These temperatures have an important influence on the safe operation of a gasifier.

By maintaining a careful check on these temperatures actions can be taken to ensure safe and efficient operations. A description of each of these points and their effect on the gasifier follows:

10.2.?.3.1 The agent temperatures - TR2

In the event that the temperatures of the incoming HP-steam and oxygen remains constant the steam/oxygen ratio will also be constant. Variations of more than 5 K in the agent temperature shall activate special observations to steam/oxygen ratio. With a constant HP-steam temperature of 400 °C and oxygen of 40 °C the agent has to be stopped if temperature drops below 33 °C. A drop in the temperature will indicate a reduced steam flow and the oxygen concentration will therefore increase. If this occurs, the possibility will exist that clinker formation will begin and an oxygen channeling may occur. This can lead to an explosive situation. Any drop in the agent temperature must be immediately investigated and if necessary the gasifier has to be shut down.

Guide lines for the control of Gasifier Temperatures

TR2

SYMPTOMS	CAUSES	ACTIONS
1) Agent temp. rises.	Steam flow increases or oxygen flow drops	a) Check steam/oxygen ratio b) Check steam impulse lines for blockages c) If necessary change to manual control and set steam and oxygen by controlling CO_2 d) Have thermocouple checked.
2) Agent temp. drops	Steam flow drops or oxygen flow increases	a) Check steam/oxygen ratio b) Check steam impulse lines for blockages c) If necessary change to manual control and set steam and oxygen by controlling CO_2 d) Have thermocouple checked.
3) Agent temp. rises and drops	High or low HP steam temperature	Do CO_2 analysis and adjust oxygen/steam ratio when necessary

10.2.1.3.2 The Ash Lock Temp.- TR3

The ash lock temperature indicates the level of the ash bed and should be maintained between 280 °C and 330 °C. This temperature will normally fluctuate according to the grate speed and the frequency at which ash is drawn. Too high temp. however can cause damage to the grate and ash lock internals.
The grate speed and thus the speed at which ash is turned out into the ash lock depends on the load of the gasifier. The grate is used to correct temperatures which are out of the normal range.

The particle size of the ash as well as the coal plays a big part in the distribution of agent and so far in the efficiency of the operation of the gasifier. The agent distribution tends for channeling if the ash is too coarse (too much clinker). Too much fine ash also has an effect on the efficiency of the gasifier. If this is too fine the whole bed can be lifted by the agent.

Ash lock temperature begins to drop (TR3)

CAUSES	SYMPTOMS	ACTIONS
Grate stops	a) No electric current b) Ash lock temp. drops sharply.	Start grate again
Grate turns for too long against a closed top cone.	a) Electric current much higher than normal	Stop grate
	b) Ash lock temp. drops sharply.	Operate the top cone a few times.
	c) Top cone in the closed position	Start the grate and watch current.
Grate jammed becaase of clinkers	a) Current high	Increase steam/oxygen ratio
	b) Grate stops or slips c) Ash lock temp. drops d) Clinkers in the ash	Decrease load Check instruments Stop grate and start again
	e) CO_2 in raw gas lower than normal.	If grate will still not start shut down gasifier.
	f) Channeling has begun and CO_2 is lower than normal	
	g) Steam/oxygen ratio faulty.	
Grate jammed due to overfull ash lock	a) Ash lock temp. drops	Stop grate
	b) current higher than normal	Reduce load
	c) Periods between de-ashing too long	Blow steam into ash lock and attempt closing top closure by opening and closing
	d) Ash lock top cone not operating	After de-ashing - open and close top cone until operating normally.
		Stop grate.
		If above procedure is not successful depressurize gasifier.

CAUSES	SYMPTOMS	ACTIONS
Agent flows into ash lock	a) Sudden increase in temperature b) Gas production drops c) Can occur only during de-ashing d) Top cone not properly closed e) Ash lock being depressurised.	Stop depressurising ash lock Flush with steam by pressurising. Close the top cone Once the top cone has sealed depressurise once again.
N.B. This situation is extremely dangerous		
Channelling in a gasifier	a) Ash lock and gas outlet temps. change simultaneously. b) Temperatures, jacket steam. RRL to provide flow measurement later and gas production become unstable. c) Clinker formation d) CO_2 varies	Reduce gas load Increase steam/oxygen ratio by increasing steam Check for fines in raw coal Check feed water level Do CO_2 and oxygen analyses Check instrumentation Increase grate speed If the above do not help shut down gasifier

10.2.1.3.3 The gas outlet temperature - TR4

The gas outlet temperature plays an important part in determining the state of the ash bed in the gasifier. If this temperature varies it indicates that the ash bed has moved either nearer to or further from the gas outlet point. If TR3 and TR4 temperatures increase it is usually an indication of channelling. CO_2 analyses will also be effected.

Channelling means that canals begin burning through the coal bed. This causes TR4 to increase. If this occurs increase the grate speed. This can cause burning coal to enter the ash lock and TR3 will increase rapidly. If this happens the gasload must be reduced by reducing the oxygen throughput until conditions return to normal.

With the test coal TR4 should be able to be controlled at between 400 ^{o}C and 450^{o}C, depending on gas load and coal particle size. The temperature should not be allowed to exceed 450 ^{o}C as this will cause damage to equipment.

GAS OUTLET TEMPERATURE RISES (TR4)

CAUSES	SYMPTOMS	ACTIONS
Too little coal	a) TR7 rapidly increases b) TR4 rapidly increases c) TR3 remains normal d) Jacket steam production increases N.B. This is a dangerous situation and must be quickly corrected	Reduce load to 40% C.R. Check coal lock operations Ensure that there is coal in the bunker If the situation is not corrected in a very short time shut down gasifier.
Grate stops	a) Sudden variation in TR4 temp. b) Current zero	Start the grate and check reasons for stoppage.
Ash bed too high	a) TR4 temp. increases b) TR3 temp. lower than normal	Increase grate speed Check that ash lock top cone is fully open
Channelling	a) TR3 and TR4 temps. increase. b) Gas production and temps. become unstable and uncontrollable. c) Clinkers and unburnt coal in the ash d) CO_2 unstable. e) Danger exists of an oxygen breakthrough	Reduce load to 40% C.R. Increase steam/oxygen ratio Do CO_2 and oxygen analyses Check instrumentation Increase grate speed for short periods and attemp to bring temperatures back to normal Determine amount of carbon in the ash. If CO_2 is uncontrollable or oxygen content in raw gas is higher than 2% shut down gasifier.
Ash bed too low	a) TR4 lower than normal b) TR3 higher than normal.	Reduce grate speed

10.2.1.3.4 Crude gas to aftercooler (TR5)

If WHB is empty on the steam side not cooling of raw gas will occur, that indicated by rising of the outlet temperature of WHB. In that case check water load in steam dense, cut the load and fill WHB and steam dense to the normal level.

10.2.1.3.5 The Gasifier top temperature TR7

The thermocouple is located below the bottom coal lock closure in the upper part of gasifier. If no coal is fed in, the hot gases will heat up the top of the gasifier. By quickly loading two or three coal locks the problem can soon be overcome. If TR7 rises above acceptable limits operate the grate at higher speed to discharge more ash, a high TR7 can also indicate a high level of the combustion zone inside the gasifier. If TR7 can not be brought back to a normal range the agent has to be dropped. The normal temperature is approx. 150 °C.

10.2.1.3.6 The jacket water temperature

Under normal operating conditions this temperature remains constant. If the gasifier pressure varies so the boiling point of the water. The following table shows these variations.

Jacket Pressure (Bar) abs.	Jacket Pressure (Bar) gauge	Boiling Point (°C)
1.2	0.30	105
2.3	1.40	124
3.6	2.70	140
6.3	5.40	161
9.1	8.20	176
14.6	13.70	197
21.5	20.6	216
25.0	24.1	224
26.5	25.6	227
27.5	26.6	229
28.0	28.1	230

(Local pressure = 0.9 bar)

10.2.2. FLOWS, PRESSURES AND LEVELS

Utility	Changes	Result	Corrective action
Oxygen flow	Controller faulty, opens fully	rises	a) Change oxygen and steam to hand control b) Check instruments, readjust the flow c) DoCO_2 analysis
-"-	Control valve faulty, closes	drops	a) Change oxygen and steam to hand control and close the controllers. b) Check instruments, readjust the flow. c) Close oxygen and steam control valves as well manually operated valves, if flows are not controllable.
-"-	Load decreases	drops	-
-"-	Faulty HP steam control valve	varies	a) Change steam and oxygen to hand control b) Check instruments and readjust the flow. c) Do CO_2 analysis.
High pressure steam flow	Control valve faulty-closes	drops	a) Change oxygen and steam to hand control and close b) Close oxygen and steam manually operated valves c) Check instruments.
Raw Gas Flow	Flow impulse line blocked	does not indicate flow	Have checked by Instrument Dept.
	Steam blown into gasifier from ash lock pressurising valve	Rises	Close pressurising valve at ash lock.
	High ash bed	Drops	Increase grate speed
	Oxygen and steam shut off	Drops	Start up again on steam and oxygen if shut down period less 15 minutes.

Utility	Changes	Result	Corrective Action
H.P.Feed Water flow (Flow meter to be provided later)	Jacket drain open	Rises	Close drain.
	Load increased	Rises	-
	Load reduced	Drops	-
	Feed water control valve faulty-opens or by-pass open	Rises	Check level gauge glas Have checked by Instrument Dept. Maintain level with by-pass until controller repaired
	Jacket level glas bursts	Rises	Isolate level glas Have level glas replaced by maintenance
	Feed water leaks	Rises	Shut down gasifier. Repair leak.
Raw Gas Pressure	Raw gas control valve not fully open	Rises	Change raw gas control to manual Control in addition with bypass valve
	Impulse line blocked and controller closes slowly	Rises	Change raw gas controller to manual and open fully Have checked by Instrument Dept. Change again to automatic.

Utility	Changes	Result	Corrective Action
Jacket level	Jacket feed water valve jams in close position	Level drops	Isolate control valve Maintain level with by-pass Have checked by Instrument Dept. Commission after repair
	Jacket feed water valve jams in open position	Level rises	Isolate control valve Check level at glas Open by-pass valve Have checked by Instrument Dept. Commission after repair
WHB feed waterlevel at steam drum	Controller faulty, fully open.	Rises	Change to hand control and close valve Maintain level through by-pass Have Instrument Dept.checked Commission when repaired.
-"-	Controller faulty, closed.	Drops	Change to hand control and close valve and isolate. Reduce load Maintain level through by-pass Have controller checked by Instrument Dept. and commission when repaired.
-"-	Drain valve open too far	Drops	Close drain
-"-	Control valve sticks in one position	Rises or drops	Open by-pass and control manually. Isolate control valve Have Instrument Dept. checked Have maintenance remove control valve for cleaning

Utility	Changes	Result	Corrective action
WHB feed water level at steam drum	Control valve closes too slowly	Rises	Isolate controller and have checked by Instrument Dept.
	Control valve opens too slowly	Drops	Isolate controller and have checked by Instrument Dept.

10.2.3 GASIFICATION OPERATION QUESTIONS

1) Describe each temperature point on the recorders completely

2) What is the operating temperature of each one?

3) What will be the cause, result and corrective steps, in the event of the following happening?

TR2 H/P steam control valve is too far open

TR7 (a) Coal bunker is empty

(b) Blockage in coal lock top closure

Jacket temp.

(a) Gasifier jacket is empty

(b) Feedwater leak in gasifier jacket

TR3 (a) Ash too fine, CO_2 too high

(b) Gasifier channelling

TR4 (a) Too much fine coal dust in the coal

(b) Grate is slipping

4) What will be the cause, result and corrective steps, in the event of the following happening.

(A) Oxygen flow

(a) HP steam pressure drops below 28 bar

(B) Raw-gas flow

(a) Gasifier channelling

(b) Ashlock pressurising valve stays open

(c) WHB gasliquor control valve blocked

(C) HP feedwater flow

(a) Pressure from the H/P feedwater pumps too low

(b) Jacket feedwater control valve is fully open.

11. COAL LOCK

11.1 Description of the coal lock

The coal lock is a pressure vessel situated between the coal bunker and the gasifier and is isolated from the coal bunker and gasifier by two manually operated valves called the top cone and the bottom cone.

Coal flows into the coal loack out of the bunker above the coal lock, through the telescopic pipe and the top closure.

As soon as the coal lock is full of coal the telescopic pipe is closed. Some coal remains in the telescopic pipe above the top cone and this must be worked into the coallock. This is done by moving the lever of the top cone. This action allows the coal to enter into the space below the top closure. Moving the lever is continued until a dull sound is heard at the top cone closure.

The coal lock is now completely full of coal (i.e. coal feeder in closed position. Do not more lever twice, otherwise the space between the coal feeder and top cone will be filled again with coal and there will be insufficient space under the top closure to work this coal into the coal lock. Then the top cone will not move and the coal lock is overfilled.

After telescopic pipe and top cone are closed, the coal lock is pressurised to gasifier pressure by pressurising valve. The coal lock bottom cone is then opened and coal flows into the gasifier.

When all the coal in the coal lock has run into the gasifier, the coal lock temperature below lower cone rises due to warm gas entering the coal lock, indicating that it is empty. The coal lock bottom cone is now closed, thus isolating the coal lock from the gasifier. The coal lock is now depressurised. As soon as the coal lock is at atmospheric pressure the top cone and coal feeder are opened and coal runs again from the bunker into the coal lock.

Both the top cone and bottom closures, the coal feeder, as well a the pressurising and depressurising valves are manually operated.

The frequency at which the coal lock cycle must be operated depends on the gas load of the gasifier. At a gas load of 1500 m^3_n raw gas per hour the cycle must be repeated approx. every 30 minutes. The volume of the coal lock is 0.875 m^3 and it holds about 0.6t of coal. The coal lock cycle takes about 8 to 10 minutes.

11.2 <u>Operation of the coal lock</u>

All the valves on the coal lock are manually operated.

<u>Coal feed to gasifier</u>:

It is very important that the gasifier is always maintained full of coal. This ensures that the top of the gasifier does not get hot and is safely operated. The cold coal entering the gasifier is initially heated up, evaporate the water and volatiles such as tar and oil; Considerable heat is required for this process and therefore the temperature in the top of the gasifier can be kept low. If the top of the gasifier gets too hot, the flange gasket between the coal lock and the gasifier can be distorted . resulting in a large gas leak.

<u>Operation of the coal lock</u>

The coal lock operation is described in following steps.

Step 1

The coal lock bottom cone has to be closed.	Move the hand lever a few times so that all the coal between the cone and the seat falls into the gasifier. Listen for the metal against metal sound which indicates that the bottom cone is tightly closed. The coal lock is now sealed off from the gasifier.

Step 2

The depressurising valve has to be opened.	The raw gas flows out of the coal lock and the pressure drops. As soon as the pressure reaches 5 bar below gasifier pressure the leakage test has to be carried out by watching the coal lock pressure. The pressure must remain constant. If the pressure rises the coal lock bottom cone is not tightly shut. Wait until the coal lock pressure is the same as the gasifier pressure and then reclose the coal lock bottom cone. Move the hand lever of bottom cone some times and start again step 2 to test that bottom cone is tightly shut. Continue depressurising until the pressure reaches atmospheric pressure.

Step 3

The coal lock top cone has to be opened.	The coal lock top cone must only be opened when the coal lock is at atmospheric pressure otherwise large quantities of poisonous gases and coal dust will be blown into the surrounding area.

Step 4

Coal feeder has to be opened.

Coal now runs into the coallock. Listen if coal is running into coal lock correctly. Coal flow can also be checked with the provided holes on the side of the coal feeding chute.

Step 5

Coal feeder has to be closed.

After the telescopic pipe has been put in upper closed position there is still coal in the telescopic pipe above the top cone which must be worked into the coal lock.

Step 6

Top cone has to be closed.

The top cone will not immediately close tightly because there is coal between the top valve seat and cone. By moving the hand lever the coal can be worked into the coal lock. This action must be continued until a dull sound is heard. The coal lock is now full.

It is very important not to turn feeder lever again as the space in the telescopic pipe above the top cone will again be filled with coal and there will be not sufficient space in the coal lock for this coal. The top cone will then be unable to move and the coal lock is overfilled.

Step 7

Pressurising valve bas to opened.

Raw gas from the outlet of the after cooler now flows into the coal lock. As soon as the pressure reaches 5 bar close the pressurising valve and do a leak test. If the pressure in the coal lock remains constant which indicates that the top cone has sealed properly, then continue with the pressurising until it equals gasifier pressure.

Step 8

Bottom cone has to be opened.	The coal lock bottom cone opens and coal flows into the gasifier. It is very important to make sure that the bottom cone is fully open.

Coal lock cycle finished.

DANGERS concernd with the Operation of the Coal lock

As already stated it is essential that the coal lock is operated in such a way as to always maintain the gasifier full of coal. This is necessary so that the top of the gasifier does not get too hot thus causing the flange between coal lock and gasifier to become distorted and therefore leak.

If the coal level in the gasifier continues to fall by ignoring the rise of the gasifier-gas outlet and -top temperatures a condition could be reached where there is insufficient coal in the gasifier for reaction. If now no action is taken oxygen can pass through the coalbed into the raw gas possibly resulting in an explosion in the top of the gasifier. This can result in very serious damage and therefore great care must be taken in maintaining the gasifier full of coal. (Note: This temperature point is mounted on the coal lock but extends down into the top part of the gasifier underneath the coal lock bottom cone).

In the main control room there is a temperature recorder. The temperature should not increase beyond 200 ^{O}C.

By quickly carrying out several coal lock cycles so that the gasifier is full of coal again the temperature can be reduced to normal.

The main task of the coal lock operator is to operate the coal locks in such a way as to make certain that the gasifier is maintained full of coal. If any problems occur which delay or prevent the loading of coal, the supervisor must be immediately informed so that the problems can be solved before the temperature rises too high and the gasifier has to be shut down.

TYPICAL QUESTIONS ON THE COAL LOCK

1. What is the purpose of the coal lock?
2. What is the volume of a coal lock and how much coal does it hold?
3. How is a coal lock depressurised, where does the expansion gas go to?
4. What is the purpose of the coal lock top closure?
5. What is the purpose of the coal lock bottom closure?
6. Why does the coal lock bottom cone close on the gasifier side?
7. How will you know that a coal lock bottom cone leaks and how will you handle this?
8. Why is it very important to maintain a gasifier full of coal?
9. How will you know that a gasifier is full of coal?
10. What is the cause of an overfilled coal lock and how is this handled?
11. What will happen if there is a blockage in the coal lock top closure?
12. What temperature points are provided in the coal lock and what are the normal temperature ranges within which the coal lock must be operated?
13. What corrective steps must be taken if a coal lock top closure does not seal tightly?(gas blows into the atmosphere)!
14. What is the most important task of the coal lock operator?

12. ASHLOCK

12.1 Description of the Ashlock

The ashlock is a pressure vessel connected with flanges to the bottom of the gasifier. The ashlock volume is $0.875m^3$. As with the coallock, the ashlock valves are manually operated.

There is an expansion vessel connected to the ashlock which is kept full of water during operation and in which the steam condenses when the ashlock is depressurised. The purpose of the ashlock is to receive the ash produced in the gasifier and drop the ash batchwise into the ash trolleys. In order to do this the ashlock is operated in cycles as described below.

1. The grate turns the ash out of the gasifier and it falls through the open top cone into the ashlock. During this operation the bottom cone and all the other valves are closed, and the ashlock as well as the expansion vessel are at the same pressure as the gasifier.

2. After about one hour (depending on the gas load of the gasifier), the ashlock is about three quarters full and must be emptied. The grate is now switched off to prevent ash moving over the top cone seat and the top cone is closed. When it is certain that the top cone is tightly closed the grate is switched on again (after the leak test).

3. The ashlock is now depressurised by opening isolation and control valves respectively on the expansion vessel. A pressure test is carried out at 5 bar below the gasifier operating pressure to ensure that the top cone is tightly closed. The expansion vessel is full of cold

water and the steam from the ashlock blows through the immersed pipe into the expansion vessel and condenses. By this process the ashlock is depressurised and the water in the expansion vessel is heated up.

4. As soon as the pressure in the ashlock reaches atmospheric, the water in the expansion drum is drained out completely through the drain valve.

5. To cool ash continuously during the ash removal from ash lock, lushing water valve has to be opened. The ashlock bottom cone is now opened and the ash falls through the bottom opening into the ash trolley. The flushing water is kept running to clean the seat.

6. The water filling valve is opened to flush the bottom of the expansion vessel and the draining line. After this the valve on the expansion drum drain line is closed. Filling is continued till the expansion drum is full of cold water which is indicated by the overflow line.

7. The water filling valve and depressurising valves are closed. The expansion vessel system is ready for the next cycle.

8. The supply of flushing water to the ash lock is closed. The bottom cone is also closed.

9. Now the ashlock is pressurised with steam by opening the pressurising valve.

10. As soon as the ashlock pressure reaches 5 bar, the pressurising valve is closed in order to determine if the bottom cone is tightly sealed. If the ashlock pressure remains constant the pressurising is continued.

11. When the ashlock pressure is the same as the gasifier pressure, the top cone is opened and then pressurising valve is closed. So that the ash can once more fall into the ashlock. After a specified time the ashlock cycle is repeated.

Operation of the Ashlock

Step 1
Top cone closes

Before removal of ash, the grate must be switched off. Wait about 10 seconds so that all the ash between the top cone and the seat has fallen into the ashlock before closing the top cone. Open and close the top cone a few times until a clear metal against metal sound is heard.

Step 2
Depressurising valves.

The depressurising valves are opened and steam condenses in the expansion drum. When the pressure drops to about 5 bar below gasifier pressure, close depressurising valve again to determine if the top is tightly sealed. If the ashlock pressure stays constant then re-open the valve. If the attempts to close the top cone tightly fail, this indicates that the top cone seat is not tight and the supervisor must be informed immediately.

Step 3
Drain valve on expansion vessel open

This drain valve is open to drain the hot water into the pit. If this valve is opened at a pressure above 1 bar the discharge system can be damaged.

Step 4

Flushing water supply opened.

Step 5
Bottom cone open

When the ashlock is at atmospheric pressure, the bottom cone is opened slowly so that the ash does not fall too quickly into the ash trolley. The bottom cone is slowly opened and closed a few times to make sure that the ash is flowing out.

Step 6
Water filling valve on expansion drum open

Water flows into the expansion drum. At this stage the drain valve is still open and the expansion vessel will not become full until the drain valve is closed.

Step 7
Drain valve on expansion vessel is closed.

When water runs out of the overflow line the expansion drum is full of water.

Step 8
Water filling valve, depressurising valves are closed.

As soon as the expansion drum is full of water the "water filling" valve must be immediately closed. This is to prevent water overflowing into the ashlock. The filling water valve and the depressurising valves are closed.

Step 9
Bottom cone closes.

Open and close the bottom cone a few times until dull sound is heard thus ensuring that the bottom cone is tightly sealed.

Step 10

Flushing water closed.

Step 11
Pressurising steam valve is opened.

Steam at 30 bar pressure and 400°C flows into the ashlock. As soon as the ashlock pressure reaches 5 bar the pressurising valve is closed. Untightness of the bottom seat can be seen by blowing out of steam.

Step 12
Top cone is opened.

The ashlock top cone is opened and ash once again falls into the ashlock. The ashlock operator must ensure that the top cone is fully open so that ash can fall freely into the ashlock.

Step 13
Pressurising steam valve closes.

As soon as the top closure is open, the pressurising valve is closed.

Ashlock cycle completed.

5.2.6 Guidelines for the control of the Ashlock

OPERATION PROBLEM WITH THE ASHLOCK	POSSIBLE REASONS	CORRECTIVE AND/OR PREVENTIVE ACTION
1. Ashlock top cone will not close	a) Ashlock is overfull b) Clinkers between cone and seat.	a) De-ash at correct time b) Open the top cone so that the clinkers fall into the ashlock.
2. Ashlock bottom cone will not open.	a) Ashlock is not at atmospheric pressure. The pipeline between ashlock and expansion drum is blocked.	a) Close the isolation valve on the pressurising line and depressurise the ashlock through the depressurising valve. Report to the supervisor before continuing further with the cycle.
	b) The ash in the ashlock is wet. Water has overflowed into the ashlock whilst the bottom cone was closed.	b) Depressurise the ashlock in the normal manner and report to the supervisor so that arrangements can be made to open the bottom cone. If the ash will not fall out when the bottom cone is open, poke the ash out with an iron bar.
	c) The ashlock pressurising valve is leaking and the ashlock is still under pressure.	c) Close the valve properly on the pressurising line and then depressurise the ashlock.

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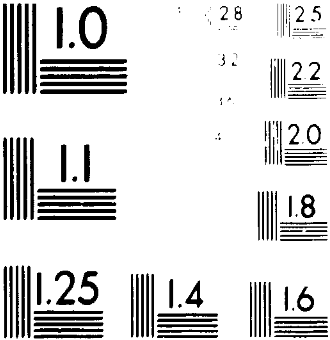

MICROCOPY RESOLUTION TEST CHART

	d) The ashlock top cone leaks and the ash-lock is still under pressure.	d) Repressurise the ash-lock and close the top cone properly. (This will only happen when the pressure test is not carried out).
3. Ashlock cannot be depressurised	a) Steam pressurising valve leaks.	a) Close the valve properly on the pressurising line. If the ashlock will still not depressurise, follow point b) below.
	b) Ashlock top cone leaks	b) Try to seal the top cone properly. If this is impossible, report to the supervisor so that the oxygen and steam flow can be cut off. If the top cone leaks gasification agent containing oxygen can pass into the ash-lock and an explosion can result.
4. Ash lock can not be pressurised.	a) Steam pressurising valve is stuck in the closed position, or ashlock bottom cone leaks.	a) Report to the supervisor so that arrangements can be made to shut down the gasifier.
5. Expansion drum becomes warm or shakes during depressurising	a) Ashlock depressurising valves leak.	a) Close the valves properly or change them if necessary.
	b) The dip pipe in the expansion drum is loose or broken	b) Report to the supervisor so that the dip pipe can be changed.

c) The expansion drum is empty. Caution: Depressurize system slowly because dangerous steam with ash content is removed.	c) Ensure that the expansion drum is completely full of water.

5.2.7 Dangers associated with mal-operation of the Ashlock

If the correct operating procedures are followed and no short-cuts are taken, the ashblock can be safely operated and the necessary action taken if something goes wrong. However, if the wrong procedures are followed or intentionally disobeyed the gasifier has to be shut down if not injury to personnel can occur.

The following mal-operations must never be carried out:

a) Under no circumstances must any attempt be made to depressurise the ashlock if the top cone is not properly sealed. This mal-operation can result in warm gas from the gasifier entering the ashlock and causing an explosion.

b) The drain valve on the expansion drum must not be opened if the pressure is above 1 bar. This can result in the water discharge system bursting with possible injury to personnel.

c) While the ashlock bottom cone is open and ash is falling into the ash trolley, the ashlock depressurising valves must not be closed because if the top cone should develop a leak whilst the bottom cone is open. If ash blocks between bottom seat and cone a blockage might occur and pressure will build up.

d) As soon as the expansion drum is full of water, the "water filling" valve must be immediately closed. This is to prevent water overflowing into the ashlock. If water runs into the ashlock (especially if there is still hot ash in the ashlock), steam is formed. The wet ash can easily cause a blockage in the ash lock and pressure will build up in the system as in the case of a leaking top cone.

e) The grate must not be run with a closed top cone for too long. When the top cone is closed the ash cannot be removed from the gasifier and the ash collects in the space between the grate and the top cone. This can result in the grate slipping. The operation of the grate against a closed top should be less than 4 revolutions to avoid over-filling the space under the grate.

f) Under no circumstances must water be used for cooling the ashlock. This is a dangerous practice and can lead to distortion of the protection plates.

Typical Questions on the Ashlock

1. What is the purpose of the ashlock?
2. Where does the ash come from and how does it get into the ashlock?
3. Why must the ash be removed from the ash lock in regular intervals?
4. Give possible reasons why an ashlock top cone will not open or close!
5. Give possible reasons why an ashlock bottom cone will not open or close!
6. What is the purpose of the ash lock top cone?
7. What is the purpose of the ash lock bottom cone?
8. What is used to pressurize the ashlock and what is the pressure and temperature of the pressurizing agent?
9. What is the purpose of the expansion drum and why is it filled with water?
10. How will you know that the expansion drum is full of water?
11. What harmful effects and danger is there when water overflows into the ashlock?
12. Where is the 'dip'-pipe installed and what is its purpose?
13. What causes an ashlock expansion drum to get hot and what danger does this present?
14. What is the purpose of the inner skirt in the ashlock and where is it installed?
15. What is the purpose of lubrication of the ashlock top closure gland and why is it important?
16. How will you know if the ashlock top closure gland is not being lubricated?
17. Why must the ash lock be depressurized if the gland is blowin out?
18. How will you know that an ashlock is empty?

19. What will happen if an ashlock top closure is closed for too long whilst the grate is turning?

20. What are the drawbacks when the ashlock is already pressurized and the top closure will not open?

21. How do you test an ashlock top closure to ensure that it is tightly sealed?

22. What are the dangers when a top closure leaks and how should this problem be solved?

23. What are the causes of the expansion drum shaking when the ashlock is brought up to pressure?

24. Why are there an isolation and control valve on the ashlock depressurising line?

25. What temperature point is provided on the ash lock and what is its purpose?

26. What should be done if the following happens: Describe the causes and the corrective action to be taken:

a) Ashlock depressurising valves will not open.

b) Ash does not fall out of the ashlock.

c) Ashlock can not be depressurised.

d) Ashlock can not be pressurised.

e) The ashlock depressurising line shakes violently.

f) Ashlock top closure gland blow out.

13) Description of gas analysis

The purpose of this chapter is to instruct on the following:

1) To know the duties of the analysis operator.

2) To know when, where and how to take a raw gas sample.

3) How to use the Orsat apparatus.

4) The purpose of the Orsat apparatus.

5) The importance of CO_2 and oxygen analyses.

6) Why specific CO_2 percentages are used.

7) What occurs in the oxydation zone.

8) The dangers associated with ineffective analyses.

ANALYSES OPERATOR DUTIES

1) Perform CO2 analyses on the gasifier every 1/2 hour or at any other time on request from the Main Control Room.

2) Report all defective equipment.

3) Report faulty Orsat apparatus.

4) Carry out instructions from the Shift Coordinator.

5) Maintain working area and analysis room in a clean condition.

Taking a raw gas sample

When taking a raw gas sample the following must be born in mind:

1) Isolation valve on the sample line, which is situated on the raw gas line, before the control valve, must be open.

2) The sample point is fitted with a pipe to which the sample holder is connected when the sample is taken.

3) All condensate is to be blown out of the gas line before a sample can be taken.

4) Report immediately if condensate continues to blow from the gas line.

5) Before gas is blown into the atmosphere, ensure that no cutting or welding is taking place in the area. Remember that raw gas is highly combustible. Inform the main control room if this situation is arising.

6) When taking a raw gas sample always position yourself downwind.

7) When all condensate has been exhausted the sample holder can be tightly connected to the valve.

8) Open both valves on the sample holder.

9) After sample holder is full, close the sample holder inlet valve.

10) Now close the valve on the sample point. This prevents the possibilities of accidental injuries or gassing.

11) Take the sample holder to the analysis room.

Note:

When a gasifier is changed to HP steam and oxygen any CO_2 and O_2 measurements which are requested must be done as quickly as possible. This is the most dangerous period when starting a gasifier. The CO_2 and O_2 analysis will determine whether it is safe to continue or not.

The Combustion Zone

It is extremely important to perform CO_2 analyses on the gasifiers as they indicate temperature variations in the oxydation, or firezone CO_2 (Carbon dioxide) has the quickest reaction when temperatures vary.

We use high pressure steam and oxygen to produce gas from coal. This gasifying agent is fed into the gasifier below the ashbed where it is evenly distributed by the grate. The oxygen then comes in contact with the hot coal, where the first reaction takes place. This is calle the combustion zone. The high pressure steam is used only to control temperatures i.e. the less the steam the higher the temperature in the combustion zone and more steam will give a lower temperature. Therefore when the CO_2 is lower than appr. 28 % (depending on the type of coal) steam must be added to the agent to cool the gasifier and to prevent clinker formation. In other words when too little steam is fed to a gasifier too much CO_2 will effect the CO (Carbon Monoxide) percentage. The opposite will apply if too much steam is used.

First Reaction

$C + O_2 = CO_2$ + Heat and similarly CO_2 + Heat $+ C = CO$.
In the first reaction zone we also find CO_2 but this later increases.
The correct description of the chemical reaction in the combustion zone should be written thus:
$2C + O_2 = 2CO$

If the CO_2 in a gasifier falls to appr. 28 % or below the responsible person is to be advised immediately.
If the CO_2 shows 45% the gasifier must be taken off line. This indicates that the fire is out and oxygen can then not be used as it will mix with the raw gas to form an explosive mixture.

Raw gas consists approximately of the following compounds using GODAYARI KHANI coal.

1)	Hydrogen	(H_2)	=	42	%
2)	Carbon Dioxide	(CO_2)	=	30	%
3)	Carbon monoxide	(CO)	=	16	%
4)	Methane	(CH_4)	=	12	%
5)	Nitrogen	(N_2)	=	0	%

operating condition (24 bar, steam/oxygen = 5.5 kg/m^3n)

The orsat-apparatus and how to use it:

1. The orsat apparatus consists of a glass buret, graduated upwards from 0 to 100 ml, and is provided with a water filled jacket. The buret is connected at the top to a stop cock manifold constructed of capillary tubing. To this manifold at each stop cock position, are connected absorption pipettes each containing a liquid absorbant which is used to remove one or more constituents from gas sample, and a combustion pipette. The manifold stop cocks are arranged in such a way that the buret may be connected to the atmosphere or may be connected to/or bypass any or all of the pipettes. The bottom of this buret is connected to a movable reservoir containing a confirming fluid such as acidified water. By adjusting tar height of the reservoir gases in the buret may be brought to the desired volume, according to the pressure of the confirming fluid and may be brought to the atmospheric pressure by aligning the liquid levels in both the reservoir and buret. The orsat is provided with four absorption pipettes and a combustion pipette.

2. The first absorption pipette: (for CO2). This absorption pipette is filled with Potassium hydroxide solution. It is here, the CO2 in the gas is removed and the CO2 content determined.

3. The second absorption pipette: (for CO2). This absorption pipette is filled with alkaline pyrogalic acid pollution and it is here the O2 in the gas is removed and the O2 content is determined.

4. The third absorption pipette: (for CO). This absorption pipette is filled with ammoniacal cuprous chloride solution and it is here the CO in the gas is removed and CO content is determined.

5. The fourth absorption pipette: This absorption pipette is filled with acidified water and is used for removal of any ammonia vapour from the ammoniacal cuprous solution before taking the final reading. It will also serve for storing the remaining gas sample before the estimation of H2 and CH4 by combustion.

6. Combustion pipette: A know volume (say) of the gas stored in the absorption pipette 5 and 7 or 8 times the volume air are drawn into the buvette. The reading of this volume of the mixture is noted (say). The mixture is passed into the combustion pipette. The platinum coil is brought to red heat slowly by supplying a current of 6 volts from a 6 volts battery or from a step down transformer. After parsing the gas mixture for a sufficient time over the platinum coil, the power supply is put off. The reading of the volume of the mixture is taken (say Z). The CO2 in the mixture is now estimated by absorption in the first pipette (CO2 = a).

$$2\ H_2 + O_2 \longrightarrow 2\ H_2O$$

$$CH_4 + 2\ O_2 \longrightarrow CO_2 + 2\ H_2O$$

Hydrogen combustion and also the combustion of methane give rise to water vapour, which condenses and produces reductions in volume.

Calculation of H2 and CH4 in the sample taken for combustion

Total reduction in volume y - z

Reduction tue to combustion of CH4 is two times this volume of CH4 . CO2 volume produced = 2 a

Reduction due to Hydrogen combustion

$$= (y - z) - 2a$$

(i) % Hydrogen

$$= \frac{(y - z) - 2a \quad 2}{3} \times \frac{\text{(volume of gas remaining after estimation of CO2, O2 and CO)}}{x}$$

(ii) % Methane

$$= \frac{a}{x} \times \text{(volume of gas after estimation of CO2, O2 and CO)}$$

14) GASIFIER CHECKLIST

No.1 The planned shutdown of a gasifier to atmospheric pressure

No.2 The emptying and cooling of a gasifier before blanks can be installed.

No.3 Preparation for installation of blinds after a gasifier has been emptied and cooled

No.4 The installation of blinds after a gasifier is empty and cold

No.5 The precaution to be taken before entering a gasifier for inspection and/or maintenance after the blinds have been installed.

No.6 The preparation and removal of blinds from a gasifier after an internal inspection or major maintenance before the gasifier can be started up

No.7 The start up of a gasifier with high pressure steam and air.

No.8 The switching over of a gasifier from air to oxygen

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CHECKLIST NO. 1 FOR THE PLANNED SHUTDOWN OF A GASIFIER TO ATMOSHPERIC PRESSURE.............

Steps	Control points	Dangers Associated in carrying out/ ignoring of procedures	Action by	Completed by (Signed)	Date	Ref to shift coordinator
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Coal feed to Gasifier bunker stopped	1. Eight to ten hours before the gasifier is to be shut down.					
2. Gas load reduced to 40% oxygen	When coal bunker is nearly empty.					
3. Control valve on raw gas line on automatic.	PRC 4115					
4. Deash and grate stopped.						
5. Oxygen control valve closed. FRRC 4302	1. Control valve on manual control and set to zero	First oxygen FRRC 4302 and then high pressure steam stopped. FRC 4301.				
6. High pressure steam control valve closed	FRC 4301					
7. Oxygen isolation valve F 001 closed.	F 001					
8. High pressure steam isolation lvalve DH004 closed	DH004					

CHECKLIST NO. 1 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
9. Manually operated valve on oxygen line closed.	F 412					
10. Manually operated valve on high pressure steam line closed	DH 414 PIC 4102, DH 431					
11. Valves to gas cleaning plant closed	HOLD					
12. Starting of de-pressurizing Maintain BFW level in BFW Drum.	1. Raw gascontrol valve open. Depressurize 1 bar each 10 min. Hold at 5 bar. PI 4105 and PI 4109.					
13. Pressure difference between gasifier and jacket to be watched.	2. Maintain level in water seal in flare stack.					
14. Coal feed to gasifier completely stopped.						
15. Isolation valve on coal lock pres-surising line closed	GS 431					
16. Coal lock bottom cone closed.						

CHECKLIST NO. 1 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
17. At 5 bar the sumps of waste heat boiler and aftercools have to be washed 3 times by filling with injection gas liquor from section 800. Discharge the washings to expansion vessels F801 and F802. At 5 bar switch raw gas controller from automatic to manual. Washcooler sump and circulation pump as well after cooler sump are drained completely.	Open valve below catch pot hold and WU 404 as well WO 404					
18. Isolation valves on waste heat boiler gas liquor line closed.	1. "Dusty gas liquor" WT 401, 402, 403					
19. Keep drain valves on gas liquor line at waste heat boiler and after cooler open.	WK 404, Hold, WO 404					

CHECKLIST NO. 1 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
20. Raw gas control valve closed.	PRE 4115					
21. Valve to flare opened.	G/GR 413					
22. Raw gas control valve ±25% open	PRC 4115					
23. Wash cooler pump stopped						
24. Gasifier at atmospheric pressure						
25. Isolation valves on injection water line to wash cooler WG421 and to after cooler WG 422 to be closed.	Stop first H.P.gas liquor injection pump in gas liquor separation unit					

CHECKLIST NO. 2 FOR THE EMPTYING AND COOLING OF A GASIFIER BEFORE BLANKS CAN BE INSTALLED........

Steps	Control points	Dangers Associated in carrying out/ignoring of procedures	Action by	Completed by (Signed)	Date	Ref to shift coordinator
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Checklist number 1 is completed and signed						
2. Grate started and ash removed as normal						
3. Low pressure boiler feed water to waste heat boiler and L.P. Steam system to be closed	SW 431,432,433					
4. Isolation valves on low pressure BFW pump closed.						
5. Vent on high low feed water line opened	SW 434					
6. Ashlock top cone closed	1. Gasifier empty					
7. Jacket drained to normal level.	WA 411, 412					

CHECKLIST NO. 3 FOR PREPARATION FOR INSTALLATION OF BLINDS AFTER A GASIFIER HAS BEEN EMPTIED AND COOLED....

Steps	Control points	Dangers Associated in carrying out/ ignoring of procedures	Action by	Completed by (Signed)	Date	Ref to shift coordinator
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Checklists numbers 1 and 2 are completed and signed.						
2. Gasifier at atmospheric pressure.						
3. Gasifier empty						
4. Manually operated and isolation valves on high pressure steam line closed.	DH 414, DH 004, DH.PB1					
5. Bypass valve at DH 004 on high pressure steam line closed.						
6. Vent valve on high pressure steam line opened.	DH 413					
7. Isolation valve on start up air line closed	Separate air line will be provided later for start up					
8. Isolation valve and manual valve on oxygen line closed.	F 001, F 412					

CHECKLIST NO. 3 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
9. Vent valve on oxygen line open	F 413					
10. Isolation valve on high pressure feed water line to jacket closed	WS 422, 423, 424 425					
11. Isolation valve on the low pressure steam system from the waste heat boiler closed.	DN 437, DN 434, 435					
12. Vent valve on the low pressure steam line open.	DN 433					
13. Safety valve on waste heat boiler to be removed.	SV 431					
14. Valves to flare closed.	PRC 4115, G/GR 415, 416 G/GR 413, 419					
15. Isolavtion valve on the coallock depressurising line closed.	GS 433 - 1,2					
16. Blinds in coal chute under bunker in closed position.						

CHECKLIST NO. 3 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
17. Isolation valve on filling water	WV 403					
18. Line to ashlock expansion drum closed.						
19. Electric fuses removed from the following a) Grate motor b) Wash cooler circulation pump. c) H.P. Gas liquor injection pumps d) Cooling water pumps						

CHECKLIST NO. 4 FOR THE INSTALLATION OF BLINDS AFTER A GASIFIER IS EMPTY AND COLD ....

Steps	Control points	Dangers Associated in carrying out/ ignoring of procedures	Action by	Completed by (Signed)	Date	Ref to shift coordinator
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0. Checklist Nos. 1,2,3 must be completed						
1. The Blinds of the following lines are installed:						
a) Oxygen line	F412,FOO4, LN 411					
b) High pressure steam line	DH 414, DH.PB1					
c) Start-up air line						
d) Coal lock pressurising line	GS 431					
e) Coal lock depressurising line	GS 433-1,2					
f) High pressure feed water line	WS 422, 424, 425					
g) Low pressure feed water line	Hold for UA LE No. L.P./H.P connection					
h) High pressure feed injection water line to wash cooler and to aftercooler.	WS 426, 427					

CHECKLIST NO. 5 FOR THE PRECAUTION TO BE TAKEN BEFORE ENTERING A GASIFIER FOR INSPECTION AND/OR MAINTENANCE AFTER THE BLINDS HAVE BEEN INSTALLED..........

Steps	Control points	Dangers Associated in carrying out/ ignoring of procedures	Action by	Completed by (Signed)	Date	Ref to shift coordinator
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Checklist number 4 for installation of blinds completed and signed.						
2. Gasifier empty						
3. Gasifier cold						
4. Coal lock removed						
5. Gasifier blown through with clean air	Open ash lock top and bottom cone					
6. CO and explosive gas tests done and result negative	Suck the gas from the gasifier					
7. Airmask in gasifier						
8. Two safety belts						

CHECKLIST NO. 5 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
9) Person on standby at coal lock						
10) Valid permit for entering a gasifier made out and signed.						
11) Gasifier has to be washed and cleaned from remaining coal and ash if an inspection found necessary.						

CHECKLIST NO. 6 FOR THE PREPARATION AND REMOVAL OF BLINDS FROM A GASIFIER AFTER IN INTERNAL INSPECTION OR MAJOR MAINTENANCE BEFORE THE GASIFIER CAN BE STARTED UP

Steps	Control points	Dangers Associated in carrying out/ ignoring of procedures	Action by	Completed by (Signed)	Date	Ref to shift coordinator
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Internal inspection carried out.						
2. Maintenance work completed						
3. Coal lock replaced						
4. The following blinds removed:						
a. High pressure steam line	DH 414, DH.PB1					
b. Start up air line						
c. Coal lock depressurising line.	GS 433- 1,2					
d. High pressure BFW line	WS 422, 424, 425					
e. Low pressure feed water line to waste heat boiler/ steam drum system	Hold No. for HP/LP BFW					
f. High pressure feed water line to wash cooler and aftercooler	WS 426, 427					

CHECKLIST NO. 6 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
g) Coal chute to be opened after bunker is refilled.						
5. Clearance for start up signed.						
6. External inspection carried out.	1. All flanges tight 2. All bolts in position 3. All scrap material etc. removed					
7. Coal lock and ash-lock cycles tested.	All instruments in order.					
8. Scraper tested.						
9. The following tested by instrument section: a) All the alarms b) Instrument charts, pens etc. c) Trip system d) Control valves indication.						

CHECKLIST NO. 6 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
10. Jacket water drained and refilled with boiler feed water.						
11. Waste heat boiler drained and refilled with boiler feed water.						
12. Isolation valve on low pressure steam line from waste heat boiler system open and all vents to be closed.						
13. The following fuses are replaced: a) Grate motors b) Wash cooler pump motor H.P. c) Gas Liquor Injection pumps d) Cooling water pumps						

CHECKLIST NO. 6 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
14. Motors and valves tested.						
15. Injection water to waste heat boiler open and aftercooler and level normal.						

CHECKLIST NO. 7 for the Start-up of a Gasifier with High pressure Steam and Air

Steps	Control points	Dangers Associated in carrying out/ ignoring of procedures	Action by	Completed by (Signed)	Date	Ref to shift coordinator
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Checklist no. 6 completed in full and signed.						
2. Jacket and waste heat boiler (WHB) steam drum full of feedwater	Gasifier jacket-60% WHB-Steam drum-40%					
3. Low pressure steam isolation valves open at WHB to BFW-heating system.	DN 434, 435 with the injection H.P. Steam to the steam injection cooler 2.8 bar (g) saturated steam is produced. It is used to heat the BFW-tank up to 105 °C. The dip heater is used to heat the water up to 100 °C, the other to dearate the water entering the dearator. PRC 4115. G/GR 415, 416					
4. Gasifier rawgas control valve on manual and fully open.	G/GR 419					

CHECKLIST NO. 7 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
5. Rawgas bypass valve fully open	G/GR 419					
6. High pressure steam line warmed-up with all available drains.	Open only 1" bypass valve on the high pressure steam isolation valve DH 004. RRL will provide later. DH 002, 413, 005, 008, 007.					
7. Before loading purge with gasifier HP-steam for approx. 15 minutes. Work through ashlock and coal lock while gasifier is being blown with steam.						
8. Purge steam isolation valve open.	Provided to WHB safety valves.					
9. Close high pressure steam control valve on manual	FRC 4301					

CHECKLIST NO. 7 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
10. Blow gasifier with 100 m^3n air at atmospheric pressure						
11. Load gasifier with 3 coal locks of coal.	Ensure that coal runs through into gasifier					
12. Coal lock bottom cone open	Filling time of coal lock approx. 2 minutes. Coal lock empty. Close air control valve FRC 4302					
13. Close coal lock bottom and ash top cones. Open high pressure steam manual control valve fully.	DH 414					
14. High pressure steam control valve on manual and adjust card reading 90%.	1. Open valve slowly FRC 4301 2. Check pressure differential between jacket and gasifier. PI 4105, 4109 3. Permissible pressure differential 2 bar					

CHECKLIST NO. 7 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
15. Valves on drain lines on WHB and aftercoolers to be opened to the pit to control level. WD 404 and valve below the catchpot.						
16. Injection water to washcooler and aftercooler open.	Emergency injection water closed (HP-BFW)					
17) Cooling water to wash cooler recirculation pump open.	Gland cooling valve WV 405.					
18) Washcooler pump drain valve closed.	WK 404					
19) Wash cooler recirculation pump in commission.	1. In and outlet isolation valves open, WU 401, 402 2. Gasliquor level in WHB normal.					
20) Rawgas control valve on manual	Valve fully open PRC 4005					

CHECKLIST NO. 7 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
21. Oxygen air control valve on manual	Valve fully closed. FRC 4302					
22. Tr 2 controlled between 320 °C and 350 °C Agent temp (TR2)	High pressure steam flow Chart reading 90%, approx. 300 kg Steam/h					
23. Coal in gasifier heated with high pressure steam for2 to 3 hrs.	Gasifier outlet temperature TR 4 approx. at 100°C for 1 hr. Go through complete ash lock cycle every 30 minutes to remove condensate from gasifier.					
24. For grate check that lubrication is available.						
25. Reduce high pressure steam flow.	1. Close steam control valve on manual FRC 4301 2. Close high pressure steam isolation valve DH 004					

CHECKLIST NO. 7 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
26) Slowly open high pressure steam isolation valve. Just crack open.	High pressure steam line is at full pressure up to control valve.					
27. Open start-up air isolation valve.						
28. Open start-up air control valve	+60 m^3n/h, 90 % chart reading. Take attention to Gas outlet temperature TR 4. Increase showing that ignition started. 5 Minutes after starting with air gas samples are analysed for CO_2 and O_2 every 10 minutes.					
29. Open high pressure steam control valve a little on manual	1. Control tr2 at +200°C. 2. Pay attention that pressure difference between gasifier and jacket is not higher than 2.5 bar.					
30. Gasifier pressure increased to 25 bar	Raw gas control valve and vent bypass valve still in open position. Pressure controlled only with bypass valve.					

CHECKLIST NO. 7 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
31. CO_2 analysis done and under control at about 18% to 21%.						
32. Raw gas flow starts increasing.						
33. Gasifier gradually filled with coal.	When temperature (tr4) begins to rise and exceeding 150 ^{o}C load a coal lock of coal					
34. Control CO_2 between 18 % to 21 %.	Gasifier full of coal.					
35. Turn grate for 2 minutes each thru low speed.	Watch gas outlet temperature (tr4)					
36. CO_2 and O_2 analyses done and O_2 0.6% found in gas. Increase the gasifier pressure to 5 bar.	1 bar/10 min. Ash lock top cone must be closed with each pressure increase. Close PRC 4005 - Bypass G/GR 419 fully and adjust controller around 50 %.					

CHECKLIST NO. 7 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
37. De-ash very 30 minutes to remove ash and condensate from gasifier	Ensure ash lock is empty. Use packing facilities.					
38. Control gas outlet temperature at 150 - 200 °C.						
39. Gasifier to be kept full with coal.						
40. Gasifier on air and steam for 6-8 hrs.						
41. No unburnt coal in ash.	If coal prices appear in ash reduce grate speed.					
42. Retighten all hot flanges. (hot pull up).						

Checklist No. 8 for: THE START-UP OF GASIFIER WITH HIGH PRESSURE STEAM AND SWITCHING OVER FROM AIR TO OXYGEN.

Steps	Control points	Dangers Associated in carrying out/ ignoring of procedures	Action by	Completed by (Signed)	Date	Ref to shift coordinator
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Boiler feedwater to jacket and waste heat boiler steam drum checked, level normal.	40% Jacket 50 % Steam drum 20 to 30%					
2. Wash cooler recirculation in operation and in order.						
3. Gasifier full of coal.						
4. Temperature settled out. CO_2 and O_2-content in raw gas within limits. CO_2: 18 to 21% O_2: 0.6 %	1. Ashlock temperature TR 3 approx. agent temperature 2. Gas outlet temp. 150 °C to 200 °C. Flare has to be ignited.					
5. All instruments in order	Instrument technician present.					

CHECKLIST NO. 8 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
6. Gasliquor level in WHB sump normal.	50 %					
7. Oxygen isolation valve closed. Open vent on oxygen line	F 001 R 413. Line pressure drops.					
8. Oxygen/air control valve on manual and closed.	FRC 4302					
9. Change from air to oxygen supply in O_2 plant.						
10. Blank air/nitrogen utility line	LN 411					
11. Gasifier deashed and expansion drum full of water.	1. Ashlock bottom cone closed. 2. Ashlock top cone closed. Grate is to be stopped.					
12. Check with process coordinator that oxygen and high pressure steam is available.						
13. Isolation valve in oxygen line open	F 001					

CHECKLIST NO. 8 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
14. Gasifier raw-gas isolation valve to be closed to put of the flame at the flare.	G/GR 415 or 416					
15. Adjust steam flow to 40 %, and keep it constant.						
16. Open oxygen control valve	FRC 4302					
17. Slowly open high pressure steam manual control valve fully - if not already.	Keep steam flow and differential pressure under observation.					
18. Slowly open oxygen control valve	Oxygen flow chart reading should be adjusted in accordance with chart reading of HP steam flow depending of the type of coal used.					

CHECKLIST NO. 8 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
19. Increase gasifier pressure to 10 bar.	Pressure difference between gasifier and jacket below 15 bar.					
20. Rawgas control valve must not close completely.						
21. CO_2 and O_2 analyses done.	CO_2 might rise to between 35 % and 40 % and then fall to 28 % to 30 %. O_2 in rawgas less than 0.4%.					
22. Increase gasifier pressure to 15 bar.						
23. Ashlock in operation.						
24. Gasifier full of coal.						
25. De-ash every one hour.	Grate drive position and running time of grate has to be adjusted with the load of the gasifier.					
26. High pressure steam and oxygen flows checked by instrument technician.						

CHECKLIST NO. 8 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
27. High pressure steam and oxygen control valves switched to automatic						
28. Second Hot pull-up on flanges done	Gasifier/ash lock main flange and other flanges if necessary					
29. Ashlock temp. (tr.3) and gas outlet temp. (tr.4) inside normal limits						
30. Readjust oxygen to steam ratio.	By watching CO_2-content and ash quality.					
31. Control CO_2 in raw gas between 28% and 30 %						
32. Gasifier pressure increased to 20 bar	Ashlock top cone closed during pressure increase.					
33. Gasifier pressure increased to about 25 bar.						

CHECKLIST NO. 8 (continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
34. Switch over to gas cleaning plant						
35. Ashlock in operation de-ashing as normal.						
36. Increase gasifier load.	First steam followed by oxygen.					

Comments:

1) Gasifier jacket and WH 8 drain samples have to be analysed once a week to check BFW quality.

15. GAS COOLING

The purpose of this chapter is to explain the following:

1. how the raw gas is cooled in the gas coolers
2. the equipment used in the cooling process
3. how to control the cooling process.

GAS COOLING

15.1. PURPOSE OF GAS COOLING:

The purpose of the gas Coolers are to cool down the raw gas coming from the Gasifier to the temperature level required at the inlet of the gas cleaning section.

15.2. GENERAL PROCESS DESCRIPTION:

The raw gas from the Gasifier is cooled down to the required temperature level in two stages, namely, wash cooler, waste heat boiler and after cooler. The wash cooler is located on the top of the waste heat boiler and attached to the gasifier outlet. Gas liquor is sprayed here to quench the gas to below the saturation temperature.

15.2.1 Waste Heat Boiler:

The gas from the wash cooler enters the waste heat boiler at about 180°C. It is cooled by boiler feed water sent to the shell side. The waste heat boiler is a shell and tube heat exchanger i.e. the hot raw gas flows through the tubes and the boiler feed water flows between the tubes and shell. Due to the cooling down of the raw gas condensate (Tar and gas liquor) is formed and this collects in the sump. The level in the sump is automatically controlled and the Tary gas liquor is routed to the gas liquor separation plant.

The normal temperature of the raw gas entering the waste heat boiler is 180°C and the normal temperature of the gas leaving is 160°C.

15, 2.2 AFTER COOLER:

This cooler is basically the same as the Waste Heat Boiler. Gas liquor is injected into the top of the after cooler to prevent the formation of ammonium carbonate and bicarbonate crystals. The gas is cooled by means of "Cooling water".

Normal inlet raw gas temperature is 160°C and the normal outlet temperature is 40°C. The condensate formed is oil and gas liquor and is routed to the expansion vessel.

15. 3. OPERATING PROCEDURES:

15. 3.1 TEMPERATURE OF GAS TO GAS CLEANING SECTION:

Overload or fouling of the coolers is indicated by the increasing temperature the outlet temperature at the after cooler (normal 40°C). If this occurs it should be checked that,

a) the cooling water valve at the after cooler is fully open

b) the injection water line to the after cooler is open

c) levels in waste heat boiler and after coolers sump are being controlled correctly i.e. there are no high levels which could block the gas flow.

15.3.2 LEVEL CONTROL OF SUMPS

All levels are controlled automatically. At extreme high level the gas flow can be blocked. At low level the gas may enter into the gas liquor line to gas liquor separation(note:this will blow the safety seals at gas liquor separation).

If an automatic level control system fails the level can be controlled by the bypass for the appropriate valve. Therefore the bypass valves are so installed that the level can be watched when the bypass valves are operated.

If a gas break through has occured immediate action is required and the appropriate control valve or the shut off valve must be closed and the level controlled manually using the bypass.

15.4. TYPICAL QUESTIONS ON GAS COOLING:

1. Describe how raw gas is cooled in the following:
   a) Waste heat boiler
   b) After cooler
2. How are the tubes of the after cooler kept free of blockages.
3. What poisonous gas is found in raw gas ?
4. How would you control the temperature of raw gas to gas cleaning section ?

5. How is the gas liquor levels in the waste heat boiler and after cooler controlled ?

6. What will happen if gas enters the gas liquor lines to the gas liquor separation section ?

7. If any automatic level controllers on the cooling system fail, can the levels still be controlled. How ?

8. How will you know if a gas break through has occured on gas liquor lines ?

9. What are the raw gas inlet and outlet temperatures on each cooler ?

10. Describe the waste heat boiler .

11. Describe the aftercooler .

12. How do the tubes in the after cooler become blocked ?

13. In the event of the raw gas temperature to gas cleaning section being too high (above 40°C), what should be checked ?

14. What is the purpose of the gas cooling ?

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16. GAS LIQUOR SEPARATION

The purpose of this chapter is to provide with a basic knowledge of:

1. How the gas liquor separation section is connected to the gasification section.
2. The feed streams into the gas liquor separation section
3. The general process flow within the gas liquor separation section.
4. How the various feed streams are processed.
5. The equipment used within the section
6. The product streams from the unit.

16. 1. PURPOSE AND CAPACITY OF THE UNIT

16.1.1 PURPOSE

The purpose of the gas liquor separation is to separate various gaseous, liquid and solid components from the gas liquor streams which originate in the gas coolers. Separation takes place by gravity.

The gas liquor streams from the gas coolers originate from cooling and washing of the raw gas from coal gasification. The raw gas contains a large amount of water vapor (undecomposed steam, products of carbonization such as tar, oil, naphta, phenols, chlorine, fluorine and fatty acids. It also contains dissolved gases, mostly ammonia (NH_3) carbon dioxide (CO_2), hydrogen (H_2) and a small amount of combustible gases and coal dust, as well as inorganic salts.

The dissolved gases are removed from the gas liquor by expansion to almost atmospheric pressure. The different liquids and solids are separated in separators by means of physical methods based on settling time and differences in densities.

The products from gas liquor separation are expansion gases, oil, clean tar, heavy dusty tar and a relatively clean water, which is pumped to the biological plant. Oil and possible clean tar products are collected in the existing oil and tar tanks.

16.1.2 CAPACITY

The gas liquor separation unit is designed for a total gas liquor flow of approx. $2 m^3/h$.

16.1.3 NORMAL TEMPERATURES AND PRESSURES OF MAIN STREAMS

There are two streams routed into the gas liquor separation; the dusty gas liquor from the waste heat boiler and the oily gas liquor stream from the after cooler.

16. 1.3.1. DUSTY GAS LIQUOR

This is the condensate form the Waste Heat Boiler (WHB) sump. It contains the coal dust, the main portion of higher phenols and tar, the fatty acids, the chlorine and fluorine and a certain quantity of NH_3 and dissolved gases.

16. 1.3.2. OILY GAS LIQUOR

This condensate originates from the raw gas after-cooler.

The oily gas liquor stream contains the oil (lighter than water), the monophenols and the main portions of NH_3 and dissolved gases and minor portions of the components mentioned for the dusty gas liquor.

16.1.4 FEED STREAMS

16.1.4.1 FLOW OF DUSTY GAS LIQUOR

The dusty gas liquor is released from the waste heat boiler sump in gasification by a level controller, and fed to the primary expansion drum. In the expansion drum, the gas liquor is expanded to almost atmospheric pressure. The expansion gases which escape consist of flashing steam and a part of the gas previously dissolved in the gas liquor. The expanded dusty gas liquor flows by gravity to the tar separators which are working in parallel or in series. To avoid a gas break through to the separators, each expansion drum is equped with a seal of about 6 m. height.

16 .1.4.2 PRIMARY AND SECOODARY TAR SEPARATORS

The dusty gas liquor from the primary expansion drums is mixed with the gas liquor from the tar slop pit before it enters the primary tar separators.

The mixture of the gas liquors is routed to a central inlet pipe in the primary tar separator in which it flows downwards and from where it is distributed radially into the settling zone. In this zone, dust and the heavier tar is separated and settled down into the conical bottom section of the separator.

The gas liquor flows radially back to the outerwall of the separator, where it passes an overflow for oily gas liquor and leaves the primary tar separator. It is combined with the oily gas liquor from the secondary separator working in series or parallel and flows by gravity to the oil separator. A second gas liqu or over-flow is connected to the outer wall of the tar separators, where the clean gas liquor leaves the separators and is routed directly to the gas liquor tank. Tar, which is separated in the settling zone and settled down on the conical roof, is drained through dip pipes to the conical bottom.

The heavy, dusty tar is drained from the bottom of the primary and secondary tar separator to the drain system.

The clean tar settled in the primary and secondary tar separators is withdrawn batchwise from the tar outlet nozzels of the tar separators and is routed by gravity flow to the tar run down tanks. The level of the clean tar can be checked by sample nozzles arranged at the cylindrical wall of the separator. The tar separators are equipped with heating coils, to avoid blockages at the conical bottom, resulting from the high viscosity of cold dusty tar.

16. 1.4.3 FLOW OF OILY GAS LIQUOR (SEE SKETCH 8)

The oily gas liquor from the after cooler is expanded into the secondary expansion drum.

1.4.3.1 SECONDARY EXPANSION DRUM

In the secondary expansion drum the gas liquor from the after cooler is expanded to almost atmospheric pressure. The expansion gases which escape consist of

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flashing steam and carbon dioxide with minor portions of hydrogen, carbon monoxide, ammonia and methane.

To avoid pressure build up in the expansion drums resulting from a failure of the level control valves in gas cooling each expansion drum is equipped with a seal of 6 m height. The gases from the expansion drum are vented to atmosphere , the water is drained to the tar slop pit washer and further to the tar slop pit.

16. 1.4.3.2 OIL SEPARATOR

The expanded gas liquor from the secondary expansion drum flows by gravity to the oil separator. The design of the oil separator is similar to the tar separators and the mode of operation is the same. Since only a very small quantity of tar is expected to settle down in the conical bottom section, the oil separator has no heating coils.

The settled tar is drained batchwise to the trench system leading to the tar slop pit, from where it is pumped back to the separators. The oil separated in the oil separator flows via a fixed internal wier and an adjustable overflow to the oil run down tanks as required. The treated gas liquor flows by gravity to the gas liquor tank.

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The gas liquor is further treated in the biological gas liquor treatment.

16. 1.5 FLOWS WITHIN THE UNIT

16. 1.5.1. FLOW OF GAS LIQUOR FROM TAR SLOP PIT

There are various streams running into the tar slop pit;

a) Gas liquor from gasification

b) Gas liquor (including tar, oil and dust) from "trenches" resulting from draining of equipment in gas liquor separation, gasification and gas cooling.

c) Flushing gas liquor which was used for cleaning purposes.

d) Rain water from the paved area in gas liquor separation.

The gas liquor from the tar slop pit is normally pumped by the tar slop pit pump to the primary tar separators where it is treated together with the dusty gas liquor.

16 .1.6 RECYCLED HIGH PRESSURE INJECTION GAS LIQUOR

High pressure injection gas liquor is needed for injection into the wash cooler and into the after cooler. The gas liquor is taken from the gas liquor tank and pumped by the h.p.gas liquor injection pumps.

16. 1.7 FLOWS OUT OF UNIT

1.7.1 GAS LIQUOR

The treated gas liquor is transferred from gas liquor separation to the biological gas liquor treatment pumps .

16. 1.7.2 OIL

The oil separated in gas liquor separation flows to the oil run down tank.

16 .1.7.3 TAR

The heavy dusty tar is drained to the slop pit and has to be removed by from time to time.
The clean tar settled in the primary tar separators flows by gravity to the tar run down tanks.

16.1.7.4 EXPANSION GASES

The expansion gas lines from the primary and secondary expansion drums are routed to atmosphère.

TYPICAL QUESTIONS ON GAS LIQUOR SEPARATION

1. What is the purpose of the gas liquor separation unit ?
2. Define dusty gas liquor and describe the flow to the tar separators.
3. Define oily gas liquor and describe the flow.
4. Apart from dusty gas liquor what other gas liquor stream is fed to the tar separators ?
5. What is the purpose of the tar separators ?
6. What is the purpose of the oil separator ?
7. Describe what takes place in the expansion drums?
8. What is the tar slop pit and from where does it get its feed?
9. High pressure injection gas liquor is needed in various parts of the plant, (a) what are they ? (b) from where is it taken ? (c) how is it pumped ?
10. What are the tar run down tanks.
11. Draw a rough sketch of the dusty and oily gas liquor flow.

17) MAINTENANCE GUIDES

EXPANSION VESSEL

No special maintenance work to be done.

(a) Gasifier:

Checking: Water level glasses daily
(to be drained)
No further actions are necessary.

(b) Grate and Grate drive:

following work to be done:

1) Checking: Every 4 hours tightness of stuffing box.

2) Lubrication to be done:

1) Every shift grate bearings
2) Every 4 hours.
a) Pinion bearing
b) Stuffing box.

3) Testing: After 2000 hours of operation dismantel pinion and check surface of teeth, also clearance of pinion bearing.

COAL LOCK

1) Checkings

1.1 Before new test run fill up space for packing with asbestos rings.

1.2 Every shift tightness of stuffing box

1.3 After each test run dismantel top flange of top closure and check rubber ring.

Replace new rubber ring carefully (Plastic hammer).

2) Lubrication: Stuffing box every shift.

3) Repair of top and bottom closure-seats:
This has to be done by special welding and grinding procedure.

ASH LOCK

1) Checking:

1.1 Before new test run fill up space for packing with asbestos rings.

1.2 Every shift tightness of stuffing box.

1.3 After each test run dismantel lower flange of bottom closure and check rubber ring.

Replace rubber ring carefully. (plastic hammer).

2) Lubrication:

2.1 Stuffing box every shift.

3) Repair of top and bottom closure-seats:

This has to be done by special welding and grinding procedure.

G 433 <u>MER - Recirculating Pump.</u>

(a) <u>Checking:</u>

1) Stuffing box every 4 hours (slight dripping normal, too tight stuffing box produces burning of material)

If leakage increases tighten slightly.

2) Watch cooling water flow for stuffing box.

3) Smooth running of pumps

4) Bearings to be checked, temperature normal about 50°C; temperature must not exceed 80°C.

5) Renew oil according description in manual.

(b) <u>Lubrication:</u>

1) Keep oil level in sight glas

2) Renew oil according to service Instructions in manual.

Remarks: See also instructions in manual.

STEAM DRIVEN FEED-WATER PUMPS

(a) Checking:

1) If necessary tighten stuffing boxes slightly and evenly.

2) Renew packings from time to time.

3) If service decreases, grind pump valves with fine emery and oil.

(b) Lubrication:

1) Watch lubrication of steam cylinders regularly.

Remarks: See also instructions in manual.

HP-FEED WATER PUMP

(a) Checking:

1) Smooth and non-vibrating running
2) Bearing temperatures (50-80°C)
3) Cooling water flow.
4) Stuffing box.

(See also G 433 Recirculating Pump)

(b) Lubrication:

1) Grease- lubricated bearings: Renew bearing grease every 6 months (Fill only 2/3 of free space).

Remarks: See also instructions in manual.

18) SAFETY REGULATION

1 **Introduction**

1.1 Safety regulations are to be adhered to at all times.

1.2 These regulations are binding on all persons.

1.3 All operating personnel should be familiar with the Safety Regulations, and emergency procedures at all times.

1.4 All operating personnel are to make themselves familiar with fire and emergency equipment in the plant and no obstructions are to be placed near this equipment.

2 **Coal handling plant**

2.1 Inspection of coal and gasifier bunkers.

2.1.1 No person is to enter a bunker unless authorised.

2.1.2 A safety belt and Drager gas mask willl be worn by any person entering a bunker, the safety belt to be securely anchored.

2.1.3 For every person entering a bunker two persons are to be on standby. They will also be equipped with safety belts and gas masks.

2.1.4. If any ladders are hung inside a bunker they must be securely anchored at the top of the bunker.

2.1.5 Maintenance personnel who intend working on a conveyor must ensure that the equipment is isolated before work begins.

2.1.6 Cleaning of conveyors

No cleaning on, under or alongside moving conveyors is permitted.
No bent iron bars etc.are to be used to clean chutes. If this is necessary the rod must be smooth, straight and have no sharp ends.

2.1.7 No person may climb over a moving or stationary conveyor excepting where walkways are provided.

3 Gasifiers

3.1 Work in or inside inspection of a gasifier

3.1.1 No work or inspection may take place unless all precautions, according to relevant check-lists, have been taken.

3.1.2 No person may enter a gasifier unless the coal lock has been removed.

3.1.3 No person may enter a gasifier unless fresh air is blowing into the gasifier.

3.1.4 Any ladder hanging inside a gasifier is to be firmly tied at the top.

3.2 <u>Tightening of ash lock top and bottom cone glands</u>

Under no circumstances can this work be performed while the ash lock is under pressure.

3.3 <u>Opening of ash lock bottom cone</u>

The ash lock operator must ensure that no persons are in the immediate vicinity of the ash lock when the bottom cone is opened.

3.4 <u>Removing an ash lock bottom cone and seat while the ash lock is still full of ash or water</u>

It must always be borne in mind that it is extremely dangerous to perform this task while the ash lock may be full of ash or water, and as such, may only be carried out under the direct supervision of the shift coordinator. To prevent accidents and injuries the following procedure must be strictly adhered to;

Ash lock depressurised.

3.5 Under no circumstances must any equipment be operated above stated pressures or temperatures. A dnagerous situation can result if this occurs.

3.6 No water may be fed into the gasifier from the ash lock while it is still hot.

4. Gas liquor separation and gas cooling

Entry into sumps, ash canals, tanks or sewers

4.1 No person may enter any of the above mentioned without a permit.

4.2 No person may sign his own permit. This may only be done by an authorised official.

4.3 When manholes are opened, and until safe for entry, the area is to be fenced off and a "no entry" sign hung.

4.4 Before any of the above are entered a standby person must be in attendance. He is not to leave his post until the person working inside has left the vessel, canal or sewer.

5. General Safety Regulations

5.1 Operating

The plant is to be kept in a neat and tidy condition to minimise fire hazards.

5.2 Gloves are to be worn when opening valves on steam or hot product lines.

5.3 Safety goggles are to be worn to prevent eye injuries.

5.4 Gas masks are to be worn by any person shutting down equipment where gas is present, e.g., wash cooler pumps when the packing has blown out, process lines which have developed

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leaks, and leaking flanges on a W.H.B. In these circumstances a senior person must be on standby until the equipment is safe.

5.5 All temperature alarms must be checked atleast once per shift. If any are found to be faulty the fact is to be reported immediately.

6 General Maintenance Regulations

6.1 In an emergency, maintenance personnel are responsible to the shift incharge or more senior official.

6.2 Certain maintenance requires, apart from a work permit, a check-list which is to be completed before work can commence. Maintenance personnel are expected to be familiar with these check-lists.

6.3 All persons doing standby where welding is being carried out are to wear welding goggles and not look directly at the welding.

6.4 No oxygen or acetylene cylinders are allowed on the coal lock floor of the gasification building, or any other high floor where they may fall through. They must always be placed on the lowest possible floor and long hoses used to reach higher levels.

6.5 All safety equipment, as laid down in the Safety Regulations, must be available before entry into any sump, tank or gasifier,. Regulations regarding entry into sumps, vessels, gasifiers etc.must be adhered to.

6.6 The person on standby where maintenance is being performed must be aware of safety precautions written in the permit and must ensure that these are carried out.

6.7 If safety precautions, written on a permit, are not strictly adhered to the standby person is to stop all work until such time as they are.

6.8 Protective clothing, as specified on the permit, must be worn until the work has been completed.

7. <u>Procedure in the event of a fire or gas emergency</u>

7.1 <u>General</u>

7.1.1 If a fire is discovered, inform the shift incharge and try to contain the fire.

7.1.2 The shift Coordinator or more senior official is to discuss strategy. Request the use of special fire suits to isolate equipment if necessary.

7.1.3 The Shift incharge or senior official will decide which equipment is to be isolated.

7.1.4 Persons not involved with the fire will remain in their positions (according to emergency procedures) and may only leave those positions on instructions from the shift coordinator or more senior officials.

7.2 Fire fighting

7.2.1 Gas Fires

a) Isolate equipment and depressurise through the flare, and if possible blow nitrogen or steam through the relevant equipment.

b) Contain secondary fires with fire extinguishers or steam hoses and keep equipment cool with water.

7.2.2 Electrical Fires

a) Attempt to swtich off electric motor and ask electrical department to isolate.

b) Contain fire with CO_2 and dry powder extinghishers. Never use water or foam on an electrical fire.

7.3 Gas Emergencies

7.3.1. When a serious gas leak developes which can be a danger to people, fire hazard or explosive hazard, a Drager gas mask, which are situated in strategic positions, must be worn.

7.3.2. Inform Shift Coordinator and other departments.

7.3.3. Proceed as laid down in the emergency procedures.

7.3.4 Rescue of persons who are trapped in dangerous or awkward positions must be carried out by the rescue team.

8. <u>BY-LAWS TO SAFETY REGULATIONS:</u>

Dangerous and hazardous materials which are handled in the gasification section or which arise from problems in adjoining sections.

Action to be taken in the event of an emergency and procedures to be followed in combating specific emergencies.

The following dangerous and hazardous materials are handled in the gasification plant or can be present as a result of problems in adjoining plants.

a) Ammonia (NH_3)
b) Carbon dioxide (CO_2)
c) Carbon monoxide (CO)
d) Hydrogen (H_2)
e) Hydrogen sulphide (H_2S)
f) Nitrogen (N_2)
g) Oxygen (O_2)
h) Raw gas
i) Hydrochloric acid (HCL)
j) Potassium hydroxide (KOH)
k) Hot water and steam
l) Gas liquor
m) Lime

n) Coal dust

o) Tar and oil

p) Polyrad foam depressant

1 Ammonia (NH_3)

1.1 Characteristics

This is a colourless gas with a sharp, pungent smell. It affects the eyes and skin and can cause severe irritation even in small quantities. Under certain conditions a mixture of ammonia and air is explosive (between 15 and 28% NH_3 in air). 53 ppm is the lowest percentage which can be detected by smell. A Drager tube detector can be used to detect an ammonia concentration of higher than 100 ppm (0,01%).

Note: Concentration above 100 ppm are dangerous, and above 5 000 ppm fatal, if inhaled for a few minutes.

1.2 Treatment

In the event of a person being overcome by ammonia gas he must be removed to fresh air immediately. Apply artificial respiration and call for an ambulance. Keep the patient warm.

2. Carbon dioxide (CO_2)

2.1 Characteristics

This is a colourless, odourless, tasteless, and non-explosive gas which is heavier than air, and is found in the bottom of tanks, containers and sumps. In high concentrations it causes suffocation followed by death. A gas mask should always be worn when entering tanks etc which may contain CO_2

2.2 Treatment

Remove the patient to fresh air immediately and apply artificial respiration. Use oxygen if necessary. Keep the patient warm and call for ~~c~~an ambulance and medical help.

3 Carbon monoxide (CO)

3.1 Characteristics

This is a highly poisonous gas, even in low concentrations. It is colourless, odourless and tasteless and is lighter than air. Symtoms of gassing are a pinkish tinge to the skin, pink lips and a generally healthy appearance, headaches and a feeling of restlessness. The maximum acceptable concentration for an eight hour period is 100 ppm. The explosive range, when mixed with air, is 12,5-74,0%.

3.2 Precautions

Use a Drager CO detector whenever it is

a) possuble that CO may be present. In the event of a positive result being obtained a gas mask must be used immediately and notices posted.

b) a gas mask must always be worn when tanks or vessels are opened.

3.3 Treatment

As for Carbon Dioxide treatment 2.2

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4 Hydrogen (H_2)

4.1 Characteristics

This is the lightest known gas and is highly combustible. It is colourless, odourless and not poisonous. If under pressure it becomes hot as the pressure is reduced. When mixed with air it is highly explosive and it is difficult to see its flame during day light.

4.2 Precautions

Leaks are to be reported immediately and a steam lance to be directed onto the leak until repaired or isolated.

5 Sulphurated hydrogen (H_2S)

5.1 Characteristics :

This is a colourless gas with a smell of rotten eggs. It is heavier than air, poisnous and explosive. It affects the eyes and lungs and causes diaorea and itching . Symptoms of low concentrations are; vomiting, swollen and watery eyes . The explosive percentage, mixed with air is 4,3 to 45% and the permissible concentration over an eight hour period is 20 ppm.

5.2 Precautions

Always wear a gas mask in areas where H_2S may be present.

5.3 Treatment

Immediately remove the patient to fresh air and apply artificial respiration, or administer oxygen. Call for an ambulance and medical assistance.

6 Nitrogen (N_2)

6.1 Characteristics

This is a colourless, odourless, non-flammable gas and is lighter than air. When released it can thin the air to below the necessary 18% oxygen content and thus cause death.

6.2 Precautions

a) A gas mask must be worn when entering vessels which have been purged with nitrogen.

b) Keep away from vessels with open manholes when they are being purged with nitrogen.

c) Post notices and fence off areas where nitrogen is used to purge open vessels.

7. 6.3 Treatment

As for sulphurated hydrogen 5.3.

7. Oxygen (O_2)

7.1. Characteristics

It is a colourless, odourless and tasteless gas which constitutes 20% of the earth's atomosphere. It is highly reactive and it therefore follows that materials such as oil, grease etc. can be ignited at room temperature, by a spark. If the oxygen concentration exceeds 25% it becomes known as an oxygen atmosphere. Persons who are exposed to this atmosphere must keep away from all sources of ignition. This condition also causes inert materials such as steel and other metals to burn.

7.2 Precautions

a) Never use grease or lubricants on any oxygen valves or other equipment.

b) When working with oxygen never wear clothing or wear gloves which are oil or grease stained.

c) Oxygen, under pressure, must never be blown off unless an authorised permit has been issued.

d) When oxygen valves are opened this must only be done slowly.

e) In the event of a fire isolate the oxygen immediately and quench the fire with water.

f) Oxygen back-pressure into a gas line can cause an explosion - prevent this.

7.3 Treatment

a) Oxygen fires cause 3rd degree burns. Move the patient out of danger immediately.

b) Do not attempt to remove patients clothing or apply any ointments.

c) Call for an ambulance and medical assistance.

8 Raw Gas

8.1 Characteristics

This is a highly inflammable, poisonous gas with a very marked smell. It contains CO_2, CO, H_2 and CH_4 with traces of sulphur, the last named being the source of the smell. Raw gas is lighter than air and forms an explosive mixture when mixed with air.

8.2 Precautions

As for CO_2, CO, H_2 (2.2.,3.2., 4.2)

8.3 Treatment

As for CO_2, CO, H_2 (2.3., 3.3., 4.3)

9 Hydrochloric acid (HCL)

9.1 Characteristics

This is a colourless to light yellow fluid with an irritating smell. It causes wounds on the skin and in some cases permanent damage. It gives off heat when mixed with water.

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9.2 <u>Precautions</u>

a) When handling hydrochloric acid always wear protective clothing, i.e. PVC suit, face shield, PVC gloves and gum boots.

b) If spilt use sufficient water to flush away. In the event of a large spillage first neutralise the HCl with lime and use large volumes of water to wash away.

9.3 <u>Treatment</u>

If HCl is spilt onto the body first remove all clothing and rinse the body with plenty of water.

10 <u>Potassium hydroxide (KOH)</u>

10.1 <u>Characteristics</u>

In the solid form it is crystallised, In the liquid form and in a water solution it has an adverse effect on human limbs. It causes burn wounds , scarring and blindness, if splashed into the eyes.

10.2 <u>Precautions</u>

a) Use PVC gloves and safety goggles when handling KOH.

b) prevent spillage and wash away if this occurs.

10.3 <u>Treatment</u>

a) In the event of calcium hydroxide being splashed over the clothes and body remove clothing and wash body with plenty of running water.

b) Call for an ambulance and medical assistance.

11 Hot Water

11.1 Precautions

a) Use plastic containers when sampling hot water or condensate and wear gloves and goggles.

11.2 Treatment

a) Move the patient out of danger, call for an ambulance and medical assistance.

12 Polyrad foam

12.1 Characteristics

This is a thick, syrupy, liquid which is dark brown in colour and is used for the chemical cleaning of equipment. It is not poisonous but irritating when in the eyes.

12.2 Precautions

Use PVC gloves and safety goggles when handling the foam.

12.3 Treatment

Wash the eyes and affected parts of the body with water as soon as possible.

13 Gas liquor

13.1 Characteristics

Gas liquor contains ammonia and fenols and is a yellow liquid with a sharp smell. It has an

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adverse effect on the skin and irritates the eyes. Fenols are quickly absorbed through the skin. Symptoms of poisoning are jerky breathing, listnessness, a feeling of lameness partial blindness and a heaviness of the eye lids. The maximum acceptable phenol concentration is 5 ppm.

13.2 Precautions

a) Wear a face shield and PVC gloves when sampling or handling gas liquor.

b) Have all leaks on valves, pipes and containers repaired immediately.

c) Rub "Barrier" cream on all exposed parts of the body before handling gas liquor.

13.3 Treatment

a) If a person is overcome by gas liquor fumes he must be removed to fresh air and artificial respiration applied.

b) Call for an ambulance and medical assistance.

c) Any gas liquor which has come into contact with the eyes or skin must be washed away with running water.

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14 Lime

14.1 Characteristics

This is a white powder which when mixed with water forms an alkali solution. During the mixing, heat is generated. In the powder form form it causes irritatation to the skin, eyes and affects breathing.

14.2 Precautions

Use gloves, safety goggles and a nose mask when handling lime.

14.3 Treatment

If the eyes or any part of the body are effected wash off with running water.

15 Coal dust

15.1 Characteristics

Coal dust causes irritation to the eyes and can permanently damage the cornea of the eye. It will burn and is explesive when well mixed with air , for example in an empty vessel.

15.2 Treatment

Wash the eyes with running water.

16 Tar and oil

16.1 Characteristics

Tar is a black, course liquid when above melting temperature and is heavier than water. Oil is a brown, smooth liquid which floats on water. THBy contain phnols and ammonia.

16.2 Precautions

a) Ensure that tar and oil does not come in contact with the skin.

b) When handling these products wear PVC gloves and safety goggles. Do not wear leather gloves as they become saturated with the product.

c) Do not inhale tar or oil fumes.

16.3 Treatment

When tar or oil come in contact with skin or eyes they cause irritation. Wash immediately with running water.

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