# Point Wise response by IOCL Barauni Refinery on additional information sought by MoEF:

**1.0 Total Plot area of the refinery. Area earmarked for greenbelt. A layout plan may be submitted.**

- Total plot area of the refinery including BTP : 887.83 acres.
- Green belt area in Refinery : 148.39 acres
- Green belt area in Refinery Township : 82.19 acres
- Total green belt area : 230.58 acres

Layout plans showing Green belt area in Refinery & Township are enclosed in **Annexure - 1A & 1B.**

In view of unavailability of space within the refinery premises, scope for extensive tree plantation is limited. However, tree plantation is being taken up both in refinery and township at available spaces. 1627 nos of trees were planted during the year 2015-16. Further, 5000 nos of tree plantations have been planned during 2016-17 covering 5 acres approx.

**2.0 Point wise TOR compliance statement.**

Point wise TOR compliance statement is enclosed as **Annexure-2.**

**3.0 Details of Sulphur balance in the existing and proposed Refinery.**

Present SO2 emission limit for Barauni Refinery as per last MoEF clearance vide clearance letter noJ-1101/491/2007-IA II (I) dated 18.03.2008 is 1035 kg/hr whereas the actual SO2 emission is maintained at the level of 700 kg/hr. The detailed breakup of furnace-wise SO2 emission and Sulphur balance is as follows:

| Furnace wise SO2 emission at present | | | | | | | |
|---|---|---|---|---|---|---|---|
| **UNIT** | **FUEL OIL CONSUM PTION** | **FUEL GAS CONSUM PTION** | **"S" in FO** | **"S" in FG** | **Total "S" burnt in Furnace** | **Corresponding "SO2" generated in Furnace** | **Total "SO2" generated in Furnace** |
| | **MT/day** | **MT/day** | **MT / Day** | **MT / Day** | **MT / Day** | **MT / Day** | **kg/hr** |
| **AVU -I** | 41.3 | 18.8 | 0.40 | 0.00 | 0.41 | 0.82 | 33.97 |
| **AVU-II** | 39.5 | 19.6 | 0.39 | 0.00 | 0.39 | 0.78 | 32.53 |
| **AVU-III** | 38.5 | 70.8 | 0.38 | 0.01 | 0.39 | 0.78 | 32.43 |
| **COKER-A** | 2.9 | 39.2 | 0.03 | 0.01 | 0.03 | 0.07 | 2.87 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **COKER-B** | 4.2 | 51.0 | 0.04 | 0.01 | 0.05 | 0.10 | 4.11 |
| **CRU** | 0.0 | 86.4 | 0.00 | 0.01 | 0.01 | 0.03 | 1.15 |
| **HGU** | 64.2 | 165.4 | 0.01 | 0.03 | 0.04 | 0.08 | 3.28 |
| **DHDT** | 0.0 | 60.8 | 0.00 | 0.01 | 0.01 | 0.02 | 0.81 |
| **TPS (BOILERS)** | 305.8 | 94.2 | 3.00 | 0.02 | 3.01 | 6.02 | 250.99 |
| **TPS (GT)** | 274.0 | 0.0 | 0.05 | 0.00 | 0.05 | 0.11 | 4.57 |
| **RFCCU** | 369.6 | | 14.78 | 0.00 | 14.78 | 7.98 | 332.64 |
| **NHDT** | 0.0 | 2.8 | 0.00 | 0.0004 | 0.0004 | 0.0009 | 0.04 |
| **PRIME-G** | 0.0 | 3.1 | 0.00 | 0.0005 | 0.0005 | 0.0010 | 0.04 |
| **SRU** | | | | | 0.32 | 0.17 | 7.10 |
| **Total** | | | | | | | **707** |

Post BS-IV project, there will be an additional load of 33.32 MMKCal/hr due to installation & revamp of process unit furnaces. Also there will be an extra load of 12 MW of power and 90 tons/hr of steam for which 95.22 MMKCal/hr of extra energy will be required.

Due to extra consumption of fuel post BS-IV project, SO2 emission will increase from the present level. However to reduce SO2 emission, sulphur content in Internal Fuel Oil (IFO) will be reduced from current level of 0.98% to 0.75% (through change in IFO blend and more LS VR component) resulting in total SO2 emission of 815 kg/hr post BS-IV project.

Detailed SO2 emission projection post BS-IV project is as under.

| **Furnace wise SO2 emission post BS-IV Project** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **UNIT** | **FUEL OIL CONSUM-PTION (Per Day)** | **FUEL GAS CONSUM-PTION (Per Day)** | **"S" in FO** | **"S" in FG** | **Total "S" burned in Furnace** | **Total "SO2" generated in Furnace** | **Total "SO2" generated in Furnace** |
| | **(MT)** | **(MT)** | **MT / Day** | **MT / Day** | **MT / Day** | **MT / Day** | **kg/hr** |
| **Existing** | | | | | | | |
| **AVU -I** | 41.3 | 18.8 | 0.31 | 0.003 | 0.31 | 0.63 | 26.06 |
| **AVU-II** | 39.5 | 19.6 | 0.30 | 0.003 | 0.30 | 0.60 | 24.96 |
| **AVU-III** | 38.5 | 70.8 | 0.29 | 0.01 | 0.30 | 0.60 | 25.04 |
| **COKER-A** | 2.9 | 39.2 | 0.02 | 0.01 | 0.03 | 0.06 | 2.32 |
| **COKER-B** | 4.2 | 51.0 | 0.03 | 0.01 | 0.04 | 0.08 | 3.31 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CRU** | 0.0 | 86.4 | 0.00 | 0.01 | 0.01 | 0.03 | 1.15 |
| **HGU** | 64.2 | 165.4 | 0.01 | 0.03 | 0.04 | 0.08 | 3.28 |
| **DHDT** | 0.0 | 60.8 | 0.00 | 0.01 | 0.01 | 0.02 | 0.81 |
| **TPS (BOILERS)** | 305.8 | 94.2 | 2.29 | 0.02 | 2.31 | 4.62 | 192.38 |
| **TPS (GTG-1)** | 274.0 | 0.0 | 0.05 | 0.00 | 0.05 | 0.11 | 4.57 |
| **NHDT** | 0.0 | 2.8 | 0.00 | 0.000 | 0.00 | 0.00 | 0.04 |
| **PRIME-G** | 0.0 | 3.1 | 0.00 | 0.000 | 0.00 | 0.00 | 0.04 |
| **RFCCU** | 369.6 | | 14.78 | 0.00 | 14.78 | 7.98 | 332.64 |
| **SRU** | | | | | 0.12 | 0.06 | 2.68 |
| **Extra Fuel Required** | | | | | | | |
| Power | 75.0 | 0.0 | 0.56 | 0.000 | 0.56 | 1.13 | 46.88 |
| HP Steam | 163.0 | 0.0 | 1.22 | 0.000 | 1.22 | 2.45 | 101.90 |
| Fuel for Furnace | 75.0 | 8.2 | 0.56 | 0.001 | 0.56 | 1.13 | 46.96 |
| **Total** | | | | | | | **815** |

Further, sulphur balance before and after BS-IV project is given in **Annexure-3**.

**4.0 GLC for post project SO2 emission is estimated to be 66.9 µg/m3, which seems to be in higher side. Recheck the prediction modeling or clarify with reasons. In this context, air pollution Control measures to be given appropriately to reduce the GLC for SO2 emissions.**

The absolute maximum of the predicted GLC for SO2 was calculated to be 66.9 µg/m3. During this modeling SO2 emission for the IOCL Barauni Refinery was taken as 1034.59 kg/hr. However, presently IOCL Barauni Refinery total SO2 stack emission is in the range of 690 to 720 kg/hr and post project scenario SO2 stack emission will be 815 kg/hr. Hence, actual GLC is expected to be considerably lower than 66.9 µg/m3. Various air pollution control measures considered in the proposed project is given in Para 5.0.

**5.0 Proposed unit wise air pollution control devices.**

Following air pollution control devices/measures are being installed in the proposed project:

1. Low NOx/Ultra low NOx burners will be installed in all new furnaces.
2. Coker A will be operated in Single furnace mode operation.
3. Installation of additional amine absorption column and regenerator.

4. Off gases from Biturox Unit will be routed to CO incinerator in RFCCU ensuring total oxidation.

5. BenSat (Benzene Saturation) Unit will be installed as part of the proposed project in line with benzene specification in BS-IV MS.

**6.0 Complete water balance chart indicating total water requirement, water losses, waste water generation and water recycled.**

Water balance chart post BS-IV project scenario is enclosed as **Annexure-4** indicating total water requirement, water losses, waste water generation and water recycle.

New ETP RO plant which is currently under construction is scheduled to be commissioned in Aug 2016. RO plant will be operated to meet the requirement of DM plant feed water. RO reject so to be generated will be utilized for the following purpose:

1. 20 $m^3$/hr - For the purpose of Coke Cutting water and fire water makeup after dilution with treated water.
2. 12 $m^3$/hr – Makeup for Eco Pond, Horticulture and green belt after dilution with treated water.
3. 18 $m^3$/hr – for spraying in Coke yard.

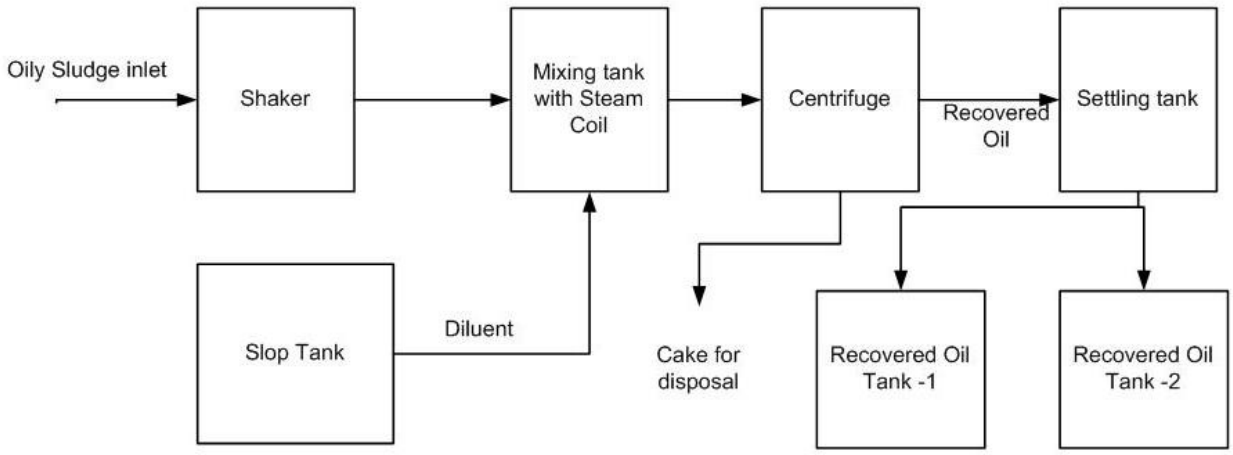
**7.0 Whether unit is a zero discharge unit or plan to be drawn for complete ZLD of existing and proposed expansion.**

As of now, conventional ZLD plant is not envisaged for IOCL Barauni Refinery. However, as clarified under Point no. 6.0 above, there will be no discharge to outside except during heavy rainfall, when excess surface run off may have to be allowed to flow into Refinery owned pit (Burrow Pit) adjacent to refinery premise in the West.

**8.0 Oily sludge management plan.**

Oily sludge is generated mainly during cleaning of storage tanks and from ETP. It is processed by **"Mechanized Skid Process"** for recovery of 90-95% oil from oily sludge and generation of minimum quantity of residual oily sludge. Mechanical extraction method uses solvent & steam heating and then oily sludge is processed in a plant equipped with centrifuge in order to recover maximum possible oil and water. The sludge is broken down into water, oil and base sediments. Water is drained into ETP for further treatment while the recovered oil is pumped into slop oil tanks for reprocessing in the refinery. The base sediment (residual oily sludge) in solid state has an oil content of around 3-8 %wt and is disposed through bioremediation facility inside the refinery.

Detailed process flow diagram for the same is shown as below.




**Bioremediation of residual Oily Sludge**

Residual sludge generated from mechanized skid process is disposed off by means of bioremediation in lined pits. In this process, residual oily sludge generated is degraded into water and carbon dioxide by spreading sludge on earmarked site and applying bacterial consortium Oilivorous-S along with nutrients. The designated area is tilled every fortnight using a tractor trailer. The Oilivorous –S bacteria, developed jointly by M/S TERI and IOCL (R&D), eats away the residual oil.

ALL DIMENSIONS ARE IN MM

Annexure-1A

| JOB NO. | DESCRIPTION |
|---|---|
| 101 | ATMOSPHERIC AND VACCUM UNIT NO.–1 |
| 102 | ATMOSPHERIC AND VACCUM UNIT NO.–2 |
| 104 | COKING UNIT |
| 152 | STORES |
| 154 | FUEL OIL STATION TANKAGE |
| 155 | SOLVANT STORAGE |
| 156 | CHEMICAL STORAGE |
| 156/1 | POWDER LIME STORAGE |
| 156/2 | AMMONIA CYLINDER STORAGE |
| 156/3 | CAUSTIC STORAGE |
| 156/4 | SULPHURIC ACID STORAGE |
| 157 | TANK CAR LOADING RACK FOR LIGHT OIL PRODUCT |
| 158 | TANK CAR LOADING RACK FOR BLACK PRODUCT |
| 160 | LABORATORY |
| 161 | CRUDE TANKAGE |
| 162 | FINISHED MOTOR GASOLINE TANKAGE |

| JOB NO. | DESCRIPTION |
|---|---|
| 163 | FINISHED MOTOR GASOLINE TANKAGE |
| 164 | FINISHED AVIATION GASOLINE TANKAGE TURBINE FUEL TANKAGE |
| 165 | FINISHED KEROSENE TANK |
| 166 | IFO/COKER FEED TANK |
| 167 | LDO TANK |
| 168 | FINISHED FURNACE & RESIDUAL FUEL OIL TANKAGE |
| 169 | LIQUEFIED GASES TANKAGE |
| 170 | ATMOSPHERIC AND VACCUM UNIT NO.–1 INTERMEDIATE TANKAGE |
| 171 | ATMOSPHERIC AND VACCUM UNIT NO.–2 INTERMEDIATE TANKAGE |
| 172 | COKING UNIT INTERMEDIATE TANKAGE |
| 173/1–2 | KEROSENE TREATING UNIT INTERMEDIATE TANKAGE |
| 174 | TRUCK LOADING RACK TANKAGE |
| 176 | BITUMEN UNIT INTERMEDIATE TANKAGE |
| 177/1–2 | TRANSFER PUMP STATION |
| 178/1–2 | FINISHED PRODUCT PUMP STATION/TANK CAR LOADING |
| 180 | AIR COMPRESSOR HOUSE |
| 183 | FLARE |
| 184 | COKE STORAGE |
| 185 | FINISHED PRODUCT STORAGE HOUSE |
| 188 | PHENOL EXTRACTION CHARGE INTERMEDIATE TANKAGE |
| 189 | DEWAXING CHARGE INTERMEDIATE TANKAGE |
| 190 | CONTACT FILTRATION CHARGE INTERMEDIATE TANKAGE |
| 191 | C.B.F.S.–80 TANKAGE |
| 192 | MS TANK |
| 193 | BITUMEN AND CBFS TANKS |
| 194 | FINISHED OIL PUMP HOUSE |
| 195 | ADDITIVE STORAGE |

| JOB NO. | DESCRIPTION |
|---|---|
| 200 | TWIN WAGON WEIGH BRIDGE. |
| 201 | REFINERY OFFICE |
| 202 | FIRST AID STATION |
| 203/1,2 | SHOWER BATH ROOM & CHECK AND CHANGE HOUSE |
| 203/3 | FINISHED PRODUCTS HANDLING OFFICE & CHECK AND CHANGE HOUSE |
| 204/1,2 | GAURD HOUSE |
| 205 | CAFETERIA |
| 206/1 | GAURD TOWER NO.1–10 |
| 206/2 | GAURD SHEDS NO.1–10 |
| 207 | FIRE HOUSE |
| 208 | FIRE FIGHT EQUIPMENT STORAGE |
| 209 | YARD LAVATORY |
| 210 | MECHANICAL SHOP |
| 211/1–3 | WARE HOUSES & SPARE PARTS STORAGE |
| 212 | GARAGE |
| 213 | ARBITRATION SAMPLES STORAGE |
| 301–350 | POWER PLANT |
| 353/1,3 | TRANSFORMER SUB–STATION |
| 357 | TELEPHONE EXCHANGE (REFINERY OFFICE) |
| 361 | CONDENSATE COLLECTING STATION |
| 501/1 | FIRE AND RECIRCULATING COOLED WATER PUMP STATION |
| 501/2 | RECIRCULATING HOT WATER PUMPING STATION |
| 502/1–8 | COOLING TOWER |
| 503/1–6 | RECIRCULATING WATER SYSTEM OIL SEPERATORS |
| 505/1–3 | FIRE WATER TANKS |
| 511/1 | WATER CHLORINATION SYSTEM |
| 511/2 | CHLORINE STORAGE |
| 521 | STORM WATER TANKS |
| 522 | SAND TRAP |

| JOB NO. | DESCRIPTION |
|---|---|
| 523 | OIL SEPERATORS |
| 524 | EMERGENCY BASINE NO.–1 |
| 525 | PUMPING STATION NO. 1 OF IND. AND STORM WATER SEWAGE |
| 532 | SKIMMED OIL PUMPING STATION |
| 534 | SKIMMED OIL SETTLERS |
| 535 | SILT ACCUMULATORS |
| 536 | GAURD BASINE NO.–2 |
| 537/1 | EMERGENCY BASINE NO.–2 |
| 537/2 | GAURD BASINE NO.–2 |
| 542 | SERVICE AND FECAL SEWAGE PUMPING |
| | **JOBS OUT SIDE REFINERY** |
| 01/1–8 | 14"–20" DIA PROCESS WATER TUBE WELL |
| 02/1–2 | 20"–27" DIA STEEL PUMPING MAIN FOR PROCESS WATER |
| 03 | 45"–60" DIA R.C.C. GRAVITY MAIN FOR EFFLUENT |
| 04/1–2 | 0"–12" DIA DRINKING WATER TUBE WELL |
| 05 | 8" DIA STEEL PUMPING MAIN FOR DRINKING WATER |
| 06 | PUMPING STATION BUILDING FOR EFFLUENT |
| 07 | FECAL SEWARAGE TREATMENT PLANT |
| | **JOBS FOR 3 MILLION TONNES** |
| 603 | ATMOSPHERIC UNIT CAPACITY 1 MILLIAN TONNES/YR |
| 605 | ATMOSPHERIC UNIT (JOB 603) INTERMIDIATE TANKAGE |
| 609 | REFINERY TRANSFER PUMP STATION |
| 611 | FINISHED HIGH SPEED DIESEL OIL TANKAGE |
| 620 | TRANSFER OPERATION CONTROL HOUSE |
| 703 | COOLING TOWER |
| 704 | RECIRCULATING WATER SYSTEM OIL SEPERATORS NEW MARKETING TTL INSTALLATION, NEW S/S |
| 9908 | FCC FEED TANKS |
| 161/2 | CRUDE TANK (NO.501) |
| SEC.12 | NEW CRUDE TANK (NO.502) |

LEGENDS — GREEN LAND

| REV. | DATE | DESCRIPTION | INITIAL | DATE |
|---|---|---|---|---|
| 33 | 10.07.2015 | LOCATION PLAN OF CRUDE TANK NO :– 502. | | |
| 32 | 13.05.2015 | REVISED PLOT PLAN OF COKER–A REVAMP UNDER CONSTRUCTION | | |
| 31 | 18.09.2014 | REVISED PLOT PLAN AFTER CONSTRUCTION OF CRUDE TANK NO :– 502. | | |
| 30 | 17.06.2014 | REVISED PLOT PLAN AFTER DISMANTLING OF TANKS NEAR AT GATE NO: 10. | | |
| 29 | 24.06.2013 | REVISED PLOT PLAN AFTER DISMANTLING OF SDU/WHFU/TEL BLENDING WAX PALATFATION. | | |
| 28 | 16.04.2009 | LOCATION PLAN OF FO TANK. | | |
| 27 | 17.02.2009 | LOCATION PLAN OF ATU | | |
| 26 | 19.01.2008 | LOCATION PLAN OF NEW MSQ. | | |
| 25 | DO | LOCATION PLAN OF NEW HGU. | | |
| 24 | 01.08.2006 | MODIFICATION OF LPG TRETMENT (LTU) | | |
| 23 | DO | REVAMP FOR AVU – I & II FOR YEO | | |
| 22 | 13.02.06 | PSA REVAMP IN HGU | | |
| 21 | 22.12.04 | NEW LPG BOTTLING PLANT. | | |
| 20 | 01.10.2002 | HYDROGEN GENERATION UNIT. | | |
| 19 | – DO – | DIESEL HYDROTREATING UNIT. | | |
| 18 | – DO – | ARU, SRU, SWS | | |
| 17 | 01.10.2002 | RFCCU. | | |
| 16 | 12.07.2002 | NEW LPG BULK LOADING FACILITY WITH EVACUATION COMPRESSER | | |
| 15 | 13.03.2002 | ADDITIONAL REFINERY PIPING SYSTEM UNDER BXP | | |
| 14 | – DO – | COMPRESSED AIR SYSTEM UNDER BXP | | |
| 13 | – DO – | ADDITIONAL OSBL CAUSTIC TANK. | | |
| 12 | – DO – | NEW FLARE. | | |
| 11 | – DO – | COOLING TOWER AND COOLING WATER TREATEMENT | | |
| 10 | – DO – | DM PLANT OF BXP. | | |
| 9 | – DO – | CRUDE OIL TANKS NO. 238, 239 AND 240 | | |
| 8 | – DO – | RFCCU FEED TANKS NOS. 801, 802, AND 803 | | |
| 7 | 13.03.2002 | PRESSURISED CIRCULATING WATER SYSTEM | | |
| 6 | 05.03.2002 | 6 X 1500 KL MOUNTED BULLETS. | | |
| 5 | 15.01.2001 | 1 X 20 MW GT. | | |
| 4 | 29.11.2000 | NEW 2 X 20,000 KL HSD TANKS NOS. 402 AND 403 | | |
| 3 | 5.7.2000 | NEW HSD TANKS (2 X 20,000 KL) NO. 401. | | |
| 2 | 25.02.99 | NEW CRUDE TANKS (2 X 40,000 KL) NOS. 236 AND 237 | | |
| 1 | 14.8.98 | NEW FACILITIES INCORPORATED | | |

ALL DIMENSION ARE IN MM.
UNLESS OTHER–WISE STATED.

| REV.NO. | DATE | DESCRIPTION | INITIAL | DATE |
|---|---|---|---|---|
| 33 | 03.02.2016 | ISSUED FOR CCE APPROVAL | | |
| 33 | 13.05.2015 | ISSUED FOR EXECUTION | | |

INDIAN OIL CORPORATION LTD.
BARAUNI REFINERY

TITLE:–
OVERALL PLOT PLAN AT BR.

PREPARED BY BARAUNI REFINERY

DRAFTED BY MULTI TECH SYSTEM, PATNA

| DRAWN. BY | CHKD. BY | APPROVED BY |
|---|---|---|
| | | |

REF.DRAWING NO.

| SCALE | JOB NO. | UNIT | DRAWING NO. | | | | REV |
|---|---|---|---|---|---|---|---|
| 1:3000 | | OFF | 2008 | 861 | A0 | C | 337 | 33 |

CAD FILE NAME : MTSC–AO–337 (SHD–337)

Annexure-1B

TO PLANT SITE
TO BEGUSARAI
BOUNDARY OF TOWN SHIP
JUBLI DHABA
INDIAN OIL PETROL PUMP
NURSERY
SWIMMING POOL
FOOTBALL GROUND
D.A.V. SCHOOL
BSNL OFFICE
PETROL PUMP
TEMPLE AREA
HINDI D.A.V. SCHOOL
CHHADH POND.
TEMPLE
KALYAN KENDRA
NURSE'S HOSTEL
HOSPITAL
BOUNDRY WALL OF CEATRAL SCHOOL
CENTRAL SCHOOL
GIRLS SCHOOL
OPEN FIELD
STADIUM.
HELIPAD
PRIMARY SCHOOL
PUMP HOUSE NO.3
WATRE TOWER
MOSQUE
C.I.S.F. DUTY POST
B.M.P. GATE
TO ULAO
BOUNDARY OF BMP POLICE
BOUNDRY LINE OF TOWN SHIP
LEGENDS
GREEN LAND

**Annexure-2**

## Point wise TOR compliance statement

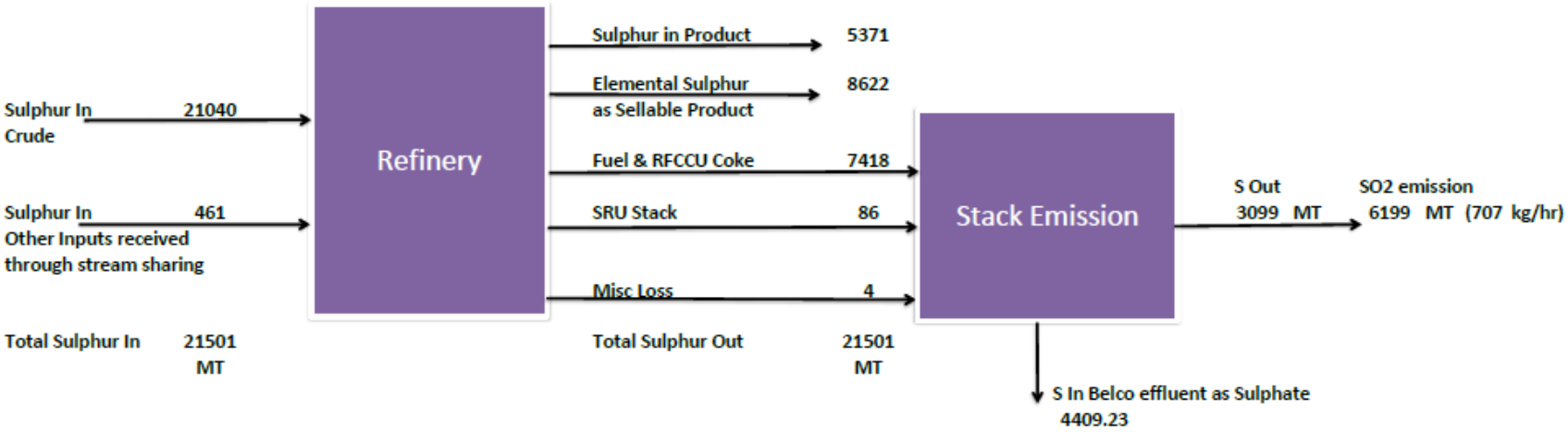
| S.N | TOR | Status |
|---|---|---|
| 1 | A separate chapter on status of compliance of Environmental Conditions granted by State/Centre to be provided. As per circular dated 30th May, 2012 issued by MoEF, a certified report by RO, MoEF on status of compliance of conditions on existing unit is to be provided in EIA-EMP report. | Status of compliance of Environmental Conditions granted by State/Centre is attached as **Flag-1, 1.1 & 1.2.** Certified report by RO MOEF on compliance of environmental conditions is uploaded earlier in the website as "Annexure-Certified monitoring report". Same is not being uploaded due to size limitation. |
| 2 | Project Description and Project Benefits. | Project Description and Project Benefits is attached as **Flag-2.** |
| 3 | Manufacturing process details along with the chemical reactions and process flow diagrams for the proposed project. | Manufacturing process details along with the chemical reactions and process flow diagrams for the proposed project is attached as **Flag-3.** |
| 4 | Is there additional storage required for the proposed project, if yes details thereof. | No additional storage is required for the proposed project. |
| 5 | Baseline data for air, water and soil for last one year. | Baseline data for air, water and soil for 2014-15 is attached as **Flag-4.** |
| 6 | Ambient air quality monitoring data for PM2.5, PM10 SO2, NOx, (methane & non-methane HC) and VOCs particularly in the downwind direction. | Ambient air quality monitoring data for 2014-15 is attached as **Flag-5.** |
| 7 | Existing status of stack emission, raw water requirement, treated effluent quantity & quality data, noise pollution and solid waste management in the existing units. | Existing status of stack emission, raw water requirement, treated effluent quantity & quality data, noise pollution and solid waste management in the existing units is attached as **Flag-6.** |
| 8 | Details of Sulphur balance in the existing refinery unit. | Sulphur balance in the existing refinery unit is attached as **Flag-7.** |
| 9 | Additional SO2 emissions due to the proposed project. | Total SO2 emission due to the proposed projects was estimated to be 915 kg/hr i.e. an additional 214 kg/hr of emission from exiting level of 707 kg/hr. However, after meeting with EAC, SO2 emission has been reviewed and total emission has been reduced to 815 kg/hr. Detailed breakup is attached as **Flag-8.** |

| | | |
|---|---|---|
| 10 | A note on how SO2 and NOX will be controlled at the existing level leading to no increase in pollution load. | Attached as **Flag-9.** |
| 11 | Unit-wise air pollution control devices to be installed for the proposed units. | Details of air pollution control devices / measures is attached as **Flag-10.** |
| 12 | Water Balance chart for the existing unit and due to the proposed project. Action plan for reduction of water requirement. | Attached as **Flag-11.** |
| 13 | Quantity of effluent generation and the existing effluent treatment scheme. | Attached as **Flag-12.** |
| 14 | Detailed solid waste generation, collection, segregation, its recycling and reuse, treatment and disposal. | Attached as **Flag-13.** |
| 15 | Oily sludge management plan. | Attached as **Flag-14.** |
| 16 | Details of membership of TSDF for hazardous waste disposal. | No TSDF exists in Bihar as per list enclosed as **Flag-15**. Due o this Barauni Refinery is not a member of TSDF. Hazardous waste is being disposed as per details given in S.N. 14 through approved CPCB recyclers. |
| 17 | Details of proposed preventive measures for leakages and accident. | Attached as **Flag-16.** |
| 18 | Environmental Management Plan | Attached as **Flag-17.** |
| 19 | Risk Assessment & Disaster Management Plan<br>a. Identification of hazards<br>b. Consequence Analysis<br>c. Risk assessment should also include leakages and location near to refinery & proposed measures for risk reduction. | Quantitative Risk Assessment and Emergency Response and Disaster Management Plan of Barauni Refinery is uploaded earlier in the website as “Annexure-Risk Assessment”. Same is not being uploaded due to size limitation. |
| 20 | Total capital cost and recurring cost/annum for environmental pollution control measures. | Attached as **Flag-18.** |

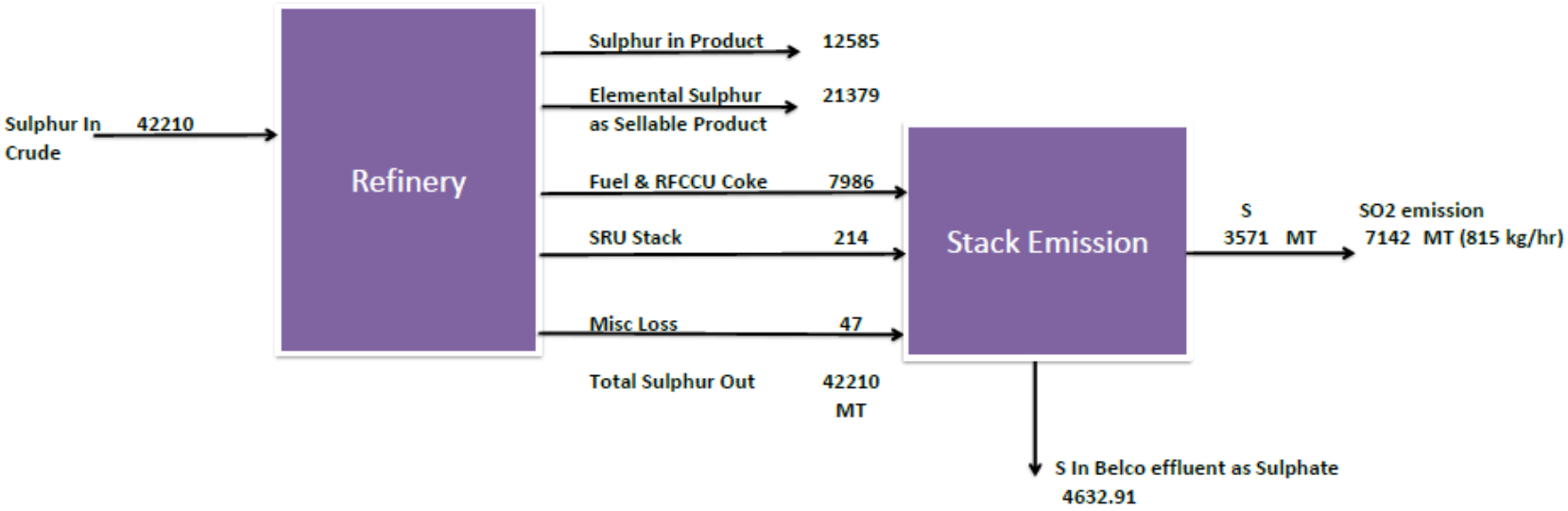
**Annexure-3**

## Sulphur Balance in Existing Refinery unit

**(For the year 2014-15)**

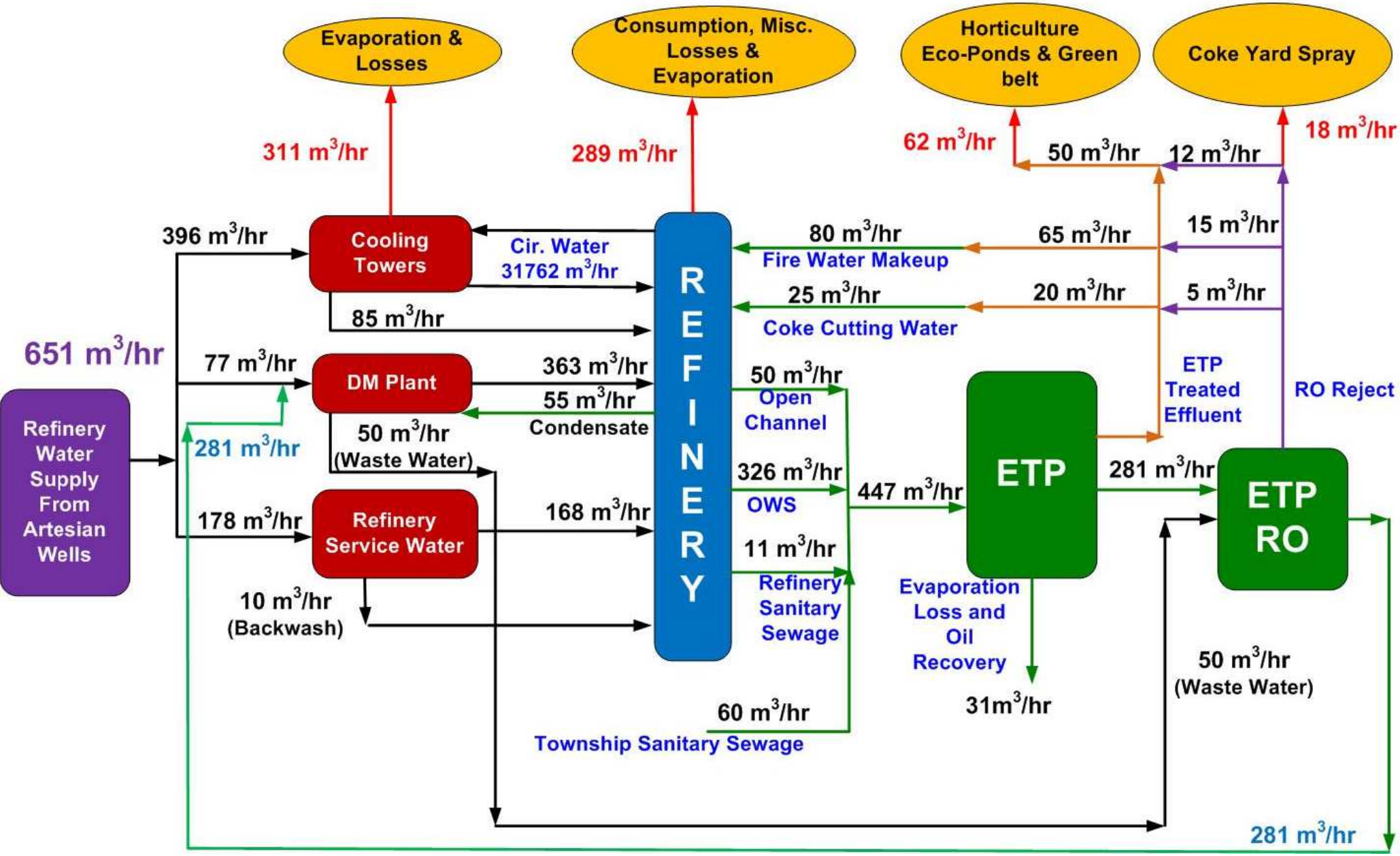


## Annualized Sulphur Balance post BS-IV Project



Annexure-4

# Water balance Post BS-IV Project



**Total water requirement, water losses, waste water generation and water recycle post BS-IV Project**

| S.N | Parameter | Value (m3/hr) |
|---|---|---|
| 1 | Fresh Water requirement | 651 |
| 2 | Waste water generation | 497 |
| 3 | Water recycle | 466 |
| 4 | Evaporations loss in Cooling Towers | 311 |

**Flag-1**

## Status of compliance of Environmental Conditions granted by State/Centre

1. **Status of compliance of Environmental Conditions for MS Quality Up-gradation, HSD Quality Up-gradation and High Sulphur Crude Maximization Project**

   **Ref: Ministry's clearance letter noJ-1101/491/2007-IA II (I) dated 18.03.2008**

| SN | Point | Status |
|---|---|---|
| 1. | The company shall comply with new standards/norms that are being proposed by the CPCB for petrochemical plants and refineries. | • Major facilities required for meeting treated effluent quality as per revised MoEF standard has been commissioned in Mar-14.<br>• With the commissioning of desulphurization facilities (Amine treating unit) for fuel gas from old plants in Oct 2010, Barauni refinery now meets the revised $SO_2$ emission standards. $H_2S$ content in FG is also within the revised standard.<br>• 20 nos. of $SO_x$ and $NO_x$ analyzer are installed for continuous monitoring of SOx/NOx.<br>• Double seal has been provided in 23 nos. of floating roof tanks.<br>• Please refer Flag-1 for detailed status and action plan of Barauni refinery for compliance of revised MoEF standards. |
| 2. | The process emissions ($SO_2$, NOx, HC, VOCs and Benzene) from various units shall conform to the standards prescribed by the Bihar State Pollution Control Board from time to time. At no time, the emission levels shall go beyond the stipulated standards. In the event of failure of pollution control system(s) adopted by the unit, the unit shall be immediately put out of operation and shall not be restarted until the desired efficiency has been achieved. | • SOx & NOx are monitored continuously in 20 nos. of stacks with online SOx/NOx analyzers.<br>• Process emissions from all units are monitored once in two months except SRU (which is monitored monthly) by M/s Envirotech East Pvt. Ltd and conform to revised MoEF 2008 standards.<br>• Total $SO_2$ emissions from existing units and new facilities at BR are less than the stipulated limit of 1035 kg/hr.<br>• **COMPLIED.** |

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| 3. | Ambient air quality monitoring stations, [SPM, $SO_2$, NOx and NMHC, Benzene] shall be set up in the Refinery complex in consultation with SPCB, based on occurrence of maximum ground level concentration and down-wind direction of wind. The monitoring network must be decided based on modeling exercise to represent short term GLCs Continuous on-line stack monitoring equipment should be installed for measurement of $SO_2$ and NOx. | • Five nos. of offline ambient air quality monitoring stations (four in refinery and one in township) and one no. of continuous ambient air quality monitoring station has been provided at strategic locations at BR for monitoring of ambient air quality.<br>• Ambient air quality is checked twice in a week in four nos. of offline ambient air quality monitoring stations as per revised MoEF standards 2009.<br>• **COMPLIED.** |
| | | • Total 20 nos. of SOx/NOx analyzers have been provided at BR for continuous online stack monitoring.<br>• **COMPLIED** |
| 4. | Quarterly monitoring of fugitive emissions shall be carried out as per the guidelines of CPCB by fugitive emission detectors and reports shall be submitted to the Ministry's regional office at Bhubaneswar. For control of fugitive emission all unsaturated hydro carbon will be routed to the flare system and the flare system shall be designed for smoke less burning. | • Quarterly monitoring of fugitive emission as per CPCB guidelines is carried out and report is submitted to regional office, Ranchi.<br>• **COMPLIED** |
| | | • Smokeless flare system already exists at BR and all unsaturated hydrocarbons are routed to it.<br>• **COMPLIED** |
| 5. | Fugitive emissions of HC from product storage tank yards etc must be regularly monitored. Sensors for detecting HC leakage shall also be provided at strategic locations. The company shall use low sulphur fuel to minimize $SO_2$ emission. | • Quarterly monitoring of fugitive emission from tank farm area is carried out.<br>• **COMPLIED.** |
| | | • 27 nos. of HC Gas detectors at critical locations are installed in LPG storage/loading area.<br>• 83 nos. of HC Gas detectors and 6 nos. of $H_2$ detectors are installed at strategic locations in existing process units of BR.<br>• 205 nos. of HC detectors have been installed at strategic locations in new facilities under MSQ project.<br>• 100 nos. of additional HC detectors are installed for early warning in the existing tank farm area for Class-A product.<br>• **COMPLIED** |

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| | | • 'S' in fuel oil conforms to the revised MoEF standards 2008 (<1%Wt.).<br>• $H_2S$ in FG conforms to the revised MoEF standards 2008 (<150 mg/Nm3).<br>• **COMPLIED** |
| 6. | The effluent after treatment and conforming to the MINAS standards shall be discharged into the river Ganga. The company shall undertake measures for water conservation and treated effluent to the extent possible shall be used for fire water make up , coke cutting water, make up water for eco pond and irrigation of eco park etc. | • To reduce Raw water consumption, treated effluent is re-used as<br>  • Fire water make up<br>  • Coke cutting water<br>  • Make up water for Eco Ponds.<br>  • Irrigation of Eco park<br>  • Cooling Tower makeup water<br>• After ETP modernization, reuse of treated effluent in refinery operations has increased significantly resulting in Zero Discharge of Treated Effluent.<br>• RO plant is also being installed at BTP of Barauni Refinery and same is expected to be commissioned in year 2016-17. |
| 7. | M/s 1OCL shall investigate cause of odour problem in one of the wells as reported during the public hearing meeting held on 25.9.2007 and report submitted to the Ministry's Regional office at Bhubaneswar. | • Ground Water samples from hand pump of Keshawe village are tested once in a quarter by M/S Envirotech and found meeting potable water quality norms.<br>• Water samples were also randomly taken from hand pumps and wells of the surrounding area of Keshawe village several times and tested by M/S PDIL. Found meeting potable water quality norms. The odor of water has been detected as a localized problem.<br>• Further, in keeping with Indian Oil's motto **"People before Profit"**, Barauni refinery lined up the M/S PDIL in 2009 for establishing the ground water quality and its movement in and around Barauni Refinery to investigate cause of odor problem in Keshawe village. PDIL submitted its report in Feb 2010 and it was concluded that "no ground water from the refinery flows beyond the refinery boundary. Hence, ground water contamination from the refinery beyond boundary can be ruled out. The ground |

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| | | water contamination due to refinery activities in the Keshawe village is not at all possible."<br>Further it was also observed "that the poor sanitation around the hand pumps in Keshawe village around BTP area and the presence of Iron in the tube well water produces synergetic impact on the odour. Similarly, the installation of septic tanks and Khatals are responsible for poor quality w.r.t odour."<br>• **COMPLIED** |
| 8. | The oily sludge shall be subjected to melting pit for oil recovery and the residues shall be bio-remediated. The sludge shall be stored in the HDPE lined pit along with proper leachate collection system. | • Synthetic lined pit for storage of hazardous solid waste (Residual Oily Sludge) is in place and mechanized skid process has been deployed for better recovery of oil from oily sludge in place of melting pit. Presently M/s Balmer Lawrie is engaged for this job.<br>• Residual oily sludge is bio-remediated.<br>• **COMPLIED.** |
| 9. | The company shall strictly follow all the recommendation mentioned in the charter on Corporate Responsibility for Environmental Protection (CREP). | • All the recommendations mentioned in the charter on Corporate Responsibility for Environmental Protection (CREP) are strictly followed.<br>• Please refer Flag-2 for detailed status on CREP.<br>• **COMPLIED.** |
| 10. | The Company shall take necessary measures to prevent fire hazards, containing oil spill and soil remediation as needed. At place of ground flaring, the overhead flaring stack with knockout drums shall be installed to minimize gaseous emissions during flaring. | • Fire protection facilities as required by OISD standards exist in refinery.<br>• Area within the units and around having the possibility of oil spillage has been paved.<br>• All units, tank farm area and facilities are well connected with a closed underground OWS system to prevent any oil spill.<br>• Knockout drums exist in overhead flaring stack to minimize gaseous emissions during flaring.<br>• Fire protection facilities as required by OISD standards have been provided in new facilities and all the area within the units' battery limits have been paved. |

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| | | • To further prevent fire hazards, additional facilities as recommended by M B Lal committee on Jaipur Terminal Fire are being installed in the refinery and are at various stages of implementation.<br>• **COMPLIED** |
| 11. | To prevent fire and explosion at Oil and Gas facility, potential ignition sources should be kept to a minimum and adequate separation distance between potential ignition sources and flammable material shall be in place. | • Distances between various units / equipments including potential ignition sources are as per OISD standards.<br>• OISD standards have been followed for the distances between various units / equipments including potential ignition sources in the new facilities.<br>• **COMPLIED** |
| 12. | Occupational health surveillance of worker shall be done on a regular basis and records maintained as per the Factory Act. | • A full fledged Occupational Health centre is established in the Refinery Hospital. Regular Occupational health monitoring of employees is carried out regularly as per the program.<br>• Occupational health surveillance records are maintained by the refinery hospital as per the Factory Act.<br>• **COMPLIED** |
| 13. | Greenbelt shall be developed to mitigate the effect of fugitive emission all around the plant in a minimum 30% plant area in consultation with DFO as per CPCB guidelines. | • Spread over an area of 75 acres, Barauni Refinery has developed a beautiful Ecological Park (Eco Park) with sprawling lawns, flowers and ornamental plants, potted plants, diverse habitat of tress and the forest vegetation. The garden has more than 279 plant species under 81 families including some medicinal plants both indigenous and exotic.<br>• More than 67,000 plants were planted during the period 00-01 to 14-15 in a phased manner to develop green belt in & around refinery controlled area in consultation with forest department.<br>• 1627 nos. plants were planted in year 2015-16.<br>• Plantation in refinery is continuing. However, existing land of refinery is saturated with greenery.<br>• **COMPLIED** |

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| 14. | Environment protection measures suggested in the EIA/ EMP risk assessment report and during the public hearing meeting shall be implemented. | • Environment protection measures suggested in the EIA/ EMP risk assessment report have been implemented / are being implemented.<br>**Public Hearing Points**<br>• Rise in Respiratory Ailments<br>o Survey conducted by panel of doctors/paramedics from Government Hospital delegated by Civil Surgeon. No adverse effects / increase in respiratory ailments observed.<br>• Stunted Growth of Papaya Plant<br>o Issue referred to Rajendra Agricultural University, Pusa. In response booklet on "Technology for Growing Papayas in Bihar" received. It says, "viral disease is the major limiting factor in Papaya cultivation in all regions of Bihar and attempts are on to select papaya lines showing strong tolerance to viral diseases."<br>• Few hand pump's water have odour in Keshawe Village<br>o Please refer status of condition no. 7 above.<br>• Water overflow from Borrow Pit inundating fields<br>o With the modernization of ETP, all the water in the refinery has been diverted into ETP resulting in no discharge of water to Burrow Pit except in monsoon season.<br>• Medical Camps to be increased in surrounding area<br>o Medical Camps are being conducted regularly.<br>• **COMPLIED** |
| 15. | The project authorities must strictly adhere to the stipulations made by the concerned State Pollution Control Board | • Stipulations being followed.<br>• **COMPLIED** |

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| | (SPCB) and the State Government and any other statuary body. | |
| 16. | No further expansion or modification in the project shall be carried without prior approval of the Ministry of Environment and Forests. In case of deviations or alternations in the project proposal from those submitted to the Ministry for clearance, a fresh reference shall be made to the Ministry. | • Prior approval of ministry is always taken before carrying out any expansion or modification of the plant.<br>• **COMPLIED** |
| 17. | At no time, the emissions should go beyond the prescribed standards. In the event of failure of any pollution control system, the respective well site should be immediately put out of operation and should not be restarted until the desired efficiency has been achieved. Provision of adequate height of stack attached to DG sets & flare is to be done. | • There is no well site at Barauni refinery.<br>• Stacks and flare of adequate height have been provided in Barauni refinery to control emissions.<br>• **COMPLIED** |
| 18. | Wastewater shall be properly collected and treated so as to conform to the standards prescribed under EP Act & Rules and mentioned in the Consents provided by the relevant SPCB. | • Adequate waste water drainage and collection facilities exist in refinery.<br>• Appropriate drainage and collection facilities have been provided in new facilities in the MSQ project and are connected with the existing drainage facilities of refinery.<br>• Oily waste water is treated in ETP/BTP and conforms to the CPCB/SPCB standards.<br>• **Complied.** |
| 19. | The overall noise levels in and around the premises shall be limited within the prescribed standards (75 dBA) by providing noise control measures including acoustic hoods, silencers, enclosures etc. on all sources of noise generation. The ambient noise levels should conform to the standards prescribed under EPA Rules, 1989 viz. 75 dBA (day time) and 70 dBA (night time). | • The ambient noise levels from existing facilities conform to the standards prescribed under EPA Rules, 1989 / Noise Pollution (Regulation and control) Rules 2000.<br>• For personnel working in the proximity of high noise generating equipments, appropriate PPEs are used, and exposure is controlled through job rotation, education and awareness.<br>• Adequate noise control measures have been taken in new facilities in the project.<br>• No impact has been observed on plant boundary proximity area with the new |

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| | | facilities in the project, and ambient noise levels from new facilities conforms to the standards prescribed under EPA Rules, 1989 / Noise Pollution (Regulation and control) Rules 2000.<br>• **COMPLIED** |
| 20. | The project authorities must strictly comply with the provisions made in Manufacture, Storage and Import of Hazardous Chemicals Rules 1989 as amended in 2000 for handling of hazardous chemicals etc. Necessary approvals from Chief Controller- of Explosives must be obtained before commission of the expansion project, if required. Requisite On-site and Off-site Disaster Management Plans will be prepared and implemented. | • Provisions made in Manufacture, Storage and Import of Hazardous Chemicals Rules 1989 as amended in 2000 for handling of hazardous chemicals etc are strictly complied in existing facilities of refinery, and same have also been strictly complied in the project.<br>• Necessary approvals from Chief Controller-of Explosives, wherever required have been obtained before commission of the project.<br>• Comprehensive On-site and Off-site Disaster Management Plans exist in refinery and are updated regularly.<br>• On-site & Off-site mock drills are conducted quarterly and annually respectively. The Off-site drill is conducted with involvement of District Authority.<br>• **COMPLIED** |
| 21. | Disposal of hazardous wastes shall be as per the Hazardous Wastes (Management and Handling) Rules, 2003. Authorization from the State Pollution Control Board must be obtained for collections/ treatment/storage disposal of hazardous wastes. | • Disposal of hazardous wastes is done as per the Hazardous Wastes (Management, Handling & Transboundary Movement) Rules 2008 under authorization from SPCB.<br>• **COMPLIED** |
| 22. | The project authorities will provide adequate funds as non-recurring and recurring expenditure to implement the conditions stipulated by the Ministry of Environment and Forests as well as the State Government along with the implementation schedule for all the conditions stipulated herein. The funds so provided should not be diverted for any other purposes. | • Being complied.<br>• In addition to one time investment in facilities for combating pollution, separate funds are allocated for specific activities such as bio-remediation of sludge, environment monitoring, and studies related to environment etc.<br>• **COMPLIED** |

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| 23. | The company shall develop rain water harvesting structures to harvest the run off water for recharge of ground water. | • Rain water harvesting has been implemented at 12 places at Barauni Refinery. Further for year 2016-17, a comprehensive study for implementation of rain water harvesting system in refinery and township has been taken.<br>• **COMPLIED** |
| 24. | The stipulated conditions will be monitored by the concerned Regional Office of this Ministry /Central Pollution Control Board/State Pollution Control Board. A six monthly compliance report and the monitored data should be submitted to them regularly. It will also be displayed on the Website of the Company. | • Being complied.<br>• A six monthly compliance report and the monitored data are submitted regularly. |
| 25. | The Project Proponent should inform the public that the project has been accorded environmental clearance by the Ministry and copies of the clearance letter are available with the State Pollution Control Board/ Committee and may also be seen at Website of the Ministry of Environment and Forests at http://www.envfor.nic.in. This should be advertised within seven days from the date of issue of the clearance letter at least in two local newspapers that are widely circulated in the region of which one shall be in the vernacular language of the locality concerned and a copy of the same should be forwarded to the concerned Regional office of this Ministry. | • Information published in Hindustan and Hindustan Times on 27th Mar 2008.<br>• **COMPLIED.** |
| 26. | A separate environment management cell with full fledged laboratory facilities to carry out various management and monitoring functions shall be set up under the control of a Senior Executive. | • BR has a full-fledged environment protection cell and a well equipped dedicated pollution control laboratory established back in 1975.<br>• **COMPLIED** |
| 27. | The project authorities shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities and the date of start of the project | Noted for compliance |

**2. Status of compliance of Environmental Conditions for Expansion of Barauni Refinery to 6.0 MMTPA with matching secondary processing facilities**

**Ref: Ministry's clearance letter no J-1101/23/98-IA II (I) dated 08.03.1999**

| SN | ITEM | STATUS |
|---|---|---|
| 1. | The gaseous emissions from the process stacks must conform to the standards prescribed under the EPA rules and/ or state pollution control board. At no time, the emission level should go beyond the prescribed standards. Specially, the total $SO_2$ emissions must not go beyond 1080 kg/hr as confirmed by the company. In the event of failure of any pollution control system adopted by the units, the respective unit must be put out of operation immediately and should not be restarted until control measures are rectified to achieve desired efficiency. | • Process emissions at BR conform to the standards prescribed under the EPA rules<br>• Total SO2 emissions from existing units at BR are much less than the stipulated limit of 1035 kg/hr.<br>• **COMPLIED.** |
| 2. | In consultation with SPCB, the project authority must set up sufficient number of air quality monitoring stations to monitor SPM, $SO_2$, $NO_X$, CO & $NH_3$. Stack emissions should be monitored regularly. Data on stack emission and ambient air quality including work zone should be submitted to the ministry (Regional Office, Bhubaneshwar) once in six months and SPCB once in three months along with statistical analysis. | • Ambient air quality is checked twice in a week in five nos. (Four in refinery and one in township) of ambient air quality monitoring stations.<br>• One no. of continuous ambient air quality monitoring station in the refinery has been commissioned in 2009 for continuous monitoring of ambient air in refinery.<br>• Ambient air quality is well within stipulated standards w.r.t all parameters except PM.<br>• The results are furnished to the BSPCB and the MoE&F (Regional office, Ranchi) at regular intervals as prescribed.<br>• Process emissions from all units are monitored once in two months except SRU (which is monitored monthly basis) and results on stack emission, and work zone monitoring are furnished to the BSPCB and the ministry (Regional Office, Bhubaneshwar).<br>• **COMPLIED.** |

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| 3. | Adequate effluent treatment facilities (primary, secondary & tertiary) should be provided so that liquid effluents conform to the standards prescribed under EPA rules/ SPCB before discharging into river Ganga. The outfall point in the river must be approved by Bihar Pollution Control Board. | • ETP of 1000 m3/hr capacity and BTP of 1400 m3/hr capacity have been provided for treatment of effluent.<br>• Treated effluent is completely reused in refinery operations, horticulture, and eco ponds make up.<br>• **COMPLIED.** |
| 4. | Adequate number of effluent quality monitoring stations must be set up in consultation with SPCB to monitor the water quality parameters as per EPA / SPCB regulations. Monitored data along with analysis should be submitted to this ministry (Regional Office, Bhubaneshwar) once in six months and SPCB once in three months. | • Effluent quality monitoring points has been set up in consultation with BSPCB. The results are regularly furnished to the BSPCB and regional office, MoEF, Ranchi.<br>• **COMPLIED** |
| 5. | The company must identify and implement water conservation and treated effluent recycling / reusing schemes to minimize the raw water consumption and to achieve zero-pollutant discharge to the river Ganga. | • To reduce Raw water consumption, treated effluent is re-used as<br>  • Fire water make up<br>  • Coke cutting water<br>  • Cooling tower makeup<br>  • Make up water for Eco Ponds<br>  • Irrigation of Eco park<br>• **COMPLIED.** |
| 6. | The hazardous solid wastes like spent catalysts must be disposed off in a secured landfill with facility for leachate collection and treating in the ETP. | • Synthetic lined pit for storage of hazardous solid waste (Residual Oily Sludge) is in place and mechanized skid process by M/S Balmer Lawrie has been deployed for better recovery of oil from oily sludge.<br>• Residual oily sludge is bio-remediated.<br>• Spent catalyst is co-processed in cement manufacturers as alternative raw material.<br>• **COMPLIED.** |
| 7. | The proposed storage for LPG shall be of mounded type in order to reduce the risk level. The OISD guidelines must be strictly followed. | • 6 nos. of mounded LPG storage bullets as per OISD guidelines for storage of LPG have been provided (commissioned in 2002).<br>• **COMPLIED.** |
| 8. | In addition to the above stipulations, the company must undertake additional afforestation and Eco- | • Spread over an area of 75 acres, Barauni Refinery has developed a beautiful Ecological Park (Eco Park) with sprawling lawns, flowers |

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| | development work in the area. In this regard, the company must augment its tree plantation activities by 25 thousand trees in a phased manner. Further, the company has around 120 acres of borrow-pit area in and adjoining to the plant premises. The company must give an action plan to ecologically develop this area within 3 months. | and ornamental plants, potted plants, diverse habitat of tress and the forest vegetation. The garden has more than 279 plant species under 81 families including some medicinal plants both indigenous and exotic.<br>• More than 62,500 plants were planted during the period 00-01 to 08-09 in a phased manner to develop green belt in & around refinery controlled area in consultation with forest department.<br>• Plantation in refinery is continuing. However, existing land of refinery is saturated with greenery.<br>• **COMPLIED** |
| 9. | The project authority must adhere to the stipulations made by Pollution Control Board and state government. | • Stipulations being followed.<br>• **COMPLIED** |
| 10. | No expansion or modification of the plant should be carried out prior approval of this ministry. | • Prior approval of ministry is always taken before carrying out any expansion or modification of the plant.<br>• **COMPLIED** |
| 11. | A green belt of adequate width and density should be provided all around the plant in consultation with the state forest department. A norm of 2500 plants/ hectare may be followed and minimum of 25% area must be covered by green belt. | • Spread over an area of 75 acres, Barauni Refinery has developed a beautiful Ecological Park (Eco Park) with sprawling lawns, flowers and ornamental plants, potted plants, diverse habitat of tress and the forest vegetation. The garden has more than 279 plant species under 81 families including some medicinal plants both indigenous and exotic.<br>• More than 62,500 plants were planted during the period 00-01 to 08-09 in a phased manner to develop green belt in & around refinery controlled area in consultation with forest department.<br>• Plantation in refinery continuing. However, existing land of refinery is saturated with greenery.<br>• **COMPLIED** |

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| 12. | Handling, manufacturing, storage and transportation of hazardous chemicals should be carried out in accordance with The Manufacture, Storage & Import Of Hazardous Chemicals Rules, 1989, as amended in 1991. On-site and Off-site emergency preparedness plans shall be prepared adequately and permissions from state and central nodal agencies in this regard must be obtained. | • Handling & storage of hazardous chemicals are done in accordance with the rules as amended in 1991.<br>• Comprehensive On-site and Off-site Disaster Management Plans exist in refinery and are updated regularly.<br>• On-site & Off-site mock drills are conducted quarterly and annually respectively. The Off-site drill is conducted with involvement of District Authority.<br>• **COMPLIED** |
| 13. | Hazardous wastes, if any, must be handled and disposed as per Hazardous Waste (Management And Handling) Rules, 1989. Authorization from State Pollution Control Board in this regard must be obtained. | • Disposal of hazardous wastes is done as per the Hazardous Wastes (Management and Handling) Rules under authorization from SPCB.<br>• **COMPLIED** |
| 14. | Proper housekeeping and adequate occupational health programme must be taken up. | • A full fledged Occupational Health centre is established in the Refinery Hospital. Regular Occupational health monitoring of employees is carried out as per the program.<br>• **COMPLIED** |
| 15. | Adequate provisions for infrastructure facilities such as water supply, fuel sanitation etc. should be ensured for construction workers during the construction phase so as to avoid felling of trees and pollution of water and the surroundings. | • **COMPLIED** |
| 16. | Occupational health surveillance of the workers should be done on a regular basis and records maintained. | • A full fledged Occupational Health centre is established in the Refinery Hospital. Regular Occupational health monitoring of employees is carried out regularly as per the program.<br>• Occupational health surveillance records are maintained by the refinery hospital as per the Factory Act.<br>• **COMPLIED** |
| 17. | The project proponent shall also comply with all the environmental protection measures and safeguards recommended in the EIA and Risk Analysis report. | • Environment protection measures suggested in the EIA/ EMP risk assessment report have been implemented<br>• **COMPLIED** |

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| 18. | The project proponent should have a scheme for social upliftment in the surrounding villages with reference to contribution in road construction, education of children, festivals, health centres, sanitation facilities, drinking water supply, community awareness and employment to local people whenever and wherever possible both for technical and non-technical jobs. | Social upliftment activities under "Community Development Program" are carried out on regular basis in the villages near the refinery.<br>The major works undertaken are<br>❖ Installation of hand pumps for drinking water.<br>❖ Repair & construction of road.<br>❖ Health Camps.<br>❖ Facilitation and renovation of school building and library etc.<br>❖ Women's Education and empowerment.<br>• **COMPLIED.** |
| 19. | A separate environmental management cell with full fledged laboratory facilities to carry out various management and monitoring functions should be set up under the control of senior executive. | • A separate Environment Management Cell with well equipped dedicated pollution control laboratory exists at Barauni Refinery.<br>• **COMPLIED** |
| 20. | The funds earmarked for the environmental protection measures should not be directed for any other purpose and year-wise expenditure should be reported to this ministry and SPCB. | • Apart from installation of Diesel Hydrotreating Unit (DHDT) and Sulphur Recovery Unit (SRU), all the facilities envisaged for environmental protection and monitoring have been provided in Barauni refinery expansion project.<br>• In addition to one time investment in facilities for combating pollution, separate funds are allocated and utilized for specific activities such as bio-remediation of sludge, environment monitoring, and studies related to environment etc.<br>• **COMPLIED.** |
| 21. | Six monthly status report on the project vis-a-vis implementation of environmental measures should be submitted to the ministry (Regional Office, Bhubaneswar) / CPCB / SPCB). | • A six monthly compliance report and the monitored data are submitted regularly.<br>• **BEING COMPLIED.** |

**Flag- 1.1**

# Status and Action Plan for Compliance of Revised Emission and Effluent Standards 2008 at Barauni Refinery

**DATE: 19th Apr 2016**

## Scehdule -I: Petroluem Oil Refinery

### A. Effluent Discharge

| SN | Standard | BR status and action plan |
|---|---|---|
| 1 | **Treated Effluent Quality** | **> COMPLIED.** |

### B. Emissions

| SN | Standard | BR status and action plan |
|---|---|---|
| 2 | **$H_2S$ in Fuel Gas** | **> COMPLIED.** |
| 3 | **$SO_2$ Emissions** | **> COMPLIED.** |
| 4 | **$NO_x$ Emissions** | **> COMPLIED.** |
| 5 | **CO Emissions** | **> COMPLIED.** |
| 6 | **Particulate Matter (PM) Emissions** | **> Limiting value as per MoEF standards 2008:**<br>FCC = 100 mg/NM3<br>Other units:<br>Gas firing = 10 mg/NM3<br>Liquid firing = 100 mg/NM3<br>*In case of mixed firing, the limit shall be computed based on heat supplied by gas and liquid fuels.<br><br>> **Current Status:**<br>> Barauni refinery complies this standard for RFCCU, HGU, CRU, GT-1 and GT-2. These units together consume major part (about 60%) of the total refinery fuel.<br><br>> However, for other furnaces and boilers, PM emissions are higher than the revised standard.<br><br>> It is very difficult for Barauni refinery to meet the revised standard for these existing furnaces and boilers, as the limit fixed (10 &100 mg/$NM^3$ for FG & FO respectively) is considered too stringent for PM emission with fuel gas, fuel oil and mixed fuel firing.<br><br>> CPCB has been requested vide BR letters dated 10th April 2009 & 22 Jan 2010 to exempt the existing furnaces and boilers from the revised standard for PM emissions**.**<br><br>> The above points have also been discussed in all the CREP meetings.<br><br>> However, operational improvements have been done in the past few years resulting in bringing down PM emission in these stacks from earlier level of 130 mg/Nm3 (2009-10) to around 100 mg/Nm3 at present.<br><br>> Meanwhile, PM analyzers are under procurement for installation in all stacks, which will enable close monitoring of PM emission and better adjustment in firing so as to minimize PM emission.. |
| 7 | **Nickel and Vanadium (Ni+V) Emissions** | **> COMPLIED.** |
| 8 | **Sulphur Content in Liquid Fuel** | **> COMPLIED.** |
| 9 | **Continuous Monitoring System for $SO_2$ & $NO_x$ emissions** | **> COMPLIED.** |

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| 10 | **Opacity of Flue Gas ex FCCU Regenerators** | > RFCCU at Barauni Refinery has been provided with flue gas scrubbing technology supplied by M/s BELCO, USA. As the flue gas is scrubbed with water / dilute caustic to remove SOx and particulate matter, PM level in flue gas is less than 30 mg/Nm3. On the other hand, But high volume of condensed water vapor (generated during water scrubbing of flue gas) escapes through the BELCO stack as whitish plume. Opacity meter under such condition is not considered relevant; Further, opacity meter may not work effectively because of high moisture content in flue gas.<br><br>**> CPCB had been requested vide BR letters dated 10th April 2009 & 22 Jan 2010 to exempt Barauni refinery from providing opacity meter for flue gas ex RFCCU regenerators.** |
| 11 | **Sulphur Recovery from SRU** | > SRU at Barauni refinery meets the revised standard.<br>**COMPLIED.** |
| 12 | **$H_2S$ emissions from SRU** | > SRU at Barauni refinery meets the revised standard.<br>**COMPLIED.** |

## C. Fugitive Emission

| SN | Standard | BR status and action plan |
|---|---|---|
| 13 | **Storage tanks with capacity between 4 to 75 m3 and TVP of more than 10 kpa** | **> Not Applicable.** |
| 14 | **Storage tanks with capacity between 75 to 500 m3 and TVP of 10 to 76 kpa** | > **Not Applicable.** |
| 15 | **Storage tanks with capacity of more than 500 m3 and TVP of 10 to 76 kpa** | > Storage tanks of Crude, MS & SRN have TVP of 10 to 76 kpa. All such tanks are IFRT or EFRT.<br>**COMPLIED.** |
| 16 | **Storage tanks with capacity of more than 500 m3 and TVP of more than 76 kpa** | **> Not Applicable** |
| 17 | **Provision of secondary seals in floating roof tanks** | > All such tanks at Barauni Refinery are equipped with double seal.<br>**COMPLIED.** |
| 18 | **Emission control in Rail Tank Wagon/ Road Tank Truck loading for Gasoline and naphtha for VOC reduction** | > Installation of Vapour Recovery System in Rail Tank Wagon / Road Tank Truck gantry is required for specified VOC reduction and emission control.<br><br>> Existing gantry at Barauni refinery does not have adequate space for laying a bigger dia header all along the gantry and other equipments for vapour recovery system. It will also require the shutdown of product loading gantry for 3-4 months to install this facility. Outage of gantry for such a long period cannot be allowed in view of the chances of market dry out of the major petroleum products.<br><br>> Further, modifications are required in the existing BTPN wagons for vapor collection system. This involves the intervention of other ministries (eg. Railways).<br><br>> In view of the above, BR has requested vide letters dated 10th April 2009 & 22 Jan 2010 to exempt Barauni refinery for this norm.<br><br>> Same was also indicated by refineries in the meeting of all Indian refineries with CPCB, conducted by CPCB on 22nd Jan. 2011 at Parivesh Bhawan, New Delhi. CPCB informed they would examine this issue.<br><br>> The above point has also been discussed regularly in all the CREP meetings. |
| 19 | **Equipments leak and LDAR programme** | **COMPLIED.** |

## D. Emission Standards for VOC from Wastewater Collection and Treatment

| | | |
|---|---|---|
| 20 | **VOC Collection & Treatment System** | > VOC treatment system as a part of ETP modernization project has been installed and commissioned.<br><br>**> COMPLIED.** |

## Scehdule -VI, Part C: Petroluem Oil Refinery

| SN | Standard | BR status and action plan |
|---|---|---|
| 21 | **Quantum limit for discharge of total effluemt** | > **COMPLIED.** |
| 22 | **Limit of quantity of effluent discharged** | > **COMPLIED.** |

**Flag-1.2**

**CHARTER ON CORPORATE RESPONSIBILITY FOR ENVIRONMENTAL PROTECTION (CREP)**

**STATUS OF IMPLEMENTATION OF CREP OBLIGATIONS AT BARAUNI REFINERY**

| Sl. No | ACTIVITY | STATUS |
|---|---|---|
| | **Air Pollution Management** | |
| 1. | All the refineries located in the critically polluted areas, identified by CPCB, should submit an action plan for reduction of $SO_2$ emission from the present level. | • With the commissioning of desulphurization facilities (Amine Treating Unit) for fuel gas from old plants in Oct 2010, Barauni refinery now meets the revised $SO_2$ emission standards for all the furnaces, boilers and captive power plant including RFCCU regenerator and SRU.<br>• The quantum of total $SO_2$ emissions from Barauni Refinery has further reduced by more than 150 Kg/hr after the commissioning of ATU in Oct 2010.<br>• **Complied.** |
| 2. | Future refineries should have Sulphur Recovery Unit (SRU) with minimum 99% efficiency. | • SRU with more than 99 % efficiency is in operation at BR.<br>• **Complied.** |
| 3. | For the SRUs in the existing refineries, an expert committee to be constituted to look into various aspects and suggest a road map within six months. | • Existing SRU at Barauni Refinery has 99 % efficiency.<br>• **Complied.** |
| 4. | (a) With regard to NOx emission, the new refineries/process units should install low NOx burners.<br><br>(b) For retrofitting of low NOx burners in existing units the same expert committee will suggest the strategies and action plan within six months. | • Low NOx burners have been installed in all furnaces and boilers of Barauni Refinery except AVU-1 &-2, Coker-B and Boiler 1 & 2.<br>• As per the present configuration of the plant, Coker B is not in operation and it will not be in operation in future as well. Accordingly, it is not envisaged to replace burners of Coker B furnace.<br>• Boiler 6 has been recently commissioned at BR after which operation of Boiler 1 and 2 is being done on intermittent basis. Also it is noted that NOx emission of Boiler 1 and 2 is around 140 mg/Nm3 which is well within the limit of 425- 435 mg/Nm3. |
| 5. | The flare losses should be minimized and monitored regularly. | Following actions are in practice :<br>• Viewing through Closed Circuit TVs |

| Sl. No | ACTIVITY | STATUS |
|---|---|---|
| | | installed in RSM Office & DDCS- II C/R.<br>• Monitoring through opening / closing of C/V of Fuel gas to flare.<br>• Fuel Gas balance on daily basis.<br>• Flare Gas Recovery Unit has been commissioned for use of flare gas as fuel gas in furnaces/boilers. Project has been registered by UNFCC under CDM projects on 04th May 2009.<br>• CO2 emissions from BR have reduced by about 6000 MT per annum after commissioning of this project. (Total CER in BR account = about 6000)<br>• **Complied.** |
| 6. | Refineries should install continuous emission monitoring system for $SO_X$ and $NO_X$ in major stacks. | • 11 additional nos. of stacks have been provided with online SOx & NOx analysers. (Commissioned in Feb'11)<br>• SOx & NOx are now monitored continuously in 20 nos. of stacks with SOx/NOx analyzers.<br>• **Complied.** |
| 7. (a)<br><br><br><br><br>7. (b) | Refineries should also monitor total HC and Benzene in the premises (particularly at loading/un-loading operations and ETP). The status and action plan to be submitted within 6 months.<br><br>The expert committee will also suggest an action plan , within six months for control and monitoring of hydrocarbon loss & VOC emissions , leak detection and repair (LDAR) programme and vapour recovery systems ( for loading & unloading operations within refineries only ) | • HC & Benzene are monitored regularly in Tank wagon Gantries, ETP & QC lab.<br><br>• VOC emissions monitored through Detection instrument and LDAR Program is in place.<br>• **Complied.** |
| | **Waste Water Management** | |
| 1. | Refineries will prepare action plan for conservation of water resources and maximizing reuse/recycling of treated effluent within six months. The treated effluent discharge quantity should be limited to 0.4 m3/per tonne (for 90% of time) except for the monsoon season. | • Treated liquid effluent is reused in refinery operations / horticulture / eco ponds make up completely except in rainy season after modernization of ETP/BTP. |

| Sl. No | ACTIVITY | STATUS |
|---|---|---|
| 2. | Oil spill response facilities at coastal refineries should be in position within 3 years. | • Not applicable. |
| | **Solid Waste Management** | |
| 1. | Refineries will explore new technologies for reduction in the generation of oily sludge. Strategy and action plan for liquidation of existing sludge should be submitted within 6 months. | Following procedures are in place for minimization of oily sludge generation:<br>• Operation of side entry mixers in crude oil tanks.<br>• Hot Gas oil circulation in crude oil tanks before handing over for cleaning.<br>• For better recovered of oil from oily sludge, Mechanized skid process by M/S Balmer Lawrie has been deployed.<br>• Recovery of oil is excellent (95-98%) against only 40-50% in case of oil recovery from melting pit.<br>• Quality of oil in residual sludge is much lower (less than 10%).<br>• Quality of final residual is very less (less than 5% of oily sludge processed).<br>• The left over residual oily sludge is subjected to bio-degradation using Bio-remediation method developed by M/s TERI and IOCL (R&D).<br>• **Complied.** |
| 2. | The petroleum coke having high sulphur content should only be sold to/reused by organized industries, which have systems to control $SO_2$ emissions).<br><br>This will be ensured by June 2003. | • RPC is being sold to reputed calciner.<br>• **Complied.** |

**Flag-2**

# Project Description & Benefits

IOCL Barauni Refinery has taken up below listed projects

1. **High Sulphur Crude maximization Project**
2. **BS-IV Project**

## 1. High Sulphur Crude maximization Project

The subject project is intended for the replacement of coke drums/reactors for reliability improvement in Coker A Unit along with inclusion of new Biturox Unit. It is also one of the projects proposed under High Sulphur Crude maximization plan of the Barauni Refinery in 2006.

### 1.1. Coker A revamp project:

Existing reactors/coke drums have been in operation for the last 30 years and already outlived its life. In this project, the coke drums will be replaced with higher metallurgy to process high sulphur feed. It may be mentioned that no capacity augmentation is envisaged in the project however certain automation facilities like automatic heading-un heading devices, coke drum level indication, coke cutting system etc are proposed. In addition, energy optimization measures are also proposed by adding 5 numbers of new heat exchangers in preheat circuit and one furnace will be decommissioned out of total two furnaces.

### 1.2. New Biturox Unit

Installation of Biturox plant at Barauni Refinery is intended for the production of 150TMTPA Bitumen to meet the region's demand. Different grades of Bitumen viz VG-10, 20, 30 & 40 shall be produced from this unit. The subject unit is licensed by M/s Poerner Inc, Austria. This project also comes under High Sulphur Crude maximization plan of the Barauni Refinery

## 2. BS-IV Project

Total BS-IV MS/HSD supply being statutory requirement, low cost option has been explored with maximum utilization of the existing assets i.e, revamp of existing units has been considered instead of new units to the extent feasible. An in-house study has been performed by exploring various means of achieving 100 % BS-IV MS & HSD. The study is based on Licensor's input, literature survey/ in-house expertise and information. The study indicated, capacity revamp of DHDT and NSU, CRU revamp or New CCRU, Prime G+ Revamp and additional RFCC gasoline de-sulphurisation Unit is required to meet 100 % HSD and MS of BS-IV specifications.

| Unit | Capacity Augmentation Envisaged, MMTPA | | Remarks |
|---|---|---|---|
| | Present | Proposed | |
| NSU | 0.464 | 0.76 | **Revamp / New Unit :** New NSU as existing NSU revamp not feasible |
| NHTU | 0.30 | 0.472 | **Revamp:** Revamp or New unit |
| CRU | 0.3 | 0.47 | **Revamp:** Revamp or New unit |
| PRIME-G+ | 0.32 (SHU)<br>0.22 (HDS) | 0.76 (SHU)<br>0.56 (HDS) | **New Unit :** PG+ Revamp or Parallel new RFCC gasoline treatment unit |
| DHDT | 2.2 | 3.3 | **Revamp:** BS IV Revamp to 3.3 MMTPA |

For revamp units, the necessary hardware modifications shall be performed in the existing available plot plan of the corresponding units. In case of additional new units, the area currently rendered vacant which is adjacent to existing ISOM unit (MSQ block) location is proposed.

With the above facilities, at current crude processing capacity of 6.3 MMTPA the refinery can produce about 1.3 MMTPA and 3.2 MMTPA of BS-IV MS & HSD respectively along with flexibility to produce 25 % of Euro V specifications. Comparison of units T'put in BS-IV scenario vis- a- vis current actual operating /design capacity is compiled below.

| Attribute | Design | BS-III Scenario (Actual for 2013-14) | BS-IV Scenario |
|---|---|---|---|
| | MMTPA | MMTPA | MMTPA |
| Crude Tput | 6.0 | 6.47 | 6.3 |
| HS% | 13-15 | 8.98 | 19.7 |
| Coker A T ‘put | 0.6 | 0.38 | 0.26 |
| Coker B T ‘put | 0.5 | 0.12 | 0.00 |
| RFCCU T ‘put | 1.43 | 1.69 | 1.7 |
| Biturox T ‘put | 0.15 | - | 0.15 |

| | | | |
|---|---|---|---|
| DHDT T 'put | 2.2 | | |
| CRU T 'put | 0.2 | 0.36 | 0.47 |
| NHDT T 'put | 0.18 | 0.25 | 0.24 |
| ISOM T 'put | 0.13 | 0.23 | 0.25 |
| SHU | 0.32 | - | **0.46** |
| Prime G+ (HDS) | 0.22 | 0.27 | **0.48** |
| SRU | 80 MTPD | 28.4 MTPD | 59.54 MTPD |
| F&L | - | 8.99 | 9.0 |
| Margin $/bbl | - | 5.45 | 6.84 |
| BS-III MS | 700 | 1190 | Nil |
| BS-IV MS | Nil | Nil | 1312 |
| BS-III HSD | - | 3249 | Nil |
| BS-IV HSD | 2156 | Nil | 3210 |
| SKO | 750 | 820 | 250 |

## 2.1. MS Quality Up-gradation Path-forward

MS pool consist of mainly three streams namely Heavy Reformate, Isomerate and treated RFCC gasoline. Thus meeting final MS pool specifications depends the combined performance of the units i.e CRU (including NHTU) , ISOM (including NHDT) and Prime G+ unit.

## 2.2. HSD Quality Up-gradation Path-forward

With back-blending of about 25 wt % (BS Iil scenario), DHDT is currently operated at about 2.6-2.7 MMTPA against the design capacity of 2.2 MMTPA, but with bottlenecks. Execution of Low cost DHDT revamp along with replacement of advance catalyst variant is scheduled in Nov'14 S/D, will ensure operation of DHDT up to 2.9 MMTPA. Major modifications envisaged in the low cost revamp include augmentation of feed filter, replacement of feed & Product pumps, control valves etc' Moreover the new catalyst charge is designed to handle 3.3 MMTPA scenario as well. Following modifications are essential for operation of DHDT at 3.3 MMTPA. Envisaged major modifications include:

- Additional MUG compressor
- Additional Feed pump
- 2 additional heat exchangers
- Wash water pump, coalscers & Piping modifications.

**2.3. Present and Post Project Scenario**

| Attribute ( Figures in MMTPA ) | Design | BS-III Scenario (Actual 2013-14) | BS-IV Scenario (Post Project) |
|---|---|---|---|
| **Crude T'put** | 6.00 | 6.47 | 6.30 |
| **High Sulphur Crude %** | 13-15 | 8.98 | **19.70** |
| **Coker A : T' put** | 0.60 | 0.38 | 0.26 |
| **Coker B : T' put** | 0.50 | 0.12 | **0.00** |
| **RFCCU : T' put** | 1.43 | 1.69 | 1.70 |
| **Biturox : T' put** | 0.15 | - | **0.15** |
| **DHDT : T' put** | 2.20 | 2.49 | **3.30** |
| **CRU : T' put** | 0.30 | 0.36 | **0.47** |
| **NHDT : T' put** | 0.18 | 0.25 | **0.24** |
| **ISOM : T' put** | 0.13 | 0.23 | **0.25** |
| **Prime G+** | 0.4 (0.32+0.08) | 0.27 | **0.76** |
| **SRU** | 80 MTPD | 28.4 MTPD | **59.54** MTPD |

## 3. Project Cost

### 3.1. High Sulphur Crude maximization Project

Total cost of Rs 480.31 Cr for Coker A revamp & Rs 71.73 Cr for New Biturox Unit

### 3.2. BS-IV Project

Total capital expenditure has been estimated to be Rs 1327 Cr (with + 30 % accuracy), inclusive of 81 Cr. financial cost component, calculated on a period of four years of Phasing.

## 4. Project Benefits

### 4.1. High Sulphur Crude maximization Project :

a) Coker A Revamp Project :
- Reliability Improvement
- High Sulphur Maximization

b) New Biturox Unit :
- Production of International Grade Bitumen Product
- High Sulphur Maximization

### 4.2. BS-IV Project

a) 100% production of BS IV specification MS (commonly known as Petrol)

b) 100% production of BS-IV specification HSD (commonly known as Diesel)

**Flag-3**

# Process Details with Chemical Reactions and Process Flow diagrams

## 2.1 Biturox Unit

## 2.1.1 INTRODUCTION

The Biturox unit shall be designed for production of viscosity graded paving bitumen VG10, VG20, VG30 and VG40 using Biturox process by oxidation of the Vacuum Residue and VGO obtained from the Vacuum Unit of the refinery.

The Design Basis includes the basis for the unit design, the basic information about utilities and side conditions.

## 2.1.2 DESIGN BASIS & CHEMICAL REACTIONS

**Duty and Capacity**

The unit is designed for a design capacity of 150000 TPA considering

- the specification of the design product grade VG30 and the alternative grades VG10, VG20 and VG40.
- continuous production of 24 hours per day and 8000 operating hours per year.

Based on this the design throughput related to the design product grade VG30 is **18.750 MTH**.

The Biturox unit is designed for continuous production. The turn down rate for production of the design product grade VG30 is 75%.

**Feed material**

The feed components for bitumen production are the **vacuum residue** and the **vacuum gas oil** obtained from the VDU by processing of the high sulphur crudes as Basrah Light, Arab Mix (a mixture of 20% Arab Light and 80% Arab Heavy), Upper Zakum, Kuwait, Iran Mix (a mixture of 25% Iran Light and 75% Iran Heavy) or a blend thereof.

**Vacuum Residue**

The main feedstock for bitumen production is the Vacuum Residue produced in the vacuum unit of the refinery with the following specification.

| VACUUM RESIDUE (MAIN FEED COMPONENT) | | | |
|---|---|---|---|
| **CHARACTERISTICS** | **UNIT** | **Sample Analysis** [1)] LKNr. 2013/002218 | **Range** [2)] |
| Penetration @ 25°C | 0.1 mm | 177 | 150-200 |
| Softening Point | °C | 37.8 | 36-40 |
| Density @ 15°C | $g/cm^3$ | 1.0298 | 1.028 – 1.032 |
| API Gravity | API° | 5.8 | 5.5 – 6.1 |
| Kin. Viscosity @ 100°C | $mm^2/s$ | 1357.00 | 1200 - 1700 |
| Kin. Viscosity @ 135°C | $mm^2/s$ | 203.10 | 180 – 240 |
| Kin. Viscosity @ 150°C | $mm^2/s$ | 110.40 | 100 - 125 |
| Dynamic Viscosity @ 60°C | Pa.s | 53.4 | 40 - 65 |
| Flash Point COC | °C | 342 | min. 300 |
| Asphaltenes (nC7-insoluble) | mass % | 7.66 | 6.5 – 8.5 |
| Paraffin Content (EN 12606-1) | mass % | 1.90 | max. 2.2 |
| Sulfur Content | mass % | 4.5580 | 4.0 – 5.0 |
| **Heating Test RTFOT** | | | |
| Change of mass | % | 0.05 | max. 0.07 |
| Retained Penetration @ 25°C | 0.1 mm | 113 | - |
| Retained Penetration @ 25°C | % of origin | 63.8 | min. 60 |
| Softening Point after RTFOT | °C | 42.4 | - |
| Increase of Softening Point | °C | 4.6 | max. 5 |
| Viscosity @ 60°C after RTFOT | Pa.s | 87.2 | - |
| Viscosity Ratio @ 60°C | - | 1.63 | max. 2 |
| **Distillation Analysis** | | ASTM D 7169, ASTM D 6352 | |
| 0 mass% (IBP) | °C | 415.8 | - |
| 10 mass% | °C | 516.8 | 500 - 520 |
| 20 mass% | °C | 548.0 | - |
| 30 mass% | °C | 571.4 | - |
| 40 mass% | °C | 591.8 | - |
| 50 mass% | °C | 612.0 | - |
| 70 mass% | °C | 656.6 | - |
| 90 mass% | °C | 714.0 | - |

## Vacuum Gas Oil

Below shows the specification of the VGO that will be used as a flux component if required to fulfil the requirements on the feed material.

| VGO (FLUX COMPONENT) | | | |
|---|---|---|---|
| **CHARACTERISTICS** | **UNIT** | **Sample Analysis** [1)] LKNr. 2013/02221 | **Range** [2)] |

| | | | |
|---|---|---|---|
| Density @ 15°C | $g/cm^3$ | 0.9285 | 0.925 – 0.930 |
| Kin. Viscosity @ 40°C | $mm^2/s$ | 127.80 | 90 – 150 |
| Kin. Viscosity @ 60°C | $mm^2/s$ | 36.41 | 30 – 50 |
| Kin. Viscosity @ 80°C | $mm^2/s$ | 17.39 | 15 – 20 |
| Kin. Viscosity @ 100°C | $mm^2/s$ | 9.80 | 8 - 11 |
| Flash Point | °C | 188.5 | min. 185 |
| Sulfur Content | mass% | 2.8620 | 2.3 – 3.4 |
| DISTILATION ANALYSIS: | | ASTM D 7169, ASTM D 6352 | |
| 0 mass% (IBP) | °C | 294.2 | |
| 10 mass% | °C | 387.8 | 370 – 400 |
| 20 mass% | °C | 414.2 | |
| 30 mass% | °C | 432.0 | |
| 40 mass% | °C | 448.0 | |
| 50 mass% | °C | 463.4 | |
| 60 mass% | °C | 478.6 | |
| 70 mass% | °C | 494.8 | |
| 80 mass% | °C | 513.4 | |
| 90 mass% | °C | 539.2 | 530 - 550 |
| 100 mass% | °C | 637.4 | |

## Product Specification

The Biturox unit shall be capable of producing the grades VG10, VG20, VG30 and VG40 with the specifications shown below.

| **PRODUCT SPECIFICATION**<br>**PAVING GRADES** | | | | | | |
|---|---|---|---|---|---|---|
| **CHARACTERISTICS** | **UNIT** | **TEST METHOD** | **VG10** | **VG20** | **VG30** | **VG40** |
| Absolute Viscosity @ 60°C | Poise | IS-1206 (Part II) | 800-1200 | 1600- | 2400- | 3200- |
| Kinematic Viscosity @ 135°C, (min.) | cSt | IS-1206 (Part III) | 250 | 300 | 350 | 400 |
| Flash Point COC, (min.) | °C | IS-1209A | 220 | 220 | 220 | 220 |
| Solubility in Trichloroethylene, (min.) | mass % | IS-1216 | 99.0 | 99.0 | 99.0 | 99.0 |
| Penetration @ 25°C, 100g, 5s, (min) | 0.1 mm | IS-1203 | 80 | 60 | 45 | 35 |
| Softening Point (R&B), (min.) | °C | IS-1205 | 40 | 45 | 47 | 50 |
| **Tests on residue after RTFOT (Rolling Thin Film Oven Test):** | | | | | | |
| Viscosity Ratio @ 60°C, (max.) [1)] | - | IS 1206 (Pt II) | 4.0 | 4.0 | 4.0 | 4.0 |
| Ductility @ 25°C, (min.) | cm | IS-1208 | 75 | 50 | 40 | 25 |

## 2.1.3 PROCESS DESCRIPTION

Biturox is a process for production of blown bitumen. Various qualities of bitumen can be made out of different residues - with or without blending components - under atmospheric conditions or with elevated pressure.

Biturox process is oxidation of feed material at an operating temperature between 240 - 270°C and pressure up to 2.0 $kg/cm^2$ g.

To reach high efficiency of the reaction between feed stock and oxygen a large reaction surface of the air bubbles is required. For that reason the Biturox reactor is equipped with a three - stage agitator to break up the incoming air bubbles. To ensure a small bubble size through the whole length of liquid column in the guiding cylinder the air bubbles are collected by coalescing plates under each agitator disc to break them up again whereby the reaction surface is renewed.

On the other hand, due to the large size of the air pipes the process air is introduced into the liquid product in a form of big bubbles with a small reaction surface. This prevents a fast start of the reaction between fresh feed and oxygen and prevents coke formation. So the Biturox reactor has low servicing needs and this effects minimum operating costs.

This technique replaces the conventional air pipes with small openings which are closed due to coke formation within short time.

**Biturox Reactor**

The reactor section, where the Biturox Process occurs, consists of three main components:

- Biturox Reactor
- Agitator, with three stages of disc mixers.
- The guiding cylinder, located concentric to the shell and containing two coalescing plates, one is located under the middle disc mixer and the other under the upper disc mixer.

Controlled amount of feedstock, air and water are simultaneously fed into and processed within the reactor unit.

# 2.2 Coker-A

## 2.2.1 INTRODUCTION

The Coker-A unit of Barauni Refinery is designed for processing 600,000 MT per year of reduced crude from atmospheric/ vacuum distillation units. The unit can process vacuum residues from a wide variety of crude oils including Bonny Light and Arab Mix crudes. It can also process a number of low value streams such as extracts and de-waxed oils from Lube plants and decant oil from the bottom of FCC units in addition to the vacuum residues. The unit is designed to produce unstabilised Naphtha, LPG rich off gas, Reduced Petroleum Coke (RPC) and components for HSD, LDO and Fuel Oil pools. The unit upgrades heavy residual oil converting it to above products.

A delayed Coker unit mainly consists of a furnace, coke chambers (reactors), fractionator and light ends recovery system. The associated facilities include coke cutting/ handling and water re-use system. Coker-A unit is to be designed to process 0.6 MMTPA of feed in 7200 on-stream hours per year.

## 2.2.2 DESIGN BASIS & CHEMICAL REACTIONS

The unit is designed for the following three cases :

| | |
|---|---|
| CASE-I | Feed corresponding to future refinery configuration having ResidDesulphurisation unit, while processing 0.6 MMTPA high sulphur crude (50:50 wt Arab mix) |
| CASE-II | Feed corresponding to future refinery configuration without Resid Desulphurisation, while processing 0.6 MMTPA low sulphur crude (Bonny light). |
| CASE-III | Feed corresponding to future refinery configuration without Resid Desulphurisation, while processing 0.42 MMTPA low sulphur crude (Bonny light). |

Coker A Feed :

a) Vacuum Residue from AVU's.
b) Phenol Extract from Phenol Extraction Unit.
c) VGO from AVU's
d) CLO

Coker A Products :

a) Off gas : To be routed to existing LPG recovery unit for LPG recovery.
b) Coker Naphtha : To be routed to existing LPG recovery unit for stabilization/ LPG recovery.
c) Coker Kero : Suitable for routing to DHDS unit (Cases 1&2)/ blending into HSD pool.
d) Coker LDO : To be routed to FCC Unit (Cases 1&2) / LDO pool (Case-3).
e) Coker fuel oil : Suitable for blending into 'Fuel Oil' Pool.
f) Coker residue : Suitable for blending into Fuel oil pool.
g) Coke

Chemistry behind coking:

Delayed Coking is a thermal conversion process by which a residual stock or crudes' "bottom of the barrel" material is upgraded to more valuable distillates. This process also produces a solid carbonaceous matter called coke. This coke, depending upon its quality can be used for the manufacture of electrodes for aluminum production (called anode grade), for electrodes in the electric arc furnace for steel making (this grade is known as needle coke) or other miscellaneous applications e.g. Titanium-di-oxide manufacture, coke ovens, silicon carbide etc. Cokes required for such applications requires "Calcination" which essentially means driving off the water and the oily volatile matters from the coke. The quality of the coke mainly depends on the feedstock. If the feedstock is not of good quality, the coke (called the fuel grade) can be used as a fuel in the cement industry or power plant.

The mechanism for the formation of coke is rather complicated. However, two independent mechanisms exist. First mechanism involves the polymerization and condensation of the aromatics portion in the feed. The aromatics ring cross link to such a degree to form coke. The formation of this so called "thermal coke" is the most desired one for a good quality coke (e.g. needle coke). In the second mechanism the colloidal asphaltene and the resin gets distorted and precipitate out of the solution to form a highly cross linked structure. This is known as "asphaltene coke" and undesired for a good coke quality. Formation of these two types of coke are governed more by the feedstock quality than by the operating parameters. These reactions proceed in following three distinct phases :

- Partial vaporisation and mild cracking of the charge stock as it passes through the heater.
- Successive cracking and polymerisation of the liquid in the drum until it is converted to vapor and coke.
- Cracking of the vapor as it passes through the coke drum.

## 2.2.3 PROCESS DESCRIPTION

The Quench column K-6 has been provided to further condense the heaviest fraction of the Coke chamber vapor by LDO quench on temperature control of Column overhead cascaded with flow control. The internals of the column consist of a Disc and doughnut arrangement. The bottom material i.e. residue is pumped using residue pumps, H-22/22A on flow cascaded with level control of the Quench Column bottom to the main fractionator bottom as recycle to the furnace. To avoid coking of Quench Column bottom, a portion of fresh preheated feed from 604-EE-00-003 A/B is used as quench and is routed on temperature control to the Quench Column bottom.

Provision to route a part of the residue as product to storage is also kept. For this, residue from H-22, apart from being routed to fractionator, a part will be cooled in the residue cooler 604-EE-00-008 (T-13 Box cooler). A part of this cooled residue will be routed back to Quench Column as Quench, instead of fresh feed, during this mode and the rest is sent as product to storage.

Delayed Coker unit is divided into following sections :

- Feed handling and preheat
- Furnace
- Coke chambers
- Quench column
- Fractionator and Strippers
- Quench, flushing & Instrument Purge Oil system

# 2.3 NSU, NHTU & CRU

## 2.3.1 INTRODUCTION

To get motor spirit of low lead and high octane it was proposed to have a Catalytic Reformer Unit (CRU) in Barauni Refinery in 1990. The plant is having following facilities:

1. Naphtha Splitter Unit – NSU.
2. Naphtha Hydro-Treater Unit - NHTU.
3. Catalytic Reformer Unit – CRU.

## 2.3.2 DESIGN BASIS & CHEMICAL REACTIONS

| SL. NO. | NAME (MT/YR) | CAPACITY RATIO | TURN DOWN |
|---|---|---|---|
| 01. | Naphtha Splitter Unit (NSU) | 0.54 | 40% |
| 02. | Naptha Hydro-Treater Unit (NHTU) | 0.30 | 50% |
| 03. | Catalytic Reformer Unit (CRU) | 0.30 | 50% |

### PURPOSE

The purpose of Reformer is to enhance the octane number by changing the hydrocarbon structure in the presence of catalyst and hydrogen. It is not advantageous to operate reformer with lighter hydrocarbons. So splitter was required to get suitable cut of feed for reformer. Since reforming reaction is to be carried out in presence of catalyst, but impurities/water act as catalyst-poison, so we need hydro-treater to remove impurities and water.

### NAPHTHA SPLITTER UNIT (NSU)

**FEED** : IBP-140 $^{0}$C cut naphtha from storage tanks

**PRODUCTS** : IBP 70 $^{0}$C cut naphtha is sent to Hydrogen Generation Unit as their feed.
IBP 70-140 $^{0}$C cut naphtha is sent to NHTU and storage tank.

### NAPHTHA HYDRO-TREATER UNIT (NHTU)

**FEED** : Feed to NHTU comes from Naphtha Splitter Unit(NSU) bottom.

**PRODUCTS** : NHTU stripper bottom is fed to CRU or sent to storage for subsequent start up.
Specific Gravity: 0.765.

### Catalytic Reformer Unit – CRU

**FEED** : NHTU stripper bottom is feed for CRU.

**PRODUCTS :**

**A) Reformate:**

| **Component** | **SOR** | **EOR** |
|---|---|---|
| Specific Gravity | 0.788 | 0.787 |
| RON | 95.0 | 95.0 |
| MW | 93.0 | 92.8 |
| RVP at $38^0$C | - | 0.40 Max. |

**B) Hydrogen Rich Gas :**

| **Component** | **SOR (Mole %)** | **EOR (Mole %)** |
|---|---|---|
| H-2 | 93.0 | 88.8 |
| C-1 | 2.9 | 5.1 |
| C-2 | 1.5 | 2.5 |
| C-3 | 0.7 | 1.3 |
| C-4 | 0.5 | 0.8 |
| C-5 + | 1.4 | 1.5 |
| MW | 4.6 | 5.6 |

**C) LPG Absorber off Gas :**

This LPG absorber off gas goes to fuel gas network.

| **Component** | **SOR (Mole %)** | **EOR (Mole %)** |
|---|---|---|
| H-2 | 52.6 | 46.7 |
| C-1 | 10.6 | 16.9 |
| C-2 | 19.7 | 22.5 |
| C-3 | 13.6 | 9.5 |
| C-4 | 1.7 | 2.5 |
| C-5 + | 1.8 | 1.9 |
| MW | 17.3 | 17.7 |

**D) Stabilizer over head liquid :**

This liquid goes to LPG Recovery Unit for LPG recovery.

| **Component** | **SOR (Wt. %)** | **EOR (Wt. %)** |
|---|---|---|
| C-1 | 0.0 | 0.2 |
| C-2 | 7.7 | 9.6 |
| C-3 | 62.5 | 44.1 |
| C-4 | 29.8 | 45.9 |
| C-5 | 0 | 0.2 |
| MW | 45.5 | 46.9 |
| Specific Gravity | 0.504 | 0.510 |
| Octane No. | 95.0 | 95.0 |

## CHEMICAL REACTIONS:

## NHTU :

To protect the reformer catalyst, the feed is to be pretreated in order to eliminate the following poisons: Sulfur, Nitrogen, Water, Diolefins, Olefins, Arsenic and Metals.

Elimination of these poisons are achieved in Naptha Hydro-treater Unit (NHTU) by the use of specific catalyst and operating conditions, except for water which is eliminated in the stripper, though bulk amount of water is separated in hydrotreater separator.

**A) HYDROREFINING REACTIONS :**

***a) Desulfurisation:***

Mercaptans, sulphide and disulphide easily react, leading to the corresponding saturated hydrocarbons.

$R\text{-}SH + H_2 \rightleftharpoons RH + H_2S$

$R\text{-}S\text{-}R' + 2H_2 \rightleftharpoons RH + R'H + H_2S$

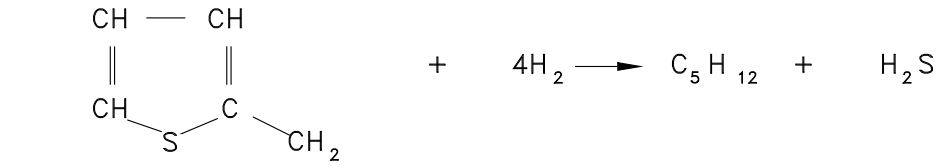
$R\text{-}S\text{-}S\text{-}R' + 3H_2 \rightleftharpoons RH + R'H + 2H_2S$

*Example:*

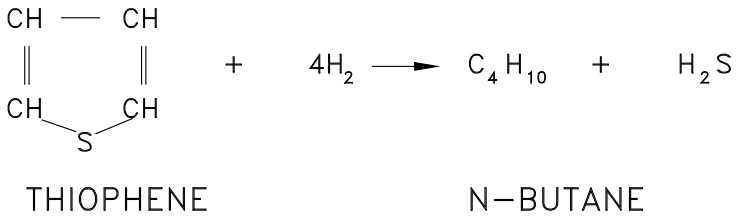
$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}SH + H_2 \rightleftharpoons C_5H_{12} + H_2S$

***d) Amyl Mercaptan*** ***N-Pentane***

Sulfur combined into cycles of aromatic structure like thiophene, is more difficult to eliminate. In that case the main reaction involves the opening of the heterocycle giving the corresponding hydrocarbon and hydrogen sulfide.




METHYL THIOPHENE N–PENTANE

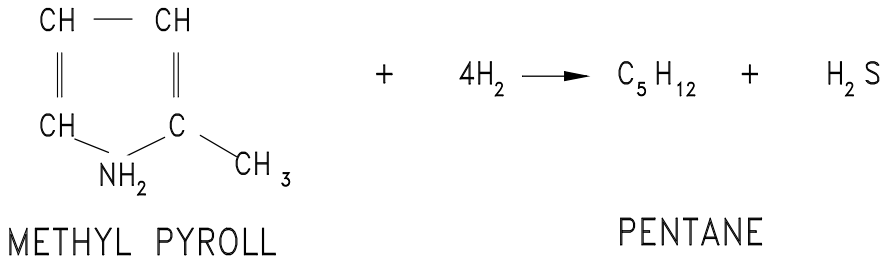



***b) Denitrification:***

This is the most important reaction in HTU, besides the desulfurization. It results in Production of Ammonia.

$$R\text{-}NH_2 + H_2 \rightleftharpoons R\text{-}H + NH_3$$

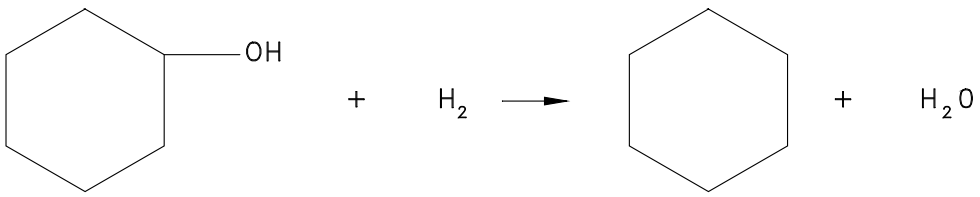
*Example:*




Its rate is lower than the desulfurization reaction, mainly in the case of hetrocyclic compounds, having an aromatic structure.

**c) *De-oxygenation***

Oxygen dissolved or present in the compounds of the same type as the Sulphiding Compounds or as peroxides or Phenols, is eliminated in the form of water.




**B) HYDROGENATION REACTIONS:**

These reactions affect the diolefins, olefins and aromatics and are highly exothermic.

- Diolefins and olefins, if any, are converted into saturated compounds.
- Aromatics hydrogenation occurs as a consequence of temperature and hydrogen partial pressure. The use of this specific catalyst (HR 306) along with H2S partial pressure allows the limitation of these hydrogenation reactions. Less than one percent of the aromatics of the feed are hydrogenated in the hydrotreaters.

**C) ELIMINATION OF ARSENIC AND METALS:**

These compounds are adsorbed on the catalyst. The adsorption occurs on the upper layers of the catalytic beds and progressively extends down to the lower part. If these compounds affect the catalyst, its activity is drastically reduced.

## CRU

In Catalytic Reforming Unit, the structure of hydrocarbon (low octane) is changed to hydrocarbon of higher octane number (mainly aromatics) through various reactions in the presence of specific catalyst.

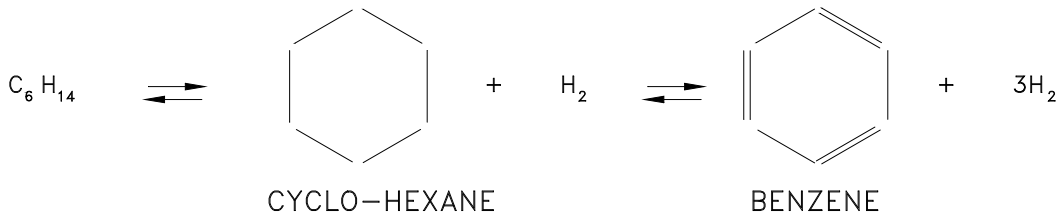
## Main reactions :

**A) DEHYDROCYCLISATION OF PARAFFINS**
**B) DEHYDROGENATION OF NAPHTHENE**
**C) ISOMERIZATION OF PARAFFIN**

**A) DEHYDROCYCLISATION OF PARAFFINS:**

This reaction leads to an important increase in octane number. The hydrogen production being of 4 moles per mole of paraffin transformed.

This reaction is highly exothermic (-60 Kcal/mole) and limited by the kinetics.




Due to it's relatively low rate, operating conditions must be more severe for this reaction than for the other ones thus leading to coke formation.
The volumetric yield of product from this reaction is only 70 to 80%.

**B) DEHYDROGENATION OF NAPHTHENE :**

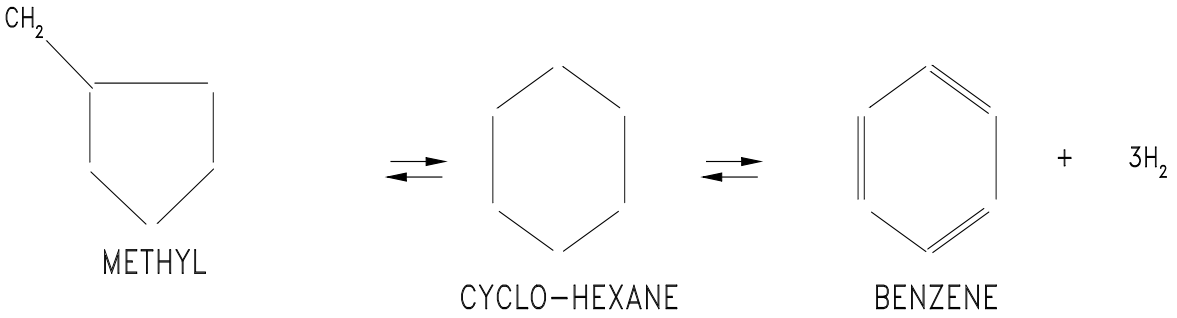
This reaction also leads to an important increase in octane number, the hydrogen production being lower than from the previous reaction.

This reaction is highly endothermic (-50 Kcal/mol). The conversion is almost the same as foreseen by the thermodynamics.

In case of cyclopentanic naphthenes, they must be first isomerized to C5 ring naphthenes before being hydrogenated.

**C) ISOMERISATION OF PARAFFINS :**

This reaction leads to an increase in octane number as branched paraffin has higher octane number than the corresponding linear paraffin. There is no hydrogen production in this reaction.




$C_6H_{14}$ ⇌ $CH_3$-CH($CH_3$)-$CH_2$-$CH_2$-$CH_3$

N-HEXANE ISO-HEXANE

This reaction is slightly exothermic (2 Kcal/mole) and the conversion is limited, by the thermodynamics. This later limits the gain in octane number as the branched to normal paraffin ratio at equilibrium decreases when the molecular weight increases.

Its rate is high and its volumetric yield is 100%.

## SIDE REACTIONS:

**A) CRACKING**

***i) Hydro cracking***

***ii) Hydrogenolysis***

**B) DEALKYLATION**

**C) COKING**

**D) DISMUTATION**

**E) ALKYLATION**

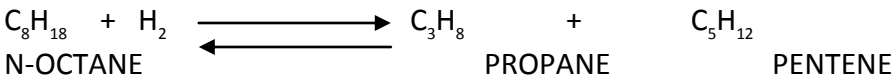
**A) CRACKING:**

This reaction results in the degradation of the molecules and must be, as far as possible avoided.

Two different ways of cracking takes places :

***i) Hydro cracking:***

This degradation reactions leads to low molecular weight paraffin mainly $C_3$ and $C_4$.




This is highly exothermic reaction and relatively slow reaction. Hydro cracking of straight chain paraffin result in octane improvement but hydro cracking of naphthene will reduce the naphthene potential used for conversion to aromatics.

***ii) Hydrogenolysis:***

This degradation reaction leads to light hydrocarbons ($C_1$, $C_2$, $C_3$) and the complimentary paraffin. These reactions are of no interest in a classical reforming except when LPG production is expected.

This degradation first affects the higher paraffin, which otherwise, would have been more easily dehydrocyclised to corresponding aromatics. However when naphthenes are involved in the cracking reactions potential aromatics are eliminated.

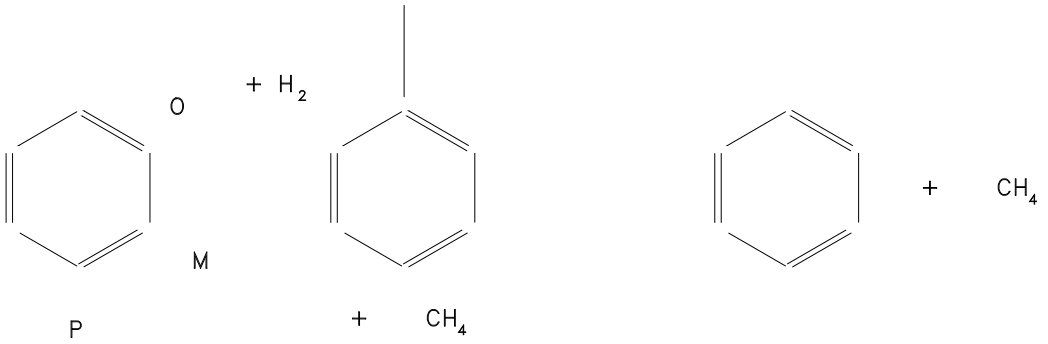
Thus these reactions must be normally avoided as they result in a low reformate yield and due to the light gases formation, in a lower purity of the recycled hydrogen gas.

These reactions are exothermic and non-equilibrated. Their rate is low at low temperature faster than the rate of other reactions.

**B) DEALKYLATION:**

This reaction consumes hydrogen. It does not improve the octane of the gasoline.

It could be interesting in case of aromatics production as it leads to lower aromatics at the cost of higher aromatics.

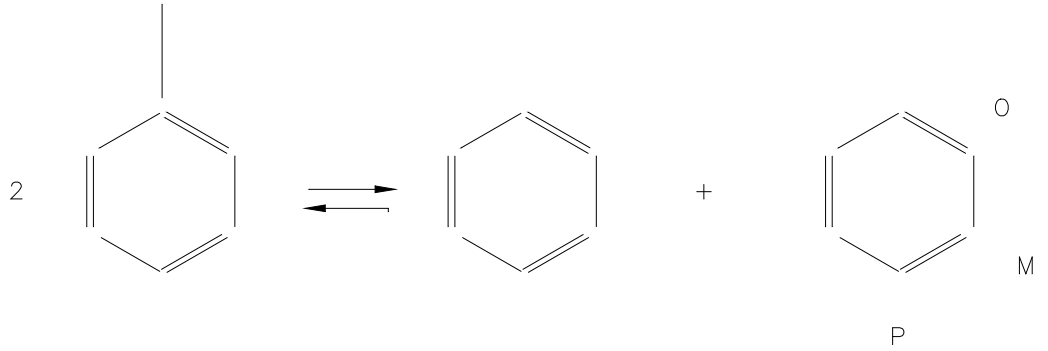



**C) COKING :**

Heavy polyaromatics leading to coke are formed by alkylation, dismutation and cyclisation reactions. High temperature enhances these reactions.

**D) DISMUTATION :**

It is basically of no interest in a normal refining operation. This is of interest for an aromatic operation, as toluene can be transformed to pentene and xylenes.



**E) ALKYLATION:**

This reaction has no influence on the octane number of the gasoline and takes place without any hydrogen exchange. As it leads to heavier molecule this reaction can give products whose boiling point may be higher than the final boiling point of the gasoline cut on the other hand, high molecular weight hydrocarbons can be considered as coke precursors.

Due to their rate, the reactions will take place mainly in the following order, in different reactors.

| | | |
|---|---|---|
| *First Reactor* | : | Dehydrogenation |
| | : | Isomerization |
| *Second Reactor* | : | Dehydrogenation |
| | : | Isomerization |
| | : | Cracking |
| | : | Dehydrocyclisation |
| *Third Reactor* | : | Cracking |
| | : | Dehydrocyclisation |

Thus the temp. drop will be high in the first reactor, less in the second and third reactor.

## 2.3.3 PROCESS DESCRIPTION

## NAPHTHA SPLITTER UNIT (NSU):

IBP-140 $^0$C cut naphtha from storage is fed to splitter column under flow control by off site pump at tray No. 14. The feed is heated up to 95 $^0$C in splitter feed/bottom exchanger against splitter bottom stream before it enters the column.

The overhead vapors are totally condensed in air condensers. The liquid collected is pumped by splitter reflux pump and one part sent as top reflux back to the column under flow control to maintain the top temperature. The balance, which constitutes the IBP-70 $^0$C cut naphtha is sent to HGU as their feed and rest light naphtha is sent to storage under reflux drum level control after cooling in a water cooler. Reflux drum boot water is drained in OWS manually.

The pressure of splitter is controlled at reflux drum by passing a part of hot column overhead vapors around the condenser or releasing the reflux vapors to flare through a split range controller.

The splitter bottom product which constitutes 70-140 $^0$C cut naphtha is pumped to splitter feed/bottom exchanger by hydro treater feed pumps. The bottom product after exchanging heat with feed is split into two streams. One is fed to the hydro treater unit at a temp. of 65 $^0$C and the other is sent to storage under column level control after being cooled in splitter bottom column.

The heat necessary for splitter reboiling is supplied by splitter reboiler furnace and desired temperature maintained by controlling the fuel firing. Splitter reboiler pumps provide the circulation through reboiler is double pass vertical cylindrical furnace having four burners fired from the bottom. It has soot-blowing facility for convection section.

## NAPHTHA HYDROTREATER UNIT (NHTU):

### A) REACTION AND SEPARATION SECTION:

The naphtha from NSU is fed to HTU by a pump. The feed flow is controlled by flow control valve. The feed then mixed with Rich Hydrogen Gas from HP separator of reformer. controls the Rich Hydrogen gas flow. Both the liquid naphtha and rich hydrogen gas are pre-heated in a series of exchangers, which are feed/reactor effluent heat exchangers. Then mixture is heated up to reaction temperature in a furnace and fed to the reactor. The furnace is four pass having three burners fired from bottom. The furnace is having facility of soot blowing. The reactor inlet temperature is maintained by cascaded with either fuel oil or fuel gas PC's. The furnace is provided with all safety shut down inter locks. It has also provision of decoking.

The desulfurisation and hydro treating reaction takes place in at almost constant temperature since heat of reaction is quite negligible. The reactor is provided with facility of steam and air for regeneration of catalyst.

The reactor catalyst bed has been provided with five number of thermo couple points at various location to get the bed temperature during regeneration of the catalyst.

A line has been provided to feed the naphtha to stripper, during start up, bypassing the reaction/separation section.

### B) STRIPPER SECTION :

The separator liquid is pumped by 02-PA-001A/B under flow control 02-FC-1201 cascaded with 02-LC-1201 to stripper feed/bottom exchanger 02-EE-003 A/B/C when it gets heat exchanged by hot stripper bottom stream.

The stripper column consists of 28 Nos. of valve trays one to eight number of trays are single pass and the rest double pass. Feed coming from 02-EE-003 A/B/C enters at

9th tray from two sides. The overhead vapors are cooled down in 02-EA-002-air condenser and collected in 02-VV-002-stripper reflux drum. The fan load can be adjusted. The condensed hydrocarbons are returned to column top by pump 02-PA-002A/B under flow control 02-FC-1301 cascaded with 02-LC-1302 as reflux to maintain the top temp. The water accumulated in the boot is sent for disposal as sour water. 02-PC-1301 releasing excess gas in the FG system maintains the reflux drum pressure. The facility is there to inject corrosion inhibitor by pump 02-PA-005A.

Stripper bottom product exchanged heat with stripper feed in 02-EE-003A/B/C and then sent to reformer as hot feed. The excess or required hydro-treated naphtha is sent to storage after being cooled in 02-EE-004 A/B under level control 02-LC-1301.

02-FF-002 reboiler heaters supply the necessary heat for stripper reboiling. 02-CC-001 products are circulated through 02-FF-002 single pass cylinders vertical furnace by 02-PA-003 A/B. Partial vaporization occurs in 02-FF-002. 02-TC-1301 at 3rd plate from the bottom of 02-CC-001 controls reboiling. Furnace is provided with all safety inter locks.

## CATALYTIC REFORMER UNIT (CRU)

Hydro treated naphtha from hydro treater unit is pumped to required pressure by 03-PA-001 A/B under flow control 03-FC-1101 A/B and mixed with recycle gas from the recycle gas compressor (03-KA-001). The mixed feed is pre heated in the feed-effluent exchanger 03-EE-001 followed by feed/effluent exchanger 03-EE-002. Then the mixture is brought up to the reaction temperature (480 0C) by heating in the pre-heater 03-FF-001 and then fed to 1st reactor 03-RB-001.

As the reaction is endothermic, the temperature drops, so the first reactor effluent is heated in the first inter heater 03-FF-002 prior to be sent to the second reactor 03-RB-002.

In the same way 03-RB-002 effluents are heated in the second inter heater 03-FF-003 prior to be fed to the third reactor 03-RB-003.

The effluent from the last reactor 03-RB-003 is split into two streams and send for heat recovery parallely to feed/effluent exchanger (03-EE-002) and stabilizer reboiler (03-EE-003). The outlet from the two exchangers is combined by a these way valve 03-TIC-1101 and then cooled down successively in the Zeemann Secathen exchanger (03-EE-001), reformer effluent cooler 03-EA-001 and effluent trim cooler 03-EE-004. The cooled reactor effluent is flashed in the reformer separator 03-VV-001.

Vapor and liquid phase are separated in separator 03-VV-001. Part of the gas phase constitutes the hydrogen recycle gas to the reactor circulated by recycle gas compressor 03-KA-001. The hydrogen rich gas compressor 03-KA-002 A/B compresses remaining amount, corresponding to the amount of gas produced. The pressure control in separator is achieved by

a kick back gas flow from HP Absorber (03-VV-003) to separator. Should the gas be produced in excess to 03-KA-002 A/B capacity, degassing in split range to fuel gas is performed, through 03-PC-1401 A and 03-PC-1402.

The separator liquid is sent by reformer separator bottom pumps (03-PA-002 A/B) under level control 03-LC-1401 for recontacting with the gas compressed by 03-KA-002 A/B.

The hot flue gases from all the three reformer furnaces are combined and sent to stream generation system for waste heat recovery to produce MP steam. Provision is there to dry the recycle gas into a dryer (03-RB-004). The dryer can later be regenerated.

The unit has also been provided with facilities for continuous chloriding, water injection, DMDS/Ccl4 injection and caustic soda circulation.

The separator (03-VV-001) vapor after passing through KO drum (03-VV-002) is compressed in the H2 Rich Gas Compressor (03-KA-002 A/B) and recontacted with separator liquid. The recontacted vapor and liquid is cooled in a cooler (03-EE-005) and then fed to HP absorber (03-VV-003). The aim of this device is to allow for high recovery of the C5 contained in the gas phase of separator and improves the quality (H2 concentration) of the produced gas.

A part of hydrogen rich vapor goes to HTU as a make up hydrogen through 02FC1202 and balance goes to the suction KO drum of HGU compressor K-05 that is run to provide H2 to DHDT after purification in a PSA unit through 3PC1601B.03PC1601 remains inline with fuel gas system at a slight higher set point than 3PC1601B.So that any excess gas can be routed to FG system through 03PC1601.

The liquid from the 03-VV-003 is drawn off under level control 03-LC-1601 and mixed with stabilizer vapor distillate. The combined stream is cooled in LPG absorber feed cooler 03-EE-006 and flashed in LPG absorber. Off-gas is sent under pressure control to fuel gas system. Stabilizer feed pumps 03-PA-003 A/B pumps the liquid from 03-VV-004. After pre heating in stabilizer feed/bottom exchanger 03-EE-007 the mixture is fed to the stabilizer 03-CC-001 at tray No. 13.

Stabilizer over head vapours is partially condensed in stabilizer condenser 03-EE-008 and flashed in stabilizer reflux drum 03-VV-005. The vapor phase is sent to LPG absorber for $C_3$ and $C_4$ recovery. A part of condensed liquid is pumped as reflux to the column by stabilizer reflux pump 03-PA-004 A/B under the flow control and the balance is sent to LPG Recovery Unit under level control of reflux drum.

The heat of reboiling to the stabilizer is provided by the hot reactor effluent in the stabilizer reboiler 03-EE-003 and the desired temperature maintained by controlling the flow of reactor effluent by the three way valve.

The bottom product, stabilized reformate, is cooled in the feed/bottom exchanger 03-EE-007 followed by reformate cooler 03-EA-002 and reformate trim cooler 03-EE-009 before being routed to storage Tk 77 to 84.

# 2.4 Prime G+ Unit

## 2.4.1 Introduction

SHU section, treating the full range RFCC LCN gasoline, converting Diolefins to olefins and light fraction sweetened to recover a sweet desulfurized light cut to be sent to Gasoline Pool and a heavy cut sent to HDS section along with fresh HCN feed. This section allows to reach very high selectivity and to minimize the octane loss to recover a sweet desulfurized heavy cut to be sent to Gasoline pool.

## 2.4.2 Chemical Reactions :

### SHU Reactor

In this reactor, the diolefins are hydrogenated in order to avoid gum formation in the hydrotreating section where hydrodesulphurization takes place. Light mercaptans and some other light sulfur compounds are converted to heavier sulfur compounds enabling the production of a light naphtha fraction almost free of mercaptans and light sulfides. In addition, external olefins are isomerized to internal olefins.

**Chemical reactions**

The cracked gasoline contains the following unsaturated components:

- Diolefins (aliphatics or cyclics),
- Olefins,
- Aromatics.

Several chemical reactions can take place during the diolefin hydrogenation. The most important ones are:

- The hydrogenation of diolefins,
- The conversion of light mercaptans and some light sulfur compounds into heavier sulfur species,
- The isomerization of olefins,
- The hydrogenation of olefins.

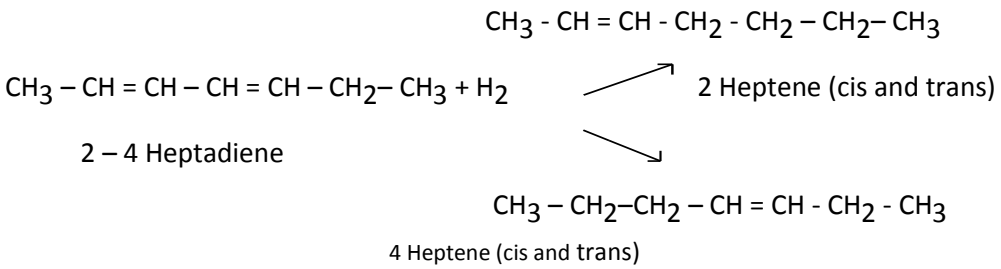
The last reaction must be avoided as much as possible to minimize octane loss.

**Hydrogenation of diolefins**

Diolefins are hydrogenated into corresponding olefins and some of the olefins are hydrogenated into corresponding paraffins. The diolefins content is measured with the Diene Value (DV) or the Maleic Anhydride Value (MAV) analysis.

**Diolefins:**

Their hydrogenation produces several isomers, for example:




Moreover double bond migration can also occur within the newly generated olefins.

Diolefins are very unstable compounds which polymerize easily into gums. Therefore conversion of diolefins into olefins improves the product quality. These reactions are highly exothermic. The difference between the Diene Value (DV) or the Maleic Anhydride Value (MAV) of the feed and the DV or MAV of product measures the extent of these reactions and is related to the hydrogen consumption.

**Isomerization of olefins**

$CH_2 = CH - CH_2 - CH_2 - CH_2 - CH_3 \rightarrow CH_3 - CH = CH - CH_2 - CH_2 - CH_3$

1 - Hexene 2 - Hexene

This reaction, thermodynamically enhanced by low temperatures (less than 200 deg. C) takes place when diolefins are almost completely eliminated. It offers the advantage of leading to internal olefins that are more stable towards hydrogenation than external olefins. Thus the selectivity is improved. In addition, internal olefins often have a higher octane number.

**Hydrogenation of olefins**

These reactions are undesirable because they reduce the octane number.

The hydrogenation of diolefins is faster than the hydrogenation of olefins. Nevertheless it is difficult to completely avoid some olefins hydrogenation.

This reaction is also exothermic.

The difference between the feed bromine number (BrN) and the product BrN measures the conversion rate of this reaction and is related to the hydrogen consumption.

**Sulfur reaction**

**Conversion of Light Mercaptans to Heavier Sulfides**

RSH + R' ($C_5$ to $C_7$ olefin) $\leftrightarrow$ RS R'

**Conversion of Light Mercaptans to Heavier Mercaptans**

**Step 1**

RSH + H2 $\leftrightarrow$ RH + $H_2S$

**Step 2**

H2S + R' ($C_5$ to $C_7$ olefin) $\leftrightarrow$ R'SH

**Conversion of Sulfides to Heavier Mercaptans**

$CH_3 – S – CH_3$ or $C_2H_5 – S – CH_3$ + H2 $\rightarrow$ $CH_4$ and $C_2H_6$ + $H_2S$

$H_2S$ + R' ($C_5$ to $C_7$ olefin) $\leftrightarrow$ R'SH

**Conversion of $H_2S$ to Heavier Mercaptans**

$H_2S$ + R' ($C_5$ to $C_7$ olefin) $\leftrightarrow$ R'SH

## HDS Reactor

**Chemical reactions**

Sulfur removal reactions are the desired chemical reactions and are accompanied by Olefin saturation reactions. In addition, denitrogenation reactions can take place but in a much lower extent.

All these reactions are exothermic.

**Desulfurization**

The typical sulfur compounds in cracked gasoline are of the thiophenic and benzothiophenic types.

The desulfurization of the sulfur compounds occurs in several steps:

Thiophene ⟶ Thiophane ⟶ Mercaptans ⟶ $H_2S$

The desulfurization reactions are exothermic, but given the relatively low concentration of reactant involved, these reactions do not significantly contribute to the overall reactor exotherm.

Benzothiophenes are essentially converted and the residual sulfur is essentially in the form of thiophenes and mercaptans.

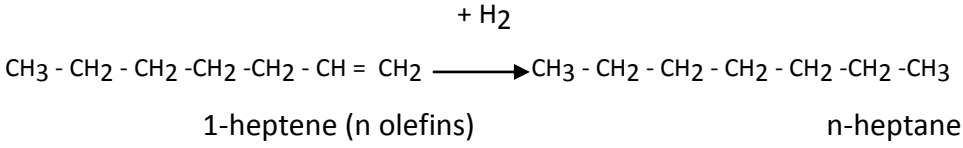
**Hydrogenation of olefins**

Hydrogenation or olefin saturation is the addition of a hydrogen molecule to an unsaturated hydrocarbon to produce a saturated product. Olefinic hydrocarbons are found in high concentrations in cracked gasolines. The olefin saturation reaction is highly exothermic and is controlled by the process. The comparative reactivity of olefins (from more reactive to less reactive) is as follows:

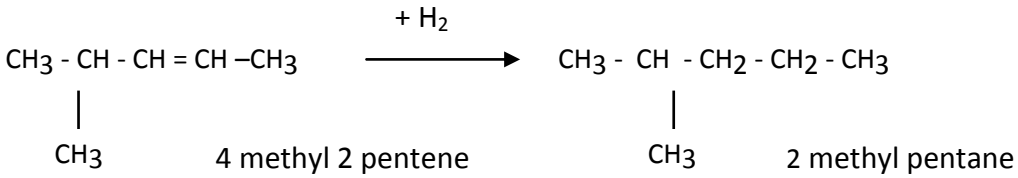
n alpha - olefins / n internal olefins / alpha branched olefins / cyclic olefins / internal branched olefins.

This reaction is exothermic (delta H = 30 kcal/mol) and most of the heat release in the reactor is due to the heat of reaction of the olefins hydrogenation. Under the selected operation conditions, the olefin hydrogenation level is lower than that of hydro-desulfurization. Therefore, good selectivity is achieved. In order to desulfurize the FCC naphtha while maximizing octane retention, the olefin saturation must be minimized. The catalyst selectivity is defined as the hydrodesulfurization rate divided by the olefin saturation rate.

Typical olefins hydrogenation reactions are:




1-heptene (n olefins) n-heptane



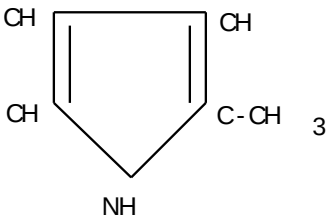

4 methyl 2 pentene (branched internal olefins) 2 methyl pentane

**Denitrification or Denitrogenation**

Nitrogen is removed in catalytic hydrotreating by breaking the C-N bond producing-nitrogen free aliphatic hydrocarbons and ammonia. Breaking the C-N bond is more

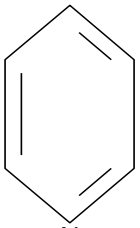
difficult to achieve than the C-S bond in desulfurization. Consequently, denitrification occurs to a lesser extent than desulfurization.

Nitrogen compounds typically found in cracked gasolines are methylpyrrol and pyridine types.




$$+4H_2 \longrightarrow C_5H_{12} + NH_3$$

Methylpyrrol n-pentane ammonia




pyridine

$$+ 5\,H_2 \longrightarrow C_5H_{12} + NH_3$$

n- pentane ammonia

The heat released by the denitrification reactions is also negligible owing to the small amount of nitrogen compound involved.

**$H_2S$ Influence**

$H_2S$ is a strong inhibitor of the hydrodesulfurization reactions and favors recombinant mercaptans formation. However, it does not decrease the olefin hydrogenation level. As a result, $H_2S$ decreases both catalyst activity and selectivity.

For this reason, the $H_2S$ is removed from the recycle gas through an amine absorber.

**Relative rates of reaction**

Under the selected operating conditions and the choice of catalyst, these reactions are classified in decreasing order of reaction extent:

hydrodesulfurization > olefins hydrogenation > > > aromatic hydrogenation

## 2.4.3 PROCESS DESCRIPTION

**SHU : Reaction Section**

The unit feed is Light Cracked Naphtha (LCN) gasoline coming directly from the RFCC unit or mixed with a limited quantity of feed from storage tank-31/32. The feed is first routed to LCN feed filters 803-G-01, in order to remove scale particles and gummy ingredients.

***Feed from storage will be limited to 10% of total feed.***

The RFCC LCN gasoline (IBP - 140°C Cut) feed is then charged to the SHU Feed Surge Drum, 803-V-01. The SHU Feed Surge Drum pressure is maintained @ 2.3 by split range control of hydrogen and venting to flare. The unit feed is pumped to the SHU (Selective Hydrogenation Unit) section by SHU Feed Pumps, 803-P-01 A/B, under flow control. The hydrogen make-up is coming from HGU (Hydrogen plant) or CRU (Unit 03) via the first stage of hydrogen make-up compressors of Isomerization unit (Unit 802), 802-K-01 A/B@ 35 kg/cm2g. These $H_2$ make-up compressors allow working at 26.0 kg/cm²g at SHU Reactors inlet. The flow of hydrogen is mixed with the feed to SHU reaction section under flow control to the LCN gasoline feed.

The mixture of gasoline feed and hydrogen make-up is preheated in the SHU feed / Splitter bottom exchanger, 803-E-01 and then by exchanging heat with the SHU reactor effluent in the SHU Feed / Effluent Exchanger, 803-E-02. The mixture is then heated to the proper reactor inlet temperature 150-200°C in SHU Preheater, 803-E-03, by desuperheated Medium High Pressure steam (MHS) under flow control reset by temperature control at the SHU reactor inlet.

To allow a good control of the SHU reactor inlet temperature, a minimum temperature increase of 5 deg. C must be achieved in the SHU Preheater, 803-E-03. For that purpose, a bypass of SHU Feed / Splitter bottom exchanger, 803-E-01, and SHU Feed / Effluent Exchanger, 803-E-02 cold side is installed. This bypass line is only required for the start-up operation, as both exchangers are designed for the EOR conditions.

During start-up, the heat exchangers are clean, potentially oversized and the catalyst may be very active. In order to maintain the inlet temperature of the splitter close to the normal operating conditions, a bypass of the SHU Feed / Effluent Exchanger, 803-E-02, hot side is provided to limit high fluctuations at the splitter inlet and avoid an overload of the splitter bottom section.

The SHU Reactors 803-R-01 A/B are two identical single bed downflow reactors. Both reactors are designed to operate in the lead/lag position or in a single reactor configuration to enable on-line catalyst replacement. The piping arrangement and

valves allow the flexibility to take one reactor off line for isolation and catalyst change out, while the other reactor remains in operation. After catalyst change out, the isolated reactor is then put back on line in tailing position. This reactor arrangement provides the operating flexibility to ensure a continuous operation.

The fluid entering the SHU Reactors is mostly liquid. The vaporization in the reactor is kept to a minimum in order to achieve the required reactor performances.

The reactor effluent is cooled down by exchanging heat with the feed in the SHU Reactor Feed / Effluent Exchanger, 803-E-02. Then the effluent flows to the SHU Splitter, 803-C-01, under pressure control of the SHU Reactor inlet.

As the selective hydrogenation reactor is operated mainly in liquid phase, a sufficient liquid velocity shall be maintained at its inlet. Therefore, the hydrocarbon flowrate to the reactor shall be at least 75 % of the design flowrate. In case of turndown (50% of capacity), part of the HDS stabilizer bottom shall be recycled to the Feed surge drum 803-V-01, via LCN feed filters, under flow control. This recycle line is installed after cooling down by 803-E-11 A/B, 803-AC-06 and 803-E-14 in order to maintain a temperature of about 45deg. C in 803-V-01 and consequently keep the same heat recovery in the exchanger train.

**SHU : Splitter Section**

The SHU Splitter 803-C-01 has 51 trays and the feed enters the column at tray 38. The purpose of the SHU Splitter is to fractionate the selective hydrogenation reactor effluent to produce a Light Light Cracked Naphtha (LLCN), a Heart Cut and a Heavy LCN stream. The LLCN / Heart Cut cut-point is adjusted to produce LLCN with low sulfur content and minimal thiophene carry-over, while simultaneously recovering a large portion of olefins. This is possible since the heavier boiling components contain a disproportionate amount of sulfur relative to olefins. The Heart Cut / Hy. LCN cut-point is adjusted to produce a rich $C_5$-$C_6$ cut to send to Isomerization Unit after further hydrotreatment.

The SHU Splitter overhead is partially condensed in the SHU Splitter overhead air condenser 803-AC-01A/B.Then it flows to the SHU Splitter Reflux Drum, 803-V-02, where the vapor phase and liquid phase are separated. The vapor phase (excess of hydrogen and light ends in the hydrogen make-up) is further cooled in SHU Splitter Post-Condenser, 803-E-05. Liquid condensates are routed to the SHU Splitter Reflux Drum, 803-V-02 while sweet vapor phase is routed to the refinery Fuel Gas system under pressure control to maintain the Splitter overhead pressure. In case of total hydrogen consumption in SHU Reactors, hydrogen injection maintains the pressure in the Splitter.

The liquid from the SHU Splitter Reflux Drum, 803-V-02, is pumped by the SHU Splitter Reflux Pumps 803-P-02 A/B, and sent to the top of the Splitter as reflux of the column, under flow control reset by SHU Splitter Reflux Drum level control.

The LLCN product is drawn from a partial-draw off chimney tray located on tray 6 of the Splitter, on flow control reset by Splitter tray 10 temperature control. The LLCN product is cooled down in LLCN Air Cooler, 803-AC-02, pumped by LLCN Product Pumps, 803-P-03 A/B and cooled down in LLCN Cooler, 803-E-06, in order to meet the battery limit conditions. LLCN product is directly sent to Gasoline MS Pool.

The Heart Cut product is drawn from a partial-draw off chimney tray located on tray 26 of the Splitter, on flow control reset by Splitter tray 29 temperature control. The Heart Cut product is cooled down in Heart Cut Air Cooler, 803-AC-03, pumped by Heart Cut Pumps, 803-P-04 A/B and cooled down in Heart Cut Cooler, 803-E-07, in order to meet the battery limit conditions. A part of Heart Cut product is sent to NHDT Feed Surge Drum, 801-V-01, of NHDT unit (Unit 801) while the remaining part is sent to the Gasoline MS Pool.

The splitter is reboiled with desuperheated Medium High Pressure steam (MHS) in a thermosyphon reboiler, SHU Splitter Reboiler, 803-E-04. The MHS steam rate is under flow control. The SHU Splitter bottom product is cooled down in SHU Feed / Splitter bottom exchanger, 803-E-01.

The SHU splitter bottoms product is mixed with Heavy Cracked Naphtha (HCN) gasoline feed from the RFCC unit (RFCCU), and routed to HDS Feed Surge Drum, 803-V-03. Part of this SHU Splitter bottoms product can be sent to NHDT Feed Surge Drum, 801-V-01, of NHDT unit (Unit 801) after cooling down in HCN to NHDT Air Cooler, 803-AC-07, and HCN To NHDT Trim Cooler, 803-E-16.

If there is no HCN gasoline feed to process, part of the Splitter bottoms (after SHU Feed / Splitter bottom exchanger) can be cooled down through HCN to NHDT Air Cooler, 803-AC-07, to maintain the operating temperature in the HDS Feed Surge Drum, 803-V-03.

**HDS Section**

Before mixing with Splitter bottoms in the HDS Feed Surge Drum, 803-V-03, the Heavy Cracked Naphtha (HCN) gasoline feed from the RFCC unit (RFCCU) is first routed to HCN feed filters 803-G-03, in order to remove scale particles and actual gums.

The HDS Feed Surge Drum, 803-V-03, pressure is maintained by split range control of hydrogen and venting to flare. The HDS feed is pumped to the HDS reaction section by HDS Feed Pumps, 803-P-05 A/B, under flow control.

HDS liquid feed is combined with the recycled hydrogen and is preheated in the HDS Feed/Effluent Exchangers, 803-E-08 A/B/C/D/E before entering HDS Reactor, 803-R-02.

The HDS Reactor operates downflow in totally vaporized phase. The HDS reactor is divided into 2 beds: each bed contains HR-806 catalyst. The overall temperature rise in the reactor is controlled by injection of liquid quench between the first and second bed. The liquid quench is coming from HDS Separator drum, 803-V-04, via HDS Quench Pumps, 803-P-06 A/B, under flow control in cascade with the inlet temperature control of the second catalytic bed.

The HDS effluent is further heated in the HDS Heater, 803-F-01. The heater is located downstream the reactor so that the effluent entering is fully vaporized. The HDS reactor inlet temperature is controlled with the heater outlet temperature by the duty of the fired heater via fuel gas regulation control.

The effluent from the HDS heater is then cooled by the HDS Feed / Effluent Exchangers 803-E-08 A/B/C/D/E and HDS Effluent Air Condenser, 803-AC-04, and flows to the HDS Separator drum, 803-V-04, in which two phases are separated.

The reactor effluent is water washed to dissolve any precipitation of ammonium salts prior to cooling in the HDS Effluent Air Condenser. Salt formation, especially ammonium chloride ($NH_4Cl$) and ammonium bisulfide ($NH_4HS$) in a lesser extent may precipitate depending on the partial pressures of $H_2S$, $NH_3$ and Cl in the vapor phase. Wash water is coming from condensates from NHDT unit 801-P-08 pump and is injected intermittently, when required, upstream the HDS Effluent Condensers. A water phase containing $H_2S$ plus some $NH_3$, is removed and sent to the Sour Water Stripper Unit under interface level control.

The liquid hydrocarbon phase is routed to the Stabilizer section, under flow control reset by HDS Separator Drum level control, and the remaining part to the HDS Quench Pumps, 803-P-06 A/B.

The vapor hydrocarbon phase is cooled down in Amine Absorber Feed Cooler, 803-E-09, and flows to the Amine Absorber KO Drum, 803-V-05, to remove any entrained liquid droplets responsible of foaming in the amine absorber. Then the vapor phase flows to the Amine Absorber, 803-C-02, where $H_2S$ is substantially removed from the gas.

# 2.5 DHDT

## 2.5.1 INTRODUCTION

Diesel Hydrotreater (DHDT) is installed to improve the diesel quality with respect to Cetane No. & other specification.

The design feed is a blend containing Straight run Gasoil from low sulphur imported crude (SRGO-LS), Straight run Gasoil from high sulphur imported crude from middle east (SRGO-HS), Total Cycle Oil from FCCU (TCO), Light Coker Gasoil from Coker unit (LCGO) with below mentioned properties.

**UNIT CAPACITY**

1) Design Capacity : 2.2 MMTPA
2) Stream Factor : 8,000 hours per year
3) Turndown : 40% of design capacity

## 2.5.2 BASIS OF DESIGN & CHEMICAL REACTIONS

**Feedstock properties**

Depending on the case, the feed is a blend of different gasoil streams with the following properties:

| | LS GO | HS GO | LS LVGO | HS LVGO | CK | CGO | HCN | LCO |
|---|---|---|---|---|---|---|---|---|
| Density@15$^0$C | 0.8640 | 0.8544 | 0.8862 | 0.875 | 0.8436 | 0.9050 | 0.8293 | 0.9519 |
| Total Sulphur, wt% | 0.15 | 2.2 | 0.21 | 3.0 | 2.31 | 3.84 | 0.53 | 2.5 |
| Total Nitrogen, ppmw | 70 | 60 | 500 | 400 | 700 | 1550 | 400 | 1500 |
| Bromine Number | 2 | 2 | 2 | 2 | 25 | 50 | 40 | 25 |
| Flash Point, $^0$C | 75 | 80 | 114 | 112 | 35 | 85 | 37 | 80 |
| Pour Point, $^0$C | Specific | 3 | 9 | -3 | 12 | 15 | 0 | 0 |
| Viscosity@40 $^0$C, cSt | 4.5 | 4.0 | 7.0 | 6.5 | 30. | 7.0 | - | 6.0 |
| Cetane Number | 44 | 50 | 42 | 46 | 36 | 38 | 18 | 20 |
| Metals | | | | | | | | |
| Ni + V, ppmw | 0.04 | 0.2 | 0.2 | 0.2 | 0.1 | 0.07 | 2.0 | 4.0 |
| Fe, ppmw | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Chliride, ppmw | 0.3 | 0.3 | 0.5 | 0.5 | 10 | 12 | - | 10 |
| Silicon, ppmw | - | - | - | - | 3.0 | 3.0 | - | 0 |
| Distillation Temp,% | D-86 | D-86 | D-1160 | D-1160 | D-86 | D-86 | D-86 | D-86 |
| IBP | 192 | 190 | 242 | 225 | 140 | 181 | 130 | 173 |
| 5% | 235 | 230 | 268 | 252 | 164 | 193 | 139 | 202 |
| 10% | 252 | 249 | 274 | 265 | 173 | 220 | 142 | 214 |
| 30% | 276 | 272 | 295 | 287 | 202 | 250 | 149 | 247 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 50% | 292 | 296 | 312 | 302 | 226 | 275 | 157 | 275 |
| 70% | 315 | 318 | 340 | 330 | 252 | 315 | 171 | 307 |
| 90% | 362 | 364 | 380 | 360 | 279 | 340 | 192 | 354 |
| 95% | 375 | 370 | 400 | 375 | 290 | 365 | 202 | 367 |
| EBP | 395 | 390 | 420 | 395 | 316 | 380 | 213 | 372 |

**Each feed throughput is as follows**:

| | **Feed 1** | **Feed 2** | **Feed 3** |
|---|---|---|---|
| Feed Rate, kg/hr | 275000 | 275000 | 275000 |
| LS GO, wt% | 56.0 | 45.0 | 36.5 |
| HS GO, wt% | 5.0 | 8.0 | 21.0 |
| LS LVGO, wt% | 5.0 | 5.0 | 0 |
| HS LVGO, wt% | 1.0 | 2.0 | 5.5 |
| CK, wt% | 6.0 (1) | 6.0 (1) | 9.0 |
| CGO, wt% | 3.5 (1) | 4.0 (1) | 4.5 |
| HCN, wt% | 9.0 (1) | 10.0 (1) | 10.5 |
| LCO, wt% | 14.5 (1) | 20.0 (1) | 13.0 |
| Total Cracked Components, wt% | 33.0 | 40.0 | 37.0 |

(1) Sulphur content of 0.32%, 0.42%, 0.14% and 1.19% wt% respectively in CK, CGO, HCN and LCO considered for Feed 1 and Feed 2.

**The specified properties of the feed stocks are as follows:**

| | **Feed 1** | **Feed 2** | **Feed 3** |
|---|---|---|---|
| Specific Gravity | 0.871 | 0.876 | 0.869 |
| Sulphur, wt% | 0.454 | 0.602 | 1.443 |
| Nitrogen, wtppm | 421 | 513 | 430 |
| Bromine Number, g/100g | 11.8 | 13.7 | 13.2 |
| Mono aromatics content, wt% | 19.0 | 20.0 | 18.0 |
| Di aromatics content, wt% | 12.8 | 13.7 | 10.3 |
| Tri aromatics content, wt% | 3.0 | 3.4 | 3.2 |
| ASTM D86 Distillation Temperatures | | | |
| IBP, | 130 | 130 | 130 |
| 10%, | 197 | 193 | 190 |
| 30% | 252 | 249 | 246 |
| 50% | 280 | 278 | 276 |
| 70% | 307 | 306 | 305 |
| 90% | 355 | 354 | 353 |
| EBP | 402 | 402 | 400 |

**The product specifications required to be met are as follows:**

| | |
|---|---|
| Unit Feed rate, kg/hr | 275000 |
| Total pressure drop across catalyst beds in three reactors, $kg/cm^2$ | 8.5 max |

| | |
|---|---|
| Product Diesel total Sulphur max, ppm | 40 |
| Product Diesel Density @ $15^0$C, kg/$m^3$ | 0.840 max |
| Product Diesel Cetane Number | 51.5 |
| Product Diesel 95 vol% distillation ( D86 ), $^0$C | 360 |
| Diesel yield at $40^0$C Flash Point, wt% | 92.0 |

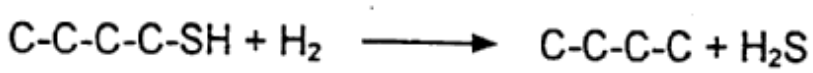
## HYDROTREATING CHEMISTRY WITH REACTIONS

The following chemical steps and/or reactions occur during the hydro treating process:

**Sulfur Removal**

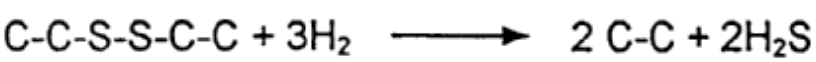
Typical feed stocks to the Union fining unit will contain simple mercaptans, sulfides and disulfides. These compounds are easily converted to H2S. However, feed stocks containing heteroatomic aromatic molecules are more difficult to process. Desulfurization of these compounds proceeds by initial ring opening and sulfur removal followed by saturation of the resulting olefin. Thiophene is considered 15 times more difficult to process compared to diethyl sulfide.

a. Mercaptan

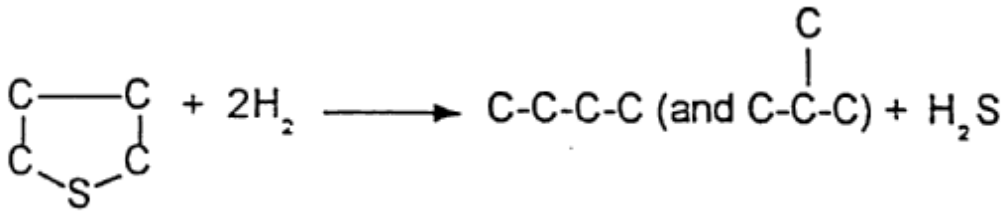



b. Sulfide

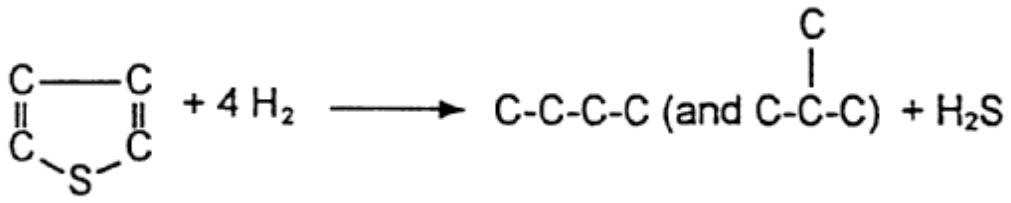
c. Disulfide




d. Cyclic Sulfide



e. Thiophenic

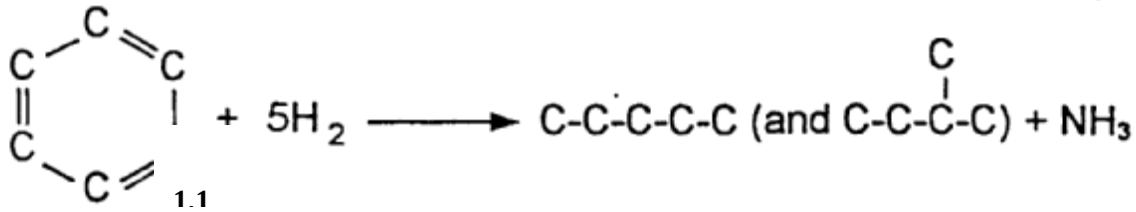



**Nitrogen Removal**

Denitrogenation is generally more difficult than desulfurization. Side reactions may yield nitrogen compounds more difficult to hydrogenate than the original reactant. Saturation of heterocyclic nitrogen-containing rings are also hindered by large attached groups.

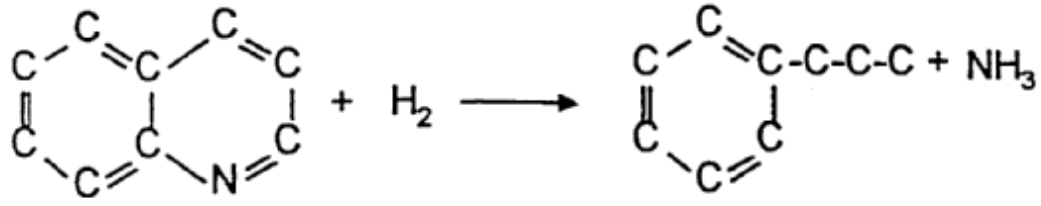
The reaction mechanism steps are different compared to desulfurization. The denitrogenation of pyridine proceeds by aromatic ring saturation, ring hydrogenolysis, and finally denitrogenation.

a. Pyridine

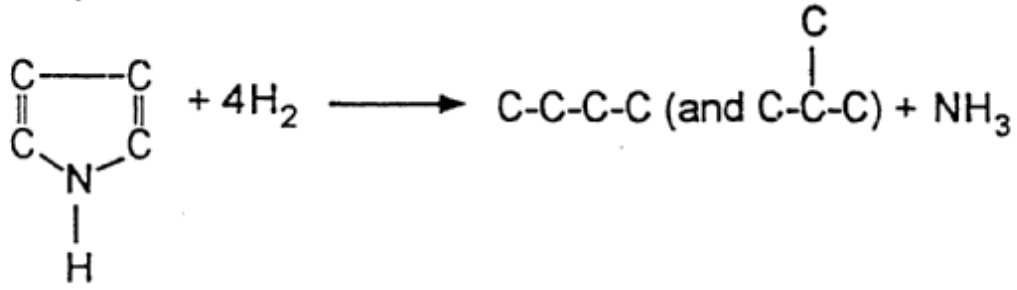



1.1

b. Quinoline



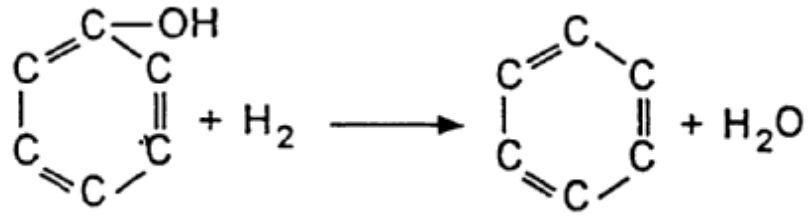

c. Pyrrole




**Oxygen Removal**

Organically combined oxygen is removed by hydrogenation of the carbon-hydroxyl bond forming water and the corresponding hydrocarbon.

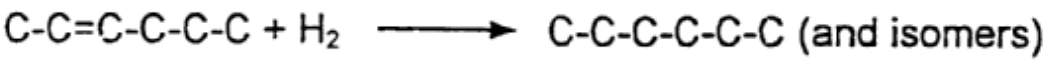
a. Phenols



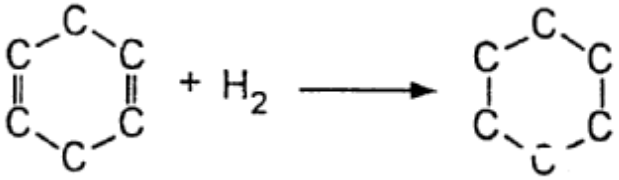

**Olefin Saturation**

Olefin saturation reactions proceed very rapidly and have a high heat of reaction.

a. Linear Olefin

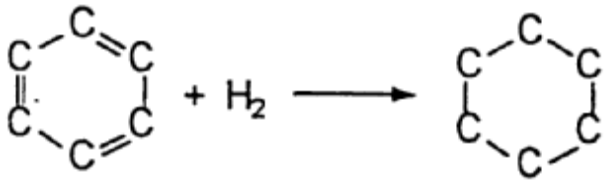



b. Cyclic Olefin



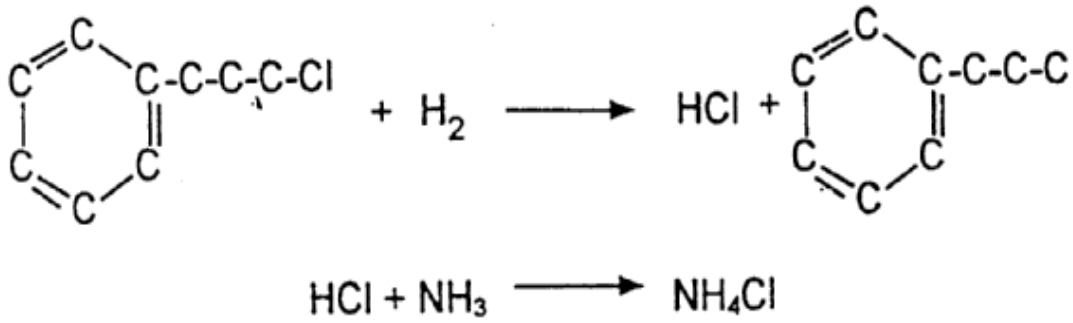

**Aromatic Saturation**

Aromatic saturation reactions are the most difficult. The reactions are influenced by process conditions and are often equilibrium limited. Unit design parameters would consider the desired degree of saturation for each specific unit. The saturation reaction is very exothermic.




**Halides Removal**

Organic halides, such as chlorides and bromides, are decomposed in the reactor. The inorganic ammonium halide salts which are produced when the reactants are cooled are then dissolved by injecting water into the reactor effluent or leave with the stripper off-gas. Decomposition of organic halides is considered difficult with a maximum removal of ~90%.



**Reaction Rates**

The approximate relative heats of reaction per unit of hydrogen consumption for these reactions are:

| | |
|---|---|
| Desulfurization | 1 |
| Olefin Saturation | 2 |
| Denitrification | 1 |
| Aromatics Saturation | 1 |

All of the reactions discussed above are exothermic and result in a temperature rise across the reactor. Olefin saturation and some desulfurization reactions have similarly rapid reaction rates, but it is the saturation of olefin which generates the greatest amount of heat. The temperature rise expected for a given charge stock along with the desired product quality will play a very important role in determining the number, size, and arrangement of the reactors, heat exchange, and hydrogen circulation rate.

## 2.5.3 PROCESS DESCRIPTION

The exact arrangement of lines, vessels, etc. may vary from unit to unit, but basically all units will consist of a reaction section and a fractionation section. These two sections are described below in general terms.

**REACTION SECTION**

**Fresh Feed System**

The feed to the unit can be either cold (40 deg C) and hot (100 deg C). Feed obtained from offsite storage tanks at 40 deg C is pumped into a Feed coalescer for the removal of potential free water. The feed is further heated to 100 deg C in a preheater exchanger. Hot feed is sent from offsite and pumped by Hot feed pumps. The combined feed is sent through a Feed Filter for removal of suspended solids to the feed surge drum which is blanked with nitrogen to

prevent gum formation resulting in possible equipment fouling.

The feed pumps take suction from the feed surge drum and pumps the raw oil to reactor loops and the feed is preheated via process exchangers with reactor effluent.

The feed pumps are high head machines capable of pumping large volumes of oil at pressures of over 120 kg/cm$^2$. The manufacturer's instructions must be consulted before operating the charge pumps since special care must be taken to avoid damage due to low flow, high temperatures, vibration, etc. Proper lubrication and cooling must be assured at all times both for the pump and its driver if serious damage is to be avoided. This type of pump should never be operated against a blocked discharge, nor at flow rates below the minimum recommended by the manufacturer. A spillback to the surge drum may be added to maintain minimum flow at reduce throughput.

**Feed Heat Exchange**

In a more commonly used heat recovery scheme, the reactor charge is preheated by the reactor effluent in a series of feed-effluent exchangers before entering the reactor charge heater This attempts to recover as much heat as possible from the heat of reaction. Liquid feed is preheated separately with reactor-effluent exchanges before combining with the recycle gas which is also preheated with reactor-effluent exchanges. The combined feed stream enters a mixed phase heater to reach the desired reactor inlet temperature (340-370℃). A fresh feed bypass around one or more exchangers is used to provide better control of the charge heater outlet temperature.

Austenitic stainless steel materials are normally used in the hottest heat exchangers. These materials provide the best resistance to the corrosive atmosphere and severe operating conditions. However, they are subject to stress corrosion when exposed to air and moisture. This type of corrosion can be avoided by neutralizing the sulfide scale on the tube walls and by avoiding the condensation of moisture in the tubes.

**Makeup Hydrogen System**

Make-up $H_2$ is obtained from Hydrogen unit at a pressure of 19.5 kg/cm$^2$g. Since the reactor section pressure is 90-95 kg/cm$^2$g, the make-up gas must be compressed before it can join the system. The compression system consists of two identical makeup compressors. Reciprocating compressors are used to raise the pressure of the gas, with two stages of compression varying in accordance with the difference between the supply and reaction section pressures. From the discharge of the last stage of compression, the makeup gas joins the recycle gas just before Effluent condenser. The point of entry into the reactor circuit depends on whether or not a stage of compression can be saved by entering the circuit at a lower pressure location.

On multi-stage compressors the gas from the first stage must be cooled to about 45 deg C before it can enter the second stage. The spillback gases, used to control the inter-stage suction from and make up suction drum pressures also need to be cooled in First stage discharge cooler and First stage discharge trim cooler before being returned to the first suction drum.

Reciprocating compressors are driven by electric motors. The manufacturer's

instructions for the startup, shutdown and care of these units must be studied and well understood. In general, close attention must be paid to the compression ratio across each cylinder as well as the suction and discharge temperatures. Excessive compression ratios must be avoided since they will lead to high cylinder discharge temperatures, rapid wear, low compressor efficiency, and a possible overloading of the drive.

The cylinder discharge temperatures give a very good indication of the performance of the machine and should be recorded on a regular basis. Higher than normal temperatures show that cylinder or inter stage cooling may be inadequate, or that the compressor valves are faulty. In such cases, quick remedial action must be taken in order to avoid overheating and damaging the cylinders. It must be remembered that higher than design compression ratio and high molecular weight gases (as indicated by a reduction in $H_2$ purity) will increase the load on the driver.

The flow of makeup gas through the compressor and into the unit is controlled by a complex system of pressure controllers on the high pressure separator and the first stage suction drum. The basic philosophy of the control scheme is to control the flow of gas as the demand for hydrogen dictates (as determined by the pressure in the high pressure separator). As hydrogen is consumed in the reactors, the pressure in the high pressure separator will start to decrease. This will in turn call for more makeup gas by closing the control valve in the spillback line from the final stage discharge to suction.

In the event that the unit is calling for more makeup gas than is available (hydrogen consumption is too high), the pressure control system essentially works in reverse. The first stage suction drum pressure will start falling because there is not sufficient gas available from the hydrogen plant to replace what is being pumped out of the suction drum. When this happens, the pressure controller on the first stage suction drum senses the decrease in pressure and, in order to protect the first stage of the compressor from excessive compression ratio, forces the first stage spillback valve to open. This spill backs more gas back to the first stage suction drum to build the pressure back up. The high pressure separator pressure will start decreasing. At this point the operator will recognize that hydrogen consumption is exceeding supply and must be reduced either by decreasing reactor temperatures or feed rate or both. Alternatively, the hydrogen supply may be increased.

It is very important for operating personnel to become familiar with the mode of control used so that pressure beyond the capability of the equipment may be avoided. The maximum allowable compressor temperatures and compression ratios should be obtained from the manufacturer and posted in the control room or near the compressors.

**Recycle Hydrogen System**

After separation of the gas and liquid phases in the high pressure separator, the gas leaves from the top of the high pressure separator and flows to the suction of the recycle gas compressor via Recycle gas K.O drum. The recycle gas will be sent to an amine scrubber to remove H2S in the future.

Non-condensable gases are removed from the condensate receiver by means of steam jet ejectors. The condensate is removed from the receiver and pumped to the refinery condensate header or H2 Plant in OSBL. Note that condensate should never be allowed to enter the turbine since it would seriously damage the rotor and other internals. Whenever the

compressor is out of service the turbine casing drains should be kept open and sufficient steam flow should be maintained to keep the turbine warm.

Lube oil circulation should also be maintained when the compressor is down, and only shut off when required for maintenance.

After the recycle compressor discharge, some recycle gas will be split off the main stream for use as quench gas between catalyst beds in the reactor. Separate quench gas streams are used to reduce reactor inter bed temperatures before each catalyst bed. Quench flow is regulated by a flow controller cascaded from a temperature controller at the top of the catalyst bed below the quench zone.

The makeup gas joins the recycle gas before the recycle gas compressor in order for a makeup stage of compression to be saved. The combined makeup and recycle gas is divided into passes which are normally allow controlled into the combined feed passes going to the combined feed exchanger. The object is to maintain equal gas flow to each reactor charge heater pass at a sufficiently high rate to avoid overheating the tubes. From this point until it returns to the high pressure separator, the gas flows along with the liquid through the reactor circuit in the same manner previously described.

**Reactor**

Once the feed and recycle gas have been heated to the desired temperature, the reactants enter the top of the reactor. As the reactants flow downward through the catalyst bed, various exothermic chemical reactions occur and the temperature increases. Each bed will contain a 3 element radial thermocouple assembly at the top and at periodic levels down through the bed dependent upon bed length.

Multiple catalyst beds are provided depending upon the heat of reaction and unit capacity. Reactor skin thermocouples will be provided at the bottom of each bed and on the bottom reactor head, for monitoring the reactor wall temperature.

Specific reactor designs will depend upon several variables. Reactor diameter is typically set by the cross-sectional liquid flux. As the unit capacity increases, the reactor diameter increases to the point where two parallel trains would be considered. Reactor height is a function of the amount of catalyst and number of beds required. Other local factors may also influence the reactor design including seismic activity and weight limitations. Crane, bridges and road capacities are also factors.

The reactors are typically divided into individual catalyst beds supported on a beam and grid support system. The support system is separated from the next bed of catalyst by a quench gas distributor, reactant mixing internals and a vapor/liquid re-distributor tray. The reasons for separating a reactor into separate beds are the following:

a. If the gas and liquid flows become poorly distributed part way through the reactor, the catalyst will not be effectively utilized, by separating a reactor into multiple beds with redistribution trays in between, the reactants existing one bed are redistributed evenly across the cross-sectional area of the next catalyst bed. In this way, should there be a problem with distribution in a bed; the catalyst in the lower beds will still be effectively utilized.

b. If the radial temperature profile becomes skewed part way through a reactor, the reaction rates will be different in different parts of the catalyst bed. This overworks the part of the catalyst that is hotter and under-utilizes the part of the catalyst bed that is cooler. It is also potentially hazardous if the hotter portion becomes significantly higher than the bulk temperature and forms a hot spot, especially if the hot spot is next to the reactor wall. Mixing of the reactants reestablishes thermal equilibrium and thus, after every quench zone, assures that all the catalyst is efficiently utilized.
c. In certain situations the heat of reaction will be large enough that the temperature increase across a reactor will be greater than the design. If this were allowed to happen, a reaction could become unstable and result in a temperature runaway. Therefore, cold recycle gas about 40-65deg C is brought into the reactor at the inter bed quench points in order to cool the reactants and thus control the reaction rate.

Good distribution of reactants at the reactor inlet and at the top of each subsequent catalyst bed is essential for optimum catalyst performance. UOP's proprietary reactor internals are used to accomplish this distribution.

**FRACTIONATION SECTION**

The function of the fractionation section is to separate sour gas and naphtha from the diesel product. This can be accomplished with a column fractionation scheme. The hydrocarbon liquid collected in the Flash drum is sent to a stripper column on level control. The feed is preheated by reactor effluent. Stripping steam (MP steam) is used under flow control to re boil the stripper. Steam added to the bottom of the tower helps strip light ends from the bottoms.

Light ends and $H_2S$ gather at the top of the stripper and are partially condensed in stripper overhead condenser and Stripper overhead trim cooler. Corrosion inhibitor is injected into the stripper overhead line ahead of the overhead condenser. Three phases are separated in the stripper overhead drum. Sour water is combined with the sour water from the Flash drum and sent to waste water stripping unit at battery limit.

The liquid hydrocarbon are pumped through the stripper reflux pumps and split into three streams. First one is reflux which is returned to top of the stripper under level control and second is other reflux routed to the $7^{th}$ tray of the stripper under the flow control after being heated by the diesel product – hot naphtha recycle exchanger . And third stream is liquid distillate (un stabilized naphtha) which is routed to Naphtha stabilizer commissioned in August 2010 under DHDT revamp (Earlier it was sent to FCCU).

Vapor stream is sent to the absorber knockout drum. This stream is mixed with gas from the Flash drum and gas from naphtha stabilizer & MSQ (Under DHDT revamp in 2010) before it enters Absorber knockout drum. The gas from absorber knockout drum is routed to the bottom of the LP absorber. Lean amine is fed directly from battery limit into the absorber under flow control. After washing the $H_2S$ in the hydrocarbon gas the amine gets collected in the bottom of the absorber. Rich amine is sent under level control to the amine treating unit at battery limit. The overhead gases from the absorber are routed to the Stripper gas amine knockout drum to remove the traces of amine in the carryover. The sweet gas is routed to fuel gas header under the pressure control of the stripper receiver.

The stripper bottom product exchanges against the returned naphtha reflux to $7^{th}$ tray of the

stripper and undergoes further cooling in the feed preheat exchanger, the diesel product cooler and the diesel product trim exchanger. Water is removed from the diesel product in the diesel product coalescer and the diesel product is sent under flow control to the storage tank at battery limit.

**Flag-4**

# Baseline Data for air, water and soil for last one year.

## One Year Baseline Data for Air

| IOCL - BARAUNI REFINERY | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMBIENT AIR QUALITY MONITORING RESULTS (MONTHLY AVG. VALUES) | | | | | | | | | | | | | | | |
| LOCATION: BTP | | | | | | | | | | | | | | | |
| **Month** | **RPM(<10)** | **RPM <2.5** | **$SO_2$** | **$NO_2$** | **$NH_3$** | **Pb** | **CO (1 hour)** | **CO (8 hours)** | **Ozone (1 hour)** | **Ozone (8 hours)** | **HC** | **Benzene** | **Benzo(a) pyrene** | **Arsenic** | **Nickel** |
| **Unit** | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($mg/m^3$) | ($mg/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | (ppm) | ($\mu g/m^3$) | ($ng/m^3$) | ($ng/m^3$) | ($ng/m^3$) |
| **Limits** | 100 (24 Hr) 60 (Ann) | 60 (24 Hr) 40 (Ann) | 80 (24 Hr) 50 (Ann) | 80 (24 Hr) 40 (Ann) | 400 (24 Hr) 100 (Ann) | 1.0 (24 Hr) 0.5 (Ann) | 4.0 | 2.0 | 180 | 100 | NA | 05 (Ann) | 01 (Ann) | 06 (Ann) | 20 (Ann) |
| **Apr-14** | 74.38 | 26.13 | 9.50 | 21.88 | 15.63 | 0.31 | 0.95 | 0.93 | 30.38 | 30.08 | 0.8 | 4.1 | BDL | BDL | BDL |
| **May-14** | 73.00 | 27.75 | 9.88 | 22.00 | 15.38 | 0.30 | 1.00 | 0.92 | 30.38 | 30.00 | 0.79 | 3.89 | BDL | BDL | BDL |
| **Jun-14** | 73.13 | 30.75 | 10.13 | 22.00 | 15.25 | 0.29 | 0.91 | 0.93 | 29.75 | 30.04 | 0.88 | 4.19 | BDL | BDL | BDL |
| **Jul-14** | 71.22 | 28.67 | 9.67 | 20.22 | 14.67 | 0.28 | 0.99 | 0.98 | 30.89 | 30.22 | 0.93 | 3.79 | BDL | BDL | BDL |
| **Aug-14** | 71.14 | 24.14 | 9.86 | 18.86 | 15.29 | 0.31 | 0.91 | 0.90 | 30.57 | 30.29 | 0.87 | 4.24 | BDL | BDL | BDL |
| **Sep-14** | 69.00 | 23.50 | 9.25 | 18.25 | 14.00 | 0.29 | 0.88 | 0.90 | 30.13 | 29.71 | 0.8 | 4.3 | BDL | BDL | BDL |
| **Oct-14** | 71.88 | 25.75 | 10.00 | 18.75 | 14.25 | 0.29 | 0.93 | 0.93 | 30.25 | 30.13 | 0.7 | 4.1 | BDL | BDL | BDL |
| **Nov-14** | 74.75 | 28.25 | 9.88 | 18.50 | 15.38 | 0.30 | 0.96 | 0.91 | 29.75 | 29.17 | 0.7 | 4.0 | BDL | BDL | BDL |
| **Dec-14** | 75.33 | 30.00 | 9.11 | 19.33 | 15.11 | 0.29 | 0.96 | 0.89 | 29.67 | 29.81 | 0.7 | 4.2 | BDL | BDL | BDL |
| **Jan-15** | 76.89 | 32.11 | 8.78 | 19.67 | 15.56 | 0.29 | 0.92 | 0.87 | 30.44 | 29.96 | 0.76 | 3.73 | BDL | BDL | BDL |
| **Feb-15** | 78.50 | 30.38 | 8.88 | 19.00 | 15.63 | 0.30 | 0.86 | 0.85 | 29.38 | 29.04 | 0.80 | 4.15 | BDL | BDL | BDL |
| **Mar-15** | 76.00 | 30.13 | 9.00 | 19.13 | 15.75 | 0.30 | 0.94 | 0.93 | 30.00 | 29.54 | 0.83 | 4.03 | BDL | BDL | BDL |

## IOCL - BARAUNI REFINERY

## AMBIENT AIR QUALITY MONITORING RESULTS (MONTHLY AVG. VALUES)

## LOCATION: BR REFINERY TOWNSHIP (ESTATE OFFICE)

| Month | RPM(<10) | RPM <2.5 | $SO_2$ | $NO_2$ | $NH_3$ | Pb | CO (1 hour) | CO (8 hours) | Ozone (1 hour) | Ozone (8 hours) | HC | Benzene | Benzo(a) pyrene | Arsenic | Nickel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($mg/m^3$) | ($mg/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | (ppm) | ($\mu g/m^3$) | ($ng/m^3$) | ($ng/m^3$) | ($ng/m^3$) |
| **Limits** | 100 (24 Hr) 60 (Ann) | 60 (24 Hr) 40 (Ann) | 80 (24 Hr) 50 (Ann) | 80 (24 Hr) 40 (Ann) | 400 (24 Hr) 100 (Ann) | 1.0 (24 Hr) 0.5 (Ann) | 4.0 | 2.0 | 180 | 100 | NA | 05 (Ann) | 01 (Ann) | 06 (Ann) | 20 (Ann) |
| **Apr-14** | 62.86 | 22.29 | 4.86 | 14.71 | 12.43 | 0.05 | 0.57 | 0.54 | 14.00 | 14.00 | 0.26 | 0.47 | BDL | BDL | BDL |
| **May-14** | 61.00 | 21.44 | 4.78 | 14.44 | 11.89 | 0.05 | 0.57 | 0.53 | 13.67 | 14.19 | 0.24 | 0.42 | BDL | BDL | BDL |
| **Jun-14** | 63.00 | 24.11 | 4.89 | 14.78 | 13.00 | 0.05 | 0.51 | 0.50 | 13.89 | 13.96 | 0.23 | 0.41 | BDL | BDL | BDL |
| **Jul-14** | 58.63 | 22.00 | 5.13 | 12.50 | 11.38 | 0.04 | 0.48 | 0.45 | 13.75 | 13.50 | 0.23 | 0.46 | BDL | BDL | BDL |
| **Aug-14** | 57.63 | 21.38 | 4.88 | 16.00 | 12.25 | 0.05 | 0.49 | 0.49 | 12.88 | 13.13 | 0.21 | 0.40 | BDL | BDL | BDL |
| **Sep-14** | 56.11 | 19.33 | 4.78 | 16.44 | 12.11 | 0.05 | 0.49 | 0.46 | 12.78 | 12.59 | 0.20 | 0.39 | BDL | BDL | BDL |
| **Oct-14** | 60.43 | 20.86 | 5.29 | 16.00 | 12.71 | 0.05 | 0.47 | 0.50 | 14.14 | 13.62 | 0.21 | 0.37 | BDL | BDL | BDL |
| **Nov-14** | 64.78 | 23.89 | 5.00 | 15.00 | 12.56 | 0.05 | 0.43 | 0.46 | 14.89 | 13.15 | 0.17 | 0.34 | BDL | BDL | BDL |
| **Dec-14** | 63.13 | 22.38 | 4.88 | 15.50 | 12.38 | 0.04 | 0.40 | 0.45 | 14.63 | 13.88 | 0.16 | 0.31 | BDL | BDL | BDL |
| **Jan-15** | 67.13 | 24.25 | 4.88 | 16.38 | 12.25 | 0.05 | 0.49 | 0.45 | 15.00 | 14.29 | 0.15 | 0.33 | BDL | BDL | BDL |
| **Feb-15** | 65.88 | 23.00 | 4.63 | 15.38 | 12.13 | 0.05 | 0.46 | 0.47 | 14.75 | 14.88 | 0.14 | 0.43 | BDL | BDL | BDL |
| **Mar-15** | 64.63 | 22.50 | 4.38 | 14.63 | 11.63 | 0.05 | 0.44 | 0.45 | 14.13 | 14.58 | 0.13 | 0.40 | BDL | BDL | BDL |

# One Year Baseline Data for Water

| GROUND WATER QUALITY MONITORING RESULTS AROUND BR | | | | | | |
|---|---|---|---|---|---|---|
| Well at Govindpur (0.5 km East of BR) | | | | | | |
| **SN** | **Parameter** | **Unit** | **Jun-14** | **Sep-14** | **Dec-14** | **Mar-15** |
| 1 | Temperature | $^{o}$C | 31.5 | 31.9 | 24.6 | 26.2 |
| 2 | pH | | 7.69 | 7.84 | 7.69 | 7.56 |
| 3 | Turbidity | NTU | < 2 | < 2 | < 2 | < 2 |
| 4 | Conductivity | µmhos/cm | 872 | 859 | 819 | 786 |
| 5 | Total Hardness | mg/L | 343 | 356 | 362 | 372 |
| 6 | Ca Haednrss as CaCO3 | mg/L | 172 | 157 | 159 | 162 |
| 7 | Magnesium Hardness as CaCO3 | mg/L | 42 | 48 | 39 | 51 |
| 8 | M-Alkalinity as CaCO3 | mg/L | 377 | 342 | 347 | 362 |
| 9 | BOD | mg/L | BDL | BDL | BDL | BDL |
| 10 | COD | mg/L | BDL | BDL | BDL | BDL |
| 11 | Ammoniacle N | mg/L | BDL | BDL | BDL | BDL |
| 12 | Kejaldhal N | mg/L | BDL | BDL | BDL | BDL |
| 13 | Sulphides as (S) | mg/L | BDL | BDL | BDL | BDL |
| 14 | Sodium as Na | mg/L | 41 | 49 | 43 | 43 |
| 15 | Potasium as K | mg/L | 10.1 | 10.7 | 10.2 | 13.6 |
| 16 | Total Dissolved Solids | mg/L | 516 | 504 | 498 | 473 |
| 17 | Total Suspended Solids | mg/L | 4 | 6 | 5 | 6 |
| 18 | Total Sulphides | mg/L | BDL | BDL | BDL | BDL |
| 19 | Oil and Grease | mg/L | BDL | BDL | BDL | BDL |
| 20 | Dissolved Oxygen | mg/L | 7.6 | 7.9 | 7.4 | 7.6 |
| 21 | Chloride | mg/L | 93 | 82 | 76 | 88 |
| 22 | Nitrate | mg/L | 9.6 | 8.8 | 8.3 | 8.2 |
| 23 | Sulphate as SO4 | mg/L | 36 | 41 | 44 | 36 |
| 24 | Total Silica as SiO2 | mg/L | BDL | BDL | BDL | BDL |
| 25 | Phosphate as PO4 | mg/L | BDL | BDL | BDL | BDL |
| 26 | Fluoride | mg/L | 0.62 | 0.67 | 0.58 | 0.63 |
| 27 | Iron | mg/L | 0.52 | 0.59 | 0.39 | 0.51 |
| 28 | Lead | mg/L | BDL | BDL | BDL | BDL |
| 29 | Phenol | mg/L | BDL | BDL | BDL | BDL |
| 30 | Nickel | mg/L | BDL | BDL | BDL | BDL |
| 31 | Arsenic | mg/L | BDL | BDL | BDL | BDL |
| 32 | Zinc | mg/L | 0.29 | 0.32 | 0.31 | 0.32 |
| 33 | Mercury | mg/L | BDL | BDL | BDL | BDL |
| 34 | Cadmium | mg/L | BDL | BDL | BDL | BDL |
| 35 | Selenium | mg/L | BDL | BDL | BDL | BDL |
| 36 | Cynide | mg/L | BDL | BDL | BDL | BDL |
| 37 | Chromium (Hexavalent) | mg/L | BDL | BDL | BDL | BDL |

| | | | | | | |
|---|---|---|---|---|---|---|
| 38 | Chromium (Total) | mg/L | BDL | BDL | BDL | BDL |
| 39 | Copper as Cu | mg/L | BDL | BDL | BDL | BDL |
| 40 | Vanadium as V | mg/L | BDL | BDL | BDL | BDL |
| 41 | Phosphorous | mg/L | BDL | BDL | BDL | BDL |
| 42 | Benzene | mg/L | BDL | BDL | BDL | BDL |
| 43 | Benzo (a) pyrene | mg/L | BDL | BDL | BDL | BDL |

| **Hand Pump at Kesabe (1.5 km South East of BR)** | | | | | | |
|---|---|---|---|---|---|---|
| **SN** | **Parameter** | **Unit** | **Jun-14** | **Sep-14** | **Dec-14** | **Mar-15** |
| 1 | Temperature | $^{o}$C | 31.5 | 32.0 | 25.4 | 25.8 |
| 2 | pH | | 7.61 | 7.73 | 7.83 | 7.82 |
| 3 | Turbidity | NTU | < 2 | < 2 | < 2 | < 2 |
| 4 | Conductivity | µmhos/cm | 671 | 685 | 652 | 768 |
| 5 | Total Hardness | mg/L | 314 | 342 | 327 | 368 |
| 6 | Ca Haednrss as CaCO3 | mg/L | 141 | 169 | 172 | 174 |
| 7 | Magnesium Hardness as CaCO3 | mg/L | 42 | 42 | 45 | 47 |
| 8 | M-Alkalinity as CaCO3 | mg/L | 251 | 272 | 265 | 283 |
| 9 | BOD | mg/L | BDL | BDL | BDL | BDL |
| 10 | COD | mg/L | BDL | BDL | BDL | BDL |
| 11 | Ammoniacle N | mg/L | BDL | BDL | BDL | BDL |
| 12 | Kejaldhal N | mg/L | BDL | BDL | BDL | BDL |
| 13 | Sulphides as (S) | mg/L | BDL | BDL | BDL | BDL |
| 14 | Sodium as Na | mg/L | 56 | 69 | 63 | 56 |
| 15 | Potasium as K | mg/L | 7.9 | 7.1 | 7.4 | 11.6 |
| 16 | Total Dissolved Solids | mg/L | 406 | 390 | 384 | 396 |
| 17 | Total Suspended Solids | mg/L | 3 | 4 | 5 | 7 |
| 18 | Total Sulphides | mg/L | BDL | BDL | BDL | BDL |
| 19 | Oil and Grease | mg/L | BDL | BDL | BDL | BDL |
| 20 | Dissolved Oxygen | mg/L | 7.2 | 7.5 | 7.3 | 6.9 |
| 21 | Chloride | mg/L | 75 | 83 | 79 | 88 |
| 22 | Nitrate | mg/L | 6.2 | 6.6 | 26 | 6.2 |
| 23 | Sulphate as SO4 | mg/L | 21 | 28 | 29 | 32 |
| 24 | Total Silica as SiO2 | mg/L | BDL | BDL | BDL | BDL |
| 25 | Phosphate as PO4 | mg/L | BDL | BDL | BDL | BDL |
| 26 | Fluoride | mg/L | 0.51 | 0.56 | 0.51 | 0.58 |
| 27 | Iron | mg/L | 0.48 | 0.52 | 0.32 | 0.51 |
| 28 | Lead | mg/L | BDL | BDL | BDL | BDL |
| 29 | Phenol | mg/L | BDL | BDL | BDL | BDL |
| 30 | Nickel | mg/L | BDL | BDL | BDL | BDL |
| 31 | Arsenic | mg/L | BDL | BDL | BDL | BDL |

| | | | | | | |
|---|---|---|---|---|---|---|
| 32 | Zinc | mg/L | 0.19 | 0.22 | 0.19 | 0.26 |
| 33 | Mercury | mg/L | BDL | BDL | BDL | BDL |
| 34 | Cadmium | mg/L | BDL | BDL | BDL | BDL |
| 35 | Selenium | mg/L | BDL | BDL | BDL | BDL |
| 36 | Cynide | mg/L | BDL | BDL | BDL | BDL |
| 37 | Chromium (Hexavalent) | mg/L | BDL | BDL | BDL | BDL |
| 38 | Chromium (Total) | mg/L | BDL | BDL | BDL | BDL |
| 39 | Copper as Cu | mg/L | BDL | BDL | BDL | BDL |
| 40 | Vanadium as V | mg/L | BDL | BDL | BDL | BDL |
| 41 | Phosphorous | mg/L | BDL | BDL | BDL | BDL |
| 42 | Benzene | mg/L | BDL | BDL | BDL | BDL |
| 43 | Benzo (a) pyrene | mg/L | BDL | BDL | BDL | BDL |

| **Hand Pump at Raichiahi (2.0 km South of BR)** | | | | | | |
|---|---|---|---|---|---|---|
| **SN** | **Parameter** | **Unit** | **Jun-14** | **Sep-14** | **Dec-14** | **Mar-15** |
| 1 | Temperature | $^{o}$C | 32.6 | 32.1 | 26.1 | 26.6 |
| 2 | pH | | 7.38 | 7.62 | 7.65 | 7.42 |
| 3 | Turbidity | NTU | < 2 | < 2 | < 2 | < 2 |
| 4 | Conductivity | µmhos/cm | 712 | 788 | 7.79 | 792 |
| 5 | Total Hardness | mg/L | 266 | 289 | 279 | 285 |
| 6 | Ca Haednrss as CaCO3 | mg/L | 119 | 126 | 121 | 163 |
| 7 | Magnesium Hardness as CaCO3 | mg/L | 36 | 40 | 38 | 30 |
| 8 | M-Alkalinity as CaCO3 | mg/L | 162 | 177 | 172 | 232 |
| 9 | BOD | mg/L | BDL | BDL | BDL | BDL |
| 10 | COD | mg/L | BDL | BDL | BDL | BDL |
| 11 | Ammoniacle N | mg/L | BDL | BDL | BDL | BDL |
| 12 | Kejaldhal N | mg/L | BDL | BDL | BDL | BDL |
| 13 | Sulphides as (S) | mg/L | BDL | BDL | BDL | BDL |
| 14 | Sodium as Na | mg/L | 51 | 59 | 56 | 74 |
| 15 | Potasium as K | mg/L | 7 | 9 | 8 | 13.2 |
| 16 | Total Dissolved Solids | mg/L | 374 | 489 | 467 | 436 |
| 17 | Total Suspended Solids | mg/L | 3 | 5 | 4 | 6 |
| 18 | Total Sulphides | mg/L | BDL | BDL | BDL | BDL |
| 19 | Oil and Grease | mg/L | BDL | BDL | BDL | BDL |
| 20 | Dissolved Oxygen | mg/L | 7.1 | 7.5 | 7.2 | 7.6 |
| 21 | Chloride | mg/L | 68 | 78 | 73 | 87 |
| 22 | Nitrate | mg/L | 6.2 | 5.6 | 5.2 | 6.2 |
| 23 | Sulphate as SO4 | mg/L | 25 | 31 | 32 | 49 |
| 24 | Total Silica as SiO2 | mg/L | BDL | BDL | BDL | BDL |
| 25 | Phosphate as PO4 | mg/L | BDL | BDL | BDL | BDL |

| | | | | | | |
|---|---|---|---|---|---|---|
| 26 | Fluoride | mg/L | 0.5 | 0.8 | 0.6 | 0.7 |
| 27 | Iron | mg/L | 0.39 | 0.43 | 0.23 | 0.63 |
| 28 | Lead | mg/L | BDL | BDL | BDL | BDL |
| 29 | Phenol | mg/L | BDL | BDL | BDL | BDL |
| 30 | Nickel | mg/L | BDL | BDL | BDL | BDL |
| 31 | Arsenic | mg/L | BDL | BDL | BDL | BDL |
| 32 | Zinc | mg/L | 0.22 | 0.29 | 0.25 | 0.37 |
| 33 | Mercury | mg/L | BDL | BDL | BDL | BDL |
| 34 | Cadmium | mg/L | BDL | BDL | BDL | BDL |
| 35 | Selenium | mg/L | BDL | BDL | BDL | BDL |
| 36 | Cynide | mg/L | BDL | BDL | BDL | BDL |
| 37 | Chromium (Hexavalent) | mg/L | BDL | BDL | BDL | BDL |
| 38 | Chromium (Total) | mg/L | BDL | BDL | BDL | BDL |
| 39 | Copper as Cu | mg/L | BDL | BDL | BDL | BDL |
| 40 | Vanadium as V | mg/L | BDL | BDL | BDL | BDL |
| 41 | Phosphorous | mg/L | BDL | BDL | BDL | BDL |
| 42 | Benzene | mg/L | BDL | BDL | BDL | BDL |
| 43 | Benzo (a) pyrene | mg/L | BDL | BDL | BDL | BDL |

| **Hand Pump at Mahna (2.0 km South West of BR)** | | | | | | |
|---|---|---|---|---|---|---|
| **SN** | **Parameter** | **Unit** | **Jun-14** | **Sep-14** | **Dec-14** | **Mar-15** |
| 1 | Temperature | $^{o}$C | 31.9 | 31.8 | 25.4 | 25.8 |
| 2 | pH | | 7.82 | 7.56 | 7.47 | 7.82 |
| 3 | Turbidity | NTU | < 2 | < 2 | < 2 | < 2 |
| 4 | Conductivity | µmhos/cm | 745 | 771 | 768 | 748 |
| 5 | Total Hardness | mg/L | 334 | 353 | 351 | 356 |
| 6 | Ca Haednrss as CaCO3 | mg/L | 162 | 185 | 181 | 168 |
| 7 | Magnesium Hardness as CaCO3 | mg/L | 42 | 41 | 38 | 46 |
| 8 | M-Alkalinity as CaCO3 | mg/L | 284 | 261 | 267 | 266 |
| 9 | BOD | mg/L | BDL | BDL | BDL | BDL |
| 10 | COD | mg/L | BDL | BDL | BDL | BDL |
| 11 | Ammoniacle N | mg/L | BDL | BDL | BDL | BDL |
| 12 | Kejaldhal N | mg/L | BDL | BDL | BDL | BDL |
| 13 | Sulphides as (S) | mg/L | BDL | BDL | BDL | BDL |
| 14 | Sodium as Na | mg/L | 36 | 41 | 39 | 62 |
| 15 | Potasium as K | mg/L | 8.8 | 8.1 | 8.3 | 8.2 |
| 16 | Total Dissolved Solids | mg/L | 444 | 478 | 471 | 442 |
| 17 | Total Suspended Solids | mg/L | < 2 | < 2 | < 2 | < 2 |
| 18 | Total Sulphides | mg/L | BDL | BDL | BDL | BDL |
| 19 | Oil and Grease | mg/L | BDL | BDL | BDL | BDL |
| 20 | Dissolved Oxygen | mg/L | 7 | 7.5 | 7.2 | 8.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 21 | Chloride | mg/L | 84 | 89 | 87 | 66 |
| 22 | Nitrate | mg/L | 6.9 | 6.2 | 5.7 | 6.4 |
| 23 | Sulphate as SO4 | mg/L | 29 | 33 | 31 | 37 |
| 24 | Total Silica as SiO2 | mg/L | BDL | BDL | BDL | BDL |
| 25 | Phosphate as PO4 | mg/L | BDL | BDL | BDL | BDL |
| 26 | Fluoride | mg/L | 0.51 | 0.55 | 0.52 | 0.57 |
| 27 | Iron | mg/L | 0.58 | 0.63 | 0.25 | 0.66 |
| 28 | Lead | mg/L | BDL | BDL | BDL | BDL |
| 29 | Phenol | mg/L | BDL | BDL | BDL | BDL |
| 30 | Nickel | mg/L | BDL | BDL | BDL | BDL |
| 31 | Arsenic | mg/L | BDL | BDL | BDL | BDL |
| 32 | Zinc | mg/L | 0.18 | 0.22 | 0.19 | 0.25 |
| 33 | Mercury | mg/L | BDL | BDL | BDL | BDL |
| 34 | Cadmium | mg/L | BDL | BDL | BDL | BDL |
| 35 | Selenium | mg/L | BDL | BDL | BDL | BDL |
| 36 | Cynide | mg/L | BDL | BDL | BDL | BDL |
| 37 | Chromium (Hexavalent) | mg/L | BDL | BDL | BDL | BDL |
| 38 | Chromium (Total) | mg/L | BDL | BDL | BDL | BDL |
| 39 | Copper as Cu | mg/L | BDL | BDL | BDL | BDL |
| 40 | Vanadium as V | mg/L | BDL | BDL | BDL | BDL |
| 41 | Phosphorous | mg/L | BDL | BDL | BDL | BDL |
| 42 | Benzene | mg/L | BDL | BDL | BDL | BDL |
| 43 | Benzo (a) pyrene | mg/L | BDL | BDL | BDL | BDL |

| **Hand Pump at Nurpur (1.0 km West of BR)** | | | | | | |
|---|---|---|---|---|---|---|
| **SN** | **Parameter** | **Unit** | **Jun-14** | **Sep-14** | **Dec-14** | **Mar-15** |
| 1 | Temperature | $^{o}$C | 33.5 | 32.5 | 25.3 | 26.1 |
| 2 | pH | | 7.43 | 7.69 | 7.91 | 7.98 |
| 3 | Turbidity | NTU | < 2 | < 2 | < 2 | < 2 |
| 4 | Conductivity | µmhos/cm | 769 | 778 | 769 | 748 |
| 5 | Total Hardness | mg/L | 361 | 342 | 339 | 372 |
| 6 | Ca Haednrss as CaCO3 | mg/L | 206 | 184 | 179 | 158 |
| 7 | Magnesium Hardness as CaCO3 | mg/L | 38 | 38 | 33 | 52 |
| 8 | M-Alkalinity as CaCO3 | mg/L | 275 | 291 | 284 | 264 |
| 9 | BOD | mg/L | BDL | BDL | BDL | BDL |
| 10 | COD | mg/L | BDL | BDL | BDL | BDL |
| 11 | Ammoniacle N | mg/L | BDL | BDL | BDL | BDL |
| 12 | Kejaldhal N | mg/L | BDL | BDL | BDL | BDL |
| 13 | Sulphides as (S) | mg/L | BDL | BDL | BDL | BDL |
| 14 | Sodium as Na | mg/L | 38 | 42 | 39 | 53 |
| 15 | Potasium as K | mg/L | 7 | 5 | 4 | 9.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 16 | Total Dissolved Solids | mg/L | 436 | 506 | 501 | 452 |
| 17 | Total Suspended Solids | mg/L | 4 | 6 | 5 | 6 |
| 18 | Total Sulphides | mg/L | BDL | BDL | BDL | BDL |
| 19 | Oil and Grease | mg/L | BDL | BDL | BDL | BDL |
| 20 | Dissolved Oxygen | mg/L | 7.3 | 7.8 | 7.2 | 8.3 |
| 21 | Chloride | mg/L | 91 | 85 | 96 | 82 |
| 22 | Nitrate | mg/L | 7.9 | 7.2 | 6.5 | 6.4 |
| 23 | Sulphate as SO4 | mg/L | 33 | 39 | 33 | 41 |
| 24 | Total Silica as SiO2 | mg/L | BDL | BDL | BDL | BDL |
| 25 | Phosphate as PO4 | mg/L | BDL | BDL | BDL | BDL |
| 26 | Fluoride | mg/L | 0.56 | 0.61 | 0.58 | 0.63 |
| 27 | Iron | mg/L | 0.49 | 0.53 | 0.28 | 0.56 |
| 28 | Lead | mg/L | BDL | BDL | BDL | BDL |
| 29 | Phenol | mg/L | BDL | BDL | BDL | BDL |
| 30 | Nickel | mg/L | BDL | BDL | BDL | BDL |
| 31 | Arsenic | mg/L | BDL | BDL | BDL | BDL |
| 32 | Zinc | mg/L | 0.21 | 0.26 | 0.21 | 0.31 |
| 33 | Mercury | mg/L | BDL | BDL | BDL | BDL |
| 34 | Cadmium | mg/L | BDL | BDL | BDL | BDL |
| 35 | Selenium | mg/L | BDL | BDL | BDL | BDL |
| 36 | Cynide | mg/L | BDL | BDL | BDL | BDL |
| 37 | Chromium (Hexavalent) | mg/L | BDL | BDL | BDL | BDL |
| 38 | Chromium (Total) | mg/L | BDL | BDL | BDL | BDL |
| 39 | Copper as Cu | mg/L | BDL | BDL | BDL | BDL |
| 40 | Vanadium as V | mg/L | BDL | BDL | BDL | BDL |
| 41 | Phosphorous | mg/L | BDL | BDL | BDL | BDL |
| 42 | Benzene | mg/L | BDL | BDL | BDL | BDL |
| 43 | Benzo (a) pyrene | mg/L | BDL | BDL | BDL | BDL |

| **Hand Pump at Papraur (2.0 km North West of BR)** | | | | | | |
|---|---|---|---|---|---|---|
| **SN** | **Parameter** | **Unit** | **Jun-14** | **Sep-14** | **Dec-14** | **Mar-15** |
| 1 | Temperature | $^{o}$C | 31.8 | 32.3 | 26.3 | 26.3 |
| 2 | pH | | 7.67 | 7.84 | 7.76 | 7.39 |
| 3 | Turbidity | NTU | < 2 | < 2 | < 2 | < 2 |
| 4 | Conductivity | µmhos/cm | 786 | 758 | 749 | 762 |
| 5 | Total Hardness | mg/L | 326 | 349 | 342 | 366 |
| 6 | Ca Haednrss as CaCO3 | mg/L | 191 | 174 | 169 | 156 |
| 7 | Magnesium Hardness as CaCO3 | mg/L | 33 | 43 | 41 | 51 |
| 8 | M-Alkalinity as CaCO3 | mg/L | 251 | 266 | 253 | 248 |
| 9 | BOD | mg/L | BDL | BDL | BDL | BDL |
| 10 | COD | mg/L | BDL | BDL | BDL | BDL |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11 | Ammoniacle N | mg/L | BDL | BDL | BDL | BDL |
| 12 | Kejaldhal N | mg/L | BDL | BDL | BDL | BDL |
| 13 | Sulphides as (S) | mg/L | BDL | BDL | BDL | BDL |
| 14 | Sodium as Na | mg/L | 49 | 53 | 48 | 47 |
| 15 | Potasium as K | mg/L | 6 | 11 | 9 | 12.6 |
| 16 | Total Dissolved Solids | mg/L | 465 | 470 | 465 | 443 |
| 17 | Total Suspended Solids | mg/L | 3 | 5 | 4 | 5 |
| 18 | Total Sulphides | mg/L | BDL | BDL | BDL | BDL |
| 19 | Oil and Grease | mg/L | BDL | BDL | BDL | BDL |
| 20 | Dissolved Oxygen | mg/L | 7.4 | 7.7 | 7.2 | 7.2 |
| 21 | Chloride | mg/L | 82 | 94 | 91 | 82 |
| 22 | Nitrate | mg/L | 7.5 | 6.9 | 6.7 | 6.2 |
| 23 | Sulphate as SO4 | mg/L | 26 | 30 | 28 | 35 |
| 24 | Total Silica as SiO2 | mg/L | BDL | BDL | BDL | BDL |
| 25 | Phosphate as PO4 | mg/L | BDL | BDL | BDL | BDL |
| 26 | Fluoride | mg/L | 0.7 | 0.76 | 0.74 | 0.84 |
| 27 | Iron | mg/L | 0.68 | 0.59 | 0.52 | 0.61 |
| 28 | Lead | mg/L | BDL | BDL | BDL | BDL |
| 29 | Phenol | mg/L | BDL | BDL | BDL | BDL |
| 30 | Nickel | mg/L | BDL | BDL | BDL | BDL |
| 31 | Arsenic | mg/L | BDL | BDL | BDL | BDL |
| 32 | Zinc | mg/L | 0.14 | 0.11 | 0.09 | 0.16 |
| 33 | Mercury | mg/L | BDL | BDL | BDL | BDL |
| 34 | Cadmium | mg/L | BDL | BDL | BDL | BDL |
| 35 | Selenium | mg/L | BDL | BDL | BDL | BDL |
| 36 | Cynide | mg/L | BDL | BDL | BDL | BDL |
| 37 | Chromium (Hexavalent) | mg/L | BDL | BDL | BDL | BDL |
| 38 | Chromium (Total) | mg/L | BDL | BDL | BDL | BDL |
| 39 | Copper as Cu | mg/L | BDL | BDL | BDL | BDL |
| 40 | Vanadium as V | mg/L | BDL | BDL | BDL | BDL |
| 41 | Phosphorous | mg/L | BDL | BDL | BDL | BDL |
| 42 | Benzene | mg/L | BDL | BDL | BDL | BDL |
| 43 | Benzo (a) pyrene | mg/L | BDL | BDL | BDL | BDL |

| **Hand Pump at Masadpur (1.0 km North of BR)** | | | | | | |
|---|---|---|---|---|---|---|
| **SN** | **Parameter** | **Unit** | **Jun-14** | **Sep-14** | **Dec-14** | **Mar-15** |
| 1 | Temperature | $^{o}$C | 31.7 | 32.2 | 24.3 | 26.7 |
| 2 | pH | | 7.62 | 7.42 | 7.56 | 7.82 |
| 3 | Turbidity | NTU | < 2 | < 2 | < 2 | < 2 |
| 4 | Conductivity | µmhos/cm | 872 | 855 | 8.46 | 986 |
| 5 | Total Hardness | mg/L | 341 | 354 | 343 | 377 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6 | Ca Haednrss as CaCO3 | mg/L | 215 | 185 | 179 | 159 |
| 7 | Magnesium Hardness as CaCO3 | mg/L | 31 | 41 | 38 | 53 |
| 8 | M-Alkalinity as CaCO3 | mg/L | 259 | 274 | 271 | 287 |
| 9 | BOD | mg/L | BDL | BDL | BDL | BDL |
| 10 | COD | mg/L | BDL | BDL | BDL | BDL |
| 11 | Ammoniacle N | mg/L | BDL | BDL | BDL | BDL |
| 12 | Kejaldhal N | mg/L | BDL | BDL | BDL | BDL |
| 13 | Sulphides as (S) | mg/L | BDL | BDL | BDL | BDL |
| 14 | Sodium as Na | mg/L | 51 | 56 | 52 | 71 |
| 15 | Potasium as K | mg/L | 13 | 19 | 17 | 12.2 |
| 16 | Total Dissolved Solids | mg/L | 519 | 547 | 534 | 518 |
| 17 | Total Suspended Solids | mg/L | 3 | 4 | 5 | 7 |
| 18 | Total Sulphides | mg/L | BDL | BDL | BDL | BDL |
| 19 | Oil and Grease | mg/L | BDL | BDL | BDL | BDL |
| 20 | Dissolved Oxygen | mg/L | 7.6 | 7.1 | 6.8 | 7.6 |
| 21 | Chloride | mg/L | 94 | 105 | 109 | 137 |
| 22 | Nitrate | mg/L | 7.8 | 7.4 | 6.5 | 7.6 |
| 23 | Sulphate as SO4 | mg/L | 30 | 26 | 24 | 36 |
| 24 | Total Silica as SiO2 | mg/L | BDL | BDL | BDL | BDL |
| 25 | Phosphate as PO4 | mg/L | BDL | BDL | BDL | BDL |
| 26 | Fluoride | mg/L | 0.63 | 0.67 | 0.63 | 0.72 |
| 27 | Iron | mg/L | 0.56 | 0.61 | 0.32 | 0.65 |
| 28 | Lead | mg/L | BDL | BDL | BDL | BDL |
| 29 | Phenol | mg/L | BDL | BDL | BDL | BDL |
| 30 | Nickel | mg/L | BDL | BDL | BDL | BDL |
| 31 | Arsenic | mg/L | BDL | BDL | BDL | BDL |
| 32 | Zinc | mg/L | 0.14 | 0.17 | 0.13 | 0.21 |
| 33 | Mercury | mg/L | BDL | BDL | BDL | BDL |
| 34 | Cadmium | mg/L | BDL | BDL | BDL | BDL |
| 35 | Selenium | mg/L | BDL | BDL | BDL | BDL |
| 36 | Cynide | mg/L | BDL | BDL | BDL | BDL |
| 37 | Chromium (Hexavalent) | mg/L | BDL | BDL | BDL | BDL |
| 38 | Chromium (Total) | mg/L | BDL | BDL | BDL | BDL |
| 39 | Copper as Cu | mg/L | BDL | BDL | BDL | BDL |
| 40 | Vanadium as V | mg/L | BDL | BDL | BDL | BDL |
| 41 | Phosphorous | mg/L | BDL | BDL | BDL | BDL |
| 42 | Benzene | mg/L | BDL | BDL | BDL | BDL |
| 43 | Benzo (a) pyrene | mg/L | BDL | BDL | BDL | BDL |

| **Well at Harpur (1.0 km North East of BR)** | | | | | | |
|---|---|---|---|---|---|---|
| **SN** | **Parameter** | **Unit** | **Jun-14** | **Sep-14** | **Dec-14** | **Mar-15** |
| 1 | Temperature | $^{o}$C | 33.2 | 32.5 | 25.3 | 25.9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | pH | | 7.76 | 7.89 | 7.96 | 7.58 |
| 3 | Turbidity | NTU | < 2 | < 2 | < 2 | < 2 |
| 4 | Conductivity | µmhos/cm | 1078 | 1123 | 1059 | 1036 |
| 5 | Total Hardness | mg/L | 463 | 486 | 476 | 384 |
| 6 | Ca Haednrss as CaCO3 | mg/L | 231 | 231 | 253 | 182 |
| 7 | Magnesium Hardness as CaCO3 | mg/L | 56 | 62 | 58 | 49 |
| 8 | M-Alkalinity as CaCO3 | mg/L | 379 | 394 | 387 | 375 |
| 9 | BOD | mg/L | BDL | BDL | BDL | BDL |
| 10 | COD | mg/L | BDL | BDL | BDL | BDL |
| 11 | Ammoniacle N | mg/L | BDL | BDL | BDL | BDL |
| 12 | Kejaldhal N | mg/L | BDL | BDL | BDL | BDL |
| 13 | Sulphides as (S) | mg/L | BDL | BDL | BDL | BDL |
| 14 | Sodium as Na | mg/L | 62 | 65 | 61 | 72 |
| 15 | Potasium as K | mg/L | 17 | 22 | 19 | 24 |
| 16 | Total Dissolved Solids | mg/L | 681 | 685 | 598 | 723 |
| 17 | Total Suspended Solids | mg/L | 5 | 4 | 5 | 5 |
| 18 | Total Sulphides | mg/L | BDL | BDL | BDL | BDL |
| 19 | Oil and Grease | mg/L | BDL | BDL | BDL | BDL |
| 20 | Dissolved Oxygen | mg/L | 7.2 | 7.15 | 7.36 | 8.20 |
| 21 | Chloride | mg/L | 109 | 113 | 124 | 118 |
| 22 | Nitrate | mg/L | 8.1 | 7.6 | 6.7 | 6.9 |
| 23 | Sulphate as SO4 | mg/L | 43 | 37 | 32 | 38 |
| 24 | Total Silica as SiO2 | mg/L | BDL | BDL | BDL | BDL |
| 25 | Phosphate as PO4 | mg/L | BDL | BDL | BDL | BDL |
| 26 | Fluoride | mg/L | 0.49 | 0.41 | 0.36 | 0.34 |
| 27 | Iron | mg/L | 0.81 | 0.66 | 0.22 | 0.56 |
| 28 | Lead | mg/L | BDL | BDL | BDL | BDL |
| 29 | Phenol | mg/L | BDL | BDL | BDL | BDL |
| 30 | Nickel | mg/L | BDL | BDL | BDL | BDL |
| 31 | Arsenic | mg/L | BDL | BDL | BDL | BDL |
| 32 | Zinc | mg/L | 0.26 | 0.31 | 0.33 | 0.22 |
| 33 | Mercury | mg/L | BDL | BDL | BDL | BDL |
| 34 | Cadmium | mg/L | BDL | BDL | BDL | BDL |
| 35 | Selenium | mg/L | BDL | BDL | BDL | BDL |
| 36 | Cynide | mg/L | BDL | BDL | BDL | BDL |
| 37 | Chromium (Hexavalent) | mg/L | BDL | BDL | BDL | BDL |
| 38 | Chromium (Total) | mg/L | BDL | BDL | BDL | BDL |
| 39 | Copper as Cu | mg/L | BDL | BDL | BDL | BDL |
| 40 | Vanadium as V | mg/L | BDL | BDL | BDL | BDL |
| 41 | Phosphorous | mg/L | BDL | BDL | BDL | BDL |
| 42 | Benzene | mg/L | BDL | BDL | BDL | BDL |
| 43 | Benzo (a) pyrene | mg/L | BDL | BDL | BDL | BDL |

# Baseline Data for Soil

| S.N | Parameter | Govindpur | Bihat | Pipradewas | Ladaura | Pachama |
|---|---|---|---|---|---|---|
| **PHYSICAL CHARACTERESTICS** | | | | | | |
| 1 | Texture | Clay Loam | Clay Loam | Clay Loam | Clay Loam | Clay Loam |
| 2 | Bulk Density (g/cm3) | 1.24 | 1.23 | 1.21 | 1.19 | 1.17 |
| 3 | Porosity (%) | 52.59 | 52.76 | 49.84 | 58.61 | 61.27 |
| 4 | Water Holding Capacity (%) | 22.54 | 20.18 | 19.94 | 19.87 | 21.58 |

| S.N | Parameter | Govindpur | Bihat | Pipradewas | Ladaura | Pachama |
|---|---|---|---|---|---|---|
| **CHEMICAL CHARACTERESTICS** | | | | | | |
| 1 | pH | 8.37 | 8.41 | 8.49 | 8.51 | 8.69 |
| 2 | Conductivity | 251 | 192 | 224 | 247 | 212 |
| 3 | Calcium (mg/100g) | 179.4 | 236.7 | 271.9 | 228.7 | 234.5 |
| 4 | Magnesium (mg/100 g) | 52.7 | 48.9 | 61.5 | 62.4 | 58.1 |
| 5 | Sodium (ppm) | 2.74 | 1.92 | 1.12 | 1.37 | 2.04 |
| 6 | Potassium (ppm) | 2.89 | 3.07 | 2.76 | 1.02 | 1.49 |
| 7 | Nitrate (ppm) | 72.1 | 71.9 | 69.2 | 73.5 | 77.4 |
| 8 | Phosphate (ppm) | 2.36 | 1.84 | 1.72 | 1.34 | 1.21 |

**Flag -5**

## Ambient air quality monitoring data

| IOCL - BARAUNI REFINERY | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMBIENT AIR QUALITY MONITORING RESULTS (MONTHLY AVG. VALUES) | | | | | | | | | | | | | | | |
| LOCATION: TIME OFFICE | | | | | | | | | | | | | | | |
| **Month** | **RPM(<10)** | **RPM <2.5** | **$SO_2$** | **$NO_2$** | **$NH_3$** | **Pb** | **CO (1 hour)** | **CO (8 hours)** | **Ozone (1 hour)** | **Ozone (8 hours)** | **HC** | **Benzene** | **Benzo(a) pyrene** | **Arsenic** | **Nickel** |
| **Unit** | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($mg/m^3$) | ($mg/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | (ppm) | ($\mu g/m^3$) | ($ng/m^3$) | ($ng/m^3$) | ($ng/m^3$) |
| **Limits** | 100 (24 Hr) 60 (Ann) | 60 (24 Hr) 40 (Ann) | 80 (24 Hr) 50 (Ann) | 80 (24 Hr) 40 (Ann) | 400 (24 Hr) 100 (Ann) | 1.0 (24 Hr) 0.5 (Ann) | 4.0 | 2.0 | 180 | 100 | NA | 05 (Ann) | 01 (Ann) | 06 (Ann) | 20 (Ann) |
| **Apr-14** | 72.71 | 30.29 | 9.29 | 20.86 | 15.00 | 0.28 | 0.96 | 1.01 | 30.14 | 30.33 | 1.06 | 3.89 | BDL | BDL | BDL |
| **May-14** | 72.89 | 27.33 | 10.11 | 20.33 | 14.89 | 0.26 | 0.96 | 0.97 | 29.67 | 30.19 | 1.01 | 3.77 | BDL | BDL | BDL |
| **Jun-14** | 71.33 | 29.22 | 9.33 | 20.56 | 14.44 | 0.27 | 0.93 | 0.97 | 29.56 | 30.00 | 1.00 | 3.86 | BDL | BDL | BDL |
| **Jul-14** | 70.63 | 27.50 | 9.63 | 19.00 | 14.38 | 0.28 | 0.90 | 0.95 | 30.50 | 29.96 | 0.95 | 4.14 | BDL | BDL | BDL |
| **Aug-14** | 73.75 | 26.63 | 11.25 | 20.00 | 15.63 | 0.30 | 1.00 | 0.95 | 30.75 | 29.96 | 0.94 | 4.23 | BDL | BDL | BDL |
| **Sep-14** | 73.22 | 26.33 | 11.11 | 20.89 | 15.78 | 0.28 | 0.94 | 0.93 | 30.56 | 30.04 | 0.91 | 4.38 | BDL | BDL | BDL |
| **Oct-14** | 77.86 | 30.00 | 11.29 | 19.86 | 16.43 | 0.30 | 1.01 | 0.96 | 30.86 | 30.57 | 0.89 | 3.81 | BDL | BDL | BDL |
| **Nov-14** | 80.13 | 32.38 | 10.25 | 20.00 | 16.00 | 0.30 | 1.00 | 0.96 | 31.13 | 30.63 | 0.9 | 4.1 | BDL | BDL | BDL |
| **Dec-14** | 74.63 | 29.38 | 9.63 | 19.88 | 16.25 | 0.31 | 0.99 | 0.98 | 30.88 | 30.92 | 0.9 | 4.3 | BDL | BDL | BDL |
| **Jan-15** | 78.13 | 31.00 | 9.88 | 18.38 | 16.00 | 0.30 | 0.99 | 0.99 | 30.50 | 30.88 | 0.83 | 3.79 | BDL | BDL | BDL |
| **Feb-15** | 75.75 | 28.13 | 9.25 | 17.88 | 15.25 | 0.29 | 0.96 | 0.99 | 30.00 | 30.96 | 0.84 | 3.56 | BDL | BDL | BDL |
| **Mar-15** | 74.63 | 28.13 | 8.88 | 17.25 | 15.38 | 0.29 | 0.99 | 1.01 | 30.00 | 30.21 | 0.81 | 3.54 | BDL | BDL | BDL |

## IOCL - BARAUNI REFINERY

## AMBIENT AIR QUALITY MONITORING RESULTS (MONTHLY AVG. VALUES)

## LOCATION: LPG Substation 16

| Month | RPM(<10) | RPM <2.5 | $SO_2$ | $NO_2$ | $NH_3$ | Pb | CO (1 hour) | CO (8 hours) | Ozone (1 hour) | Ozone (8 hours) | HC | Benzene | Benzo(a) pyrene | Arsenic | Nickel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($mg/m^3$) | ($mg/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | (ppm) | ($\mu g/m^3$) | ($ng/m^3$) | ($ng/m^3$) | ($ng/m^3$) |
| **Limits** | 100 (24 Hr) 60 (Ann) | 60 (24 Hr) 40 (Ann) | 80 (24 Hr) 50 (Ann) | 80 (24 Hr) 40 (Ann) | 400 (24 Hr) 100 (Ann) | 1.0 (24 Hr) 0.5 (Ann) | 4.0 | 2.0 | 180 | 100 | NA | 05 (Ann) | 01 (Ann) | 06 (Ann) | 20 (Ann) |
| **Apr-14** | 73.25 | 29.13 | 9.88 | 23.63 | 16.75 | 0.30 | 1.03 | 1.03 | 31.13 | 30.88 | 1.21 | 3.96 | BDL | BDL | BDL |
| **May-14** | 75.38 | 29.00 | 10.50 | 23.13 | 16.38 | 0.29 | 1.03 | 1.01 | 30.75 | 30.58 | 1.14 | 4.10 | BDL | BDL | BDL |
| **Jun-14** | 73.63 | 30.50 | 10.75 | 22.38 | 16.13 | 0.29 | 1.00 | 0.99 | 31.38 | 30.38 | 1.13 | 4.06 | BDL | BDL | BDL |
| **Jul-14** | 72.78 | 28.67 | 10.67 | 21.22 | 15.89 | 0.30 | 1.02 | 0.97 | 31.44 | 30.74 | 1.11 | 4.61 | BDL | BDL | BDL |
| **Aug-14** | 76.14 | 30.86 | 12.71 | 20.29 | 14.71 | 0.33 | 0.96 | 1.01 | 31.29 | 30.86 | 1.03 | 4.77 | BDL | BDL | BDL |
| **Sep-14** | 75.75 | 29.25 | 13.13 | 21.50 | 15.88 | 0.33 | 1.01 | 1.03 | 31.38 | 30.96 | 1.00 | 4.85 | BDL | BDL | BDL |
| **Oct-14** | 78.63 | 30.25 | 13.25 | 21.38 | 16.13 | 0.32 | 1.05 | 1.04 | 31.50 | 30.71 | 0.96 | 4.63 | BDL | BDL | BDL |
| **Nov-14** | 80.63 | 31.75 | 11.63 | 22.50 | 16.38 | 0.32 | 1.00 | 0.95 | 31.00 | 30.79 | 0.9 | 4.5 | BDL | BDL | BDL |
| **Dec-14** | 76.78 | 29.22 | 11.11 | 21.67 | 16.67 | 0.32 | 1.04 | 0.98 | 31.56 | 30.93 | 0.9 | 4.0 | BDL | BDL | BDL |
| **Jan-15** | 79.22 | 33.33 | 11.33 | 20.56 | 16.56 | 0.30 | 1.00 | 0.99 | 31.11 | 31.30 | 0.86 | 3.91 | BDL | BDL | BDL |
| **Feb-15** | 77.13 | 29.25 | 10.50 | 19.63 | 16.13 | 0.30 | 1.01 | 1.01 | 30.25 | 30.71 | 0.89 | 4.14 | BDL | BDL | BDL |
| **Mar-15** | 75.38 | 30.88 | 10.75 | 19.88 | 15.75 | 0.30 | 1.03 | 1.00 | 29.63 | 30.33 | 0.90 | 3.93 | BDL | BDL | BDL |

## IOCL - BARAUNI REFINERY

## AMBIENT AIR QUALITY MONITORING RESULTS (MONTHLY AVG. VALUES)

## LOCATION: CRU CONTROL ROOM

| Month | RPM(<10) | RPM <2.5 | $SO_2$ | $NO_2$ | $NH_3$ | Pb | CO (1 hour) | CO (8 hours) | Ozone (1 hour) | Ozone (8 hours) | HC | Benzene | Benzo(a) pyrene | Arsenic | Nickel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit** | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | ($mg/m^3$) | ($mg/m^3$) | ($\mu g/m^3$) | ($\mu g/m^3$) | (ppm) | ($\mu g/m^3$) | ($ng/m^3$) | ($ng/m^3$) | ($ng/m^3$) |
| **Limits** | 100 (24 Hr) 60 (Ann) | 60 (24 Hr) 40 (Ann) | 80 (24 Hr) 50 (Ann) | 80 (24 Hr) 40 (Ann) | 400 (24 Hr) 100 (Ann) | 1.0 (24 Hr) 0.5 (Ann) | 4.0 | 2.0 | 180 | 100 | NA | 05 (Ann) | 01 (Ann) | 06 (Ann) | 20 (Ann) |
| **Apr-14** | 75.57 | 30.86 | 11.00 | 22.71 | 17.71 | 0.34 | 1.06 | 1.05 | 30.86 | 30.95 | 1.60 | 4.83 | BDL | BDL | BDL |
| **May-14** | 74.44 | 29.22 | 10.67 | 22.22 | 17.11 | 0.33 | 1.04 | 1.01 | 30.67 | 30.63 | 1.48 | 4.67 | BDL | BDL | BDL |
| **Jun-14** | 75.00 | 30.89 | 11.44 | 22.22 | 16.44 | 0.34 | 1.03 | 1.00 | 31.00 | 30.70 | 1.38 | 4.78 | BDL | BDL | BDL |
| **Jul-14** | 75.63 | 31.63 | 12.50 | 22.38 | 16.88 | 0.37 | 1.10 | 1.05 | 31.88 | 31.13 | 1.33 | 4.78 | BDL | BDL | BDL |
| **Aug-14** | 75.50 | 28.88 | 13.88 | 23.00 | 16.50 | 0.39 | 1.09 | 1.03 | 32.00 | 31.33 | 1.29 | 5.33 | BDL | BDL | BDL |
| **Sep-14** | 74.89 | 27.44 | 12.78 | 22.67 | 17.22 | 0.38 | 1.11 | 1.03 | 31.44 | 30.93 | 1.36 | 5.29 | BDL | BDL | BDL |
| **Oct-14** | 79.29 | 31.14 | 14.43 | 24.00 | 17.57 | 0.39 | 1.20 | 1.08 | 32.00 | 31.14 | 1.24 | 5.03 | BDL | BDL | BDL |
| **Nov-14** | 84.13 | 33.88 | 13.00 | 23.50 | 17.00 | 0.36 | 1.04 | 1.00 | 31.25 | 30.92 | 1.2 | 5.1 | BDL | BDL | BDL |
| **Dec-14** | 79.63 | 31.38 | 11.38 | 22.50 | 18.00 | 0.36 | 1.11 | 1.03 | 31.25 | 31.00 | 1.1 | 5.1 | BDL | BDL | BDL |
| **Jan-15** | 83.00 | 34.25 | 12.13 | 22.38 | 17.75 | 0.36 | 1.03 | 1.07 | 31.88 | 31.21 | 1.00 | 5.21 | BDL | BDL | BDL |
| **Feb-15** | 80.13 | 32.00 | 11.63 | 21.25 | 17.00 | 0.35 | 1.08 | 1.07 | 31.50 | 31.63 | 1.03 | 5.08 | BDL | BDL | BDL |
| **Mar-15** | 77.38 | 31.13 | 11.75 | 21.13 | 17.13 | 0.33 | 1.13 | 1.09 | 31.13 | 31.04 | 0.91 | 4.80 | BDL | BDL | BDL |

**Flag-6**

# Stack Emission Monitoring

## TABLE 1.0 : SO2 EMISSIONS (Conc.)

| S.N. | Source | Fuel | Limit | Apr-14 | May-14 | Jun-14 | Jul-14 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Dec-14 | Jan-15 | Feb-15 | Mar-15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Name | % of Gas Firing | Conc (mg/ Nm3 ) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) |
| 1 | AVU - I | 50 | 871 | 221.7 | | 227.6 | | 231.7 | | 219.7 | | 237.6 | | 243.7 | |
| 2 | AVU - II | 50 | 871 | | 269.7 | | 277.6 | | 273.8 | | 288.6 | | 293.4 | | 277.6 |
| 3 | AVU - III | 60 | 705 | 273.4 | | 289.4 | | 314.2 | | 309.4 | | 298.1 | | 286.3 | |
| 4 | CRU - R | 85 | 296 | | 61.2 | | 63.4 | | 66.2 | | 63.8 | | 61.5 | | 63.2 |
| 5 | CRU - S | 85 | 296 | | 59.4 | | 57.9 | | 59.8 | | 56.4 | | 54.2 | | 52.9 |
| 6 | COKER - A | 80 | 378 | 63.8 | | 61.8 | | 63.4 | | 65.2 | | 62.7 | | 59.8 | |
| 7 | COKER - B | 80 | 377 | | | | | | | | | | | | |
| 8 | BOILER -I | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 1201 | | 317.2 | | 321.5 | | | 352.6 | | 374.2 | | 377.2 | |
| | DUCT - B | 30 | 1201 | | 293.6 | | 313.2 | | | 329.2 | | 337.6 | | 343.7 | |
| 9 | BOILER -II | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 1201 | 287.4 | | 311.5 | | 324.5 | | 336.2 | 357.5 | | 351.2 | | 359.1 |
| | DUCT - B | 30 | 1201 | 279.6 | | 296.7 | | 314.9 | | 347.8 | 329.4 | | 333.6 | | 341.5 |
| 10 | BOILER -III | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 1201 | 293.2 | | | | | 329.7 | | 349.1 | | 361.1 | | |
| | DUCT - B | 30 | 1201 | 288.6 | | | | | 341.5 | | 355.8 | | 359.4 | | |
| 11 | BOILER -IV | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 1201 | | | 317.2 | | 321.6 | | 331.6 | | 352.4 | | 349.6 | |
| | DUCT - B | 30 | 1201 | | | 305.1 | | 317.5 | | 349.6 | | 341.2 | | 357.1 | |
| 12 | BOILER - V | 30 | 1201 | | | | | | 337.9 | | | | | | |
| 13 | FCCU | NA | 1700 | | 87.3 | | 84.7 | | 82.9 | | 79.4 | | 77.3 | | 73.6 |
| 14 | HGU | 75 | 461 | 57.1 | | 59.6 | | 61.8 | | 63.2 | | 59.7 | | 57.7 | |
| 15 | DHDT | 100 | 50 | 49.3 | | 53.4 | | 56.3 | | 54.1 | | 52.3 | | 51.8 | |
| 16 | GT - I | 0 | 1700 | | 49.8 | | 51.4 | | 53.9 | | 49.9 | | 51.3 | | 49.6 |
| 17 | GT - II | 0 | 1700 | | 53.2 | | 54.3 | | 51.7 | | | | 47.9 | | 46.1 |
| 18 | SRU | NA | NA | 1447.3 | 1321.6 | 1405.9 | 1355.6 | 1432.8 | 1327.6 | 1396.3 | 1289.6 | 1278.8 | 1266.2 | 1196.4 | 1296.5 |
| 19 | MSQ (NHDT) | 100 | 50 | 14.6 | | 14.9 | | 15.3 | | 15.9 | | 16.2 | | 15.4 | |
| 20 | Prime G | 100 | 50 | 13.7 | | 15.3 | | 16.7 | | 17.1 | | 17.9 | | 16.7 | |
| 21 | Boiler 6 | 30 | 1201 | | 321.70 | | 329.2 | | 356.4 | | 328.4 | | 317.2 | | 321.6 |

## TABLE 2.0 : NOx EMISSIONS (Conc.)

| S.N. | Source | Fuel | Limit | Apr-14 | May-14 | Jun-14 | Jul-14 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Dec-14 | Jan-15 | Feb-15 | Mar-15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Name | % of Gas Firing | Conc (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) |
| 1 | AVU - I | 50 | 400 | 129.6 | | 133.4 | | 139.1 | | 143.6 | | 149.2 | | 153.9 | |
| 2 | AVU - II | 50 | 400 | | 123.5 | | 91 | | 129.4 | | 143.2 | | 146.3 | | 143.9 |
| 3 | AVU - III | 60 | 390 | 141.2 | | 153.7 | | 163.7 | | 169.4 | | 173.6 | | 177.4 | |
| 4 | CRU - R | 85 | 365 | | 83.5 | | 12.3 | | 83.4 | | 81.4 | | 79.8 | | 77.5 |
| 5 | CRU - S | 85 | 365 | | 78.7 | | 11.9 | | 75.3 | | 73.1 | | 71.6 | | 69.7 |
| 6 | COKER - A | 80 | 370 | 81.5 | | 79.7 | | 83.2 | | 81.1 | | 79.7 | | 77.3 | |
| 7 | COKER - B | 80 | 370 | | | | | | | | | | | | |
| 8 | BOILER -I | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 420 | | 143.2 | | 107 | | | 163.2 | | 167.9 | | 162.5 | |
| | DUCT - B | 30 | 420 | | 136.5 | | 103 | | | 169.4 | | 163.4 | | 169.2 | |
| 9 | BOILER -II | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 420 | 136.2 | | 149.3 | | 156.3 | | 159.4 | 159.6 | | 162.3 | | 166.2 |
| | DUCT - B | 30 | 420 | 131.9 | | 157.4 | | 167.4 | | 161.3 | 138.6 | | 147.2 | | 152.7 |
| 10 | BOILER -III | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 420 | 129.8 | | | | | 143.2 | | 148.3 | | 153.4 | | |
| | DUCT - B | 30 | 420 | 133.4 | | | | | 139.4 | | 145.9 | | 148.6 | | |
| 11 | BOILER -IV | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 420 | | | 161.6 | | 166.8 | | 156.7 | | 162.3 | | 168.5 | |
| | DUCT - B | 30 | 420 | | | 145.3 | | 159.1 | | 162.5 | | 143.8 | | 159.3 | |
| 12 | BOILER - V | 30 | 420 | | | | | | 145.2 | | | | | | |
| 13 | FCCU | NA | 450 | | 66.1 | | 19.2 | | 61.6 | | 58.7 | | 61.6 | | 59.8 |
| 14 | HGU | 75 | 375 | 41.5 | | 43.1 | | 41.9 | | 43.7 | | 41.8 | | 39.6 | |
| 15 | DHDT | 100 | 350 | 71.6 | | 73.6 | | 77.4 | | 74.2 | | 77.2 | | 74.9 | |
| 16 | GT - I | 0 | 450 | | 139.4 | | 13.4 | | 147.6 | | 139.5 | | 133.6 | | 131.2 |
| 17 | GT - II | 0 | 450 | | 133.9 | | 11.8 | | 141.9 | | | | 139.4 | | 136.7 |
| 18 | SRU | NA | 350 | 147.2 | 83.4 | 152.3 | 17.6 | 157.4 | 79.4 | 166.9 | 77.2 | 163.5 | 73.2 | 161.8 | 71.9 |
| 19 | NHDT | 100 | 250 | 23.4 | | 21.7 | | 23.6 | | 21.6 | | 23.1 | | 21.9 | |
| 20 | Prime G | 100 | 250 | 31.2 | | 33.6 | | 34.9 | | 29.9 | | 31.2 | | 29.7 | |
| 21 | Boiler 6 | 75 | 275 | | 147.6 | | 93 | | 153.7 | | 149.6 | | 166.4 | | 169.4 |

## TABLE 3.0 : CO EMISSIONS (Conc.)

| S.N. | Source | Fuel | Limit | Apr-14 | May-14 | Jun-14 | Jul-14 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Dec-14 | Jan-15 | Feb-15 | Mar-15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Name | % of Gas Firing | Conc (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) | Actual (mg/Nm3) |
| 1 | AVU - I | 50 | 175 | 8.66 | | 8.89 | | 9.01 | | 9.23 | | 9.46 | | 9.23 | |
| 2 | AVU - II | 50 | 175 | | 9.01 | | 8.78 | | 8.89 | | 8.66 | | 8.44 | | 8.66 |
| 3 | AVU - III | 60 | 170 | 9.35 | | 9.58 | | 9.80 | | 10.03 | | 10.15 | | 9.92 | |
| 4 | CRU - R | 85 | 157 | | 7.41 | | 7.18 | | 7.30 | | 7.18 | | 6.95 | | 7.07 |
| 5 | CRU - S | 85 | 157 | | 7.18 | | 6.95 | | 7.07 | | 6.95 | | 6.73 | | 6.61 |
| 6 | COKER - A | 80 | 160 | 8.21 | | 8.32 | | 8.66 | | 8.44 | | 8.55 | | 8.32 | |
| 7 | COKER - B | 80 | 160 | | | | | | | | | | | | |
| 8 | BOILER -I | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 185 | 0.00 | 24.28 | | 22.34 | | | 24.28 | | 22.46 | | 21.55 | |
| | DUCT - B | 30 | 185 | 0.00 | 23.83 | | 21.55 | | | 22.57 | | 20.29 | | 22.91 | |
| 9 | BOILER -II | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 185 | 23.14 | | 24.40 | | 23.83 | | 25.42 | 24.28 | | 22.46 | | 23.14 |
| | DUCT - B | 30 | 185 | 24.74 | | 25.31 | | 24.28 | | 23.60 | 22.57 | | 20.75 | | 22.69 |
| 10 | BOILER -III | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 185 | 24.40 | | | | | 23.60 | | 21.32 | | 20.41 | | |
| | DUCT - B | 30 | 185 | 22.91 | | | | | 22.12 | | 23.14 | | 21.09 | | |
| 11 | BOILER -IV | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 185 | | | 23.83 | | 24.05 | | 23.83 | | 21.32 | | 22.00 | |
| | DUCT - B | 30 | 185 | | | 24.40 | | 25.42 | | 21.89 | | 23.14 | | 23.60 | |
| 12 | BOILER - V | 30 | 185 | 0.00 | | | | | 24.28 | | | | | | |
| 13 | FCCU | NA | 400 | | 8.89 | | 9.46 | | 10.03 | | 10.15 | | 10.60 | | 10.37 |
| 14 | HGU | 75 | 162 | 6.38 | | 6.16 | | 6.38 | | 6.50 | | 6.38 | | 6.50 | |
| 15 | DHDT | 100 | 150 | 7.30 | | 7.64 | | 8.21 | | 8.09 | | 8.32 | | 8.66 | |
| 16 | GT - I | 0 | 200 | | 7.52 | | 7.07 | | 7.52 | | 7.30 | | 7.52 | | 7.30 |
| 17 | GT - II | 0 | 200 | | 7.30 | | 7.30 | | 7.18 | | 0.00 | | 7.07 | | 6.95 |
| 18 | SRU | NA | 150 | 7.52 | 8.09 | 7.64 | 8.21 | 7.41 | 8.09 | 7.75 | 7.87 | 7.52 | 7.64 | 7.30 | 7.52 |
| 19 | NHDT | 100 | 100 | 4.10 | | 4.33 | | 4.10 | | 4.22 | | 4.33 | | 4.45 | |
| 20 | Prime G | 100 | 100 | 4.33 | | 4.79 | | 4.67 | | 4.79 | | 4.90 | | 4.67 | |
| 21 | Boiler 6 | 75 | 113 | | 23.60 | | 24.28 | | 23.60 | | 21.20 | | 22.46 | | 23.71 |

## TABLE 4.0 : PM EMISSIONS (Conc.)

| S.N. | Source | Fuel | Limit | Apr-14 | May-14 | Jun-14 | Jul-14 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Dec-14 | Jan-15 | Feb-15 | Mar-15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Name | % of Gas Firing | Conc (mg/ Nm3) | Actual (mg/Nm 3) | Actual (mg/Nm 3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/Nm 3) |
| 1 | AVU - I | 50 | 55 | 87 | | 89 | | 91 | | 97 | | 103 | | 97 | |
| 2 | AVU - II | 50 | 55 | | 83 | | 91 | | 89 | | 93 | | 103 | | 107 |
| 3 | AVU - III | 60 | 46 | 93 | | 95 | | 103 | | 107 | | 109 | | 107 | |
| 4 | CRU - R | 85 | 23 | | 13.8 | | 12.3 | | 13.4 | | 12.2 | | 13.6 | | 12.7 |
| 5 | CRU - S | 85 | 23 | | 13.1 | | 11.9 | | 12.6 | | 11.9 | | 12.1 | | 11.9 |
| 6 | COKER - A | 80 | 28 | 41 | | 43 | | 47 | | 49 | | 53 | | 51 | |
| 7 | COKER - B | 80 | 28 | | | | | | | | | | | | |
| 8 | BOILER -I | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 73 | | 91 | | 107 | | | 103 | | 106 | | 103 | |
| | DUCT - B | 30 | 73 | | 94 | | 103 | | | 112 | | 96 | | 109 | |
| 9 | BOILER -II | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 73 | 103 | | 101 | | 107 | | 109 | 107 | | 109 | | 102 |
| | DUCT - B | 30 | 73 | 98 | | 96 | | 98 | | 94 | 96 | | 101 | | 105 |
| 10 | BOILER -III | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 73 | 101 | | | | | 105 | | 93 | | 105 | | |
| | DUCT - B | 30 | 73 | 105 | | | | | 97 | | 89 | | 112 | | |
| 11 | BOILER -IV | | | | | | | | | | | | | | |
| | DUCT -A | 30 | 73 | | | 105 | | 97 | | 105 | | 101 | | 105 | |
| | DUCT - B | 30 | 73 | | | 103 | | 106 | | 96 | | 104 | | 98 | |
| 12 | BOILER - V | 30 | 73 | | | | | | 102 | | | | | | |
| 13 | FCCU | NA | 100 | | 17.1 | | 19.2 | | 21.4 | | 21.8 | | 29.7 | | 23.4 |
| 14 | HGU | 75 | 32 | 12.9 | | 13.1 | | 12.4 | | 13.2 | | 12.7 | | 13.6 | |
| 15 | DHDT | 100 | 10 | 14.3 | | 12.9 | | 13.7 | | 15.1 | | 14.5 | | 14.9 | |
| 16 | GT - I | 0 | 100 | | 14.3 | | 13.4 | | 12.7 | | 14.2 | | 11.8 | | 12.4 |
| 17 | GT - II | 0 | 100 | | 12.9 | | 11.8 | | 13.4 | | | | 12.1 | | 13.1 |
| 18 | SRU | NA | NA | 15.7 | 15.7 | 14.7 | 17.6 | 15.7 | 15.8 | 14.9 | 13.7 | 13.2 | 12.9 | 12.4 | 11.8 |
| 19 | MSQ (NHDT) | 100 | 5 | 13.1 | | 12.9 | | 11.7 | | 12.1 | | 11.8 | | 11.3 | |
| 20 | Prime G | 100 | 5 | 12.9 | | 13.3 | | 12.4 | | 12.9 | | 12.3 | | 12.1 | |
| 21 | Boiler 6 | 75 | 16 | | 89 | | 93 | | 96 | | 98 | | 91 | | 98 |

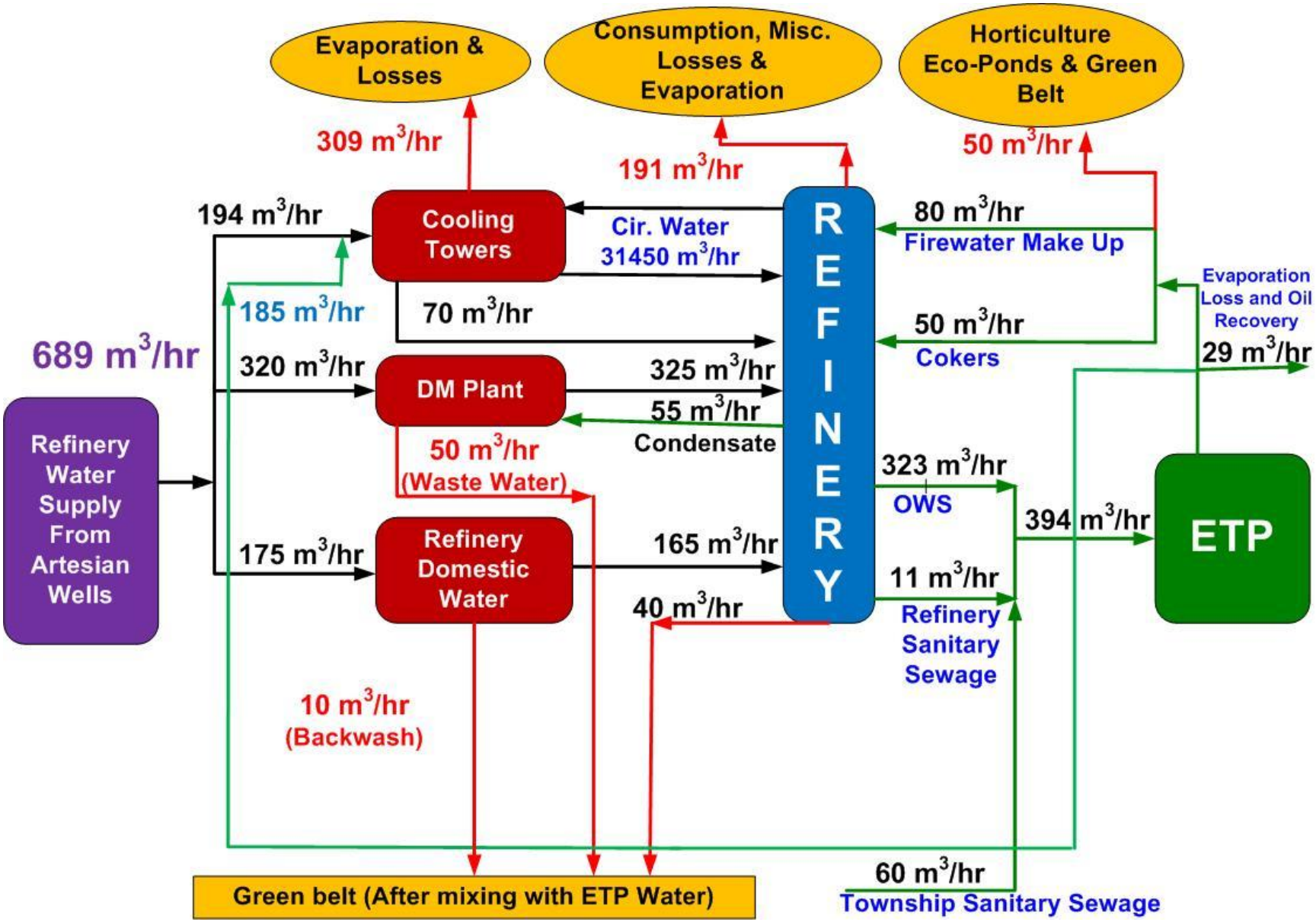
## TABLE 5.0 : Ni+V EMISSIONS

| S.N. | Source | Limit | Apr-14 | May-14 | Jun-14 | Jul-14 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Dec-14 | Jan-15 | Feb-15 | Mar-15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Name | Conc (mg/ Nm3) | Actual (mg/Nm 3) | Actual (mg/Nm 3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/N m3) | Actual (mg/Nm 3) |
| 1 | AVU - I | 5 | BDL | | BDL | | BDL | | BDL | | BDL | | BDL | |
| 2 | AVU - II | 5 | | BDL | | BDL | | BDL | | BDL | | BDL | | BDL |
| 3 | AVU - III | 5 | BDL | | BDL | | BDL | | BDL | | BDL | | BDL | |
| 4 | CRU - R | 5 | | BDL | | BDL | | BDL | | BDL | | BDL | | BDL |
| 5 | CRU - S | 5 | | BDL | | BDL | | BDL | | BDL | | BDL | | BDL |
| 6 | COKER - A | 5 | BDL | | BDL | | BDL | | BDL | | BDL | | BDL | |
| 7 | COKER - B | 5 | | | | | | | | | | | | |
| 8 | BOILER -I | | | | | | | | | | | | | |
| | DUCT -A | 5 | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | | BDL | |
| | DUCT - B | 5 | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | | BDL | |
| 9 | BOILER -II | | | | | | | | | | | | | |
| | DUCT -A | 5 | | | | | | | BDL | | BDL | BDL | | BDL |
| | DUCT - B | 5 | | | | | | | BDL | | BDL | BDL | | BDL |
| 10 | BOILER -III | | | | | | | | | | | | | |
| | DUCT -A | 5 | | | | | | BDL | | BDL | | BDL | | |
| | DUCT - B | 5 | | | | | | BDL | | BDL | | BDL | | |
| 11 | BOILER -IV | | | | | | | | | | | | | |
| | DUCT -A | 5 | | | | | | | | | | | | |
| | DUCT - B | 5 | | | | | | | | | | | | |
| 12 | BOILER - V | 5 | | | | | | BDL | | BDL | | | | |
| 13 | FCCU | 5 | | BDL | | BDL | | BDL | | BDL | | BDL | | BDL |
| 14 | HGU | 5 | BDL | | BDL | | BDL | | BDL | | BDL | | BDL | |
| 15 | DHDT | 5 | BDL | | BDL | | BDL | | BDL | | BDL | | BDL | |
| 16 | GT - I | 5 | | BDL | | BDL | | BDL | | BDL | | BDL | | BDL |
| 17 | GT - II | 5 | | BDL | | BDL | | BDL | | BDL | | BDL | | BDL |
| 18 | SRU | NA | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 19 | MSQ (NHDT) | 5 | BDL | | BDL | | BDL | | BDL | | BDL | | BDL | |
| 20 | Prime G | 5 | BDL | | BDL | | BDL | | BDL | | BDL | | BDL | |
| 21 | Boiler 6 | 5 | | BDL | | BDL | | BDL | | BDL | | BDL | | BDL |

## TABLE 6.0 : EMISSIONS (Load)

| S.N. | Source | Limit | Apr-14 | May-14 | Jun-14 | Jul-14 | Aug-14 | Sep-14 | Oct-14 | Nov-14 | Dec-14 | Jan-15 | Feb-15 | Mar-15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Name | Kg/hr | Actual (Kg/hr) | Actual (Kg/hr) | Actual (Kg/hr) | Actual (Kg/hr) | Actual (Kg/hr) | Actual (Kg/hr) | Actual (Kg/hr) | Actual (Kg/hr) | Actual (Kg/hr) | Actual (Kg/hr) | Actual (Kg/hr) | Actual (Kg/hr) |
| 1 | SO2 | 1035 | 698 | 712.00 | 703.00 | 702.00 | 695.00 | 697.00 | 701.00 | 707.00 | 692.00 | 709 | 702 | 697 |
| 2 | NOX | NA | 175.23 | 181.74 | 179.20 | 191.47 | 193.41 | 213.92 | 233.09 | 202.86 | 207.14 | 219.28 | 213.36 | 190.42 |
| 3 | CO | NA | 17.37 | 18.33 | 17.24 | 19.55 | 18.71 | 22.83 | 24.77 | 22.50 | 22.17 | 22.40 | 21.50 | 19.33 |
| 4 | PM | NA | 75.12 | 75.85 | 73.05 | 83.21 | 81.79 | 97.65 | 109.44 | 103.13 | 104.51 | 108.74 | 103.51 | 87.91 |

**Present Water balance indicating raw water requirement and treated effluent quantity and its reuse**



# Treated Effluent Quality data

| SN | Parameter | Limit | Apr-14 | | | May-14 | | | Jun-14 | | | Jul-14 | | | Aug-14 | | | Sep-14 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (mg/l except pH) | MAX | MIN | AVG | MAX | MIN | AVG | MAX | MIN | AVG | MAX | MIN | AVG | MAX | MIN | AVG | MAX | MIN | AVG |
| 1 | pH | **6.0 – 8.5** | 7.9 | 6.6 | 7.31 | 8.2 | 6.8 | 7.29 | 7.4 | 7 | 7.19 | 7.3 | 6.8 | 7.14 | 7.60 | 6.90 | 7.38 | 8 | 7.4 | 7.60 |
| 2 | Oil & Grease | **5** | 5 | 3 | 3.98 | 5 | 3 | 4.45 | 5 | 3.6 | 4.63 | 5 | 3 | 4.44 | 4.20 | 2.40 | 3.08 | 3 | 2.2 | 2.47 |
| 3 | BOD | **15** | 15 | 12 | 14.63 | 15 | 6 | 12.85 | 15 | 12 | 14.20 | 15 | 8 | 13.80 | 15.00 | 8.00 | 12.10 | 15 | 8 | 12.73 |
| 4 | COD | **125** | 125 | 72 | 98.00 | 120 | 80 | 96.27 | 110 | 46 | 80.24 | 124 | 48 | 93.95 | 80.00 | 24.00 | 54.63 | 110 | 20 | 51.95 |
| 5 | TSS | **20** | 22 | 18 | 19.42 | 21 | 12 | 18.85 | 22 | 18 | 19.00 | 21 | 5.2 | 13.41 | 5.90 | 3.80 | 4.59 | 10.4 | 4.4 | 5.43 |
| 6 | Phenols | **0.35** | 0.3 | 0.02 | 0.05 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.032 | 0.017 | 0.02 |
| 7 | Sulphides | **0.5** | 0.5 | 0.26 | 0.39 | 0.5 | 0.26 | 0.38 | 0.5 | 0.26 | 0.40 | 0.5 | 0.26 | 0.41 | 0.39 | 0.26 | 0.31 | 0.39 | 0.26 | 0.33 |
| 8 | CN | **0.2** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | Ammonia as N | **15** | 2.7 | 1.9 | 2.3 | 2.9 | 2.4 | 2.7 | 2.7 | 2.2 | 2.45 | 2.6 | 1.5 | 2.1 | 3.3 | 2.2 | 2.8 | 2.1 | 1.5 | 1.8 |
| 10 | TKN | **40** | 26.6 | 20.5 | 24 | 24.5 | 20.8 | 22.7 | 23.2 | 20.1 | 21.65 | 26.4 | 21.5 | 24.0 | 28.6 | 24.1 | 26.4 | 25.5 | 20.6 | 23.1 |
| 11 | P | **3.0** | 1.1 | 1.7 | 1.4 | 1.6 | 1.2 | 1.4 | 1.7 | 1.1 | 1.4 | 1.6 | 1.3 | 1.5 | 1.8 | 0.9 | 1.4 | 1.5 | 0.6 | 1.1 |
| 12 | Cr (Hexavalent) | **0.1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | Cr (Total) | **2.0** | 1.4 | 1.2 | 1.3 | 1.2 | 0.9 | 1.1 | 1.4 | 0.5 | 0.95 | 1.2 | 0.9 | 1.1 | 1.2 | 0.7 | 1.0 | 1.1 | 0.8 | 1.0 |
| 14 | Pb | **0.1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | Hg | **0.01** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | Zn | **5.0** | 2.2 | 1.6 | 1.9 | 2.2 | 1.6 | 1.9 | 1.8 | 1.3 | 1.55 | 2.1 | 1.5 | 1.8 | 2.1 | 1.4 | 1.8 | 1.8 | 0.9 | 1.4 |
| 17 | Ni | **1.0** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | Cu | **1.0** | 0.21 | 0.14 | 0.18 | 0.18 | 0.15 | 0.17 | 0.16 | 0.12 | 0.14 | 0.16 | 0.09 | 0.13 | 0.13 | 0.11 | 0.12 | 0.13 | 0.00 | 0.07 |
| 19 | V | **0.2** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | Benzene | **0.1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | Benzo (a) - Pyrene | **0.2** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| SN | Parameter | Limit | Oct-14 | | | Nov-14 | | | Dec-14 | | | Jan-15 | | | Feb-15 | | | Mar-15 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (mg/l except pH) | MAX | MIN | AVG | MAX | MIN | AVG | MAX | MIN | AVG | MAX | MIN | AVG | MAX | MIN | AVG | MAX | MIN | AVG |
| 1 | pH | **6.0 – 8.5** | 7.80 | 7.40 | 7.61 | 8 | 7 | 7.23 | 7.8 | 7.0 | 7.30 | 8.2 | 7.1 | 7.34 | 7.20 | 6.80 | 7.03 | 7.90 | 6.60 | 7.10 |
| 2 | Oil & Grease | **5** | 5.00 | 2.00 | 3.32 | 5 | 3 | 4.08 | 5.0 | 3.3 | 4.30 | 5.0 | 3.6 | 4.85 | 5.00 | 2.30 | 4.28 | 5.00 | 3.20 | 4.30 |
| 3 | BOD | **15** | 15.00 | 10.00 | 13.64 | 15 | 7 | 12.28 | 15.0 | 4.0 | 8.00 | 15.0 | 3.0 | 11.39 | 15.00 | 8.00 | 13.17 | 15.00 | 9.00 | 13.00 |
| 4 | COD | **125** | 124.00 | 27.50 | 92.80 | 125 | 32 | 87.64 | 112.0 | 40.0 | 58.40 | 121.0 | 16.0 | 63.67 | 72.00 | 24.00 | 50.71 | 120.00 | 24.00 | 54.00 |
| 5 | TSS | **20** | 6.80 | 4.20 | 4.75 | 20 | 4.8 | 12.92 | 20.0 | 7.2 | 13.10 | 20.00 | 3.00 | 12.47 | 20.00 | 12.00 | 18.21 | 20.00 | 9.00 | 17.00 |
| 6 | Phenols | **0.35** | 0.30 | 0.02 | 0.04 | 0.2 | 0.03 | 0.07 | 0.3 | 0.03 | 0.06 | 0.20 | 0.05 | 0.12 | 0.25 | 0.05 | 0.12 | 0.15 | 0.05 | 0.11 |
| 7 | Sulphides | **0.5** | 0.39 | 0.26 | 0.30 | 0.5 | 0.13 | 0.24 | 0.5 | 0.13 | 0.21 | 0.50 | 0.13 | 0.37 | 0.50 | 0.26 | 0.42 | 0.50 | 0.13 | 0.40 |
| 8 | CN | **0.2** | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | Ammonia as N | **15** | 1.9 | 1.2 | 1.6 | 1.6 | 1.1 | 1.4 | 1.9 | 1.66 | 1.8 | 0.055 | 0.066 | 0.061 | 6.8 | 8.50 | 7.7 | 8.8 | 6.80 | 7.80 |
| 10 | TKN | **40** | 23.5 | 20.3 | 21.9 | 24.1 | 20.8 | 22.5 | 25.7 | 21.8 | 23.8 | 35.1 | 39.2 | 37.2 | 26.6 | 30.8 | 28.7 | 33.6 | 29.6 | 31.6 |
| 11 | P | **3.0** | 1.8 | 1.2 | 1.5 | 1.6 | 1.5 | 1.6 | 1.6 | 1.5 | 1.6 | 0.6 | 0.6 | 0.6 | 0.4 | 0.5 | 0.5 | 0.5 | 0.4 | 0.5 |
| 12 | Cr (Hexavalent) | **0.1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 13 | Cr (Total) | **2.0** | 1.5 | 1.3 | 1.4 | 1.3 | 0.8 | 1.1 | 1.3 | 0.90 | 1.1 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 14 | Pb | **0.1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 15 | Hg | **0.01** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| 16 | Zn | **5.0** | 2.4 | 2.1 | 2.3 | 2.8 | 2.1 | 2.5 | 2.3 | 1.9 | 2.1 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 17 | Ni | **1.0** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 18 | Cu | **1.0** | 0.16 | 0.11 | 0.14 | 0.22 | 0.11 | 0.17 | 0.14 | 0.09 | 0.12 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 19 | V | **0.2** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 20 | Benzene | **0.1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 21 | Benzo (a) - Pyrene | **0.2** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |

## Existing status of Noise pollution

| Equivalent Noise Level in the Study Area, dB(A) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.N. | LOCATIONS | Sep-14 | | | | | | Mar-15 | | | | | |
| | | DAY | | | NIGHT | | | DAY | | | NIGHT | | |
| | | Min | Max | Leq | Min | Max | Leq | Min | Max | Leq | Min | Max | Leq |
| 1 | GATE NO. 1 | 69 | 72 | 69.9 | 55 | 57 | 56.7 | 67 | 71 | 68.6 | 55 | 57 | 56.8 |
| 2 | GATE NO. 2 | 70 | 74 | 72.9 | 61 | 65 | 63.9 | 69 | 73 | 70.4 | 59 | 63 | 62.1 |
| 3 | BIO –TREATMENT PLANT GATE | 77 | 80 | 78.9 | 71 | 75 | 73.8 | 74 | 78 | 76.1 | 72 | 75 | 73.8 |
| 4 | BIO –TREATMENT - CONTROL ROOM | 68 | 70 | 69.2 | 62 | 65 | 63.6 | 70 | 73 | 70.7 | 64 | 66 | 64.7 |
| 5 | OIL INDIA GATE (NEAR GOVINDPUR VILLAGE) | 62 | 65 | 63.6 | 51 | 55 | 54.2 | 61 | 64 | 63.2 | 52 | 55 | 54.2 |
| 6 | GATE NO. 10 | 66 | 70 | 65.3 | 56 | 59 | 57.4 | 67 | 70 | 65.3 | 57 | 59 | 57.9 |
| 7 | RFCCU SITE CLOSE TO THE BOUNDARY | 62 | 64 | 63.6 | 58 | 62 | 60.7 | 63 | 65 | 64.2 | 58 | 62 | 60.7 |
| 8 | SRU SITE CLOSE TO THE BOUNDARY | 63 | 66 | 65.3 | 60 | 63 | 61.6 | 64 | 66 | 65.5 | 61 | 63 | 61.8 |
| 9 | CISF COLONY | 56 | 60 | 60.2 | 48 | 52 | 50.9 | 57 | 60 | 60.6 | 48 | 51 | 50.6 |
| 10 | NEAR BURROW PIT | 57 | 62 | 61.1 | 55 | 61 | 58.1 | 56 | 64 | 62.3 | 53 | 57 | 56.3 |

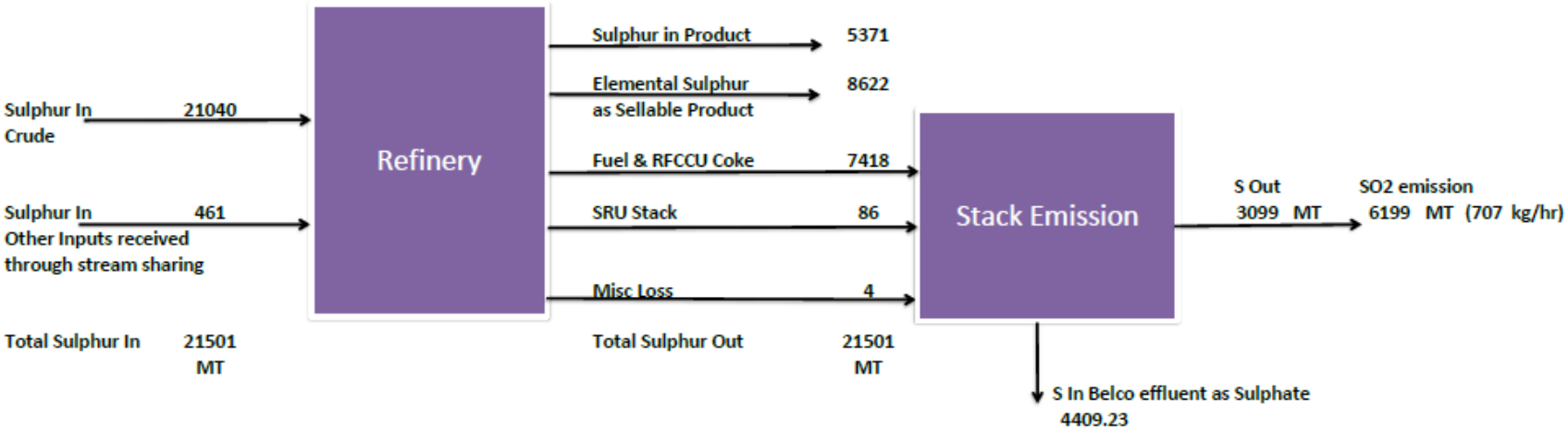
## Solid Waste Management

| Sl.No | Waste | Disposal methodology |
|---|---|---|
| 1 | Oily Sludge | • Mechanized Skid Process.<br>• Currently M/s Balmer Lawrie is lined up. |
| 2 | Spent Catalyst | • RFCCU Spent Cat: Co-processing in Cement Industry.<br>• One time Catalyst: Disposal through MSTC. |
| 3 | e-Waste | • Disposed under buyback scheme. |
| 4 | Horticulture Waste | • Processed in Organic Waste Convertor. |
| 5 | Kitchen solid wastes of Township & Canteen mixed Wastes | • Processed in Organic Waste Convertor. |
| 6 | Waste Batteries | • Waste batteries generated and returned back to manufactures/vendors under buyback scheme. |
| 7 | Metal Waste drums | • Disposal through MSTC. |

**Flag- 7**

## Sulphur Balance in Existing Refinery unit

**(For the year 2014-15)**



**Flag-8**

**Additional SO2 emissions due to the proposed project.**

Post BS-IV project, there will be an additional load of 33.32 MMKCal/hr due to installation & revamp of process unit furnaces. Also there will be an extra load of 12 MW of power and 90 tons/hr of steam for which 95.22 MMKCal/hr of extra energy will be required.

Due to extra consumption of fuel post BS-IV project, SO2 emission will increase from the present level. However to reduce SO2 emission, sulphur content in Internal Fuel Oil (IFO) will be reduced from current level of 0.98% to 0.75% (through change in IFO blend and more LS VR component) resulting in total SO2 emission of 815 kg/hr post BS-IV project.

Detailed SO2 emission projection post BS-IV project is as under.

| Furnace wise SO2 emission post BS-IV Project | | | | | | | |
|---|---|---|---|---|---|---|---|
| **UNIT** | **FUEL OIL CONSUM - PTION (Per Day)** | **FUEL GAS CONSUM - PTION (Per Day)** | **"S" in FO** | **"S" in FG** | **Total "S" burned in Furnace** | **Total "SO2" generated in Furnace** | **Total "SO2" generated in Furnace** |
| | **(MT)** | **(MT)** | **MT / Day** | **MT / Day** | **MT / Day** | **MT / Day** | **kg/hr** |
| **Existing** | | | | | | | |
| **AVU -I** | 41.3 | 18.8 | 0.31 | 0.003 | 0.31 | 0.63 | 26.06 |
| **AVU-II** | 39.5 | 19.6 | 0.30 | 0.003 | 0.30 | 0.60 | 24.96 |
| **AVU-III** | 38.5 | 70.8 | 0.29 | 0.01 | 0.30 | 0.60 | 25.04 |
| **COKER-A** | 2.9 | 39.2 | 0.02 | 0.01 | 0.03 | 0.06 | 2.32 |
| **COKER-B** | 4.2 | 51.0 | 0.03 | 0.01 | 0.04 | 0.08 | 3.31 |
| **CRU** | 0.0 | 86.4 | 0.00 | 0.01 | 0.01 | 0.03 | 1.15 |
| **HGU** | 64.2 | 165.4 | 0.01 | 0.03 | 0.04 | 0.08 | 3.28 |
| **DHDT** | 0.0 | 60.8 | 0.00 | 0.01 | 0.01 | 0.02 | 0.81 |
| **TPS (BOILERS)** | 305.8 | 94.2 | 2.29 | 0.02 | 2.31 | 4.62 | 192.38 |
| **TPS (GTG-1)** | 274.0 | 0.0 | 0.05 | 0.00 | 0.05 | 0.11 | 4.57 |
| **NHDT** | 0.0 | 2.8 | 0.00 | 0.000 | 0.00 | 0.00 | 0.04 |
| **PRIME-G** | 0.0 | 3.1 | 0.00 | 0.000 | 0.00 | 0.00 | 0.04 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **RFCCU** | 369.6 | | 14.78 | 0.00 | 14.78 | 7.98 | 332.64 |
| **SRU** | | | | | 0.12 | 0.06 | 2.68 |
| **Extra Fuel Required** | | | | | | | |
| Power | 75.0 | 0.0 | 0.56 | 0.000 | 0.56 | 1.13 | 46.88 |
| HP Steam | 163.0 | 0.0 | 1.22 | 0.000 | 1.22 | 2.45 | 101.90 |
| Fuel for Furnace | 75.0 | 8.2 | 0.56 | 0.001 | 0.56 | 1.13 | 46.96 |
| **Total** | | | | | | | **815** |

**Flag-9**

**Note on how SO2 and NOX will be controlled at the existing level leading to no increase in pollution load.**

**Following measures will be taken so as to control SO2 and NOX emissions:**

1. Existing SRU of 80 MTPD capacity will be utilized for recovering excess Sulphur.
2. Use of low sulphur fuels for internal fuel purpose.
3. The heights of new stacks will be determined taking into consideration the "Guidelines for Minimum Stack Height" as per notification by MoEF dated 19th May 1993, which fixes the minimum stack height based on emission of Sulphur dioxide.
4. Low/Ultra low NOx burners will be provided in all new furnaces.
5. RLNG as substitute of IFO will be introduced in the refinery in synchronization with cross country gas pipeline laying in the region. Enabling activities viz. gas conversion in HGU and gas skids etc have commenced. With introduction of RLNG the SO2 emission is expected to come down to present emission level.

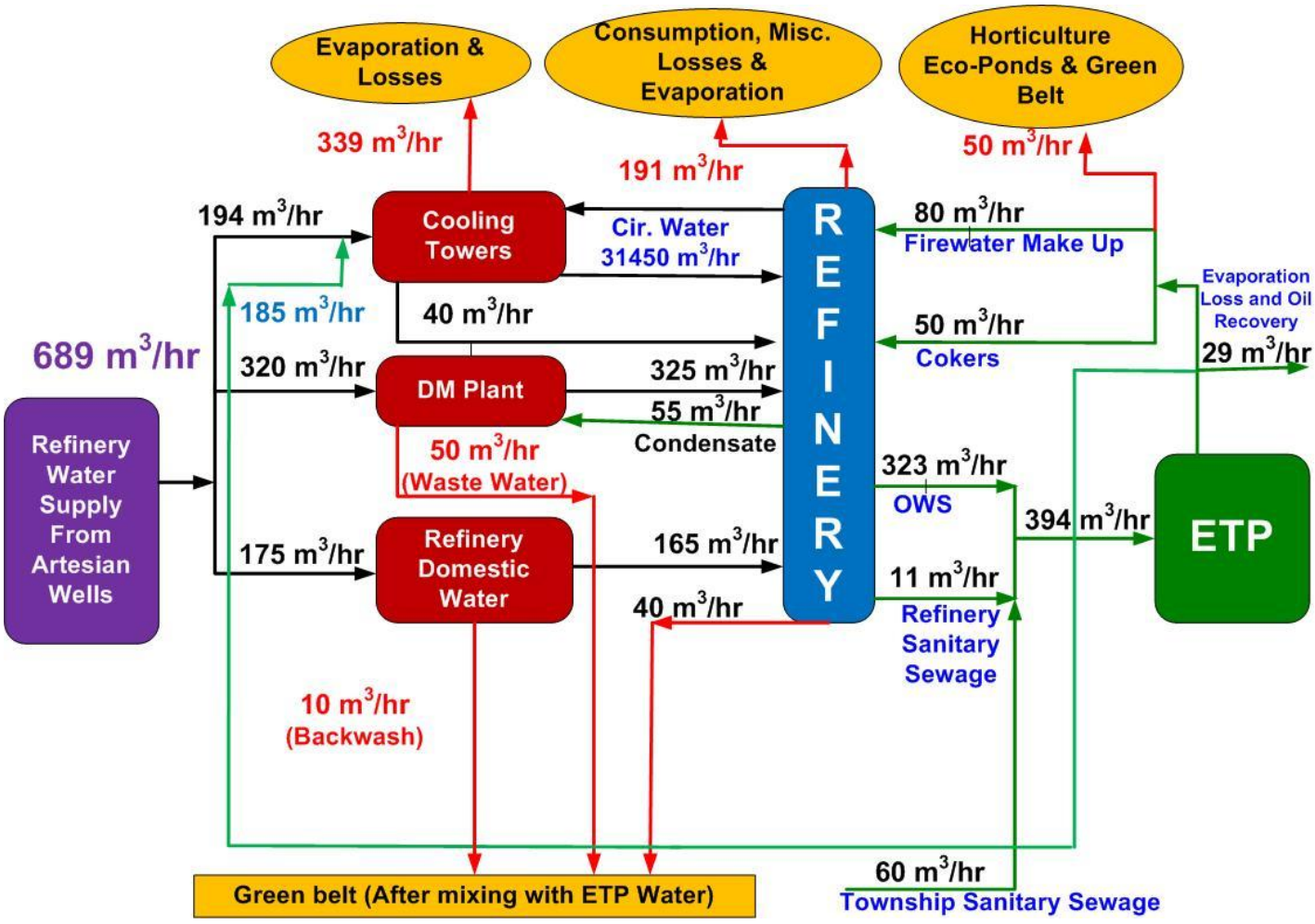
**Flag-10**

**Unit-wise air pollution control devices to be installed for the proposed units**

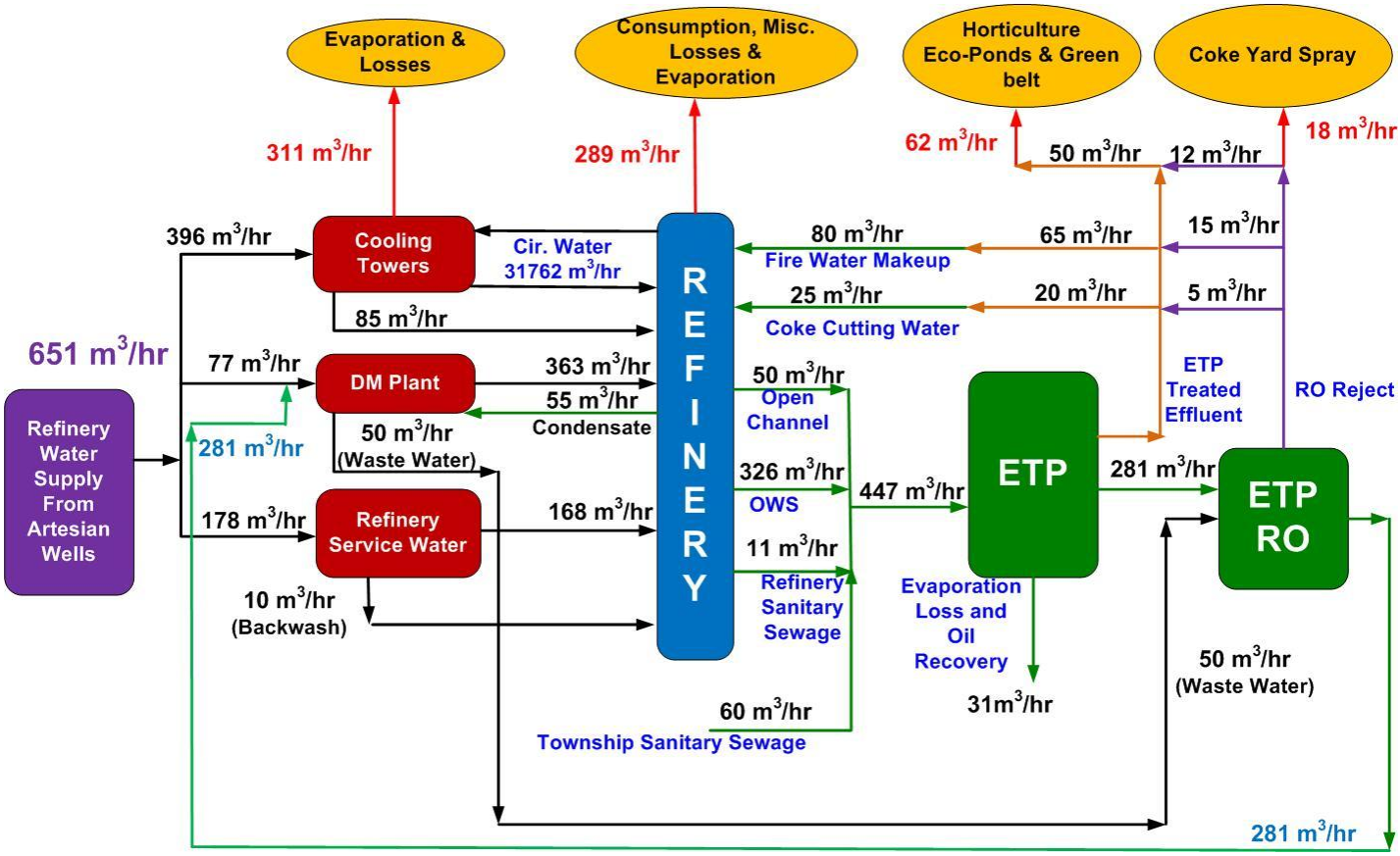
1. Low NOx/Ultra low NOx burners will be installed in all new furnaces.
2. Coker A will be operated in Single furnace mode operation.
3. Installation of additional amine absorption column and regenerator.
4. Off gases from Biturox Unit will be routed to CO incinerator in RFCCU ensuring total oxidation.
5. BenSat (Benzene Saturation) Unit will be installed as part of the proposed project in line with benzene specification in BS-IV MS.

Flag-11

## Present Water balance Chart



## Water balance Chart after BS-IV Project

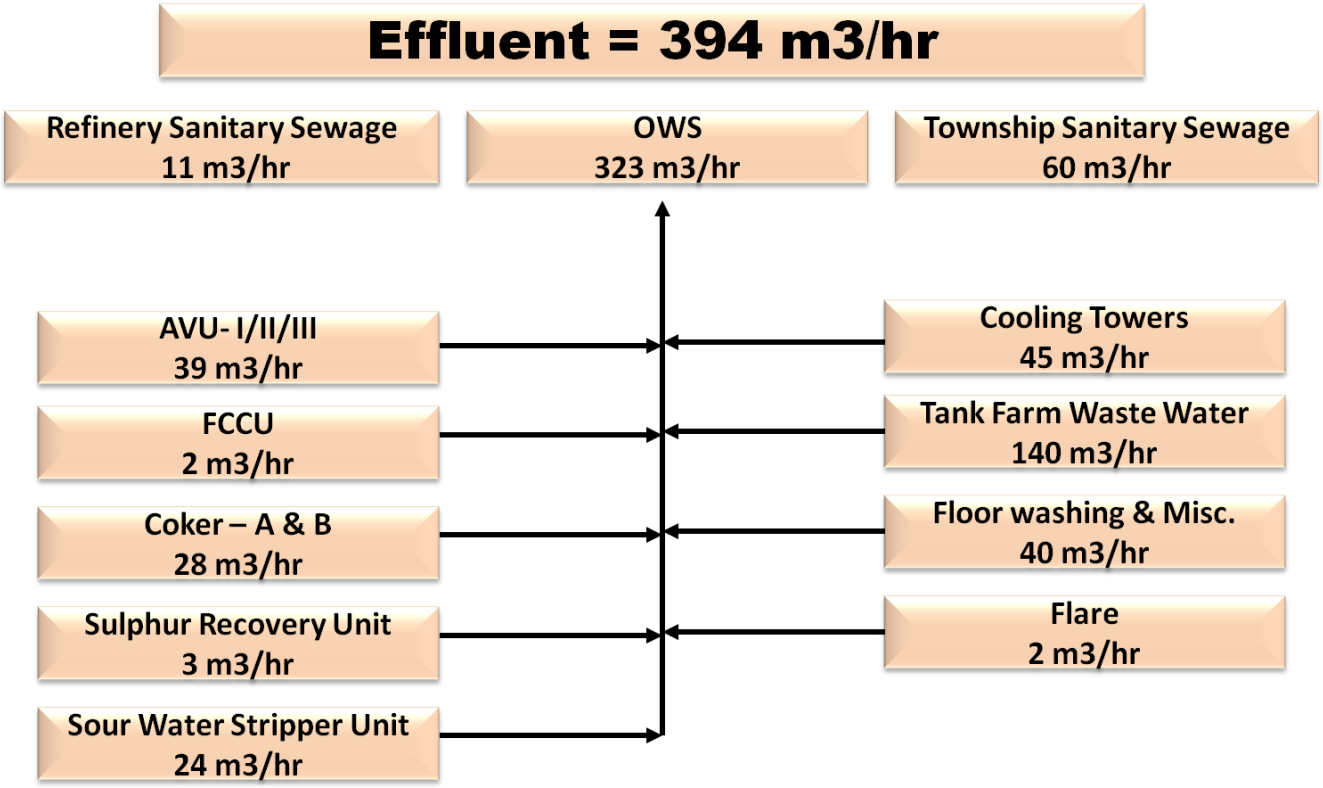



## Action plan for reduction of water requirement:

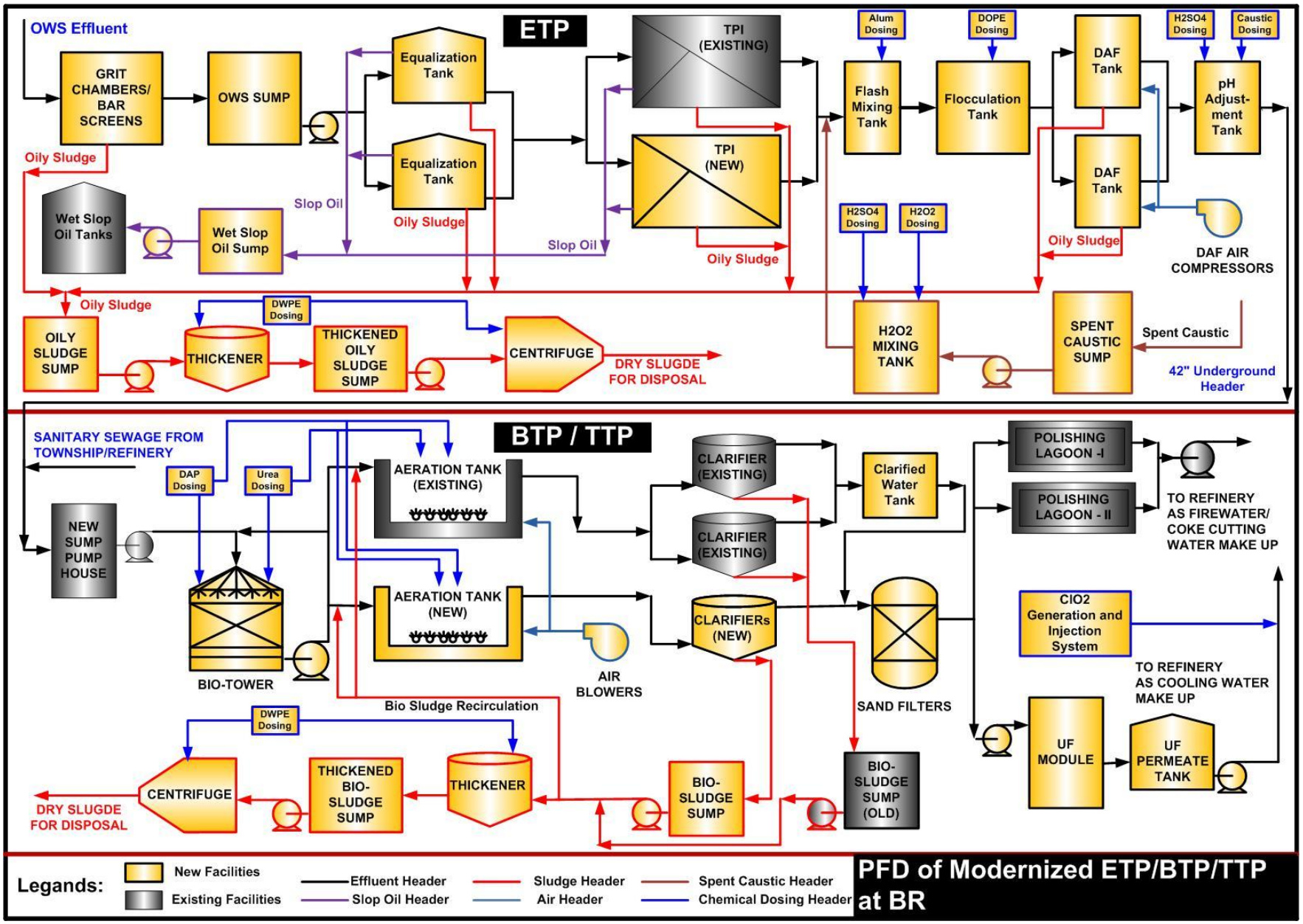
RO Plant is under construction at Barauni Refinery after which treated effluent will be reused as DM Plant makeup resulting in reduction of fresh water consumption from 689 $m^3$/hr to 651 $m^3$/hr.

Flag-12

## Quantity of Effluent generation of Barauni Refinery at present:



# Present Effluent Treatment Scheme



# ETP (Effluent Treatment Plant) at Barauni Refinery

Barauni Refinery has modernized its Effluent Treatment Facilities for the treatment of refinery waste water (Oily water Sewage) generated from process units and tank farm area as well as township & Refinery sanitary sewage at a cost of Rs. 112 Crore.

Following facilities (modifications & new facilities) have been installed under this project

**Primary treatment (Modifications & New Facilities)**

1. Equalization Tank with fixed roof to absorb shock loads and to contain VOC emissions.
2. Removal of free & emulsified oil with a combination of Tilted Plate Interceptor (TPI) & Dissolved Air Floatation (DAF) system. Free oil & Grease (Globule Dia.>60 microns) will be removed with the help of gravity in TPI. Thereafter residual free oil and emulsified oil will be removed with the help of chemical coagulation and flotation/settling in DAF system.
3. Bio-sludge Thickener and Centrifuge to reduce the amount of sludge generated by drying it out and recovering maximum amount of water and oil entrapped.
4. Spent caustic Treatment by $H_2O_2$ for converting poisonous sulfides into harmless sulphates .

**SECONDARY TREATMENT**

1. Bio-tower as first stage bio-treatment for transforming and breaking pollutants down into more treatable and less polluting forms of matter biologically.
2. Extended aeration system based on Fine Bubble Diffusers as second stage bio-treatment.
3. Clarifiers for effectively removing the bio-sludge generated.
4. 8nos. of Low Pressure Sand Filters with air scouring and backwashing arrangements to achieve supplemental removal of suspended solids.
5. Bio-sludge Thickener and Centrifuge to reduce the amount of sludge generated by drying it out and recovering maximum amount of water and oil entrapped.

**TERTIARY TREATMENT**

Ultra-filtration Modules (UFM) along with all necessary treatment facilities have been installed for treatment of a part of the effleunt for reducing suspended solids, turbidity and BOD levels in the filtered water so that the treated effluent can be re-used as fresh water make up in the cooling towers.

**Flag-13**

**Detailed solid waste generation, collection, segregation, its recycling and reuse, treatment and disposal.**

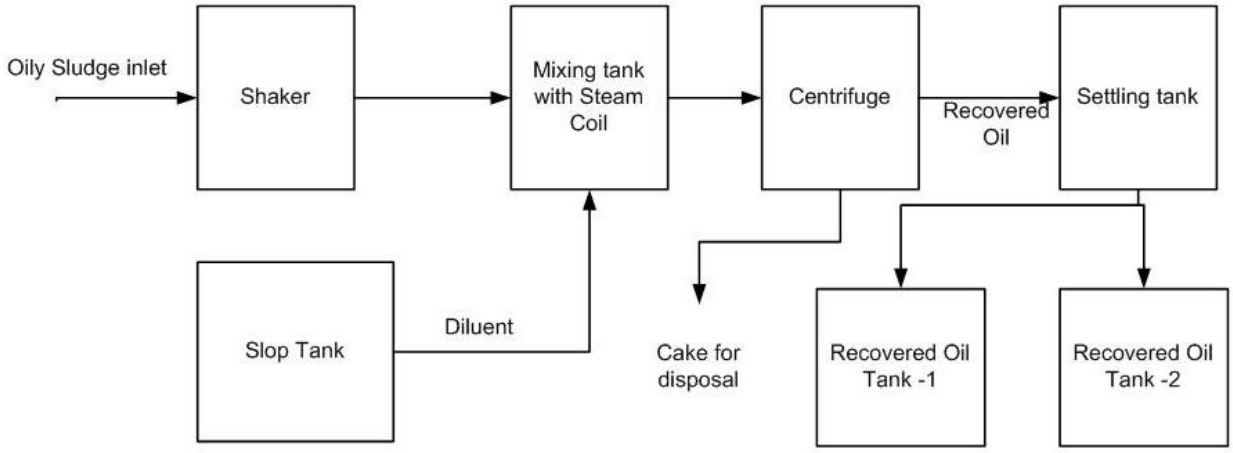
| Sl.No | Waste | Generation, Collection, Segregation Disposal methodology |
|---|---|---|
| 1 | Oily Sludge | • Oily sludge is mainly generated from tank cleaning and ETP. Oily sludge is collected in closed tankers and loaded in tractor for disposal through mechanized skid process.<br>• Currently M/s Balmer Lawrie has been lined up for processing of Oily sludge through this process. |
| 2 | Spent Catalyst | • RFCCU Spent Cat is generated on continuous basis in which a part of catalyst being circulated in the reactor-regenerator section is taken out so that activity of catalyst is maintained.<br>• RFCCU Spent catalyst is stored in the jumbo bags in which fresh catalyst are stored. Same is co-processed in Cement Industry.<br>• One time Catalyst is generated whenever the activity of catalyst is reduced to such a level that further plant operation is not possible. These catalysts are stored in drums and are disposed off through MSTC. |
| 4 | Horticulture Waste | • Since refinery is built in such a large area hence horticulture waste mainly grass is generated which is processed in Organic Waste Convertor. |
| 5 | Kitchen wastes of Township & Canteen mixed Wastes | • Kitchen wastes are generated in every household of the township. Also canteen wastes are generated in refinery. Both these waste are collected and processed in Organic Waste Convertor. |
| 6 | Waste Batteries | • Waste batteries generated and returned back to manufactures/vendors under buyback scheme. |
| 7 | Metal Waste and drums | • Metal waste and drum waste generated are disposed through MSTC. |

**Flag -14**

## Oily Sludge Management

Oily sludge is generated mainly during cleaning of storage tanks and from ETP. It is processed by **"Mechanized Skid Process"** for recovery of 90-95% oil from oily sludge and generation of minimum quantity of residual oily sludge. Mechanical extraction method uses solvent & steam heating and then oily sludge is processed in a plant equipped with centrifuge in order to recover maximum possible oil and water. The sludge is broken down into water, oil and base sediments. Water is drained into ETP for further treatment while the recovered oil is pumped into slop oil tanks for reprocessing in the refinery. The base sediment (residual oily sludge) in solid state has an oil content of around 3-8 %wt and is disposed through bioremediation facility inside the refinery.

Detailed process flow diagram for the same is shown as below.




## Bioremediation of residual Oily Sludge

Residual sludge generated from mechanized skid process is disposed off by means of bioremediation in lined pits. In this process, residual oily sludge generated is degraded into water and carbon dioxide by spreading sludge on earmarked site and applying bacterial consortium Oilivorous-S along with nutrients. The designated area is tilled every fortnight using a tractor trailer. The Oilivorous –S bacteria, developed jointly by M/S TERI and IOCL (R&D), eats away the residual oil.

**Availability of Common Integrated Treatment, Storage & Disposal Facilities (TSDFs) with Common Incinerators & Secured Landfills in various States/UTs**

| S. No. | Name of the State/UT | Integrated TSDFs (with both SLF and Incinerator) | TSDFs with Only Common Incinerators | TSDFs with only Common Secured Landfills |
|---|---|---|---|---|
| 1. | Andhra Pradesh | 1 | - | - |
| 2. | Gujarat | 4 | 1 | 4 |
| 3. | Haryana | 1 | - | - |
| 4. | Himachal Pradesh | - | - | 1 |
| 5. | Karnataka | - | 5 | 1 |
| 6. | Kerala | - | - | 1 |
| 7. | Madhya Pradesh | 1 | - | - |
| 8. | Maharashtra | 3 | - | 1 |
| 9. | Orissa | - | - | 1 |
| 10 | Punjab | - | - | 1 |
| 11 | Rajasthan | | 1 | 2 |
| 12 | Tamil Nadu | 1 | - | - |
| 13 | Telangana | 1 | - | - |
| 14 | UP | 2 | 1 | 1 |
| 15 | Uttarakhand | 1 | - | - |
| 16 | West Bengal | 1 | - | - |
| 17 | Daman, Diu, Dadra & Nagar Haveli | 1 | - | - |
| **TOTAL** | | **17** | **8** | **13** |

**State-wise availability of Common Hazardous Waste Treatment, Storage & Disposal Facility (TSDF) & Common Incinerators in various States/UTs**

| S.No. | Name of the State/UT | Name and Address of the facilities |
|---|---|---|
| 1. | Andhra Pradesh | No of TSDFs - 01<br><br>TSDFs integrated – 1 no.<br>(i) M/s Coastal Waste Management Project, Jawaharlal Nehru Pharma City, E-Bonangi, IDA, Parawada, Vishakhapatnam |
| 2. | Arunachal Pradesh | Nil |
| 3. | Assam | Nil |
| 4. | Bihar | Nil |
| 5. | Chhattisgarh | Nil |
| 6. | Delhi | Nil |
| 7. | Goa | Nil |
| 8. | Gujarat | No of TSDFs - 09<br><br>TSDFs Integrated – 4 nos<br>(i) M/s Nandesari Environment Control Ltd, 519-P, GIDC, Nandesari, Dist. Vadodara<br>(ii) M/s Bharuch Enviro Infrastructure Ltd. Plot no. 9701-9716, GIDC, Ankleshwar-393 002 (Gujrat)<br>(iii) M/s Gujarat Env. Protection & Infrastructure Ltd., Village Gabheni, Near Sachin G.I.D.C. Surat – 394 230. Gujarat.<br>(iv) M/s Saurashtra Enviro Projects Pvt Ltd. Survey no. 415, 417 & 418, Vill Juna katariya, Tal-Bhachau, Dist-Kutch, Gujarat<br><br>TSDFs with common SLFs - 4 nos<br>(i) M/s Naroda Enviro Project Ltd., GIDC Odhav, Dist-Ahmedabad<br>(ii) M/s The Green Environment Services Co-op. Society Ltd. Survey no. 89-90-91, Vill Vinzol, Ahmedabad, Gujarat<br>(iii) M/s Vapi Wate & Effluent Management Co. Ltd. Plot no. 4807, etc. Phase IV GIDC, Vapi, Dist: Valsad, Gujarat<br>(iv) M/s Gujarat Maritime Board, Alang Dist. Bhavnagar<br><br>TSDFs with only Common Incinerator – 1 nos<br>(i) M/s Gujarat Eco Textile Park, Palsana Crossing NH-8, District Surat–394 315, Gujarat |
| 9. | Haryana | No of TSDFs - 01<br><br>TSDF integrated – 1 no.<br>(i) M/s Gujarat Env. Protection & Infrastructure Ltd, Pali, Faridabad, Haryana |

| S.No. | Name of the State/UT | Name and Address of the facilities |
|---|---|---|
| 10. | Himachal Pradesh | No of TSDFs - 01<br><br>TSDF with only common SLF – 01 no.<br>(i) M/s Shivalik Solid Waste Management Ltd. Vill Majra, P.O. Dabhota, Teh. Nalagarh, Distt Solan (H.P.) |
| 11. | Jammu & Kashmir | Nil |
| 12. | Jharkhand | Nil |
| 13. | Karnataka | No of TSDFs - 06<br><br>TSDF with only common SLF – 1 no.<br>(i) M/s Karnataka Waste Management Project , NH-207, Doddaballapur Road, KIADB, Industrial Area, Dobbaspet, Nelamangal Tq, Bangalore Rural, Distt-562111<br><br>TSDF with only common Incinerators – 5 nos<br>(i) M/s Haat Incinerators India Pvt Ltd, #35 B & C, Jigani Industrial Area, Bangalore – 560 105<br>(ii) M/s Gomti Incinco, # 3 – B-2, 1st Phase, KIADB Indl Area, Kumbalgodu, Mysore Road, Bangalore – 560 074<br>(iii) M/s Century Refineries (P) Ltd, # 17 A & B, KIADB Indl. Area, Hoskote Taluk, Bengaluru – 562114<br>(iv) M/s. Bangalore Incinerator Pvt. Ltd., No. 28, KIADB Industrial Area,Kallanayakana Village, Huthridurga Hobli, Kunigal Taluk, Tumkur<br>(v) M/s. E Nano Incintech, Plot No.,342-B, of Harohalli Industrial Area,2nd Phase, 2nd Sector, Ramanagar |
| 14. | Kerala | No of TSDFs - 01<br><br>TSDF with only common SLF – 1 no.<br>(i) M/s Keral Enviro Infrastructure Ltd., Common TSDF Project, Inside Fact-CD Campus, Ambalmedu, Kochi-682 303 |
| 15. | Madhya Pradesh | No of TSDFs - 01<br><br>TSDF Integrated – 1no.<br>(i) M/s Madhya Pradesh Waste Management Project (Division of Ramky Enviro Engineers Ltd.) Plot No. 104, Industrial Area No.-II, Pithampur, Dist- Dhar 454 775 (M.P.) |
| 16. | Maharashtra | Total TSDFs - 04<br><br>TSDFs Integrated – 3 nos<br>(i) M/s. Vidharbha Enviro Protection Ltd., Sr.No.7 to 15, 131 & 162, Butibori Industrial Area, Mouza- Mandawa, Taluka- Hingana, Dist- Nagpur<br>(ii) M/s. Maharashtra Enviro Power Ltd., Plot No. 56, MIDC Ranjangaon, Taluka- Shirur, Dist – Pune.<br>(iii) M/s Mumbai Waste Management Ltd., Plot No. P-32, MIDC Taloja, Tal: Panvel, Dist. Raigad- 410 208 |

| S.No. | Name of the State/UT | Name and Address of the facilities |
|---|---|---|
| | | TSDFs with only common SLF– 1 nos<br>(i) M/s. Trans Thane Creek Waste Management Association,P-128, Shil-Mahape Road, Next to L&T Infotech Ltd. Mahape, Navi-Mumbai-400105 |
| 17. | Manipur | Nil |
| 18. | Meghalaya | Nil |
| 19. | Mizoram | Nil |
| 20 | Nagaland | Nil |
| 21. | Orissa | No of TSDFs – 01<br><br>TSDF with only common SLF - 1 no.<br>(i) M/s Orissa Waste Management Project a Div of M/s Ramky Enviro Engineers Ltd), At- Village Kanchichuva, Po-Mangalpur, Via-Sukinda, Jajpur |
| 22. | Punjab | No of TSDFs – 01<br><br>TSDF with only common SLF - 1 no.<br>(i) M/s Punjab Waste Management Project, Village-Nimbua, PO-Rampur Sainia, Teh-Derabassi, Distt-Mohali (Punjab) |
| 23. | Rajasthan | No of TSDFs – 03<br><br>TSDF with only common SLF - 2 nos.<br>(i) M/s Rajasthan Waste Management Project (a Div of M/s Ramky Enviro Engineers Ltd) Survey no. 1018/13, Vill-Gudli,Tehsil-Mavli, Zinc Choraha to Debari Railway Station Road, Dist-Udaipur (Rajasthan)<br>(ii) M/s Balotra Waste Management Project (a Div of M/sRamky Enviro Engineers Ltd), Survey No & Plot No-1114/274/13 & 1115/274/14, Village Kher, Tehsil- Pachpadra, Distt- Barmer (Rajasthan)<br><br>TSDF with only common Incinerator – 1<br>(i) M/s Continental Petroleum Ltd., Bheror, Distt- Alwar |
| 24. | Sikkim | Nil |
| 25. | Tamil Nadu | No of TSDFs – 01<br><br>TSDF Integrated - 1 no.<br>(i) M/s. Tamil nadu Waste Management Ltd (M/s Ramky Agencies, Hyderabad) Gummidpoondi in Thiruvallur District |
| 26. | Telangana | No of TSDFs – 01<br><br>TSDF Integrated - 1 no.<br>(i) M/s Hyderabad Waste Management Project (Ramky Enviro Engineers Ltd) Survey no. 684/1, Dundigal village, Qutbullapur |

| S.No. | Name of the State/UT | Name and Address of the facilities |
|---|---|---|
| | | Mandal, R.R. Dist- 500 043 (A.P.) |
| 27. | Tripura | Nil |
| 28. | UP | No of TSDFs – 04<br><br>TSDFs Integrated - 2 nos.<br>(i) M/s Bharat Oil & Waste Management Ltd. Gate No. 672, Vill. Kumbhi, NH-2, Kanpur Dehat (UP)<br>(ii) M/s Uttar Pradesh Waste Management Project (M/s Ramky Enviro Engineers Ltd.,) Plot No. 672, Village – Kumbhi, Tehsil: Akbarpur, on Sikandara Road-NH –2, Dist – Kanpur Dehat (U.P.)<br><br>TSDFs with only common SLF - 1 no.<br>(i) M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.<br><br>TSDFs with only common Incinerator – 1 no.<br>(i) M/s Bharat Oil Company (India) Regd., E-18, Site IV, Sahibabad Industrial Area, Ghaziabad, UP 201010, India |
| 29. | Uttarakhand | No of TSDFs – 01<br><br>TSDFs Integrated - 1 no.<br>(i) M/s Bharat Oil & Waste Management Ltd. Mauza Mukimpur, Roorkee-Laskar Road, Roorkee, Haridwar |
| 30. | West Bengal | No of TSDFs – 01<br><br>TSDFs Integrated - 1 no.<br>(i) M/s West Bengal Waste Management Ltd. J.L. no. -103, Mouza-Shrikrishnapor, P. S. -Sutahata Dist- Purba Midnapore, Haldia-721 635 (W.B.). |
| 31. | Andaman & Nicobar Islands | Nil |
| 32. | Chandigarh | Nil |
| 33. | Daman, Diu, Dadra & Nagar Haveli | No of TSDFs – 01<br><br>TSDFs Integrated - 1 no.<br>(i) M/s Gujarat Enviro Protection & Infrastructure (D&NH) Pvt Ltd, Survey no. 9/1, Mota Randha Village,Silvassa-396230 |
| 34. | Lakshdweep | Nil |
| 35. | Pondicherry | Nil |

**Flag-16**

**Details of proposed preventive measures for leakages and accident.**

- Job safety analysis: Carried out by a multi-disciplinary team for all critical jobs to identify job related hazards
- Structured safety tour: Top management (DGMs & above) makes visit to site as per TPM visit calendar. Special attention is given to unsafe acts, unsafe conditions.
- Lock out tag out system: 100% Implementation of LOTO at all the locations for HT and LT feeders.
- Internal Safety Audit: Yearly Internal safety audit of refinery is being done as per OISD standard.
- System Audit: Annual 15 nos. System Audit for system monitoring and recommendations are and liquidation plan is monitored.
- Process Safety Performance Indicator: Critical Process parameters of units are listed out and regularly monitored by online RTDBMS. Committee is analyzing the critical findings in meeting and accordingly action plan is taken.
- Near miss analysis : All accidents / incidents / near-misses are analyzed for identification and elimination of root causes. Actionable points identified are liquidated in time bound manner.
- Tool Box talk record before any critical job: Ensured Tool Box talk before any critical job at site.
- Electrical audit by senior officers: A quarterly electrical audit by senior officers to verify the electrical permit system and its compliance is in practice.
- Standard Operating Procedures: Checklist based SOP and Work Instruction format is being followed.
- Sectional Safety & Health Committee Meeting: SSHCM is in practice at different locations in the Refinery in a month to record different safety issues & all points are discussed to liquidate immediately the Safety & Health related issues.
- MSHCM: On 1st working day of every month, Management safety meeting is held and all the safety issues are discussed and action plan is circulated to liquidate the recommendations. Also meeting start with safety talk. Minutes are noted and circulated accordingly.

**Flag-17**

## Environment Management Plan

Barauni Refinery has a detailed Environmental Management Programme and it meets all statutory requirements. Point wise Environment Management Plan is as follows:

1. **Air Environment**

   The gaseous emissions from the Refinery complex will be controlled to meet all the relevant standards stipulated by the regulatory authorities. Standards applicable to this Refinery project can be classified into three categories:

   - Emission Standards
   - Ambient Air Standards and
   - VOC Control, Emission and Monitoring

   The standards and compliance to the above standards are given below:

   - **Emission Standards:**
     - Heaters/furnaces will be provided with well proven Low NOx burners to reduce the emissions of Nitrogen Oxides (NOx).
     - The heights of new stacks will be determined taking into consideration the "Guidelines for Minimum Stack Height" as per notification by MoEF dated 19th May 1993, which fixes the minimum stack height based on emission of Sulphur Dioxide.

   - **VOC Control, Emission and Monitoring**

     Fugitive emissions originate from the static and dynamic compressor joints and seals used in flanges, pumps, valve packings and connection joints to the atmosphere like sampling, relief valves, etc.

     In order to minimize the fugitive emissions, the following measures will be taken:
     - Usage of minimum number of flanges, valves, etc.
     - High grade gasket material for packing.
     - Usage of state-of-the-art low leakage valves preferably with bellow seals.
     - Usage of pumps with mechanical seals.
     - Provision of seals in the drains and manholes.

2. **Noise Environment**

Comprehensive measures for noise control, at the design stage, shall be followed in terms of the following:

- Noise level specification of various rotating equipment as per Occupational Safety and Health Association (OSHA) standards.
- Equipment layout considering segregation of high noise generating sources.
- Erecting suitable enclosures, if required, to minimize the impact of high noise generating sources.
- Sizing the flare lines with low Mach number to have lower noise levels.'

3. **Water Environment**

- **Raw water requirement:** Post project fresh water will be taken from ground water. For this purpose, 7 nos of artesian wells will be used.
- **Effluent treatment plant:** Existing effluent treatment plant which has recently been modernized is sufficient to cater to the effluent load after the implementation of project. Further RO Plant is under installation which will further treat the effluent and will help in reuse of treated effluent in DM Plant.

4. **Land Environment**

During the design stage itself due care will be taken to select the process technologies generating minimum solid wastes so that their handling, treatment and disposal do not cause any serious impact on the existing land environment. The solid wastes management plan proposed is briefly described below.

There are primarily four types of solid wastes generated in a refinery:

1. ETP Sludge's
2. Tank Bottoms
4. Chemicals

**ETP Sludge**

The oily & chemical sludge separated in different units of ETP, viz., TPI/DAF shall be dewatered, handled and disposed as per existing practice.

**Tank Bottom Sludge**

This sludge is generated periodically during tank cleaning operations. Tank bottom sludge shall be handled and disposed as per existing practice.

**Chemicals**

Chemicals used in various process units will be procured, stored and use as per the rules of "Manufacture Storage and import of hazardous chemicals Rules 1989, amended 2000

**Flag-18**

**Total capital cost and recurring cost/annum for environmental pollution control measures.**

| **Capital Cost** | | |
|---|---|---|
| **S.N** | **Activity** | **Expenditure (Rs Crore)** |
| 1 | Effluent Treatment Plant (ETP), Biological Treatment Plant (BTP & Tertiary Treatment Plant (TTP) | 110 |
| 2 | 04 Manual Ambient Air Quality Monitoring Stations | 1.2 |
| 3 | 01 Continuous Ambient Air Quality Monitoring Station | 0.75 |
| 4 | 19 Stack Monitoring Stations | 3.5 |
| 5 | Connectivity of CAAQMS & Stack Monitoring to CPCB server | 0.66 |
| 6 | Development of Bio-remediation site | 0.50 |
| 7 | RO plant for treated effluent at BTP | 67.0 |
| 8 | Rain Water Harvesting | 0.45 |
| 9 | Alternate Fuel ( 25 KW Solar Panel ) | 0.27 |
| **10** | **Total** | **184.33** |

| Total Recurring Cost/annum | | |
|---|---|---|
| **S.N** | **Activity** | **Expenditure Rs (Lac/annum)** |
| 1 | Operation & Maintenance of ETP, BTP & TTP | 150.00 |
| 2 | Ambient Air Quality Monitoring, Stack Monitoring, Ground Water Monitoring, Noise monitoring, Work area monitoring and VOC/LDAR monitoring by accredited consultants | 32.21 |
| 3 | Recovery of oily from oily sludge on Turnkey basis | 168.00 |
| 4 | Dedicated effluent treatment plant Lab | 20.00 |
| 5 | Repair & Maintenance of AAQMS & Stack analyzers | 25.26 |
| 6 | Bio-remediation | 11.09 |
| 7 | Tree plantation | 15.25 |
| 8 | Rain Water Harvesting | 20.25 |
| 9 | Eco park & Green Belt development | 12.25 |
| **10** | **Total** | **454.31** |