SUMMER TRAINING REPORT

Indian oil Corporation Ltd, Mathura

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Submitted to: Mr. K.K TIWARI

Training & Development Department,

IOCL

Submitted by:
Suraj Choudhary

102120059

Topic - In-depth study of MSQU unit for the production of motor spirit (petrol) incompliance with the latest BS-VI norms.)

In partial fulfilment of requirements for the degree of

BACHELOR OF TECHNOLOGY

IN

CHEMICAL ENGINEERING

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

KATTANKULATHUR

PREFACE

Industrial training plays a vital role in the progress of future engineers. Not only does it provide insights about the future concerned, it also bridges the gap between theory and practical knowledge. I was fortunate that I was provided with an opportunity of undergoing industrial training at INDIAN OIL CORPORATION LTD. Mathura. The experience gained during this short period was fascinating to say the least. It was a tremendous feeling to observe the operation of different units and processes. It was overwhelming for us to notice how such a big refinery is being monitored and operated with proper coordination to achieve desired results. During my training I realized that to be a successful chemical engineer one needs to put his/her concepts into action. Thus, I hope that this training serves as a steppingstone for me in future and help me carve a niche for myself in this field.

ACKNOWLEDGEMENT

My indebtedness and gratitude to the many individuals who have helped to shape this report in its present form cannot be adequately conveyed in just a few sentences. Yet I must record my immense gratitude to those who helped me undergo this valuable learning at IOCL Mathura.

I am highly obliged to Training and Development Department for providing me this opportunity to learn at IOCL. I have further to thank the officers of production for sharing their knowledge about the plant and production process. It is really great opportunity for me by which I have learned here many practical knowledges which are usually hard to find in textbooks.

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About IOCL

Indian Oil Corporation (Indian Oil) is India's largest commercial enterprise, with a sales turnover of Rs. 4,38,710 crore (USD 65,391 million) and profits of Rs. 19,106 crores (USD 2,848 million) for the year 2016-17. The improvement in operational and financial performance for FY 2016-17 reflected in the market capitalization of the Company, which grew two-fold, from Rs. 95,564 crores as on 31st March 2016 to Rs. 1,87,948 crores as on 31st March 2017. In view of its rising share price and market capitalization, Indian Oil was included in the Nifty50 index (NSE benchmark index of 50 best performing corporates). Indian Oil is ranked 161st among the world's largest corporates (and first among Indian enterprises) in the prestigious Fortune 'Global 500' listing for the year 2016.

As India's flagship national oil company, with a 33,000-strong work-force currently, Indian Oil has been meeting India's energy demands for over half a century. With a corporate vision to be 'The Energy of India' and to become 'A globally admired company,' Indian Oil's business interests straddle the entire hydrocarbon value-chain – from refining, pipeline transportation and marketing of petroleum products to exploration & production of crude oil & gas, marketing of natural gas and petrochemicals, besides forays into alternative energy and globalization of downstream operations.

Having set up subsidiaries in Sri Lanka, Mauritius and the UAE, the Corporation is simultaneously scouting for new business opportunities in the energy markets of Asia and Africa. It has also formed about 20 joint ventures with reputed business partners from India and abroad to pursue diverse business interests.

INDIAN OIL (ENERGY OF INDIA)

Indian Oil accounts for nearly half of India's petroleum products market share, 35% national refining capacity (together with its subsidiary Chennai Petroleum Corporation Ltd., or CPCL), and 71% downstream sector pipelines through capacity. The Indian Oil Group owns and operates 11 of India's 23 refineries with a combined refining capacity of 80.7 MMTPA (million metric tonnes per annum).

The Corporation's cross-country pipelines network, for transportation of crude oil to refineries and finished products to high-demand centers, spans about 12,848 km. With a throughput capacity of 93.7 MMTPA for crude oil and petroleum products and 9.5 MMSCMD for gas, this network meets the vital energy needs of the consumers in an efficient, economical and environment-friendly manner.

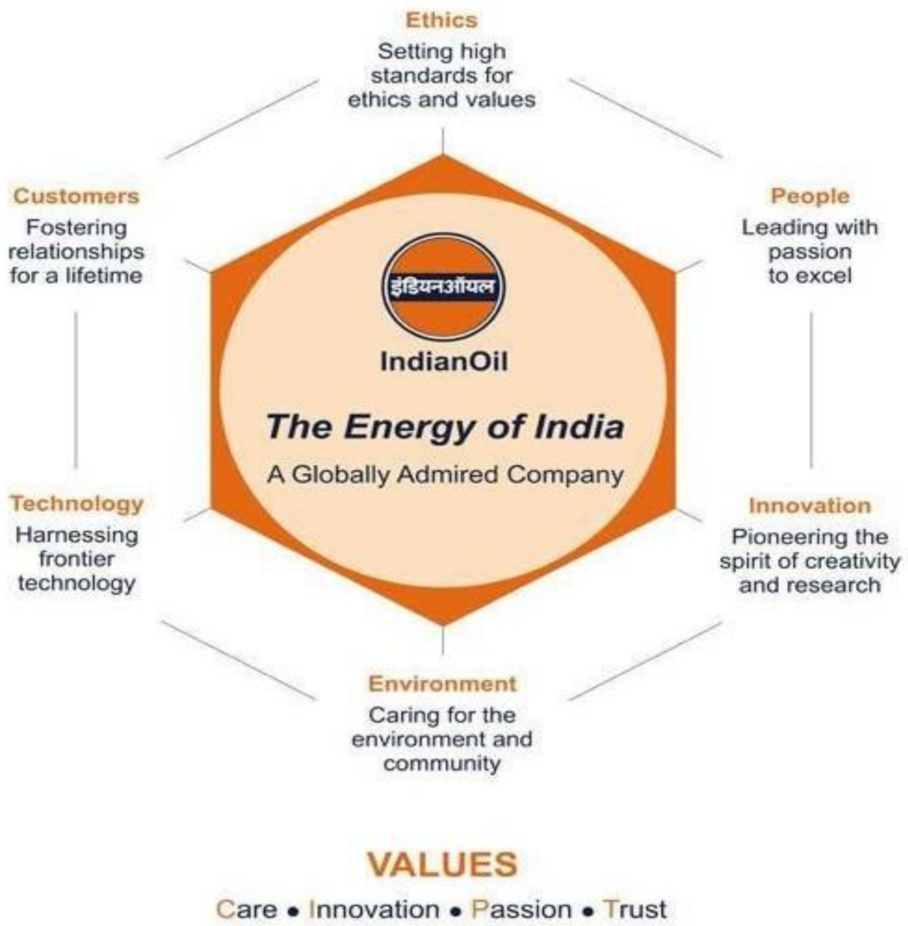
The Corporation has a portfolio of leading energy brands that includes Indane LPG cooking gas, SERVO lubricants, XTRAPREMIUM petrol, XTRAMILE diesel, PROPEL petrochemicals, etc. Besides Indian Oil, both SERVO and Indane have earned the coveted Super brand status.

Countrywide Reach

Indian Oil's network of over 46,000 customer touch-points reaches petroleum products to every nook and corner of the country. These include more than 26,000 petrol & diesel stations, including 6,565 Kisan Seva Kendra outlets (KSKs) in the rural markets. Over 10,000 fuel stations across the country are now fully automated.

The Corporation has a 65% share of the bulk consumer business, and almost 6,500 dedicated pumps are in operation for the convenience of large-volume consumers like the defence services, railways and state transport undertakings, ensuring products and inventory at their doorstep. They are backed for supplies by 129 bulk storage terminals and depots, 101 aviation fuel stations and 91 LPG bottling plants.

VISION



Indian Oil's 'Vision with Values' encompasses the Corporation's new aspirations – to broaden its horizons, to expand across new vistas, and to infuse new-age dynamism among its employees.

Adopted in the company's Golden Jubilee year (2009), as a 'shared vision' of Indian Oil People and other stakeholders, it is a matrix of six cornerstones that would together facilitate the Corporation's endeavors to be 'The Energy of India' and to become 'A globally admired company.'

More importantly, the Vision is infused with the core values of Care, Innovation, Passion and Trust, which embody the collective conscience of the company and its people and have helped it to grow and achieve new heights of success year after year.

Refineries

❒ Digboi Refinery

The **Digboi Refinery** was set up at Digboi in 1901 by Assam Oil Company Ltd. The Indian Oil Corporation Ltd (IOC) took over the refinery and marketing management of Assam Oil Company Ltd. with effect from 1981 and created a separate division. This division has both refinery and marketing operations. The refinery at Digboi had an installed capacity 0.50 MMTPA (million metric tonnes per annum). The refining capacity of the refinery was increased to 0.65 MMTPA by modernization of refinery in July 1996. A new delayed Coking Unit of 1,70,000 TPA capacity was commissioned in 1999. A new Solvent Dewaxing Unit for maximizing production of microcrystalline wax was installed and commissioned in 2003. The refinery has also installed Hydrotreater-UOP in 2002 to improve the quality of diesel. The MSQ Upgradation unit has been commissioned. A new terminal with state-of-the-art facility is under construction and expected to be completed by 2016.

❒ Guwahati Refinery (Assam)

The **Gujarat Refinery** is an oil refinery located at Koyali (Near Vadodara) in Gujarat, Western India. It is the Second largest refinery owned by India Oil Corporation after Panipat Refinery. The refinery is currently under projected expansion to 18 MMTPA.

❒ Haldia Refinery

The **Haldia Refinery** for processing 2.5 MMTPA of Middle East crude was commissioned in January 1975 with two sectors - one for producing fuel products and the other for Lube base stocks.

❒ Gujarat Refinery

The **Gujarat Refinery** is an oil refinery located at Koyali (Near Vadodara) in Gujarat, Western India. It is the Second largest refinery owned by Indian Oil Corporation after Panipat Refinery. The refinery is currently under projected expansion to 18 MMTPA.

Barauni Refinery

Barauni Refinery in the Bihar state of India was built in collaboration with the Soviet Union at a cost of Rs.49.4 crores and went on stream in July 1964. The initial capacity of 1 MMTPA was expanded to 3 MMTPA by 1969. The present capacity of this refinery is 6.100 MMTPA. A Catalytic Reformer Unit (CRU) was also added to the refinery in 1997 for production of unleaded motor spirit. Projects are also planned for meeting future fuel quality requirements.

Bongaigaon Refinery

Bongaigaon Refinery is an oil refinery and petrochemical complex located at Bongaigaon in Assam. It was announced in 1969 and construction began in 1972.

Paradip Refinery

Paradip refinery is the 11th refinery being set up by Indian Oil Corporation in Paradip town in the state of Odisha. The installed capacity of refinery was 15 MMTPA.

Panipat Refinery

Indian Oil Company's (IOC) seventh refinery is located at Panipat, 125km from Delhi, in the state of Haryana in northern India. The main units of the facility are a once-through hydrocracker (OHCU), a residual fluid catalytic cracker and a continuous catalytic reformer unit, as well as other secondary treatment units. The 6mmpta Panipat refinery was constructed and commissioned in 1998 with an investment of Rs38.68bn, which included the costs of marketing and pipeline installations. The refinery capacity was expanded to 12mmtpa in 2006. The capacity was further expanded to 15mmtpa in November 2010.

Mathura Refinery

The **Mathura Refinery**, owned by Indian Oil Corporation, is in Mathura, Uttar Pradesh. The refinery processes low sulphur crude from Bombay High, imported low sulphur crude from Nigeria, and high sulphur crude from the Middle East.
The refinery, which cost Rs.253.92 crores to build, was commissioned in January 1982. Construction began on the refinery in October 1972. The foundation stone was laid by Indira Gandhi, the former prime minister of India. The FCCU and Sulphur Recovery Units were commissioned in January 1983. The refining capacity of this refinery was expanded to 7.5 MMTPA in 1989 by debottlenecking and revamping. A DHDS Unit was commissioned in 1989 for production of HSD with low sulphur content of 0.25% wt. (max.).

The major secondary processing units provided were Fluidised Catalytic Cracking Unit (FCCU), Vis-breaker Unit (VBU) and Bitumen Blowing Unit (BBU). The original technology for these units was sourced from erstwhile USSR, UOP etc. Soaker drum technology of EIL was implemented in VBU in the year 1993. For production of unleaded Gasoline, Continuous Catalytic Reforming Unit (CCRU) was commissioned in 1998 with technology from Axens, France. A Diesel Hydro Desulphurisation Unit (DHDS) licensed from Axens, France was commissioned in 1999 for production of HSD with low Sulphur content of 0.25% wt. (max). With the commissioning of Once Through Hydrocracker Unit (licensed from Chevron, USA) in July 2000, capacity of Mathura Refinery was increased to 8.0 MMTPA.

Diesel Hydro-treating unit (DHDT) & MS Quality Up-gradation Unit (MSQU) was installed with world class technology from Axens and UOP respectively in 2005 for production of Euro-III grade HSD & MS w.e.f. 1st April 2005 as per Auto Fuel Policy of Govt. of India. Project for FCC Gasoline Desulphurization (FCCGDS) and Selective Hydrogenation Unit (SHU), the Prime-G technology of Axens, France was commissioned in February 2010 and supply of Euro-IV grade MS and HSD started on continuous basis from February 2010.

Mathura Refinery is having its own captive power plant, which was augmented with the commissioning of three Gas Turbines (GT) and Heat Recovery Steam Generator (HRSG) in phases from 1997 to 2005 using Natural Gas (NG) as fuel to take care of environment. For upgrading environmental standards, old Sulphur Recovery Units (SRU) were replaced with new Sulphur Recovery Units with 99.9 % recovery in the year 1999. Additional Sulphur Recovery Unit is under implementation as a hot standby. Mathura Refinery had also set up four nos. of continuous Ambient Air Monitoring Stations far beyond the working area before commissioning of the Refinery in 1982 as a mark of its concern towards the environment and archaeological sites. Its proximity to the magnificent wonder Taj Mahal adds extra responsibility towards maintaining a cleaner environment.

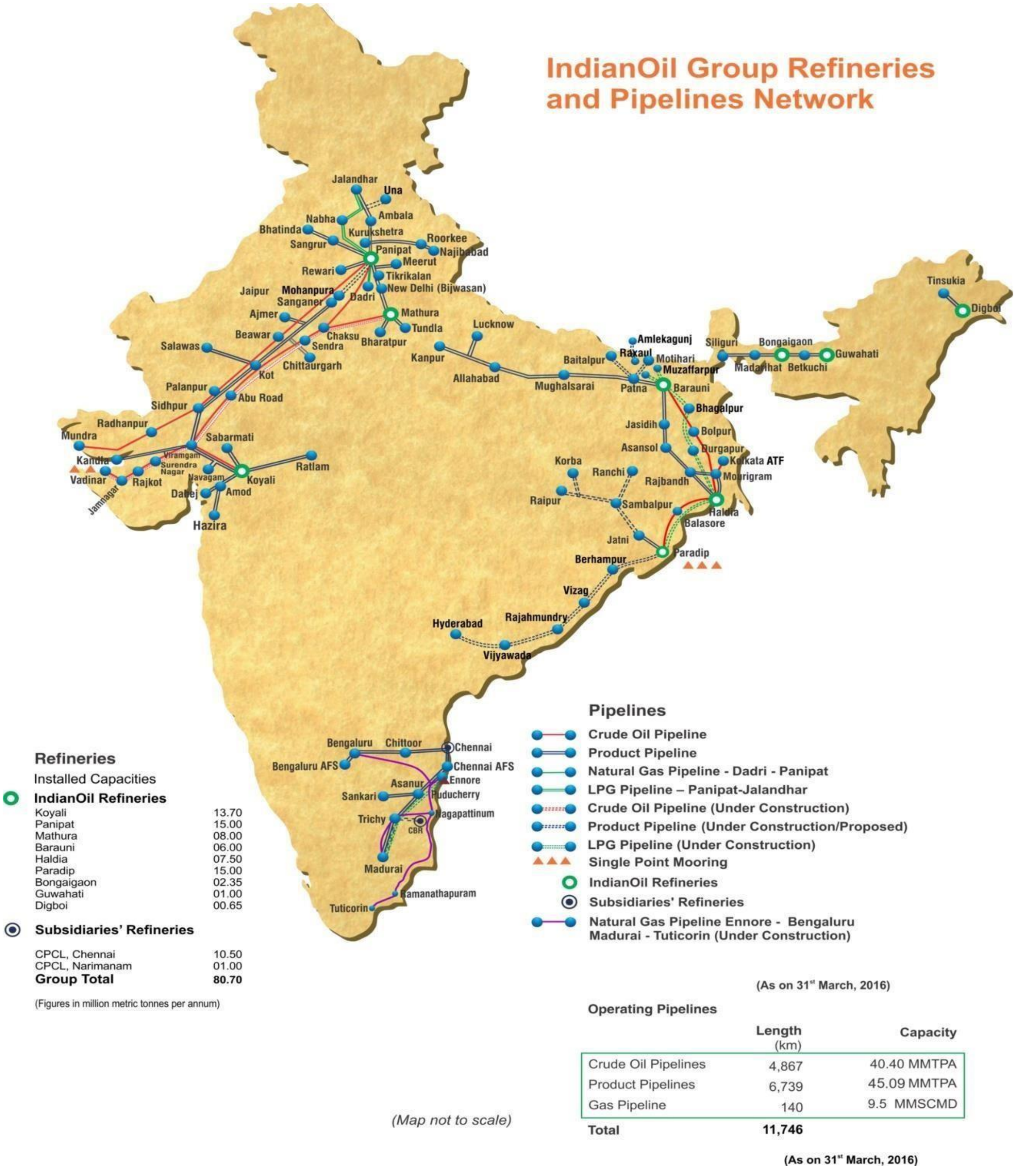
Mathura Refinery has planted 1, 67,000 trees in surrounding areas including refinery & township and 1, 15,000 trees in Agra region around Taj Mahal. The Ecological Park which is spread across 4.45 acres, is a thriving green oasis in the heart of sprawling Refinery.

At Mathura Refinery, technology & ecology go hand in hand with continuous endeavour for Product Quality up-gradation, Energy Conservation and Environment Protection. Mathura Refinery is the first in Asia and third in the world to receive the coveted ISO-14001 certification for Environment Management System in 1996. It is also the first in the World to get OHSMS certification for Safety Management in 1998 and 50001 certifications for Environment Management System in 2018.

IOCL Pipelines

IOCL operates a network of about 12848 km long crude oil, petroleum product and gas pipelines.

Map for IOCL Pipelines throughout the country.



ABOUT MATHURA REFINERY

Mathura Refinery, was commissioned in 1982 with a capacity of 6.0 MMTPA to meet the demand of petroleum products in north western region of the country, whichincludes National Capital Region. Refinery is located along the Delhi-Agra National Highway about 154 KM away from Delhi.

The major secondary processing units initially were Fluidised Catalytic Cracking Unit (FCCU), Vis-breaker Unit (VBU) and Bitumen Blowing Unit (BBU). The original technology for these units was sourced from erstwhile USSR, UOP etc. Soaker drum technology of EIL was implemented in VBU in the year 1993.

For production of unleaded Gasoline, Continuous Catalytic Reforming Unit (CCRU)was commissioned in 1998 with technology from IFP, France.

A Diesel Hydro Desulphurisation Unit (DHDS) was commissioned in 1999 for production of HSD with low Sulphur content of 0.25%wt (max).

With the commissioning of Once Through Hydrocracker Unit in 2000, Capacity of Mathura Refinery was increased from 6.0 to 8.0 MMTPA. FCCU Revamp was undertaken in 2014 to increase the processing capacity of the unit from 1.3 to 1.5 MMTPA.

Its close proximity to the magnificent wonder Taj Mahal adds to extra responsibility towards a cleaner environment. For upgrading environmental standards, old Sulphur Recovery Units (SRU) were replaced with new Sulphur Recovery Units with 99.9 % recovery in the year 1999. Additional Sulphur Recovery Unit (4th SRU) was implemented as a hot standby and was commissioned by 2011.

Refinery had also set up four nos. of continuous Ambient Air Monitoring Stations far beyond the working area before commissioning in 1982 as a mark of its concern towards the community and archaeological sites. At Mathura Refinery, technology and ecology go hand in hand with continuous endeavour for Product Quality up-gradation, Energy Conservation and Environment Protection. Mathura Refinery.

Following units were added to meet the fuel specifications-

- Diesel Hydro-treating unit (DHDT) & MS Quality Up-gradation Unit (MSQU) were installed with world class technology in 2005 for production of Euro-III grade HSD & MS as per Auto Fuel Policy of Govt. of India.
- Mathura refinery was one of the 1st refineries in the country to produce BS VI grade fuels, and has been supplying National Capital Territory, New Delhi with BS VI fuels since 1 Apr' 2018.
- Project for FCC Gasoline Desulphurization (FCCGDS) and Selective Hydrogenation Unit (SHU) was commissioned in 2010 and supply of Euro-IVgrade MS and HSD started on continuous basis from February 2010

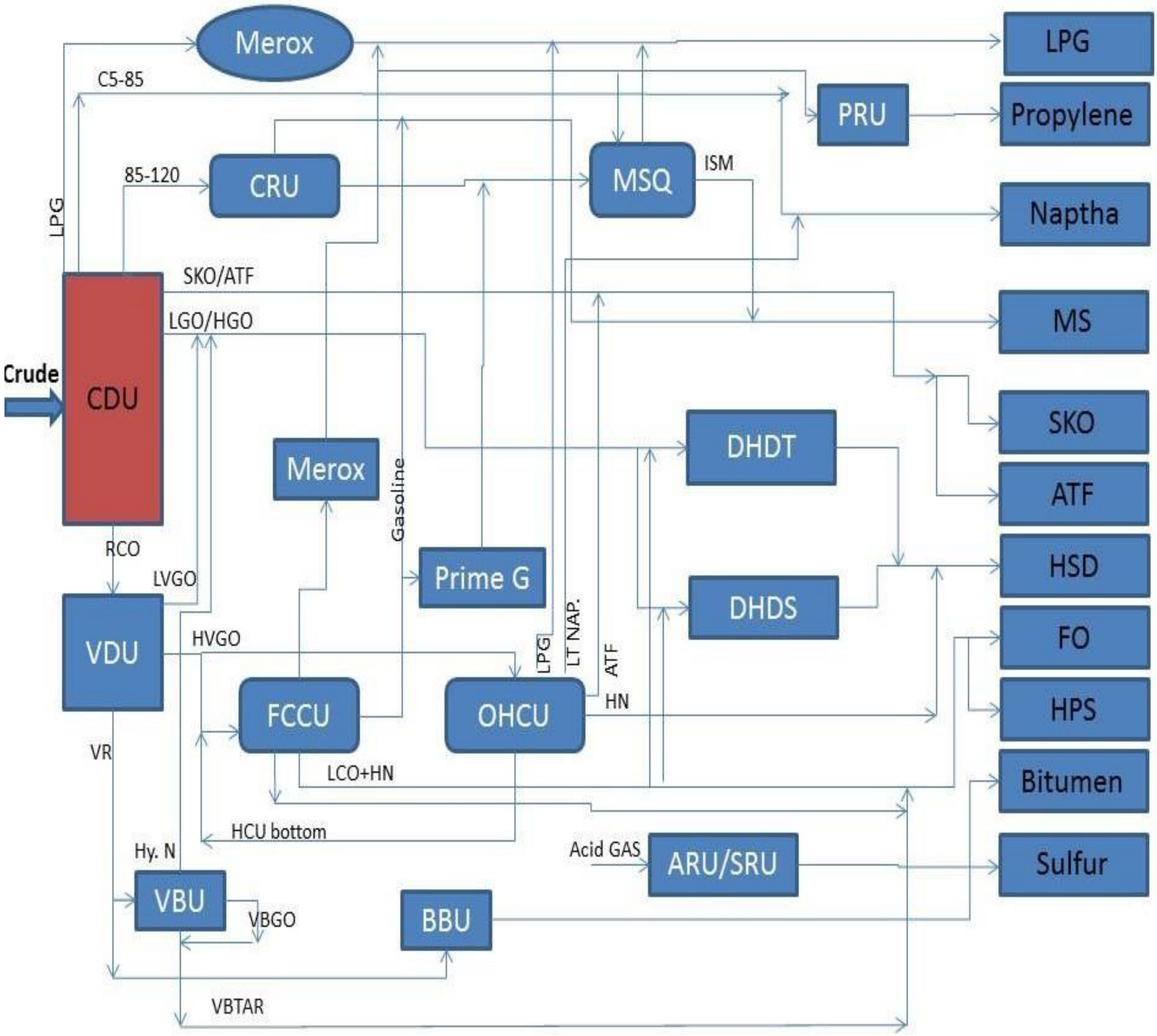
Upcoming projects: Residue Upgradation Project at Mathura Refinery (9.2 MMTPA) is being considered to improve the distillate yield and quality keeping in consideration the environmental effect.

Major products: LPG, Motor spirit (BS-VI), Superior Kerosene Oil, High Speed Diesel (BS-VI), Naphtha, propylene for PP production, Bitumen, Sulphur.

Mode of Product Dispatch:

- **Product pipeline:** MDPL, MAGPL, MBPL
- **Tank Wagon** for MS, HSD, Naphtha, FO.
- **Tanker trucks** for LPG, MS, HSD and ATF.

Process Flow Diagram of Mathura Refinery



MOTOR SPIRIT QUALITY UPGRADATION UNIT

MSQU unit consists of majorly two subunits –

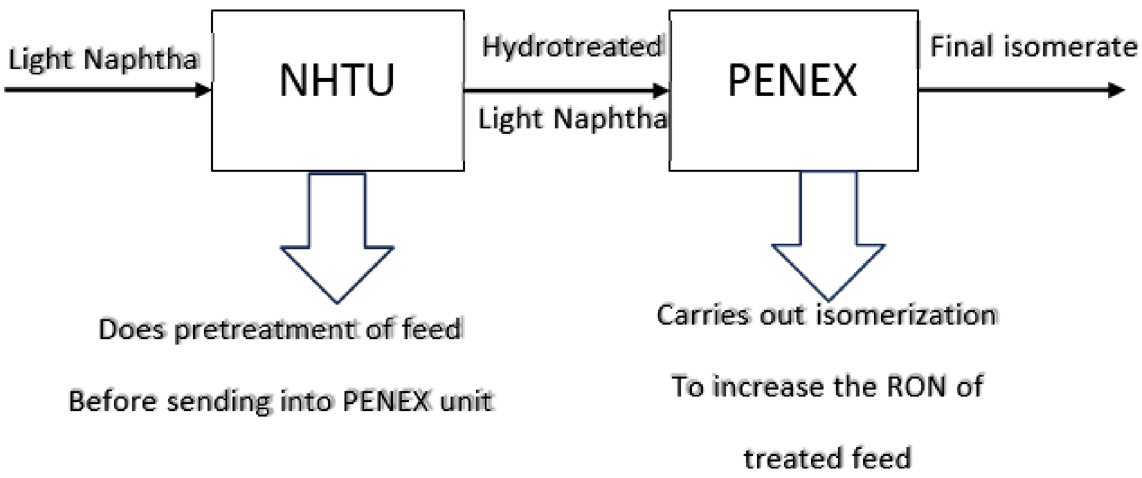
1. Naphtha Hydro Treatment Unit (NHTU)
2. PENEX / ISOMERIZATION Unit (ISOM)

WHY DO WE NEED MSQU UNIT?

The feed to the MSQU unit is Light Straight Run (LSR) naphtha with feed cut ofC5-85 which majorly contains carbon chains of 5C and 6C (of which 4-5% is benzene) and sulfur content of about 400 ppm which is much more than BS-VInorms. Also the Research Octane Number (RON) of the feed LSR Naphtha is around (64-70) which has to be increased to around (84-86) with the help of isomerisation to meet RON conditions of BS-VI afterwards.

The feedstock that is Light Naphtha first enters into the NHTU and is pretreatedbefore being sent into the PENEX unit for quality upgradation by increasing RON and removing benzene which is carcinogenic

The current capacity of the MSQU unit is 440 TMTPA.



NAPHTHA HYDROTREATING UNIT (NHTU)

1. NHTU PROCESS OVERVIEW

OBJECTIVE – To remove the sulfur and other impurities and to saturate the olefins in FCC portion of feed for PENEX unit

FEEDSTOCK – Feed consists of Light SR Naphtha produced from high "S" imported crude or low "S" crude, FCC Gasoline Heart Cut. Various feed component in design case are as follows:

➢ LSR Naphtha – High S	260TMTPA
➢ LSR Naphtha – Nigerian	60TMTPA
➢ FCC gasoline – Heart Cut	120TMTPA
➢ LSR Naphtha – BH	0TMTPA
TOTAL	440TMTPA

PRODUCT: The product is Hydro-Treated Naphtha, which is the geed for the PENEX-DIH Process unit. The properties of hydro treated product are as follows:

Parameters	Target
• Total sulphur, wt-ppm	0.05
• Total Nitrogen, wt-ppm	0.05
• Total oxygenates, wt-ppb	Nil
• Lead, wt-ppb	Nil
• Arsenic, wt-ppb	Nil
• Copper, wt-ppb	Nil
• Fluorides, wt-ppb	Nil
• Other Metals: Iron, Sodium	Nil

POWER & UTILITIES:

- Power: 1097.8 kW
- MP Steam: 6800kg/h
- Cooling Water: 88.2m3/h
- Fuel: 1.8 Mmkcal/h

FEEDSTOCK PROPERTIES:

Attributes	LSR HS	LSR Nigerian	FCC Gasoline (Heart Cut)	LSR Bombay High
Cut Range, C	C5-85	C5-85	70-90	C5-85
Density@15deg C	0.666	0.681	0.69	0.6971
Olefins%vol	Nil	Nil	60	Nil
Sulfur, ppmw	400	100	200	100
Chloride, ppmw	<10	<10	<10	<10
Nitrogen, ppmw	<1	<1	8	<1
Total metals, ppmw	<100	<100	<100	<100

2. REACTION MECHANISMS

The Main purpose of the Naphtha Hydrotreating Process Unit is to "Clean-up" the lightnaphtha so that it is suitable as charge to the Penex Unit. Reactions that occur in the Naphtha Hydro Treating Unit are as follows:

1) Olefin Saturation: Olefin saturation is almost as rapid as desulfurization and is highly exothermic Most straight run naphthas contain only trace amounts of olefins, but cracked naphthas usually have high olefin concentrations. Processing high concentrations of olefinsin NHTU must be approached with care because of the high exothermic heat of reaction associated with the saturation reaction.

2) Sulfur Removal: Sulfur removal in the NHTU is relatively easy and for the best operation ofa PENEX Unit, the Hydrotreated light naphtha sulfur content should be maintained below 0.1PPMW. Minimizing sulfur in the stripper bottoms will increase the life of the Sulfur Guard Bed. Commercial operation at 0.1 PPMW sulfur or less in the light hydrotreated naphtha is common. Operating NHTU at too high a temperature for maximum sulfur removal is possible but recombination of hydrogen sulfide with small amounts of olefins or olefin intermediatescan then result which produces mercaptans in the product.

3) Nitrogen Removal: Nitrogen removal is considerably more difficult than sulfur removal in NHTU. The rate of de-nitrification is only about one-fifth the rate of desulfurization. Most LSRN contain much less nitrogen than sulfur, but for PENEX catalyst a maximum of 0.1 PPMW nitrogen allowed. Cracked naphtha’s are expected to contain higher nitrogen levels. Any organic nitrogen that does enter the Penex will cause permanent catalyst poisoning andwill decompose to NH, and react with the chloride to form ammonium chloride leads to permanent catalyst poisoning. NH.CI then deposits in the cold sections of the Penex Unit. These problems can be avoided or minimized by maximizing nitrogen removal in the NHTU.

4) Oxygen Removal: Organically combined oxygen, such as phenols, is removed in the Naphtha

Hydrotreating Process Unit by hydrogenation of the carbon-hydroxyl bond, formingwater and the corresponding aromatic molecule.

5) Halide Removal: Organic halides can be decomposed in the Naphtha Hydrotreating Process Unit to the corresponding hydrogen halide, which is either absorbed in the reactoreffluent water wash or removed with the stripper overhead gas. Decomposition of organic halides is much more difficult than desulfurization. Maximum organic halide removal is thought to be about 90 percent, but is much less at operating conditions set for sulfur and nitrogen removal only. For this reason, periodic analysis of the hydrotreated (product) naphtha for organic chloride content should be made.

6) Metal Removal: Most metallic occur at PPB level in naphtha. However, UOP hydrotreatingcatalysts are capable of removing these materials at fairly high concentrations, up to 5 weight ppm or more, on an intermittent basis at normal operating conditions. Most metallicimpurities are permanently deposited on the catalyst when removed from the naphtha. Thecatalyst loses activity for sulfur removal as higher metal loadings are reached. Some commonly detected components found on used hydrotreating catalysts are arsenic, iron, calcium, magnesium, phosphorous, lead, silicon, copper, and sodium. Removal of metals is essentially complete above temperatures of 315 °C up to a total metal loading of about 2-3 weight percent on the catalyst.

The appropriate relative reaction rates, heats of reaction (in KJ per kg of feed per cubic meter of hydrogen consumed) and relative heats of reaction for the three major reactionsare:

Reaction	Relative Reaction Rate
De-sulfurization	100
Olefin Saturation	80
De-nitrification	20

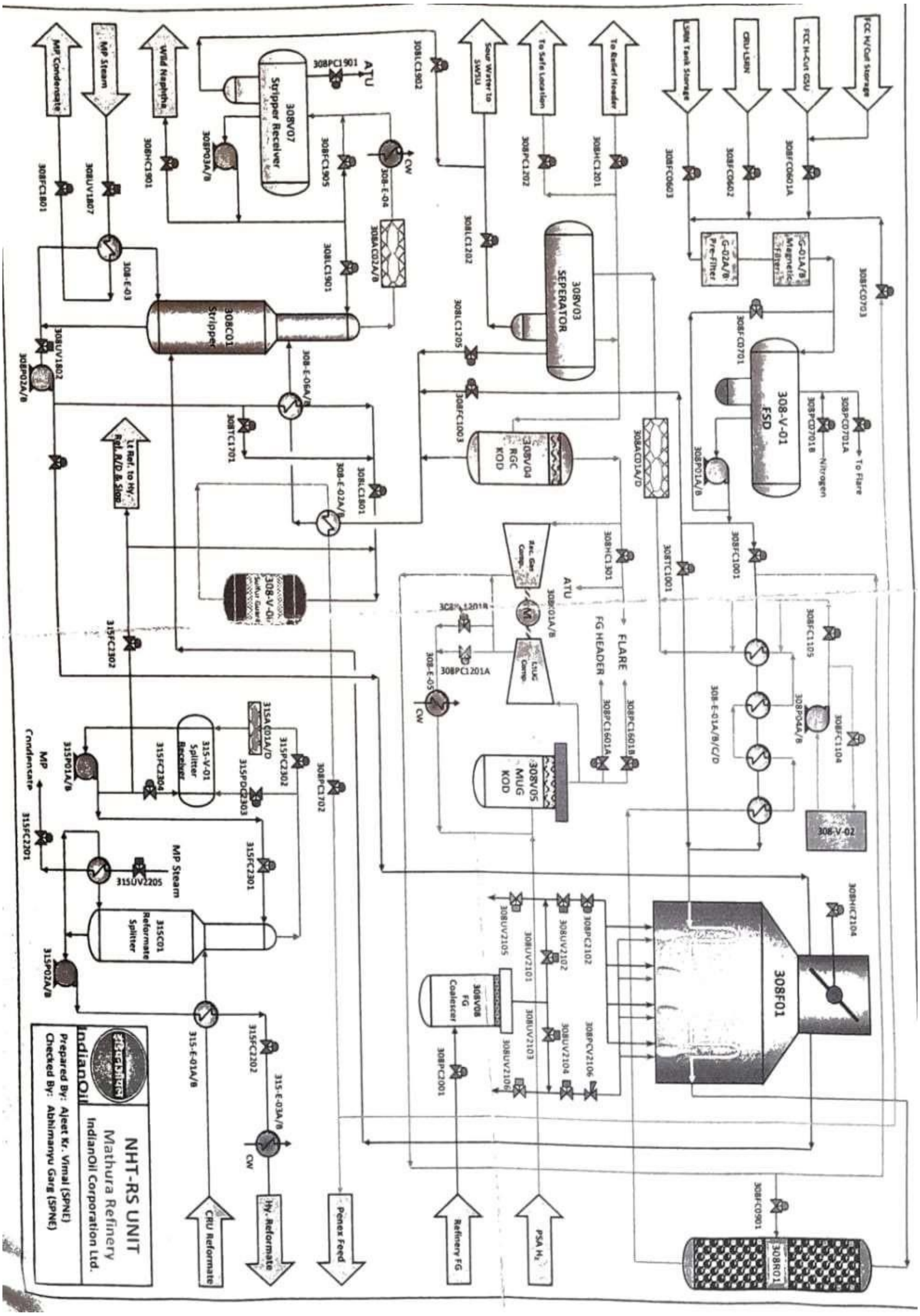
3. CATALYST PROPERTIES

The following summarizes the physical properties of a UOP hydrotreating catalyst, S-120

- UOP S-120 CATALYST (1^{st} Catalyst)
  Form: Pellets Active Metals: Mo, Co

- Sud-Chemie HD Max-350 (Current Catalyst)
  Form: Pellets Active Metals: Mo, Co

4. PROCESS FLOW DIAGRAM OF NHT UNIT



5. NHTU PFD EXPLAINATION

1) Feed System: The first vessel in the Naphtha Hydrotreating Process Unit is the Feed Surge Drum (308-V-01). The feed Surge Drum (308-V-01) pressure is controlled by dead band controller (PV-0701 A/B) On a low-pressure signal, Nitrogen will be added to the drum by opening the upstream gas control valve (PV-0701A). On a high-pressure signal, the vent line control valve (PV-0701B) opens to vent excess gas to the flare system. At steady state conditions both valves would normally be closed. In this unit unsaturated feed comes from a blanketed storage tank and also directly from other units It is very important that the storage tank be properly nitrogen gas blanketed to prevent oxygen from being dissolved in the naphtha. Even trace quantities of oxygen and/or olefin in the feed can cause polymerization of olefins in the storage tank when stored for long periods. This result in fouling in 308-E-01 A/B/C/D and a loss of heat transfer efficiency and polymer formation on the catalyst in the diene saturation reactor. As this unit does not have a pre-fractionation section, light naphtha flows directly from the Feed Surge Drum (308-V-01) by the Charge Pumps (308-P-01 A/B) through the Combined Feed Exchanger (308-E-01 A/B/C/D) to the Combined Feed heater (308-F-01).

At the suction of the Charge Pumps (308-P-01 A/B), there is a connection for sulfide addition (Line no. 1 ½" - ZC-0504) that is used for catalyst sulfiding during initial startup or if the sulfurin the reactor feed is less than 15 ppmw. There is a minimum flow spillback (Line no. 4"-P- 0704) on the Charge Pump discharge to protect the pump from damage. The Charge Pump (308-P-01 A/B) discharge flow is directed to the Combined Feed Exchanger (308-E-01 A/B/C/D). The flow to the reactor is set by a Flow Indicating Controller (FIC-1001). Low flow will shut the feed inlet control valve (FV-1001) to prevent channelling in reactor Recycle gas from the recycle compressor (308-K-01 A/B) mixes with the naphtha and enters the Combined Feed Exchanger (308-E- 01 A/B/C/D) which uses the reactor effluent for heating the feed and hydrogen. The feed and hydrogen exit the Combined Feed Exchanger (308-E-01 A/B/C/D) and enters the Combined Feed Heater (308-F-01). An automatic temperature control system (TC-0902) is used to maintain the reactor (308-R-01) inlet temperature by adjusting the gas flow to the burner to control the Combined Feed Heater (308-F-01) outlet temperature.

2) Reactor System: The recycle gas and feed enter the Combined Feed Exchanger (308-E-01 A/B/C/D) which is heated using reactor effluent. For low temperature operation and for unitstartup, the outlet temperature of the Combined Feed Exchanger (308-E-01 A/B/C/D) is controlled by a hand instrument controller when operating the reactor at low temperature. The feed and hydrogen exit from the Combined Feed Exchanger (308- E-01 A/B/C/D) and enter the Combined Feed Heater (308-F-01) where the stream temperature is raised to the desired reactor inlet temperature. A temperature instrument controller (TC-0902) at the Combined Feed Heater (308-F-01) effluent controls the gas flow rate to the burner.

The Combined Feed Heater (308-F-01) effluent enters the reactor (308-R-01) and flows down through the catalyst bed. There is a temperature recorder (T1-0903) at the reactor outlet to warn against high reactor outlet and delta temperatures. Differential pressure controllers (PDY-0902 & PDY-0903) are installed to monitor pressure drop as scale, polymerized material, and coke plug up the reactor. Recycle gas purge is used at both the low- and high- pressure points to prevent hot hydrocarbons and scale from moving into the transmitter impulse lines. The Combined Feed Heater (308-F-01) will shut down automatically when the recycle gas going to the reactor registers low flow, when the fresh feed flow rate is too low, when the pilot (fuel) gas pressure drops below the minimum set point, or when the emergency shutdown switch is activated.

3) Wash Water System: In this unit Wash water injection points (Lines 1"-WSS-1007 & 1 - WSS-1105) are located in the reactor effluent line at the Combined Feed Exchanger (308-E- 01D) inlet and outlet. The other alternative point (not shown in this unit) can be just upstream of the Products condenser fin- fan bundle. The wash water is used to wash away any ammonium chloride salts and to dilute any hydrogen chloride that might be present. Thereactor effluent along with the injected water flows into the Reactor Product Condenser fin- fan (308-AC-01) and from there into the Product Separator (308-V-03). The Product Separator (308-V-03) is provided with a water boot to collect the injected water. The wash water injection pumps (308-P- 04 A/B) inject enough fresh water to the system to prevent salt buildup. Excess water is pressured out of the Product Separator (308-V-03) water boot into the sour water header via interface level controller (LIC-1202). The wash water injection pump receives its cold condensate from a wash water break tank (308-V-02). Level control (LIC-1101) allows fresh makeup condensate to come into the tank and maintain the level.

4) Product Separator and Recycle Gas Compressor Section: The Separator (308-V-03) and the Recycle Gas Compressor (308-K-01 A/B) section separates the reactor effluent into unstripped liquid product and hydrogen-rich recycle gas. The Separator (308-V-03) pressure is controlled by (PIC-1201) regulating the makeup hydrogen flow rate. The equipments in thissection are: the Reactor Product Condenser (308-AC-01), the Product Separator (308-V-03) and Recycle / Makeup Gas Compressor (308-K-01A/B). The reactor circuit pressure is controlled at the product separator (308-V-03) by pressure indicating control. This controls the makeup flow of hydrogen gas into the unit allowing enough hydrogen to replenish that was consumed by the reaction and to keep pressure constant. The makeup hydrogen is added to the unit upstream of the Combined Feed Exchangers (308-E-01 A/B/C/D). There is ahand-control valve (HV-1201) on the gas effluent line (4"-P- 1209) from the Product Separator (308-V-03) that is normally closed. It can be used for emergency unit de- pressuring to the flare.

5) High Pressure NHT Unit: Reactor effluent exits the reactor section and is partially condensed in the Reactor Product Condenser (308-AC-01). It cools the effluent to 58 °C (137

F). The cooled liquid and gas then proceed to the Product Separator (308-V-03) where they can be separated. H_2 leaves the top of the Product Separator (308-V-03) and is routed to the Recycle Gas Knockout Drum (308-V-04) and on through to the Recycle Gas Compressor (308- K-01 A/B), where the gas is recycled back to the Reactor (308-R-01). The Makeup Gas SuctionDrum (308-V-05) PIC (PIC-1601) and the Product Separate PIC float on a low-signal selector (LSS) signal on the Makeup Gas Compressor spillback control valve (PV-1601 A/B). A lower signal on the Makeup Gas Suction Drum opens the spillback control valve (PV-1601 A/B), thereby sending more gas to the suction of the Makeup Gas Compressor (308-K-01 A/B). A lower signal on the Product Separator (308- V-03) closes the spillback, thereby sending more makeup gas forward to the Product Separator.

6) Stripper Column Section: The purpose of the Stripper (308-C-01) is to remove hydrogen, light gases, water and contaminant by-products (such as hydrogen sulfide) from the naphtha before it is routed to the Penex Unit. The feed to this column is first preheated in the Stripper Feed/Bottoms Exchanger (308-E-06 A/B) before entering the Stripper (308-C-01). The Stripper re-boiler (308-E-03) is provided to supply the required heat input for generating vapors that accomplish the stripping of the naphtha hydrotreated liquid product. The naphtha in the bottom of the tower is sent to the stripper re-boiler (308-E-03). Steam is usedto heat the shell side of the re-boiler exchanger and is controlled on the outlet of the exchanger by flow control (FIC-1801). The steam flow is adjusted to obtain the required bottoms temperature on the stripper (308-C-01) column.

Stripper vapors pass overhead to the Stripper condenser (308-AC-02) and then are routed tothe Stripper Trim condenser (308-E-04) and then to the Stripper Receiver (308-V-07). Liquid from stripper receiver (308-V-07) is refluxed back into the column by stripper overhead pumps (308-P-

03 A/B). The reflux is pumped to the top tray of the Stripper Column. To increase the amount of reflux, the reboiler heat input must be increased to provide more overhead material and reflux. The net overhead gas leaves the receiver on pressure control (PIC-1901) to the gas concentration unit. The Stripper column design pressure is 14 kg/cm^3g.

6.YIELD PATTERN NHT WT%

The final concentration of naphtha in the light ends section that is the off gas and in thebottom product which mostly consists of hydrotreated naphtha.

STRIPPER OFF GAS	STRIPPER BOTTOM
0.65 %	**99.34 %**

The light Naphtha Hydrotreating Process Unit is fairly simple to monitor from a calculationand data review standpoint.

After the Hydro-treatment of Naphtha in NHT Unit, the amount of contaminants such as Sulfur, Nitrogen, Fluorides, Metals and most importantly moisture arereduced up to large extent to avoid degradation of catalyst present in PENEXUnit i.e. Platinum and thus this hydrotreated light naphtha feed can now be sent to PENEX unit for isomerization to increase the RON of the feed to our desired value of MSQU unit that is 86-88 and to reduce the amount of benzene content by ring opening as a side reaction.

Therefore, NEXT UP

PENEX/ISOMERIZATION

UNIT

PENEX / ISOMERIZATION UNIT

1. PENEX UNIT PROCESS OVERVIEW

- PENEX unit is used for converting low octane straight run naphtha (64-70) to high octane naphtha (84-86). Octane number is boosted by isomerization of n-paraffin (C5and C6) to iso-paraffin (C5 and C6) in the presence of HCl and Pt-AlCl3 catalyst.
- Other side reaction also takes place such as benzene saturation to cyclo-hexane, cyclo-paraffins ring opening and isomerization and cracking on some amount of n-C7to C3 and C4 which is sent to LPG storage.

Thus, some amount of LPG is also made in PENEX unit due to cracking

FEEDSTOCK:

Feed Stock Component	Case1 High Benzene (TMTPA)	Case 2 Low Benzene (TMTPA)
LSR Naphtha-HS	0	260
LSR Naphtha-Nigerian	131.6	60
LSR Naphtha-BH	131.6	0
Heart Cut FCC Gasoline	120	120
Light Reformate	56.8	
Total	440	440
Hydrogen Consumption		
Nm3/Std m3 feed	138	91

PRODUCTS:

ISOMERATE PRODUCT	CASE-1	CASE-2
Sulfur Content-wt. ppm	0.3	0.3
Benzene Content %vol	0.1	0.1
RON (min)	87	87
MON (min)	84	83
Olefins-vol%(max)	0.1	0.1
RVP-kPa max	85	85
LPG Product		
Volatility@95vol% (max)	+2	+2
V.P.@65degC kg/cm2g (max)	16.87	16.87

FINAL PRODUCTION COMPARISON OF ISOMERATE & LPG:

Sl. No.	Products	wt%
1	Motor Spirit	90-91
2	LPG	10-11

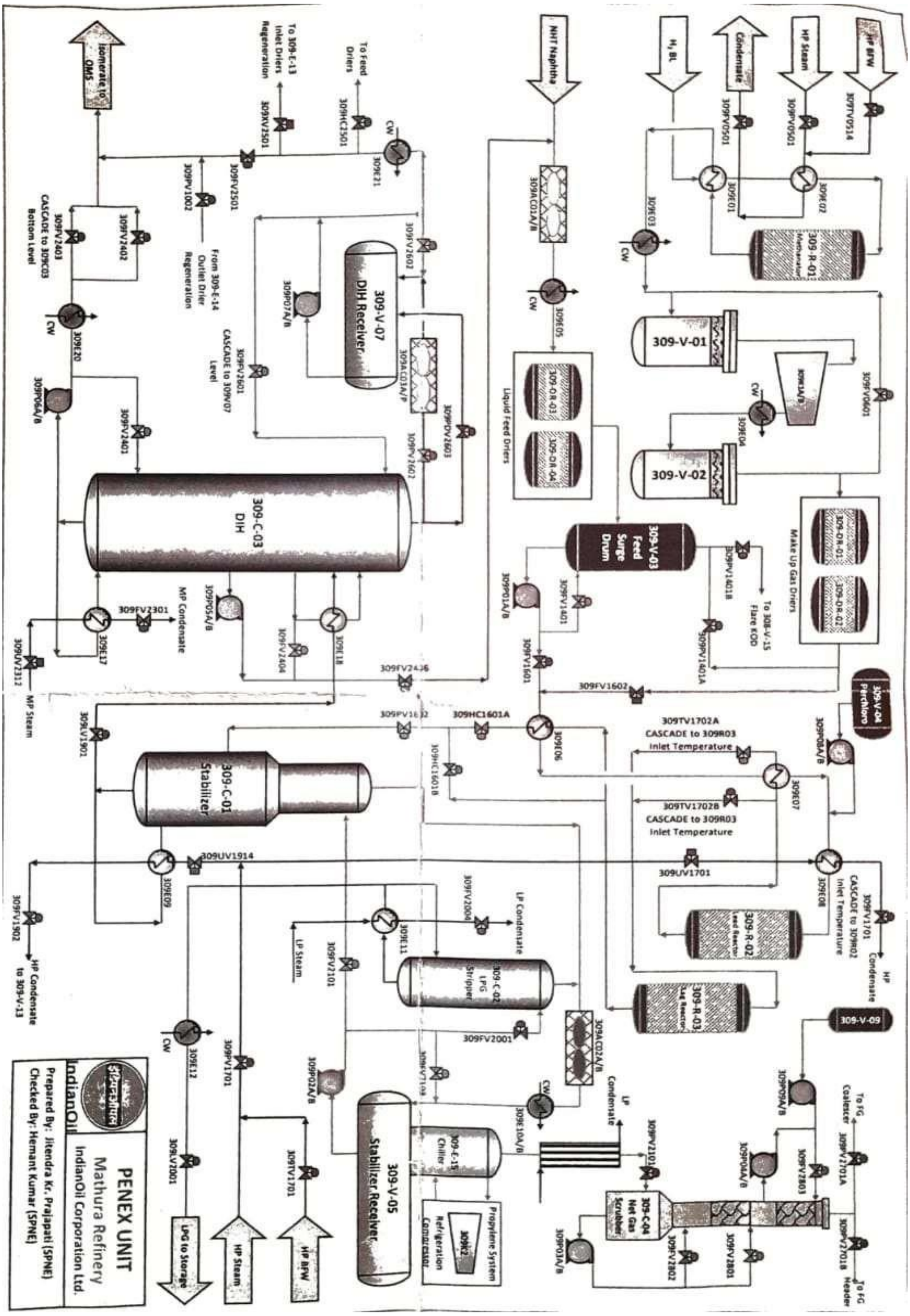
POWER & UTILITIES:

- POWER: 1955.3kW
- HP STEAM: 28600kg/hr
- MP STEAM: 19900kg/hr
- LP STEAM: 700kg/hr
- COOLING WATER: 724.6 m3/hr
- FUEL: 0.1MMkcal/hr
- N2: 20 nm3/hr

CATALYST:

Pt catalyst with constant perchloro dozing to provide acidic medium.PERCHOLORO FORMULA – C2CL4 (PERCHLORO ETHYLENE)

2. PENEX UNIT PROCESS FLOW DIAGRAM



3. PENEX UNIT PFD EXPLAINATION

1) **Feed Surge Drum**: Reformate Splitter Overhead and Stripper Bottoms from the Naphtha Hydrotreating Unit are combined with the DIH-Deisohexanizer (309-C-03) Side Draw and cooled in the Feed Cooler (309-AC-01) and Feed Trim Cooler (309-E-05). The liquid feed is cooled to 45°C for optimum dryer operation. Cooled feed is sent through the Liquid Feed Driers (309-DR-03 and 309-DR-04) to Feed Surge Drum (309-V-03). Side Draw from DIH is also routed through the dryers to ensure maximum potential catalyst life. The Feed Surge Drum is blanketed with make-up hydrogen. The combined feed is pumped by the Charge Pumps (309-P-01 A/B) to the Cold Combined Feed Exchanger (309-E-06) on flow control (FIC-1601, FIC-1401). Upstream of the Cold Combined Feed Exchanger the liquid is mixed with the make-up hydrogen from the Make-up Gas Driers (309-DR-01 and 309-DR-02).

2) **HYDROGEN:** The source of the make-up gas is an existing POLYBED PSA unit. The make-up hydrogen contains CO and CO. Both of these gases need to be removed prior to being sent tothe Penex Reactor Section. Both CO and CO_2 are removed via conversion in the Methanator Reactor (309-R-01). The Make-up gas is heat exchanged with the Methanator Effluent (in
309-E-01) and further heated to the operating temperature of 240°C with Methanator Heater (309-E-02). Methanator effluent is heat exchanged with the make-up gas from battery limits and cooled in the Make-up Gas cooler (309-E-03). Cooled gas is compressed bya single stage reciprocating compressor (309-K-01 A/B) and dried in 309-DR-01 and 309-DR-
02. Dried hydrocarbon & H, are mixed upstream of the Cold Combined Feed Exchanger. Thecontrol valve in the spill back line controls make-up gas flow rate.

3) **Cold Combined and Hot Combined Feed Exchangers (CCFE/HCFE):** Combined feed is heated through Cold Combined Feed exchangers (309-E-06) and Hot Combined Feed exchangers (309-E-07 A/B) against reactor effluent and Charge Heater (309-E-08) utilizing HPsteam. Then, combined feed is sent to the Penex Reactors (309-R-02 and 309-R-03). PERC is injected upstream of 309-E-08 into the combined food stream. Organic chloride promoter is added continuously with the feed and is converted to hydrogen chloride in the reactor. Unit employs two reactors in a series flow configuration with the total required catalyst being equally distributed between the two vessels. Valves and piping are provided which permit reversal of the processing positions of the two vessels and the isolation of either for partial catalyst replacement. With time, the Penex catalyst will become deactivated by water, not coke, because the water deactivation proceeds as a sharp front that moves down the bed in a piston-like fashion; catalyst downstream of front remains unaffected. When catalyst in the lead reactor is spent the reactor is taken off-line for reloading. During the short period of time the reactor is out of service, the second reactor is capable of maintaining continuous operation at design throughout. After catalyst reloading is completed, the processing positions of the two reactors may be reversed i.e., the reactor with fresh catalyst will be in the lag position Reactor effluent is heat exchanged with combined feed in Cold and Hot Combined Feed Exchangers (309-E-06 and 309-E-07A/B) then taken directly to the Stabilizer

(309-C-01). The pressure control valve (PV-1602) located in the feed line to the Stabilizer controls the operating pressure on the reactor circuit. The Stabilizer (309-C-01) and LPG Stripper (309-C-02) overhead vapors are condensed and cooled in the Stabilizer Condenser (309-AC-02) and Stabilizer Trim Condenser (309-E-10). The Stabilizer produces three products: bottoms liquid, net overhead vapor and overhead liquid. The overhead liquid fromthe Stabilizer is sent to the LPG Stripper (309-C-02) for LPG recovery on flow control reset by level control. The finished LPG is cooled (in 309-E-12, LPG Cooler) and sent to storage on level control (LV-2001). Light ends from the Stabilizer Receiver (309-V-05) are cooled throughthe Stabilizer Net Gas Economizer and Stabilizer Net Gas Chiller (309-E-15) located on the overhead off-gas line. Gas from Stabilizer Net Gas Chiller is heated back in the steam jacketed pipeline prior to be being sent to the Net Gas Scrubber-NGS (309-C-04). LPG condenses and returns to the Stabilizer Receiver (309-V-05). In NGS (309-C-04) the off-gases are scrubbed with caustic to remove hydrogen chloride before being sent to NHTU Fuel Gas Coalescer (308-V-08) on pressure control. Pump (309-P-03 A/B) at the bottom of the scrubber column circulates the caustic. To remove any entrained caustic a water wash section has been provided on top of the caustic wash section. Water Circulation Pump (309- P-04 A/B) taking suction from trap tray and circulates the water. Any water lost due to hydration is replaced by the injection of condensate into the circulating water line. Stabilizedisomerate liquid product from Stabilizer (309-C-01) bottom passes to DIH column (309-C-03) on level control.

4) **DEISOHEXANISER (DIH):** DIH Tower is used to recover pentanes and product iso-hexane from stabilized products from PENEX. DIH side drawn (mainly contains 2MP, 3MP, and n- hexane) is recycled back to PENEX for further upgradation. PENEX can upgrade light straight run naphtha from 70.0 RONC to 82.0-84.0 RONC. There is a significant amount of C6 that canbe further upgraded to 2-2DMB. The overhead product from a DIH has the potential to have an octane value of 88.0-90.0 RONC. DIH is typically designed to process C/C, naphtha mixture and produce an overhead product with octane values of approximately 90.0 RONC.

DIH column has 80 trays. Stabilized & isomerized naphtha routed to DIH through heat exchange (309-E-18) where it is cooled and enters to DIH middle tray. The column operates at 1.34-2.31 kg/cm2 g and a reflux/feed ratio of about 1.8. Overhead vapor from the DIH is condensed via the air cooler 309-AC-03 and the liquid accumulates in the DIH receiver (309- V-08) which serves as reflux drum. Overhead product is further cooled in cooler (309-E-21) and is pumped over to tank or to gasoline blending. Larger portion (60%) of overhead liquid is pumped pump back to DIH column as reflux and balance as net product. Overhead draw ison compositional control via upper tray temperature control cascaded to net overhead drawflow control. The "conventional" composition control system was used to control simple two product fractionators such as a DIH. That is, fixing the pressure and heat input, having the receiver level control the net overhead product flow and using the composition control (typically a column tray temperature) to adjust the reflux flowrate. In late 1960's, articles were published that suggested that there may be a better way to control this type of column. This alternate scheme has been discussed in a number of texts and is commonly known as themateria l balance or flywheel control scheme.

5) **METHANATOR OPERATIONS:** Methanator (309-R-01) is used for treating the makeup H, gas to an Isomerization Unit as catalysts are extreme sensitivity to oxygenated compounds. Any amounts of CO or CO2, in the makeup H, gas will affect catalyst life. Methanator can prolong the catalyst life by reducing the CO/CO2, concentration to low ppm levels that in the case of CO, will be further reduced to essentially nil by the Isomerization Unit's molecular sieve driers.

<u>CO/CO2 SOURCES:</u> There are two principal sources of CO and CO, in the makeup H, 1" is catalytic reformer which periodically has one of its reactors taken off line, regenerated and put back on stream. CO and CO; generated during the regeneration will be present in the nethydrogen from this type of reformer and may find its way to the Isomerization Unit. Another type of reformer (those with continuous catalyst regeneration) also can have moderately high levels of CO/CO2, depending on the operating conditions. 2Nd is HGU plant Hy gas which may contain as much as one mole percent CO plus CO2. Many hydrogen plants have their own Methanator that will reduce CO and CO2, concentration to lower levels. However, most H, plant Methanator is not designed to assure low enough CO/CO2, levels to be acceptable to an Isomerization Unit. Even concentrations of 5-10 ppm CO/CO2, may be sufficient for justifying a separate Methanator for the makeup gas to the Isomerization Unit. The CO and CO2, are consumed in the following reactions:

$$CO + 3\,H_2 \rightleftarrows CH_4 + H_2O \qquad \Delta H = -206.1\ \mathrm{kJ\ mol^{-1}} \qquad (1)$$

$$CO_2 + 4\,H_2 \rightleftarrows CH_4 + 2\,H_2O \qquad \Delta H = -165.0\ \mathrm{kJ\ mol^{-1}} \qquad (2)$$

4. DESIGNED YIELD PATTERN OF PENEX

YIELD PATTERN OF PENEX WT%			
FG	**LPG**	**LIGHT ISOMERATE**	**DIH BOTTOM**
1.03	**12.71**	**84.46**	**1.81**

5. TRANSPORT OF LIGHT ISOMERATE TO MS POOL

The light isomerate that is obtained from the MSQU unit having RON of 86-88 is now sent tomotor-spirit pool for blending with other high RON products such as reformates from CCRU, desulfurized FCCU gasoline from Prime-G to get our desired min. RON of 91 and which can be now be sent from the refinery for consumption in the market. And some amount of LPG produced is sent to LPG Storage section of refinery.

REFERENCES

1. Motor Spirit Quality Upgradation Unit Pocket ManualBy the Production Department, IOCL.
2. Motor Spirit Quality Upgradation Unit Operation ManualBy the Production Department, IOCL.
3. Process Flow Diagram of NHTUBy Ajeet Kr. Vimal (SPNE), IOCL.
4. Process Flow Diagram of PENEX By Jitendra Kr. Prajapati (SPNE), IOCL.
5. Overall Refinery Process Flow Diagram By Technical Services Department, IOCL.

ABBREVIATIONS

- OM&S - Oil Movement and Storage
- IOCL - Indian Oil Corporation Limited
- AVU - Atmospheric and Vacuum Distillation Units
- VDU - Vis Breaker Unit
- FCCU - Fluidized Catalytic Cracking Unit
- CCRU - Continuous Catalytic Reforming Unit
- MerOx - Mercaptan Oxidation Unit
- PRU - Propylene Recovery Unit
- BBU - Bitumen Blowing Unit
- DHDS - Diesel Hydro Desulphurization Unit
- DHDT - Diesel Hydro Treatment Unit
- OHCU - Once through Hydro Cracker Unit
- HGU - Hydrogen Generation Unit
- MSQU - Motor Spirit Quality Unit
- ARU - Amine Recovery Unit
- SWS - Sour Water Stripper
- SRU - Sulphur Recovery Unit
- ETP - Eluent Treatment Plant
- MMTPA – Million Metric Tonne per Annum
- TMTPA – Thousand Metric Tonne per Annum