INDIAN OIL CORPORATION

Propelled by a sense of determination fueled, fueled by a spirit of innovation the effort of thousands of dedicated Indians wrote a glorious, new chapter on the Indian oil story.

Only three decades ago, Indian looked to the world for help in its quest for oil. Then slowly, but surely the scenario changed. Indian oil corporation ltd.(Estd.1958) with Indian oil company(Estd.1959)played a leader role in this transformation.

Today, Indian oil owns and operates 6 refineries at Digboi, Guwahati, Haldia, Barauni, Mathura and Gujarate amongst the country's twelve refineries, with a combined crude oil refining capacity of over 24 million tones which is about 47% of the total refining capacity in India. Indian oil's seventh grassroots refinery is coming up at Karnal in Haryana with a capacity of 6 million tones per annum.

Indian oil's first product pipeline in the Guwahati-Siliguri sector carned itself the honors of being the first petroleum product pipeline to be constructed on the eastern side of suez canal.Indian oil's pipeline length progressively grew to today's level of over 3800 km maintaining an uninterrupted flow of crude oil to refineries and petroleum products to the consuming centers across the length and breadth of the country.Currently, Indian oil is executing its longest ever petroleum product pipeline ,all of 1454 km, originating from Kandla in Gujarat and terminating at Bhatinda in Punjab.

What's more, Indian oil reaches a wide spectrum of customers through its marketing wing .it sells over 32 million tones of petroleum products annually through a country wide marketing network. Indian oil commands a market share of about 57% on the whole. it is interesting to note that Indian oil runs a retail outlet at the world's highest point kaza in Himalayas as well.

Indian oil is the only oil refining and marketing company in India India which has a full fledged research and development center. nearly 600 of the lubricant formulations developed at this center have been commercialized thereby indegenising over 95% of the lubricant marketed by Indian oil. This center has mastered the complete know how of FCC catalyst evaluations and manufacturing in India with its own formulation apart from giving support services on fcc's to Indian refineries.

MATHURA REFINERY

The modern temple : Mathura refinery standing bold on the outskirts of Mathura on Delhi-Agra highway, has been the harbinger of technological advancement in this region in perfect harmony with the environment. Nurturing technology amidst the greens has been a pioneering experiment of a modern industry and Mathura refinery takes pride in successfully accomplishing this arduous task since its inception.

A torch bearer of north west India: Mathura refinery has been the focal point of development in industrial and transportation sector for almost the entire northwest India since it's commissioning in jan.82. This 7.5 million tonne refinery is india's latest and most modern refinery. Also, it has the wide adaptability of processing over 30 types of crude oil. This ranges from indigenous Bombay offshore crude to imported crudes of Australian origin in the east and Nigeria and Venezuela in the far west. Mathura refinery has the distinction of having single largest capacity crude distillation unit which has the unique engineering marvel of 67 m high crude distillation column. the crude to the refinery is received from salary in west coast through a dedicated cross country 1078km pipeline . Products from this refinery are dispatched through rail, road and Mathura-Delhi-Ambala-Jalandhar pipeline .the contribution of Mathura refinery in meeting the petroleum products demand of north west India is about 68%. The LPG bottling plant situated with in Mathura refinery premises bottles nearly 7 million cylinders per annum for catering to domestic market. Major fertilizes industries at Kanpur,Panipat, Nangal, Bhatinda and Kota are supplied with naphtha or furnace oil/ heavy petroleum stock as fertilizer feed stocks from Mathura refinery. Also, thermal power plants of Nangal, Obra and Badarpur get fuel oil supply from this refinery. Apart from this, Mathura refinery is privileged to provide the necessary energy to the pulsating capital, New Delhi and also boost the standards of the farmers belonging to the crop rich lands of Punjab and Haryana.

The other important product, bitumen, has paved the transportation sector in this region on to road worthiness. To keep the environment clean and green.Mathura refinery recovers nearly 10,000kgs of sulphur everyday as a by-product from crude oil.

PRODUCTS AND THEIR SPECIFICATION

The following petroleum products are obtained from crude oil in Mathura refinery,

1. Liquidified petroleum gas
2. Motor sprit or petrol
3. Naphtha
4. Aviation turbine fuel
5. Kerosene oil
6. High speed diesel oil
7. Light diesel oil
8. Fertilizer feed stock
9. Heavy petroleum stock
10. Bitumen
11. Sulphur

PRODUCT SPECIFICATION:

L.P.G:

1. Copper corrosion at 38ºC for one hour.
2. Total volatile sulphur = 0.02%max
3. Vapour pressure at 65ºC = 16.87ºC Kg/cm² gauge.
4. Hydrogen sulfide = absent.
5. Dryness =no free entrained water.
6. Weathering test =83ºC

MOTOR GASOLINE:

1. Colour usually orange
2. Copper strip corrosion for 3 hrs at 50ºC.
3. Octane number = 88RON, 93RON
4. Residue on evaporation = 4mg/100m³.
5. Sulphur total =0.25wt%
6. Vapour pressure at 38ºC = 0.70Kg/cm²
7. Flash point = below 25ºC.

ATF:

1. Appearance =usually clear and bright free from.
2. Flash point = 38ºC
3. Freezing point = -50ºC
4. Smoke point = 20 mm max.

ATMOSPHEREIC AND VACUUM UNIT

The crude distillation unit was designed for desalting and primary distillation of light Arabian crude and North Rumalia mixture in the proportion of 1:1.

The nominal designed capacity of the unit was 6MMTPA of the above crude on mixture. However the designed provided a possibility of processing 7MMTPA of crude of containing 2% weight of gas. Process calculation, sizing of vessels and equipment was made for the same.

The unit has been revamped in different stages to raise its capacity and to process different types of crude including indigenous crude from Bombay High. Subsequent to these revamps, the nominal capacity of the unit stands at 8 MMTPA for processing imported Middle East crude and 7MMTPA for processing Bombay High. Based on 50:50 processing of imported and BH crudes in blocked out operation, the nominal capacity of the unit stands at 7.5 MMTPA.

The unit has been designed to produce the following cuts:

LPG	To be sent to Merox treating unit
C_5 –140 °C	Naphtha component
140-250°C	To be used as ATF after Merox treatment
140-270 °C	To be used as superior kerosene after Merox treatment
250(270)-320 °C	Light gas oil (HSD component)
320-380 °C	Heavy gas oil (HSD component)
< 380 °C	Light Vacuum gas oil to be used as HSD component or as LDO
380-425 °C	LDO to be used as LDO component or FCCU feedstock
425-530 °C	FCCU feedstock
Vacuum slops	To be blended into finished FO or to FFS
Hydrocarbon gas	To be sent to refinery fuel gas system
Atmospheric Residue	To be used as VBU feed component for the internal fuel oil and as a FFS component
Vacuum Residue	To be used as feed for BBU,VBU, a component for internal fuel oil and a

	FFS component

Crudes being processed in Mathura Refinery:

Low sulphur crudes	Indian Nigerian	Bombay High Qua Iboe
High sulphur crudes	Saudi Arabian Kuwait Egypt Dubai Abu Dhabi	Arab Medium Burgan, Ahmedi etc. Gulf of Suez Dubai Export Zakum Upper

Stream Days: Number of stream days per year is 345 days for crude distillation and vacuum section.

DESCRIPTION OF PROCESS FLOW SCHEME:

FEED SUPPLY: crude is stored in eight storage tanks (six having a nominal capacity of 50,000 m^3 each and remaining two are of 65,000m^3 each). Booster pumps located in the off-sites are used to deliver crude to the unit feed pumps. Filters are installed on the suction manifold of crude pumps to trap foreign matter. For processing slop, pumps are located in the off site area which regulate the quantity of slop into the crude header after filters. Provision to inject proportioned quantity of demulsifier into the unit crude pumps suction header with the help of dosing pump is available.

FEED PREHEAT (PRE-DESALTER) CIRCUIT: Crude oil from feed pumps is charged to heat exchangers in two parallel streams.

DESALTING: Desalting is a purifying process used for the removal of salts, inorganic particles and residual water from crude oil and thereby reducing corrosion and fouling of equipments. These impurities are brought along with the residual water content of the crude oil. Water drops ordinarily are so small that simple gravity settling is very poor .in an oil pool, the molecules that are least similar to the bulk of oil are subjected to less intermolecular forces. Being less attracted to the inner body of the oil, the exceptional material will be rejected to an inter-face of the oil/water drops. Such rejected surface active materials comprise a physical barrier that prevents water drops from getting close enough to bring about coalesce. Before the drops can coalesce the stabilizer film must be reduced in thickness, tenacity and therefore ruptured.

The electric field is a powerful tool for overcoming the resistance of stabilizing films. The collision and coalescence of drops is accomplished by an induced dipole attraction between them. As the droplets then approach each other, the force between them becomes very great. The stabilizing films are squeezed between the drops and coalescence is rapid. The large water droplets produced fall through the oil phase at a faster rate. This desalting process consists of three main stages, viz. heating, mixing and settling. Crude oil is heated to 125-135 °C in the pre-desalter heat exchanger train. Water is injected under flow control upstream of mixing valves. Provision is given at crude pumps suction also to facilitate break-up of tightly bound oil-water emulsion. Brine outlet from the desalters is cooled in air cooler and water cooler before final disposal. Desalter pressure is controlled between 11-12 kg-12 kg/cm^2 by a conyrol valve located at the discharge end of the crude feed pumps.

POST DESALTER CRUDE PREHEATING: Desalted crude from desalter is pumped by post desalter pumps into streams going through a second train (two in parallel) of heat exchangers. Downstream of the exchangers trains, crude oil streams combine to average out the temperature. Normal preheat temperature is in the range of 230-250 °C.

FIRED HEATERS: the preheated crude is further heated and partially vaporized in three parallel tubular heaters. Each furnace is four pass heater with air preheater. Each furnace is provided with 14 burners capable of firing FO and FG, either fully or partially. Convection section has 8 rows of tubes with 8 tubes in each row. Two rows of shock tubes just above the radiant section are plain tubes with out studs. In the convection section 4 studded tubes are for the service of superheating MP stream for strippers. The radiant box has 21 tubes in each pass. Convection zone had 12 rotary and 12 retractable soot blowers in two rows.

AIR PREHEATER SECTION: To recover waste heat from flue gases of CDU and VDU furnaces four identical parallel stationary air preheater units are provided and installed in parallel. At APH cold combustion air will pick up heat flue gas poat tobeme routed to the burner could to the burners for efficient combustion. Three FD fans each capable of 55% of full load are provided with SCAPH in there discharge to heat the air unto 45 °C. the combustion air requirement of each heater is controlled by individual FICS damper located in the air duct to the respective furnace. Load on the fans is varied by regulating the inlet guide vances. Heaters are provided with slain temp O_2 analyzer and draft gauges.

Furnaces are provided with different trip logic to save the equipments under different abnormalities.

CORROSION INHIBITOR: A solution of corrosion inhibitor in light hydrocarbon is required to be properly dispersed in vapor stream to combat corrosion of the overhead system. Most of the inhibitor is active in specific ranges closes to neutral.

DEMULSIFIER: the injection rate should be around 6-8 ppm on crude.

GENERAL:

Corrosion inhibitor drums	165 kg/drum
Ammonia cylinders	60 kg/cylinder
Demulsifier drums	185 kg/drum

VISBREAKER UNIT

The visbreaker unit is designed for processing a mixture a mixture of atmospheric and vacuum residue from 1:1 mixture of light Arabian and north Rumalia crudes. It reduces the viscosity and pour point of heavy petroleum fractions so that product can be sold as fuel oil. The capacity of the plant is 0.8 – 1.0 MMTPA of mixed feed. Products of this unit are LPG, Gasoline, gas oil and VB tar.

THEORY OF VISBREAKING:

The visbreaker is essentially a thermal cracking unit designed to operate at mild conditions and to retain all the cracked light oils in the bottom product. In the thermal cracking reaction heavy oil is kept at a high temperature for a certain amount of time and this causes the larger molecules to breakup. The resulting product has a random distribution of molecular sizes resulting in products ranging from light gas to heavy gas oil. Whenever a molecule breaks up one of the resulting molecules is an olefin.

$CH_3CH_2CH_2CH_2CH_2CH_2CH_3 \rightarrow CH_3CH_2CH{=}CH_2 + CH_3CH_2CH_3$

Cracked products are unstable and form gum. During the cracking operation, some coke is usually formed. Coke is the end product of polymerization reaction in which two large olefinic molecules combine to form an even larger olefinic molecule.

$C_{10}H_{21}CH{=}CH_2 + CH_2{=}CHC_{10}H_{21} \rightarrow C_{10}H_{21}CH{=}CHCH_2CH_2C_{10}H_{21}$

When the above reaction gets repeated several times the end product is coke. Severity of overall reaction is determined by residence time and temperature of cracking.

PROCESS FLOW DESCRIPTION:

General: the feed stock form AVU is received in the surge drum. Pumps take suction from the drum and discharges through a set of preheat exchangers into two furnaces operating in parallel. Each furnace has two passes and provided heat required for preheating and cracking reaction of feed under controlled conditions. The furnace effluent is sent to a soaker for further cracking. The residence time in the soaker is as large as 30 minutes. Soaker effluent is quenched by injecting cooled VB tar to arrest further cracking. There is also provision of processing slop in the unit.

The quenched effluent enters the main fractionators where gas and gasoline are withdrawn as overhead, heavy naphtha and gas oil as side streams and VB tar as bottom. The over from the fractionators are cooled and condensed. The gas goes to FCC and the gasoline is partly refluxed and the rest sent to stabilizer. The stabilized gasoline is sent to naphtha Merox unit for sulphur removal.

The heavy naphtha drawn is steam stripped in heavy naphtha stripper. It is then cooled and mixed with MGO and LDO.

The gas oil is drawn from the pan of the tower and is steam stripped in the stripper to meet flash point specification. It is cooled in air cooler and mixed with VB tar leaving the unit or can be routed HSD pool. The VB tar from the main column bottom flows into tar stripper where gas oil fractions are evaporated as a result of pressure reduction. The tar after cooling is partly sent to the bottom of flash fractionators, tar stripper, heat transfer lines such as quench and the rest goes to storage tank after further cooling by either mixing with oil or alone.

FEED SUPPLY AND PREHEATING: the unit feed is normally supplied from tank to feed surge drum at a temperature of 90°C and during prolonged run of imported crude, from AVU at 150°C. From the surge drum, the feed is pumped successively via feed /VB tar exchangers where feed is heated from 125 - 335°C and VB tar is cooled 351 - 257°C.

VISBREAKER FURNACES: VBU is provided with two identical natural draft furnaces. They are upright steel structures with outer steel casing lined with refractory material. Each of the furnaces has a radiation section at the bottom, convection section above it and stack at the top. The convection section is provided to increase thermal efficiency of the furnace by removing further heat from the flue gases leaving the radiation section. It is having steam superheater tubes, steam-generating tubes and oil tubes each of these numbering 6,10 and 14 respectively. The radiation section houses the radiation tubes numbering 30 in each pass. In this section heat is transferred primarily by radiation by flame and hot combustible gases. The maximum allowed tubes skin and box temperature in the heaters are 650°C and 750°C respectively. Boiler feed water is circulated through steam generating coils to recover heat from the flue gas.

Feed from exchangers is supplied to furnaces in two parallel streams at a pressure of 17.6 kg /cm^2. Each furnace has got two passes. Flow through each pass is controlled by flow control valves and feed is heated up to 485°C.

The feed is first heated in the convection section and then it passes through radiant zone coils located in the two compartments of each furnace. Each compartment has individual firing controls. Combinations of oil and gas burners have been provided. Return lines are provided on all the four fuel oil headers of the furnaces. A 1:1 ratio of fuel oil consumption to return is provided to obtain good control on firing and prevent congealing of the internal fuel oil system.

Pressure of atomizing steam to burner for all the four passes are controlled by differential pressure controllers provided in field 1.5 kg /cm^2 differential pressure between fuel oil and atomizing steam is maintained to achieve good atomization and efficient burning of fuel oil i.e. steam pressure is 1.5 kg/cm^2 more than fuel oil pressure.

To arrest cracking reactions, material from each pass of the two furnaces is individually quenched by the injection of cooled VB tar at 232°C. The quench rate is controlled by flow controller. To increase turbulence and to prevent coke deposit in the coil, there is provision to inject steam in each pass.

VB FRACTIONATOR: furnace effluent after quenching enters the fractionator. Temperature in the flash zone is around 427°C. From the column, gas and gasoline are separated as side stream and the VB tar as bottoms. The fractionator has 22 valve trays and one blind tray. Feed enters flash zone below the blind accumulator tray. The overhead vapors from the column are condensed and cooled. The liquid vapor mixture is separated in the reflux drum. Gasoline from the reflux drum is picked up by pumps and partly pumped to column top as reflux. Top temperature is maintained at about 137°C. The remaining gasoline is routed to stabilizer under reflux drum level controller. The sour water is drained from the drum boot under interface level controller and routed to sour water stripper. Main reflux drum and its water boot are having level glasses. Uncondensed gas from the reflux drum goes to FCC/AVU furnaces/flare. Column top pressure is maintained at around 3.2 kg/cm^2. Column overhead line is provided with working and controlled safety valves. Stabilizer reflux pump takes suction from the drum and discharges it to column top as reflux. Drum is provided with a boot from where is routed to sour water stripper. Stabilizer bottom temperature is maintained about 180°C.in the reboiler, gas oil circulating reflux is cooled from 327-260°C. Stabilizer bottom goes out by its own pressure to exchanger where it cools down from 180 - 120°C. Then it is further cooled to 40°C in water cooler. Stabilized gasoline is routed to Merox unit for sulphur removal.

FLUDISED CATALYTIC CRACKING UNIT

INTRODUCTION: the unit is designed for use of high alumina micro spherical synthetic catalyst as fresh catalyst. At start up, rather than charging fresh catalyst, which is very active used catalyst, which is less active and which represents equilibrium condition when unit is in normal operation is charged to the unit as initial inventory. This type of catalyst is known as equilibrium catalyst. Fresh cannot be used for initial charge, as it will substantially over crack the feed till its activity declines to desired level. Fresh catalyst is used only as makeup for making up losses as well as to maintain catalyst activity to the desired level. It is preferred that metal factor be as low as reasonably possible. Also catalyst coke should be minimum in order to prevent high temperature at start up.

There are the two types of catalyst;

1.fresh catalyst (High alumina microspherical synthetic catalyst).

2.Equilibrium catalyst.

FRESH CATALYST:

	Apparent bulk density	Particle size analysis	Pore volume ml/gm	Chemical and impurity level	Volatile matter	Fe Wt%	NaO Wt%	SO_4 Wt%	Al_2O_3 Wt%
UOP TEST	255-65	422-63	425-63	……	408-71	340-30	410-72	742-73	256-63

METHOD									
SPEC.	0.42-0.02	……		……	16max	.04 max	.03 max	.5 max	25 min

PROCESS DESCRIPTION:

<u>CRACKING SECTION</u>: a cracking process uses high temperature to convert heavy hydrocarbon into more valuable lighter products. This can be accomplished either thermally or catalytically. The catalytic process has completely superseded thermal cracking as the catalyst helps the reactions to take place at lower temperature and pressure. At the same time the process produces a higher-octane gasoline, more stable cracked gas and less of the undesirable heavy residual product.

The fluid catalytic cracking process employs a catalyst in the form of minute spherical particles, which behave like a fluid when aerated with a vapor. This fluidized catalyst is continuously circulated from the reaction zone to the regeneration zone also transferring heat with it.

FCCU consists of two sections, the catalyst section and the fractionation section, which operate together in an integrated manner. The catalyst section consists of the reactor and regenerator, which together with the standpipes and riser form the catalyst circulation circuit. The catalyst circulates up the riser to the reactor, down through the stripper to the regenerator, across to the regenerator standpipe and back to the riser.

Feed to the FCCU is the gas oils obtained by vacuum distillation of long residue from the crude distillation unit, the vacuum cut boiling in the range 380-530deg is used as feedstock. Feed enters the unit at the base of the riser where it is vaporized and raised to the reactor temperature by the hot catalyst. This mixture of oil vapor and catalyst travels up the riser into the reactor. The gas oil commences to crack immediately when it contacts the hot catalyst in the reaction zone. The now spent catalyst flows from the reactor to the regenerator where the coke is burned off. The heat of combustion raises the catalyst temperature to the 655-700deg range and supplies heat, most of which is transferred to the charge in the riser.

In the fractionation section the reactor vapors are fractioned into recycle gas oils, which are returned to the riser for further cracking and into the product – clarified slurry, heavy cycle oil (HCO), cracked cycle oil (LCO), unstabilised gasoline and wet gas. The last two could be pumped and compressed respectively to a gas concentration unit for further separation.

PROCESS EQUIPMENT:

<u>Raw oil charge system</u>: raw oil is used for preheating the fresh feed. Before reaching the riser, the hot raw oil stream is joined by heavy recycle and slurry from the slurry settler. During starting and shut down periods steam can also be charged to the bottom of the riser, and it is also possible to recycle unstabilised gasoline if necessary to control regenerator temperature when burning off an excessive buildup of coke.

<u>Riser</u>: the reactor riser is a vertical pipe through which the mixture of catalyst and oil vapors rise into the reactor. The diameter of the riser varies across its length. The combined feed enters the riser through an injection nozzle at the base of the riser. The resulting catalyst-oil vapor mixture is raised to the designed reactor temperature by using the sensible heat of the hot catalyst from the regenerator. If due to a major upset the supply of oil should be reduced, the catalyst in the riser with slump and the riser will plug with a mass of high-density catalyst. Immediate action will break such a plug and the blasting steam connections on the riser are provided for this purpose. It is also possible to inject steam to the base of the riser to prevent the riser from plugging.

Most of the cracking reaction takes place in the riser, and a more desirable product distribution is obtained by this "riser cracking" than by the cracking obtained in the dense phase of the reactor.

<u>Reactor</u>: the catalyst enters from the riser into a cone on top of which is the reactor grid. The cone and grid reduce the velocity of catalyst and oil vapors rising from the riser so that stable dense bed of catalyst can be maintained above the reactor grid. Because of the high velocity of the material leaving the riser, a target is suspended below the grid directly opposite the riser to prevent rapid erosion of the grid.

The oil vapors disengage from the catalyst in the reactor dense phase, and leave the reactor through single stage cyclone separators suspended from the reactor top head. These cyclone separators remove entrained catalyst and return it to the dense phase of the reactor.

The main functions of the reactor are:

(a) to provide a zone for the final cracking of the oil vapors. When desired the height of the dense bed above the reactor grid can be changed to vary the contact time (space velocity) and thus have additional control over the cracking severity.

(b) To provide a disengaging space for the separation of catalyst from oil vapors.

(c) To provide a place for the cyclone separators, which recover most of the entrained catalyst and return it to the catalyst bed.

Reactor standpipe: the catalyst leaves the reactor a standpipe on the bottom of which is the catalyst slide valve. The head of catalyst standing in the reactor standpipe produces enough pressure to overcome the differential pressure between the reactor and regenerator, and causes flow through the slide valve.

Regenerator: the regenerator has a lining of insulating refractory concrete gunnited on a reinforcing support. This lining is necessary to protect the metal wall of the vessel from the high temperature at which the regenerator operates, and should keep the outer of the regenerator below 450deg F at all times. The coke deposited on the catalyst in the reactor is burned off by air distributed evently throughout the regenerator by the pipe grid at the bottom. The flue gas rises from the dense bed of catalyst in the regenerator. Passes through six two-stage cyclone separators and leaves from the top of the vessel. As in the reactor, these cyclones return the entrained catalyst to the dense catalyst bed. The flue gas leaving the top of the regenerator passes through a double disc flue gas slide valve, which maintains the back pressure on the regenerator. In normal operation, catalyst bearing about 1% coke enters the fluidized bed, which is maintained at about 1150-1250degF by the combustion of the coke. Sometimes, such as during start up, there is insufficient coke to maintain the temperature of the regenerator bed in which case torch oil can be injected through the two torch oil nozzles located above the grid. It is also possible for excessively high temperatures to result from an upset, such as a crash shut down, and water sprays are usually provided to permit the injection of water just below the inlet of each set of cyclones.

Regenerator standpipe: the hot catalyst leaves the regenerator through an alloy pipe at the bottom of which is the regenerated catalyst slide valve, which is flanged into the “Y” at the base of the riser. The regenerated catalyst slide valve is reset by a reactor temperature controller.

Air Heater: a direct-fired air heater is normally used to heat up the unit during startup. It is located on the main blower discharge line upstream of the regenerator grid. Normally, the heater is only fired during startup, although on rare occasions at very charge rates, it may be used while the unit is on stream. It is important that the air heater outlet temperatures be raised and lowered at a maximum rate of 230degF per hour to reduce the stress, which could be produced in the regenerator grid by rapid temperature changes.

Torch Oil System: torch oil is used to heat up the catalyst inventory in the regenerator on startup, and occasionally to extinguish after burning during upsets. Raw oil from the discharge of the raw oil charge pump is injected on hand control, through nozzles located above the grid. The oil is atomized with steam. When torch oil is not being used, the atomizing steam pressure should not exceed the regenerator pressure by more than 5 psi in order to minimize breaking up of catalyst.

Instrumentation: fluidized catalyst behaves like a liquid so that the pressure at any one point in the system can be measured with a pressure instrument, and the difference in pressure between the top and bottom of the vessel will give a measure of the catalyst inventory. However, if the catalyst particles were to back into the instrument connections from the body of fluidized catalyst, the connection would become plugged.

MEROX UNIT

INTRODUCTION: The purpose of this unit is to improve the quality of petroleum product obtained from various units. Removing corrosive and odourful compounds from product makes this improvement. This unit provides pure products as per requirement for treatment of various products of refinery which are as following;

(1) Kero/ATF Merox unit
(2) SR. LPG Merox unit
(3) VB Naphtha Merox unit
(4) CR. LPG Merox unit
(5) FCC Gasoline/SR Naphtha Merox unit

THEORY OF MEROX TREATMENT:

Straight (SR) petroleum products obtained from atmospheric distillation may contain hydrogen sulphide and mercaptans. FCC Gasoline also contain hydrogen sulphide and mercaptans to a greater degree compared to SR. products.

H_2S Can be easily removed by washing the petroleum product with *dilute caustic solution*. And for reducing mercaptans level the merox process is used in refinery.

Merox process can be divided in to following section ,

(a) *Pretreatment, for* removal of hydrogen sulphide and naphthenic acid, if present.

(b) *Extraction section,* where required for removal of caustic soluble mercaptans and thus reduce sulphur in the treatment products.
(c) *Sweetening,*for conversion of mercaptans to disulphide.
(d) *Post treatment,* to remove caustic haze and to control properties not affected by merox product

BITUMEN BLOWING UNIT (BBU)

INTRODUCTION: bitumen blowing unit is designed for producing 0.5MMTPA bitumen by air blowing the vacuum residue above 530°C air blowing of vacuum residue considerably increases the contents of gums and asphaltanes. Bitumen is colloidal solution of asphaltenes and associated high molecular gums. Asphaltene contents influences it solidity and softening point. Gums increase bitumen binding property and electricity.

PROCESS FLOW DESCRIPTION:

(A)FEED SUPPLY SYSTEM: the unit receives hot short residue and cold feed from tanks as per requirement .the hot feed goes to reactors at 200°-210°C in two parallel streams. The cold feed from the tanks is carried to unit by pumps and discharged through unit heater for heating to reaction temperature.

(B)BITUMEN FURNANCE: it is natural draft furnace with convection and radiation zone. The convection section forms rectangular box while the radiation section is of cylindrical shape. The two sections are having horizontal and vertical (hair pin type) feed coils respectively.

The furnace is provided with one *oil-cum* gas burner at its base. The feed first picks up heat from the fuel gases in the convection section and then it is heated in radiation zone coils.

The feed is heated up to 230°C.The two passes join together at the outlet of furnace and are routed to reactor in two parallel streams.

(C) REACTORS: Feed to reactor is controlled by feed control valves. Compressed air at 80°C is supplied through *spargor* provided at reactor bottom .Air flow to reactor is controlled by two controls valves. Oxidation of residue is carried out at a temp. of 240°-260°C. reactor's middle zone temp. is maintained by varying quench water through control valves installed in the discharge line but the facility is kept isolated currently.

Finished bitumen is pumped out from the bottom while oxidation gases passes through overhead line of reactor.

(D) <u>FINISHED BITUMEN CIRCUIT</u>: finished bitumen from reactor at 240° –260°C is pumped in two groups of air coolers. Product is cooled up to 170°-200°C By regulating air supply controlled by outlet lovers as well as fan blade angle. Facilities exist for routing a portion of cooled bitumen to reactors for deeper oxidation. Cooled bitumen is routed to storage tank.

(E) <u>REACTOR OVER HEAD SYSTEM</u>: from the top of reactors, the hydrocarbon vapors and unheated air about 220°-240°C go parallel to air coolers vapors is condensed and cooled up to 170°C. The combined vapor liquid mixture from the coolers gas to oxidation gas separators which operate in parallel.

(F) <u>OXIDATION GAS SEPARATORS</u>: the vapor liquid mixture coming from air cooler is separated at around 170°C is periodically pumped by pumps through air cooler .oil is cooled up to 80°C and sent to FPS tanks/IFO tanks. The uncondensed gas at a temp. of 170°C passes through demisters in the overheat lines, liquid separated is trained to OMS in case of high level in demesters. The two gas streams from the demisters joins a common header and go to incinerator for final combustion.

(G) <u>INCINERATOR</u>: The gases enter in incinerator from the top where it is burnt at a temp of 550°C to 580°C. Incinerator is a natural draft furnace with cylinder top. The bottom portion forms a rectangular box. It has two *oil-cum* gas burner to maintain box temperature. Combustion air for in coming gases and burner fuel is supplied by blower. Fuel gas to incinerator is supplied at a pressure of about $4.0 kg/cm^2$.

(H) <u>COMPRESSORS</u>: compressors have been provided in the unit to supply air for the oxidation reaction in reactor. The compressors are horizontal reciprocating balanced, opposed piston double stage, double acting water-cooled type. Compressed air is received in a air receiver and then sent to reactors.

(I) <u>FLUSHING OIL SYSTEM</u>: Flushing oil is generally light oil in the range of oil. This is used to displace heavy oil from the process equipment lines etc. for flushing purpose unit receives FCC light cycle oil or HGO/LGO from AVU through ∅ 80mm line.

OIL MOVEMENT & STORAGE – I

(PRODUCT RECEIPT AND BLENDING SECTION)

This unit is used to:

a) Preparation and supply of feed to unit.
b) Blending of intermediate products.
c) Receipt, storage and dispatch of finished products.
d) Measurement of petroleum products Gauging, sampling etc.
e) Supply of internal fuel oil to Units TPS.

GENERAL DISCRIPTION OF THE TANK FARM:

The tank farm in the receipt and blending section of OM&S consists of different storage tanks for the different intermediate as well as finished products. Some of the important points are:

(A) **DIP OR PRODUCT IN A STORAGE TANK**: It is the height of the oil from the datum plate up to the top oil level.

(B) **DATUM PLATE**: Inside the tank there is a small horizontal plate located approximately 5cms above the tank bottom surface. At the time of taking the dip of oil leveling a tank the bob connected with the dip tape first touches the above plate. This plate is called the datum plate.

(C) **TANK PAD** :It is the developed area with brickwork, concrete and other bituminous material upon which the whole tank shell is resting.

(D) **TANK DYKE**: In is a bound made up of soil surrounding the tank. The purpose of providing dyke is that oil will not spread out in the event to any leakage from the tank shell.

(E) **SAFE FILLING HEIGHT**: It is the height up to which the tank can be filled up safely.

(F) **REFERENCE HEIGHT**: It is the difference in height between the datum plate and the sharp edge in the rectangular groove provided at the top of the dip hatch pipe.

(G) **DIP HATCH PIPE**: It is the cylindrical pipe extending from the bottom of the tank to the top with a cover at the top. Through this pipe only, the dip tape with bob is allowed to enter inside the tank for the purpose of taking dip.

(H) **CRITICAL ZONE OF FLOATING ROOF TANK:** Depending on the height of the leg provided with the pontoon roof of floating roof of the tank starts floating at a certain dip with increase in dip. Between these two dips the pontoon remains slightly in tilting condition. When the dip of any floatation roof tank falls between the above two dips, the dip of the tank is said to be in critical zone.

(I) **ROOF DRAIN:** In floating roof tank, there is a pipe with swivel joint from the center of the pontoon roof. The line extends inside the tank and comes outside the shell from the lower portion of the tank. Rainwater gets out through this drain line.

(J) **SYPHON DRAIN:** At the lower portion of the tank shell, one siphon drain nozzle has been provided to get the water drained from the bottom of the tank after being settled.

(K) **EMERGENCY ROOF DRAIN:** In a floating roof tank, If there is any leakage in the roof drainpipe inside the tank, it cannot be operated .In that case the roof drain on the top has to be blinded. An emergency drain has been provided for draining water.

STORAGE TANKS:

There are three types of storage tanks,

(A) **FIXED ROOF TANKS:** Fixed roof tanks are used for storing low volatile products. These are vertical cylindrical vessel. The fixed roof is provided with internal truss support.

(B) **FLOATING ROOF TANKS:** Floating roof tanks are for storing products having high vapor pressure. These tanks have an increased operation at safety bought about by the absence of vapor space above the liquid as the roof rests on the fluid.

(C) **FLOATING CUM FIXED ROOF TANKS:** These tanks have got the advantages of both fixed and floating roof tanks and are particularly suited to volatile products in which entry of rain water is not permissible.

OPERATIONS AT BLENDING STATION:

Blending station operations are as following:

(1) **VB BLENDING FACILITY:** Light residue (LR) from atmospheric distillation column and short residue(SR) from vacuum distillation column are blended and stored in two tanks 707 and 708.

(2) **VBN, FCC GASOLINE BLENDING FASCILITY:** FCC Gasoline of unit from VBU is blended through R/D line stored in tanks.
(3) **FFS BLENDED FACILITY:** For FFS the LR of AVU, SR of AVU, VGO(s)/HVGO OF AVU, VBFO of VBU, LCO of FFCU are blended and stored in FFS tanks.
(4) **FO BLENDING FACILITY:** LR, VBFO, LGO, LCO, VGO(s)/HVGO and CLO are blended and stored in FO tanks.
(5) **HSD BLENDING FACILITY:** LGO, HGO, from AVU, SKO, LVGO and LDO are blended for blending and stored in HSD tanks.
(6) **LDO BLENDING FACILITY:** For LDO Blending LGO, HGO, LCO, SKO, LR, LVGO, LDO are blended and stored in LDO tanks.
(7) **TEL BLENDING STATION:** The pump station provides facilities for blending the following things;
   (a) TEL (Tetra ethyl lead)
   (b) Dye
   (c) Antioxidant.

TEL is a poisonous compound. It may be absorbed into the body through the skin when exposed to it. Hence it must be handled carefully.

The addition of TEL is required to improve the *octane number* of motor spirit .The Dye is added to meet the statutory regulation for identification of the product.

The actual dosing rate of TEL depends upon the base octane, the proportion of the intermediate product mix of the components such as FCC. Gasoline line, HAN VB naphtha and is decided by R&D section.

OMS-II (OIL MOVEMENT & STORAGE II)

OM & S-II has the three section as following:

(1) Bitumen Drum filling section.
(2) L.P.G. section
(3) Effluent treatment plant (ETP)

1.BITUMEN DRUM FILLING SECTION

In this section pumps from the storage tanks to the supply line to heat exchangers pump the bitumen. There are filling devices having the capacity of filling 2000 drums a day. The hot molten bitumen at temp about 105 degrees centigrade is filled in drums .The capacity of each drum is 160kg of

Bitumen. The filling devices have many facilities like filling weight indicator, valve, steam supply facility and hot water facility. This is an automatic device. Loading the railway wagons dispatches these filled drums. The drums are kept at yards for 48 hours for cooling the hot bitumen. On other hand the tankers dispatched the bitumen by road.

2.LPG SECTION

STORAGE OF LPG: In this section the LPG is stored in spherical vessel called **HORTON SPHERE.** There are six Horton spheres with a capacity of 1500M^3 each. Three spheres of them are for storing straight run LPG and other three are for storing cracked LPG .one of Horton sphere has direct connection to receive both SR and CR LPG. All spheres are made of stainless steel are insulated with mineral wool of 50mm thickness. There are several safety valves on the surface of sphere. The thermal valves will work immediately if temperature goes above 80 degrees centigrade by thermal relay fuses-spheres are provided with automatic level indication, mechanical gauge as well as pneumatic level indication. For draining separated water from spheres the drains are provided with two block valves and a remote controlled valve. The protection system is provided against over pressure as well as fire around the spheres. Methyl mercaptans are mixed in LPG for safety to make it full of odour. LPG is dispatched by following two methods,

(1) By bottling LPG cylinders
(2) By bulk loading /unloading
(i) Bulk dispatch by road
(ii) Bulk dispatch by train

LPG BOTTLING PLANT: LPG filling plant is designed to fill 100000MT per annum of LPG in domestic cylinders .The empty cylinder received from trucks and wagons are stored in storage sheed .The cylinders are counted manually and visually inspected .The defective and five year old cylinders are marked and separated .The cylinders are loaded vertically on the chain conveyor for transportation to the filling machines .The cylinders from slat roller conveyor of the filling machine from where they are loaded on filling machine turn automatically as per requirement of filling UN5 carousel machine each having 12 filling points .With a capacity of filling 720 cylinders per hour .The filling head is connecter to cylinder valve ,and cylinder is opened when 14.2kg of LPG is filled in cylinder .After the automatic discharge the filled cylinders pass over chain conveyor .Check weight is done for detection of over filled and under filled .Checked cylinder are tested in water for checking leakage in cylinder .Full checked cylinder are sealed and dispatched through loaded trucks.

(I) BULK LOADING: This facility is provided for dispatching 97000MT per annum of LPG by road and rail transfer.

(II) BULK LOADING BY ROAD: There are four filling point, each having a weight bridge of 30MT capacity with dial type seal flexible basis are connected with filling and the vapor return lines .A flow meter is provided on the main filling head.

3.EFFLUENT TREATMENT PLANT

INTRODUCTION:

The main objectives of plants in Mathura refinery are:
(a) The recovery of oil from oily water.
(b) Removal /Recovery of suspended solids.
(c) Reduction of biological oxygen demand (BOD) .

SOURCES:

The following liquid streams are collected and segregated into 3 basic streams based upon the nature of waste water and treatment needed to be given so as to remove the pollutants and contaminates from the waste water.

- **(a)** **INDUSTRIAL SEWER (IS):** In this sewer process oily water from units, equipment, sample points, pump house drains, electric desalter drains, loading gantries, tank drains etc . comes .
- **(b)** **SALTY WASTE WATER SEWER (CS):** In this sewer water from crude tank drains and crude booster pump house drain comes.
- **(c)** **STORM WATER SEWER (SS):** In this sewer rain water from tank farm dyked areas comes.
- **(d)** **DOMESTIC SEWAGE (DS):** In this sanitary sewage from toilets and lavatories provided in the refinery comes.

(e) **FRESH WATER SEWER (FS):**In this water used for other activities not fully oily comes.

(f) Caustic bearing waste water from MEROX, VBU and FCC units comes.

TYPES OF TREATMENT

Waste water treatment includes three steps,

(i) Physical treatment

(ii) Biological treatment

(iii) Chemical treatment

(I) PHYSICAL TREATMENT

In this treatment the physical process separates suspended solids and free oil. Oily water from different sources is coming to effluent sump by gravity, where from it is pumped to *API* oil separators. If the in flow is more than $450M^3$/hr. Excess in flow will be stored in Guard basins .In separators the velocity of the water is slowed down considerable. At such low velocity solid settle at the bottom and free oil floats on the water surface. The *skimmer* which are slowed and provided with manual gear operation mechanism, are provided for skimming the oily layer .A scrapper mechanism consisting of wooden lags provided on two endless chain running parallel is provided for skimming of oil while moving At the top of liquid level and scrapping the oily sludge. *HOPPER* for collection of sludge is provided. The slop oil collected in with drain through pipe skimmers and load to slop tanks in ETP. Waste water from *API* out let goes to equalization basin. After drain of water from tank and heating to 70 degree centigrade, slop oil will be pumped to tanks in IFO, where from it will be processed in units with crude.

Oil skimming facility is provided here to single high rate trickling filter, oily sludge from oil separators will be pumped to oily lagoons. After removing supernatant, sludge will be removed manually and disposed off.

BIOLOGICAL TREATMENT : This treatment is occurred first in trickling filter. It removes about 70% of the total organic load viz BOD phenols and practically all sulphides. It consists crushed rock to facilitate anchorage and space for biological activity as well as to per unit circulation of air. The filter is circular in shape and it enters at the discharge pipe with eight distributor arms, which sprinkles water all over the surface and entire waste water is collected by gravity in sump from the bottom. Where remaining soluble BOD is removed completely (30% BOD). Suspended solid is given sufficient resident time in aerators to completely stabilize the waste water and the mixed liquor is sent to final clarifier and a portion of bio sludge is recycled. The waste water and mixed liquor is separated in final clarifier.the treated water firm final clarifier goes to gard ponds.

CHEMICAL TREATMENT: caustic bearing wastes are collected in two storage tanks. Spent caustic from the tanks, falls in sump, where from it is pumped to caustic API oil separator. Here it is diluted with water at the inlet channel to 150M^3/hr.

From API oil separators water goes to pH adjustment chamber where the pH is adjusted to 6.5-7.5 by dilute H_2SO_4 then to reaction tanks.

$$Cl_2 + Na_2S \rightarrow 2NaCl + S$$

$$FeSO_4 + Na_2S \rightarrow Na_2SO_4 + FeS$$

The floes formed here goes here to flocculation chamber where:

(a) Additional time is provided to complete the reaction.
(b) To promote the floe growth.

Then the floe formed out of chemical reaction is settled at *clarifier cum thickener* (CCT), where from the clear water goes to equalization basin inlet.

AMINE REGENERATION UNIT (ARU)

PROCESS FLOW DESCRIPTION:

This section covers the process flow description of amine absorption unit and amine regeneration unit.

ABSORPTION: the feed of AAU (Amine absorption unit) is the gas from stabilizer over head of VBU. Gas contain 40.17kg mole/hr of H_2S and coming out of sour gas knock out drum in FCC unit and sour gas coming 3.46kg mole/hr of carbon dioxide. It enters the absorption unit at 5.5 kg/cm^2 pressure and temp of 43 8C.

Regenerated di ethanol amine (DEA) solution (15-25% weight) coming from amine regeneration section at a press. of 8.1 kg/cm^2 and a temp.of 458C enter the amine absorber at controlled flow. Amine absorber is a vertical column of 20 trays of single pass valve type. The reaction are involved in absorber are;

$$R_2NH + H_2S \rightarrow R_2NH_3S$$

$$R_2NH + CO_2 + H_2S \rightarrow (R_2NH_3)CO_3$$

where R is CH_3CH_2OH group and reaction are exothermic.

Rich DEA containing absorbed H_2O and CO_2 leaves absorber from bottom to the amine regeneration unit. At top of absorber a demister is provided to prevent any carry over of amine along with the gases. Anti foaming agent dosing is absorber is started to prevent foaming of amine solution. Vent valve and safety valve are provided in column. The sweet fuel gas stripped off its H_2S and C_2O leaves the absorber from top and enters the knock out drum and after knocking gases enters the fuel gas system.

<u>AMINE REGENERATION UNIT</u>: In the amine regenerator the rich DEA stripped of its absorbed sour gases H_2S and CO_2 using steam as stripping medium .So the regenerated amine can be reused in the absorbers. The amine regenerator is a tall vertical column 19670 mm height and has O.D. of 1800mm at top and 2000mm at bottom .It contain 23tray in which 1to 20 tray are valve type and 21 to 23 are of baffle type .The feed enters at the 20^{th} tray amine reboiler heated by LP steam and gases for stripping. LP steam is also provided for stripping and it enters the column from bottom below I^{st} tray, the steam strips out the absorbed H_2S and CO_2 present in the DEA solution .The chemical reaction involved are;

$$RNH_3S \rightarrow R_2NH + H_2S$$

$$(R_2NH_3)CO_3 \rightarrow R_2NH + CO_2 + H_2O$$

The liberated sour gas and steam at 112.3 8C and 0.8kg/Cm^2 press. Leave the regenerator from the top and enters the regenerator over head condenser. Where the gases are cooled and steam is controlled to 45 8C deg by cooling water on tube side .The condensate and the gases flow freely from the condenser to the reflux drum .The sour gases from the reflux top go to the sulphur recovery unit for production of sulphur. From the bottom of the reflux drum refluz is pumped to the regenerator top above 23^{rd} tray at 5.2 kg/cm^2 press. Level is controlled in reflux drum by level controller. From below 18^{th} tray of regenerator lean amine flows into the amine reboiler where it is heated by LP steam on the tube side. The reboiler has got two compartment separated by gravity. Anti foaming agent dosing, needed in regenerator, is done at amine absorption unit at FCC section. From the regenerator bottom lean absorption unit at FCC section. From the regeneration bottom lean amines at 120 8C and 1.05kg/cm^2 press. Enters the DEA feed bottom exchanger. Where it gets cooled from 120 8C to 76.3 8C by exchanging its heat with the incoming rich DEA solution. From exchanger lean amine is pumped out to lean amine cooler where cooling water cools amine from 76.3 8C to 45 8C. From cooler a part of lean amine is sent to the top of the amine flash column and other to filters

SULPHUR RECOVERY UNIT (SR)

INTRODUCTION: Sulphur recovery unit consists of two identical unit A&B. The process design is in accordance with common practice to recover elemental sulphur, known as the clause process. Each unit consist of a thermal stage in which H S is partially burnt with air followed by two catalytic stages. A catalytic in cinerator of tail gas has been incorporated in order to prevent pollution of the atmosphere.

SULPHUR RECOVERY PROCESS: The sulphur recovery process is applied in the present design which is known as the CLAUSE PROCESS is based upon the combustion of hydrogen sulphide with a ratio controlled flow of air which is maintained automatically in sufficient quantity to evolve the complete oxidation of all hydrocarbons and ammonia present in the sour gas feed and to burn 1/3rd of the H_2S to SO_2 and water;

$$H_2S + 3/2O_2 \rightarrow SO_2 + H_2O + HEAT$$

The major percentage of the residual H_2S combines with the SO_2 to forms according to the equilibrium reaction;

$$SO_2 + 2H_2S \rightarrow 3S + 2H_2S$$

Sulphur is formed in vapor phase in the main combustion chamber. The primary function of the waste heat boiler is to remove the major portion of the heat evolved in the combustion chamber. The secondary function of waste heat boiler is to condense the sulphur, which is drained to a sulphur pit. At this stage 60% of the sulphur present in the sour gas feed is removed. The third function of the waste heat boiler is to utilize the heat liberated there to produce the low pressure steam (4.00 Kg/cm^2).

The process gas leaving the waste heat boiler still contains a considerable part of H_2S and SO_2. Therefore the essential function of the following equipment into shifts the equilibrium by adapting a low reaction temperature. Thus removing the Sulphur as soon as it is formed.
Conversion of sulphur is reached by a catalytic process in few subsequent reactors containing a special Synthetic alumina catalyst.

Before entering the first reactor the process gas flow is heated to an optimum temperature by means of a line burner with mixing chamber in order to achieve a high conversion.
In the line burner mixing chamber the process gas is mixed with hot flue gas obtained by burning fuel gas with air. In the first reactor, the reaction between the H_2S and SO_2 recommences until equilibrium is reached. The effluent gas from the first reactor passes to the sulphur condenser where at this stage approx. 29% of the sulphur present in the sour gas feed is condensed and drained to the sulphur pit. The total sulphur present in the sour gas feed. In order to achieve a figure of 94% sulphur recovery the sour gas is subjected to one more stage. The process gas flow is once again subjected to preheating by means of a second line burner then passed to a second reactor and the sulphur condenced in the second condenser accomplishes a total sulphur recovery 94%.
A sulphur coalescar is installed downstream of the last sulphur condenser to separate entrained sulphur mist.
The heat released by the subsequent cooling of gas and condensation of sulphur in waste heat boiler and condenser results in the production of low-pressure steam. The tail gas from sulphur coalescer is sent to a catalytic incinerator to convert the residual H_2S and sulphur vapor to SO