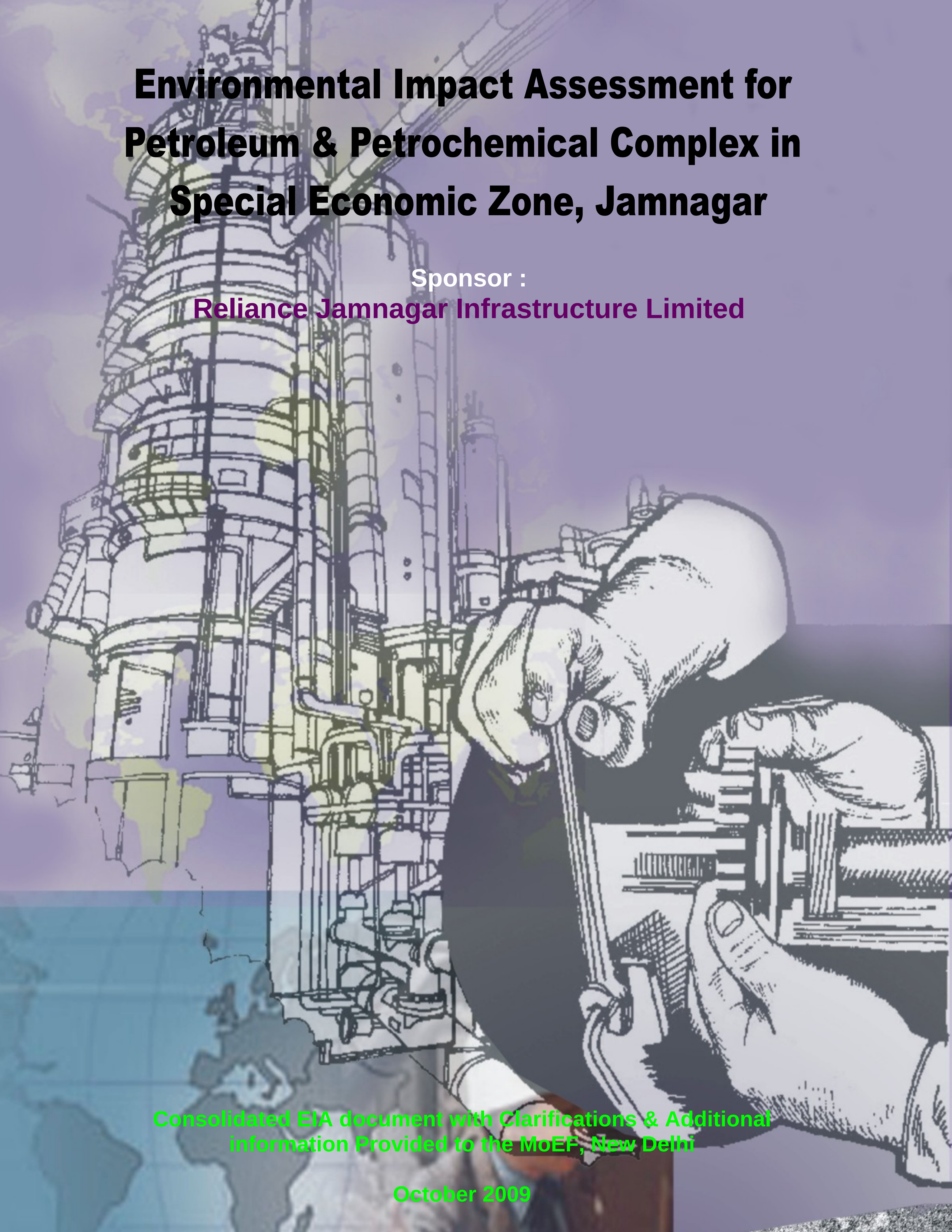

Environmental Impact Assessment for Petroleum & Petrochemical Complex in Special Economic Zone, Jamnagar

Sponsor :

Reliance Jamnagar Infrastructure Limited

Consolidated EIA document with Clarifications & Additional information Provided to the MoEF, New Delhi

October 2009

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1.0 Introduction

The enactment of SEZ Act 2005 by the Central Government and the State SEZ Act and rules notified by the State Government of Gujarat has enthused Reliance Jamnagar Infrastructure Limited (RJIL) to set up a multi-product Special Economic Zone in the backward rural area of Jamnagar district of Gujarat with modern integrated infrastructure. The SEZ will have all the required infrastructure and facilities to ensure sustainable development of medium and large-scale industries and service activities.

The proposed site is located near the State Highway No 25 on the way from Rajkot to Okha and is adjacent to the existing refinery complex of Reliance Industries Limited (RIL). The overall size of the SEZ is approximately 4,545 hectares (11,231 acres).

The latitude and longitude of the center of the proposed SEZ are 22^{o} 20’ 30” North and 69^{o} 53’ 00’’ East.

The various petroleum and petrochemical downstream units which can be set up in the proposed SEZ are as follows:

C1 Based Units

- Coke Gasification
- Methanol Synthesis
- Acetic Acid
- Vinyl Acetate Monomer
- Polyvinyl Acetate (PVA)
- Polyvinyl Alcohols (PVOH)

C2 Based Units

- Multifeed Cracker Complex
- Ehtylene Oxide Derivatives like Mono Ethylene Glycol (MEG), Di Ethylene Glycol (DEG) Tri Ethylene Glycol (TEG)

- Polyethylene polymers like Low Density Polyethylene, Linear Low Density Polyethylene (LLDPE), High Density Polyethylene

C3 Based Units

- Acrylic Acid & derivatives , Super Absorbent Polymer (SAP)
- Acrylates (Methyl, Butyl & 2 Hexyl & Oxy Alcohols)
- Propylene derivatives like Propylene Oxide, Cumene, Phenol
- Propylene Glycols
- Polyols
- Hydrogen Peroxide (H2O2)
- Polypropylene PP (Non woven)
- Polypropylene (PP)

C4/C5 Based Units

- Butyl Rubber , Styrene Butadiene Rubber (SBR) ,
- Poly Butadiene Rubber (PBR)
- Butene 1
- Maleic Anhydride (MA)
- Fumaric Acid

C6/ C7/ C8 Based Units

- Benzene
- Styrene
- Paraxylene (PX), Orthoxylene (OX)
- Putrefied Teraphthalic acid (PTA)
- Polyethylene Tera-phthalate (PET)
- Polyesters Complex Polyester Oriented Yarn (POY)
- Polyester Stable Fibre (PSF)

Carbon Black Feedstock

Lube Oil cum refinery Complex (LOBS)

Captive Power Plant

& Jamnagar Export Refinery Project (JERP) which has already been accorded Environmental Clearance by the MoEF in 2005 / 2006.

The Modernization and de-bottle necking of the existing refinery and expansion refinery (called as Jamnagar Export Refinery) along with their infrastructure had been accorded the environmental clearance by the ministry in 2005 and amended in 2006. Since this JERP is being built in the SEZ area, JERP is included in the EIA. However, the emissions of JERP are included in the analysis of this study.

The common facilities for the proposed SEZ are Captive power plant, Desalination Plant, Central ETP, Incinerator and a Secured disposal facility. The desalination plant will be providing 15,000 cu m/hr of water required for the industrial and the residential complex.

The power requirement for the proposed zone would be met through a captive power plant of 2100 MW capacity to be set up as a part of the SEZ infrastructure.

Government of India have announced a Policy of Special Economic Zones (SEZs) during March 2005 with a view to augmenting infrastructure facilities for export production.

The Central Government has offered various incentives and facilities both to developer of SEZ as well as the industrial units coming up on SEZ. All approvals are to be given by the Development Commissioner for establishment of the unit in SEZ. The management of the Special Economic Zone will be under the designated Development Commissioner.

The Development Commissioner will grant all the permissions as Single Point Clearance from his office. These will include registration of the unit, allocation of land, permission for construction of building and approval of building plan, power connection, environmental clearance, water requirement etc.

Transactions within the SEZ shall be exempted from all State taxes including Sales Tax, VAT, Motor spirit tax, luxury tax and entertainment tax, purchase tax and other state taxes.

SEZ located in the Jamnagar district the, in close proximity to Arabian Sea. The other advantages are:

- It is well connected with important state road network (state highway no. 25) and other important national node via NH- 8A. It is about 30km from Jamnagar and 340km from Ahmedabad
- A broad gauge railway network connects Reliance SEZ with Jamnagar and other rail network
- Reliance port at Sikka, being a part of Reliance industries would contribute a good deal of efficiency in the functioning of the SEZ

- Airports at Jamnagar are in near proximity to the SEZ site only 25 km.

The Reliance will develop the industry, housing, social infrastructure needed for their refinery and its allied activities. The SEZ is expected to generate employment for 40,000 people.

A new Residential township is being proposed to house the employees and the growing influx of immigration due to the new industries coming up in the SEZ unit. The township will be designed on sectoral basis where each sector will be self-sufficient in terms of commercial, retail, public/semi-public amenities.

2.0 Key Findings

2.1 Air Environment

The ambient air environment monitoring was done in the year of 2005-06 winter seasons and the analysis is as follows.

AAQM locations were monitored on 24 hourly average basis as per the guidelines of CPCB and NAAQS. The conventional and project specific parameters such as Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NOx), Ammonia (NH_3), Carbon Monoxide (CO) and Non-Methane Hydrocarbons (NMHC) were monitored at AAQM Locations.

The overall 24 hourly wind rose during winter season indicates the predominant winds from N-E sector. During winter season, 98^{th} percentile values of 24 hourly SPM concentration ranged between 99.9-396 $\mu g/m^3$. The arithmetic mean varied between 87-256 $\mu g/m^3$. 98^{th} percentile and arithmetic mean of 24 hourly RSPM concentrations varied in the range of 60.8-175 $\mu g/m^3$ and 6-114 $\mu g/m^3$ respectively. The 98^{th} percentile concentrations of 24 hourly SO_2 in winter season varied from 6-31 $\mu g/m^3$. The arithmetic mean ranges from 4.5-22 $\mu g/m^3$.The 98^{th} percentile concentrations of 24 hourly NOx in winter ranged between 10-30 $\mu g/m^3$. The arithmetic mean values varied between 6-20.33 $\mu g/m^3$.The arithmetic mean and 98^{th} percentile values of NH_3 were observed in the range of 10-192 $\mu g/m^3$ and 31-274 $\mu g/m^3$ .CO and NMHC concentrations at all the monitoring locations are observed to be varying in the range of 263-1139 $\mu g/m^3$ and BDL – 138 $\mu g/m^3$.

It was observed that SPM and RSPM concentrations exceeded the stipulated standards at most of the ambient air quality monitoring locations.

The Industrial Source Complex – Short Term Version 3 (ISCST-3) model has been developed to simulate the effect of emissions from point sources on air quality. As per the model, the maximum GLCs of SO_2 and NO_X from SEZ emission are estimated to be 57 μg/m3 (4.16 km, SSW Direction) and 56 μg/m3 (4.16 km, SSW Direction) respectively in winter season. The estimated GLCs for SO_2 and NO_X after superimposing with the baseline are in the range of 14-60 μg/m3 and 23-51 μg/m3 respectively within the stipulated standards for the industrial areas.

Subsequently, the ambient air monitoring was done for 2007-2008 winter season. The analysis as follows.

SPM:

The Ambient Air Quality Monitoring was carried out by NEERI during winter season (2008) wherein SPM concentration were observed at the border line / more than the average for the area at 15 places out of 24 locations.

As the Jamnagar SEZ located in a semi arid area with low green cover and very scanty rainfall in the last two years which are the main contributing factors for getting more values of Ground Level Concentration of SPM. The very low green cover (only 15%) can be seen from Landuse/land cover pattern satellite image given in EIA Report

The main contributing factor for the variation in the SPM values can be co-related with rainfall occurred during that period. The rainfall in 2007-08 season spread is confined to only 3 days. If the rain is spread over the season then moisture content in the soil remains for longer period which is helpful to minimize the dust resuspension and subsequently results in lower SPM value.

More SPM values are observed at Moti Khavadi, Arablus, Mungani, Satalus can be attributed because of the higher vehicular traffic, poor road conditions, dirt tracks, cattle movements etc. in the area.

SO2

The average SO_2 concentration was observed to be marginally more (than 30 μg/m3) at three locations. However, These SO_2 concentration are much less than the standards of National Ambient Air Quality Standards (NNAQS) for industrial / residential area.

Cl2

Generally the chloride in the ambient air is found out in the form of sodium chloride in the aerosol type condition typically near the sea coast due to the wind action. However, it will be quite difficult to measure by using the standard high volume sampling method. This is also has been checked in the literature.

As suggested by the honorable members of the committee “the Cl2 concentrations in the above mentioned range very rarely occur in typical urban pollution.

HCl

As in the case of CL2 the results are very erroneous.

2.2 Noise Environment

The noise levels ranged between 30-70 dBA during daytime and 38-60 dBA during nighttime. The noise levels in commercial areas varied in the range of 30-60 dBA during daytime and 43-53 dBA during nighttime.

Noise levels were measured in front of these industries during daytime and nighttime and observed to varying in the range of 46 – 59 dBA during daytime and 42 – 51 dBA during nighttime.

Noise levels were also monitored in schools, hospitals and temples in the study area. The noise levels varied from 47-55 dBA during daytime and 38-53 dBA during night time.

The noise levels are observed to be within the stipulated standards of CPCB for the respective zones in the study area except at few places.

The cumulative noise impact from different stationary sources at proposed project site has been predicted at 100mx100m grid intervals over an area of 33.52 km x 31.8 km noise impact area mainly covering project premises.

The predicted noise contours indicate that the maximum noise levels outsite the proposed SEZ would be 22 dBA. The predicted noise levels after superimposing the predicted noise levels with the baseline data is in the range of 41-60 dBA during the day time and 34-42 dBA during the night time.

2.3 Water Environment

In order to determine the surface and groundwater quality, three sampling locations for surface water, 18 sampling locations for groundwater were identified in the study area.

Surface Water

pH varied in the range of 8.6 – 8.8, turbidity 7 - 12 NTU, total dissolved solids (inorganic) 393-510 mg/l, hardness 206-313 mg/l, chloride 112-128 mg/l, and sulphate 25-32 mg/l.

Nutrient values in the form of nitrate-nitrogen and total phosphates are low in the range of 5.0 – 9.0 mg/l and 0.16-0.21 mg/l respectively. The values for demand parameters like DO, COD and BOD are in the range of 5.9 – 7.1 mg/l, 43 – 99 mg/l and 20-40 mg/l respectively. Oil & grease and hydrocarbons are found in non-detectable levels. The bacteriological characteristics of surface water showed total coliform counts in the range of 220 to 310 CFU/100 ml. Both the reservoirs were found to be faecally contaminated having faecal coliforms in the range of 30-45 CFU/100 ml.

Ground Water

The groundwater quality showed high mineral contents in the form of total dissolved solids, total hardness, chloride, sulphate and sodium and were found in the range of 477-3024 mg/l, 259-1592 mg/l, 123-1200 mg/l, 42-328 mg/l and 36-500 mg/l respectively. CFU/100 ml.

The groundwater in four villages (Gagwa, Kanachikari, Nanikhavdi and Mungni) is found to be faecally contaminated and unfit for human consumption, unless suitably treated.

The Shannon-Weaver Diversity Index for phytoplanktons varies from 2.25-3.79 and from 1.0-2.75 in surface water and groundwater (dug wells) respectively. The Shannon Weaver Diversity Index of zooplanktons which is found to vary in the range of 1.846-2.320 in surface water and 0.918 to 105 in groundwater indicates low to moderate productivity.

The proposed SEZ project requires water for boilers & heaters, processes, process cooling, utilities cooling, domestic consumption, fire water make up and greenbelt development/horticulture. The entire water requirement will be met from the desalination of seawater and supplemented with water from the Narmada Water project. The desal water requirement after expansion is estimated to be 15000 m^3/hr, and accordingly sea water requirement will be 36000 m^3/hr and the discharge back to the sea will be 23400 m^3/hr.

2.4 Land Environment

It is observed that soil texture varies from clay to sandy clay. The bulk density of soil of the impact zone is found to be 1.11 - 1.35 gm/cm^3 which is considered to be moderate. The porosity and water holding capacity of soil are in the range of 39-66% and 40-69% respectively. The soils have moderate water holding capacity.

The pH of soil in the study area are in the range of 6.52 - 8.6. The pH range of soil is found to be favorable for plant growth. Electrical conductivity, a measure of soluble salts in soil is in the range of 0.27-1.6 mS/cm. It is observed that calcium and magnesium concentrations are in the range of 0.12-3.92 meq/l and 0.02-1.43 meq/l respectively; whereas sodium and potassium are in the range of 0.08-1.03 meq/l and 0.02-0.15 meq/l respectively.

The landuse / landcover classification based on remote sensing analysis indicates 6.65% mudflat, 0.68% fringe vegetation, 2.40% saltpan, 26.09% agricultural land, 24.19 fallow land, 2.65% seawater, 3.07% built-up land, 32.23% barrenland, 2.02% waterbodies.

The major source of solid waste generated from SEZ complex will mainly consists of oily sludge, spent clay, spent catalysts, slope oil, biological sludge, canteen wastes, batteries, surplus drums, etc. The quantification of solid/hazardous wastes has been carried out and handling/management/treatment and disposal of these wastes will be carried out as per the stipulated guidelines and requirements of CPCB/MoEF.

2.5 Biological Environment

In all 30 locations were selected for study on biological aspects. The study area around the proposed SEZ comprises of terrestrial and marine ecosystems due to nearness to Gulf of Kutch. During the floristic survey in study area, a total of 165 plant species were recorded**.** A total of 76 tree species, 28 shrub species, 22 herb species, 23 grasses and 16 climbers were recorded from the study area.The study area shows presence of medicinal plants. Out of total 165 plants studied, 51 plant species including 25 trees, 10 herbs and 16 shrubs are of medicinal value. Not a single species out of 165 plant species was observed to be threatened in the study area**.** The staple food of the people in the study region is rice and wheat. The common *Kharif* crops of this region are groundnut, sesamum, cotton, castor, bajra etc. whereas wheat, gram, cumain, ajwan (semi-rabi) are the *Rabi* crops.

30 sampling sites were selected at various places in the study area for the assessment of avifauna. A total number of 20 species of birds were encountered during the survey.

2.6 Socioeconomic Environment

The study comprises 115 villages consisting of 38 villages of Jamnagar taluka, 41 villages of Khambaliya Taluka and 36 villages of Lalpur Taluka from Jamnagar district.

The significant demographic features are:

- The total no of households in the study area are 216222
- The total population in the study area is 1175132
- Sex ratio (No. of females per 1000 males) is 928
- It is observed that the study area has an average literacy rate of 60.24% and the employment rate is 30.33%

During the socio-economic survey in the 18 villages it was observed that people are facing certain problems.

The average QoL index value for the study area is leaning towards satisfactory level due to good economic status like low income, unemployment and also availability of basic needs, viz. food, clothing, and housing.

The area lacking with medical, educational facilities and social security, besides water scarcity, inadequate irrigation, lack of sanitation, which are subjective conditions and are not much satisfactory as compared to objective conditions.

It is estimated that about 50,000 construction workers on average will be involved for a period of 2-3 years. The total employment during the construction phase will be about 24 lakh man months (both skilled and non-skilled employment). The manpower required for these activities should preferably be employed from nearby villages so that avenues of employment will be open to local people

During the socio-economic survey it was observed that the proposed SEZ might create certain beneficial as well as adverse effects on the socio economic environment. Some of these impacts would be more effective for the immediate vicinity with short-term effects whereas the others would be higher order or of long term in nature.

3.0 Environmental Management Plan

RIL group has got a strong, consistent and committed corporate policy in the Environmental management in all the complexes. The Environmental parameters are internalized into the project planning, design, procurement, constructional and operational aspects. The RIL group as accorded several prestigious environmental management awards for their complexes by national and international agencies. For the purpose of the C1 to C8 petroleum and petrochemical complex the technology providers, licensors, vendors, EPC contractors and possible JV partners will be instructed to follow and implement the project environmental specifications which will be developed according to the applicable standards of Govt of India, State government and pollution control boards. The IFC /WB standards will also be integrated into the design.

3.1 Air Environment

The impact on air quality due to emissions from multiple sources during the continuous operations has been assessed by use of mathematical models. The incremental predicted GLC's of major air pollutants viz., SO2 and NOx due to the proposed SEZ developmental activities over the baseline air quality are within the stipulated standards of CPCB for industrial regions 1i.e. 120 μg/m3. However measures proposed for mitigating impacts on ambient air quality during the project operations include the following:

- Best Available Control Technology (BACT) should be installed at individual emission sources to minimize the air pollutant emissions
- Regular record on sulphur emission should be maintained at SEZ units as part of the environmental data records
- Off gases from proposed units should also be treated in amine absorption units and regeneration unit meant for H_2S removal as already in practice for desulphurization of off gases (fuel gas) in existing Reliance refinery
- Performance evaluation of Sulfur Recovery Units with Tail Gas Treatment Units should be done on regular basis (at scheduled intervals) through monitoring off gas flow rate
- In case of any failure in sulfur recovery units appropriate steps should be taken to match the generation with SRU feed
- FCCU should have particulate control systems such as Electrostatic Precipitators/cyclones/wet scrubbers
- The measures to reduce the SO_2 in furnaces, boilers, gas turbines is by quantifying the contribution of various sources in order to determine the main source, increase in the energy efficiency of the plant, heat recovery, vapor management and change of combustibles
- All the combustion units should be maintained properly at optimum efficiency
- All fuel combustion units should be operated with minimum excess air so that fuel consumption is optimized and emission of NO_x is minimized. Low NO_x burners should be implemented in all combustion units of proposed units in SEZ
- Energy conservation projects/schemes to result into reduction in quantity of fuel should be implemented
- Port holes and sampling facilities should be provided at proper location for all the stacks coming up in the SEZ for monitoring of flue gas velocity and flue gas temperature and also for checking concentration of different pollutants at regular intervals
- The SEZ complex should comply with proposed emission standards of CPCB for stacks located in the SEZ complex
- Ambient air quality with respect to SPM, SO_2, NO_x, H_2S and CO monitoring shall be done at minimum 4 locations around the SEZ complex. The monitoring stations should be set up in consultation with the GPCB

- A digital weather station for monitoring wind speed, direction, temperature, relative humidity and rainfall with automatic data logging and analysis facility should be installed at the SEZ complex. The same should be operated continuously for maintaining micrometeorological data record at SEZ site
- Continuous sources of emissions should be installed with stacks having sufficient height (CPCB norms) to ensure adequate dispersal of pollutants. Further, pollution control systems such as low NO_x burners and low sulphur fuel should be used
- Gas powered or low sulphur diesel and unleaded petrol in conventional vehicles should be used within the project area and for product evacuation.
- Proposed Incinerator design and emissions should be as per the Guidelines of CPCB
- Idling of vehicles should also be minimized during transport and handling activities
- Loading/unloading and storage areas should be paved to reduce dust emissions
- All access roads (internal as well external) to be used by the project authorities should be made pucca (either with WBM, concrete or bitumen) to suppress the dust generation along the roads

To control fugitive emissions of VOCs in the SEZ complex, following steps should be taken:

- Provision of internal floating roof tanks with flexible double seal for MS and intermediate products.
- Provision of mechanical seals in pumps
- Regular inspection of floating roof seals and proper maintenance of floating roof seals for proposed storage tanks
- Preventive maintenance of valves and other equipment
- Regular skimming of oil from separators/equalization basin in ETP
- Fugitive VOC emissions should be assessed and minimized whenever possible (vapor recovery systems, joints, pumps, fittings etc.). They shall also be monitored at regular intervals
- Fugitive emissions should be controlled through proper maintainance

- It would be a best practice to avoid burning in flaring stacks and to recover these gases whenever feasible
- Use of high grade gasket material for packing, provision of motor operated valves for critical services such as high vapour pressure components and chemicals
- Fuel leaks should be prevented from on land equipment. Further implementation of Leak Detection and Repair (LDAR) programme using a portable VOC detection instrument should be done on distribution lines and tanks
- Inventory of odorous compounds should be maintained and release of such compounds should be prevented

3.2 Noise Environment

The design of the project will be such that the sound pressure level in the work area will not exceed 90 dBA. Restricted areas will be those locations where it is not reasonably practicable to reduce the noise level below the work area limit. Wherever practicable, attempts shall be made to reduce the noise level below 85 dB(A). The noise levels will not exceed 60 dB(A) at the perimeter of the project area. The equipment will be chosen in such a way that the above noise limit is not exceeded. The noise levels at the nearest habitation after refinery expansion will be less than the stipulated standards of CPCB. However, as a good operational procedure, the following generic measures will be implemented in addition to the existing green belt:

- Similar measures as proposed in the construction phase for noise making machinery, to ensure practicably low noise levels within the work environment
- Specification for procuring major noise generating machines/ equipments should include built in design requirements to have minimum noise levels meeting CPCB/MOEF requirements. The monitored noise levels at sensitive locations should be taken to ensure that the impact due to high noise levels is practically minimized
- Monitor job and location specific noise levels for compliance with HSE regulations by verifying acceptability of noise levels caused by the project activities and comparison with noise criteria
- Conduct periodic audiometric tests for employees working close to high noise levels, such as compressors, DG sets, the loading, unloading sections etc.

- Provision of PPE’s should be done and their proper usage should be ensured for eardrum protection of the workers as well as visitors
- It should be ensured that low noise (generating) equipment are procured wherever feasible
- Acoustic laggings, and silencers should be used in equipment wherever necessary
- Sound proofing /glass paneling should be provided at critical operating stations, and control rooms
- Either Acoustic barriers / shelter should be developed in noisy workplaces or acoustic enclosures should be provided for the high noise generating equipment
- Noise generating sources in the plant areas should be monitored regularly. Monitoring of ambient noise levels should also be carried out regularly both inside the refinery area as well as outside the greenbelt

3.3 Water Environment

- Since fresh water is a scarce resource in the area, only seawater should be used for proposed expansion project. Desalination units should be installed to meet the water requirement of SEZ units. The impact on the ground water/saline intrusion if any should be monitored through the existing network of monitoring wells and piezometers
- An effluent treatment plant based on the raw wastewater quality and required treated wastewater quality should be designed. However the effluent standards should be well within the prescribed limits of GPCB & CPCB. The performance of ETP should be continuously monitored and any deviation in performance should be corrected on priority
- Reduction in water requirements should be achieved by implementation of closed circuits within the petroleum and petrochemical complex
- Use of desalinated water as service water should be minimized
- Reuse of effluent should be attempted
- Recycle of pump gland cooling water should be undertaken
- Condensate recovery should be maximized

- Treated effluent should be used for hydrotesting of vessels/tanks/pipelines instead of desalinated water. Treated effluent should also be used for cleaning of columns/vessels during turnaround
- Holding ponds should be provided so that bio-systems of wastewater treatment system should be prevented against shock load
- Dosing of chlorine or biocides as part of advanced cooling water treatment in the cooling water system should be done to take care of biological growth
- The detailed record of raw water intake at refinery (for processes, CT makeup, fire water, green belt development and sanitary and drinking purpose) as well as township complex and wastewater generation from different sources should be maintained on daily/regular basis w.r.t. flow rates and characteristics. These details should be useful in preparing comprehensive water balance at project site and also for identification and implementation of reuse/recycle practice of treated effluent at project site leading to mitigation of effluent discharges
- Water flow measurement facilities (metering) should be provided at inlet and outlets of major process units, which should help in minimizing wastage, conserving the water as well as maximizing the recycle/reuse of treated effluent
- Regular monitoring of effluent from different treatment units and also combined final discharge of treated wastewater including outlet of STP at township is recommended. Performance evaluation of effluent treatment plant as well as sewage treatment plant should be undertaken at regular intervals for all relevant parameters covered under this study
- Use of polishing pond for aquaculture should be explored, where bio-assay tests could be conducted at regular intervals
- The effluents discharged into the sea should be done through the multipore diffuser system designed by the National Institute of Oceanography (NIO). The location of discharge should also be identified by NIO. The diffuser system shall discharge the wastewater generated by the refinery, power plant and the petrochemical units
- The effluents discharged into the surface water or the natural environment, their physicochemical characteristics after any treatment should comply with the maximum levels defined by the CPCB

- Regular monitoring of the discharge of the main pollutants is required to ensure that the regulatory maximum levels are complies with. Periodic measurements of the pollutants in the natural environment is considered best practice

- A Treatment Scheme for the effluents generated from the petroleum and petrochemical complex has been suggested in the report. A Sewerage Treatment scheme also has been suggested in the report for the effluents generated from the residential colony and the sewage generated from the various units within the SEZ

3.4 Land Environment

- Soils in the adjoining areas are sandy loam to silty loam with moderate infiltration rates, amenable to groundwater pollution. Considering this fact, every precaution should be taken to avoid spillage of oils and other petroleum products on soils to protect groundwater and to avoid any danger to other soil microbial groups which are sensitive to oil pollution

- Oil is a potential hazardous substance present in wastes generated from refinery. Special care has to be taken in all oil removal operations. Disposal of Oily sludge generated from effluent treatment plant through Coker to be continued. Oily sludge from other locations may be disposed off by secured landfill / incineration.

- Greenbelt in and around the refinery may be strengthened/maintained

- A record w.r.t quantity, quality and treatment/management of solid/hazardous waste shall be maintained at environmental monitoring cell for different process units (sources)

- Mixers and insitu tank cleaning procedures which maximise recovery of oil should be adopted to reduce tank bottom sludge

- Recovery of oil from oily sludge using techniques such as centrifuging, thickening and filtration should be undertaken

- A Common Secured Landfill Facility has been suggested in the report for the disposal of the Hazardous Waste. The Hazardous Waste within the SEZ shall be compliant to the Hazardous Waste Management, Handling Storage and Disposal Rules. A Common Incinerator Facility has also been suggested for the proposed SEZ, which shall be designed and operated as per the CPCB guidelines

3.5 Biological Environment

Following measures are recommended to mitigate adverse impacts on biological activities during operation phase:

- Development of green belt with carefully selected plant species is of prime importance due to their capacity to reduce noise and air pollution impacts by attenuation/assimilation and for providing food and habitat for local macro and micro fauna. This not only overcomes the problem but also enhances the beauty of area that will attract bird and insect species and by this way ecology of the area will maintain to great extent
- For developing the greenbelt in and around proposed project site care need to be taken to plant the evergreen species. The planting of evergreen species may have certain advantages that may reduce the environmental pollution
- Survival rate of the planted trees should be closely monitored and the trees which could not survive should be counted. Equal number of trees should be replaced and their survival should be closely monitored
- The rainwater harvesting should be done. Treated sewage and effluent in the best combination should be used for greenbelt development. Water scarcity should not be the reason for not expanding and strengthening greenbelt. Provision for irrigation water should be made as part of proposed project

3.6 Socio-economic Environment

In order to mitigate the impacts likely to arise out of the proposed project and also to maintain good will of local people for the proposed project, it is necessary to take steps for improving the social environment. Necessary social welfare measures by the industry shall be useful in gaining public confidence depending on local requirement.

The EMP measures are suggested for smooth functioning of the activities are given below:

- SEZ should continue to undertaken social welfare programes for the betterment of the Quality of Life of villages around in collaboration with the local bodies
- Some basic amenities, viz. education, safe drinking water supply to the nearby villages may be taken up
- Regular medical check up should be continued on routine basis in the villages around the SEZ and also by providing mobile hospital services

- SEZ shall in collaboration with local government improve the road infrastructure in the vicinity
- Formal and informal training to provide direct and indirect employment to the affected villagers due to the project shall be taken up on priority
- Entrepreneurship Development programme (EMP) should be undertaken for both male and female group irrespective of their age and education, qualification
- Job oriented skill training, courses may be organized. Through industrial/technical training institutions for educational youth (both for male and female), like home need appliances, tailoring, plumbing, light & heavy vehicles driving
- Personal protective facilities like helmets, safety (gas) mask/safety dress, shoes etc. be ensured for all workers, engaged in operation of process units within the refinery complex
- The health checkups (diagnostic) for all regular employees at the refinery complex at scheduled intervals to be maintained along with the corresponding health records

3.7 Capital / Recurring Expenditure on Environmental Management

The details on proposed SEZ project cost and capital / recurring expenditure on environmental management.

Project Cost	:	Rs. 60,000 crores
Cost for pollution control facilities	:	Rs. 1,800 crores

3.8 Environment Monitoring in Refinery

Since the SEZ Complex is big enough, each industry should have senior executives who shall report to their respective Site President. The SEZ complex will have an Environment Cell for the entire SEZ and units therein. The Environment cell should consists of environmental professionals with experience in various aspects of Environment Management ranging from 7 years to 20 years. This cell should be set up during the construction of the SEZ itself and they should have adequate expertise and competency in handling and implementing the Environment Management systems and practices. The Environment Cell should monitor and measure the environmental performance of each industry in terms of efficiency of pollution control devices, and conduct regular energy and water audits. The cell should also on a regular basis also coordinate third party Environmental Audits. Members of the Environment Cell shall participate in National Task

Forces under CREP (Charter for Corporate Responsibility for Environmental Protection) and in committees for reviewing National Standards for the petroleum and petrochemical industry. The Corporate Environment Cell at the Headquarters shall be an advisory body on all environmental related issues and support the Environment Cell at the SEZ.

Every industry within the SEZ should in due time aim to be certified for ISO 14001 standards. The Environment cell in each industry should be responsible for implementing and maintaining environment management systems. These industry should co-ordinate with the Environmental Management Cell of SEZ for establishing and monitoring the compliance of ISO 14001. The Management Systems should be established in compliance with the ISO 14001 standards which should be audited internally by qualified internal auditors and externally by the certifying body as per the stipulated frequency.

3.9 Recommendation for compliance to the World Bank Guidelines

NEERI recommends M/s RJIL to develop the SEZ projects in compliance with the industry specific IFC Guidelines presented in this report as Annexure VII.

3.10 Environmental Clearance Process / Status

As per the Environmental Clearance procedures of 14th Sept- 2006 EC notification the project application was made (07.02. 2007) in a prescribed format along with the draft EIA & RA reports (This reports has been prepared before the 14th September 2006 notification) and submitted to MoEF.

The Expert Appraisal Committee (EAC) apprised this project in their meeting (01.03.2007) and suggested/ directed additional Terms Of Reference (TOR) to be incorporated in the EIA & RA reports and asked to conduct public hearing (28.03.2007). The public hearing was conducted (08.01.2008) by the Gujarat Pollution Control; Board (GPCB) with the EIA and RA reports updated with the additional Terms of Reference and the Minitues of Meeting was send to Ministry.

The EIA & RA documents were finalized with the public hearing comments and submitted to ministry (18.07.2008) for the Environmental Clearance. The project has gone through three appraisal meetings (19.08.2008, 15.04.2009, 15.06.2009 and the project was approved by the EAC for grant of Environmental Clearance in 15.06.2009 EAC meeting.

Subsequently, the MoEF advised to provide further clarifications with respect to the Captive Power Plant (CPP) on 3rd Aug 2009 and submit a composite updated document for the discussion with the newly constituted EAC committee_2.

Chapter 1

Introduction

1.1 Preamble

Special Economic Zones Act 2005 is a major milestone in India's Foreign Trade Policy and a clear pointer to the avowed intention of the Government of India to encourage growth of the country's manufacturing and service sectors and to usher an era of enhanced level of confidence for Indian products and services in the global arena.

The enactment of SEZ Act 2005 by the Central Government and the State SEZ Act and rules notified by the State Government of Gujarat has enthused Reliance Infrastructure Limited (RFL) to set up a Special Economic Zone in the backward rural area of Jamnagar district of Gujarat with modern integrated infrastructure. The SEZ developer, RFL, subsequently changed its name to Reliance Jamnagar Infrastructure Limited (RJIL). The development of this project will lead to fast track development of Saurashtra region of the state and will open up avenues for larger volumes of exports, employment and foreign exchange earning for the Country.

Reliance continues to be a major contributor to the national economy through its vision and commitments & believes that Government & Industry have to work together to create world-class infrastructure, which is now a pre-requisite to attain leadership in the global market

Reliance’s proposes, to build a product specific economic zone of refinery and petrochemical units, which will be further synergically developed as a multi-product zone. The Ministry of Industry and Commerce, Government of India has now notified this SEZ as a Multi-product SEZ. The proposed SEZ will be developed by Reliance Jamnagar Infrastructure (RJIL) Limited, a RIL group Company. All these proposals fall under the National Policy on Developing SEZs as notified by the Ministry of Commerce & Industry, GOI. The SEZ will have all the required infrastructure and facilities to ensure sustainable development of medium and large-scale industries and service activities. The proposed site is located near the State Highway No 25 on the way from Rajkot to Okha and is adjacent to the existing refinery complex of Reliance Industries Limited (RIL). The overall size of the SEZ is approximately 4,545 hectares (11,231 acres). The **Fig. 1.1** shows the location of the SEZ at Jamnagar and **Fig. 1.2** shows the location of SEZ area.

RIL has already established a petroleum refinery and petrochemical complex, and is in operations since 1999. This complex has got the environmental clearance from the Ministry of Environment and Forest (MoEF) to modernize and expand the refinery capacity to approximately 60 MMTPA, crude processing in 2005. The existing refinery capacity has been enhanced to 33 MMTPA by the way of debottlenecking and value/production maximization. The balance approved capacity is being implemented by Reliance Petroleum Limited as an Export oriented Refinery Project. This project is called as Jamnagar Export Refinery Project (JERP) with an integrated 1.0 MMTPA polypropylene unit by Reliance Petroleum Limited, a group Company of RIL. This Jamnagar Export Refinery Project (JERP) and the PP Plant are located in the approved SEZ area. The JERP has already got the environmental approval from the MoEF and other statutory agencies and is already under implementation and expected to go on stream shortly.

Proposed Land use in SEZ

Reliance proposes to develop a total area of 4545 Hectares, as a Multiproduct Special Economic Zone. The proposed land use for the entire SEZ is tabulated below:

Proposed land allocation	***(Area in hectares)***
Residential	810
Commercial	275
Industrial	2,275
Public/Semi – Public/Green Belt/Transportation	1,185
Total	**4,545**

1.2 Project Setting

Jamnagar district lies in the peninsular region in the North West, in the state of Gujarat, known as Kathiawar or Saurashtra. The Gulf of Kutch binds this district to the north, on the East by Rajkot district, on the South by Junagadh district and on the West by the Arabian Sea. Saurashtra region has been away from the mainstream economic development of the country. The Jamnagar region falls in an arid zone. The area is covered by Deccan trap basalt of cretaceous age. The landuse of this region highlights that maximum is scrub land (wasteland) followed by fallow land. This is one of the reason the site has been selected for the development of SEZ. Recently, industrial development of public sector undertakings and Port development has ushered in recognizable economic growth. The latitude and longitude of the center of the proposed SEZ are 22^{o} 20’ 30” North and 69^{o} 53’ 00’’ East.

Mithapur, 157 kms. from Jamnagar, has heavy chemical industrial unit manufacturing salt, soda ash, etc. by the TATA group of India named Tata Chemicals Ltd, and Moti Khavdi (Sikka) near Jamnagar, has a petroleum refinery complex by the Reliance Group, which is one of the largest grassroots refinery in the world. Even the famous & internationally renowned wollen textile-manufacturing unit DIGJAM is located in Jamnagar city. Jamnagar itself is a centre for the Brass *industry*, *Bandhani fabrics* (tie-&-dye work on fabrics) and *Zari sarees*, *Silken & Gold embroidery*. Near the refinery complex, there are other industries like a thermal Power Plant of the Gujarat Electricity Board, Cement manufacturing unit of Digvijay Cements and a fertilizer unit of the Gujarat State Fertilizer Corporation.

The following siting criterion delineated by MoEF, New Delhi has been followed by Reliance, which includes:

I. No prime agricultural land/forest land has been proposed for conversion into an SEZ.

II. Land proposed for the SEZ is a barren arid land and has sufficient space to provide for a green belt wherein the treated wastewater, could be utilized from wastewater treatment systems

III. Enough space is available for storage and disposal of hazardous / solid wastes.

IV. Layout and form of the project will conform to the landscape of the area without affecting the scenic features of that place. However the scenic beauty shall increase with the development of green belt.

V. Associated township of the project is planned to provide for space for phyto - graphic barrier between the project and the township and takes into account predominant wind direction.

In addition to the siting criteria listed above, the proposed project location is reviewed for the following salient issues:

- The site is not prone to natural disaster areas, however the industry shall be designed to the seismic codes specified by ISI and allied agencies. It is pertinent to note that Gujarat Earthquake 2002 with epicenter near Bhuj has not affected any of the facilities of the Refinery.
- The water for operation will be made available from the proposed desalination plant for SEZ. Further the Narmada water is also available for the construction and for temporary labor camps. It is proposed that desalination plant related facilities will be created upfront of the project. A CPP has been planned during the operation phase to supply power to the SEZ units and the residential colony. Roads with adequate width and capacity shall be developed to handle the increase in traffic load. All these facilities shall not exert a pressure on the local infrastructure.

1.2.1 Existing industrial Estate in Jamnagar District

The major industries like Agro & food processing, biotechnology, chemical & allied industry, drugs & pharmaceuticals, engineering industry including automotive industry, gems & Jewelry etc, are some of the industries located in the Jamnagar district of Gujarat.

The existing industrial estate by GIDC in Jamnagar is as follows:

- Shankar Tekri industrial estate, Jamnagar1
- Kamsudra industrial estate, Jamnagar 2
- Dared industrial estate, Jamnagar 3
- Jam Khambhaliya industrial estate
- Bhatia (RIDC)
- Arambhada industrial estate
- Dhrol (RIDC)
- Bhanvad

The site for the proposed SEZ covers evaluation of site with special reference to siting criteria including projects.

The principal drivers for the proposed projects in the Jamnagar SEZ are:

1. Maximize value addition of raw materials, sourced from the RIL domestic refinery, and the RPL export oriented refinery.
2. Enhance competitive strengths, by minimizing the cost of production, with intimate integration between the two refineries and the Jamnagar SEZ manufacturing complex.
3. Exploit economies of scale for each product in the Jamnagar SEZ.
4. Strive to be the lowest cost producer for each product in the Jamnagar SEZ.
5. Develop world-class infrastructure and logistics facilities to support the Jamnagar SEZ to exploit the supply chain for each product in the Jamnagar SEZ.

Proposed Jamnagar SEZ has following strengths.

1. Promoters have a successful track record in executing Mega projects and have set up technically complex projects in record time and at globally competitive project cost and at the same time adhering to the highest international standards of safety and environmental protection.
2. The SEZ is located in a highly industrialized state of India and has potential to attract Petrochemical & other industries with high export potential.
3. Jamnagar is ideally located on the western coast of the country, has a unique advantage in terms of accessibility to the Middle east & Far-east & European markets
4. The SEZ will have access to the existing port facilities, which will facilitate easy evacuation of the export products, which will not call for building new marine facilities, thereby minimizing the marine impacts.
5. The project will have state of the art infrastructure facilities to attract investment.
   The SEZ meets the siting criteria/guidelines of the MoEF for the following:
   i. Located away from the coastal belt
   ii. Barren land (entire stretch)
   iii. Road transportation will be reduced due to utilization of marine facilities
6. SEZ is well connected with the national and state highways.

The Feasibility Analysis for the location of SEZ is given in **Table 1.1**. Essentially the various petroleum and petrochemical downstream units are synergically derived of the carbon chains C1 to C8+ products and their derivatives.

The C1 to C8 complex is based on the existing refinery and petrochemical complex products. It is pertinent to note:

a. Along with the existing modernized and expanded refinery and the proposed petroleum and petrochemical complex will be under the EOU scheme, aimed to maximize the value addition along the entire carbon chain of C1 through C8 and higher.
b. The various units within this complex will be homogeneous to the C1 to C8 hydrocarbon chain. All the units and product plants are integrated with each other to derive the advantage of optimum utilization of various resources.
c. Jamnagar has the most suitable seafront in the Gulf of Kutch for raw material import and finished products export. This complex is fully integrated with the existing refinery complex as well as export oriented Refinery.

This Petrochemical Complex produces distinct petrochemical products by processing and synthesizing from the various streams of the refinery complex. The manufacturing units of these products consist of similar equipment and machinery which synergistically work to produce these distinct products. In this particular configuration of the conglomerate, the raw materials intermediate products, by-products, material and energy flows are integrated so as to:

a. Maximize value of raw materials, sourced from the RIL & RPL refineries.
b. Optimally utilize the various process streams derived from the refinery complex and petrochemical units
c. Conservation of the water resources through integrated recycle and reuse among the various process units.
d. Enhance competitive strengths, by minimizing the cost of production, with intimate integration between the two refineries and the Jamnagar SEZ manufacturing complex.
e. Exploit economies of scale for each of the products in the Jamnagar SEZ.
f. Minimal transportation cost of raw materials.
g. Minimize the requirement for infrastructural facilities.
h. Optimization of effluent treatment facilities, hazardous waste handling & disposal facilities, etc
i. Strive to be the lowest cost producer for each of the products in the Jamnagar SEZ.
j. Develop of world-class infrastructure and logistics facilities to support the Jamnagar SEZ to exploit the supply chain for each of the products in the Jamnagar SEZ.

These are synergistically integrated in three main areas. i.e

a. Process Integration of various process streams derived from the refinery complex
b. Energy integration of various producing units to optimize / minimize the energy consumption in the various units.
c. Conservation of the water resources by recycle and reuse through various utilization processes starting from the raw seawater.

By internalizing the resources and related environmental parameters the overall synergistic integration is achieved. This in turn leads to optimum utilization of all the streams into various value added products.

This integration / synergy helps in leaving a smaller carbon foot print and thus a lower impact on the environment

The environmental parameters at Jamnagar has been continuously studied and assessed for the Reliance Group of Industries at Jamnagar since 1993. For the existing Refinery a post project Environmental Impact Assessment (EIA) has been done and was also assessed by the MoEF in 2003. Later Environmental Impact Assessment (EIA) & Risk Assessment (RA) studies were conducted for the modernization and expansion of the refinery complex and the MoEF has granted the Environmental Clearance for the same in 2005 . The modernization and expansion of project is Commissioned now.

The results of these studies have been considered and internalized in the planning, design, construction and operations and specific environmental related operational characteristics like emissions, discharge and other relevant parameters. These cumulative affects already get reflected in the latest environmental baseline studies for the SEZ petroleum and petrochemical complex at Jamnagar.

Later, these draft EIA and RA reports were discussed by the MoEF EAC committee and additional Terms Of Reference (ToR) were given. Accordingly the EIA reports were updated and upgraded by incorporating the Terms of Reference (TOR). Public Hearing was conducted in 2008 and the draft EIA was finalized by updating the process related information, emissions and other relent parameters, Public hearing comments and the final reports were submitted to MoEF.

The process technology suppliers, licensors and vendors are instructed to strictly comply with the prescribed petroleum and petrochemical standards of the CPCB as the minimum criteria to be met in the basic engineering design, detailed engineering and construction, commissioning and operation to maintain the emissions within the prescribed limits.

The various units which can be set up in the proposed SEZ are as follows:

C1 Based Units

- Coke Gasification
- Methanol Synthesis
- Acetic Acid
- Vinyl Acetate Monomer (VAM)
- Polyvinyl Acetate (PVA)
- Polyvinyl Alcohols (PVOH)

C2 Based Units

- Multifeed Cracker Complex for maximising the C2, C3 , C4 and C5 carbon chains
- Ehtylene Oxide Derivatives like Mono Ethylene Glycol (MEG), Di Ethylene Glycol (DEG) ,Tri Ethylene Glycol (TEG)
- Polyethylene Polymers like Low Density Polyethylene (LDPE), Linear Low Density Polyethylene (LLDPE), High Density Polyethylene (HDPE)

C3 Based Units

- Acrylic Acid & derivatives, Super Absorbent Polymer (SAP)
- n-Butyl Acrylate, n-butylaldehyde, n-butanol and 2-ethylhexanol
- Propylene derivatives like Propylene Oxide, Cumene, Phenol
- Propylene Glycols
- Polyols
- Hydrogen Peroxide (H_2O_2)
- Polypropylene PP (Non woven)

- Polypropylene (PP)

C4/C5 Based Units

- Butyl/ Halo Butyl Rubber, ESBR, Styrene Butadiene Rubber (SBR) ,Poly Butadiene Rubber (PBR), SSBR
- Butene 1
- Maleic Anhydride (MA)
- Fumaric Acid

C6/ C7/ C8 Based Units

- Mono nitro Benzene, Aniline, Methylene Di Aniline, Phosgene, Methylene Diphenyl Diisocyanate (MDI), Toluene Diisocyanate (TDI) and Benzene
- Styrene
- Paraxylene (PX), Orthoxylene (OX)
- Putrefied Teraphthalic acid (PTA)
- Polyethylene Tera-phthalate (PET)
- Polyesters Complex Polyester Oriented Yarn (POY) Polyester Stable Fiber (PSF)

Carbon Black

Lube Oil cum Refinery Complex

Captive Power Plant

& Jamnagar Export Refinery Project (JERP) which has already been accorded Environmental Clearance by the MoEF in 2005 / 2006.

The Modernization and de-bottle necking of the existing refinery and expansion refinery (called as Jamnagar Export Refinery) along with their infrastructure had been accorded the environmental clearance by the ministry in 2005 and amended in 2006. Since this JERP is being built in the SEZ area, JERP is included in the EIA. However, the emissions of JERP are included in the analysis of this study.

The **Table 1.2** shows details of the units coming under the proposed SEZ are shown in **Fig. 1.3**.

1.2.2 Common facilities for the SEZ

The common facilities for the proposed SEZ are Captive power plant, Desalination Plant, Central ETP, Incinerator and a Secured disposal facility.

1.2.2.1 Captive Power Plant (CPP)

Captive power plant comprises of three components

- Gas turbines
- Heat recovery steam generation (HRSG)
- Steam turbo generators

Gas turbines

Gas turbines, consists of axial flow compressor, to compress air in to combustion chambers. In combustion chambers, fuel (natural gas/ syngas, liquid fuel) is added and the products of combustion are allowed to expand through impulse turbine. The turbine rotor is coupled with generator to produce electric power.

HRSG

Turbine exhaust gases are taken to a water boiler, through a duct where supplementary firing is done using a fuel in the furnace zone. The hot gases heat the water to generate steam and are exhausted to atmosphere through a boiler stack. Demineralised water, after dearation ,is fed to the water boiler for steam generation. Duct firing arrangement to consume unburnt oxygen provided to rise more steam

Steam turbine generators

High-pressure steam is expanded through a turbine/ expander to reduce the pressure and recover power. This expander is coupled with a generator to produce electric power. These STG,s can operate on back pressure basis to be integrated into the steam grid.

1.2.2.2 Desalination Plant

Considering the water shortage in the region, the seawater intake is provided at the maritime terminal area where water is pumped and treated. The desalination plant has been designed using multiple effect Distillation process integrating it with energy sources. The energy (heat) requirement for desalination is met from the waste heat from processing units. This scheme eliminates the venting of low pressure and low temperature steam from the process units and eliminates the condensing and also used as a steam sink for the effective steam requirement and balancing. This plant also integrated with the ultra filtration / reverse osmosis plant, which will/can process the gray water from the complex.

Currently the water requirement of the existing Refinery cum Petrochemical complexes is met from the Desalination of Seawater. The desalination plant is of multi affect distillation of Israeli origin technology. The existing plant capacities is 2600 Cu m/hr or 2.6 million liter/hr of water required for the complex and the residential complex.

The desalination plant is designed with flexibility to operate on a low level energy input sufficient for the operations.

For the proposed project, for SEZ the overall desalination plants capacity will be 15,000 m^3/hr with suitable number of units.

1.2.2.3 Central Effluent Treatment Plant

A central effluent treatment plant has been proposed as a common facility for effluents generated from all the units of proposed SEZ. The different effluent sources would be, effluent streams from the Refinery and downstream Petrochemical plants. The details of the common effluent treatment schemes have been given in **Chapter 6**.

1.2.2.4 Common Incinerator Facility

The incinerator shall be designed for capacity more than 200 kg/hr. Incinerator shall be installed with venturi scrubbing system, which is an air pollution control system. The incinerator will be designed as per the CPCB Guidelines.

The double chamber incinerator shall preferably be designed on "controlled-air" incineration principle, as particulate matter emission is low in such incinerator. Minimum 100% excess air shall be used for overall design. Air supply in the primary and secondary chamber shall be regulated between 30% - 80% and 170% - 120% of stoichiometric amount respectively. Primary air shall be admitted near / at the hearth for better contact. Flow meter / suitable flow measurement device shall be provided on the primary & secondary air ducting. The combustion air shall be supplied through a separate forced draft fan after accounting for the air supplied through burners. The details of common incinerator facility have been provided in **Chapter 6**.

1.2.2.5 Common Secured landfill Facility

The secured landfill facility for disposal of hazardous waste like ETP sludge, oily sludge, spent clay and incinerator ash will also be designed as per the CPCB guidelines. A detailed section comprising of selection of landfill site, design of landfill site, facilities at landfill site and the management scheme is given separately in **Chapter 6** of this report.

1.2.3 Project Cost and Schedule

Investment and NFE Earning Potential of The Zone

Reliance proposes to invest about Rs. 25000 Crores (approx. US$ 5.8 Billion) in refinery. Based on the feed stock availability, further investment in the downstream petrochemical units is expected to be around Rs. 35000 Crores (approx. US$ 8.2 Billion). Thus the Petroleum and Petrochemical Sector Specific Area would attract investment of approx. Rs. 60000 Crores (approx. US$ 14 Billion)

The Petroleum & Petrochemical Complex in the SEZ is proposed to be set up by Reliance or as a JV with an international manufacturer. The Complex will have a NFE earning potential of $18-20 Bn over a 10 year period. The other petrochemical down stream units would further contribute additional NFE earning for the country to the tune of minimum $ 5-6 Bn over a 10 year period.

Implementation Period

The components of the Special Economic Zone Projects will be implemented by M/s Reliance Jamnagar Infrastructure Ltd. (RJIL), wholly owned subsidiary of RIL & hence a Deemed Public Limited Company. The project will be developed progressively over the next 2-3 years and will be operational by 2008.

1.3 Stage of EIA

The area earmarked for the development of Special Economic Zone at Jamnagar is of about 4544.76 ha (4545 Ha). In line with the new notification for prior environmental clearance (S.O. 1533, dated 14/09/2006), this reports has been prepared for the SEZ and the proposed industrial units therein. The multi product SEZ will house a petroleum and petrochemicals complex and hence the activities within the SEZ are defined.

EIA is being carried out for the SEZ project so as to incorporate environmental concerns in the design stage of the project. The basic data required for preparation of EIA has been taken from the information report provided by the client.

1.4 Scope of EIA

The Ministry of Environment and Forests (MoEF), Govt. of India (GoI), issued a Gazette Notification on 27th January 1994, called as the EIA Notification under the Environmental protection Act 1986 and subsequently this notification has been modified / replaced on 14th Sept 2006. A transition period of two years has been provided between both notification will be concurrently operative, and the GoI to that effect issued the notification instruction /clarification. This notification set up a procedure for environmental approval / rejection of the various categories of industries and allied projects. Under this process an EIA Study is required to be conducted for projects that are enlisted in the schedule to the notification. Subsequently this notification has been replaced by a fresh notification on 14th September 2006. A transition period of two years has been provided wherein both the notifications will be concurrently reinforced.

This EIA report has been prepared basing on the guidelines including the EIA manual issued by the MoEF, New Delhi. Further the sector specific 'Environment, Health & Safety' guidelines as applicable to refinery and petrochemicals issued by the International Finance Corporation (IFC) also have been followed in preparation of EIA report. Please refer **Annexure VII** for the relevant sections of the industry specific guidelines issued by the IFC. In order to assess the environmental impacts due to the proposed development of the SEZ project, Reliance Infrastructure who is developers of this project retained National Environmental Engineering Research Institute (NEERI), Nagpur to undertake Environmental Impact Assessment for various environmental components and delineate a detailed Environment Management Plan (EMP).

1.5 Objectives

- Assessment of the present status of air, water, land, socio-economic and biological components of the environment including noise and other parameters of human interest within a 10 km radial distance surrounding the SEZ area.
- Emissions modelling for Ground Level Concentrations (GLCs) based on the emissions from units within the SEZ.
- Delineation of the proposed waste disposal scheme for the aforementioned project
- Identification of land use / land cover pattern like forest land, agricultural land, waste land, water bodies etc. in a 25 km. radius from the project site
- Delineation of the Environmental Management Plan (EMP) in line with the MOEF guidelines and preparation of EMP to be adopted for mitigation of anticipated adverse impacts.
- To meet the guidelines of IFC as a part of the process under the equator principles.

Delineation of the post project environmental quality monitoring program to be pursued by Reliance as per the requirements of the MoEF and State Government

1.6 Study Area

To decide whether proposed action is likely to cause significant adverse environmental effects, the concept of EIA is practiced. Before proceeding to establish the baseline environmental status, it is important to know the boundary limits and framework where data can be effectively utilized in impact assessment.

The study area for this EIA study is considered to be 25 km radial distance around the center of SEZ so as to have atleast 10 km clear distance from the boundary of SEZ for establishing baseline environmental status. The study area of 25 kms from the centre of the SEZ is indicated in **Fig 1.4.**

1. 7 Approaches and Methodology

The approach and methodology adopted is as per the guidelines of MOEF and the Gujarat Pollution Control Board (GPCB), Govt. of Gujarat (GoG) for baseline data collection, identification and prediction of impacts for various environmental components are presented below:

1.7.1 Establishing Baseline Environmental Status

Baseline data describing the existing environmental status of the identified study area is determined using the procedures presented in **Table 1.3**.

1.7.1.1 Physical Resources

a) Air Quality and Climate

Design of Ambient Air Quality Monitoring Network

The air quality status in the study area is assessed through a network of ambient air quality monitoring locations. The baseline studies for air environment include identification of site and project specific air pollutants prior to implementation of the project. The EIA report is based on baseline air quality during winter of 2005/06

The baseline status of the air environment is assessed through a systematic air quality surveillance program, which is planned based on the following criteria:

- Topography / terrain of the study area
- Regional synoptic scale climatological normals
- Densely populated areas within the region
- Location of surrounding industries
- Representation of regional background

- Representation of valid cross-sectional distribution in downwind direction

Methodology for Ambient Air Quality Monitoring

Ambient Air Quality Monitoring (AAQM) was carried out at 24 locations in winter season. Maximum numbers of sampling locations were selected close to the SEZ site and in the downwind direction i.e. in N-E sector considering predominant wind direction of S-W.

AAQM was carried out at number of locations, though four locations are presented in CPCB guideline to determine a finer cross-sectional distribution of air pollution in an industrial developed region. The conventional parameters such as Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur Dioxide (SO_2) and Oxides of Nitrogen (NOx) were monitored in the study area.

The standards stipulated by CPCB/ MoEF in India are given in **Annexure I**.

A temporary laboratory was setup at the project site for chemical analysis of representative air samples. An automatic weather monitoring station was also installed at project site, keeping the sensors freely exposed to the atmosphere and with minimum interference with the nearby structures. The micro-meteorological data like wind speed, wind direction, temperature and relative humidity were collected using the weather station and cloud cover was recorded manually for the study period.

The 98^{th} percentile concentrations have been compared with stipulated standards of CPCB (as per the National Ambient Air Quality Standards Notification, April 11, 1994). The 98^{th} percentile level is determined by arranging observed concentrations of any given pollutant of the ambient air quality monitoring location by arranging in ascending order and determining the pollutant concentration at 98^{th} percentile number in the series (e.g. if 100 different values of SO_2 levels at any given air quantity monitoring location are arranged in ascending order, SO_2 concentration corresponding to 98^{th} value in the series is termed as 98^{th} percentile).

b) Topography and Soil

Soil samples were collected close to RJIL SEZ site and in the study area from agricultural fields at 0-20 cm depth. The general parameters of soil analysis, in context of impact assessment, are texture, pH and conductivity (10% slurry), cation exchange capacity, infiltration rate (permeability), bulk density, porosity, water holding capacity, organic content and NPK constituents. Soil sample were collected from selected agricultural fields within the impact zone and analysed for relevant parameters

c) Surface and Ground Water

With regard to water environment, two aspects are considered in EIA, the raw water availability and surface and ground water quality. The water requirement and availability in the region has been assessed. Surface and ground water quality has been determined and compared with drinking water standards **(Annexure II)**. One sample was collected at each location for establishing the baseline water quality.

In addition to above, the coastal/creek waters are classified as given below based upon the 'best designated uses' of a particular segment:

- SW-I : Salt pans shell fishing, mariculture and ecologically sensitive zones
- SW-II : Bathing, contact water sports and commercial fishing
- SW-III : Industrial cooling, recreation (non-contact) and aesthetics
- SW-IV : Harbour
- SW-V : Navigation and controlled water disposal

d) Noise

Noise standards have been designated for different types of landuse, i.e. residential, commercial, industrial areas and silence zones, as per 'The Noise Pollution (Regulation and Control) Rules, 2000, Notified by Ministry of Environment and Forests, New Delhi, February 14, 2000'. The ambient noise standards are presented in **Annexure III**. Different standards have been stipulated during day time (6 am to 10 pm) and night time (10 pm to 6 am).

The residential, commercial, industrial areas and silence zones close to the project site and in the study area have been identified. These locations have been chosen away from the major roads and major noise sources so as to measure ambient noise levels. Equivalent noise levels (Leq) for a period of about 20 minutes have been measured twice a week during study period at each monitoring location during day time and night time. Eight observations have been made at each noise monitoring location.

1.7.1.2 Ecological Resources

a) Terrestrial Ecology

The terrestrial flora and fauna is assessed through following parameters:

Flora

i) Species List

Such a list includes common and scientific names of plants found or likely to be present in the study area. This list is prepared based on visual observation during site visits and through review of site literature. Data available with various agencies is referred for identifying rare or endangered species in the region.

ii) Plant Cover

The ground area covered by aerial portion of the plant is called its ”cover” and is used as a measure of plant’s importance. The diameter of tree trunk at breast height (4.5 ft or 135 cm) is used as an expression of cover or dominance. The phytosociological data available for the area close to the proposed port site and along the infrastructure corridor are also included in the report.

Qualitatively, flora is assessed by delineating the type, its habitat, unique vegetative features, interrelations or associations with other community members. Plants are also observed for morphological aberrations, if any, due to pollution or any other stress. Plant species are rated visually based on its foliar cover and abundance.

Fauna

Actual counts of the animals are made following the census technique. At each station a walk-through census of animals is made. Line transects of 1 km selected for the study is covered by walking and number of animal species are counted directly. Birds were observed through binoculars. Standard field identification guides were used for identifying animal species. Data is expressed based on census index, dominance index and Margalef diversity index.

b) Aquatic Ecology

Water samples were analysed for estimating plankton counts viz. zooplankton and phytoplankton. Similarly, information was collected about fisheries and coastal resources such as mangroves from secondary sources.

1.7.1.3 Economic Development

a) Industries, Infrastructure Facilities and Transportation

The information on industries, infrastructure facilities such as water supply, sewerage, flood control etc. and transportation such as roads, harbours, railway, airports and navigation were collected from secondary sources and field visits.

b) Landuse Pattern

Remote sensing data analysis was carried out for determining landuse/land cover in a study area. In order to strengthen the baseline information on existing landuse pattern, the following data at the latitude and longitude CO-ORDINATES (approx.) were used. Data available in CD format from National Remote Sensing Agency (NRSA), Department of Space and Government of India were used along with collateral data.

Salient features of methodology for landuse/land cover using remote sensing data are given below:

- Acquisition of Satellite data
- Data loading
- Data processing
- Geo-referencing Image
- Rectification
- Classification
- Ground Truthing /field Checks using Global Positioning System
- Masking

The digital image processing was performed on Erdas Imagine 8.6 System on high configured computer. Erdas Imagine software package is a collection of image processing functions necessary for pre-processing, rectification, band combination, filtering, statistics, classification etc. The powerful HP Work Station allows display and processing of the image data. Apart from contrast stretching, there are large number of image processing functions, that can be performed on HP Work Station. The images can be recorded photographically with the help of Image Coder linked to the workstation.

The satellite data from the compact disc is loaded on the hard disk and by studying quick looks (the sampled image of the appropriate area), the sub-scene of the study area is extracted.

Supervised classification using all the spectral bands can separate fairly accurately, the different landuse classes at level II on the basis of the spectral responses which involve the following three steps:

- Acquisition of ground truth
- Calculation of the statistics of training area
- Classification using maximum likelihood algorithm

The training areas for classification were homogeneous, well spread out throughout the scene with bordering pixels excluded in processing. Several training sets have been used through the scene for similar landuse classes. After evaluating the statistical parameters of training sets, the training areas were rectified by deleting no congruous training sets and creating new ones. Masks of area within 5 -15 km radius were superimposed on the final output to generate area statistics for different landuse categories.

1.7.2 Anticipated Environmental Impacts

The environmental impacts due to proposed project have been identified, predicted and evaluated.

In the present study the mathematical models that have been used for predictions include

- ISCST3 has been used to model the emission sources from the SEZ and its units to estimate the GLCs.
- Wave divergence for stationary noise sources, Federal Highway predict the Administration (FHWA) models for noise levels of vehicular sources
- For impact on water, land and biological components of environment, the predictions have been made based on available scientific knowledge and judgment.

1.7.3 Environmental Management Plan

Environmental Management Plan (EMP) is drawn after identifying, predicting and evaluating the significant impacts on each component of the environment with a view to maximising the benefits from the project. Post-project Environmental Monitoring programme is also delineated in the report.

1.8 Contents of the Report

The EIA Report is based on the primary field data generated at the project site and data collected from secondary sources.

Chapter 1.0 - Introduction

This chapter provides purpose of the EIA report, background information of the project, stage of EIA report preparation, scope, methodology and brief outline of EIA report. At the end of this chapter, the environment clearance status with respect to the project has been described.

Chapter 2.0 - Description of the Project

This chapter provides the following details:

- Type of project
- Need for the project
- Project location
- Project details including associated activities required for the project

Chapter 3.0 – Process Description

This chapter describes the process description of the refinery and petrochemical units proposed in SEZ along with the technology details and the process flow diagram.

Chapter 4.0 – Baseline Environmental Status

This chapter presents the information on study area, information on existing environmental resources, findings of field studies undertaken to establish the baseline environmental status and has been organized into the following sub-sections:

- Physical Resources
- Ecological Resources

Chapter 5.0 – Identification and Prediction Of Environmental Impacts

This chapter details the identification, prediction and evaluation of impacts on each resource. The impacts of “the project” are predicted using available computer models during construction and operational phase. The significance of impacts is determined based on applicable environmental guidelines. It describes the overall impacts of the proposed project and identifies the areas of concern, which need mitigation measures.

Chapter 6.0 - Environmental Management Plan (EMP)

This chapter provides recommendations for Environmental Management Plan (EMP) including mitigation measure for minimizing the negative environmental impacts of the project

Environmental monitoring requirements for effective implementation of mitigation measures during construction as well as operation of the project have also been delineated along with required institutional arrangements for their implementation. Budgetary cost proposed for pollution mitigation and environmental management are also provided.

Chapter 7.0 – Resettlement & Rehabilitation Plan

In this Chapter Resettlement and Rehabilitation (R&R) Plan of M/s Reliance based on National Policy on R&R (NPRR-2003) is briefly discussed.

1.9 Environmental Clearance Process

Reliance Jamnagar Infrastructure Limited (RJIL), earlier known as Reliance Infrastructure Limited (RFL), is proposing to set up a new petroleum and petrochemical complex in the multi-product SEZ at Jamnagar. This petroleum and petrochemical complex will house the export-oriented refinery of RPL, a group company of RIL, that already has been accorded Environmental Clearance by the Ministry of Environment & forests (MoEF) (letter no .J.11011/232/2005_1A(II)-I dated 3rd August 2005). This refinery complex along with the existing RIL refinery can supply the raw material and intermediate products to set up a synergically integrated homogenous petroleum and petrochemical complex.

Based on the EIA Notification of 1994, the Environment Impact Assessment & Risk Assessment Studies for the Petroleum and Petrochemical Complex were conducted by National Environmental Engineering Research Institute (NEERI). Subsequently, the EIA Notification of 1994 was superseded by the Environment Clearance Notification of 2006. Based on the new notification, the above prepared EIA & RA Studies were considered to be draft documents. An application was filed with the Ministry of Environment & Forests (Letter No 77/070207/RFL/MEL) for the endorsement of the draft Environment Impact Assessment (EIA) and Risk Assessment (RA) studies that were prepared by NEERI. The proposal was discussed along with the draft EIA at the EAC 62nd meeting of the Expert Appraisal Committee (EAC)-Industries, held on 1st & 2nd March-2007 to ascertain the adequacy of the Terms of Reference (TOR) used for the EIA Studies. Based on the review of the proposal, draft EIA& RA Documents, by the EAC, the Ministry suggested some additional TORs and directed the project proponent to approach the Gujarat Pollution Control Board (GPCB) to conduct the Public Consultation process, as per the EIA Notification 14th Sept– 2006.

An application was filed with the GPCB to conduct the Public Hearing for the proposed project. All the requisite documents along with the additional TOR Document were submitted to the GPCB for the Public Consultation Process. The Public Hearings was conducted on 8th January 2008, in line with Appendix IV of the EIA Notification-2006. The GPCB prepared the Minutes of the PH Meetings and a copy of the Minutes has been forwarded to the Ministry. The Public Hearing ended on a positive note with support for the proposed project. Thus the final EIA which incorporates the additional TORs suggested by the Ministry, suggestions / recommendations of the Public Hearing and with the updated project and process information.

The project has been appraised by the Expert Appraisal Committee (EAC) of the ministry in the month of August 2008. After the presentation and the meeting the ministry has sought the specific clarifications based on the discussion in the Expert committee meeting. After providing the specific clarifications, the appraisal committee in a meeting held on April 2009 discussed the clarifications and further asked for the additional information basing on the discussions. These additional information has been provided to the ministry and further EAC meeting held on June 2009 and recommended the project for the Environmental Clearance.

The MoEF through the letter dated 3rd Aug 2009 informed that this project proposal will be reappraised by the newly constituted Industrial Projects 2 committee, particular to the aspects of the 2100 MW of Captive Power Plant (CPP) and in general the integration of CPP with other C1 to C8 units.

As understood the instructions of the chairman of Industrial Projects -2 committee, this document (EIA) incorporates all the clarifications and additional information sought by the ministry till date as advised by the ministry.

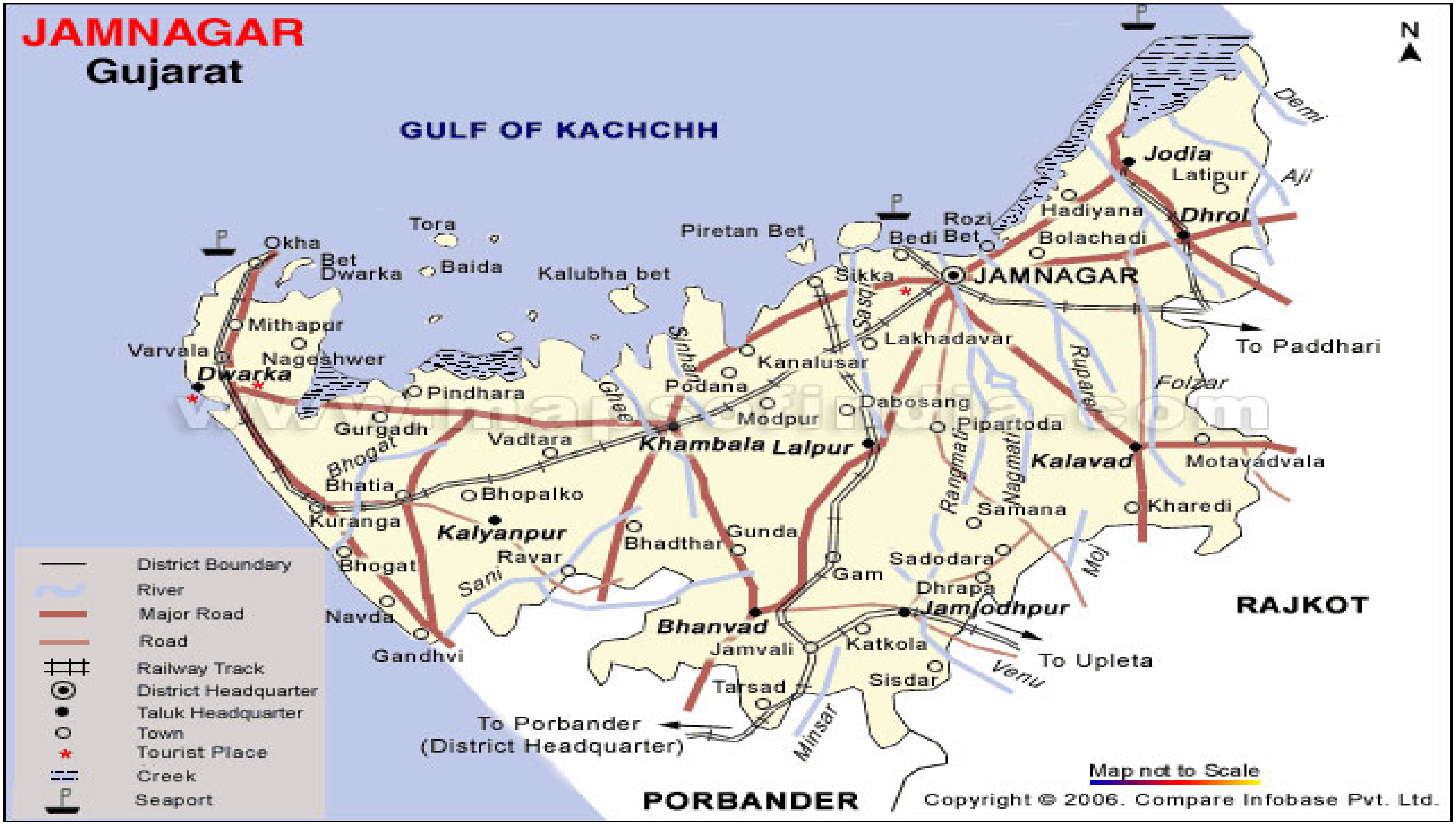


Fig. 1.1 : Location of SEZ at Jamnagar

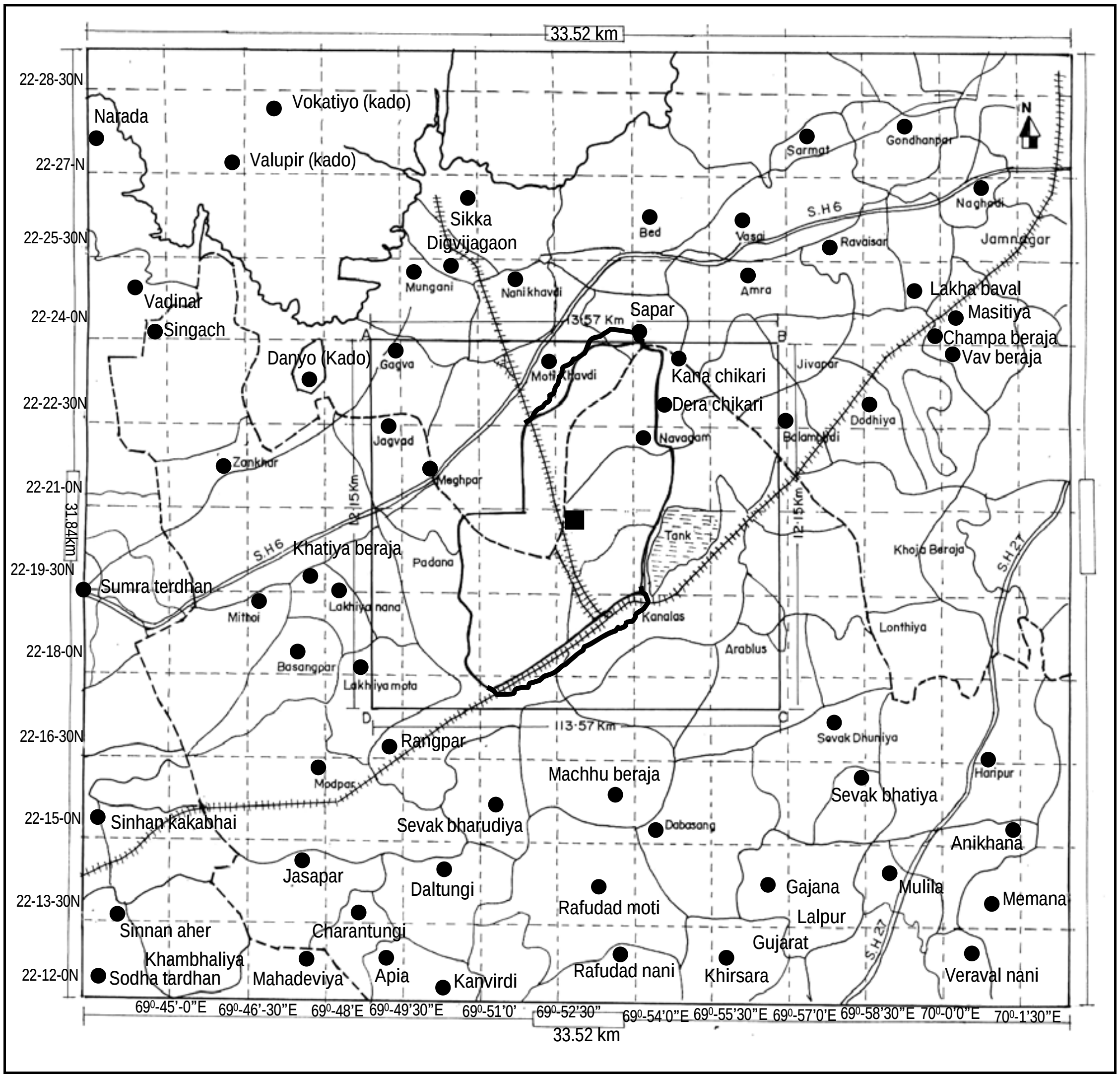


Fig. 1.2: Location of SEZ Area

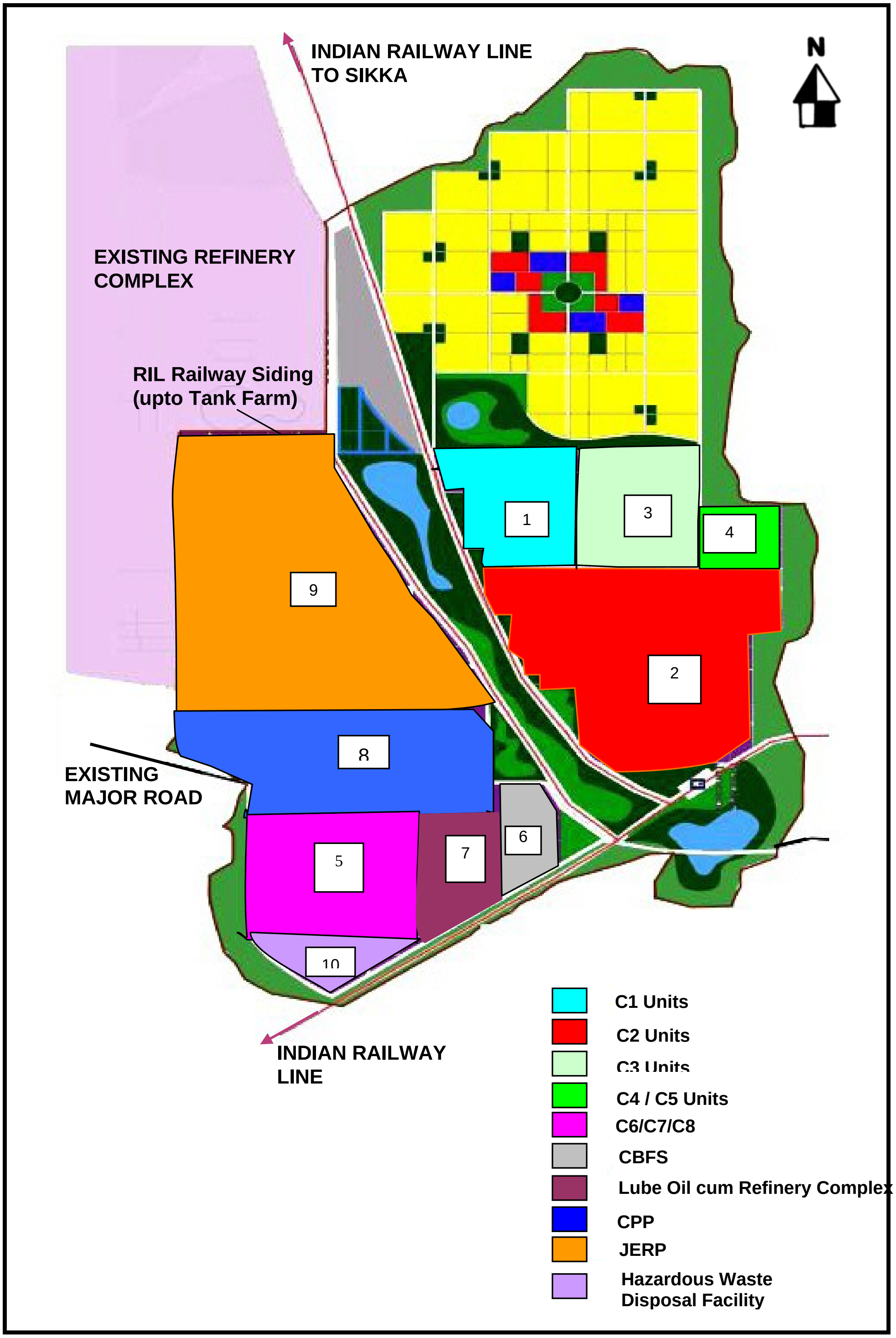


Fig. 1.3 : Overall Plot Plan of Proposed SEZ

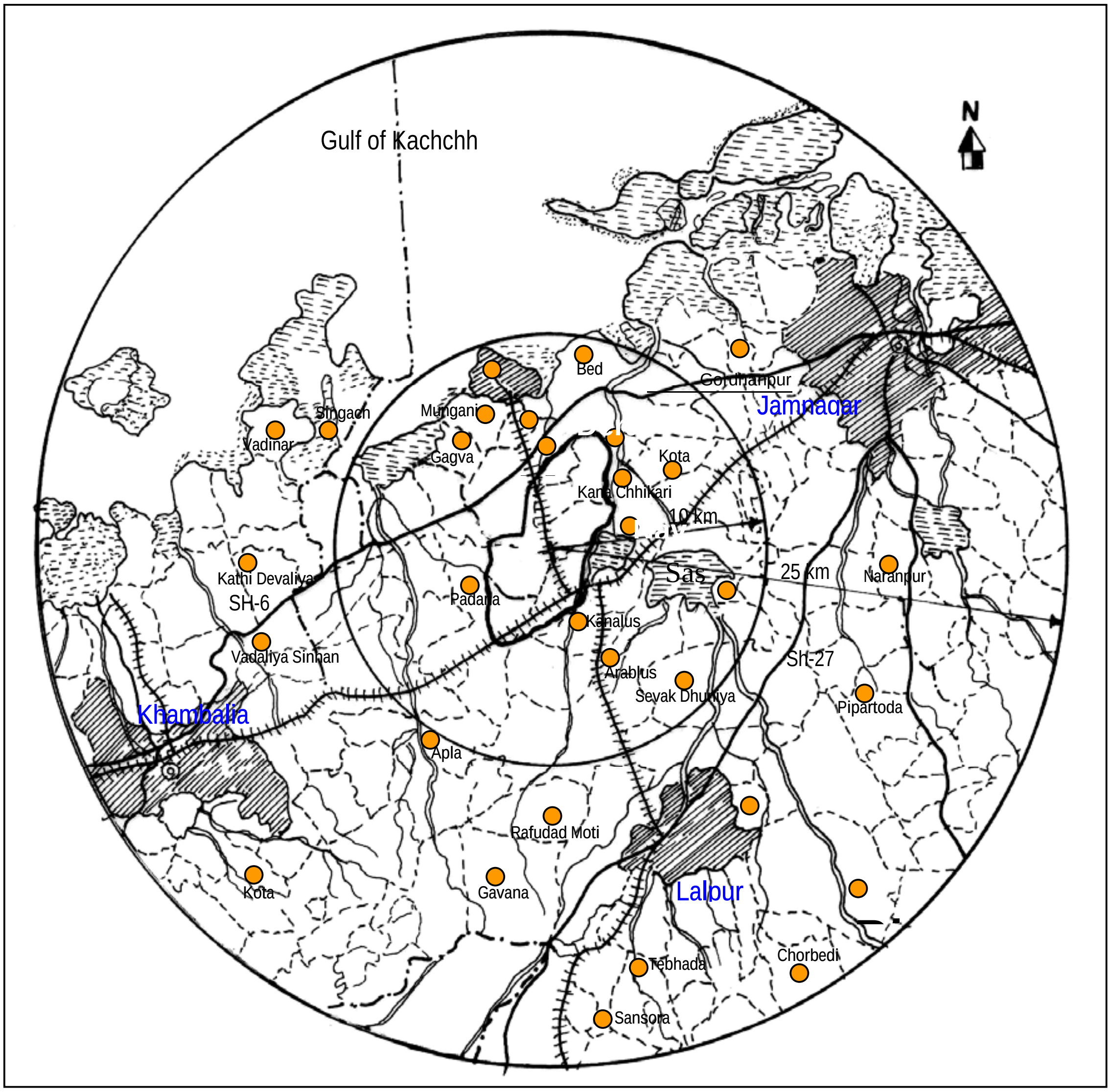


Fig. 1.4 : Study Area around the proposed SEZ

Table 1.1

Feasibility Analysis For The Location of SEZ

ATTRIBUTES	EXISTING CONDITION	POTENTIALS	POSSIBILITIES FOR DEVELOPMENT
Physiological Attributes			
Location	• Located in the state of Gujarat at village Motikhavdi, Taluka - Lalpur, District - Jamnagar. • 815 km away from Mumbai and approximately 25 kilometers from the city of Jamnagar	• Proximity to the Sikka & Bedi ports , • Adjacent to the Reliance Refinery • Proximity to: Business Capital - Mumbai, Economic Capital - Ahmedabad and Rajkot	• Basic infrastructure for export oriented petrochemical and petroleum industry is in place. • Ideal for petroleum and petrochemical multi-product SEZ
Topography / Soil Type	• Saline, sandy loam to silty loam with moderate infiltration rate, amenable to groundwater pollution	• Virgin Land - No site restrictions / obstructions in terms of the physical topography of the site.	• Precaution to be taken for integrating the EMP recommendations • Plantation to be undertaken to conserve the runoff water and enhance the scarce vegetation cover.
Climate	• Semi – arid type of extreme climate with deficit Rainfall		
Availability of water	• Water from the desalination plant, serving the existing refinery – Primary water source. • Water supply from Narmada canal is planned and is under implementation - provide additional water required for the SEZ .	• Sufficient quantity to meet the immediate water requirement of the industry. • The Reliance Desalination plant also supplies water to nearby villages in days of shortage.	• Integrated water developmental schemes will be developed for optimum generation and usage.

ATTRIBUTES	EXISTING CONDITION	POTENTIALS	POSSIBILITIES FOR DEVELOPMENT
Other Attributes			
Accessibility	• The Sikka & Bedi ports provide access through water • Nearest railway station - 3 km away. • The proposed Reliance SEZ is 5 km off the SH-25, connecting Okha and Rajkot. • The site is directly linked to the National Highway network through NH-8A ext., connecting Ahmedabad and Rajkot and State Highways SH6 & SH 48. • Air • Nearest Airport 25 kms away at Jamn agar	• Proximity to functional port with basic infrastructure ready for similar activity – asset for the Petroleum and Petrochemical based SEZ.	• Good accessibility is the pre-requisite for export oriented activities.
Site surroundings	• Close to Coastline • Adjacent to Reliance Refinery	• RIL Would support the related downstream industries	• Ideal for chemical and allied industries.
Availability of Socio-Economic infrastructure	• Surrounding villages and revenue lands – poor socio-economic infrastructure. • Reliance Refinery – Strong infrastructure	• The SEZ would depend on the Reliance Refinery initially for its basic infrastructure till it attains self-sufficiency and supports the infrastructure of the surrounding villages.	• Export oriented activities will add to the basic socio-economic infrastructure of the area.
Access to physical infrastructure	• Power – would be met through a captive power plant dedicated to SEZ . • Water – Desalination plant and water augmented from the proposed Narmada canal • Rail – The site has a rail head which can be utilized effectively for transporting freight	• Basic physical infrastructure can be easily augmented from the adjoining Reliance Refinery in the early stages till the SEZ attains self – sufficiency in terms of its own infrastructure. -Do-	• The availability of infrastructure, a pre-requisite for industrial development in the SEZ would attract the investors. • Expansion of port facilities and additional berth/jetties for container/bulk cargo -Do-

ATTRIBUTES	EXISTING CONDITION	POTENTIALS	POSSIBILITIES FOR DEVELOPMENT
	• Road – Site lies close to the state highway 25 and NH-8A • Sewerage and Drainage • Gentle slope assures Proper site drainage		

Table 1.2

List of Units Proposed for SEZ Project

Sr.No	Proposed Units	Capacity (MMTPA)	Raw material in (KTPA)	Raw Material Source
I	**C1 Based Units**			
1	Coke Gasification	8.75	8750 Coke	Refinery DTAP + JERP
2	Methanol Synthesis	0.625	660 Syngas	Coke Gasification
3	Acetic Acid	1.00	575 Syngas + 500 Methanol	Coke Gasification +Methanol Synthesis
4	Vinyl Acetate Monomer(VAM)	0.70	390 Acetic Acid +200 $C_2^=$	Acetic Acid + Multi Feed / Cat Cracker
5	Polyvinyl Acetate (PVA)	0.35	320 VAM	Vinyl Acetate Monomer
6	Polyvinyl Alcohols (PVOH)	0.125	250 PVA	Polyvinyl Acetate
II	**C2 Based Units**			
1	Multifeed Cracker Complex	3.45	2 x 625$C_2^=$(FCC) 1000 C_2 (RFG)* 190$C_2^=$ (RFG)*	Refinery DTAP + JERP
2	Ethylene Oxide Derivatives like Mono Ethylene Glycol (MEG), Di Ethylene Glycol (DEG) , Tri Ethylene Glycol (TEG)	1.25	800 $C_2^=$	Multifeed /Cat Cracker
3	Polyethylene polymers like (LDPE /LLDPE/HDPE)	0.75	765 $C_2^=$	Multifeed /Cat Cracker

III	**C3 Based Units**			
1	Acrylic Acid & derivatives, SAP	0.45	275 $C_3^=$ 65 Acrylic acid	Multifeed /Cat Cracker + Acrylic Acid
2	n-Butyl Acrylate, n-butyraldehyde, n-Butanol, 2-EthylHexanol	0.5	315 Acrylic acid + 250 Oxy alcohol	Acrylic Acid +Oxy Alcohol
3	Propylene Derivatives like Propylene Oxides, Cumene, Phenol	0.4	290 $C_3^=$ + 285 H_2O_2	Multifeed /Cat Cracker + Hydrogen Peroxide
4	Propylene Glycols	0.2	150PO	Propylene Oxide Unit
5	Polyols	0.25	225 PO + 25 EO	Propylene OxideUnit + MEG
6	Hydrogen Peroxide (H_2O_2)	0.32	165 Syngas	Methanol
7	PP (Non woven)	0.125	125 PP	Polypropylene (PP)
8	Polypropylene (PP)	0.25	250 C_3	Multifeed / Cat Cracker
IV	**C4/C5 Based Units**			
1	Butyl/Halo Butyl Rubber, ESBR, SBR,PBR, SSBR	0.47	150 $iC_4^=$ + 250 Butadiene + 62.5styrene	Refinery (DTAP + JERP) + Multifeed Cracker Aromatics 2 + Multifeed Cracker
2	Butene 1	0.0625	62.5 $C_2^=$	Multifeed Cracker
3	Maleic Anhydride (MA)	0.25	NC_4	Refinery DTAP + JERP
4	Fumaric Acid	0.125	MA	Maleic Anhydride

V	**C6/ C7/ C8 Based Units**			
1	Mono Nitro Benzene,Aniline, Methylene Di Aniline,Phosgene, Methylene Diphenyl Diisocyanate (MDI), Toluene Diisocyanate (TDI), Benzene	0.5	500 Benzene	Refinery DTAP + JERP
2	Styrene	1.0	700 Benzene + 315 $C_2^{=}$	Refinery DTAP + JERP
3	Paraxylene (PX), Orthoxylene (OX)	2.5	Reformate	Refinery DTAP + JERP
4	PTA	1.875	1250 PX+132 Acetic Acid	Aromatics
5	PET	1.5	1290 PTA +500MEG	PTA+MEG
6	Polyesters Complex (POY, PSF)	0.625	140 PTA+ 200MEG	PTA+MEG
VI	**Carbon Black**	1.5	CBFS + CSO (2.5 MMTPA total)	Refinery Unit (DTAP & SEZ)
VII	**Lube Oil Cum Refinery Complex**	8.5	140 Kbpsd crude	140 Kbpsd additional CDU/VDU
VIII	**Captive Power Plant**	2100 MW		
IX	**Jamnagar Export Refinery Project**		580 Kbpsd Crude	

- Refinery Fuel Gas
- SAP: Super Absorbent Polymer.
- PTA: Putrefied Teraphthalic acid
- MEG: Mono Ethylene Glycol
- LLDPE: Linear Low Density Polyethylene
- LDPE: Low Density Polyethylene
- PET: Polyethylene Tera-phthalate.
- POY: Polyester Oriented Yarn.
- PSF: Polyester Stable Fiber
- ESBR: Emulsion Styrene Butadiene Rubber
- SBR: Styrene Butadiene Rubber
- PBR: Poly Butadiene Rubber
- SSBR: Solution Styrene Butadiene Rubber

Note: The Petroleum and Petrochemical Complex will be manufacturing and utilizing the petrochemicals of the value chain C1 to C8 categories derived from the petroleum refining and their streams. The products and C1 to C8 derivatives mentioned hear are generic names and most commonly used and their various synonyms names are not mentioned.

The capacities indicated are based on the feed stock available from the approved capacities of the RIL refinery cum Petrochemical complex and RPL Refinery at Jamnagar.

In case there is any increase in the envisaged product capacities, the company will approach the concerned authorities and MoEF for the required approvals at that time. will be approaching the authorities for required approvals as applicable at that time.

Table 1.3

Recommended Methods of Monitoring & Analysis for Criteria Parameters and Pollutants

Attributes	Measurement Technique
Meteorological Parameters	Automatic Weather Station
Wind speed, wind direction, ambient temperature, solar radiation and cloud cover	
Air Pollutants	
Suspended Particulate matter	High volume sampler (gravimetic)
(Particle size 0.5 µ to 100 µ)	
Respirable Particulate Matter (<10µ)	High volume sampler with cyclone (gravimetric)
Sulphur dioxide (0.005 to 5 ppm)	West and Gaeke Method (Spectrophotometric)
Nitrogen dioxide (0.01 to 0.4 ppm)	Arsenite modified Hocheiser Method (Spectorophotomtric)
Hydrocarbon	Gas Chromatography
Noise	Sound Level Meter
Water and Wastewater	Standard Methods for Examination of Water and Wastewater Analysis by APHA
Soil	Reference book by M.L. Jackson Reference book by C.A. Black
Geology and hydrology	Based on data collected from secondary sources
Ecological Resources	Standard Methods for Examination of Water and Wastewater Analysis by APHA Secondary data from Govt. offices and Published Literature Flora : Sample plot method, Transects and line intercepts method, Plotless sampling method Fauna : Animal species list, Count indices
Topography and Landuse	Toposheets and / or Digital Analysis Techniques

Chapter 2

Description of the Project

2.1 Indian SEZ Policy

The Export and Import (EXIM) Policy - 2000 introduced by Government of India for setting up of Special Economic Zones in the country is with a view to provide an internationally competitive manufacturing and service and hassle free environment for exports. Under the EXIM Policy-2000, the SEZ is defined as a specifically delineated, duty-free enclave and shall be deemed to be foreign offshore territory for the purposes of trade operations and duties and tariffs.

SEZ units may be set up in SEZ for manufacture of goods and rendering of services. All the import/export operations of the SEZ units will be on self-certification basis. The units in the Zone have to be a net foreign exchange earner but they shall not be subjected to any pre-determined value addition or minimum export performance requirements. Sales in the Domestic Tariff Area by SEZ units shall be subject to payment of full Custom Duty and import policy in force. Further Offshore banking units may be set up in the SEZs.

2.1.1 Some of the Key benefits of an SEZ are as follows:

- A designated duty free enclave to be treated as foreign territory for trade operations and duties and tariffs.
- No license required for imports.

- Exemption from customs duty on import of capital goods, raw materials, consumables, spares, etc.
- Exemption from central excise duty on procurement of raw materials, spares, etc. from the domestic markets.
- Supplies from DTA to SEZ units treated as deemed exports.
- Reimbursement of Central sales tax paid on domestic purchases.
- Reimbursement of duty paid on furnace oil, procured from domestic oil companies to SEZ units as per the notified rate of drawback.
- SEZ units may be for manufacturing, trading, or service activity.
- SEZ units to be positive net foreign exchange earners for the first five years.
- Performance of the units to be monitored by a Committee headed by the Development Commissioner.
- 100% FDI in manufacturing sector allowed through automatic route except few sectors.
- Profits allowed to be repatriated freely without any dividend-balancing requirement.
- No industrial licensing restrictions on products reserved for small-scale sector and domestic sales on full duty subject to import policy in force.
- Full freedom for sub-contracting in DTA and SEZ units may also undertake job work on behalf of domestic exporters for direct exports.
- Duty Free goods could be utilized over the approval period of 5 years.
- Corporate tax holiday as per Section 10 A of the Income Tax Act.

2.1.2 SEZ, Labour and Environmental Laws

While the labour laws of the land apply to units inside SEZs the respective State Government may declare units within SEZs as public utilities. This in effect means that the laws would be more entrepreneur-friendly. Moreover, the State Government are allowed to delegate the powers to the Labour Commissioner of the SEZ or to an Officer of the State Government posted exclusively for Zone. One-stop Clearance and minimum inspection within the SEZ will be part of the State rules.

As far as the environmental laws are concerned, the approval process is same as for any other type of developmental activities. However, all units within the SEZ can be assessed together in a single approval process from environmental angle. Under the Environment Clearance notification of 2006, projects are categorized into Category A & B. If any one of the units proposed in the SEZ is categorized as “Category A”, the entire SEZ will be categorized under Category A.

2.1.3 Emerging Domestic SEZ’s in Gujarat

The attractiveness of the Center’s policy framework on SEZ has not gone unnoticed by State Governments. At present, all coastal states, as well as some non-coastal ones, are working on SEZ proposals.

Existing Export Processing Zones (EPZs), besides, have clamored for SEZ status. So on November 1, 2000, the Union Government gave SEZ status at Kandla, Santa Cruz (Mumbai), Kochi, and Surat. Besides these, it has granted in principle approval for the establishment of eleven more SEZs. These are to come up at Positra in Gujarat, Nanguneri in Tamil Nadu, Navi Mumbai in Maharashtra, Kulpi in West Bengal, Paradeep in Orissa, Gopalpur in Orissa, Indore in MP, Kanpur in Uttar Pradesh, Bhadoi in Uttar Pradesh, Kakinada in Andhra Pradesh and Hassan in Karnataka as shown in **Table 2.1** and **Fig. 2.1**.

2.1.4 Gujarat State SEZ Policy

Government of India has announced a Policy of Special Economic Zones (SEZs) during March 2000 with a view to augmenting infrastructure facilities for export production.

The Central Government has offered various incentives and facilities both to developer of SEZ as well as the industrial units coming up on SEZ. All kind of units namely manufacturing, trading of service activities are permitted in SEZ. All approvals are to be given by the Development Commissioner for establishment of the unit in SEZ. The State Governments are required under the scheme to offer specified facilities and concessions for promotion of units in SEZs.

In the context of Government of India guidelines for the establishment of SEZs, the matter of formulating a policy regarding the dispensations which the State Government will accord to promote the development of SEZs, has been under consideration of the State Government for some time past. After careful consideration, it has now been decided that the following policy will apply to all SEZs in the State namely Kandla SEZ, Surat SEZ and proposed SEZ at positra, Mundra and Dahej and at any other locations where SEZ may come up in Gujarat, subject to the framework of SEZ determined by Government of India from time to time.

Management of Zones

The management of the Special Economic Zone will be under the designated Development Commissioner. The Development Commissioner will grant all the permissions as Single Point Clearance from his office. These will include registration of the unit, allocation of land, permission for construction of building and approval of building plan, power connection, environmental clearance, water requirement etc.

SEZs in the State will be declared as Industrial Township (Notified Area)

Power

The SEZ authority will ensure continuous and quality power supply to SEZ units.

SEZ developer will be permitted for arrangement of power through establishing a Captive Power Plant.

SEZ units will be granted automatic approval to set up captive power plant.

Environment

Applications for site clearance, NOC, consent order and other clearances required from Gujarat Pollution Control Board for units and activities within SEZ under different Acts except for the industry/activities which require clearance from Ministry of Environment and Forests (MoEF), Government of India will be accepted by Development Commissioner of the SEZ for processing at appropriate levels.

Water

The SEZ developer will be granted approval for development of water supply and distribution system to ensure the provision of adequate water supply for SEZ units.

Labour Regulations

The powers of the Labour Commissioner, Government of Gujarat shall be delegated to the Development Commissioner in respect of the area within the SEZs. He will function as Registration Officer, Conciliation Officer as well as Inspector under various Labour Laws to provide Single Window Service.

All industrial units and other establishments in SEZ will be declared as “public utility service” under the provisions of Industrial Dispute Act.

For inspections relating to workers health and safety, units will be permitted for obtaining inspection reports from accredited agencies as may be notified by the State Government.

Sales Tax and Other Levies

Transactions within the SEZ shall be exempted from all State taxes including Sales Tax, VAT, Motor spirit tax, luxury tax and entertainment tax, purchase tax and other state taxes.

Inputs made to SEZ units from Domestic Tariff Area (DTA) will be except from Sales tax and other State taxes.

Sales tax will be applicable to SEZ goods as applicable to other imported goods. Same Rules and Procedure will be applicable to SEZ goods as applicable to normal imports.

2.2 The National Economy

The context, in which SEZ policy was framed, as well as the significance of its critical objectives can be more fully understood against a perspective of recent trends in India’s economy and its export policy. The performance of the Indian economy in the last fifty years has had several distinctive phases;

1950s-70s : The Hindu rate of growth phase

1980s: The first liberalization phase that lasted for a decade. This phase witnessed not only a significant set up in overall growth rates but also saw significant deterioration both in the external sector and in fiscal management.

1990s and Post 9/11: The third phase which reflect that dynamic development

During the first phase, India’s economy grew at moderate levels, typically between 3 % to 4.5% during the second phase, there were tentative initial steps towards liberalization and opening up of the economy on several key fronts. This led to the step up of growth rate to around 5% to 5.5%.

The continued period of fiscal imprudence exhibited during much of the 80s finally assumed crisis proportion in mid ‘91. This set the step for unleashing a massive wave of reforms across wide ranging sectors. As a result for the first time in the history of Independent India, Indian economy persistently grew at the healthy rate of 6% to 7% before the slow down crept in.

The country witnessed the slow down for the Fiscal years 2000-02 more so in the industrial sector. Quite clearly against the above backdrop, there had been wide ranging discussions and debates on initiating the second generation of reforms. The promulgating of the Special Economic Zone Policy framework in May 2000 can be regarded and so positioned as one of the first attempts of the Government of India to unleash second-generation reforms.

The GDP of the Indian Economy grew at 7% in the third quarter 2004-2005, as per data released in June 2005. According to the same data, services exports trade posted an astounding growth with exports more than doubling from at $ 24.9 billion in 2003-04 to $ 51.3 billion in 2004-05, an increase of 105.7%. The total foreign exchange reserves stood at $ 139.8 billion at the end of May 2005. The wholesale price indices show that inflation rates have slowed down from 5.8% in April 2005 to 5.5% in May 2005. Rate of inflation in April –May 2005 was 5.6% as against the 4.8 % in the corresponding period of the previous year.

The boom industries in India include telecom, IT/ITES, biotech, retail, aviation, entertainment and energy. The Fortune 500 list (July 2005) of the top Global corporations includes 4 Indian companies namely, Reliance Industries, Bharat Petroleum, Hindustan Petroleum and ONGC. Just as China is today considered the “factory to the world”, India is considered “the world’s back office”.

The SEZ policy is the latest and most ambitious move of export boosting efforts, but it goes much further, in that it seek to radically change the environment for exports and FDI, by offering a hassle free business-friendly environment and world class infrastructure over an unprecedented large geographical area.

India’s SEZ policy can be looked at as a logical outcome of the developments in India’s export-import policy. Trade Policy reform over the last decade have moved towards providing the Government of India has already removed or reforms some of the restrictive regulation and offered a hassle free business through the following ways;

1. In the first place, efforts have been made to remove restrictive export import regulations. An important first step in this regard is the proposal to set up SEZs.
2. Secondly, conscious steps have been initiated to ensure that the process of trade liberalization in India remains aligned to the norms of multilateral trading agreements. Thus, the incentive structure for exporters has recast to make it consistent with India’s commitments to WTO. Tariff changes and QR reforms in accordance with WTO commitments have been made.
3. Lastly, the policies have been made to provide special incentives to certain categories of Indian exports.

Importantly, the EXIM policy now seeks to motivate and involve State Governments in export promotion efforts. The current SEZ framework appropriately leaves the key administrative initiatives to be implemented by State Governments.

2.3 The State Economy

In the post-liberalization period, Gujarat has pioneered the concept of involvement of private sector in the development of infrastructure. The State has constituted a mechanism of single window clearance in the form of Gujarat Infrastructure Development Board (GIDB), headed by Chief Minister. Concession agreements are finalized in a transparent manner. GIDB had prepared a detailed Master Plan. "Infrastructure Agenda - Vision 2010", laying down 383 projects estimating an investment of Rs. 1.16,993 crore. Almost 70% of the investment is envisaged to come from private sector Blue prints for development of power generating plants, ports, roads, LNG platforms, a common gas grid, industrial parks, urban infrastructure, airports.

Advantage with Gujarat

- During the period 1960-90, Gujarat established itself as a leader in various industrial sectors - Textiles, Engineering, Chemicals, and Petrochemicals. Drugs & Pharmaceuticals. Dairy, Cement & Ceramics. Gems & Jewellery, etc., the most important one being petroleum refinery set up by Reliance Industries Limited in Jamnagar, Gujarat.
- Post-liberalization period saw Gujarat's State Domestic Product (SDP) rising at an average growth rate of 12.4% per annum in real terms (from 1994 -2002).
- Gujarat achieved as much as 35% of augmentation in its power generation capacity during the period 1995-96 and 2000-01. The Independent Power Producers (IPPs) have contributed significantly in this addition. Gujarat in fact, is one of the first few states in India to have encouraged private sector investment in the infrastructure.
- Gujarat accounts for 21% of India's Exports.
- Longest coastline - 1600 Kms. dotted with 41 ports 1 major. 11 intermediate and 29 minor. Country's first private sector ports. Pipavav and Mundra. are already in operation. In addition. The liquid cargo (Chemicals) handling port at Dahej is also set up in joint sector and made operational.

- Excellent road network - exceeding 74,000 Kms. The first phase Ahmedabad-Nadiad - of the Expressway in Gujarat now opens for transportation.
- Highest number of Airports in India - 11 including an international airport at Ahmedabad.
- An extensive rail network connecting all major centres in the State.
- The annual growth rate of industrial output on an average was witnessed at around 18% during the period 1990-2000.
- Largest producer of Salt and Soda Ash in the country.

2.3.1 Economic Growth of Gujarat

During the 1990s, there was no increase in organized sector employment in Gujarat. The primary sector, particularly agriculture, has been stagnant or even declining. By contrast, the secondary and tertiary sectors have shown statistically significant and high rates of growth over the whole period. But the factory sector in Gujarat has undergone a higher degree of concentration than in the rest of India. More importantly, the capital-intensive nature of the growth in the factory sector has been even more pronounced in Gujarat.

Looking at the sectoral growth rates, it seems that the economy of Gujarat grew in an unbalanced and volatile fashion over the period under consideration. There has been a significant transformation in occupational structure. But that transformation is out of step with the change in incomes derived from different sectors. A mismatch in the movement of income and employment shares is stronger in Gujarat than the rest of India. Further, the people living in rural Gujarat have become significantly proletarianised.

2.3.2 Sectoral growth

The growth pattern of Gujarat is not uniform across different sectors. The primary sector and particularly the agricultural sector, has been stagnant or even declining in the state. The estimated trend values indicate that neither agriculture nor the primary sector as a whole follows any statistically significant time trend over the 31-year period in the state. There is, however, a general problem of the growth estimate, which varies widely according to choice of the data source as well as the base and terminal years.

2.3.3 Industrial Development in Gujarat

As mentioned earlier, the economy of Gujarat has witnessed an ever-increasing share of industry in NSDP during the 31-year period from 1970-71 to 2000-01. Further, as per the data compiled by the Annual Survey of Industries (factory sector), the state has witnessed a marginal fall in the share of the number of factories to the all-India total during the period 1980-81 to 1999-2000.However, the shares of other important indicators (viz, employment, net value added, productive capital and value of output) to their all-India values have witnessed rising trends during the period.

The share of the number of factory employees to the all-India total has increased only marginally; but the corresponding shares of productive capital, value of output, and net value-added increased at a much faster rate, especially in the1990s. That means that in the 1990s, the factory sector in Gujarat has undergone a higher degree of concentration than in the rest of India and more importantly, the capital-intensive nature of growth in the factory sector has been even more pronounced in Gujarat than in the rest of India.

During the period 1979-80 to 1999-2000, annual compound growth rate of net value added of the manufacturing sector has-been 7.8 per cent, while that of employment has been only 0.9per cent.

- Gujarat is one of the most prosperous states and is known for the enterprise of its people. This along with good infrastructure has enabled it to create one of the strongest state economies. The state contributes 5% of Net Domestic Product even though its share of population is only 4%. Its share in bank deposits is 6.1% with more than 6700 bank branches. The state is also a major trading centre with one of the country's largest port – Kandla handling almost 15% of total Indian port traffic.
- Such strong economics translates into higher purchasing power and hence higher consumption. The state's per capita urban consumption expenditure ranks amongst the top five in the country.
- The most important industries in the state are chemicals (including petrochemicals), which contribute almost 27% of state industrial production, food products and rubber and plastic. A large part of the industry is in the small scale and unorganized sector, especially in downstream chemicals and processing industries.
- Our database search revealed that more than 250 companies amongst the top 5000 companies in India have plants or offices in the state. Though it will be premature to quantify the impact on each company, we have attempted to

assess the broad impact on industries and companies with a significant presence in the state.

Chemicals oil and gas

The largest investor in Gujarat is Reliance group who has set up a textile unit in Naroda, a petrochemical complex at Hazira and Petroleum refinery and a Petrochemical Complex in Jamnagar.

Industry and environment

The State's share of factories, [9.8%] organized employment [8.21%], productive capital [15.27%], output [12.96%], and net value addition [11.45%] in 1998-99, was way above its share of population [5%] or its geographical area [6%]. As a result, the per capita income in the sate at Rs. 18792 at current prices (1998-99) is about 30% more than the national average.

It had 19,771 registered factories and 2,33,777 small-scale industries as on 31st October 2000. According to the annual survey of industries for the year 1997-98, the chemical and chemical products group constituted 37.28% of the industries. Rubber, plastics, petroleum and coal based industries contribute another 14% while textiles contribute 8% of the industries.

In the last decade economic development has taken place in Jamnagar. Gujarat already boasts of industrial hubs of Jamnagar and Mundra.

Reliance has the capacity to take up development of large economic zones and intends to do so within the framework of the national SEZ policy. The development of such economic zone will create an investor friendly environment supported by infrastructure to accelerate industrial growth and would also open up employment opportunities for rural population.

Reliance SEZ is unique in many respects compared to the other SEZ's, developed Internationally and Nationally.

2.4 Location & Connectivity

SEZ located in the Jamnagar district, in close proximity to Arabian Sea:

- It is well connected with important state road network (state highway no. 25) and other important national node via NH- 8A. It is about 30km from Jamnagar and 340km from Ahmedabad.

- A broad gauge railway network connects Reliance SEZ with Jamnagar and other rail network.
- Reliance port at Sikka, being a part of Reliance industries would contribute a good deal of efficiency in the functioning of the SEZ.
- Airport at Jamnagar are in near proximity to the SEZ site only 25 km.

Any destination in North India is shorter by approximately 300 km in comparison to Mumbai ports (JNPT/MbPT).

2.4.1 Scale (Size - Scalability)

- Abundant availability of land in the hinterland will boost large scale planning and development of infrastructure in the SEZ, and therefore, has a vast scope for expansion and development.
- Large waterfront is available for expansion of Port oriented and terminal facilities at Sika.
- Numbers of new industries, Industrial parks are already coming up in the region. Also planned infrastructure and industries are coming up in the SEZ are being developed by Reliance group.

2.4.2 Port Operations

- Operational and efficient Port infrastructure available, Reliance port at Sikka
- Increased efficiency in functioning due to common management and unified agency for Port and SEZ operation.
- Multi-purpose terminal with state of art infrastructure / facilities for handling and storage.
- Liquid products handled are an infrastructural concern. For this purpose, a jetty dedicated to container depot has to be constructed to handle break bulk and dry bulk.
- A new terminal is proposed for handling the additional ships for liquid cargo, container traffic & bulk cargo.
- Deepest draught port in the western part of the country.
- Complete to and fro piping system for connectivity to the port and the SEZ.

2.5 Regional Attributes of Jamnagar

- The region is rich in mineral resources having a very high economic value.
- Major natural resource reserves in the region are suitable for large scale projects such as Power plants, Petro-chemical plants, Cement plants and other mineral based plants.
- An ideal destination in Gujarat for petrochemical products.
- Great business opportunity for Polyster / Textile units.
- Social infrastructure such as Markets, Schools, Hospitals, Children's Parks, Community Centers etc. are established in the area. Further, proposal of meeting international standards in the municipal and social infrastructure of planned area of Reliance are envisaged to be developed.

The project aims at developing a parcel of 11231 acres of land adjacent to the Reliance refinery by RJIL.

The multi-product SEZ will have state-of-the-art infrastructure like transportation system, sanitation, water supply, buildings, recreation facilities, parks and amusement complexes, multi-modal transport system, manufacturing and processing facilities, Business Development and International trading centers, etc.

Petrol and petroleum dominated SEZ and its environs fall in the high hazard zone. Hence utmost care needs to be taken to ensure that emissions and wastes from the refinery do not pollute the environs. The Reliance group envisages not only the preservation of the immediate environment but also the enhancement of the same.

Economy flourishes when it exists within the limit of the environment. The Reliance Group aims at promoting the SEZ as an eco-friendly infrastructure to provide most modern and hygienic living environment. The Reliance through its policy and programmes like conservation and further plantation endeavors to bring about awareness amongst the people and make them more responsive and sensitive to their surroundings.

2.6 The Development Plan

The Reliance Jamnagar SEZ has an integrated planning approach with the Petroleum and Petro-chemical – the base industries, the allied and complementary industries, the employee housing co-exist in harmony supported by a world class infrastructure.

The Reliance envisages developing the Jamnagar SEZ adjacent to its existing Refinery on a site of 11231 acres. The SEZ unit would be spread over an area of 8910 acres. The remaining 2321 acres would be dedicated to housing the employees, their social activities, Master plan as well as sectoral green buffers. The SEZ is expected to generate employment for 40,000 people.

The proposed SEZ is to be planned on the lines of gridiron planning with NS corridors as the avenues and EW corridors as Streets. The configuration in the existing activities of the Reliance Group and those of the other entrepreneurs would be delineated, though they would share the socio-economic infrastructure and green belts and open spaces.

The Reliance will develop the industry, housing, social infrastructure needed for their refinery and its allied activities.

2.6.1 Targeted Industrial Components

The various petroleum and petrochemical downstream units which can be set up in the proposed SEZ are as follows:

C1 Based Units

- Coke Gasification
- Methanol Synthesis
- Acetic Acid
- Vinyl Acetate Monomer (VAM)
- Polyvinyl Acetate (PVA)
- Polyvinyl Alcohols (PVOH)

C2 Based Units

- Multifeed Cracker Complex
- Ethylene Oxide Derivatives like Mono Ethylene Glycol (MEG), Di Ethylene Glycol (DEG) , Tri Ethylene Glycol (TEG)
- Poly Ethylene Polymers like Low Density Polyethylene (LDPE) / Linear Low Density Polyethylene (LLDPE) / High Density Polyethylene (HDPE)

C3 Based Units

- Acrylic Acid and derivatives , Super Absorbent Polymer (SAP)

- n- Butyl Acrylate, n-Butyraldehyde, n- Butanol, 2- Ethylhexanol
- Propylene derivatives like Propylene Oxides, Cumene, Phenol
- Propylene Glycols
- Polyols
- Hydrogen Peroxide (H_2O_2)
- Polypropylene PP (Non woven)
- Polypropylene (PP)

C4/C5 Based Units

- Butyl/Halo Butyl Rubber, ESBR, Butyl Rubber Styrene Butadiene Rubber (SBR), Poly Butadiene Rubber (PBR), SSBR
- Butene 1
- Maleic Anhydride (MA)
- Fumaric Acid

C6/ C7/ C8 Based Units

- Mono Nitro Benzene, Aniline, Methylene Di Aniline, Phosgene, Methylene Diphenyl Diisocyanate (MDI), Toluene Diisocyanate (TDI), Benzene
- Styrene
- Paraxylene (PX) , Orthoxylene (OX)
- Putrefied Teraphthalic acid (PTA)
- Polyethylene Tera-phthalate (PET)
- Polyesters Complex (POY, PSF)

Carbon Black

Lube Oil (LOBS) cum Refinery Complex

Captive Power Plant

& Jamnagar Export Refinery Project (JERP) which has already been accorded Environmental Clearance by the MoEF in 2005 / 2006.

The Modernization and debottile necking of the existing refinery and expansion refinery (called as Jamnagar Export Refinery) along with their infrastructure had been accorded the environmental clearance by the ministry in 2005 and amended in 2006. Since this JERP is being built in the SEZ area, JERP is included in the EIA. However, the emissions of JERP are included in the analysis of this study.

2.6.2 The Housing

A new Residential township is being proposed to house the employees and the growing influx of immigration due to the new industries coming up in the SEZ unit.

An area of 2321 acres has been allocated to residential enclave. The housing would consist of two segments – the Reliance housing and the employee housing for the other investors coming to the SEZ distributed in a ratio of 40:60. The two have been separated from each other by a green buffer zone.

The Petroleum and Petrochemical Industries have been categorized under the high-risk zone. The Residential quarters have therefore been separated from the industrial zone. The residential sector is to house 40,000 families.

The proposed gross density of SEZ will range from 150-175 DUs per Ha. The houses will have three categories in terms of the size of the dwelling unit, its specifications and location depending upon the income group.

The greenbelt will separate the complete residential enclave from the industrial SEZ. The Residential zone will have a continuous green belt along its periphery with jogging and cycle tracks.

The township will be designed on sectoral basis where each sector will be self-sufficient in terms of commercial, retail, public/semi-public amenities. The housing will be in the form of plotted development with plenty of open spaces. The sectors planned on the neighbourhood concept will have gardens, shops, primary education and health centers at 5 minutes walking distance.

The SEZ is being developed as an eco-friendly township. The recycled water from the industry will be used for irrigation through water channels along green corridors, which not only alter the microclimate but also would add aesthetic beauty to the layout giving some relief from the hot arid climate of the region.

The Jamnagar region falls in the arid zone with sparse, thorny vegetation. The conservation of the existing environment and its enhancement through tree plantation and development of green cover will be undertaken. The existing plantation by Reliance has gone a long way in restoring and improving the green cover in the region.

2.6.3 Building Social Health

With focus on employee and resident safety training, cooperating entrepreneurs or companies should establish emergency procedures and make essentials thoroughly understood. Prevention from occupational illnesses.

Health maintenance and enhancement: organizing regular health examination in order to determine the impact of chemical substances on employees' health and take appropriate preventive measures. In addition, employees that work in noisy environments should be given hearing tests and all employees to be surveyed regarding the hours spent at video-display terminals and any subjective symptoms they may have. Employees then advised on the appropriate work environment.

Reliance will hold regularly "Health Seminars" based on the principles of Total Health Promotion "Promoting Individual Health Maintenance" and "Let's Improve Our Daily Habits" efforts.

Regularly organize forest and mangrove conservation in which employees participate in as volunteers with proper coordination with the local governments to support preservation programs in undeveloped forest areas in future.

Kick off environmental education activities with raising of environment consciousness and ways to tackle environmental problems (including tours of oil refineries).

Support for Employee Volunteers to participate in increasing employee awareness of social contributions.

2.7 Infrastructure Facilities

Infrastructure is the prime need for any industrial or housing development but when the context is a Special Economic Zone it becomes the foundation for attracting investment on the virgin land with complete web of infrastructure facilities at the doorstep.

2.7.1 Water Supply

Water is a prime need for any petroleum and petrochemical industry. After careful consideration of the water resources in the area and not to exert any pressure on the existing resources, seawater was considered for sourcing of water in the SEZ as in the case of the existing refinery. The existing seawater intake provided at the marine terminal area is considered adequate to meet the seawater requirement for desalination of seawater to freshwater. The desalination plant will be designed using Multiple Effect Distillation process

(MED) integrating it with energy sources. The energy (heat) requirement for desalination is met from the waste heat from the processing units. This scheme eliminates the venting of low pressure and low temperature steam from the process units and also eliminates the use of water as a steam sink for the effective steam requirement and balancing. This plant also integrated with the ultra filtration / reverse osmosis plant, which will/can process the gray water from the complex.

The effective way to reduce freshwater consumption is to maximize the recycle and reuse of the treated wastewaters. In the petrochemical complex, the extent of wastewater generation and their quality depends on the type of pollutants and composition. One of the broad categorization is that the wastewater can be segregated as on the basis of total dissolved solids and is subjected to the pre-treatment/treatment of the specific pollutants. The treated wastewater will be used in the cooling towers where maximum consumption is for cooling water and next maximum utilization is for the steam generation. This procedure has been well utilized in the existing petrochemical and refinery complex and will be utilized in the SEZ complex also.

The domestic and other waste water is collected and treated at strategically placed sewage treatment plants, up to tertiary treatment level and the same is re-circulated for industry and non-domestic uses. The majority of uses are in the refinery & power plant cooling towers, horticulture watering etc.

2.7.1.1 Sources of Supply:

Existing Sources –

a) Desalinated water

Currently the water requirement for the existing Refinery cum Petrochemical complex is met from the Desalination Plant installed in the Complex .The desalination plant is providing 2600 cu m/hr (2.6 million liters/hr) of water required for the complex and the residential complex.

The desalination plant is designed with flexibility to operate on a low energy input sufficient for units or domestic purpose. This plant also integrated with the ultra filtration / reverse osmosis plant, which will/can process the gray water from the complex.

b) Effluent Treatment Plant

The effluent treatment plant is set up for the physical, chemical and biological treatment. The effluent to the Effluent Treatment Plant is being segregated into two streams i.e. low total dissolved solids (LTDS) and High total Dissolved Solids (HTDS). They are treated in three stages, with each stage having two sub-system of oil removal, two stage biological system and two stage tertiary/ polishing system so that the treated wastewater can be reused and recycled.

Reduction in Water Utilization:

In the petrochemical complexes bulk of the water is utilized for cooling purposes and production of steam. For cooling, cooling towers are used where the water evaporates for cooling the water. The cooling water consumption can be reduced by effective removal of heat by using air fin-fan coolers, feed product-heat exchange and improving the efficiency of the cooling towers. Recycling the condensate and utilization of low-low pressure steam in the desalination plants can reduce water consumption for steam. These are internalized and integrated with the desalination plant and effluent treatment plant.

a) Desalination plant

A new desalination plant is planned to be set up to meet the requirement of the proposed SEZ. Seawater shall be desalinated by desalination plants to the standards of water for the industrial process and potable water and will be supplied primarily for domestic use. The desalination plant will be designed using Multiple Effect Distillation process (MED) integrating it with energy sources. The energy (heat) requirement for desalination is met from the waste heat from the processing units. This scheme eliminates the venting of low pressure and low temperature steam from the process units and also eliminates the use of water as a steam sink for the effective steam requirement and balancing. The desalination plant shall provide 15,000 cu m/hr of water, required for the proposed units coming up in the SEZ and the residential complex.

Alternative Sources:

Large scale Recycling of Water

Domestic and other waste water shall be collected and treated at strategically placed sewage treatment plants, up to tertiary treatment level and shall then be re-circulated for industry and non-domestic uses. Besides this a “gray water” treatment plant with ultrafiltration and reverse osmosis process can be installed. For the majority of uses in the SEZ, from power plant cooling to horticulture watering, gray water would be of a high enough quality. It should also be noted that often “contaminated freshwater is of a lower quality than that of the plant’s process water”. Therefore, it can be cheaper to reprocess gray water than to clean supposedly fresh water.

In the longer term, industries throughout the SEZ will be entrusted to recycle their water much more effectively to achieve ‘zero discharge’. While the management can provide incentives for SEZ units to conserve water resources, the biggest impetus for change would come from an increase in water prices to reflect its scarcity in the region.

A gridiron system of pipelines shall be used for water distribution network, compatible with the sector planning of SEZ. Within the gridiron system of pipe network, all arterial and secondary mains shall be looped and interconnected. This arrangement eliminates dead ends and permits water circulation such that a heavy discharge from one mains allows draining water from other pipes. This also helps in preventing water from developing tastes and odors due to stagnation.

Besides this the dual piped water supply system for potable and non-potable water can be installed to reduce the pressure on the water where the non-potable water can be generated from recycling plants or grey water treatment plants while the fresh water can be from the desalination plants. The water distribution scheme is to be based on independent storage and distribution of treated water from the above discussed sources, for domestic, non-domestic and industrial uses. Initially, the treated water shall be stored in underground water storage tanks, and shall be subsequently pumped up to the corresponding elevated water tanks. Water shall then be distributed independently through those elevated water tanks.

An Integrated water-sewerage-drainage management plan will be prepared for the entire SEZ area after evaluating the topographical survey.

In addition to the water supply for domestic, non-domestic and industrial uses, piping system shall also cater for water supply for fire fighting, including necessary pressure boosting measures.

The water balance diagram is given in **Fig. 2.2**. Adding further watershed management facilities of SEZ will be planned to achieve effective rainwater harvesting. All buildings and paved areas will be designed in Jamnagar SEZ with built-in latest techniques of rainwater harvesting and water holding tanks.

2.7.2 Power

The power requirement for the proposed zone would be met through a captive power plant of 2100 MW capacity is planned to be set up as a part of the SEZ infrastructure, utilizing the fuels available from both the refineries Additional requirements of fuel will be met by natural gas.

The power and energy requirement is met by the captive power and steam generation units and should be installed for the SEZ. Power Generation is by Gas Turbines Generators and Heat Recovery Steam Generator (HRSG) and Steam Turbines (STG). Steam is supplied to the same unit, which will be supplemented by Steam Boilers. The grid will be so designed that itself is self-sufficient for all the requirements like peak, normal with an automatic grid balance systems for optimum fuel consumption in all the cases.

All the units of the SEZ shall be encouraged to have the primary drives based on energy integration system of electrical motor, steam turbine with extractive steam, the exhaust steam of the STG will be integrated with the desalination plant.

The use of co-generation systems is a first step in increasing overall energy efficiency. There are other energy conservation measures requiring either capital investment on the part of individual companies, and/or changes in attitude through education. Conservation can be as simple as “smart” lighting which turns off when the space is not in use, low energy light bulbs, or increased insulation to retain heat or cold (from air conditioning systems). Or, conservation can be complex with highly technical energy cascading schemes to attempt to capture and use every last joule of energy created in the industrial system.

Another feasible alternative energy source may be photovoltaic solar technology. The tropical climate is well suited to the implementation of solar energy programs. For instance, roof solar panels could run all of the air conditioners throughout the SEZ, and small solar panels could power environmental monitoring and lighting systems at remote locations, where running power lines may be impractical.

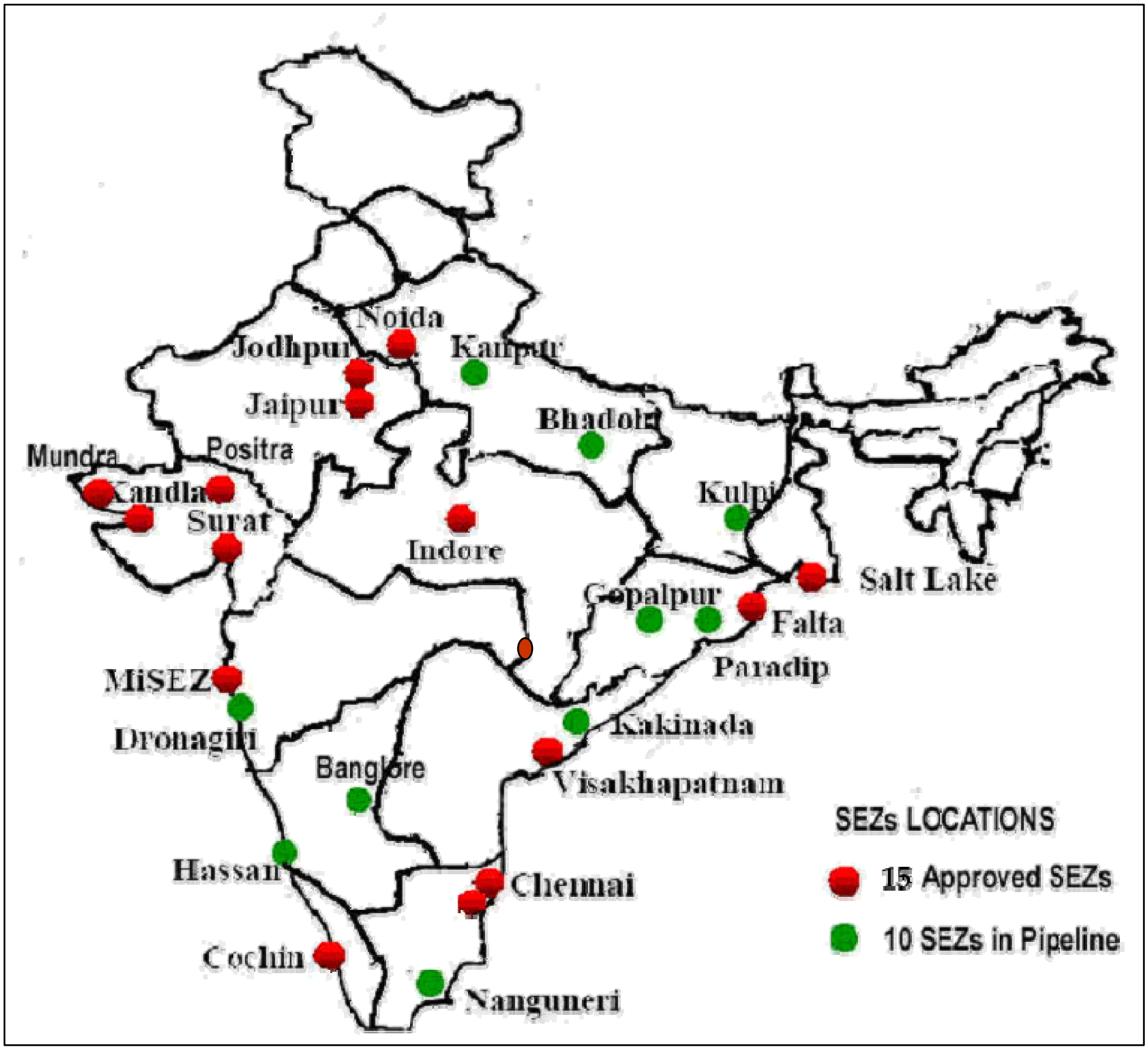


Fig. 2.1 : Existing and Proposed SEZ's in India

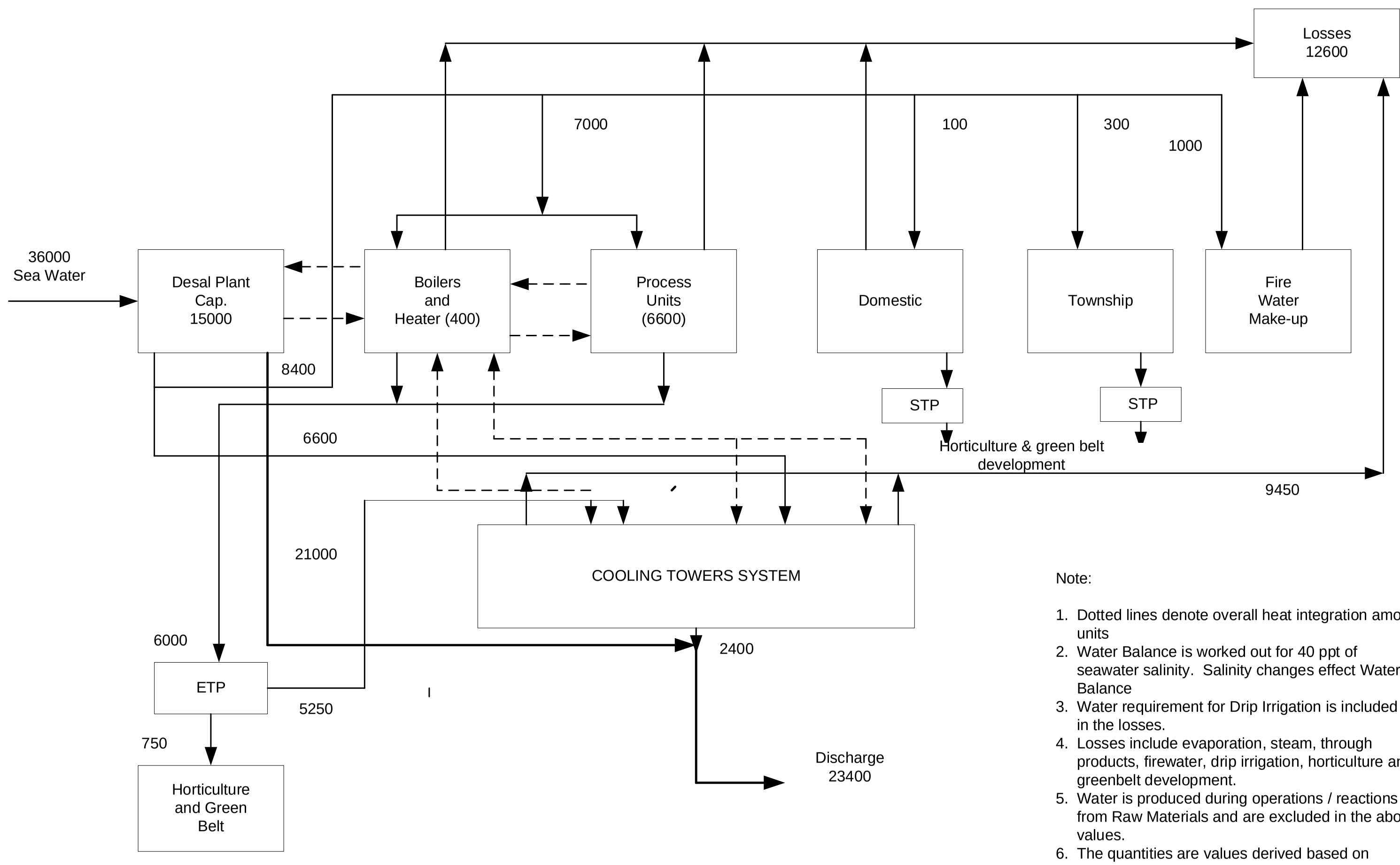


Fig. 2.2 : WATER BALANCE FOR SEZ (All figures in m3/hr)

Note:

1. Dotted lines denote overall heat integration among units
2. Water Balance is worked out for 40 ppt of seawater salinity. Salinity changes effect Water Balance
3. Water requirement for Drip Irrigation is included in the losses.
4. Losses include evaporation, steam, through products, firewater, drip irrigation, horticulture and greenbelt development.
5. Water is produced during operations / reactions / from Raw Materials and are excluded in the above values.
6. The quantities are values derived based on ambient atmospheric conditions and changes.
7. Density differences due to temperature, salinity etc. are not taken into account

Table 2.1

Existing & Proposed Special Economic Zones in India

Sr. No.	Name of the SEZ
1	Manikanchan, Salt Lake SEZ, Kolkata
2	Indore SEZ(Madhya Pradesh)
3	Moradabad SEZ(Kanpur)
4	Sitapura SEZ(Jaipur)
5	Bornada SEZ(Jaipur)
6	Kopata, Maha Mumbai SEZ
7	Positra SEZ(Gujarat)
8	Nanguneri SEZ (Tamil Nadu)
9	Hassan SEZ (Karnataka)
10	Navi Mumbai SEZ
11	Bhadohi SEZ (Uttar Pradesh)
12	Kanpur SEZ(Uttar Pradesh)
13	Greater Noida(Uttar Pradesh)
14	Kakinada SEZ (Andhra Pradesh)
15	Visakhapatanam SEZ (Andhra Pradesh)
16	Paradeep SEZ(Orissa)
17	Gopalpur SEZ (Orissa)
18	Kulpi SEZ(West Bengal)
19	Vallarpadam/Puthvypeen(Kerala)
20	Noida (UP)
21	Baikampady (Karnataka)
22	Dahej SEZ (Gujarat)
23	Ennore (Tamil Nadu)
24	Mundra SEZ (Gujarat)
25	Ranchi SEZ (Jharkhand)
26	Calcutta Leather Complex (Kolkata)
27	Mahindra City SEZ
28	Nokia SEZ

Chapter 3

Process Description

The process description updated with the clarifications and additional information sought by the MoEF in their communications.

3.1 Introduction

Demand pull is the main driver, for setting up the units in the Jamnagar SEZ, based on the potential of growth in the Asian region. This opportunity has arisen due to the open market policies being embraced by the governments, and demographics of the region. The economies of Indian and China are at a threshold limit of US$ 3000 per capita on parity basis. At this threshold, and the economies that have undergone transition from developing to developed economies, an exponential growth rate was observed in personal expenditures. The growth rate was observed in all the areas, which reflected an impact of increase in living standards. The major areas and significant change in growth rates observed are:

1. Energy Supply – Oil, Gas and Power equivalent
2. Petrochemicals – for industrial and personal products
3. Transportation – primarily personal transportation such as cars.
4. Clothing – primarily textiles
5. Personal Care Products – commensurate with rise in standard of living
6. Agriculture, Health Care & Insurance
7. Organized retailing
8. Infrastructure facilities, like telecom, roads, transport, ports etc.

In relevance to the Indian scenario, there is a large refinery complex set up by the Reliance Group and is in operation at Jamnagar. Jamnagar has arguably the most suitable seafront in the Gulf of Kutch, for raw material imports and finished product exports center, Jamnagar has an excellent hinterland connection, for having the natural advantage of protected sea to operate a very environmental-friendly, import and export terminal. The existing refinery together with the Export Oriented Refinery being implemented shall provide feedstock and an excellent integration of the downstream petroleum, petrochemical and intermediate products, and across the fence transfers.

The Jamnagar SEZ configuration is aimed for maximum value addition along the entire carbon chain C1 through C8, and higher.

C1 value chain – Petroleum coke is a residue coke from the two refineries in Jamnagar. Petroleum coke can be gasified to produce power, steam, hydrogen for consumption of the 2 refineries, as well as a world scale acetyl complex of methanol, acetic acid, vinyl acetate, poly vinyl acetate and poly vinyl alcohol. Acetic acid has synergy with polyester textiles and vinyl acetate and its derivatives are important building blocks for personal care products.

C2 value chain – Refinery fuel gas can be a low cost feedstock for ethylene and ethane cracked ethylene. Ethylene is an important building block for polymers and textile intermediates, whose demand shall grow exponentially with GDP growth. The C2 Value chain will be extended to ethylene oxide derivatives.

C3 value chain – Propylene recovered from the refinery streams, and the proposed cracker products, can be converted to acrylic acid & acrylates, super absorbent polymers, oxo-alcohols and propylene derivatives which are important for personal care products and whose demand is again linked to the GDP growth.

C4 / C5 value chain – The intermediates refinery streams can be value added to elastomer products, which are linked to the growth in personal transportation

C6 / C7 / C8 value chains – The aromatics streams from the refinery can be value added to derivatives of benzene, toluene and xylene, which are linked to growth in textiles, white goods and beverage containers.

C8 + value chain – Intermediate low value streams from the stream can be value added to lube oil and carbon black, which is intimately linked to personal transportation.

The SEZ process configuration and product slate have been generated considering the following parameters:

1. Market outlook (primarily Asian because it is in SEZ)
2. Raw material availability from the 2 refineries.
3. Utility supply from the proposed IGCC
4. Environmental aspects
5. Technologies which can be readily sourced
6. World Scale plant size to exploit the economies of scale
7. Overall funding constraints
8. Price Outlook and projections
9. Environmental specifications to meet the local regional and federal and international (IFC and World Bank standards)

Basing on the above, the overall feed material, products and utility consumption, the capacities of each production facility for each project is projected with environmental parameters (emissions) internalized for optimum use of the resources. A linear model has been developed modeling each production unit, with the Best Available Technologies (BAT) for the input-output norms and consumption parameters. All the quantitative inputs have been modeled and linear programming has been done to arrive at the optimal configuration for the Jamnagar SEZ, within the supply demand and resource constraints. The configuration of the Jamnagar SEZ and the product slate has been optimized primarily from feedstock supply push and stream utilization from the refinery demand-pull for the products from potential growth in Asia. The output of the environmental emission parameters from this SEZ business model has been extracted to be used as an input to the EIA and RA Studies.

The project environmental specifications are to be developed based on the EPA rules, standards prescribed for refinery, petrochemicals, MoEF/EAC stipulations and conditions and IFC guidelines / Equator principles. The detailed diagrams and descriptions will be available after the completion of the basic design engineering of the respective units. A brief process description along with the plant pollution load is given at the end of each process as subtitle C1, C2, C3, C4, C5, C6, C7, C8+, and Capitive Power Plant, Desal Plant **Fig. 3.1** shows the proposed units of the SEZ..

3.2 C1 based Units

3.2.1 Integrated Gasification Combined Cycle (Petcoke Gassification)

IGCC means Integrated Gasification Combined Cycle. The gasification is partial oxidation of coke with O_2. Coke gasification reaction converts coke into syngas. The primary constituents of syngas are CO and H_2. Syngas can be a gas turbine fuel, which can produce power in a combined cycle. Syngas can produce hydrogen and other chemicals, suchmethanol and acetic acid.

The major elements or processing sections for the IGCC project are:

- Feed preparation
- Gasification
- Effluent handling
- Sour block
- Air Separation Unit (ASU)

Feed preparation

Coke shall be transported by a fully enclosed conveyor, to minimize dust, from the existing coke hoppers to the IGCC plot area. The coke shall be stored in coke storage silos. The flux shall be transported by trucks and stored in flux storage silos. Coke and flux, in the proper ratio, shall be weighed. Coke particles shall be reduced to proper size by grinding. Coke and flux shall be fed to the gasifier either in the form of a slurry or as dry feed. In slurry feed, coke slurry is pumped. In dry feed, coke particles are pneumatically conveyed with nitrogen. Oxygen is supplied from an Air Separation Unit (ASU) to the gassifier.

Gasification

Petcoke feed goes to the gasification section. There will be several gasifier trains. In the gasifier, the petcoke is mixed with oxygen in a specially designed feed injector. The oxygen deficient atmosphere inside the gasifier vessel generates syngas at an average temperature 1425°C. Temperature fluctuations are in the range of +/- 25^{o}C. The operating range of the petcoke gasifier is 1400 – 1450^{o}C. The fluctuations are due to normal variations in the petcoke feed flow to the gasifier. Such flow variations in the solid handling are normal and are always expected. As the partial oxidation reaction is exothermic in nature, variations either in the petcoke feed or oxygen reflects in variation in the gasifier temperature. The temperature is controlled automatically by adjusting the oxygen flow to the gasification reactor. Audio visual alarm indication is always available in case the temperature variation is beyond preset values. If required the control can be done by manual operation as well.

The raw syngas from the gasifier consists primarily of CO, H_2, CO_2 and H_2S with minor amounts of other compounds. The fluxant concentrates the ash and minerals in the petcoke to form a molten slag. The syngas is cooled by raising high pressure steam and is further cooled in a quench chamber. The by-product slag exits the quench chamber through a lock hopper.

Fly Ash Disposal

The ash content in the Petcoke is less than 0.5%. The fluxant is added in the feed preparation section captures the ash in the petcoke and forms a molten slag in the gasification section. When the syngas is cooled in the quench section the molten slag is solidified into glassy beads. There is no generation of fly ash from this process.

These beads will be disposed off in the secured landfill facility. The feasibility of recovering metals from these beads will also be pursued

Effluent handling

In effluent handling, slag is cooled and slag and water are separated. Slag is an IGCC by-product. Waste water is recycled to the extent possible and the remaining is sent to the effluent treatment plant.

Sour block

In the sour block, the raw syngas shall be cooled and scrubbed. Then acid gases – H_2S and CO_2 – present in the syngas, are removed by amine scrubbing. It is estimated that for an annual petcoke consumption of 8750 KT with average sulphur content of 7.5%, the total flow of amine solvent is estimated at 5700 m3/hr. The syngas used for petrochemicals must have low CO_2, because CO_2 is a diluent. Hence a second stage, smaller amine absorber, with a stronger amine, shall be employed as a scrubbing medium to preferentially remove CO_2 from the syngas before routing it to the petrochemical users. The amine is regenerated in a regenerator column using LP steam as the reboiler medium. The condensate is sent to an ammonia stripper for ammonia removal.

The collective acid gas streams shall be fed to the Sulphur Recovery Unit (SRU) where the streams shall be processed and the liquid sulphur collected in the sulphur condensers and in the tail gas coalescer drains by gravity into a sulphur pit. The required SRU capacity is for 1300 TPD of liquid sulphur. From environmental considerations, the IGCC project shall have a Tail Gas Treating (TGT) unit at the back-end of the SRU.

The Tail Gas Treatment process is incorporated to further treat the flue gases and reduce the SO2 emissions. The TGT process treats the flue gases from the Sulphur Recovery Units (SRU) to convert the sulphur in the flue gas to elemental sulphur. The SRU operates with the advanced Clause and Cold Bed Adsorption process at an efficiency of +99%. With the TGT following the SRU, the overall efficiency would be enhanced to 99.9%. By reducing the SO2 emissions, TGT helps in reducing the impact on the environment.

Details of TGT Treatment

In the petcoke gasification section the sulphur present in the petcoke is converted to H_2S because of the low oxygen availability. In the sour block, the raw syngas shall be cooled and scrubbed. Then acid gases – H_2S and CO_2 – present in the syngas, are removed individually by amine scrubbing. The amine is regenerated in a regenerator column using LP steam as the reboiler medium and recycled.

The H_2S stream shall be fed to the Sulphur Recovery Unit (SRU) where the streams will be processed and the liquid sulphur collected in the sulphur condensers and in the tail gas coalescer drains by gravity into a sulphur pit. The SRU operates with the advanced Clause and Cold Bed Adsorption process at an efficiency of +99%. With the TGT following the SRU, the overall efficiency would be enhanced to 99.9%. By reducing the SO_2 emissions, TGT helps in reducing the impact on the environment

The Tail Gas Treatment process is incorporated to further treat the tail gases and reduce the SO_2 emissions. The SO_2 present in the tail gas is converted to H_2S in the presence of H_2 in a catalytic reactor. The outlet from the reactor is cooled and amine washed to remove the H_2S. These gases are then sent to an online incinerator to burn off the residual H_2S (<100 ppm) before release into atmosphere through a tall stack. The amine rich in H_2S is regenerated for reuse while the released H_2S is sent to the SRU feed.

Air Separation Unit (ASU)

The IGCC project shall have multiple ASU trains. The ASU scope shall include liquid oxygen vaporizers for emergency supply. The N_2 available from the ASU can be added as diluents in the syngas to moderate the flame temperature in the gas turbines and reduce the NOx emissions.

A process block diagram for the IGCC unit is presented in **Fig. 3.2**.

Air Emissions:

The SO_2 & NOx emissions from the coke gasification process are 0.083 and 0.012 TPH respectively.

Liquid effluent:

The estimated wastewater generation is 150 M^3 /Hr (Can be recycled in the feed preparation)

Solid waste:

The estimated solid waste generation from the coke gasification process will be 0.37 MM TPA

3.2.2 Methanol

Synthesis gas a mixture of hydrogen, carbon oxides and methane is compressed to a pressure of 100 atm by a steam driven multistage centrifugal compressor. With inter coolers and a recycle flow is added to the intermediate stage. The fresh and recycle synthesis gas at high temperature and pressure enter the top of the ICI type methanol converter. A portion of the feed gases is heated to high temperature by heat exchange with the departing reaction gases. The remaining feed gases are introduced at intermediate reactor stages to act as a thermal quench to control the temperature. These gases react in the methanol converter in presence of Zinc-copper-aluminium oxide catalyst to form methanol and water. Gases departing from the bottom of the converter are cooled by exchange with the feed gases and then in air and water coolers to condense crude methanol and water. This condensate flows to a pressure blow-down drum and then to a crude methanol storage tank. Uncondensed gases, with the exception of the purge stream, are recycled to the synthesis gas compressor.

The crude methanol is purified by fractional distillation in a 60 tray light ends column where low boiling compounds, principally dimethyl ether, are removed overhead. A second 60 tray distillation column takes methanol product from the 56th tray. A crude stream of higher alcohols is drawn from the 10th tray and wastewater from the bottom. Process flow diagram for the production of Methanol by the copper catalyzed intermediate pressure process is given **Fig. 3.3.**

Air:

The VOC & CO emissions from the process vents will be less than the 150 mg/Nm3

The SO2 & NOx emissions from the Methanol synthesis are 0.0008 and 0.331 TPH

Liquid Waste

The estimated wastewater generation from the Methanol synthesis process will be 25 TPH

Solid waste:

The solid waste generation from the methanol Synthesis is only a Catalyst

3.2.3 Acetic Acid

Methanol and carbon monoxide are continuously fed to a liquid phase reactor. The reactor contains acetic acid, water, hydrogen iodide, methyl iodide, and the rhodium catalyst complex. Methanol rapidly reacts with hydrogen iodide to form methyl iodide, and in presence of rhodium catalyst system reacts with carbon monoxide to yield product acetic acid. The reactor operates at high temperature and up to 30 kg/cm2g. Unconverted carbon monoxide leaves the top of the reactor vessel and is cooled to knock out and recover condensables before flashing. The vapor stream is then scrubbed with a slipstream of methanol feed in the gas scrubber. The bottoms stream from the gas scrubber is returned to the reactor vessel and any unconverted carbon monoxide is purged. A draw off stream is continuously taken from the reactor vessel and flashed into an adiabatic single stage flash tank, which operates at reduced pressure. The flashing process vaporizes a portion of the drawoff stream, including the net acetic acid production and also serves to remove the exothermic heat of reaction. The liquid phase in the flash tank, containing the homogeneous catalyst system, is pumped back into the reactor vessel. In this manner, carbonylation products are removed from the reactor without decomposition or excessive handling of the rhodium catalyst complex. Techniques have been developed for regenerating any trace of deactivated catalyst species formed from the reaction with corrosion products of the reactor's materials of construction.

The overhead stream from the reactor flash tank contains acetic acid, methyl iodide, water, methyl acetate, and traces of carbon monoxide and hydrogen iodide. This stream is fed to the lower portion of the product separation column where a concentrated acetic acid stream is recovered as a side stream containing water, methyl iodide, methyl acetate, and traces of hydrogen iodide. A small bottoms drawoff from this column, containing acetic acid, water, and hydrogen iodide, is removed and recycled to the reactor flash tank. The overhead stream from the product separation column is cooled to knock out condensables and sent to a phase separator. Noncondensable carbon monoxide is recovered and passed to the gas scrubber. The condensate is phase separated into a light aqueous phase and a heavy organic phase. A portion of the light phase, containing water, acetic acid, methyl acetate, and methyl iodide, is refluxed to the column; the remainder is recycled to the carbonylation reactor. The heavy phase, containing methyl iodide, acetic acid, methyl acetate, and water, is recovered and also recycled to the carbonylation reactor. A slip stream of this heavy phase is further processed in the alkane removal tower for the removal of alkanes prior to recycle to the reactor. Carbon monoxide is used to strip this stream. The overheads product from the alkane removal tower, consisting of methyl iodide, methyl acetate, and water, is recycled to the carbonylation reactor. The bottom products from the alkane removal tower consisting of alkanes, acetic acid, and traces of methyl iodide, is purged.

The concentrated acetic acid side stream from the product separation column is sent to the crude acetic acid column for further purification. Methanol is added to the lower portion of this column. The methanol reacts with the hydrogen iodide to form methyl iodide and water.

Excess methanol reacts with acetic acid to form methyl acetate. The overhead stream from the crude acetic acid column consists of acetic acid, water, methyl iodide, and methyl acetate. The condensate is partly refluxed to the column; the remainder is recycled to the carbonylation reactor. Any carbon monoxide or noncondensables are passed to the gas scrubber for recycle. The bottoms product from the crude acetic acid column consists of acetic acid with traces of water and hydrogen iodide. This stream requires additional purification for iodine removal, accomplished by distillation with or without the use of chemical agents (e.g. alkali metals).

The acetic acid stream containing traces of water and iodine is fed to the acetic acid finishing column. A mixture of high boiling acid by-products, primarily propionic acid, are removed as bottoms from this column. The overhead product from the column is condensed, with a large portion of the condensate used as reflux to the column and the remainder recycled to the carbonylation reactor. High purity acetic acid is removed as a liquid side draw near the top of the column. Process flow diagram for Acetic acid is depicted in **Fig. 3.4.**

Air Emissions:

Process vents Co and Methanol after scrubbing

The SO2 emissions from Acetic acid process will be 0.00014TPH

Liquid waste:

The estimated wastewater generation from the Acetic acid plant will be 50 M3/Hr

Solid waste:

No solid waste will be generated from the Acetic acid plant.

3.2.4 Vinyl Acetate Monomer

A gas containing ethylene, oxygen and acetic acid is passed through tubular reactors containing supported palladium-gold and potassium acetate catalyst. At high temperature and pressure of 8.2 atm, ethylene is converted with selectively to vinyl acetate. The reaction product is cooled for condensation. The remaining gas is washed first with acetic acid, then with ethylene glycol diacetate or polypropylene glycol, to recover uncondensed vinyl acetate and acetic acid. After a small part is purged, the gas is treated with potassium carbonate solution to remove carbon dioxide and is recycled. The condensate, together with the liquid recovered by absorption, is distilled to get vinyl acetate-water as the distillate. Acetic acid vapor withdrawn near the bottom is condensed and recycled for reaction. The bottom product is evaporated to get rid of the heavy residue.

The distillate consisting of vinyl acetate and water is decanted; the water layer is stripped to recover residual vinyl acetate, and the organic layer is distilled to remove acetaldehyde, which, is recycled together with acetic acid to the reactors. The crude vinyl acetate, free of light ends and water is then further distilled in a tall column, with a side stream being withdrawn for distillation in a small column to remove ethyl acetate. The distillate is refined pure vinyl acetate. Inhibitors(4-tert-Butylcatechol or other inhibitor) are added in the vinyl acetate distillation columns, which also are blanketed with nitrogen. A minute quantity of hydroquinone is added at the condensers. Process flow diagram for Vinyl Acetate Monomer is depicted in **Fig. 3.5.** There is no generation or use of Vinyl Chloride Monomer (VCM) in the process of Vinyl Acetate Monomer (VAM). Hence management of VCM is not applicable in the VAM Unit.

Air Emissions:

The Non Methane Hydrocarbon (NMHC) emissions from the Process vent- will be less than 150 mg/Nm3

Liquid Waste:

The estimated wastewater containing traces of vinyl acetate, Acetaldehyde and Ethyl acetate from the Vinyl Acetate Monomer 75 TPH

Solid Waste:

No solid waste will generate from the Vinyl Acetate Monomer process.

3.2.5 Poly Vinyl Acetate

Inhibitor in vinyl acetate monomer is removed by stripping with steam in an inhibitor stripping column. Purified VAM is stored in a VAM daytank. A solution of Benzoyl peroxide and solvent (methanol) is prepared in an initiator make up tank. The initiator solution and VAM are charged to the polymerizers.

Polymerization is carried out in two stages. Polymerization reaction takes place in glass-lined polymerizers each equipped with agitator to provide sufficient mixing. Reaction temperature is controlled with jacket cooling and reflux condensation in condenser. The polymerization reaction takes place under nitrogen blanketing. Vent gases from the reflux condenser receiver constitutes of nitrogen, methanol, carbon dioxide and vinyl acetate. Poly Vinyl acetate solution is transferred to a Polymer solution surge tank. The polymer solution can be directly diverted to downstream units like Poly Vinyl alcohol or sent to the monomer, solvent recovery section and finishing section.

The polymer solution is stripped of vinyl acetate monomer in monomer stripping column and recovered VAM is recycled back to the polymerizers. The solvent (methanol) is then recovered from the polymer solution in solvent recovery column and is transferred to a recycle solvent surge tank. The polymer is then sent to the finishing section which comprises of product centrifuge and pelletizing extruder. The finished product polymer is stored in storage bins and is sent to loading and packaging unit for dispatch. Process flow diagram for Poly Vinyl Acetate is depicted in **Fig. 3.6.**

Air Emissions:

The Non Methane Hydrocarbon emissions (NMHC) from the Process stack NMHC will be less than 150 mg/Nm3

Wastewater:

The estimated wastewater generation from the Poly Vinyl Acetate process will be 100 TPH

Solid Waste:

No solid waste will be generated from the poly vinyl acetate process.

3.2.6 Poly Vinyl Alcohol

Inhibitor in vinyl acetate monomer is removed in a stripping column and purified uninhibited VAM is stored in a day tank. Initiator solution is prepared in a make-up tank, by mixing methanol with Azobisisobutyronitrile. This solution along with VAM is charged into polymerization section.

Polymerization of vinyl acetate is carried in two stages. Reaction temperature in both reactors is controlled by reflux condensation and jacket cooling. Polymer solution from second reactor (second stage) is collected in a polymer solution surge tank. Also added in the surge tank is an inhibitor hydroquinone methyl ether which prevents any polymerization in the monomer stripping column. The polymer product from the bottom of the monomer stripping column is a 35 wt% poly vinyl acetate solution in methanol.

This solution is hydrolyzed continuously in two hydrolysis reactors in parallel. The reaction is catalyzed with sodium hydroxide-methanol solution. Neutralized poly vinyl alcohol slurry is sent to centrifuge where poly vinyl alcohol is separated from the mother liquor and washed with methanol. Washed poly vinyl alcohol containing 10 wt% methanol is dried in a rotary dryer. Closed loop nitrogen gas is used to dry poly vinyl alcohol and part of the methanol in the drying nitrogen from the dryer is condensed in a condenser and separated from the uncondensed gas in the gas separator. Dried poly vinyl alcohol from the rotary drier is collected in the product collector and is transferred to storage bins.

Crude solvent collected contains methanol, methyl acetate, some sodium acetate and water. Methanol and methyl acetate are recovered as overhead from mixed solvent column and pass into an ester hydrolyser where methyl acetate is hydrolyzed to methanol and acetic acid. The top of the hydrolyser column is packed with porous polyethylene fillers containing cation exchange to catalyze the hydrolysis reaction. The bottom section of column is packed with raschig rings and is used as a stripping zone to remove any methyl acetate. A stream of water is added at the top of the column for hydrolysis reaction and for condensation of rising vapor. Methanol is separated from the acetic acid and water from the hydrolyser column bottom stream in a methanol column and collected in the methanol storage tank before being recycled. The dilute acetic acid from the bottom of the methanol column is stored in crude acetic acid tank.

Aqueous sodium acetate from the bottom of the mixed solvent column is reacted with sulfuric acid in reactor to convert sodium acetate to acetic acid. The reaction product is combined with dilute acetic acid from the column in crude acetic acid storage tank and is extracted with ethyl acetate in a rotating disk contactor to recover acetic acid. In an acetic acid recovery column acetic acid is separated from ethyl acetate and collected in acetic acid storage tank. Part of acetic acid is used to neutralize the hydrolysis reaction product. The remainder is sent as a by product.

The sodium sulfate solution from the contactor contains ethyl acetate and is combined with the dilute ethyl acetate solution from the lower layer of phase separator for ethyl acetate recovery in the ethyl acetate recovery column. The recovered ethyl acetate is combined with ethyl acetate from the upper layer of phase separator and is used for acetic acid extraction. The bottom stream from ethyl acetate recovery column is sent to waste treatment. Process flow diagram for Poly Vinyl Alcohol is depicted in **Fig. 3.7.**

Air Emissions:

The Non Methane Hydrocarbon (NMHC) from the process stack will be less than 150 mg/Nm3

Liquid waste:

The estimated wastewater generation from the Poly vinyl Alcohol will be 140 TPH

Solid Waste:

The only solid waste generated from Poly Vinyl Alcohol is catalyst.

3.3 C_2 Based Units

3.3.1 Multifeed Cracker Complex

The Multifeed Cracker Complex proposed will be the largest to process the off gases from the refinery complex to produce cracked products. This cracker will also have the capacity to process different feeds like Naphtha, natural gas etc. The ethylene and ethane contained in refinery fuel gases / off-gases are recovered and the ethane is converted to ethylene, in the Multifeed Cracker. The refinery fuel gases are first sent to a contaminant removal section where in the impurities like H_2S, CO_2 etc are removed.

The Multifeed Cracker comprises of the following constituent sections.

- Contaminant removal
- Cracking furnaces
- Primary fractionation
- Cracked gas compression and drying
- Cold box / demethanizer
- Refrigeration section
- Deethanizer/ethylene recovery
- Propylene by Propane Dehydrogenation

Contaminant removal

The refinery fuel gas, first goes to a caustic tower, where essentially all of the hydrogen sulfide and carbon dioxide are removed with circulating caustic. Then it is water washed to prevent caustic carryover. Next in a sulfided nickel based catalytic converter, oxygen, arsine, phosphene and carbonyl sulphide are removed.

The offgasses are chilled before sending to a dryer/treater. The dryer/treater beds are designed to remove water, mercaptans, ammonia, nitriles and nitrous oxides.

Cracking furnaces

The ethane recovered from the de-ethanizer/ethylene column is fed to the Cracking furnaces along with the dilution steam. The furnace effluent is cooled in the transfer line exchangers, where in high pressure steam is generated. The cracked effluents from the furnaces are then sent to the primary fractionation section.

Primary fractionation

In the primary fractionation section the heavies comprising of fuel oil and the pyrolysis gasoline are separated out.

Cracked gas compression and drying

The cooled cracked gases are compressed, dried, and sent to the cold box (chilling train). The acid gases are also removed in a caustic tower, prior to chilling.

Cold box /demethanizer

In the chilling train/cold box, the temperature of cracked gases are reduced and fed to a demethanizer, whereas methane and hydrogen are separated and the ethylene /ethane rich streams are sent to a de-ethanizer and to an acetylene hydrogenation section.

Refrigeration system

Ethylene and propylene refrigeration systems provide the refrigeration requirements to the chilling train at different temperature levels.

De-ethanizer/ethylene recovery

The C2 streams from the deethanizer overheads are routed to an acetylene hydrogenation section where the acetylene is selectively converted to ethylene. The ethylene stream is then purified in an ethylene fractionation column where the ethane is separated from ethylene. The ethane from the bottom of the ethylene stripper is routed back to the cracking furnaces. The polymer grade ethylene is sent to storage from ethylene fractionator. There are no Ethylene emissions to the atmosphere. All emissions shall be diverted to the flare stack.

Propylene by Propane Dehydrogenation

Off-gases and LPG from the Refinery complex will be the feed source for conversion of propane to propylene. The unit is a process for the catalytic dehydrogenation of propane to propylene using continuous catalyst regeneration. Fresh feed to the unit is treated in a Huels Selective Hydrogenation Process (SHP) reactor to remove dienes and acetylenes, dried, mixed with recycle propane and fed to a Depropanizer column in the fractionation section to remove butanes and heavier components from the propane stream. Depropanizer overhead is sent into the separation system (cold box) where it is combined with recycle hydrogen and is exchanged against cold reactor effluent. The combined feed leaves the separation system and is exchanged against hot reactor effluent in the hot combined feed exchanger. The combined feed is processed in four reactors with continuous catalyst regeneration (CCR). The hot reactor effluent is cooled, compressed, then sent through a chloride treater and reactor effluent drier to remove HCl, H_2S, and H_2O before entering the separation section, where the effluent stream is separated into recycle gas, net gas and product liquid.

Product liquid is sent to another SHP reactor in the fractionation section. The SHP reactor effluent is then sent to a Deethanizer. Deethanizer net gas is used to regenerate the feed driers. The Deethanizer bottoms are sent to a heat-pumped propylene-propane splitter to produce high purity propylene product. The unconverted propane in the splitter bottoms is recycled back to the Depropanizer with the fresh propane. The Depropanizer bottoms containing butanes and heavier material is stripped with tail gas from the PSA unit. The stripped vapors are sent to fuel gas while the residual liquid is pumped offsite for use as fuel oil.

The net gas is sent to a hydrogen purification system (PSA type) and to the reactor effluent driers. PSA hydrogen is sent to the SHP reactor unit and is used for various purge streams in the CCR section of the unit. Tail gas from the PSA is used to regenerate the reactor effluent driers. The regenerant from the reactor effluent driers is scrubbed and used for fuel for the heaters while excess gas is exported as fuel for offsite boilers.

Block Flow Diagram for Multifeed Cracker is depicted in **Fig. 3.8** and Propoane Dehydrogenation is depicted as **Fig. 3.9**.

The MoEF sought clarification on Emissions from Multi-feed cracker complex

The multi-feed cracker will have thirty-six furnaces and these will be using the sweat fuel gas in the burners. The emissions from the cracker complex will be mainly from these furnaces and will emit traces of SO2 and NOx.. These Furnaces will have NOx reduction mechanism. Some of the emission management techniques proposed are listed below:

- NOx Emissions from cracker will be controlled by employing low NOx Burners.
- The off gases from decoking operation will be routed to the fire box of another furnace in operation.
- Carbon monoxide emissions will be minimized by the use of advanced combustion control schemes utilizing feedback from continuous flue gas analyzers, which will be installed as a standard package alongside the normal combustion control systems. The quality of flue gas from cracking furnace will be continuously monitored by online CO and O2 analyzers.
- Recycling and/or reusing hydrocarbon waste streams. Flare gas systems will be provided to allow safe disposal of any hydrocarbons that cannot be recovered in the process (i.e., during unplanned shutdowns and during start-ups).
- The gas fired cracking furnaces and steam super heaters will have modern firebox design with extensive energy recovery facilities giving a thermal efficiency of 92 %.

- Sampling systems will be of closed loop design. All equipment and piping systems will be designed to ensure a high level of containment and to minimize fugitive emissions. This involves seal-less or double / tandem sealed machinery, low-loss valve packing, use of spiral-wound jointing materials, and minimum use of flange connections.

The salient features of the multi-feed cracker complex are as given in Annexure – X

Fuel gas:

The fuel gas requirement for Multifeed cracker is 437.4 TPH

Air Emissions:

The Emissions SO2 & NOX are1.314 TPH and 0.471 TPH

Liquid Waste:

The estimated wastewater from the Multifeed cracker is 400 TPH

Solid Waste:

The solid waste generation from the Multifeed cracker will be coke.

3.3.2 Monoethylene glycol (MEG)/ Diethylene Glycol (DEG) and Triethylene Glycol (TEG)

The MEG is produced by first converting ethylene-to-ethylene oxide (EO) through a direct oxidation process and then hydrolyzing the same.

Ethylene, recycle gas and oxygen are thoroughly mixed, preheated and passed through the EO reactor, where ethylene is converted into EO at elevated temperature and pressure. The reaction product gas is scrubbed with neutralising liquid to remove acidic compounds and further cooled in EO absorber by counter contact with water, which absorbs EO and forms a dilute aqueous solution. The gas after scrubbing and absorption of EO is recycled back to the reactor via a recycle gas compressor. A small slip stream is taken to CO_2 removal section for removal of CO_2 formed in the reactor, by absorption in hot potassium carbonate solution. Dilute aqueous solution of EO in water is stripped off. EO from stripper are cooled, condensed and purified by passing through light ends columns, which removes lighter fractions. Purified EO mixture is heated, mixed with additional water and passed through tubular glycol reactor. The reaction takes place in liquid phase under elevated temperatures and pressure. The conversion is almost complete and the glycol water mixture is sent for evaporation. **Fig. 3.10** shows Block Diagram for Mono Ethylene Glycol.

In evaporation section, water is separated from glycol mixture in a triple effect evaporator with subsequent vacuum column.

Crude glycol mixture is separated into MEG, Diethylene Glycol (DEG) and Triethylene Glycol (TEG)

Air Emissions

The SOx emissions from the Mono Ethylene Glycol(MEG) is 0.00036 TPH VOC & Stripper vent= 0.04 Kg/hr

Process Incinerator= CO vessel vent -0.44 kg/hr

Liquid Waste:

The estimated wastewater generation is 0.193 M3 / Hr, will have pre treatment with in the plant battery limits.

Solid Waste:

The Solid waste generation from the Mono Ethylene Glycol plant is Catalyst.

3.3.3 Polyethylene Polymers

Low / High density polyethylene (LDPE / HDPE) and linear low density polyethylene (LLDPE) are polymers of ethylene. The process involves converting gaseous ethylene into solid phase PE by solution polymerization process, using cyclo-hexane as the solvent.

A purified solution of ethylene, solvent and co-monomer (octane or butene or both) is fed to the reactor. Co-monomer is added for low-density PEs. Catalyst helps to polymerise the ethylene and co-monomer. A chain terminator agent is used to control molecular weight (polymer chain length).

About 95% of the ethylene is converted to PE on each pass. The molten polymer solution flows to the extruder which feeds an under water pelletizer. The pellets formed are water conveyed to a continuous stripper to remove residual solvent, which is condensed and recovered. The stripped PE pellets are dried and fed to pneumatic blenders for blending into uniform lots. The PE is then fed to packaging or storage. **Fig. 3.11.**

Air Emissions:

The SO2 & NOx emissions from the poly Ethylene are 0.03 TPH and 0.011 TPH

Liquid waste:

The estimated wastewater generation from the poly ethylene plant is 80 TPH

Solid Waste:

The solid waste generation from the Poly Ethylene plant is column residue.

3.4 C3 Based Units

3.4.1 Acrylic acid & Acrylates

The propylene is oxidised with compressed air in a fixed bed multi-tubular single reactor. Reaction gas is made of propylene vaporized in propylene evaporator, air and the recycle gas coming from the top of the absorber. The lower half of the reactor is packed with propylene oxidation catalyst wherein the propylene is converted into Acrolein and further the Acrolein is oxidized to Acrylic Acid in the upper half of the reactor wherein the Acrolein oxidation catalyst is packed. The effluent gas containing Acrylic Acid is quenched by contacting recycled condensate, cooled through cooler and then absorbed with the descending water and the aqueous solution of acrylic acid is obtained. Part of the off gas from the top of absorbing column with non-condensables such as acrolein, acetaldehyde, propane and unreacted propylene is recycled to the oxidation reactor.

The rest of the off gas is the feed to the Waste Gas Catalytic Incineration System (WGCIS) which consists of a honeycomb type catalyst. The waste gas is heated before entering the WGCIS and the outlet is cooled through the waste heat boiler, in which the waste heat is recovered as steam.

In the water separator column, water and acetic acid are eliminated by azeotropic distillation. In the heavy end cut column the ester grade acrylic acid is obtained from the top of the column. The bottom contains acrylic dimmer and other heavy ends. This is fed to a film evaporator where the dimmer is decomposed and recovered as acrylic acid. The heavy end accumulated is sent to waste oil treatment. Aldehydes and ketones contained in the crude acrylic acid react with the hydrazine hydrate forming hydazone compounds. These are separated by distillation in the High Purity Acrylic Acid (HPAA) distillation column. Process flow diagram is shown in **Fig. 3.12**.

Acrylic Acid is one of the main raw materials for the manufacture of various other acrylates. Methanol and Acrylic Acid would give Methyl Acrylates, Ethanol and Acrylic Acid would give Ethyl Acrylates and 2 Ethyl Hexyl alcohol and Acrylic Acid would give 2Ethyl Hexyl Acrylate. In this process, the acrylic acid is continuously esterfied with the alcohol in the liquid phase using cation exchange resin as a catalyst in an Esterification Reactor. A mixture of acrylate, free alcohol and water is obtained. Water is removed by distilling it off as an azeotrope. The organic layer is returned to the reactor and the acqueous layer is sent for further purification.

Air Emissions:

The purge gases will sent to incinerator.

Liquid waste:

The estimated wastewater generation is 50 M3/hr

Solid Waste:

The solid waste generation from Acrylic acid is catalyst

3.4.2 Super Absorbent Polymer (SAP)

Process Description with process flow diagram for the production of SAP is shown in **Fig. 3.13.**

A centrifugal pump transports the monomer solution from the mixing vessel to the upper side of a vertical polymerization reactor. The reactor is insulated to insure adiabatic operation. The level of monomer solution in the reactor is maintained at 80% level. A vapor space must be maintained in the reactor above the monomer solution level. The reactor has an operating pressure of 50 psig, but a design pressure of 150 psig, consistent with concerns that sticky polymer gel may adversely affect the operation of pressure safety valves and rupture disks that are incorporated into the reactor's design. The design residence time of the reactor is 6 hours.

Nitrogen gas pressure is maintained at the top of the reactor at 50 psig. The vapor space at the top of the reactor is continually purged to remove water vapor, unreacted hydrocarbons, and other contaminants in order to avoid having them accumulate in the top of the reactor. The purge gas is first directed to a knockout drum to remove sticky gel and other particulates. The vapor from the purge drum is then directed to the process scrubbing system. Also fed to the polymerization reactor is a vapor stream containing "fines" from the final powder processing section. The "fines" are blown in an inert nitrogen gas stream from compressor. The quantity of fines recycled represents 10% of the throughput of the process. Twin screw pumps at the bottom of the reactor discharge polymer gel product from the reactor The reactor operates adiabatically, such that the polymer solution's temperature rises from the heat of polymerization. The temperature of the polymer gel at the discharge point at the bottom of the reactor is approximately 120°C. At the pressure maintained in the reactor, the water in the reactor will not boil despite the elevated temperature. Due to the potential for a thermal runaway, the sidewall of the reactor is equipped at two foot intervals with water jet flood nozzles connected to thermocouples in the wall. Should the temperature anywhere within the reactor reach a set level the water jets will open automatically and flood the reactor with water. Besides avoiding a thermal runaway, the water jets also reduce the potential for solidification of the polymer gel at high temperature. The top of the reactor is also equipped with 3 pressure sensors organized in a voting logic system. Should two of the 3 pressure sensors indicate a pressure exceeding 70 psig, a pressure control valve will open to dump the vapor into the process scrubbing system. The top of the reactor is also equipped with a rupture disk designed to fail at 75 psig, which is also connected to the process-scrubbing header. The combination pressure control valve and rupture disk are required by the propensity of the feedstock to form a sticky coating on internal services that might otherwise prevent the pressure instrumentation and pressure safety valves from performing according to design. The redox polymerization initiator creates the free radicals that begin the polymerization of acrylic acid at the moment that they are added to the acrylic acid solution. Once the redox initiators are consumed, and the reactor temperature has reached approximately 60 C, the thermal initiator, (2-2'-azobis (amidinopropane) dihydrochloride), forms free radicals that help complete the conversion of acrylic acid to polymer gel. The level of unreacted monomer in the discharge of the reactor should be approximately 1,000 ppm. The subsequent drying process should reduce the unreacted monomer content to 200 ppm in the final product.

Air Emissions:

Process stack.- Attached to scrubber for removal of acrylic acid vapoures

Liquid Waste:

The estimated wastewater generation from the Super Adsorbent Polymer is 300 m3/hr

Solid waste:

No solid waste will be generated from the process.

3.4.3 2-Ethyl Hexanol

The condensation reactor is maintained at high temperature and pressure, 15-minute residence time. The effluent from the reactor passes through heat exchanger to recover heat and is then distilled. The bottoms from the column are decanted to separate the organic 2-EPA and the aqueous caustic soda. The remainder is recycled and replenished with fresh caustic. The organic phase is washed to remove residual caustic soda. The wash water is recycled to the process. The 2-EPA is decanted again in to remove water and stored before use in the hydrogenation section. The tops are decanted to separate out water from unreacted butyraldehyde. The unreacted butyraldehyde is recycled to the condensation reactor. The aqueous phase from the distillation tops can be used as makeup process water, steam-stripped to remove residual organics, or sent directly to wastewater treatment. The 2-EPA from the condensation section, containing a small amount of heavy impurities and water, is fed to cross-countercurrent heat exchanger; where it is mixed with recycle gas. The aldehyde is then introduced to feed purification column, where it is vaporized in a stream of feed H2. The vapor-exiting column enters heat exchanger and then primary hydrogenation reactors. The shell-and-tube reactors operate isothermally at higher temperatures and boiler feed water used as a coolant to generate low-pressure steam. The cooled vapor is then further cooled and then passes through knockout drum to condense out the alcohol. The remaining gas is recycled, with a purge stream diverted to the secondary reactor after compression. The alcohol condensed from the first stage still contains a small amount of Unreacted aldehyde. The liquid is compressed to 9.6 bar and heated to higher temperature before entering secondary hydrogenation reactors. As in the primary reactor system, heat is recovered from the reactor effluent to reduce the heating duty. Because the reactor effluent contains butanol and water impurities, the crude hydrogenation product is purified by fractionation. The H_2 gas is split into a recycle steam in and a purge stream. The purged H_2 is cooled in condenser, with condensable liquids recovered. Process flow diagram for 2-EthylHexanol is depicted in **Fig. 3.14.**

A note on Management of unreacted butyraldehyde in two Ethyl Hexanol productions

2-Ethyl Hexanol is produced from n- butyraldehyde in two reaction steps. The first step is the aldolisation of n-butyraldehyde to butyraldol and dehydration of butyraldol to the more stable 2-Ethyl 3-PropylAcrolein (EPA). The second step is the hydrogenation of EPA to 2-Ethyl Hexanol.

The aldolisation and dehydration reactions are conducted in a liquid phase stirred tank reactor at 120ºC in the presence of aqueous caustic soda. Any un-reacted n-butyraldehyde is separated from the EPA in a distillation column. The overhead aqueous phase is steam stripped to recover organics, which are recycled to the column. The EPA, from the bottom of the column, is decanted from the water phase and passes directly to the EPA Hydrogenation section.

Basically it is a closed loop cycle and any un-reacted n- butyraldehyde is separated and recycled back.

Air Emissions

Flare of the purge gases

The Non methane Hydrocarbon (NMHC) from the process vent will be less than 150 mg/Nm3

Liquid Waste:

The estimated wastewater generation from the process is 75 M3/Hr

Solid waste:

The solid waste generation from the process is catalyst.

3.4.4 n-butyraldehyde

Propylene is passed through an adsorption column for removing catalyst poison. A similar column is used for treating the syngas feedstock. The syngas is then introduced, with propylene, into a primary hydroformylation reactor. The catalyst solution is an aqueous solution of Rhodium complex. Low-pressure steam is raised from the evaporator. The effluent then passes to decanter to separate the aqueous from the organic phase and to degas any entrained gases. In C3 stripper column, a stream of syngas feedstock strips any dissolved propane and propylene from the crude aldehyde product. The syngas, containing the stripped C3 components, is then recycled to the reactor. Stripping by the syngas further cools the crude aldehyde. The product is then passed through a decanter to remove remaining aqueous catalyst solution, and is then sent to surge tank before purification. Unreacted gaseous reagents are collected, cooled, and passed through vent gas knockout drum to remove condensable components. The liquid effluent from is distilled to separate the aldehyde products from the catalyst and the high-boiling byproducts. The crude aldehyde product from the secondary reactor system is combined with the product from the primary reactor system for purification. The catalyst and higher boiling components are recycled. A purge stream of the catalyst-containing organic phase is taken to control the concentration of the heavy by-products in the reactor. Process flow diagram for n-butyraldehyde is depicted in **Fig. 3.15.**

A note on Emission / effluent management during n-butyraldehyde production

The entire plant heat requirement is met by steam and there are no furnaces involved. Hence there are no emissions due to fuel firing. Un-reacted process gases are cooled to remove the condensable matter and then routed to the flare. The aqueous effluents are routed to water stripper section. Here the organic content is recovered and sent to the fuel oil pool. The stripped water is pretreated to meet the required effluent characteristics before being sent to the Central ETP of the Complex.

The spent catalyst has a useful life cycle of more than 2 years. The catalysts are leased by the process Licensors and will be returned to them at the end of their useful life.

Air Emissions:

Light end gases to fuel pool

The Non Methane Hydrocarbon emissions will be less than150 mg/Nm3

Liquid Waste

The estimated wastewater from the Process is 60 M3/Hr.

Solid Waste:

The solid waste from the process is only a catalyst.

3.4.5 n-Butyl Acrylate

Acrylic acid is fed directly to esterification reactors. The esterification reaction takes place in two reactors, in series. To the first reactor acrylic acid, n-butanol and an acid esterification catalyst is added. p-Toluene sulfonic acid is used as the esterification catalyst. To minimize polymerization of acrylic acid and n-butyl acrylate, a small amount of Phenothiazine is added to the reactors and distillation columns. The reactors are operated at 100 ^{0}C and 105 ^{0}C, respectively. Total residence time in the reactors is 3 hours. The liquid reaction mixture is discharged from two reactors. The vapors from the reactors are continuously fed to the water removal column. Although the reaction is exothermic, the vaporization cools the reaction mixture. The continuous removal of the water reaction product improves acrylic acid conversion to butyl acrylate.

In addition to the vapor streams from the reactors, fresh n-butanol and recycle n-butanol are fed to the water removal column. The column is operated at 5.5 psia. The overhead vapor stream from the column is condensed in exchanger and separated into two phases. The organic phase is completely returned to column. The aqueous phase contains mainly water and a small amount of n-butanol. The bottom stream from column is fed back to reactor. This stream contains mainly n-butanol and n-butyl acrylate.

The liquid reaction mixture-leaving reactor is fed to the high boiler separation column. In this column, high boilers, typically oligomers and polymers of acrylic are removed. A heteroazeotropic mixture containing n-butyl acrylate, water, and butanol is distilled from the column. The mixture is condensed and separated into an organic phase and aqueous phase. Portions of the organic and aqueous phases are recycled back into the column to maintain the heteroazeotropic composition in the column. The remainder of the organic stream containing mainly n-butyl acrylate and butanol is fed to the butanol separation column. The remainder of the aqueous stream is sent to wastewater treatment. The bottom stream from column contains butyl acrylate, acrylic acid, n-butanol, and oligomers and polymers. To prevent the buildup of oligomers and polymers, a portion of the stream is fed to a cracking vessel. The remainder of the bottom stream from column is recycled back to the first esterification reactor.

In the cracking vessel, the stream is heated to 180 ^{0}C and held at this temperature for at least 10 minutes. Oligomers and polymers of acrylic acid and n-butyl acrylate are converted back to the monomers. At the completion of the batch cycle, n-butanol, acrylic acid, and n-butyl acrylate are distilled off the vessel and fed back to column. The residual heavies from vessel are fed to an incineration unit.

In the butanol separation column, n-butyl acrylate is recovered in the vapor form as a side stream. The vapor stream is condensed in exchanger and sent to the n-butyl acrylate rundown tank. The distillate stream containing n butanol, residual water, and any low boilers is returned to the reactor via column. The small bottom stream containing n-butyl acrylate and a small amount of acrylic acid is fed back to column. Process flow diagram for n-Butyl Acrylate is depicted in **Fig. 3.16.**

Air Emissions

Process Incinerator

The emissions from the process vent will be less than 150 mg/Nm^3

Liquid Waste:

The estimated wastewater generation from the process is 75 M^3/hr

Solid Waste:

The solid waste from the process is only catalyst.

3.4.6 n-Butanol

Feed NBAL containing a small amount of heavy impurities is fed to cross-countercurrent heat exchanger where it is mixed with recycle gas. The aldehyde is then introduced to purification column, where it is vaporized in a stream of feed H2. The vapor exiting column passes to heat exchanger and then to gas-phase hydrogenation reactors. The shell-and-tube reactors operate isothermally at higher temperature, with boiler feedwater used as a coolant to generate low-pressure steam. The gas is recompressed and recirculated to recover heat. The cooled vapor is then further cooled and passes through a gas-liquid separator to condense out the alcohol. The remaining gas is recycled, with a purge stream diverted to secondary hydrogenation reactors after compression. The alcohol condensed from the first stage contains a small amount of unreacted aldehyde. The liquid is compressed to 9.6 bar and heated at high temperature. As in the primary reactor system, heat is recovered from the reactor effluent to reduce the heating duty. Low-pressure steam is generated from cooling the reactor. The effluent from the reactor is degassed and stored. The H2 gas is split into a recycle steam, which is compressed in a purge stream. The purged H2 is cooled in to recover condensable liquids. Process flow diagram for n-Butanol is depicted in Fig. 3.17.

Liquid Waste:

The estimated wastewater from the process is 75 M3/hr

Solid waste:

The solid waste generation from the process is catalyst.

3.4.7 Propylene Derivatives

Propylene Oxide

The unit consists of three process sections:

1. Reduction and oxidation of a working solution
2. Recovery and purification of hydrogen peroxide solution
3. Working solution regeneration.

The working solution selected is a mixture of ethylanthraquinone (EAQ), tetrahydroethylanthraquinone (THEAQ), its corresponding hydroquinone (THEAHQ), and inert compounds in a mixed solvent of 21.4-wt% triethylhexyl phosphate and 76.6-wt% aromatic solvent (mixed alkylbenzenes). The purified product is a 37-wt% hydrogen peroxide solution. The epoxidation reactor system comprises four reactors, with three in series on stream and one under regeneration or stand-by. Hydrogen peroxide solution from the hydrogen peroxide section is combined with recycled stream containing methanol from absorption column in the separation section and fed into the top of the first reactor. Fresh polymer-grade propylene and recycle propylene are combined and fed into the bottom of the third reactor. The propylene and hydrogen peroxide solution flow counter-currently in the reactors. The reaction is carried out at 65°C with H2O2/lb catalyst. The overall conversion of H2O2 is 96.8% and the selectivity to PO is 94.5 mol%. H_2O_2 decomposition to water and oxygen is the major side reaction. The deactivated catalyst is first washed with methanol. The liquid product from epoxidation reactor is flashed and released from the reaction pressure to 200 psia in separator. The loaded liquid is joined with fresh hydrogen peroxide solution and sent to the epoxidation reactors. The bottom stream from column is fed into crude PO column. Crude PO stream is recovered as overhead and is sent to the PO purification section for further purification. Crude PO is first treated to remove most of the methyl formate impurity. A small amount of PO containing impurities is purged overhead as fuel. The bottoms containing PO in TBA/water solvent are distilled in PO column to recover PO with 99.98% purity. The TBA/water solvent is recycled after the removal of methanol in column.

Propylene Derivative – Cumene

The Cumene process primarily consists of following sections:

Alkylation

The alkylation section of the cumene plant consists of a single 4-bed reactor. The overall benzene to propylene ratio is 2 to 1 (molar). All of the benzene for alkylation and a portion of the propylene feed from battery limits storage are pumped to the first bed under flow control. The remaining propylene feed is mixed with the alkylator's circulation and is fed as quench under flow control to the remaining beds. Note that treaters are included on the fresh propylene feed for removal of sulfur and nitrogen compounds.

The alkylation reaction is exothermic, and the alkylator inlet temperature as well as the temperature rise in each bed is controlled by circulation and cooling of the reactor effluent via cooling water. The net effluent from the alkylator flows to the distillation section of the plant under pressure control for recovery of the excess benzene and the cumene product.

Benzene Recovery

The benzene column recovers excess benzene from the alkylation and transalkylation reactor effluents for recycle to the reactors, removes the nonaromatic components which are contained in the benzene feedstock, and dries the fresh benzene being fed to the unit.

The alkylator effluent flows to the benzene column under static pressure. The tower is reboiled with high pressure steam as heating medium and condensed with cooling water. Fresh benzene is fed to the top of the column, and benzene product is recovered as a side stream to ensure proper removal of moisture before recycle to the reaction sections. The makeup of fresh benzene is controlled by level in the benzene surge drum, so that total inventory of benzene is maintained at a constant in the plant. Recycle benzene is sent to the alkylator and transalkylator reactors under flow control. Treaters are provided for the fresh benzene to remove basic nitrogen compounds.

The top section of the benzene column concentrates and removes light nonaromatic components contained in the benzene feed. The nonaromatics are inert in the system and need to be purged to control the benzene concentration in the recycle benzene. Small vapor and liquid distillate purges can be taken from the top of the column and an additional purge can be taken from the benzene sidedraw, depending on the specific nonaromatic compounds in the benzene feed. The overhead of the benzene recycle column is cooled by cooling water, and the nonaromatics are normally purged as a vapor product. Liquid purges, if required can be fed to other parts of the refinery. Any non-condensable light compounds such as propane that are present in the propylene feed will also be vented overhead.

Cumene Column

The bottoms from the benzene column is fed to the cumene column. This column separates the final cumene product from PIPB and heavies. The column is reboiled by high pressure steam, and low pressure steam is generated in the condenser. Cumene product is recovered as a distillate and the bottoms are pumped to the PIPB column.

PIPB Column

The PIPB column recovers DIPB and most of the TIPB from the cumene column bottoms for recycle to the transalkylation reactor. PIPB is recovered as a side stream from this column, and fed to the transalkylation reactor for conversion to cumene. A pasteurization section on top of this column serves as an outlet for aromatic impurities such as butyl benzenes and cymenes, a byproduct formed from the toluene present in the benzene feed to the plant. The column is reboiled by high pressure steam and the overhead is condensed by cooling water. Operating pressure in the PIPB column is maintained by pulling a vacuum with a liquid ring vacuum pump system. The bottoms product of the PIPB column contains components heavier than TIPB, and consists mostly of diphenylpropanes. The bottoms is combined with the PIPB overhead aromatics purge and is cooled with cooling water and purged as residue to battery limits storage

Transalkylation

The DIPB product from the PIPB column is mixed with benzene (1 to 1 on wt basis), and fed to the transalkylation reactor. DIPB and TIPB are partially converted to cumene with benzene. The conversion of PIPB in the transalkylator is optimized to minimize catalyst volume and byproduct formation by controlling the inlet temperature of the reactor. The effluent from the transalkylator flows to the benzene column for removal of the excess benzene and the subsequent recovery of cumene and PIPB. Process flow diagram for Cumene is depicted in **Fig 3.18.**

Propylene Derivative – Phenol

Phenol and acetone are produced from cumene by liquid phase oxidation of cumene to cumenehydroperoxide (CHP) followed by catalytic de-composition of CHP to phenol and acetone. Phenol, acetone, unconverted cumene, and by-products are then distilled in a series of distillation towers to recover high purity acetone and phenol, and recycle cumene.

Fresh and recycle cumene is fed to a series of oxidizers where cumene contacts air and is converted to cumene hydroperoxide (CHP). Over-head vapors from the oxidizers are cooled and condensed to recover cumene. Spent air is treated by passing it through carbon beds to adsorb residual Cumene. Process flow diagram for Cumene is depicted in **Fig 3.19.**

A note on Effluent / emission / hazardous waste generation and management during cumene and benzene production / recovery

The heat requirement for Cumene production is supplied by the steam and hence there are no emissions due to fuel firing. There is no process emission. The effluent stream will be within the stipulated parameters to be sent for treatment to the central ETP.

The catalyst used is non-corrosive, environmentally inert, and re-generable. It is free flowing before and after use and requires no special packaging or handling. It is expected to be used for two years or longer before regeneration is required. Offsite regeneration, the preferred method for the long cycle length, is chosen in this design. The catalysts are leased by the Process Licensors and will be returned to them at the end of their useful life.

Air Emissions

The Non Methane Hydrocarbons from the Process vent and flare stack will be less than 150 mg/Nm3

Liquid Waste:

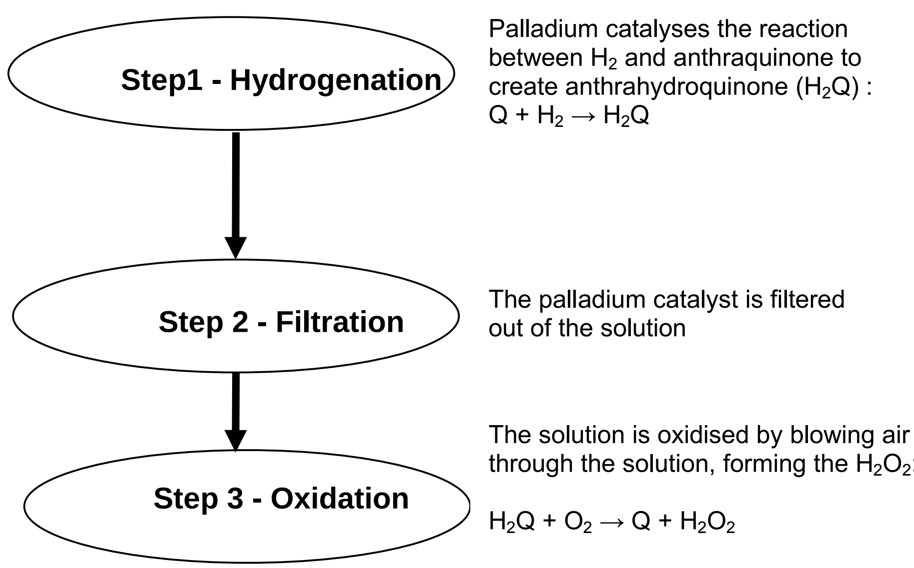
The estimated wastewater generation from the process is 90 M3/Hr

Solid Waste:

The solid waste generated from the process is catalyst.

3.4.8 Hydrogen Peroxide (H_2O_2)

The manufacturing process involves the catalysis of the reaction of H_2 (obtained from processing Maui Gas) with atmospheric O_2 to give H_2O_2. Anthraquinone (Q) is used as a H_2 carrier.



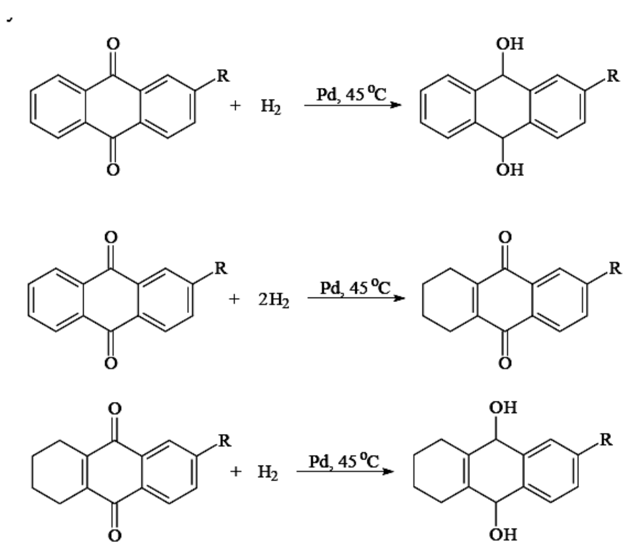
Step 4 - H_2O_2 Extraction

The hydrogen peroxide is removed in a liquid-liquid extraction column and concentrated by vacuum distillation.

Hydrogen peroxide is manufactured using the anthraquinone process. This process is a cyclic operation where the alkyl anthraquinone is reused. The Synthesis Loop consists of sequential hydrogenation, filtration, oxidation and extraction stages. A number of ancillary processes are also involved.

Step 1 - Hydrogenation

An alkyl anthraquinone is dissolved in two solvents, one nonpolar and the other polar. Collectively the anthraquinone and solvents are called the working solution. This working solution is recycled. The working solution containing the dissolved anthraquinone is hydrogenated using hydrogen gas in a slurry-type hydrogenator using alumina loaded with a small amount of palladium catalyst. Temperature is controlled to around 45_{o}C and the reactor is agitated to ensure good mixing of catalyst with working solution and hydrogen. During hydrogenation the alkylanthraquinone is converted to both the alkylanthrahydroquinone and the tetrahydroalkyl-anthrahydroquinone, although productionof the tetra-form of the quinone is preferred because it can be more easily hydrogenated.The hydrogenation stage is carefully controlled to avoid over-hydrogenation of the anthraquinone rings. Basicity and moisture content are important for optimum catalyst and activity.



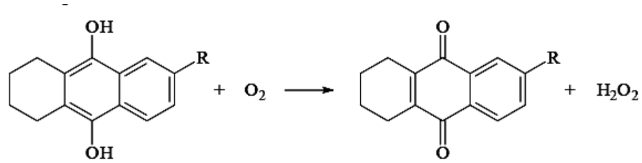
Tetra-form *rapid* *Tetra-hydro-form*

Step 2 - Filtration

The working solution that now contains hydrogenated anthraquinone is then filtered to remove any trace levels of catalyst. If the catalyst is not removed then it will decompose the hydrogen peroxide in later stages, reducing yields and causing potential hazards.

Step 3 - Oxidation

The working solution is oxidised by blowing air through it. The tetrahydroalkylanthrahydroquinone is oxidised, forming hydrogen peroxide in an organic phase. No catalyst is used and hence this step is often referred to as auto-oxidation.



Step 4 - H_2O_2 Extraction

Since the hydrogen peroxide is present in an organic phase and the product is required in aqueous phase, demineralised water is added to the top of a 35 metre high liquid-liquid extraction column. The water flows down the column over perforated trays while the working solution is pumped up the column. The extractor design and operation ensures a maximum contact of water with the working solution. The water reaches the bottom of the extractor and contains 25-35% w/w crude hydrogen peroxide, whilst the working solution that leaves the top of the extractor is free of hydrogen peroxide and is pumped back to the hydrogenator. This working solution now contains the original alklyanthraquinone and tetrahydroalkylanthraquinone. The crude hydrogen peroxide is subsequently purified and vacuum distilled to concentrations of up to 70% w/w. This concentrated product is stabilized against unwanted decomposition by adding proprietary stabilisers and then pumped to product storage tanks for final testing. The process of manufacturing H_2O_2 by Anthraquinone Process is shown in **Fig. 3.20.**

Air Emissions:

The Purge gases from the hydrogen peroxide plant will send to incinerator.

Liquid Waste:

The estimated wastewater generation from the process is 150 M3/hr

Solid waste:

No solid waste will be generated from the process.

3.4.9 Polypropylene (PP)

Homopolymer

Propylene polymerisation to PP, in presence of hydrogen and catalyst, in a fluidized bed reactor to form homopolymer resin.

Random Copolymer

Polymerisation of ethylene and propylene to PP in presence of hydrogen and catalyst in a fluidized bed reactor form random copolymer resin.

Impact Copolymer

Homopolymer PP reacted further, with ethylene, propylene and hydrogen a second reactor form impact copolymer resin.

Only one type of resin can be produced per line in a batch mode. The resin is then sent to resin degassing and unreacted monomers are sent to vent recovery and are recycled back to reactors after separation.

Wet degassed resin is sent to finishing section, wherein additives are added to stabilize the resin, and extrude it to pellets of uniform size. The block diagram is as shown in **Fig. 3.21**.

Air Emissions:

Process flare – CO2+ H20

Liquid waste generation:

The estimated wastewater generation from the process is 20 M3 /Hr

Solid waste

No solid waste will be generated from the process

3.5 C4/C5 Based Units

3.5.1 Butyl /Halo Butyl Rubber

C4 R1 Stream containing approx. 46 % Isobutylene is sent for synthesis of MTBE with Methanol. MTBE thus produced is cracked to get pure Isobutylene and raffinate is sent to LPG stream after separation of Butene1 by super fractionation with heat pump. Isobutylene will be used in Butyl / Halo butyl rubber production. Small amount of MTBE import is required (approx. 12000 MTA) to meet complete requirement of Isobutylene for Butyl Rubber Project

Butyl Rubber Production :

Isobutylene and Isoprene are co-polymerized at extremely low temperatures and operates in a semi continuous mode. The catalyst anhydrous aluminum chloride is dissolved in methyl chloride and chilled.

Both monomers are mixed, diluted with methyl chloride and chilled. Reaction produces polymer suspended in liquid methyl chloride.

Suspended polymer overflows from reactor and enters into flash-tank, were additives are added.

Solvent and un reacted monomers are evaporated by means of steam and warm water. Un reacted monomers and methyl chloride are flashed, compressed, dried and purified for reuse.

Polymer slurry from bottom of degasser to finishing equipment where polymer is separated from water. Water is recycled back to the flash-tank.

Wet polymer is dried, baled, wrapped in film and packaged.

Halo butyl Rubber :

Halo butyl rubber is produced by reaction between butyl rubber solution in organic solvent and halogenation agent in presence of nitrogen gas.

After removal of water from butyl rubber slurry, butyl rubber chips obtained from degassing vessel are dissolved in hexane. Rubber solution is pumped through cooler to halogenation reactor.

Chlorination is performed with Chlorine in gas phase while Bromination is carried out with Bromine in liquid phase. In both cases nitrogen is used as shipping agent to ship away the side products formed during reaction.

Gaseous phase leaving top of reactor is washed with caustic solution. Condensed hexane is recycled back and spent caustic solution from scrubber bottom is discharged from the plant.

Halogenated rubber in hexane after neutralization and addition of additives is sent to degassing vessel. Hexane is recovered with the help of steam and recycled back.

Halogenated rubber slurry is dewatered. Rubber crumbs are dried, baled , wrapped and palletized in wooden boxes.

SSBR / PBR

For production of SSBR / PBR swing plant will be installed . The process for both is same except few chemicals and additives.

Monomer Purification / Solvent Purification

Fresh Butadiene 1:3 (BD 1:3) is received from storage area and is mixed with recycle stream of BD 1:3 which is having lower purity. This mixed stream is fed to a series of two distillation columns where the water and heavy ends are removed. The dry BD 1:3 stream having purity of 93%~99% is fed to the polymerization section. The solvent recovered by stripping contains un reacted butadiene and other c4's. Butadiene and C4's are recovered by distillation and recycled back. Recovered solvent is sent to storage for re use.

Polymerisation

BD and solvent being purified in the purification section are sent to the polymerization section. Theses are pre cooled in the respective pre coolers by ammonia refrigeration system. Purified BD and solvent along with catalyst are fed to the reactor.

Reactors in series having agitators for mixing of high viscosity polymer solution and jackets for refrigerant to remove the heat of reaction. The temperatures of reactors are maintained in the range of 59º C to 75º C. The reactant material goes from bottom of reactors and comes out form the top. The reaction is terminated by adding PPA solution and polymer solution is sent to the blending / homogenization section.

Solvent Recovery

The rubber solution form the blend tank enters into first stripper through cement slurry mixer in which it is mixed with hot recycle water. In first stripper the BD and solvent are stripped by low pressure steam and by vapor form top of second stripper. At the same time the rubber forms crumbs. The crumb slurry from first stripper is pumped to second and then to third in which residual solvent is stripped out.

Finishing

The crumb slurry from the solvent recovery section is received n the crumb slurry tank. The crumb slurry tank has overhead condenser where condensed material is decanted and hydrocarbons are recovered. The crumb slurry from this is tank is fed to the shaker screen through distributors.

The separated hot water form bottom of the shaker screen enters into the fine crumbs tank from which fine crumbs with hot water are transferred batch wise to crumb slurry tank for recovery and hot water called serum water is transferred to the serum tank. The serum water from the serum tank is recycled to the water column in stripping section and part of water is drained.

From the shaker screen, the crumbs pass to the expeller for dewatering the rubber. Drained water from the bottom of the expeller is taken to the fine crumb tank. From the expeller, rubber expander where the water is flashed off when the rubber in the form of small crumbs leaves expander. Water vapor leaving the crumbs are taken out by blower.

Rubber crumbs are conveyed and cooled in spiral elevator and baled after automatic weighing. The bales go for packaging through a metal detector device (film wrapper & bagging). After this bales are finally packed, weighed and moved to Ware House.

3.5.2 E-SBR Project

The SBR plant at Jamnagar will consist of two process areas namely Polymerisation (including monomer recovery) and Coagulation & Finishing area.

Polymerisation Area

Styrene Butadiene Rubber (ESBR) is manufactured by emulsion polymerization technology. Main Raw materials are Styrene (23.5%) and Butadiene (76.5%). The term emulsion polymerization is used to describe polymerization process in which Styrene & Butadiene (monomers) are emulsified as droplets in water phase, with the help of emulsifying agents such as soaps.

The reaction is initiated by a catalyst system and takes place in a series of continuously agitated reactors at 5 to 10 ^oC and occurs in three phases namely initiation, chain propagation & termination. Molecular weight of the Polymer is controlled by addition of a modifier, which regulates the length of the polymer chains.

The reaction is exothermic and is controlled with the help of Ammonia circulating in specially designed coils inside the reactors. The polymerisation is carried out upto 60-65% conversion that gives optimum properties in rubber. At this point, conversion reaction is terminated by addition of shortstop. Product thus produced is called Latex.

Un-reacted Butadiene is recovered by pressure and vacuum flashing. It is compressed, condensed and recycled to the system. Unconverted Styrene is recovered by stripping of Latex and subsequent condensation and recycled back. A small portion of Styrene

& Butadiene is purged out to maintain desired purities of monomers required for polymerisation. Stripped latex is stored in tanks (and blended if required to achieve proper physical properties) and sent to finishing lines for conversion into rubber.

Finishing Area

Antioxidant is added to blended latex and latex is coagulated with the help of salt and sulphuric acid. In case of 1700 grade, Extender oil is added to the latex before coagulation. Rubber crumbs obtained in coagulation are filtered and washed with water. Crumbs containing 50% moisture are sent to expeller to reduce water content to about 10%.

Dewatered crumbs are shredded and dried in a tunnel or mechanical dryer where the moisture content in the rubber crumbs is reduced to less than 0.5%. Dried rubber crumbs are compressed in Baler to form bales which, passes through a metal detector and finally film wrapped before packing in paper bags or cartons. The process flow diagram of E-SBR is shown in **Fig. 3.22**.

Air Emissions:

The emissions from the process vents will not exceed the following standards.

Butadiene – 5 mg/Nm3

Styrene- 100 mg/Nm3

NMHC- 150 mg/Nm3

Liquid waste:

The estimated wastewater generation is 300 M3/Hr

Solid Waste:

The solid waste generation is 1500 TPA

3.5.3 Maleic anhydride

N-butane and air are fed to a fluid bed catalytic reactor (1) to produce Maleic anhydride. The fluid bed reactor eliminates hot spots and permits operation at close to the stoichiometric reaction mixture. This result in a greatly reduced relative to fixed bed process and translates in to savings in investment and compressor power, and large increase in steam generation. The fluid bed system permits online catalyst addition/removal to adjust catalyst activity and reduce downtime for catalyst change out.

The recovery area uses a pretended organic solvent to remove the maleic anhydride from the reactor effluent gas. A conventional adsorption (2)/stripping (3) scheme operation on a continuous basis. Crude maleic anhydride is distilled is to separate light (4) and heavy (5) impurities. A slipstream of recycle solvent is treated to eliminate any heavy byproducts that may be formed. the continuous nonaqueous product recovery system result in superior product quality and savings in steam consumption. Relative to an aqueous recovery system, it reduces investment, product degradation loss (and byproduct formation) wastewater. **Fig. 3.23** shows process flow diagram of Maleic Anhydride

Air Emissions:

Air Emissions: fuel gas to fuel pool

Organic Particulates: 25 mg/Nm3

Liquid Waste:

The estimated wastewater from the process is 10 M3/Hr

Solid Waste:

Solid Waste- catalyst Spent- 200 T/Yr (averaged over a 5 Year term)

3.6 C6/C7/C8 based Units

3.6.1 Mono Nitro Benzene

Benzene is converted to mononitrobenzene (MNB) in a mixture of nitric and sulfuric acids in a conventional stirred tank reactor at a selectivity of around 97%. Makeup benzene is fed to the prenitrators along with spent acid, where the excess benzene drives the reaction to near completion at 60^oC. The heat of nitration is removed with cooling water through internal cooling coils. Effluent from the reactor is decanted into a separator where organic phase is separated from the acid solution. The denitrated spent acid solution is concentrated by steam stripping and recycled back to the reactor. The organic phase from the prenitrators is reacted with replenished mixed acid in nitrators which are tubular heat exchangers. At the reactor temperature of 60^oC, 98% of the nitric acid fed to the nitrator is converted to mono or to dinitrobenzene.

The nitrator effluent is separated into organic and acid phases in separators. The two phases pass through decanters which recover entrainments during operating upsets. The spent acid is recycled to prenitrators. The organic phase is fed to neutralization and benzene recovery. The acid is neutralized with 10% caustic. The organic phase and the spent caustic phase are separated. The spent caustic phase is disposed of while the organic phase is scrubbed with water and fed to the MNB surge tank before entering the finishing column. MNB is taken as the overhead product from the finishing column along with benzene and water. The bottom product is dinitrobenzene as a 40% solution in MNB. **Fig. 3.24** gives the schematic of Mono Nitro Benzene Process.

A note on Emission / effluent management during mono-nitro benzene production

Air Emission management:

There are no furnace / process vents from the manufacturing operations.

Liquid waste management:

The source of effluent generation:

i. The effluent will be generated from the neutralization process of organic layer having likely contamination of benzene, nitro benzene etc.
ii. The wastewater generated from the acid concentration operations which may contain likely traces of nitro benzene.

The effluent from above operations will be neutralized and sent to central ETP for treatment.

Air Emissions

The Benzene from process vents will be less than 5mg/Nm3

Liquid Waste:

The estimated wastewater quantity is 10 M3/hr

The Spent caustic treatment will be given inside the battery limits.

Solid Waste:

No solid waste will be generated from the process.

3.6.2 Aniline

Makeup mononitrobenzene (MNB) is preheated at high temperature by heat exchange with the reactor effluent. Recycle hydrogen is heated at high temperature in the feed-product exchanger. Preheated MNB and makeup hydrogen are combined with a side stream of recycle hydrogen to bring the H2/MNB ratio slightly over 3. The MNB/H2 mixture is fed to the reactor through two-phase nozzle arranged in four tiers. The remainder of recycle H2 enters reactor below the catalyst grate. The hydrogenation catalyst, copper on a silica carrier, is fluidized by the H2/MNB feed passing through the reactor at ~1.5 fps. Cyclones installed internally trap entrained catalyst particles. The reactor operates under high temperature and at 6.2 Bar. The exothermic heat is removed by 5 bayonet coolers and is utilized to produce steam.

The reactor effluent is cooled by interchange with recycle hydrogen and makeup MNB. Finally the reactor effluent is cooled to 40°C to recover the organics from the recycle H2. The gas and liquid phases are separated in a separator and the H2 is recycled to the reactor via H2 compressor. The liquid phase enters effluent separator where the organic and aqueous phases are separated. The aqueous phase is stripped free of aniline in wastewater column.

The overhead stream contains 15% aniline which is condensed and sent for phase separation. The organic phase is fed to the drying column. The bottoms are essentially dry aniline and the overhead is the aniline-water azeotrope and the benzene brought in with the MNB. The overhead is condensed and the condensate is split into an organic and an aqueous layer. Half of the organic phase is sent to incineration while the other half is recycled to drying column. The aqueous layer is sent to wastewater column for recovery of dissolved aniline. The bottoms, which contain aniline and the high boiling by-products, are fed to the finishing column. Aniline is taken as overhead while the high boilers are discharged as bottoms. **Fig. 3.25** shows Process Flow Diagram for Aniline

Air Emissions:

H2 blend stream after H2 separation

Process Incinerators- As per the CPCB standards

Liquid Waste:

The estimated wastewater generation is 300 M3/Hr

Solid Waste:

The solid waste generation from the process is Catalyst.

3.6.3 Methylene Di Aniline

Methylene Di Aniline (MDA) is produced by the acid catalyzed condensation of aniline with formaldehyde. The production of MDA is a two-stage process. First, aniline is neutralized with concentrated hydrochloric acid in aqueous solution at 100°C to form aniline hydrochloride. This solution is cooled to less than 50°C. Formaldehyde solution is then added with efficient agitation to the aniline-aniline hydrochloride solution. The reaction is usually staged to control the condensation and rearrangement steps. The final reaction temperatures are normally 80-120°C. After completion of reaction, the acidic PMDA is treated with aqueous sodium hydroxide to neutralize the excess acid. The organic layer is then washed with water and stripped to remove unreacted aniline and water. The unreacted aniline is recycled back to the beginning of the reaction. The product is purified to isolate pure 4,4-MDA, packaged for shipment or treated with phosgene to produce the corresponding isocyanate. **Fig. 3.26** shows the Block diagram for MDA Production process.

A note on Emission / Effluent management during Methylene Di-Aniline production

Air Emission management:

There are no furnace / process vents/emissions from the process operations.

Liquid waste management:

- The sources of effluent generation during the process operations will be from following stages:
  - i. Neutralization process of mixed liquor from condensation process with caustic lye having traces of organic matter likely contaminants are formaldehyde, aniline etc.
  - ii. Acidic effluent from the purification process of crude Methylene-Di Aniline.

The waste water generated will be collected and neutralized at the plant and further sent for treatment at central ETP.

Solid waste Management:

The solid waste generated will be sodium chloride. From the neutralization process. This contains traces of aniline. The traces of aniline will be recovered through vacuum drying and the salts will be sent for landfill.

Liquid Waste:

The estimated wastewater generation from the process is 100 M3/hr

Solid waste:

The estimated solid waste generation from the process is Salt: of 10.41 TPA

3.6.4 Phosgene

As shown in **Figs. 3.27 A** and **3.27 B**, carbon monoxide (Stream 1) and chlorine (Stream 2) are mixed in a small excess of carbon monoxide to ensure complete conversion of the chlorine over activated carbon catalyst. The product gases (Stream 3) are condensed, the liquid phosgene (Stream 4) is sent to storage, and the remaining gases (Stream 5) are scrubbed with a hydrocarbon solvent to remove residual phosgene. Uncondensed phosgene and the solvent that is used in the scrubber may be used for subsequent processing (e.g., in the production of isocyanate).

The liquid phosgene is stored in pressurized steel tanks. A typical precautionary measure is to store the material in two tanks, neither of which is filled to more than half of its capacity. This allows the transfer of the phosgene to either tank in case a leak develops in one of the tanks or its piping system. Measures for safe management of Phosgene are listed in Annexure IX. All requisite approvals for the production, storage and handling of Phosgene will be taken from the appropriate authority.

The MoEF has sought information on the additional TOR regrinding the measures for safe management of Phosgene & approvals from concerned department shall be obtained for storage and production of phosgene.

The safe management measures are attached as Annexure IX to the document and necessary approvals will be taken from appropriate authorities before commissioning of the facility. .

Phosgene is an intermediate product in the manufacture of Methylene Diphenyl Diisocyanate (MDI) & Toluene Diphenyl Isocyanate (TDI). Since it is not a stand alone product, there will be no requirement for storage of the same. Based on the plant layout the inventory that is in the pipelines and process equipment will be the only quantity in process. The requisite approvals from the concerned agencies will be obtained for the use of Phosgene in the process. The Phosgene Panel under the American Chemistry Council has delineated the Safe management Measures for Phosgene. These measures will be strictly followed for the design and operation of the MDI & TDI Plants.

Air Emissions:

Stack exhaust from scrubber is 1 mg/Nm3

Liquid Waste:

Spent caustic treatment is given inside the battery limits

Solid Waste:

Activated carbon catalyst

3.6.5 Methylene Diphenyl Diisocyanate & Toluene Diisocyanate

The first step in Methylene Diphenyl Diisocyanate (MDI) production is the hydrochloric acid catalyzed condensation of aniline with formaldehyde, yielding a mixture of isomeric forms of diphenylmethane dianilines (MDA's) containing two or more aromatic rings. Then occurs the phosgenation of MDA's forming crude MDI (Figure 1). The non-distilled or crude MDI mixture, or polymeric MDI, consists mainly of 4,4'-diphenylmethane diisocyanate, 2,4'- and 2,2'- isomers, and condensation products with more than two aromatic rings. Crude MDI is used in rigid foam production, where it provides significant advantages in processability and in mechanical performance, such as mechanical resistance and dimensional stability. The higher aniline/formaldehyde relationship increases the ratio of di functional product. The isocyanate is purified via solvent separation and fractionation. **Fig. 3.28** represents the schematic of MDI production.

The MoEF sought clarification on Emission / effluent management and risk during methylene diphenyl diisocyanate, toluene diisocyanate / recovery (Please refer Bhopal episode)

Methylene Diphenyl Di Isocyanate (MDI):

Air Emission management:

The un-reacted phosgene from the manufacturing process of MDI is completely removed and decomposed by scrubbing with water and caustic till it becomes completely inert. The disposal of inert gas will be done after doing complete Risk Assessment under manufactures guidelines and Safe Management Practices.

Liquid waste management:

The wastewater generated from the HCl absorber & phosgene decomposing column will be neutralized and sent to Effluent treatment plant for treatment at central ETP.

Solid waste Management:

There are no solid waste generations from the process.

Toluene Di Isocyanate (TDI):

Air Emission management:

Two stage caustic scrubbers will be provided for scrubbing. The emissions generated from the second stage of phosgenation of di-amino-toluene are scrubbed in a two stage caustic scrubber. The disposal of inert gas will be done after doing complete Risk Assessment under manufactures guidelines and Safe Management Practices.

Liquid waste management:

The wastewater generated from the scrubbing of HCl gas & phosgene decomposing will be neutralized and sent to Effluent treatment plant for appropriate treatment.

Solid waste Management:

There are no solid waste generations from the process.

Air Emissions:

The MDI/TDI from the process vents will be less than 0.1 mg/Nm3

The TDI organic Particulates from the process vents will be less than 25 mg/Nm3

Liquid Waste:

The estimated wastewater generation from the process is 85 M3/hr.

Solid Waste:

No solid waste will be generated from the process.

3.6.6 Styrene

The Benzene feed to the reactor consists of fresh benzene and the benzene recovered in the distillation section. The mixture preheated and fed to the zeolitic, liquid phase reactor section (1). Ethylene feed reacts completely, leaving only inert constituents. Poly ethyl benzene that are produced by successive alkylalations are Transalkylated with benzene to produce additional EB(1)

In the distillation section, the benzene column (2) recovers and recycle benzene from the rector effluent. Two other columns (3,4) recover EB which is sent to the dehydrogenation section, and PEBs which are recycles to the reactor section.

The EB is then catalytically dehydrogenated to styrene in the presence of steam. The reaction is carried out at high temperature under vaccum. The EB (Fresh and Recycle) and primary steam are combined with superheated steam, and the mixture is dehydrogenated in a multistage reactor system(5). Between dehydrogenated stages, air or oxygen is introduced to partly oxidized the hydrogen produced over a proprietary catalyst to reheat the process as and to remove the equilibrium constraint for the dehygrgentaion reaction. The process achieves greater than 80% EB conversion purpose. Reactor effluent are cooled to recover the waste heat and condense the hydrocarbons and steam. Uncondensed offgases compressed and used as fuel. Condensed hydrocarbons (6) are sent to the distillation section. Process condensate is stirpped to remove dissolved aromatics.

A fractionation train (7,8) separates high purity styrene unconverted EB, which is recycled, relatively minor reaction by product tar. Toluene is produced (9,10) as a minor byproduct and benzene is recycled to the EB reactor section. Typical SM product purity is in the range of 99.99% to 99.95%. The process provides high product, yield, due to unique combination of catalyst and reactor operating condition. **Fig. 3.29** shows process flow diagram of styrene.

Air Emissions:

The emissions from the process vents will be in compliance with the standards

Styrene from the process vents will be less than 100mg/Nm3

Benzene from the process vents will be less than 5 mg/Nm3

The SO2 and NOx emissions from the Styrene process are 0.001 TPH and 0.004 TPH respectively.

Liquid waste:

The estimated wastewater generation from the process is 125 M3/hr.

Solid waste:

The estimated solid waste generation from the process is molecular sieve of 1100 TPA.

3.6.7 Paraxylene and Orthoxylene

The Aromatics Complex comprises of Xylene Fractionation, Parex unit and Isomar Units. Xylene Fractionation column feeds mixed xylenes to the Parex unit.

Selective adsorption of paraxylene is affected by the Parex Process to produce Paraxylene (PX), with a purity of 99.8 wt%, and recover 94-97 wt% of PX in a single pass.

Selective adsorption of ‘PX’ is done with molecular sieve adsorption and the subsequent desorption of ‘PX’ by a suitable desorbent. Adsorbent is a ‘X’-type zeolite material. Desorbent is liquid para diethyl benzene.

The simultaneous entry and withdrawal of various process streams, are accomplished by a Rotary valve called Coplanar Manifolding Indexes (CMI).

The separation in a Parex unit takes place in the two adsorbent chambers. Each adsorbent chamber is divided into 12 beds. Each bed of adsorbent is supported from below by a specialized grid, which also contains the highly engineered flow distributors. Each flow distributor is connected to the CMI or rotary valve.

PX gets adsorbed on the molecular sieve and subsequently desorbed. Two streams, which come out of the chambers are known as raffinate stream and extract stream.

The raffinate stream from the rotary valve is sent to the raffinate column for separation of C8 hydrocarbons from the desorbent.

The extract stream from the rotary valve is sent to the extract column for separation of the crude paraxylene from the desorbent. Overhead product from the extract column, which contains the paraxylene together with toluene, is sent to the finishing column. Extract column bottoms which is essentially pure desorbent. Block Diagram for Aromatics is presented in **Fig. 3.30**.

Fuel:

The fuel oil requirement for Paraxylene and Orthoxylene is 48.451 TPH

Air Emissions:

The over all SO2 and NO2 emissions are 0.045 TPH and 0.127 TPH

The emissions from the Process vent- Aromatics/Xylene/toluene will be less than 100mg/Nm3

Liquid waste:

The estimated wastewater generation from the process is 150 M3/hr

Solid waste

The estimated solid waste generation from the process is Molecular sieve of 2900 TPA

3.6.8 Purified terepthalic acid (PTA)

PTA manufacturing process consists of two steps:

- Production of PTA by air oxidation of paraxylene (PX)
- Purification of PTA

Production of PTA

The Oxidation Plant consists of three sections: reaction, product recovery and solvent recovery.

In the reaction section, PX is mixed with acetic acid solvent and catalyst solution and is fed continuously to the reactor where it is reacted with air. The terephthalic acid produced in the exothermic reaction is precipitated to form slurry in the reactor.

In the product recovery section, reactor product is depressurized and cooled in a series of three crystallizing vessels. Precipitated terephthalic acid product is recovered by continuous filtration incorporating a solvent wash stage. Residual acetic acid is then removed in a continuous drier.

In the solvent recovery section, contaminated solvent, recovered from the reaction and product recovery sections, is processed to remove water, catalyst, and unwanted reaction by-products. The contaminated solvent is continuously fractionated to produce a final product of purified acetic acid suitable for re-use in the plant. Block Flow Diagram for Production of PTA is presented in **Fig. 3.31.**

Purification of PTA

The terephthalic acid (TA) product contains a small quantity of impurities, which must be removed before the material can be used in the manufacture of polyester.

The principal impurity, 4-carboxy benzaldehyde (4CBA), an oxidation intermediate, is hydrogenated to para-toluic acid. The para-toluic acid remains in aqueous solution during the subsequent product recovery stages. This is achieved in the purification plant by selective catalyst hydrogenation of an aqueous solution of TA saturated with hydrogen at elevated temperature and pressure. The PTA is subsequently crystallized and recovered by employing solid/liquid separation and drying steps.

Air Emissions

The Air emissions SO2 & NOx are 0.008 TPH and 0.001TPH respectively.

Liquid waste generation

The estimated wastewater generation is 510 M3/hr- Own treatment unit with in the battrery limits.

Solid Waste:

The solid waste from the process is pretreatment sludge.

3.6.9 Polyester/ Polyethylene Tere-phthalate (PET)

The Purified Terephthalic Acid (PTA) and Mono-ethylene Glycol (MEG) are mixed to produce Oligomer and water in the esterification section. The oligomer is then pumped to polymerization section after addition of chemicals namely catalyst, TiO2, DEG and Glycol. The oligomer is converted into polymer, through the polymerization reaction. The polymer is sent to chippers for making chips. The water generated in the process is first stripped of hydrocarbons, and sent to ETP.

The polyester chips are post oxidized and are packed in bags. Block and Process flow diagram for 1000 KTA Bottle Grade PET: Continuous Polymerisation Section (CP) are depicted in **Fig. 3.32** and **3.33**.

PET Plant-Process Description

PET Resin – Product Types

1) Resin for water packaging applications.
2) Resin for carbonated soft drinks applications.
3) General purpose PET resin

PET plant consists of two sections Continuous Polymerization (CP) and Solid State Polymerization (SSP).

Continuous Polymerisation

Raw Materials feeding: -

- Ethylene Glycol (EG)
- Purified Terephthalic Acid (PTA)
- Isophthalic Acid (IPA)

PTA and IPA(in ratio control) are fed into the SlurryMixTank to which metered quantity of Ethylene Glycol is added to control PTA - EG mole ratio. The PTA - EG slurry thus produced is pumped into the Esterifier reactor.

Esterification

Estirification reaction takes place to produce Oligomer and water. The Water - EG mixture is distilled in a separating column where the recovered EG is separated out and recycled into the process . Reaction water is sent to stripping column from were it is discharge to effluent treatment.The Oligomer produced in the Esterifier is pumped through Oligomer filter into the Pre-Polymerizer. All additives viz. Catalyst, Diethylene Glycol (DEG), thermal stabilizer (phosphoric acid) and color inhibitor (Cobalt acetate) are added in the Oligomer Transfer line.

Polycondensation

Pre-Polymerizer (PP) :

The Pre-Polymerizer is a Dowtherm jacketed vessel. The Oligomer is Pre-heated and then polymerised under vacuum & high temperature . Excess glycol generated from the process is recycled back.

Final Polymerizer

The Final Polymeriser is a horizontal, cylindrical vessel with an agitator to achieve high surface generation. The vessel is operated at high temperature and very high vacuum. The remaining excess glycol (2 - 3%) is removed in the finisher and the polymer viscosity is increased to about 2,500 poise, suitable for Chipping in Chipper Unit. Chips produced in chipper are conveyed to storage silos and then fed to SSP Plant.

Solid State Polycondensation

Precrystallization Section:

In Precrystalliser chips are fludized and precrystallized by means of nitrogen.

Crystallization Section

Pre-crystallized PET chips are fed to two crystallizers connected in series.

Solid State Polycondensation:

The hot chips coming from second crystalliser are fed to the reactor. Inside the reactor a stream of hot nitrogen is fed counter - currently in order to facilitate removal of

Acetaldehyde and other organics and increases the viscosity to the desired level by providing the required residence time and temperature.

Product Cooling Section:

The hot PET chips are cooled in two stage fludized bed coolers and then conveyed to the Product silos from where it is bagged/stuffed in containers.

Liquid Waste generation

The estimated wastewater generation from the process is 125 M3 /Hr

Solid Waste

The Solid waste generation from the process is spent pellets.

3.6.10 PSF – Process Description

The polyester staple fiber process with a packed production capacity of 720TPD. The plant is mainly divided into following sections.

- Continuous Polymerization with 4 Reactors (750 TPD)
- Chip production.
- PSF Spinning (4 lines of 185 TPD).
- PSF Drawlines (4 machines each of 185 TPD).
- Balers – 8 nos, 02 each per drawline.
- Auxiliaries - Catalysts, Additives, $TiO_{2,}$ DEG and Spin Finish Pack handling /cleaning and AHUs.
- PSF bale handling facilities up to Warehouse.

Continuous Polycondensation

➢ ***Paste Preparation***

In this section PTA, EG (split glycol) and the polycondensation catalyst are mixed in a defined ratio to form a paste. The paste is made by mixing the continuous streams, i.e. the PTA powder and the EG are filling into the PTA preparation tank while stirring. The mixing ratio of the two streams is controlled to ensure a constant level even with a varying rate of throughput.

➢ *Esterification 1 and 2*

In the esterification section, PTA and EG react to form diglycol terephtalate (DGT) while water is spilt off, and the polycondensation reaction is initiated while EG is split off.

For this purpose, the PTA paste is subjected in series-connected reactors under stirring to an elevated temperature. Maintaining the pressure, temperature and residence time at an appropriate level controls the degree of esterification and polycondensation. The water split off during esterification and the EG released during polycondensation are discharged from the reactors in form of vapour and subjected to rectification in the process column. In this way, a maximum of EG split off during polycondensation is recycled to the esterification process.

The process column and the reactor ES2 internal heat exchanger coils are heated with liquid heat transfer medium from secondary heating circuits, supplied directly with liquid heat-transfer medium from the primary heating circuit. Internal heat exchanger of esterification 1 (ES1) is heated directly by primary HTM.

All vapour lines and all heated jackets of the reactors are heated by dowtherm vapour systems.

➢ *Prepolycondensation*

The polycondensation process initiated in the esterification is further continued in the prepolycondensation reactor and a low-molecular PET is obtained.

The product leaving the esterification stage is fed into the prepolycondensation reactor, equipped with an agitator. Maintaining the pressure, temperature and residence time at an appropriate level sets the degree of polycondensation. The EG split off during prepolycondensation is withdrawn in the form of vapour, condensed in the spray condenser with a cold EG cycle and fed back into the process column. The required vacuum is generated by a central vacuum system, serving the prepolycondensation stage and the final polycondensation reactor. The accumulating glycol load is passed back into the process. The heating coils of the reactor are heated with liquid heat transfer medium from a secondary heating circuit.

The reactor heat exchangers of the cascade-reactor are heated with liquid heat transfer medium from a secondary heating circuit, supplied directly with liquid heat-transfer medium from the primary heating system.

The vapour lines and the heating jacket of the prepolycondensation reactor are heated by dowtherm vapour systems.

- ***Polycondensation***

The product leaving the pre-polycondensation section is fed continuously into the final polycondensation reactor, where under agitation and high vacuum the final product qualities are achieved.

The degree of polycondensation measured as viscosity is set to the desired final value by maintaining the pressure, temperature and residence time at an appropriate level. The EG (split glycol) vapours are removed by suction with an EG vapour jet system and condensed with cold EG in a spray condenser system. The split glycol is passed back to the paste preparation vessel. The inert gases are removed by the vacuum pump system.

The polymer melt is led to the spinning sections respectively to the chip production by a special designed product discharge pump. Secondary liquid heat transfer medium circuit heats the product outlet line.

The disc ring reactor is heated by dowtherm vapour. The thermal energy is supplied via a dowtherm evaporator, which is heated by liquid heat transfer from primary circuit. The vapour lines and the EG-vapour jet are heated by a separate dowtherm vapour system. The motive vapour required for the EG-vapour jet system is generated in the glycol evaporator. The necessary thermal energy is delivered from a secondary liquid heat transfer medium circuit.

- ***Chip Production***

In this section the hot and highly viscous polymer is converted into chips through underwater pelletizers.

The manufactured chips are inter stored in the intermediate chip silo.

- ***Chip Handling, Chip Storage and Conveying***

The processed textile grade chips are fed with a slow motion pneumatic conveyed to storage silos for bagging.

3.6.11 Staple Fibre Production

PSF Spinning

In the spinning plant the polymer melt is directly spun into tow.

The polymer melt is to be delivered continuously from the polycondensation plant to the spinning beams.

Static mixers in the distribution pipe system guarantee a uniform temperature profile in the polymer melt without creating any dead spots in the pipe system in the spinning beams.

The polymer melt is fed by metering pumps to the spin packs at a uniform flow rate, where it is filtered and extruded through small offices in the spinnerets into filaments. The spinning beams are heated by dowtherm vapour. A special designed vapour distribution system ensures a uniform temperature for all spinnerets. The extruded filament pass through a quench duct in which they are cooled and solidified by a laminar and uniformly controlled and conditioned airflow. From there, they are led through the spinning tube down to the draw-off machine. The filament bundles of each spinning position are gathered to one single tow. The tow is then fed to the piddlers, which deposit the tow uniformly into cans.

PSF Drawlines

The various tows are being combined and drawn under constant tension into the staple fibre line.

The fibre tow passes a dipping bath receiving the necessary finish oil needed for the subsequent drawing of the fibres.

Between drawing frame I and II a pre-orientation of the fibre tow is achieved while at the same time the tows are being heated in the drawing path. The complete orientation(drawing) of the fibres is achieved between drawing frame II and the roller thermosetting unit. In the next step the fibre tows are thermoset under tension or shrinkage at high temperature depending upon the fibre type being requested. The high modulus types are then cooled under tension for stabilizing the properties. Then the tows are then reduced to one tow, which is heated in the heating chamber. The crimping of the fibre tow can be adjusted in the crimping device by pressure. After crimping the fibre tow is dried uniformly in the dryer.

Baler

Then the fibre tow is fed under uniform tension into the cutter, where it is cut into the required staple fibre length. The cut staple fibre is charged into the two baling presses , where it is compressed into bales.

Additives

Following additives are added to get the product with desired properties.

- DEG
- TiO_2

In addition to the additives, Catalyst is used to enhance the rate of polymerization in the polycondensation section.

PSF bale handling facilities

The bales are removed by means of a special designed wagon fitted with gripper and led via a driven roller conveyor to the in-line weighing and labeling unit and further to the discharge point over an undriven roller conveyor.

The bales are then led to the warehouse where the attacking of the bales is done and an inventory maintained for dispatch.

3.6.12 Downstream Process

The Spinning Process

A spinning mill carries out many processes, which transform bales of raw cotton into a yarn ready for weaving. The term "spinning" can refer to the whole activity or just to the final process of making the yarn.

Bale to Lap

The raw cotton arrives in the form of large bales. These are broken open and a worker feeds the cotton into a machine called a "breaker" which gets rid of some of the dirt. The cotton may not be consistent in quality from bale to bale and samples will be taken.

From here the cotton goes to a "scutcher". (Operated by a worker also called a scutcher). This machine cleans the cotton of any remaining dirt and separates the fibres. The cotton emerges in the form of thin "blanket" called the "lap". (Think of how "cotton wool" holds itself together). An important quantity is called the *"tex"* which basically measures the mass per metre. Ideally the tex of the emerging lap should stay more or less the same. The final end product of the mill, the yarn, needs to be of constant quality and character and this is achieved by checking the cotton through all the preceeding stages. One way to achieve this is by blending. The output from several breakers can be fed into the scutcher so that the contents of different bales are being blended to produce a more uniform output. The stress on quality control is something that has changed over the years and what used to be achieved by the experienced eye of the workers now relies more on measurement.

Lap to Sliver

Here we have two processes: CARDING and DRAWING.

Carding

A machine called a “card” does this. The fibres are separated more completely and the tex is reduced many times. The output from these machines is more like an untwisted 'rope' than a blanket. ‘strippers’ and ‘grinders’ according to Tippett do maintenance but in the census they are generally called 'cardroom hands', 'cardroom operatives'.

Drawing

This is carried out on a machine called a 'draw frame'. This further straightens the fibres. It also combines the output of several carders thus again giving a more uniform product. This combining is referred to as 'doubling'. [Note that the same term 'doubling' is used to refer to the twisting together of two finished yarns]. Sometimes drawing is supplemented by 'combing' which gets rid of short fibres. This is normally for higher quality fabrics. The output from drawing is a loose untwisted 'rope' of cotton.

Sliver to Roving

Here the yarn is further attenuated — i.e. it is being stretched so that the weight per unit length decreases further. The process is very similar to drawing. ‘Speed frames’ carry out the process and quite often there are three sets in series. The output from the first is called 'slubbing' The output from the second is called 'inter'(mediate) The output from the third is 'roving'.

'Slubber' and 'rover' are often given as census occupations.

Roving to Yarn (Spinning)

The term *"spinning"* is sometimes used to denote this final process in the production of the yarn. This involves attenuating (stretching) the yarn to the required tex. Giving the thread strength by adding twist. And winding it on to a bobbin. There are two main methods:

- Mule Spinning
- Ring Spinning

The MULE was originally developed by Samuel Crompton from the "jenny". He never patented his invention and this must have helped its wide introduction. The mule operated in two stages. In one stage the whole 'front' of the machine (perhaps 100 feet long) moved away from the back part stretching and twisting the thread as it did so. It would move several feet (say 5 feet). In stage two the front carriage moved back and at the same time wound the stretched yarn on to a bobbin (or *cop*). With the early mules the carriage was moved forward by the operators turning a wheel but the invention of the self-acting mule meant that the carriage moved forward itself. Mules would be placed in lines so that the front of one faced the front of the next. As the carriages moved forward, towards each other, only a narrow gap would be left between them for the spinner to walk between. The mules were tended by spinners, piecers, doffers. Piecers would mend broken threads and doffers would remove the full cops. Often they would be men. Mules could at one time produce much finer yarns than ring frames but as the latter have become more capable the mule has become less used.

Ring-Spinning was a development from Richard Arkwright's "water frame". Many Lancashire manufacturers found that Arkwright's patents were too restrictive so the early water frames lost out to the mule. Ring spinning was not used much in Lancashire until the later years of the 19th century (though invented in USA in 1829) and is carried out on a machine called a ring frame. The process is continuous rather than intermittent, and higher speeds can be achieved. This became the dominant method by mid-1900s. Ring frame tenters were often women and again the full bobbins are removed by doffers. THROSTLE spinning was also developed from the water frame

This is as good a point as any to say something about this occupation which can have a number of meanings. The most usual meaning in Lancashire census records is someone who looks after something, cares for something, tends it. So an "engine tenter" is someone who looks after an engine. Another usage which goes back to the early days refers to the days when bleaching was carried out by putting the cloth in the sun. In small quantities the cloth could simply be laid on the grass but later long lines were set up in bleaching crofts and the cloth was hung from these lines on "tenterhooks". The workers who did this could be "crofters" or "tenters" or "tenterers". Looking again at the Tippett book I see he has a picture of cloth going through a bleaching machine which he calls a bleach croft. So prehaps when modern chemistry enabled bleaching to be done inside the factory the word "croft" stuck. Perhaps the term "crofters" was also applied to these inside workers.

Winding

The yarn, which emerges from the spinning process, cannot usually be woven directly and needs some preparation. Winding is the process of transferring the yarn to larger bobbins or cones. The idea is to get a long continuous length. Weft-winding inolves winding on to smaller bobbins that will go into a shuttle. "Winder" is a common occupation in the census records.

3.6.13 POY process

Polyester Filament Yarn.

Pure terephthalic acid (PTA) and monoethylene glycol (MEG) are mixed to produce oligomer in the Esterification section. The oligomer is then pumped to polymerization section after addition of chemicals namely catalyst, TiO2, DEG and Glycol. The oligomer is converted into polymer through polymerization reaction and is sent to spinning for converting into partially oriented yarn (POY), Fully drawned yarn (FDY) and chippers for making polyester chips. The chips will be further polymerized by solid-state polymerization process.

The solid state polymerized chips with higher viscosity is melted and extruded in extruders and spun, drawn and annealed in a multi drawing and annealing process for production of Industrial yarn (IY).

POY produced will be partly consumed in-house in a single step false twist draw texturing process. This process involves drawing and twisting of yarn in hot condition followed by a cooling & un-twisting process, to produce twist lively yarn.

The finished products of POY, FDY and DTY yarn is finally packed in cartons and stored in warehouse ready for dispatch.

FDY and IY production is similar to PFY production; prior to wind-up the yarn passes through sets of hot godet rollers at different draw ratios followed by annealing process to produce FDY yarn. Block Flow Diagram For POY / FDY / DTY Production is presented in **Fig. 3.34.**

Draw Textursing Process

POY bobbins wound on paper tubes is the raw material for draw texturing operation. This process involves simultaneous drawing and twisting of filaments.

Polyester partially oriented yarn is unwound heated and drawn while twist is simultaneously inserted using either ceramic or solid ceramic or belt positron unit. The twisted yarn passes over cooling plate wherein the twist memory is set in the yarn.

Yarn as it leaves the twist unit gets untwisted making the yarn twist lively due to memory of twist. This yarn forms either helical coils or snarl, which imparts bulk or stretch to yarn depending on use of secondary heater to partially erase the twist memory.

Oil is then applied after the twisting unit and then yarn is wound on paper tubes.

POY filament yarn is thus textured and the yarn has high bulk properties and such yarn is sent to market for further processing to make fabric.

The Moef sought clarification on effluent management during production of polyester filament yarn

The effluent from the PFY Unit is low TDS effluent with a pH in the range of 6 to 6.5. This effluent does not call for any separate pre-treatment and will be pumped directly to the central ETP for treatment with the other effluent streams.

Air Emissions :

The Air emissions from the polyester complex are SO2 and NOx . The respective emissions are 0.075 TPH and 0.031TPH

Liquid Waste generation :

The estimated wastewater generation is 100 M3/Hr

Solid waste :

The solid waste generation from the Polyester complex is Spent yarn.

3.7 Carbon Black

Carbon black is produced by partial oxidation of CBFS. This means the reaction of a CBFS with a limited supply of combustion air, at 1320 to 1540₀C in a combustion reactor. The unburnt carbon from this partial oxidation or combustion is collected as an extremely fine, black, fluffy particle, 10 to 500 nano meters in diameter.

Fig. 3.35 shows a block flow diagram of the carbon black manufacturing process. Preheated CBFS is injected continuously in to the combustion zone of a reactor, supplied with preheated air and natural gas, as supplemental fuel. Both CBFS and air are preheated with the exhaust gases for energy integration. The CBFS undergoes partial combustion resulting in formation of carbon black. The reaction furnace is provided with a water quench, which cools down the gases to 500°C to stop further cracking reaction. The exhaust gases, with entrained carbon black particles, are further cooled to 230°C by raising steam in a WHB. The carbon black is separated from the gas streams by an efficient pulse bag filter and separates carbon black product from the smoke gas to make carbon black content in tail gas lower than 18mg/m^3. The recovered carbon black is finished to a marketable product by pulverizing and wet pelletizing to increase the bulk density. Water from the wet pelletizer is driven off in a rotary drier, fired with natural gas. The dried pellets are then conveyed to bulk storage.

Carbon black emissions can occur from the vents of the pneumatic conveying system. The gaseous emissions are controlled by using tail gas as a combustible gas in CO boilers. The tail gas contains CO, hydrogen and small amounts of carbon black, which are burned in the reboiler. The steam raised from process reboilers and CO boilers is used for generating power. Surplus power to the extent of 26 MW is exported from a 120 ktpa carbon black plant.

Fuel :

The fuel oil requirement for Carbon black process is 29.73 TPH

Air Emissions :

The SO2 & NOx emissions from the process units are 0.099 & 0.026 TPH respectively. The emissions from the process vents - Carbon black will be less than 18 mg/m3

Liquid waste:

The estimated wastewater generation is 315 M3/Hr to central ETP

Solid waste:

No solid waste will be generated from the process.

3.8 Lube Oil Cum Refinery Complex

The CDU/VDU of 140 kbpsd does primary separation of crude oils into C3/C4, naphtha, kerosene, gas oil, vacuum gas oil (VGO) and vacuum residue (VR). The primary product disposition from the proposed Lube Oil Refinery in the Jamnagar SEZ is given below:

- C3/C4 – mixed with sat LPG and goes as feed to the Alky unit, in the JERP.
- Light naphtha – blended into PC naphtha product, via depentanizer, in the JERP
- Heavy naphtha – feed to the HNHT 2/Platformer 2 in the JERP
- LK – blended into the jet product, via Kero Merox unit in the DTA refinery
- HK + AGO – blended into the diesel product, after desulphurising in the new DHDS unit in the Lube Oil Refinery.
- LOBS Feed Stock

The VR from the CDU/VDU’s shall be routed to the Solvent De-asphalting unit (SDA) in the JERP refinery to be separated into deasphalted oil (DAO) and SDA pitch, with the aid of a solvent, which may be Propane/ Butane. The SDA pitch shall be routed to the Coker and Bitumen units in the JERP refinery, for further bottom-of-the barrel processing.

The VGO from the CDU/VDU’s, along with the DAO from the SDA shall be routed to the existing Hydrocracker in JERP. This Hydrocracker shall be in the Lube oil refinery service.

The lube hydrocracker does high pressure, aromatics saturation, in the presence of catalyst and hydrogen. The unconverted hydrocracker residue is an excellent raw material for high performance LOBS. The VGOHT capacity has to be increased by 110 kbpsd to treat total VGO and DAO from the JERP. The cracked products of C3/C4, naphtha, kerosene and gas oil shall be routed to the JERP, for further processing, and blending into transportation fuels.

The unconverted hydrocracker residue shall be further processed in the 30 kbpsd Catalytic De-waxing unit to eliminate the wax from the LOBS, in a heterogeneous, catalytic reaction in the presence of hydrogen. Finally, the post processing hydro-finishing step shall be done in a 30 kbpsd Lube Hydro-finishing unit to manufacture 1.5 mmtpa of premium, LOBS. The Lube Hydrocracker produces cracked products with the following disposition :

- C3/C4 – mixed with sat LPG, and routed to the JERP Alky unit depropaniser for separation into propane product, and C4.
- Light naphtha – blended into PC naphtha product.
- Heavy naphtha – feed to the HNHT 1/Platformer 1 in the DTA refinery.
- Kero – blended into jet product in the JERP.
- Gas oil – blended into Euro V diesel product in the JERP.

A note on Emission / effluent including hazardous waste management of lube oil refinery complex

The lube oil refinery complex is essentially similar to the Jamnagar refinery complex and the emissions from the lube oil refinery complex are due to the use of fuel in the furnaces. The emission rates are given in Table 5.4 of the EIA Report and also given in Annexure III enclosed to this document. . Refinery Fuel Gas and NG utilization is maximized to control the emission of SO2 . Low NOx burners will be used for the control of NOx emissions.

The effluent / emission / hazardous waste management is similar to the practice followed for Jamnagar refinery complex. The effluent generation rate is estimated to be 300 m3/hr. The quality will be similar to the effluent generation from the refinery complex (i.e. Easily biodegradable) and will be treated in the common effluent treatment plant.

The following hazardous wastes would be generated:

1. Spent catalyst
2. Used lube oil

3. Oily rags
4. Spent clay
5. Empty drums

The hazardous waste management is described in section 6.2.4.1 of the EIA report. The specific disposal method for each category of waste is mentioned in Table 6.1 of the EIA report.

Air Emissions:

The SOx & NOx emissions from the process is 0.0008 and 0.036 TPH respectively.

Liquid waste:

The estimated wastewater generation is 300 M3/Hr. This will have a dedicated ETP inside the plant Battery Limit.

Solid waste:

The solid waste generated from the process is Equivalent catalyst of 3300 tons (once in 3 Years)

3.9 Captive Power Plant

The Integrated Captive Power Plant consists of

- Gas Turbo Generators
- Heat Recovery Steam Generators
- Steam Turbo Generators
- Auxiliary Boilers

The fuel for the CPP is supplied by both the refineries, Synthesis Gas from Coke Gasification Plant and Imported Natural Gas. The auxiliary boilers are fueled by the Refinery Fuel Oil (RFO). The CPP will be operated as an island grit basis and does not use any external fuel other than the Natural Gas.

The process flow diagram is given in Fig.3.36

Gas turbines (14 Nos. each of 110 MW)

Gas turbines, consists of axial flow compressor, to compress air in to combustion chambers. In combustion chambers, fuel (natural gas/ syngas) is added and the products of combustion are allowed to expand through impulse turbine. The turbine rotor is coupled with generator to produce electric power.

HRSG (14 Nos.)

Turbine exhaust is taken to a water boiler, through a duct where supplementary generate steam and are exhausted to atmosphere through a boiler stack. Deareated demineralised water is used in the HRSG. Duct firing facility is provided for additional fuel.

Auxiliary Boilers (8 Nos.)

Eight (8) Auxilary Boilers are provided for balancing out the steam generation requirement.

Steam turbo generators. (25 Nos. each of 30MW or 7 Nos. each of 110 MW)

High-pressure steam is expanded through a turbine/ expander to reduce the pressure and recover power. This expander is coupled with generator to produce electric power. These turbines can float on the back pressure requirement of various levels of Steam required in the other units of the SEZ. Steam requirement is provided by the HRSGs and Auxiliary boilers in the CPP and also process steam generation in the units,

Air Emissions:

The SO2 & NOx emissions from the power plant are 0.678 and 2.59 TPH respectively

Liquid waste

Only cooling water requirement which is recycled water

Solid waste:

No solid waste will be generated.

3.10 Desal Plant

The water requirement of the existing Refinery cum Petrochemical complex is met from the Desalination Plant installed in the Complex.

Considering the water shortage in the region, the seawater intake is provided at the maritime terminal area where water is pumped and treated. The desalination plant has been designed using multiple effect Distillation process integrating it with energy sources. The energy (heat) requirement for desalination is met by the low pressure steam from processing units. Thus eliminates the venting condensing of low pressure and low temperature steam from the process units, this is used as a steam sink for the optional steam balancing.

The desalination plant is designed with flexibility to operate on a low energy input to produce sufficient water for units and domestic purpose. Overall 15 new desalination units of capacity 1000 m3/hr each would be installed at proposed SEZ.

The desalination unit is based on the multi-effect distillation process. A series of horizontal-tude, falling-film type evaporative condenser serve as heat recovery effects. Through successive steps of evaporation and condensation at equilibrium vacuum conditions, a multiple amount of distillate [product] is derived from seawater using a given quantity of low-temperature steam input / sink. Steam at 3.5 kg/cm2 or a low low pressure steam availablefrom process units, is the energy source of the MED desalination process.

The train of evaporative-condenser units is divided into three groups of effects, for piping and feed pumping purposes. These groups are hereafter referred to as the “hot”, “intermediate” and “cold” groups.

Group Effects
Cold 8 TO 11
Intermediate 4 TO 7
Hot 1 TO 3

The MED process is based on counter-current flow of water vapor against sea water feed. The feed is first introduced into the cold group of effects. About 10-20% of the feed water is evaporated in the effects. The non-evaporated feed, now slightly warmed and concentrated, is introduced into the intermediate group of effects, and then, in the same way, to the hot group. The input steam is available at pressure of 3.5 kg/cm2 abs, while that required by the evaporator is about 0.33. The thermal efficiency of the process is considerably increased by routing the input steam through a conventional jet ejector [thermocompressor], which recycles a substantial portion of the vapor generated, and reintroduces it into the desalination process.

Sea Water Flow

The incoming seawater stream passes through one ion trap and two filters. Raw seawater is fed into the falling film condenser and distributed over the heat transfer tubes. The water is heated to 40oC by vapor condensing inside the tubes. Since the condenser operates at vacuum, it de-aerates the seawater as well. This seawater stream now becomes feed to the cold group. The feed is distributed evenly over the top rows of tubes of effects 8-11 by means of spray nozzles. Flowing in thin films down over the banks of tubes, part of the feed flashes into vapor as it absorbs the latent heat released by the condensing water vapor inside the tubes. The remaining feed from the cold group of effects, now slightly concentrated, is collected through piping and pumped to the intermediate group of effects. There it is similarly sprayed over the heat transfer tubes, again flashing part of the feed into vapor. This pattern of flow is repeated finally in the hot group of effects. The remaining feed [now brine] from the hot group is collected from the 1st, 2nd and 3rd effects and cascaded through a series of eight brine flash tanks. The brine is flash cooled and the heat of the flashed vapor is recovered in the subsequent evaporator effect. From the last flash tank, the residual brine is returned to the sea by the brine pumps.

Coolant Flow

Vapor from the last effect not being condensed in the main condenser will flow to the forced circulation condenser to be condensed by coolant stream from a cooling tower.

Steam and vapor Flow

The motive steam is the energy source of the process. It is introduced into the plant through the steam jet thermocompressor, which withdraws a portion of generated vapor from effect 8. The combined mixture of motive steam and vapor flows into the tubes of the 1st [hottest] effect. The vapor temperature is 2-3oC above that of the feed. Heat is always transferred from the vapors (inside the tubes) to the feed (outside the tubes). Therefore, the vapors condense inside the tubes, while the feed evaporates outside.

The vapor condensation inside the tubes generates an almost equal mass of vapor outside the tubes. This vapor serves as the motive steam for generating additional vapor in the next effect.

The evaporation-condensation process is repeated through to the last effect, each effect contributing almost a full multiple of additional product. In flowing from each effect to the next, the vapor first passes through a separator which removes entrained brine droplets and maintains the required distillate purity. The vapor generated in the last effect flows into the condensers, giving up its latent heat to the feed stream, which absorb it as sensible heat.

Condensate

The condensate [distillate] condensed from the vapor in the 1st Effect, drains to the condensate surge tank. The condensate is a sum of motive steam condensate and excess condensate of vapors withdrawn by the thermocompressor. The quality of the condensate is continuously monitored. In case condensate conductivity exceeds 7 ppm, the flow is diverted out as contaminated condensate. 3 m3/hr of condensate is circulated to the vapor duct for cooling the superheat of vapor at thermocompressor discharge to 70oC.

Process Flow

The product from effects 2 to 11 flows through a series of product flash chambers. Since the vapor space of the product flash chambers is connected to a colder effect, part of the distillate flashes off. The heat released as vapor joins the vapor generated in the former effect while the remaining product stream is cooled. The growing product stream is thus cascaded and flash cooled in stages. As with the brine stream, the heat thus given off and recovered increases the efficiency of the process. The final stage of condensation occurs in the heat rejection condensers, from which the distillate joins the cascading product stream. The product pumps deliver the product to client product storage tank. The quality of the distillate is continuously monitored. If the conductivity exceeds 7 ppm, the flow is diverted out as contaminate product. The process flow is given in **Fig 3.37**

NCG Removal

Non-condensable gases [NCG], accumulated from the steam sea water are removed by continuously bleeding out the evaporators to improve the efficient heat transfer and also minimize the corrosive.. The NCG Effect no. 1 is vented to atmosphere by steam stripping. The NSG from Effects 2 to 7, 9 to 11 are internally vented. NCG mixed with water vapor flow from effect to effect through the water vapor flow. The concentrated NCG mixed with water vapour vented directly into the main condenser.

3.11 JERP Refinery

This facility is under commissioning and has the requisite environmental approval from MoEF in 2005. However this facility will become a part of the SEZ along with the other C1 to C8 units. This refinery was implemented by Reliance Petroleum Limited (RPL) a group company of Reliance which is under amalgamation with RIL.. The process description of JERP refinery has been given below as a ready reference as both the refineries are integrated with the C1 to C8 projects.

The refinery processing units include primary process units namely atmospheric and vacuum distillation units and secondary process units like Fluid Catalytic Crackers (FCC), Delayed Coking Units (DCU) etc. Presently, the refinery has the following processing units:

- Crude complex includes primary crude atmospheric and vacuum distillation units (CDU and VDU)

- Vacuum residue from the crude complex undergoes secondary conversion in a Delayed Coker in the Coking Complex
- Fluid Catalytic Cracker (FCC) is the principal conversion unit for fuel and petrochemical (Olefin) products
- Olefins present in the cracked products from the FCC are recovered in the Olefins complex
- Hydrotreating complex includes hydroprocessing of various streams for superior product yields and qualities with low sulphur. Hydrogen plant produces required hydrogen for hydroprocessing
- Aromatics Complex includes Continuous Catalytic Regeneration (CCR) Reformer and downstream extraction to make paraxylene, benzene and orthoxylene.
- Amine Treatment Unit (ATU) complex includes individual amine absorber units in CDU, FCC, Coker, Vacuum Gas Oil Hydro Treater (VGOHT), Diesel Hydro Treater (DHT), Heavy Naphtha Hydro Treater (HNHT), Light Naphtha Heavy Treater (LNHT) and Amine Regeneration Unit (ARU).
- Sour water stripping complex includes phenolic Sour Water Stripper (SWS) and Non-phenolic SWS. Stripped gases are sent to Sulphur Recovery Units (SRUs) in Sulphur Complex.
- Sulphur Recovery Complex produces elemental sulphur from H_2S produced in hydroprocessing units.

The petroleum products from the crude refinery, LOBS will be accommodated in the existing Refinery and the Marine Tank Farm area.

Fuel oil and Fuel gas:

The fuel gas requirement for the JERP (under Implementation) is 196 TPH &

The fuel oil requirement for the JERP (under Implementation) is 84.29 TPH

Air Emissions:

The SO2 and NOx emissions from the JERP are 0.456 and 0.47 TPH respectively.

Liquid Waste:

Effluent – 1200 M3/ Hr. Dedicate ETP inside the Battery Limit

The estimated wastewater generation is 1200 M3/ Hr

Solid Waste:

The estimated solid waste generation from the process is Eq.Catalyst of 11200 T/Yr

(Averaged over 4 Yrs)

3.12 Product, Process and Utility Integration

Along with the existing modernized and expanded refinery and the proposed petroleum and petrochemical complex will be under the EOU scheme, aimed to maximize the value addition along the entire carbon chain of C1 through C8 and higher.

The various units within this complex will be homogeneous to the C1 to C8 hydrocarbon chain. All the units and product plants are integrated with each other to derive the advantage of optimum utilization of various resources.

Jamnagar has the most suitable seafront in the Gulf of Kutch for raw material import and finished products export. This complex is fully integrated with the existing refinery complex as well as export oriented Refinery.

This Petrochemical Complex produces distinct petrochemical products by processing and synthesizing from the various streams of the refinery complex. The manufacturing units of these products consist of similar equipment and machinery which synergistically work to produce these distinct products. In this particular configuration of the conglomerate, the raw materials intermediate products, by-products, material and energy flows are integrated so as to:

- Maximize value of raw materials, sourced from the RIL & RPL refineries.
- Optimally utilize the various process streams derived from the refinery complex and petrochemical units
- Conservation of the water resources through integrated recycle and reuse among the various process units.
- Enhance competitive strengths, by minimizing the cost of production, with intimate integration between the two refineries and the Jamnagar SEZ manufacturing complex.
- Exploit economies of scale for each of the products in the Jamnagar SEZ.
- Minimal transportation cost of raw materials.
- Minimize the requirement for infrastructural facilities.
- Optimization of effluent treatment facilities, hazardous waste handling & disposal facilities, etc
- Strive to be the lowest cost producer for each of the products in the Jamnagar SEZ.

- Develop of world-class infrastructure and logistics facilities to support the Jamnagar SEZ to exploit the supply chain for each of the products in the Jamnagar SEZ.

These are synergistically integrated in three main areas. i.e

a. Process Integration of various process streams derived from the refinery complex
b. Energy integration of various producing units to optimize / minimize the energy consumption in the various units.
c. Conservation of the water resources by recycle and reuse through various utilization processes starting from the raw seawater.

By internalizing the resources and related environmental parameters the overall synergistic integration is achieved. This in turn leads to optimum utilization of all the streams into various value added products. This integration / synergy helps in leaving a smaller carbon foot print and thus a lower impact on the environment The extent of integration achieved in the area of process, energy and water are depicted in Fig 3.38,Fig 3.39 & Fig 3.40.

The environmental parameters at Jamnagar has been continuously studied and assessed for the Reliance Group of Industries at Jamnagar since 1993. For the existing Refinery a post project Environmental Impact Assessment (EIA) has been done and was also assessed by the MoEF in 2003. Later Environmental Impact Assessment (EIA) & Risk Assessment (RA) studies were conducted for the modernization and expansion of the refinery complex and the MoEF has granted the Environmental Clearance for the same in 2005 . The modernization and expansion of project is under commissioning now.

The results of these studies have been considered and internalized in the planning, design, construction and operations and specific environmental related operational characteristics like emissions, discharge and other relevant parameters. These cumulative affects already get reflected in the latest environmental baseline studies for petroleum and petrochemical complex at Jamnagar..

Accordingly the EIA reports were upgraded by incorporating the Terms of Reference (TOR). Public Hearing was conducted in 2008 and the draft EIA was finalized by updating the process related information, emissions and other relent parameters, Public hearing comments and the final reports were submitted to MoEF.

This report further updated by incorporating the details as advised by the ministry

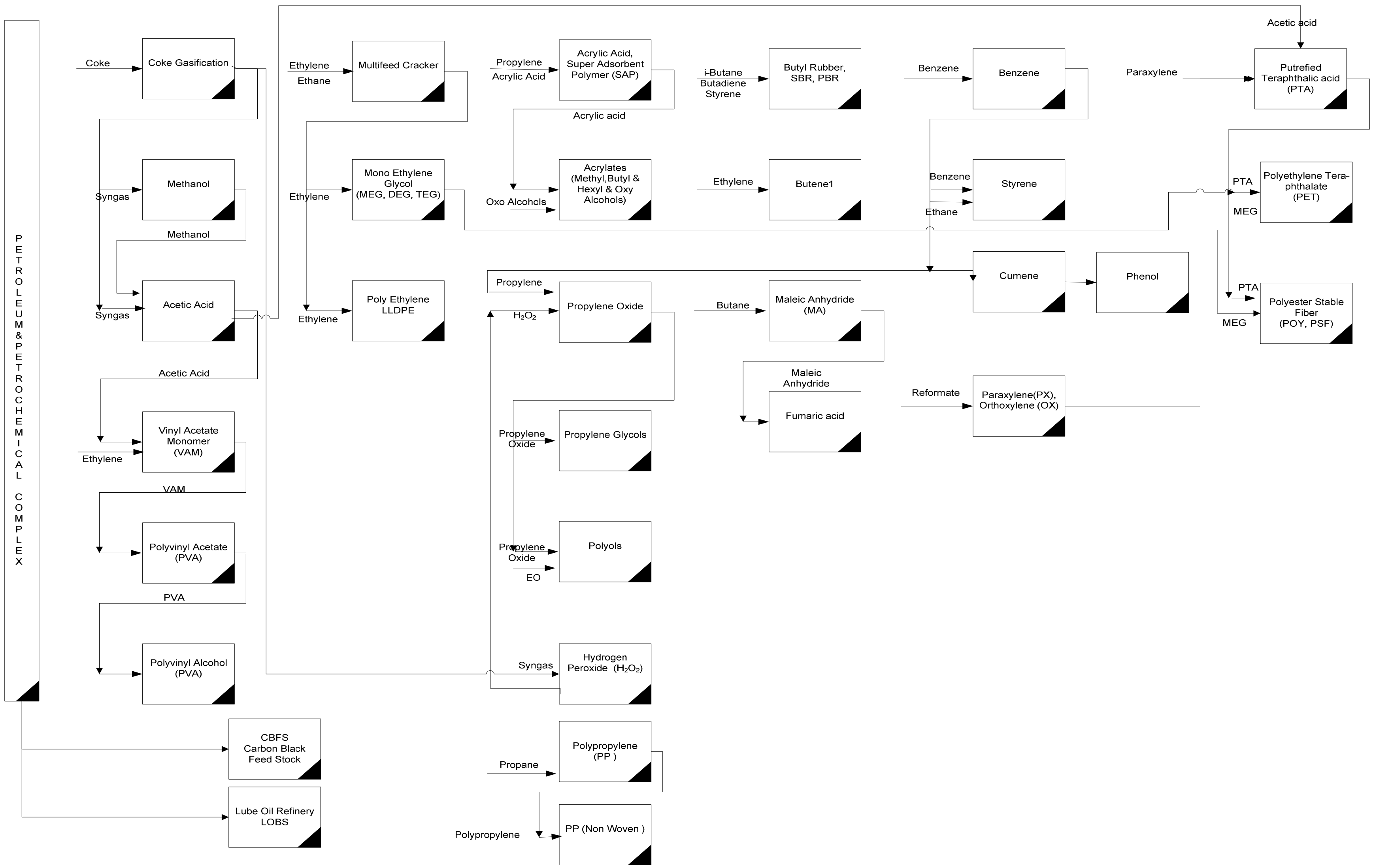


Fig. 3.1: Proposed C1 to C8 Units of SEZ

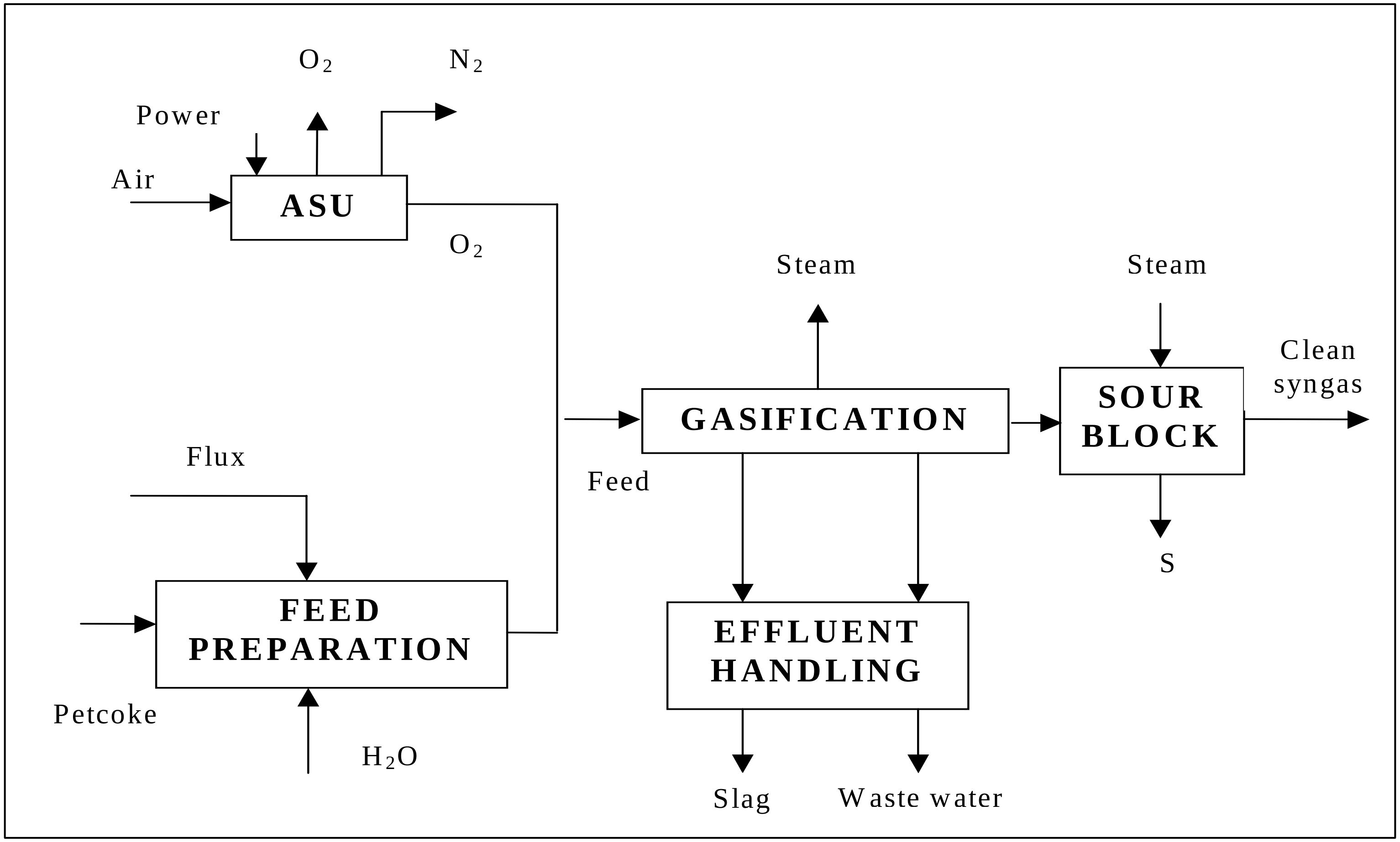


Fig. 3.2 : Process Flow Diagram for IGCC Unit

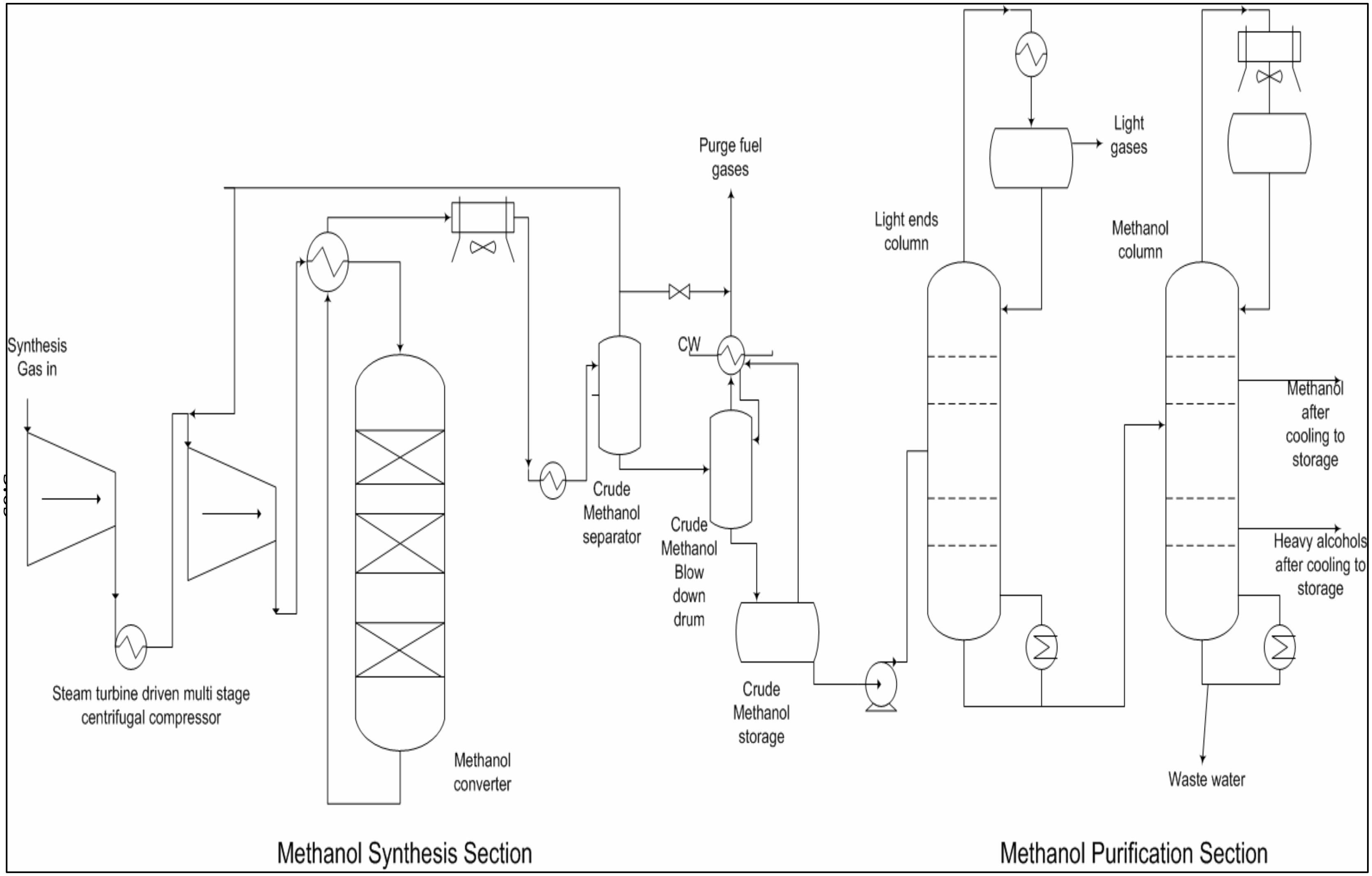


Fig. 3.3 : Process Flow Diagrams for the Production of Methanol by the Copper Catalyzed Intermediate Pressure Process

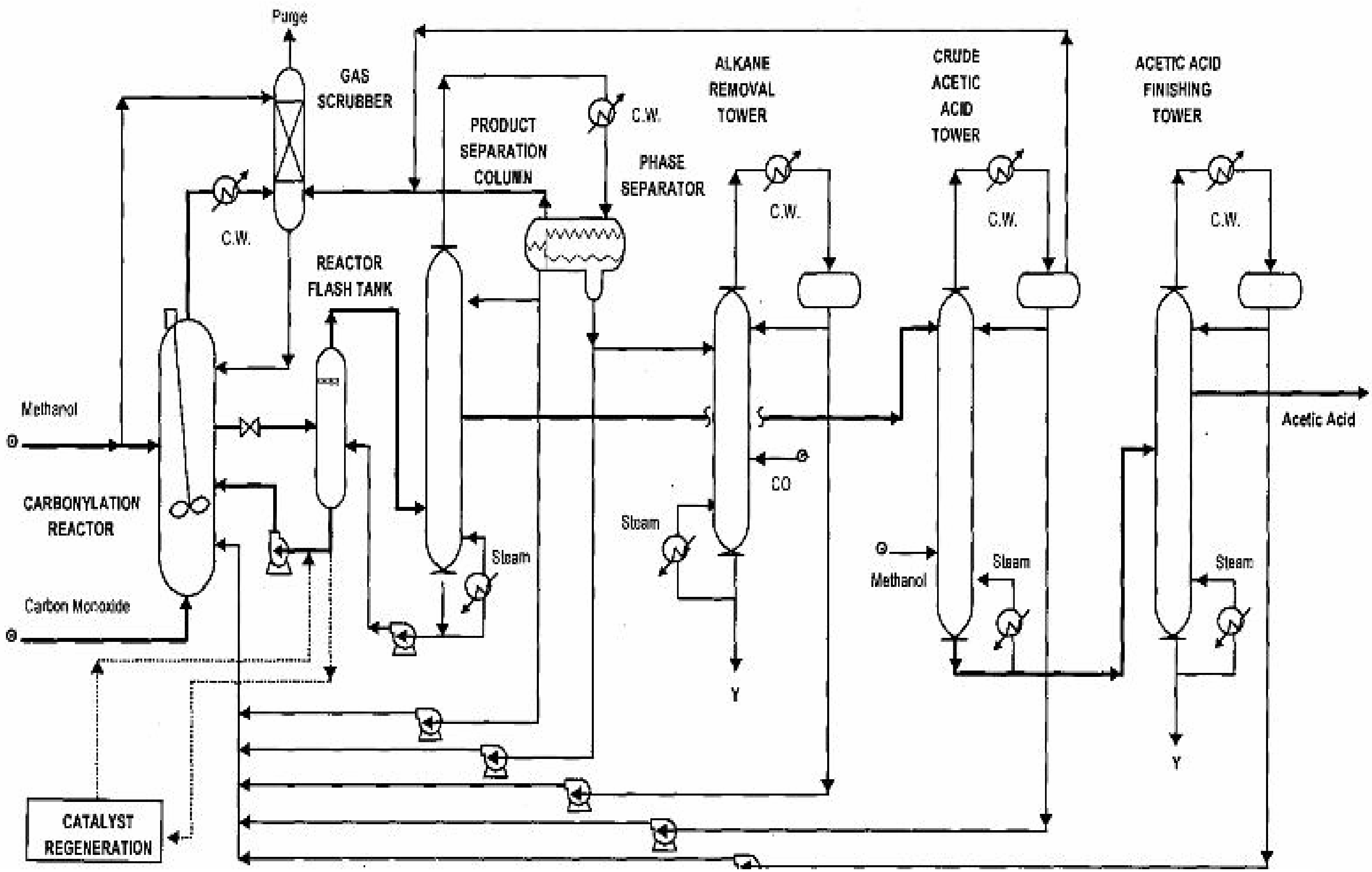


Fig. 3.4 : Process Flow Diagram for Acetic Acid

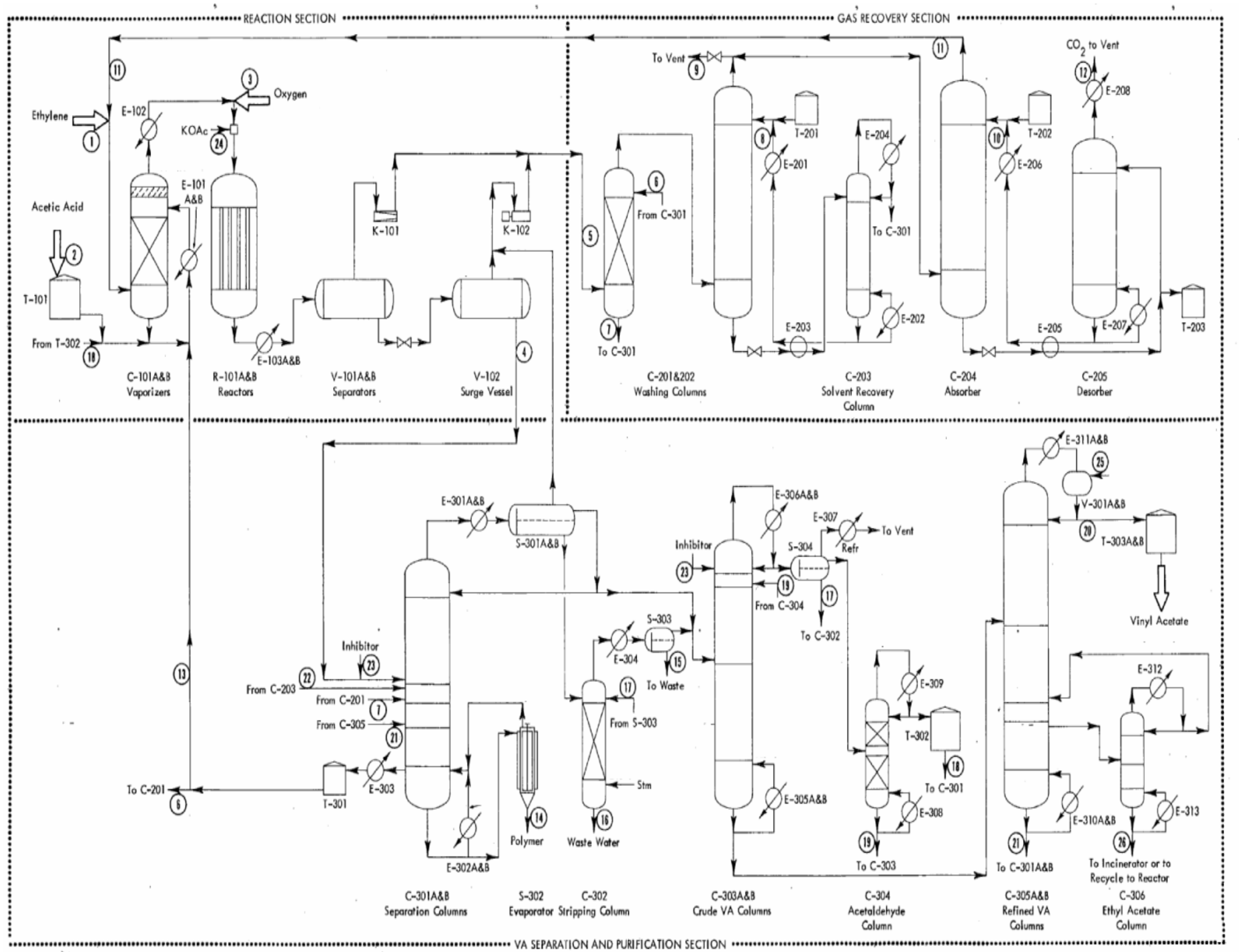


Fig. 3.5 : Process Flow diagram for Vinyl Acetate Monomer by the Vapor Process

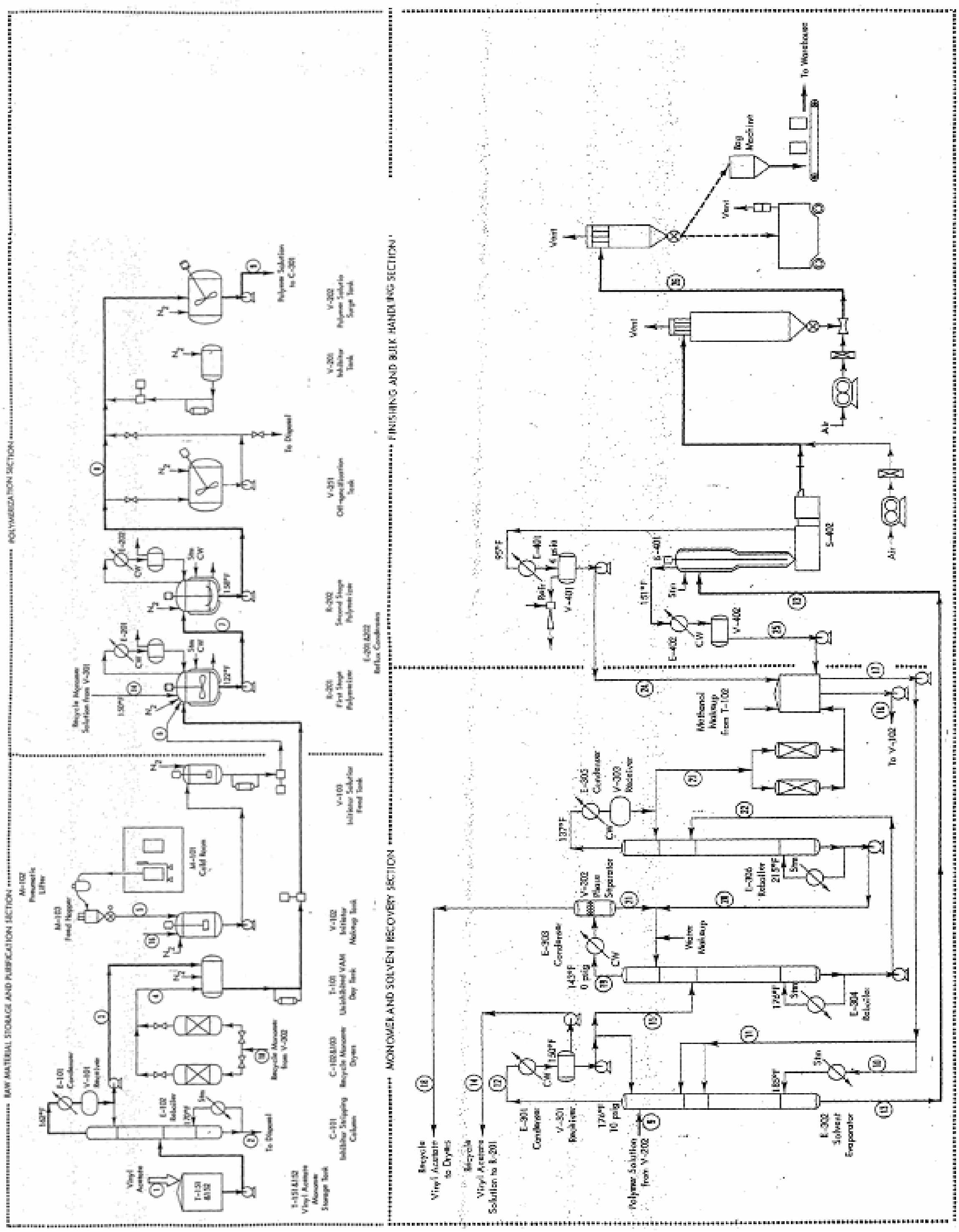


Fig. 3.6 : Process Flow Diagram for Poly Vinyl Acetate

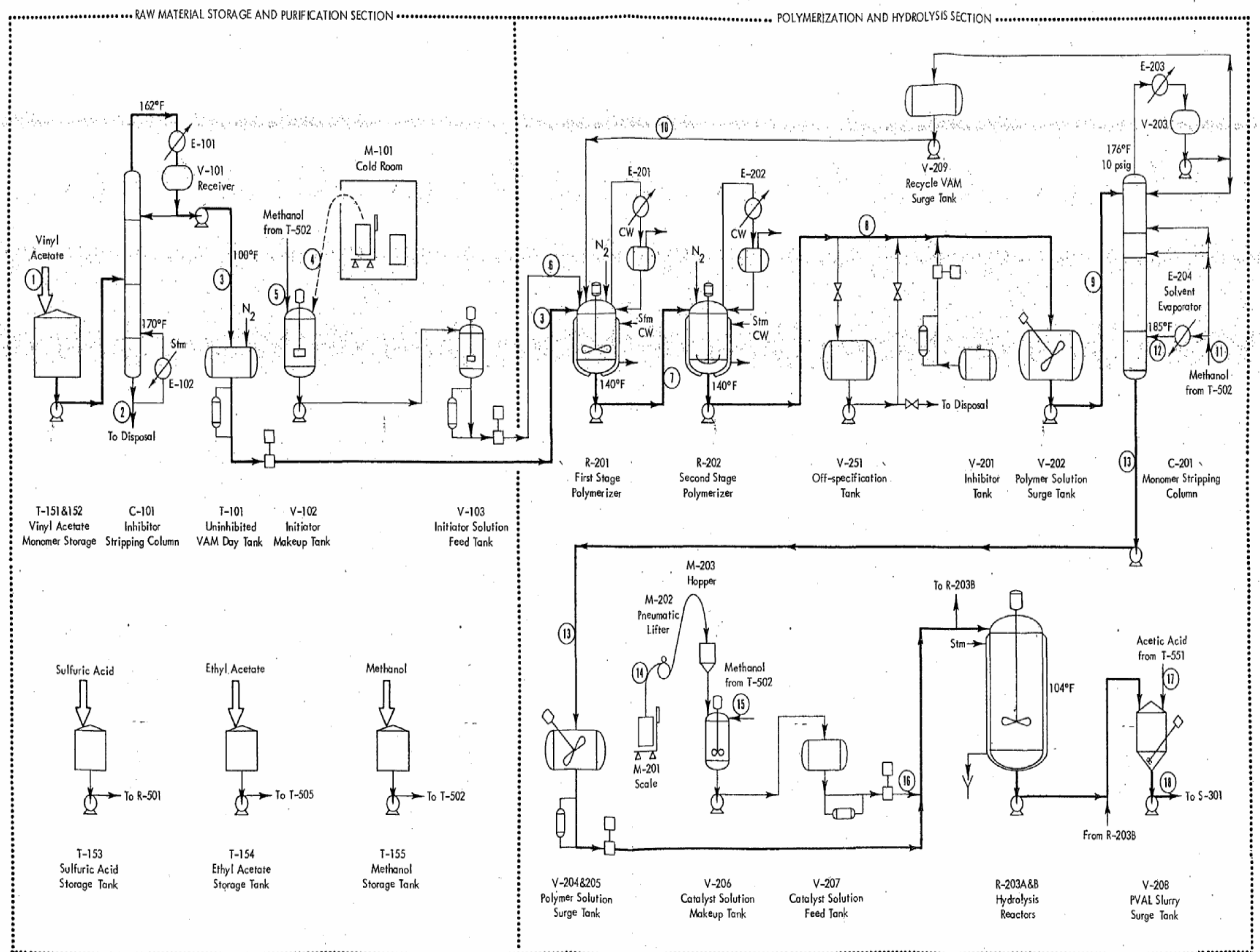


Fig. 3.7 : Process Flow Diagram For The Production Of Poly Vinyl Alcohol By Solution Polymerization

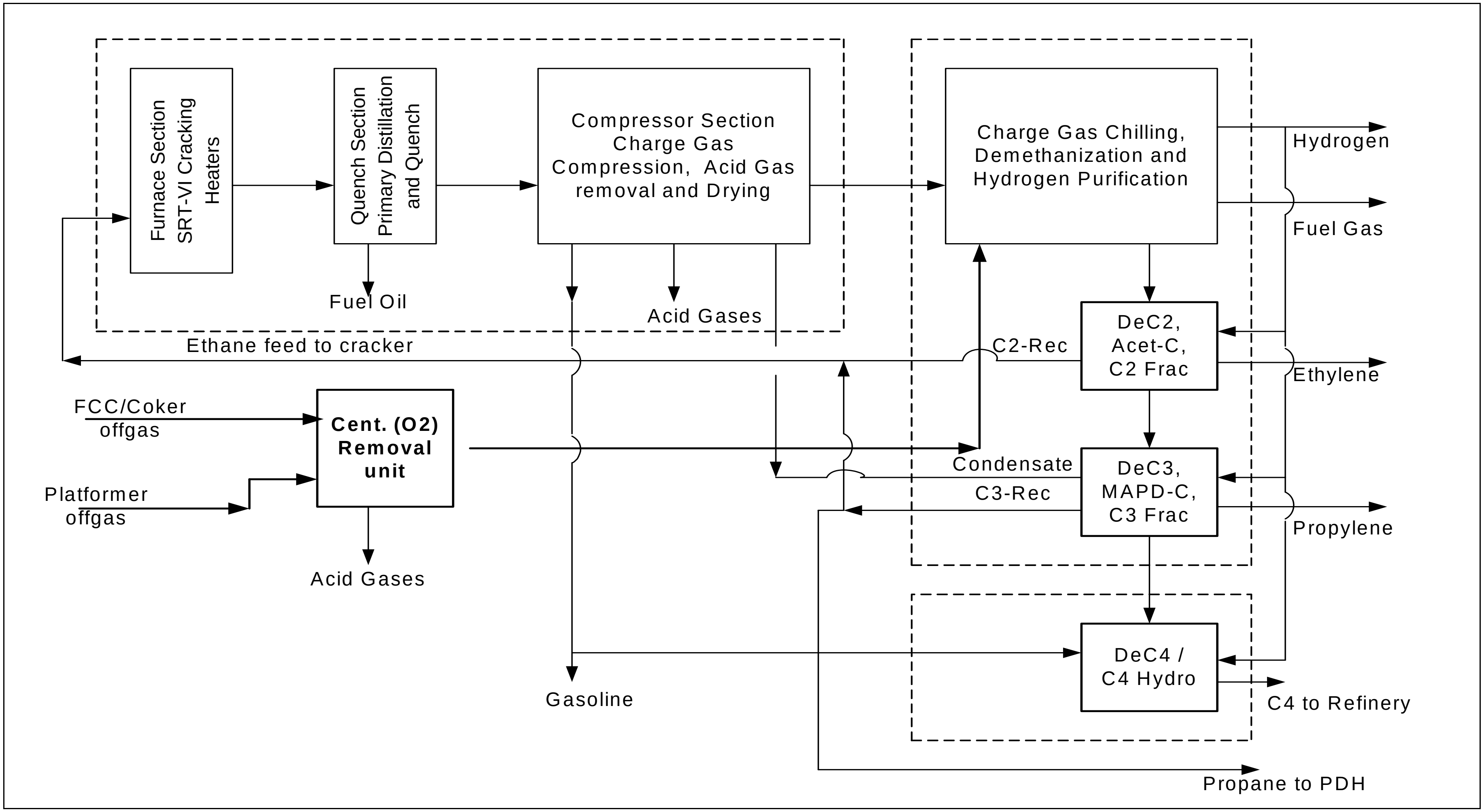


Fig. 3.8 : Block Flow Diagram for Multifeed Cracker

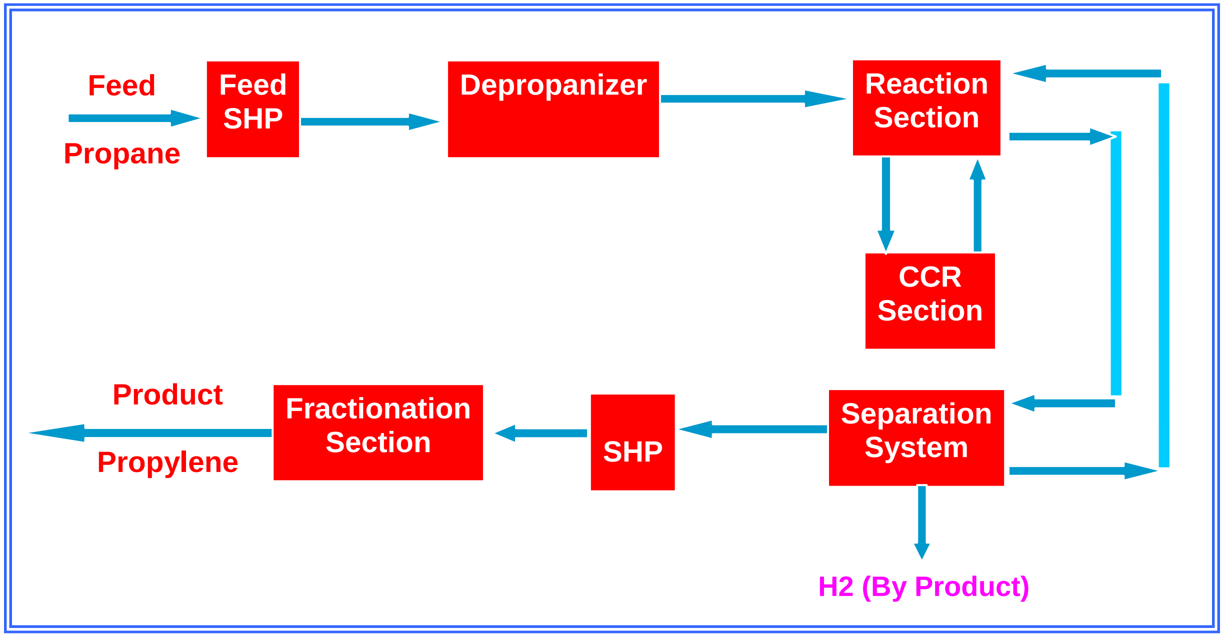


Fig. 3.9 : Propane Dehyfrogenation in Cracker Complex

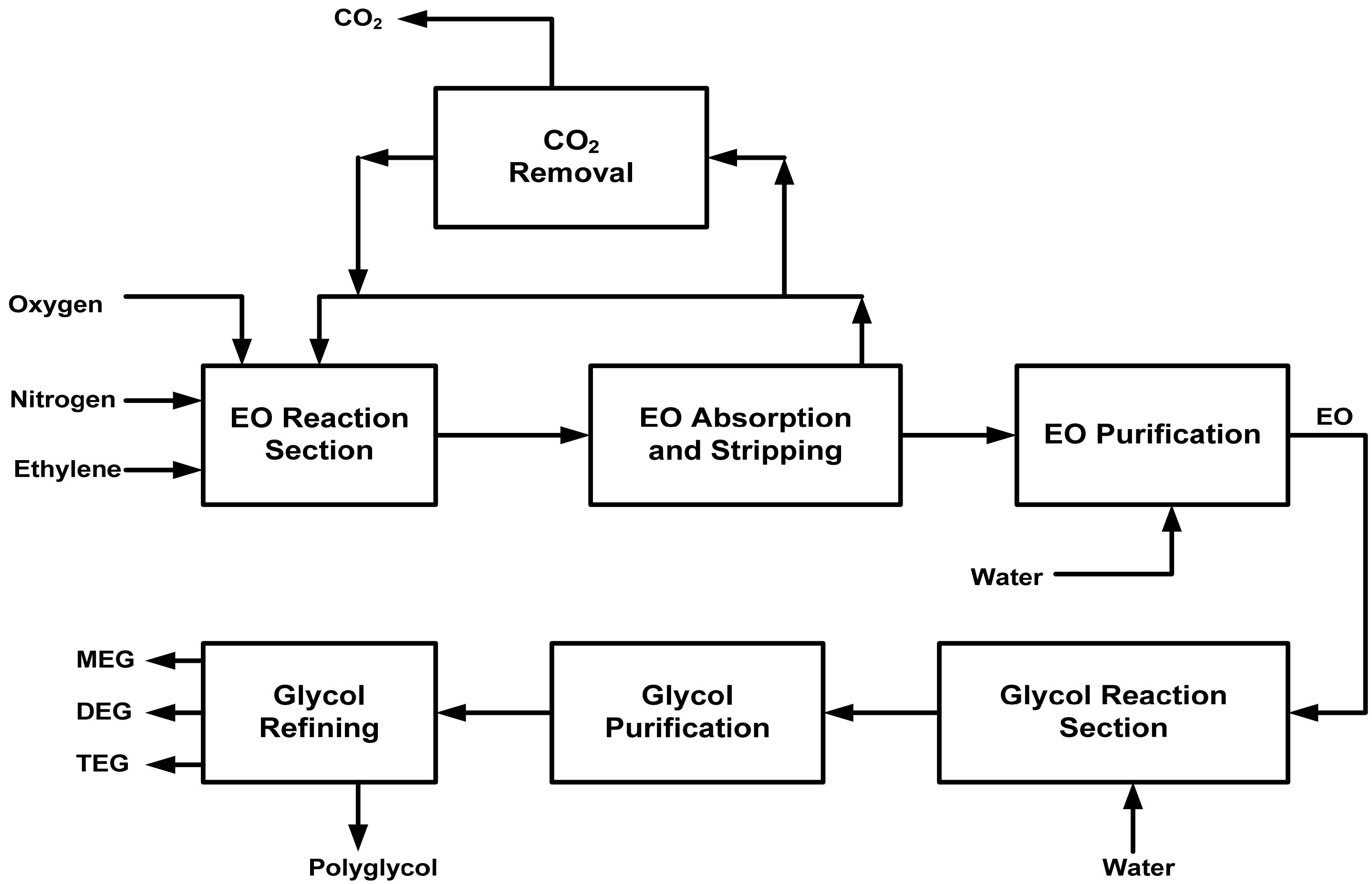


Fig. 3.10 : Block Diagram for Mono Ethylene Glycol

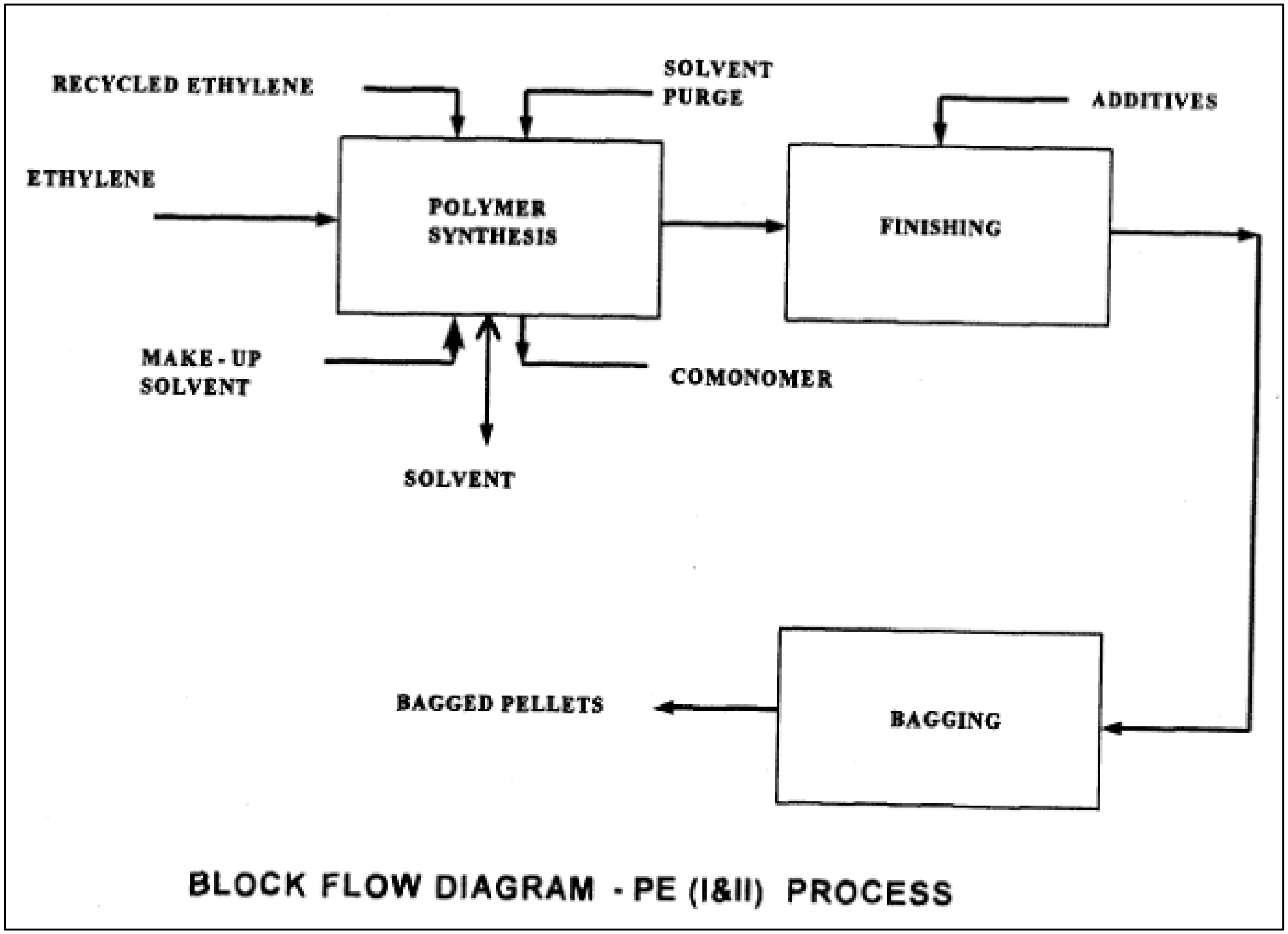


Fig. 3.11 : Block Flow Diagram of PE (I & II) Process

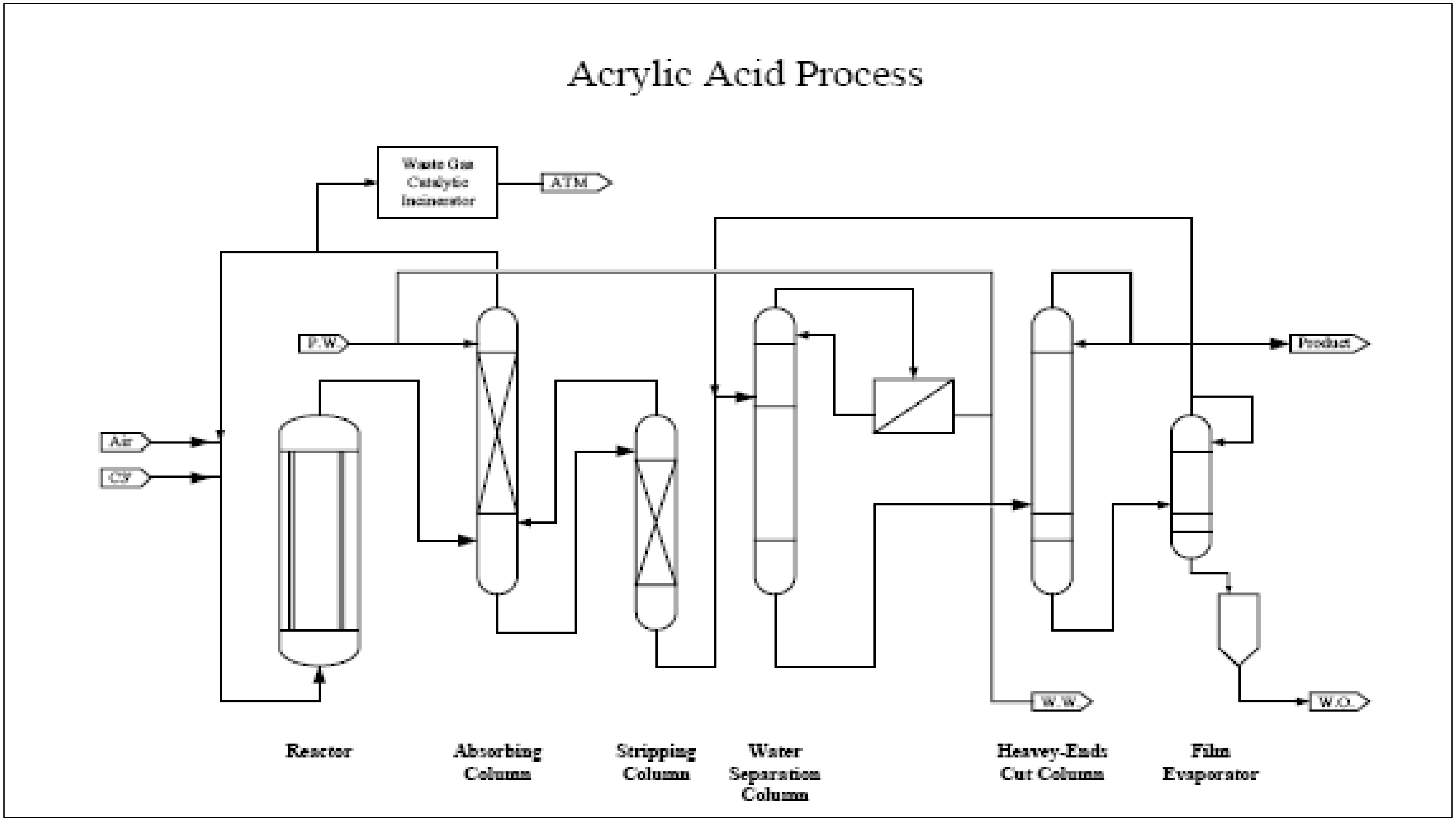


Fig. 3.12 : Process Flow Diagram for Acrylic Acid Production Process

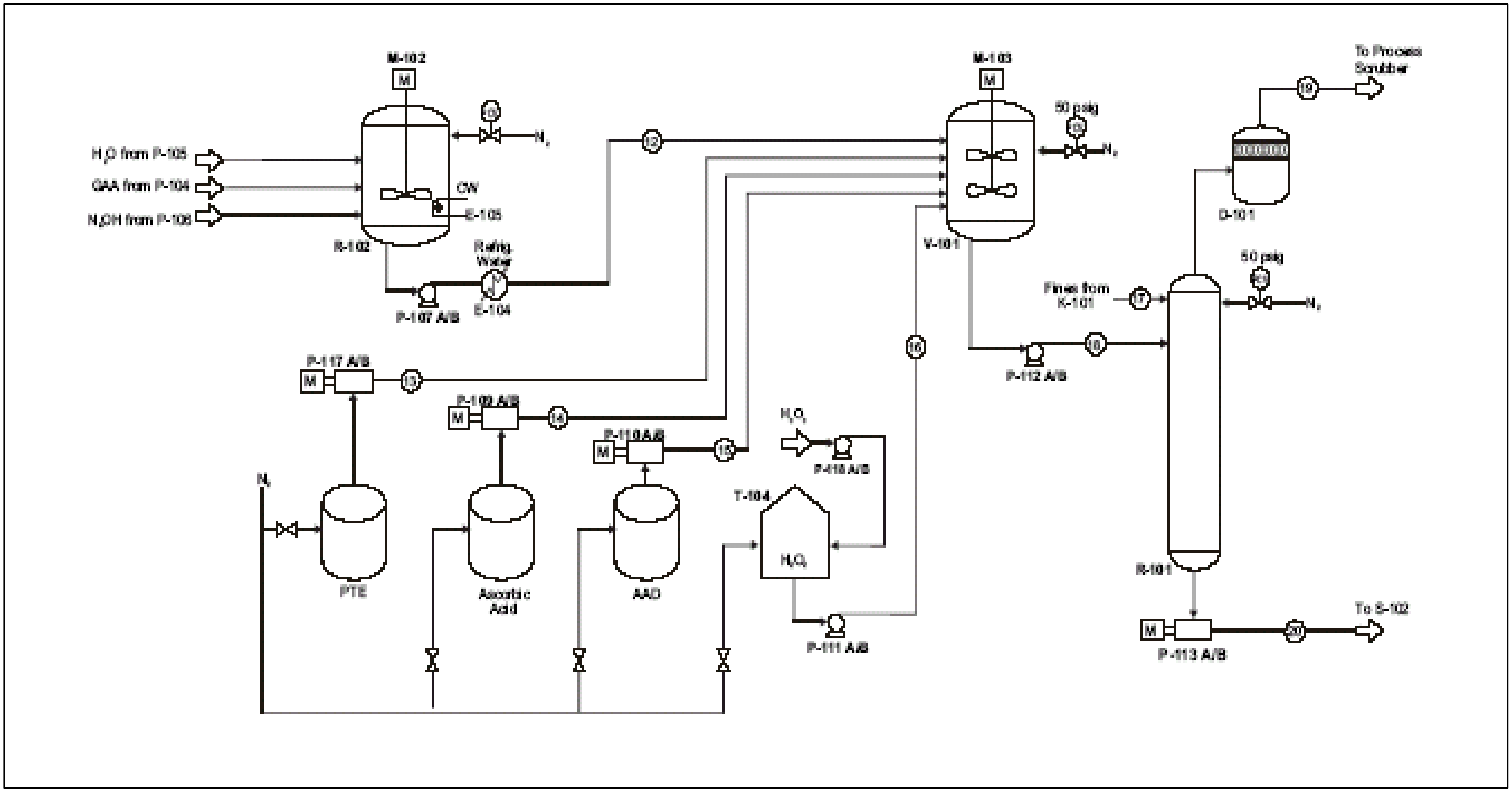


Fig. 3.13 : Process Flow Diagram for Production of SAP

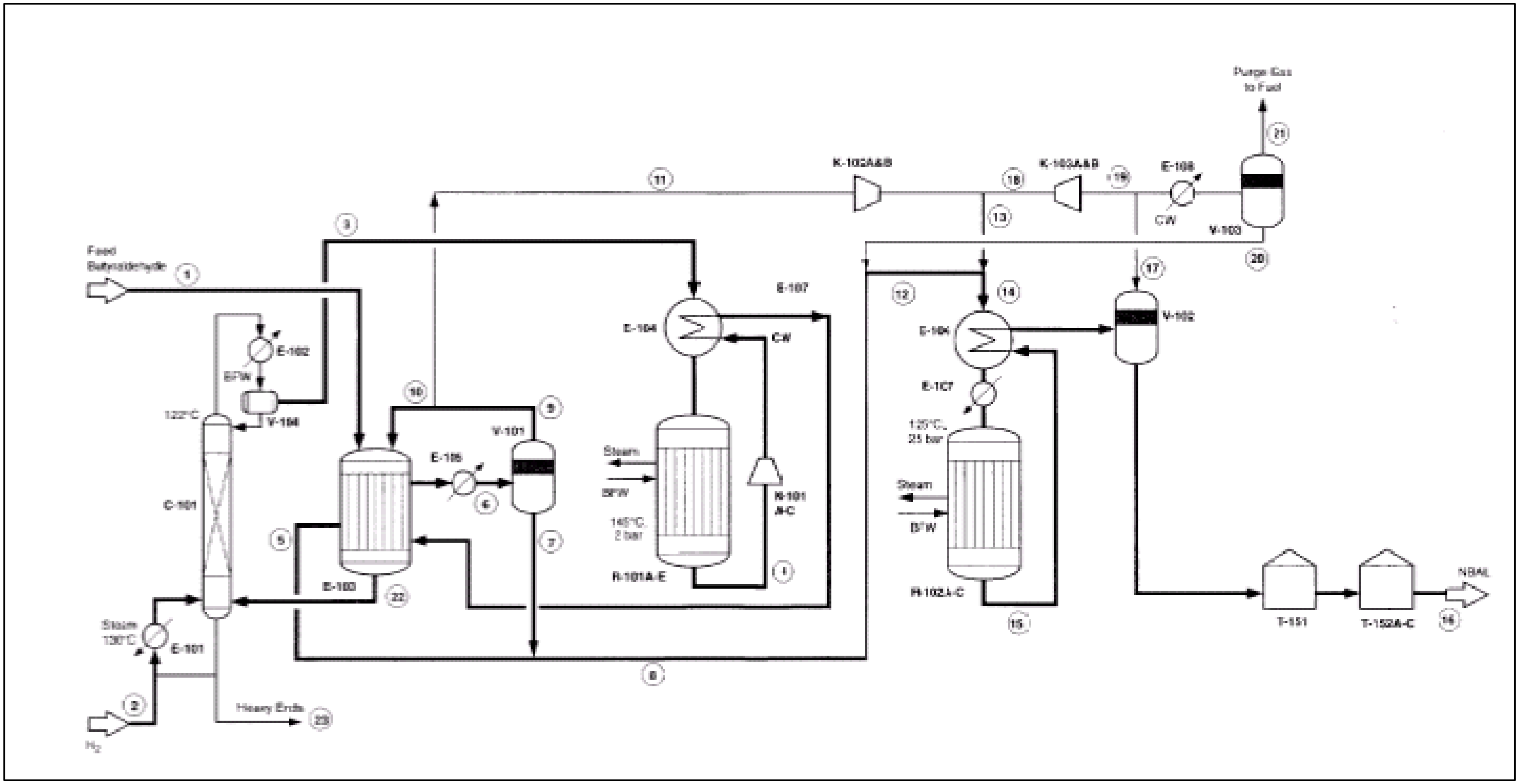


Fig. 3.14 : Process Flow Diagram for 2-EthylHexanol

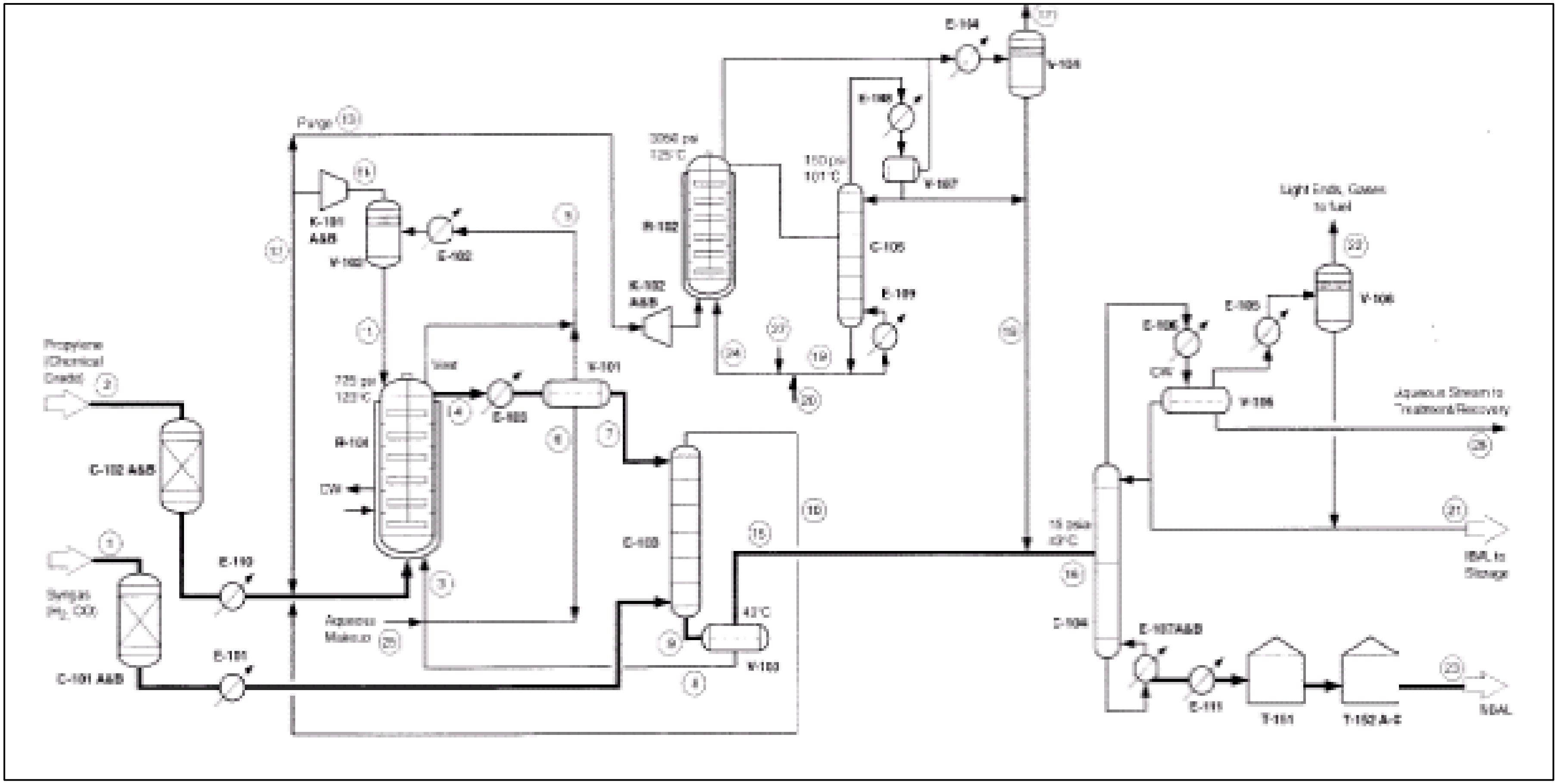


Fig. 3.15 : Process Flow Diagram for n-butyraldehyde

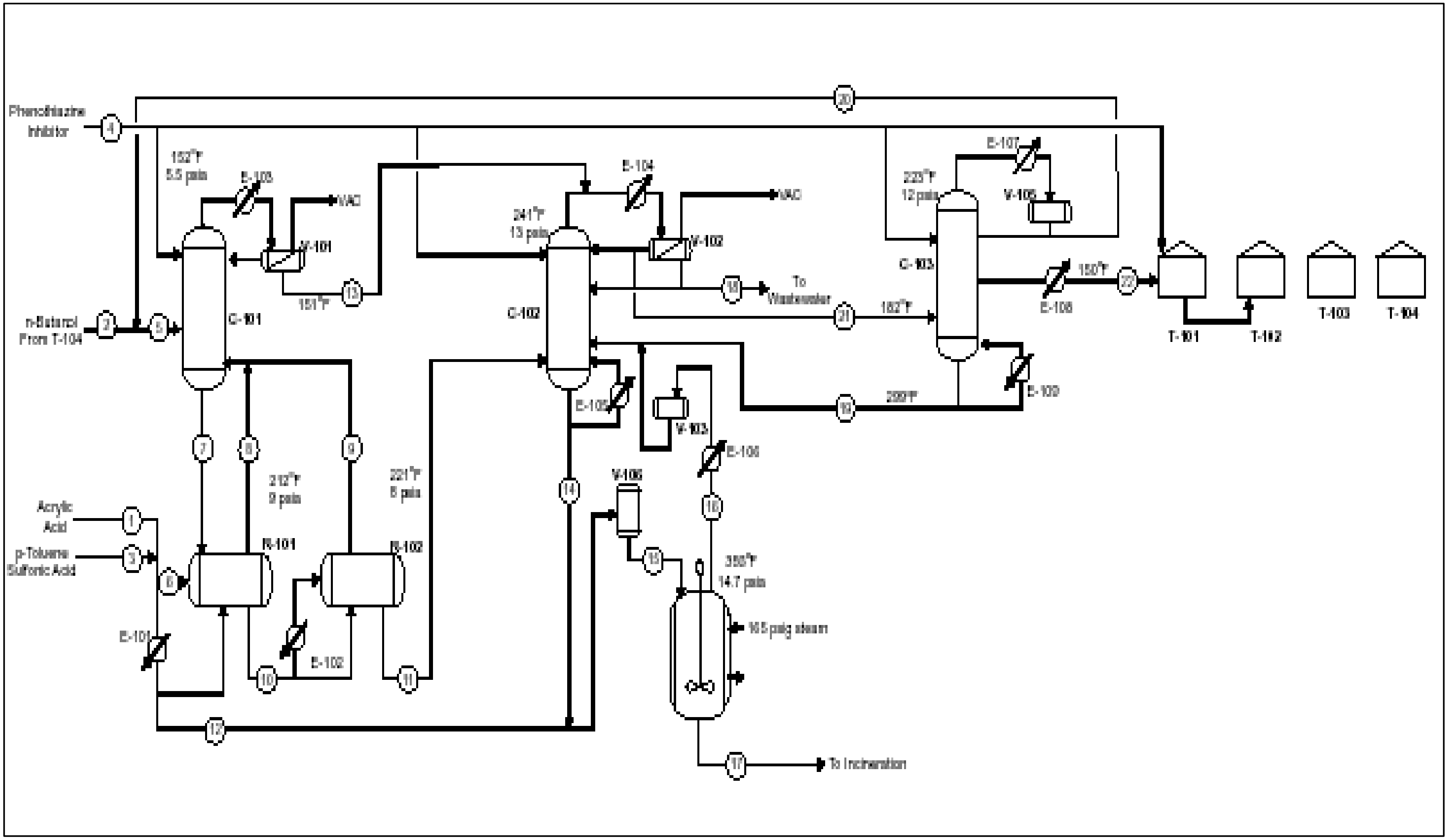


Fig. 3.16 : Process Flow Diagram for n-Butyl Acrylate

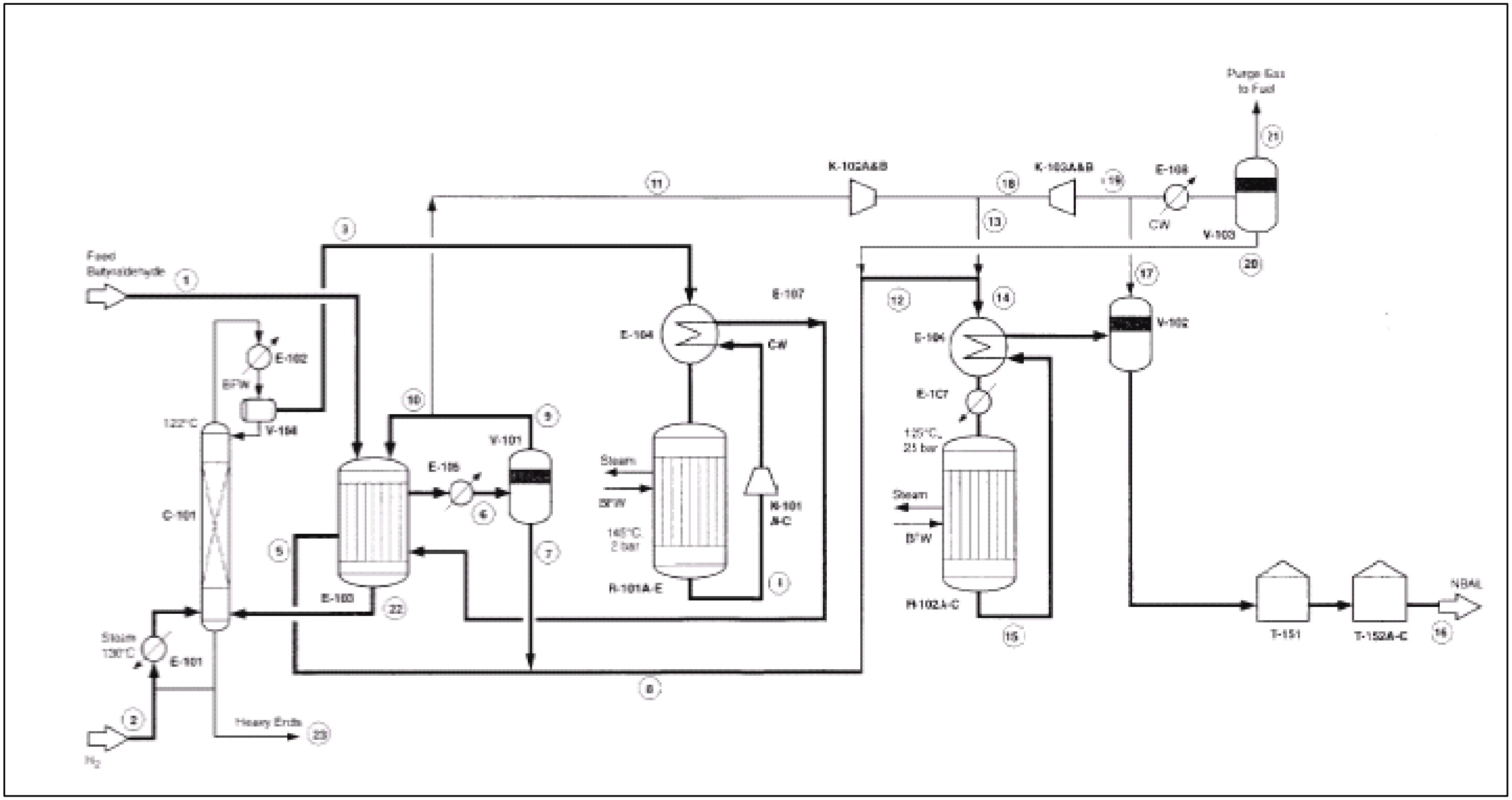


Fig. 3.17 : Process Flow Diagram for n-Butanol

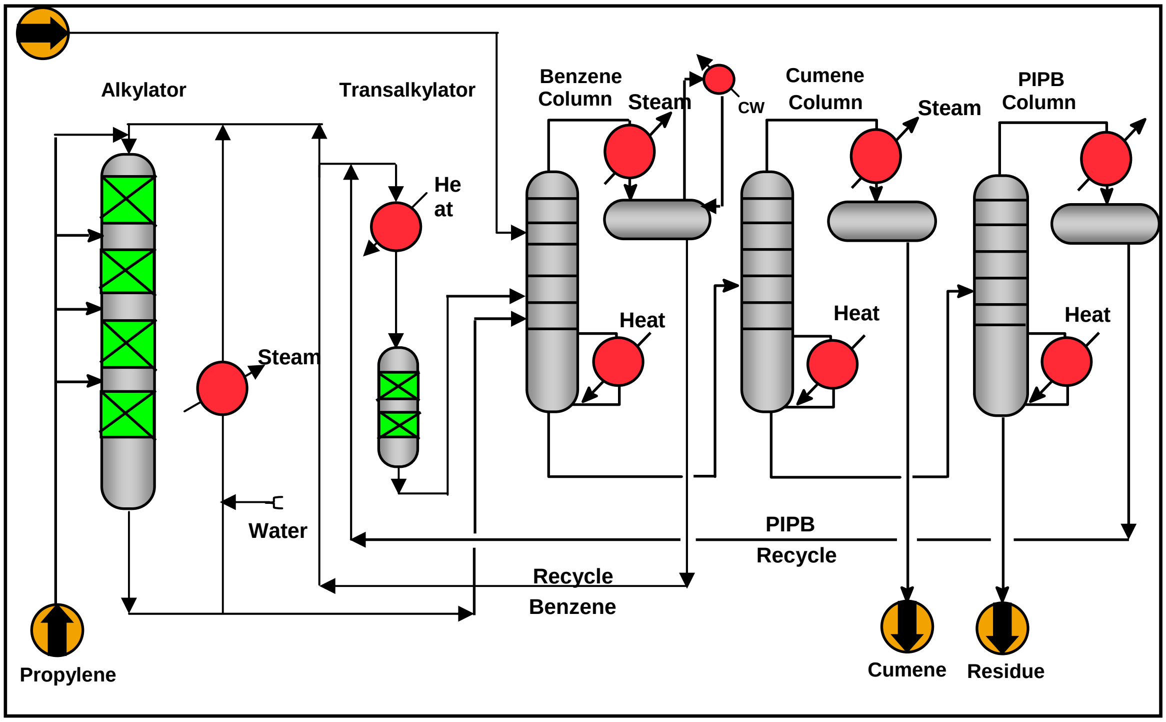


Fig. 3.18 : Propylene Derivative – Cumene Process

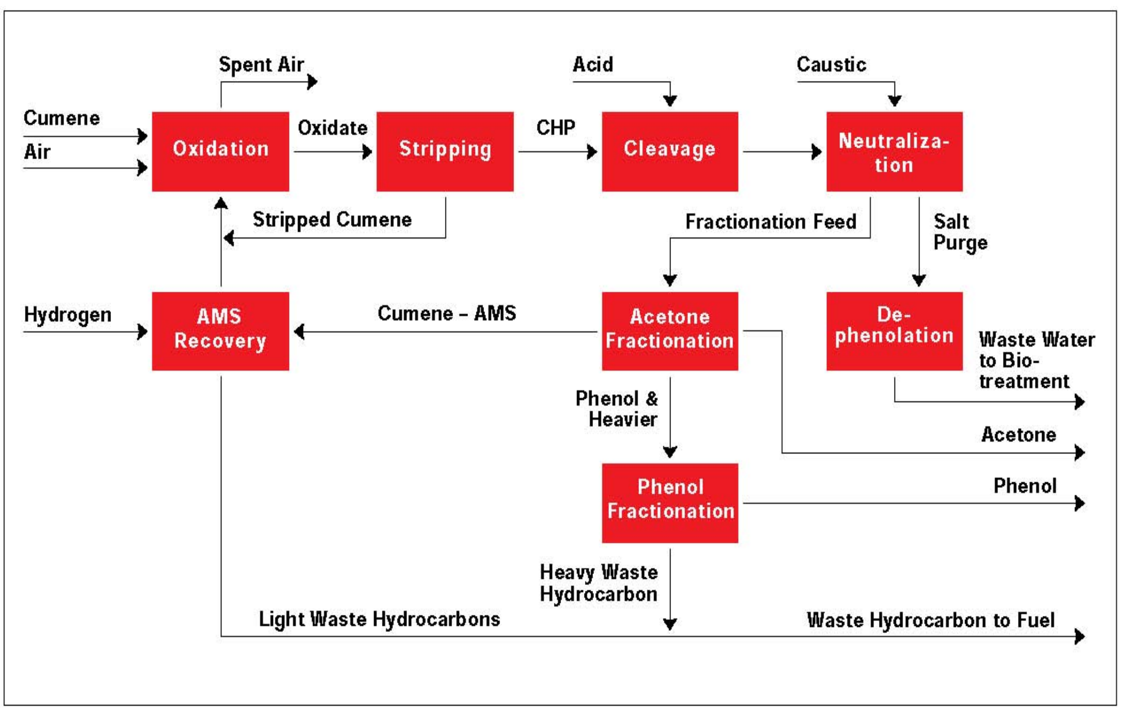


Fig. 3.19 : Propylene Derivative – Phenol Process

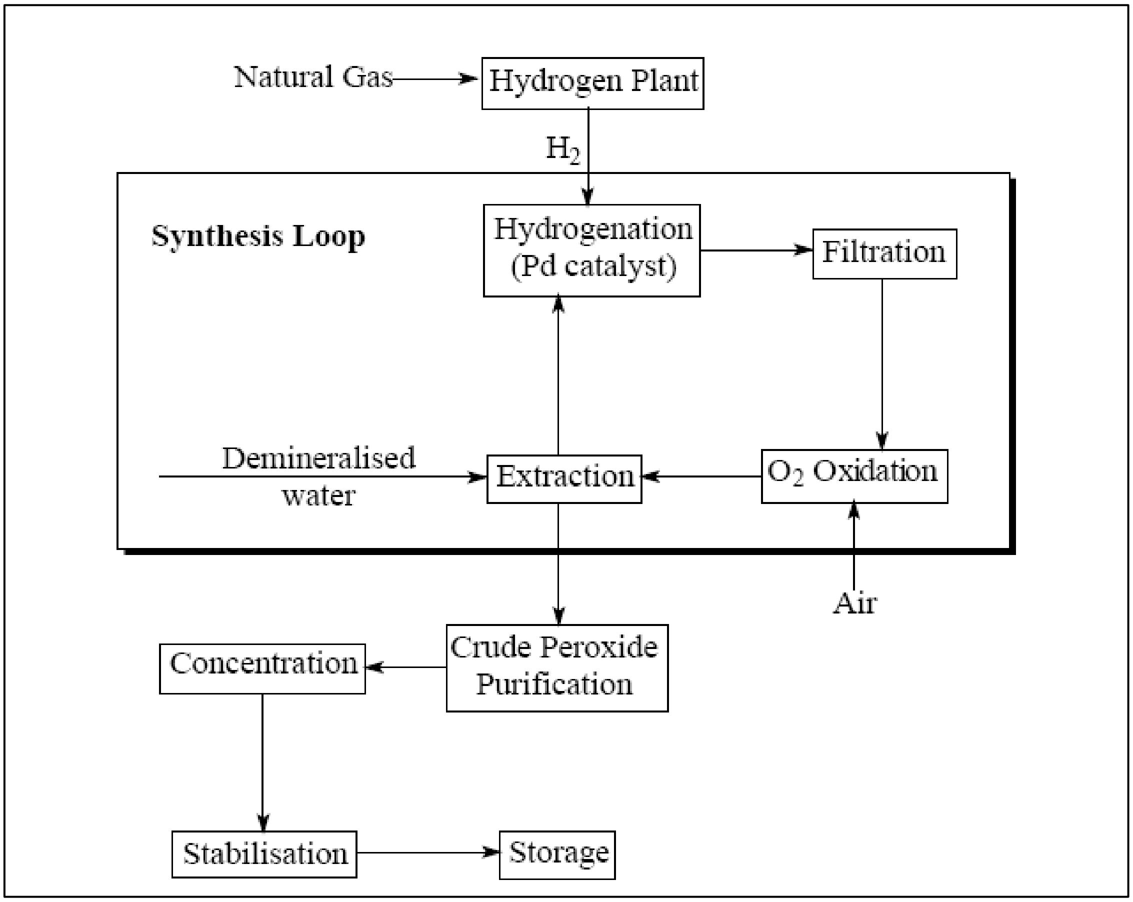


Fig. 3.20 : The Anthraquinone Process for H_2O_2 Manufacture

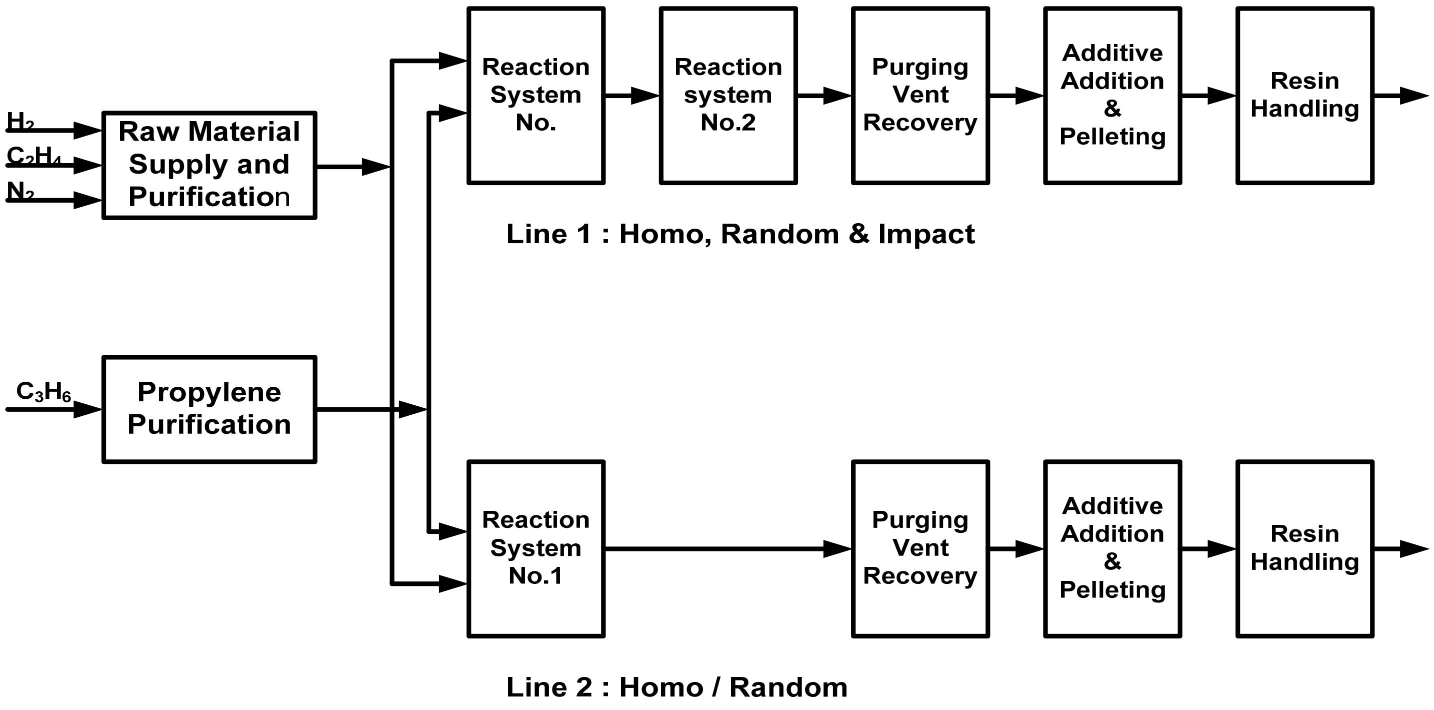


Fig. 3.21 : Block Flow Diagram of Poly Propylene (PP)

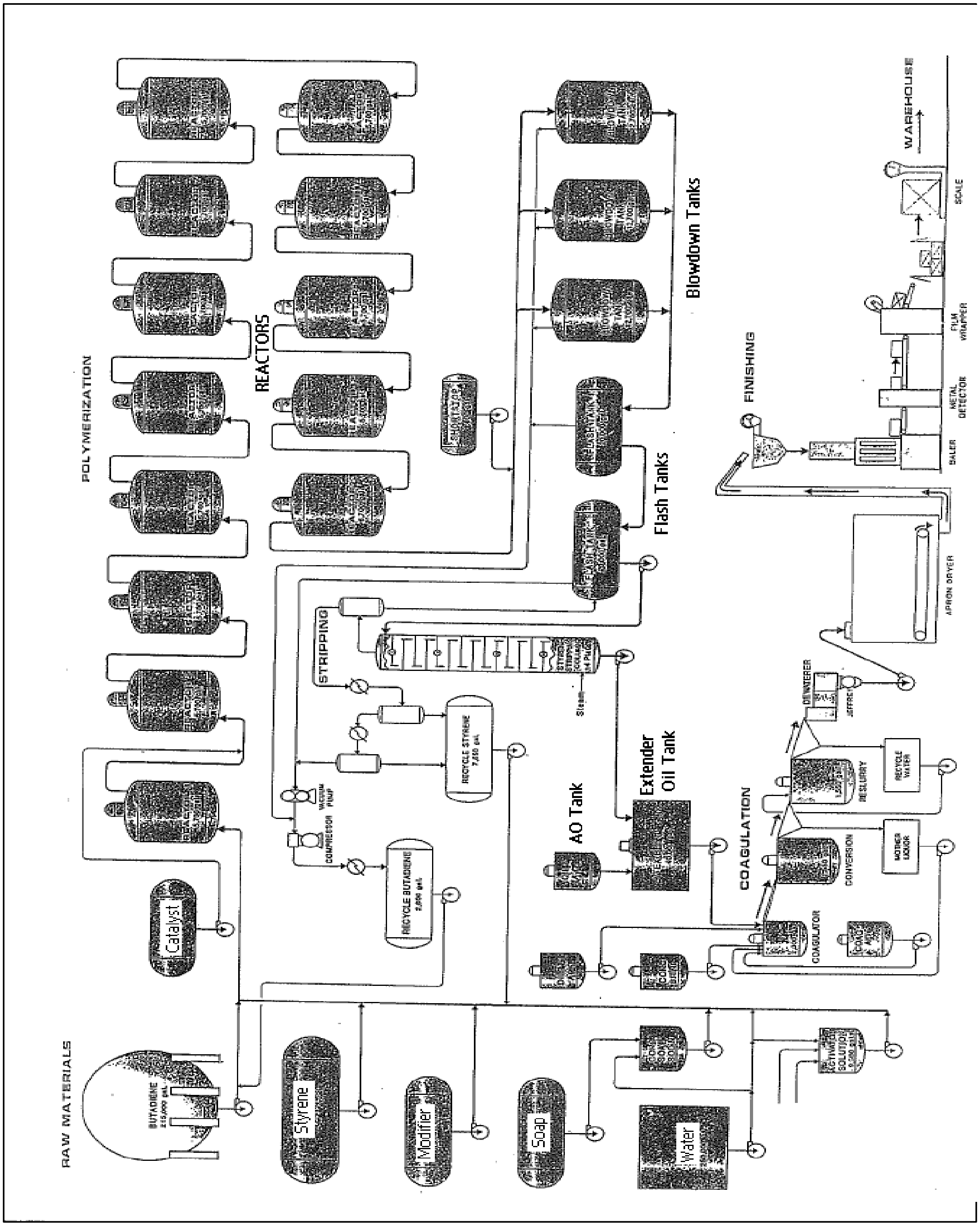


Fig. 3.22 : Process Flow Diagram of ESBR

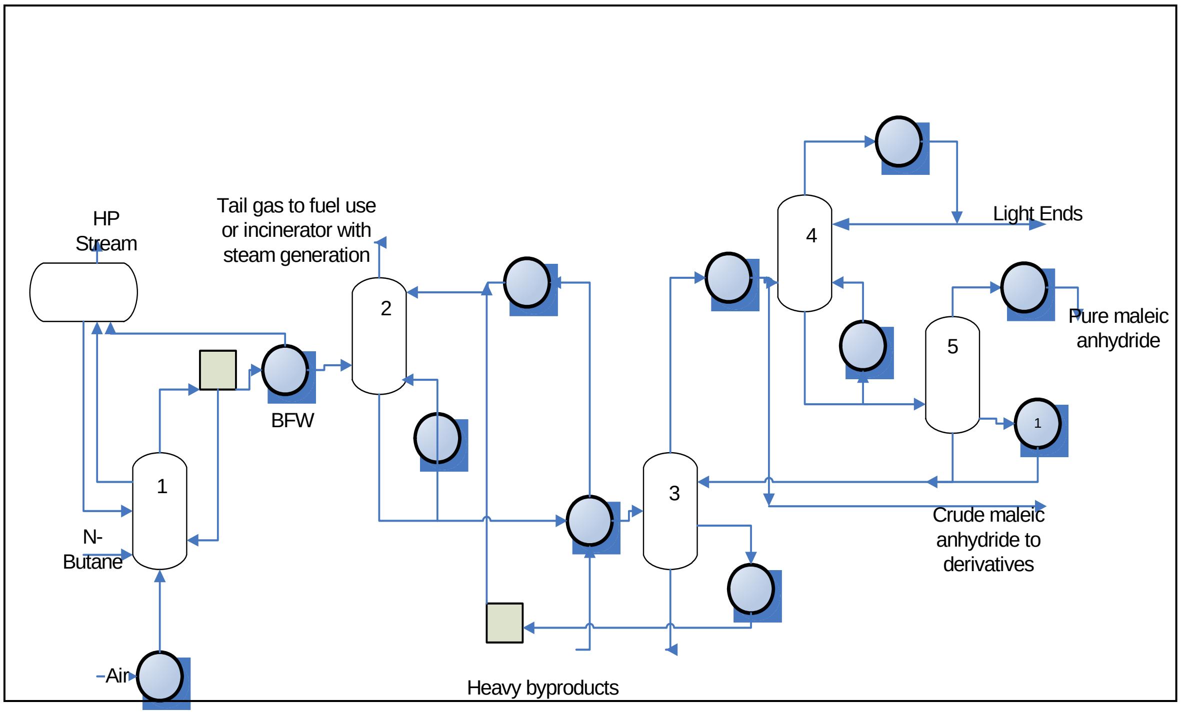


Fig. 3.23 : Process Flow Diagram of Maleic Anhydride

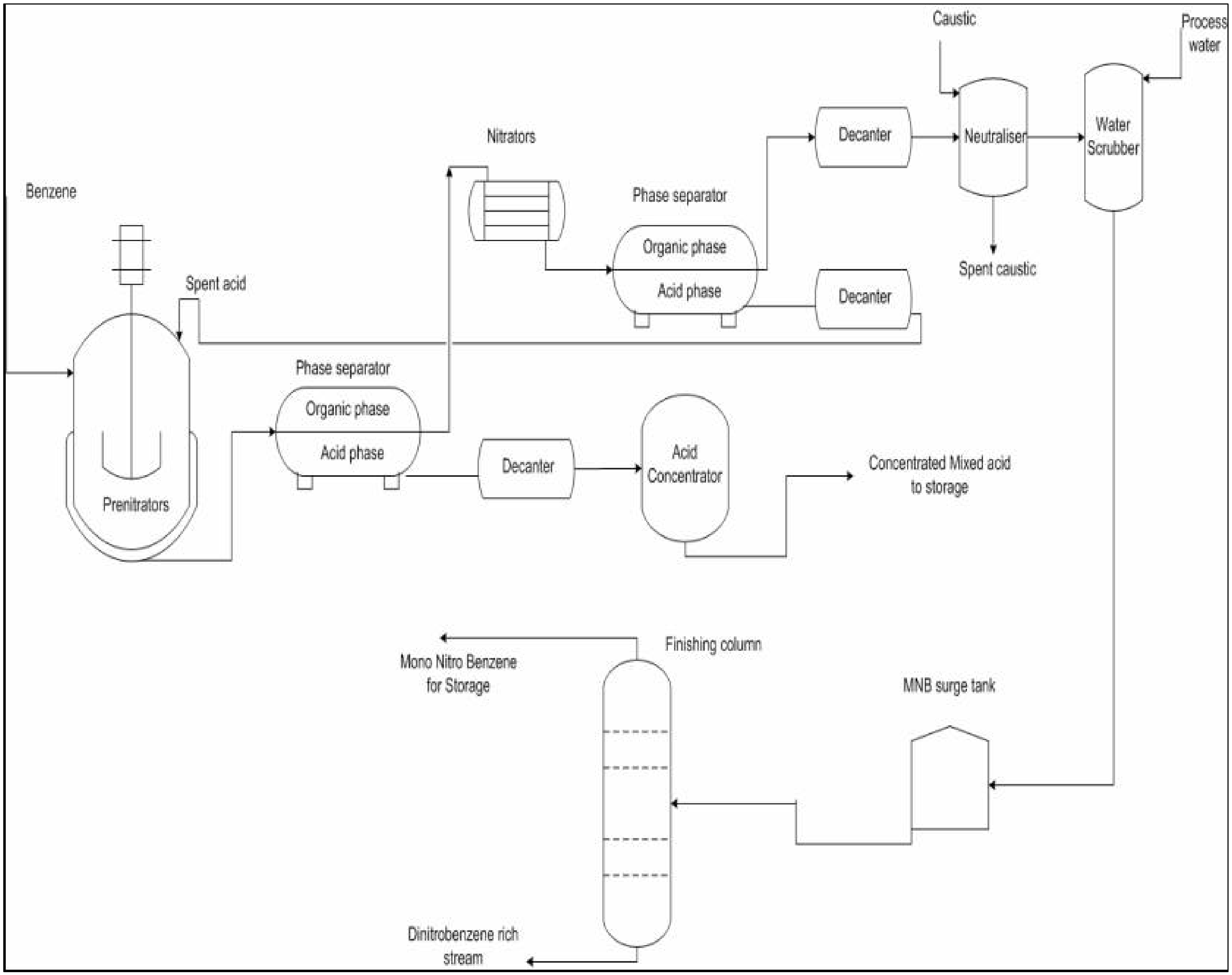


Fig. 3.24 : Schematic of Mono Nitro Benzene Process

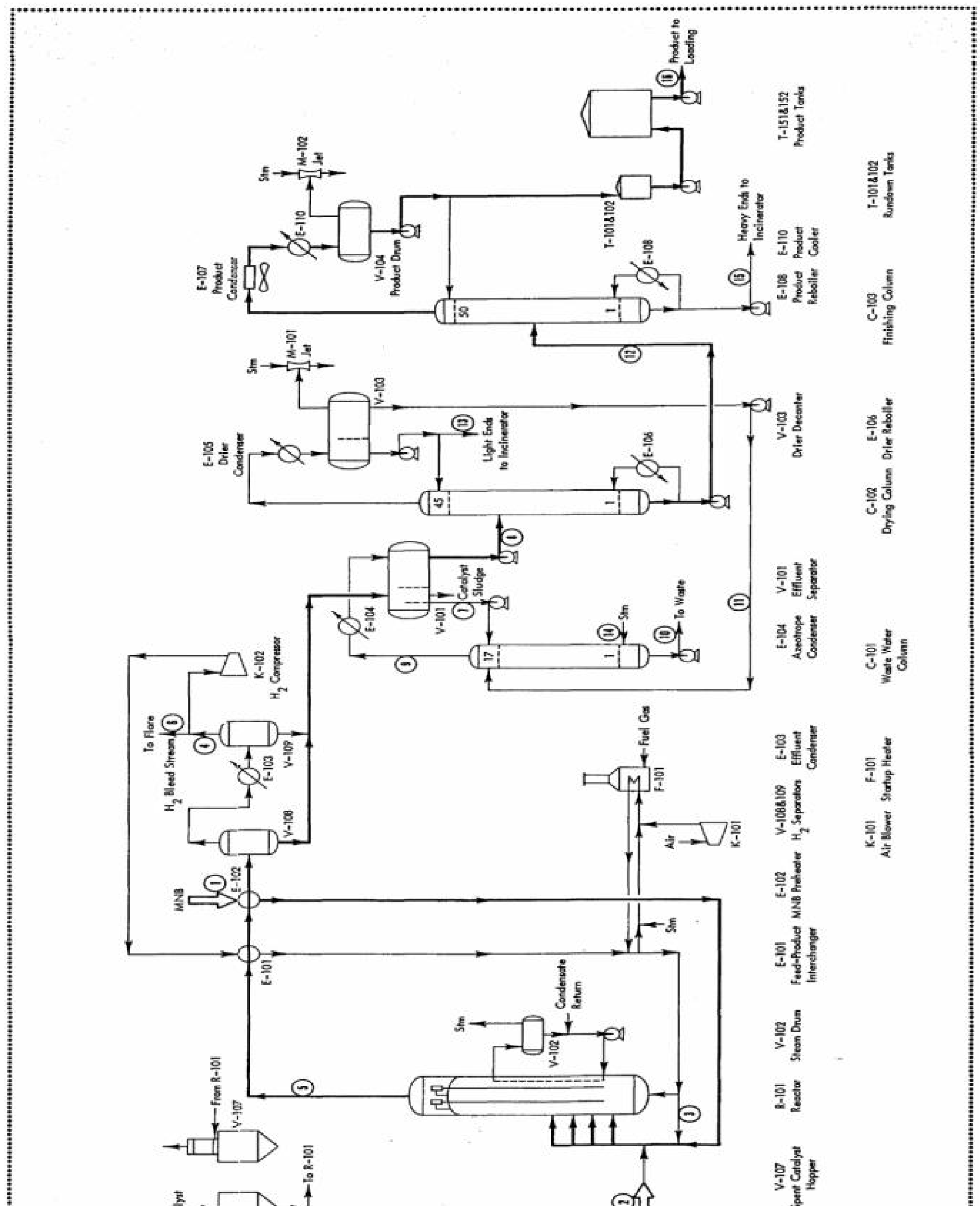


Fig. 3.25 : Process Flow Diagram for Aniline

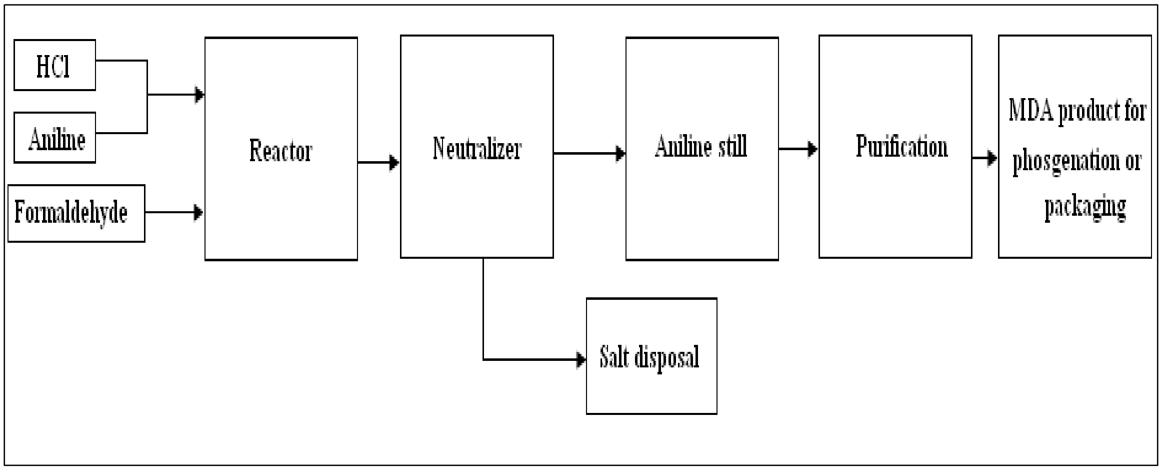


Fig. 3.26 : Block Diagram For MDA Production Process

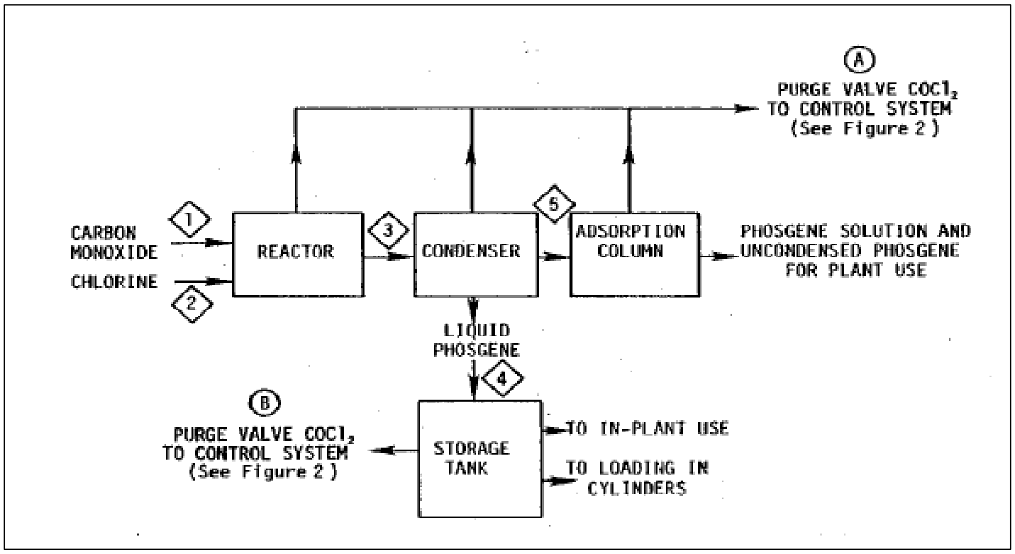


Fig. 3.27 A : Process Flow Diagram : Phosgene Manufacture

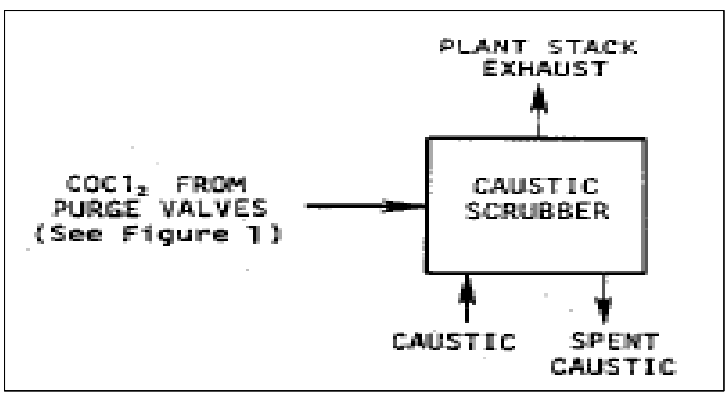


Fig. 3.27 B: Process Flow Diagram for Scrubbing of Remaining Gases

A) Cold Phosgenator, B) Hot Phosgenator, C) Wash column, D) Solvent distillation,
E) Phosgene removal, F) HCl abosorber, G) Phosgene decomposition

Fig. 3.28 : Schematic of Polymeric Methylene Dianiline Phosgenation Process

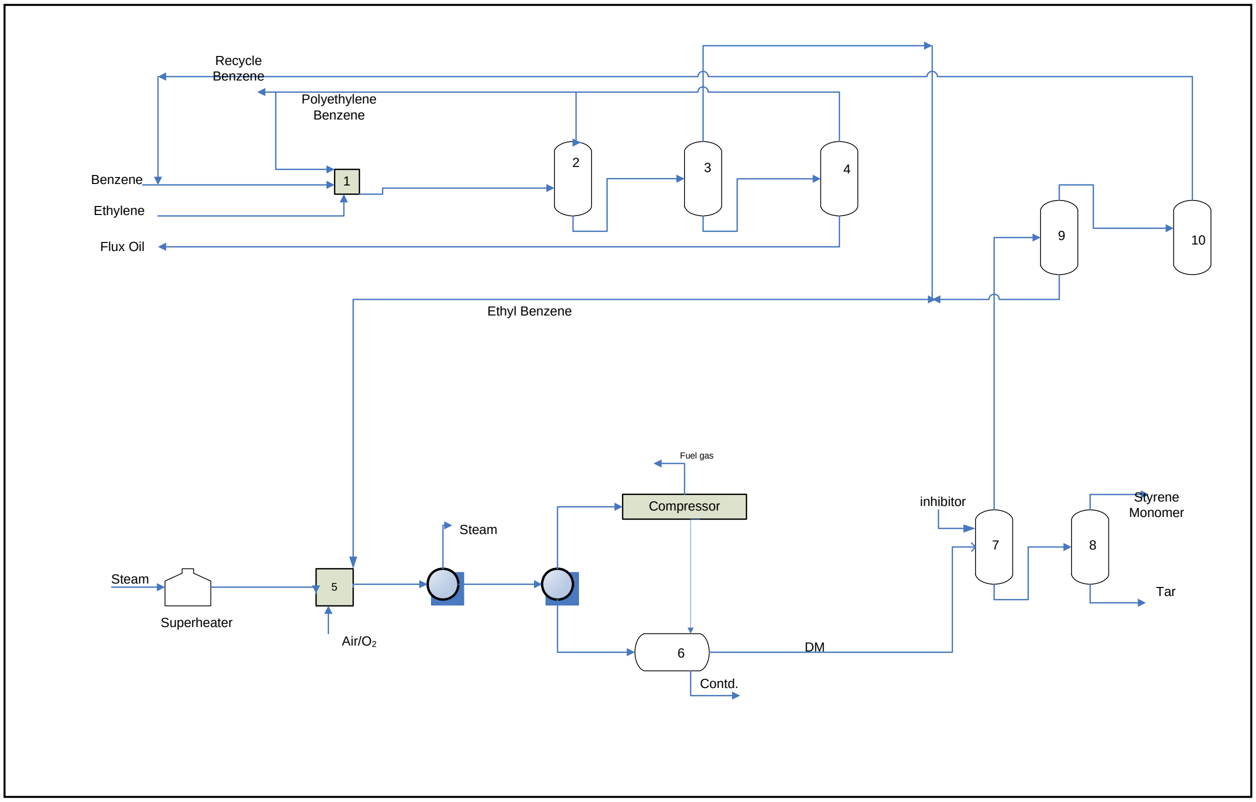


Fig. 3.29 : Process Flow Diagram of Styrene

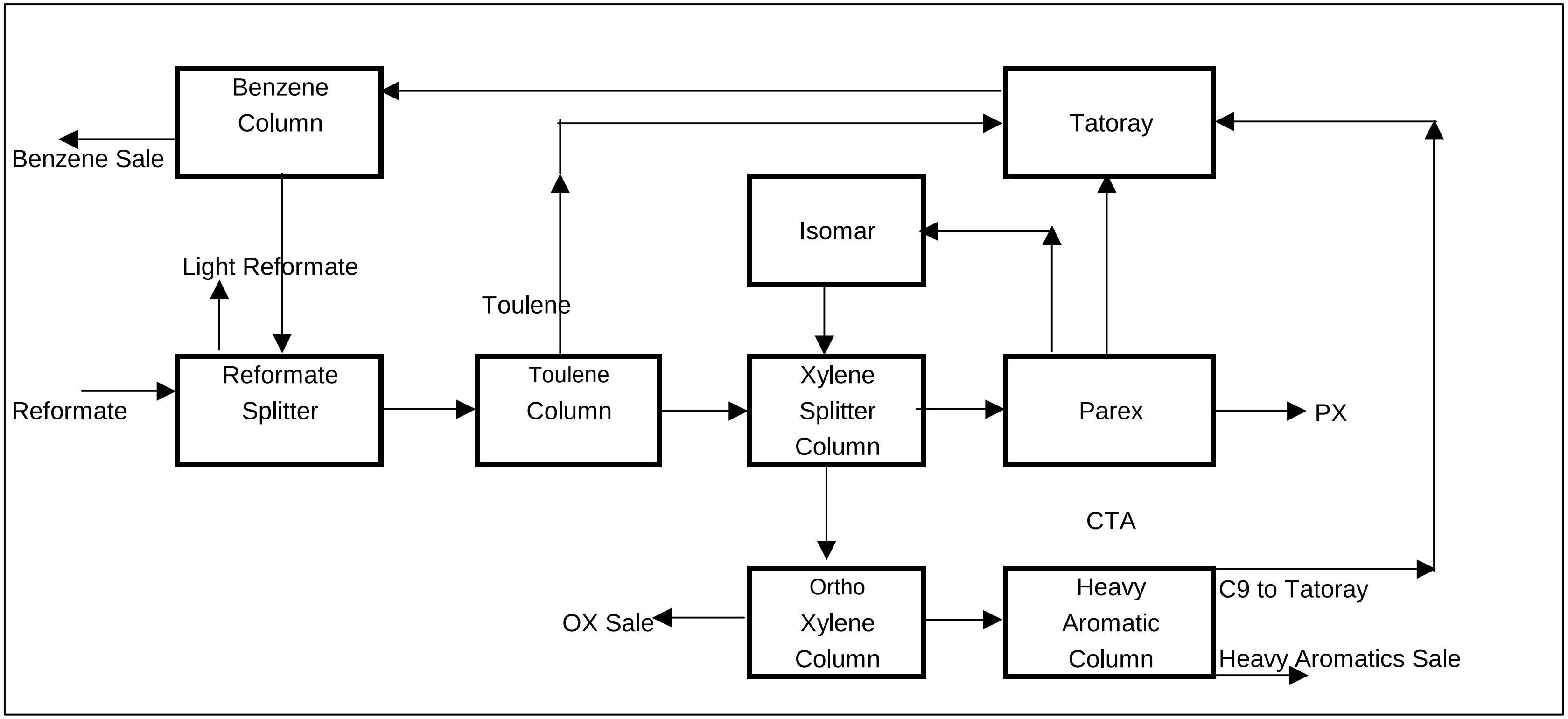


Fig. 3.30 : Block Diagram for Aromatics

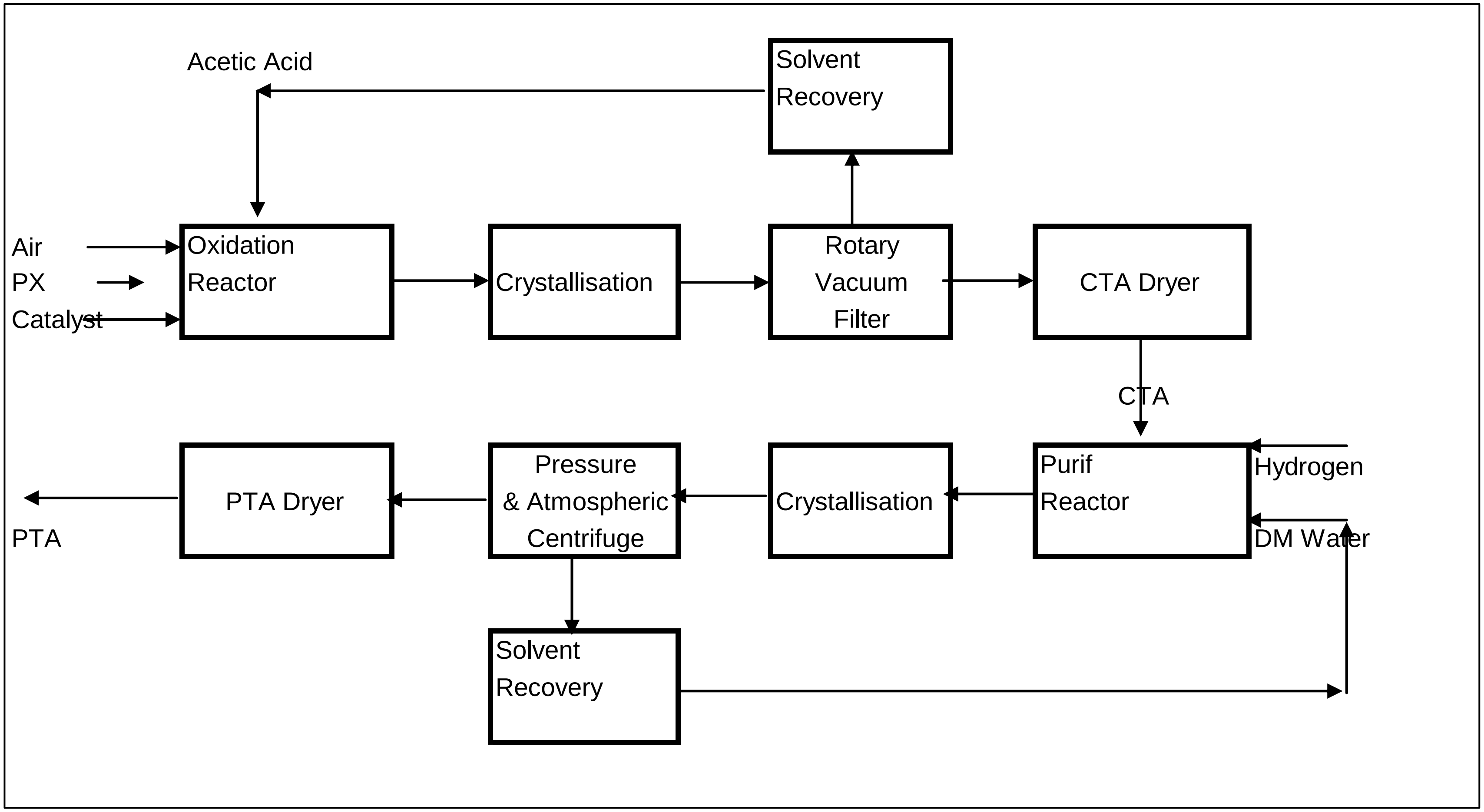


Fig. 3.31 : Block Flow Diagram for Production of PTA

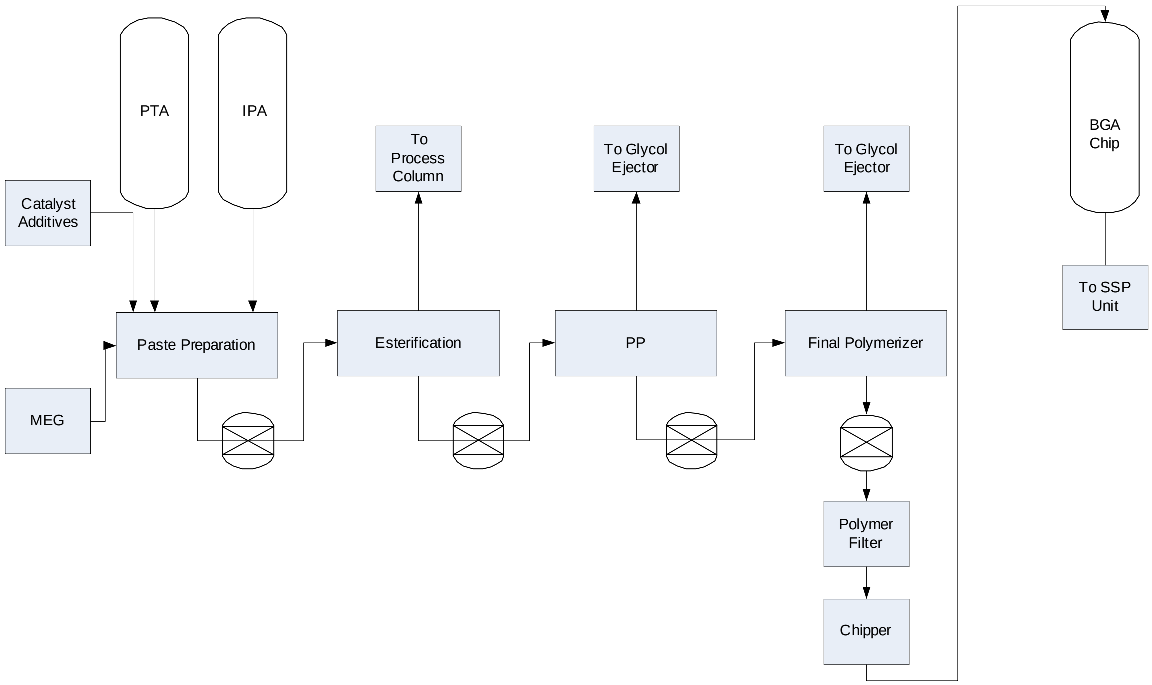


Fig. 3.32 : Bottle Grade PET: Continuous Polymerisation Section (CP)

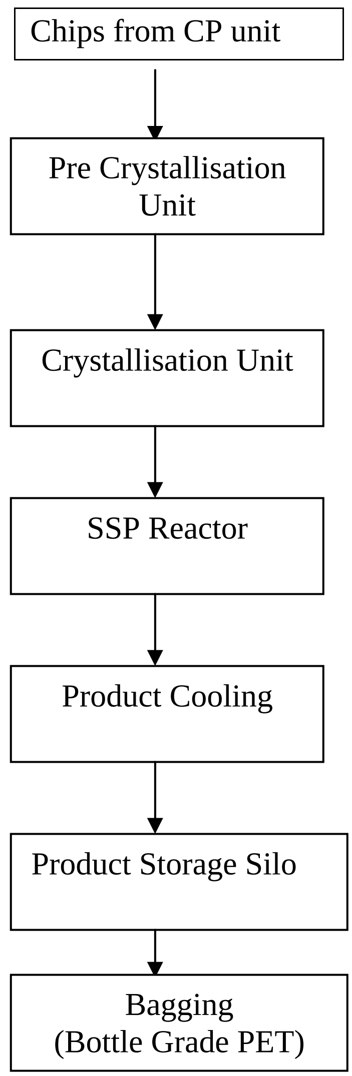


Fig. 3.33 : Block Diagram for production and Packing of Bottle Grade PET

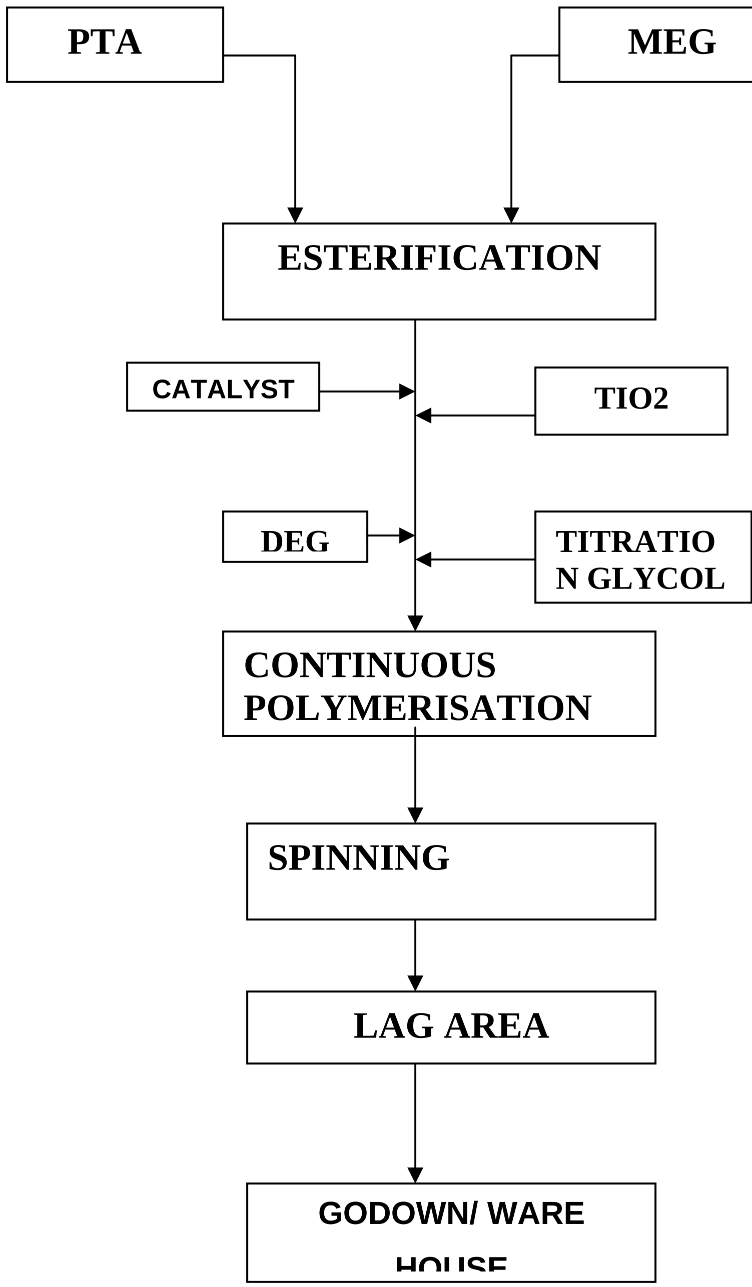


Fig. 3.34 : Block Flow Diagram For POY / FDY / DTY Production

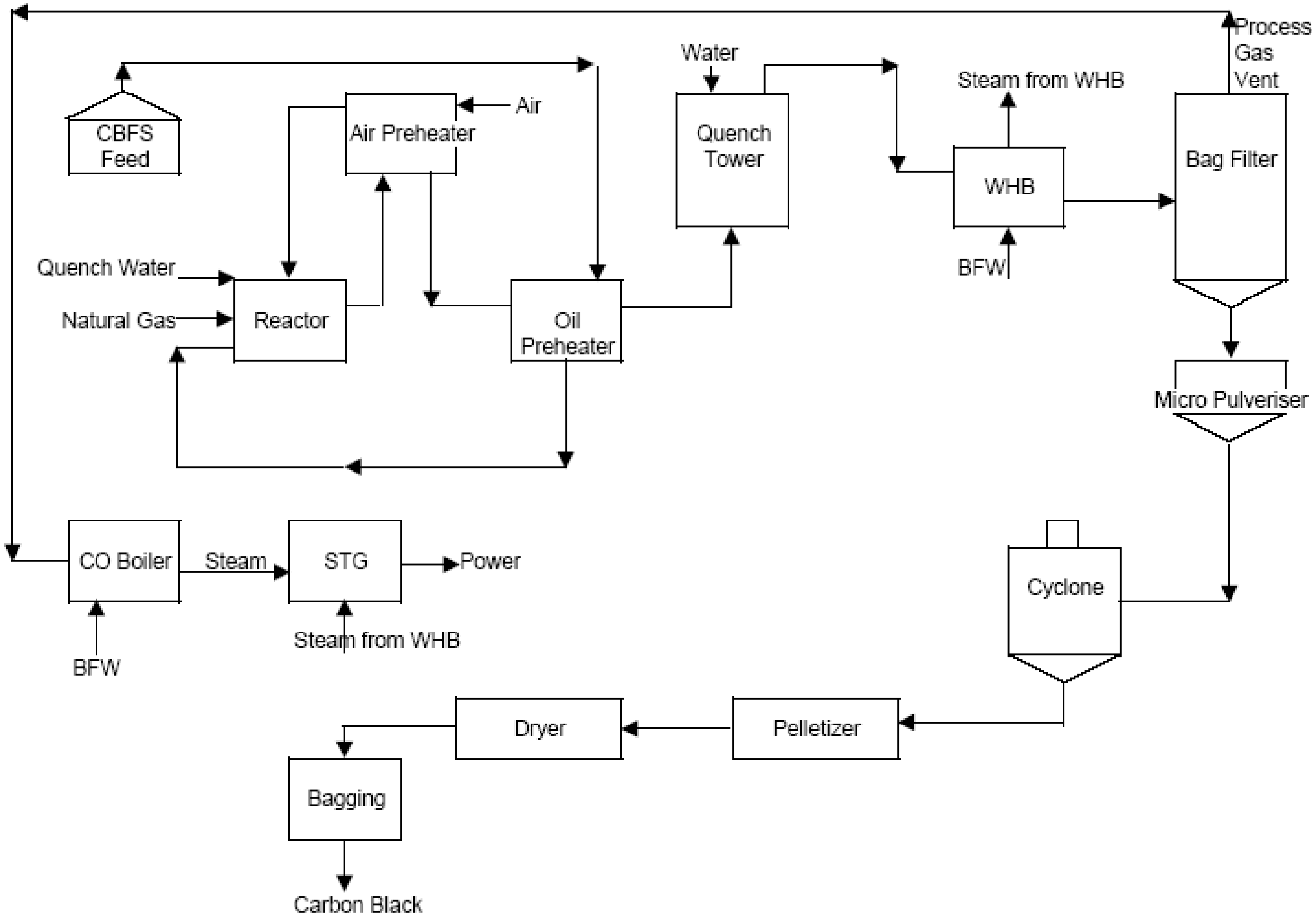


Fig. 3.35 : Block Diagram of the Carbon Black Manufacturing Process

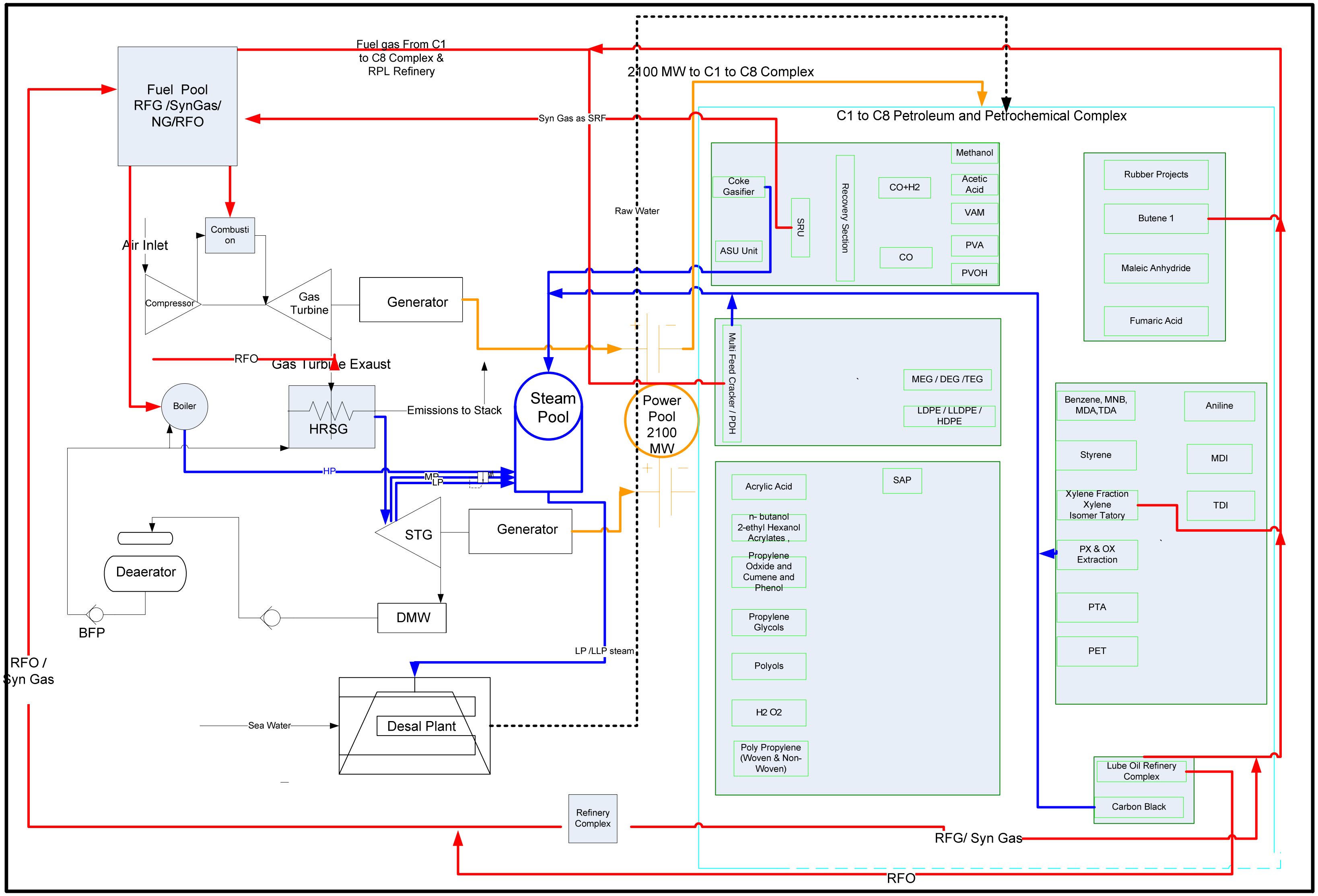


Fig: 3.36 : Integration of CPP with C1 to C8 Petroleum and Petrochemical Complex

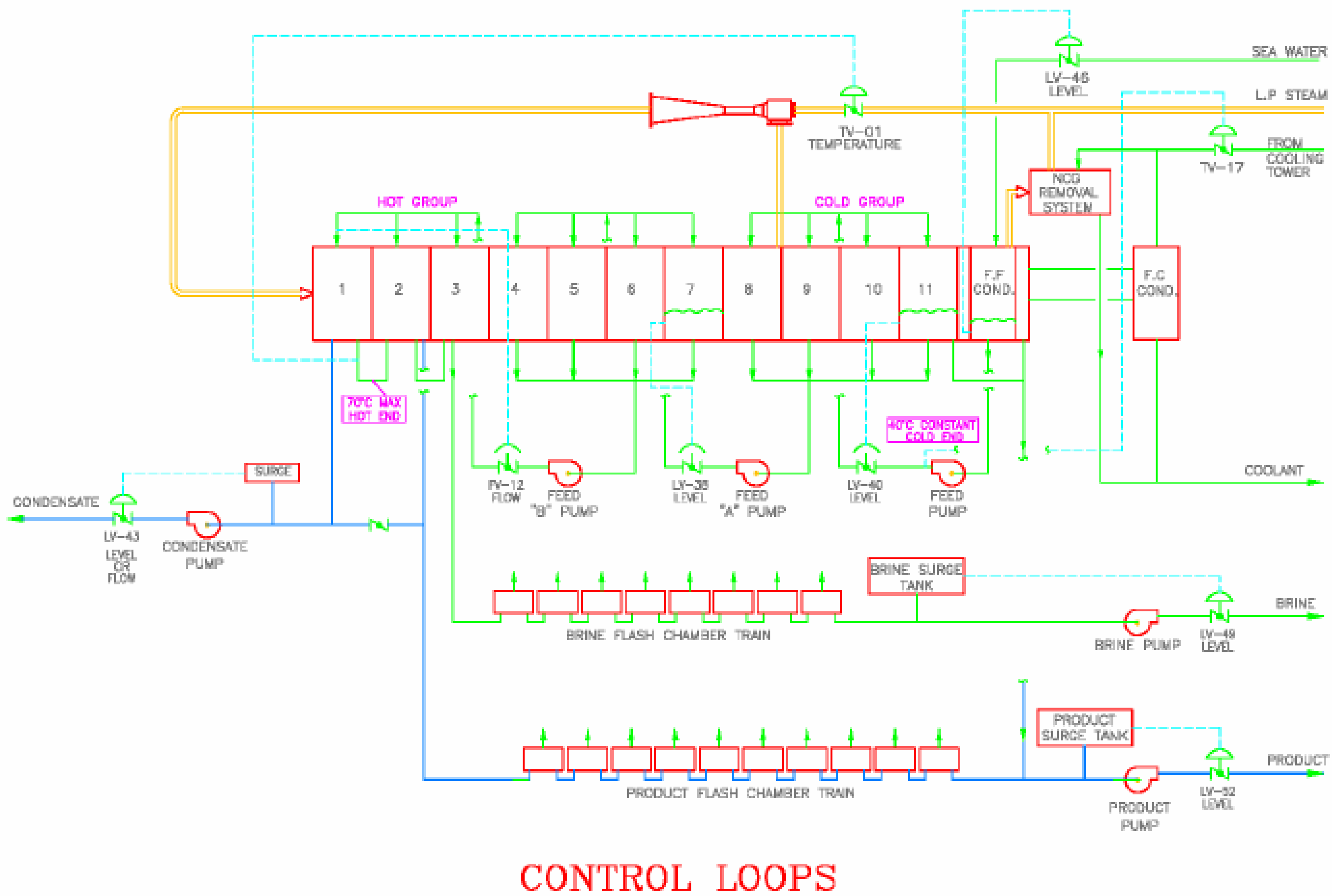


Fig: 3.37 Process Flow Diagram of Desal Plant

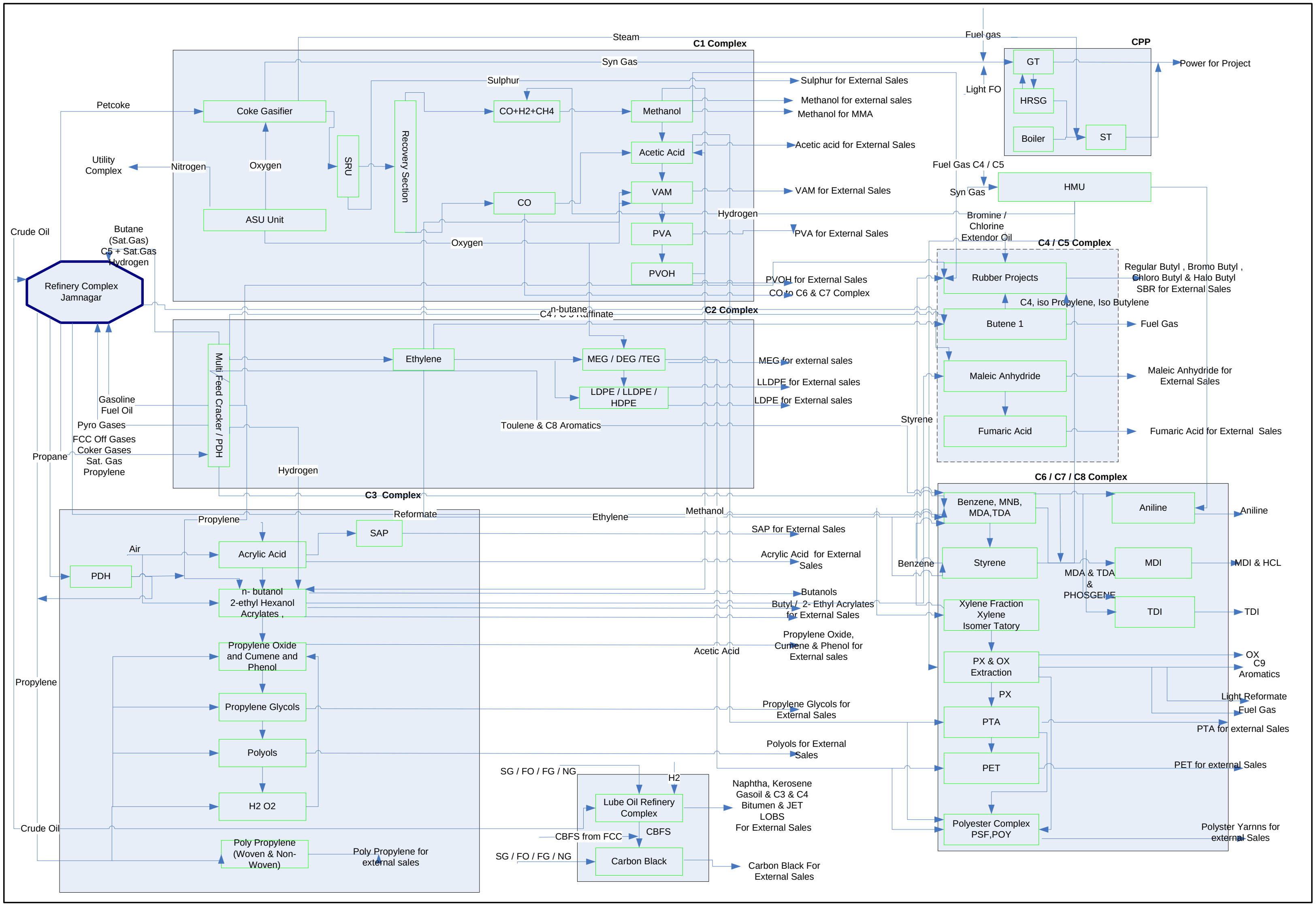


Fig 3.38 : Overall Integration of Petroleum and Petrochemical Complex

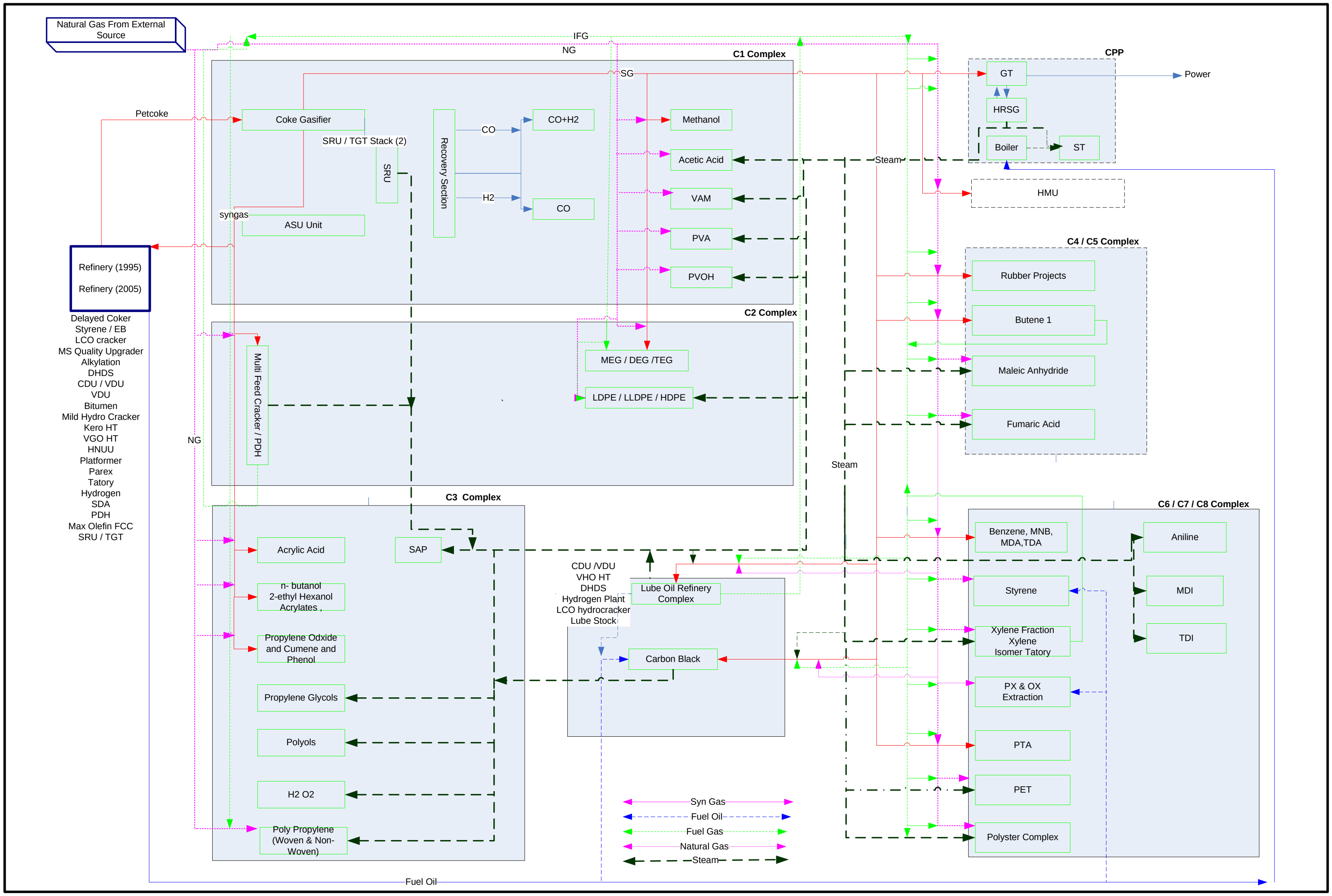


Fig 3.39 : Overall Energy Integration of Petroleum and Petrochemical Complex

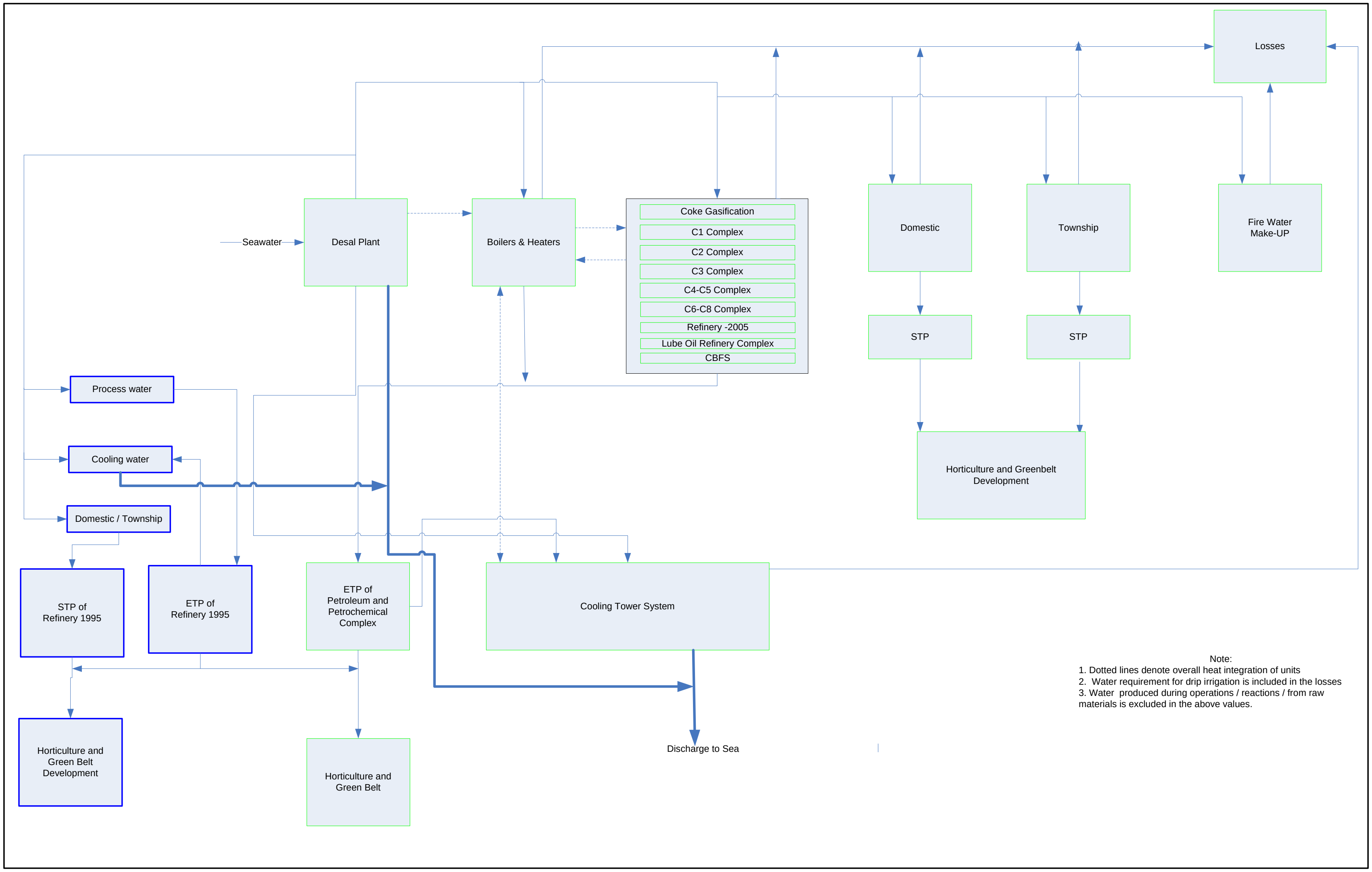


Fig 3.40 : Overall Water Balance of Petroleum and Petrochemical Complex

Table 3.1
Proposed Storage tanks – SEZ

Sr. No.	Product	Capacity In m^3
1	Crude	90683
2	VR feed to coker	51009
3	Sour VGO to VGO Unionfiners	64307
4	Sweet VGO (FCC feed)	90683
5	HNUU feed to NHT	51009
6	DHDS feed (straight run)	68389
7	DHDS feed (LCGO)	68389
8	KHT feed	51009
9	Heavy CN Unionfiner feed	47493
10	Scanfiner feed	68389
11	LSWR	64307
12	PC Naphtha	20347
13	Diesel E IV	68389
14	Diesel Euro I / LHO	68389
15	Gasoline E IV/US RFG	36173
16	Gasoline US RFG/ NIOC	7948
17	Aromatics (Benzene)	4808
18	Aromatics (o-Xyl/P-Xyl)	4808
19	PTU feed / LCNO	9813
20	PTU feed / LCO Diesel	9813
21	Kerosene to diesel blending	7948
22	Alkylate (product)	20347
23	Reformate	14130
24	Scanfiner product	14130
25	Lt Naphtha from LCO	2649
26	Hvy Hvy Naphtha from LCO	7948
27	Meroxed Pentane	7948
28	Light Reformate	7948
29	Cetane Improver	1227
30	ED Raffinate	7948
31	Straight run slop	4808
32	Cracked slop	14130
33	Heavy slops	9813
34	CBFS	4808
35	Flushing Oil	9813

Sr. No.	Product	Capacity In m^3
36	Crude	132885
37	Alkylate	47493
38	Gasoline	68389
39	PC Naphtha	68389
40	JET/ATF	36173
41	Diesel	68389
42	O-xylene	20347
43	LSWR	51009
44	Methanol	4808
45	Styrene	31793
46	MEG	31793
47	DEG	31793
48	Refinery Fuel Oil tank	9813
49	CPP Diesel Distillate	4710
50	CPP CSO Fuel Oil	2649
51	Sludge Tank	2722
52	Fresh Acid Tank	6782
53	Swing Acid Tank	6782
54	Spent Acid Tank	6782
55	Amine Make-up Tank	172
56	Amine Storage Tank	622
57	Liquid Sulpher Tank	10613
58	n-Butanol	1050
59	Acrylic Acid	2000
60	Glacial Acrylic Acid	450
61	Hydrogen peroxide	300
62	n-Butyraldehyde	2000
63	Iso-Butyraldehyde	600
64	Glycol Diacetate	200
65	Vinyl Acetate (5 tanks)	11000 (Each)
66	Liquid Acetic Acid (5 tanks)	11500 (Each)
67	Vinyl Acetate Monomer (2 Tanks)	2000 (Each)
68	2 Ethyl Hexanol	900
69	Propylene (Sphere)	1200
70	Toluene	5000
71	Propylene Oxide	11200
72	n Butyl Acrylate	8000
73	Butanol	4500

Table 3.2

Proposed Solid Storage Tanks – SEZ

Solid Storage	Quantity
Coke Storage Silos	80,000 Tons
Flux Storage Silos	2500 Tons

Table 3.3

Proposed Storage Tanks for the Liquid Products

Sr. No	Product	Vol in KL (Each)
1	Caustic 50% (CS5)	997
2	Caustic 20% (CS2)	90
3	MEG	10202
4	DEG	1050
5	TEG	626
6	CBFS	1495

Table 3.4

Proposed Storage Tanks for Safe Stock

Sr. No	Storage tank	Safe Stock in MT
1	Propylene(Cry)	11500
2	PX	22000
3	CBFS	3010
4	Benzene	8250
5	Toulene	1300
6	Ethylene(Cry)	11500

Chapter 4

Baseline Environmental Status

The existing environmental setting is considered to adjudge the baseline environmental conditions, which are described with respect to climate, physiography, geology, hydro-geological aspects, atmospheric conditions, water quality, soil quality, vegetation pattern, ecology, socio-economic profile, land use and places of archaeological importance. This Report incorporates the baseline data collected during October 2005 to January 2006 (representing winter season) and secondary data collected from various Government and Semi-Government agencies.

As per Indian statutory regulations, CPCB provided the guidelines for the baseline environmental status monitoring for air, noise, water, land (land use / land cover), biological, and socio-economic guidelines to be followed.

Sr. No	Environmental Parameters	CPCB Guidelines on monitoring of Env. Parameters (Distance in km) from centre of SEZ
1	Ambient air quality	7-10
2	Noise	10
3	Water Quality	25
4	Land Environment	25
5	Biological Environment	25
6	Socio-Economic Environment	25

Ref: EIA Manual, Ministry of Environment and Forest.

The methodology to study the baseline status of various environmental components is highlighted in **Table 4.1.1**.

4.1 Air Environment

The knowledge of quality of ambient air plays an important role in assessing the environmental scenario of the locality. The ambient air quality status in the vicinity of the project site forms an indispensable part of the Environment Impact Assessment studies. The quality of ambient air depends upon the concentrations of specific contaminants, the emission sources and meteorological conditions. Data collected during winter season of 2005-06 has been analysed and presented herewith.

The baseline studies on air environment include identification of specific air pollutants and assessing their existing levels in ambient air within the impact zone. The existing status of air environment with respect to the identified air pollutants is assessed through air quality surveillance programme with scientifically designed ambient air quality monitoring network.

Micrometeorological data collection is an indispensable part of any air pollution study. The meteorological data collected during air quality survey is used for proper interpretation of existing air pollution status. The ambient air quality monitoring was carried out through reconnaissance followed by air quality surveillance programme and micrometeorological study.

Baseline Ambient air environment was done for the season 2005-06 winter and latter collected for the 2007-08 winter as per MoEF Commitee advice. The sampling locations and values are given in appropriate tables.

4.1.1 Design of Network for Ambient Air Quality Monitoring Locations

The ambient air quality status in the impact zone is assessed through a network of ambient air quality monitoring locations. The studies on air environment include identification of specific air pollutants for assessing the impacts of existing project operations. Accordingly, air quality monitoring was carried out in winter season of 2005-06. The existing status of air environment is assessed through a systematic air quality surveillance program, which is planned based on the following criteria:

- Topography/terrain of the study area
- Regional synoptic scale climatological normal
- Densely populated areas within the region
- Location of surrounding industries
- Representation of valid cross-sectional distribution in downwind direction of refinery

4.1.2 Reconnaissance

Reconnaissance was undertaken to establish the existing status of air environment in the study region. Ambient Air Quality Monitoring (AAQM) locations were selected based on guidelines of network siting criteria based on meteorological data of winter season. Similarly, AAQM locations of earlier studies were also considered for locating the AAQM locations. The ambient air quality monitoring was carried out in a study area of 10 km radial distance around the proposed SEZ. The relative directions and distances of these locations with respect to the project site are given in **Fig. 4.1.1** and details of these locations are described in **Table 4.1.2**.

4.1.3 Ambient Air Quality Monitoring

AAQM locations were monitored on 24 hourly average basis as per the guidelines of CPCB and NAAQS. AAQM was carried out at 24 locations (though AAQM is required at 4 locations as per CPCB guidelines) to determine a finer cross-sectional distribution of air pollution in an industrial developed region. The conventional and project specific parameters such as Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NOx), Ammonia (NH_3), Carbon Monoxide (CO) and Non-Methane Hydrocarbons (NMHC) were monitored at AAQM Locations. Samples of CO and NMHC were collected in the study area and analyzed in the laboratory (HC mentioned elsewhere in the report means NMHC).

4.1.4 Instruments used for Analysis

A temporary laboratory was setup at project site for chemical analysis of representative air samples. The micro-meteorological data on wind speed, wind direction, temperature and relative humidity were collected using weather monitoring station and cloud cover was recorded manually during the study period. The make and model of the instruments used for analysis of the samples collected during the field monitoring are given in **Table 4.1.3**. The techniques used for ambient air quality monitoring and their minimum detectable level are given in **Table 4.1.4**.

The concentrations of various pollutants at all the AAQM locations were processed for different statistical parameters like arithmetic mean, standard deviation, minimum concentration, maximum concentration and percentile values.

The existing baseline levels in winter season with respect to SPM, RPM, SO_2, NO_x and NH_3 expressed in terms of various statistical parameters are presented in **Tables 4.1.5** to **4.1.11**. The spot concentrations of CO and NMHC are presented in **Table 4.1.12**.

The 98th percentile concentrations have been compared with stipulated standards of CPCB (as per the National Ambient Air Quality Standards Notification, April 11, 1994 in **Annexure I**) and presented in **Table 4.1.13**.

4.1.5 Micrometeorology

The study of micro-meteorological conditions of a particular region is of utmost importance in knowing the ambient air quality status of that particular region. The prevailing micrometeorology at project site plays a crucial role in transport and dispersion of air pollutants released into the atmosphere. The persistence of the predominant wind direction and wind speed during a particular time period at the project site will decide the direction and extent of the worst impact zone at that time. The principal variables which affect micrometeorology are horizontal convective transport (average wind speed and directions), vertical connective transport (atmospheric stability) and topography of the area.

Climatological Tables of Observatories in India (1951-1980), published by the India Meteorological Department, were used to obtain historical data for the region. Jamnagar is the nearest meteorological observatory to the project site established in the year 1899 at Aerodrome. Temperature varied in the range of 0.7°C (January 28, 1973) – 45.6°C (May 21, 1903). Annual rainfall varied in the range of 78.2 (1911) – 1121.5 mm (1953) with normal annual rainfall of 578.9 mm. The annual average of rainy days (rainfall above 0.254 cm in a day) is 24. The annual average wind speed is predominantly observed between 1 and 19 km/h. Seasonal variation in predominant wind direction is observed at Jamnagar. Winds from N-E sector were predominant in the winter season.

The months of November, December and January are considered to be representative of winter season. It is referred that minimum and maximum daily temperature varied in the range of 10°C – 12°C and 25°C - 27°C respectively. Monthly mean relative humidity was in the range of 36% -72%. The predominant wind direction is from N-E sector. The wind speed remains in the range of 1-19 Km/h for most of the days and cloudless sky is observed for 80-85% of the duration during winter season.

The primary data recorded has been processed further to draw wind rose. The wind rose drawn on 24 hourly basis is presented in **Fig. 4.1.2**.

The overall 24 hourly windrose during winter season indicates the predominant winds from N-E sector. During the period of study, calm conditions were observed for only 2.5% of the time. The predominant wind directions observed during the study period with low and medium wind speeds (1-15 kmph) were from N-E sector. The wind speed was observed to be predominantly in the range of 11-15 kmph.

4.1.5.1 Mixing Height/Inversion Study

The atmospheric mixing height at project site is one of the most important micrometeorological parameter, which have direct influence on dilution of air pollutants in the project region. Mixing height is the thickness of atmospheric layer in which vertical mixing is vigorous. The vertical extent of mixing is primarily regulated by ambient air temperature at ground level, atmospheric stability/turbulence and wind speed. The mixing height varies diurnally, from season to season and it is also affected by topographical features in the impact zone. The mixing height is generally minimum at late night (before sunrise) and increases during the daytime reaching maximum in the afternoon hours. The maximum mixing height also will have seasonal variability with highest values during summer and the lowest values in winter. The mixing height at a given time of the day can be estimated from the ground level ambient temperature together with vertical profile of temperature.

In the present study, a minisonde system (Model 3003 of Aero-Aqua Inc., Canada) has been used for on site measurements of mixing height at plant site including diurnal variations. The minisonde flight package consists of balloon filled with hydrogen, a battery operated temperature sensor and signal transmitter assembly. The minisonde is used for measurement of vertical temperature profiles up to 4 km height in the atmosphere to be carried by a balloon filled with hydrogen. Temperature is measured continuously and transmitted at 400-405 MHz frequency range to a receiving station at ground level. The model 3003 consist an electronic modulator to process non-linearised frequency output from the receiver into linearised signal. The modulator produces actual temperature profile in engineering units which is fed into personal computer through the RS232 port to obtain real time ambient temperature and potential temperature profiles.

The mixing height study using minisonde was carried out during winter season. The flight packages were released at the intervals of 3 hours round the clock on each sampling day. The ascent rate of flight package has been fixed at 3m/sec (180 m/min) with necessary hydrogen fill. The vertical temperature profiles were continuously recorded till the flight package reaches the altitude of about 3900 m above ground level. These records were used to determine mixing heights representative in the project area. During the study period the maximum mixing height was observed about 1100 m in the afternoon hours including local influences of residential & commercial activities. However during night time the ground based inversion (radiation inversion) was observed upto 160 m above ground level.

4.1.6 Existing Ambient Air Quality Status

The range of 98th percentile concentrations during winter season reflects the levels of the existing status of ambient air quality. The baseline ambient air quality status is given in **Tables 4.1.5** - **4.1.11**.

During winter season, 98th percentile values of 24 hourly SPM concentration ranged between 99.9-396 $\mu g/m^3$. The arithmetic mean varied between 87-256 $\mu g/m^3$ in winter season (**Table 4.1.5** and **Table 4.1.7**). Similarly, 98th percentile and arithmetic mean of 24 hourly RPM concentrations varied in the range of 60.8-175 $\mu g/m^3$ and 6-114 $\mu g/m^3$ respectively (**Table 4.1.5** and **Table 4.1.8**).

In general, comparatively high levels of SPM and RPM are observed in the study area due to dry and arid land cover and scanty rainfall. The traffic on dusty roads, agriculture and construction activities, burning of wood as fuel, etc. also contribute to SPM. The present status of SPM indicates that Jamnagar region has very high levels of SPM.

The 98th percentile concentrations of 24 hourly SO_2 in winter season varied from 6-31 $\mu g/m^3$. The arithmetic mean ranges from 4.5-22 $\mu g/m^3$ in winter season **(Table 4.1.5 and Table 4.1.9)**.

The 98th percentile concentrations of 24 hourly NOx in winter ranged between 10-30 $\mu g/m^3$. The arithmetic mean values varied between 6-20.33 $\mu g/m^3$ in winter season (**Table 4.1.6** and **Table 4.1.10**). It is observed that SO_2 and NOx concentrations are well below the stipulated standards of CPCB for residential/rural region.

The arithmetic mean and 98th percentile values of NH_3 were observed in the range of 10-192 $\mu g/m^3$ and 31-274 $\mu g/m^3$ (**Tables 4.1.6** and **4.1.11**). It is also observed that concentrations of NH_3 are also below the stipulated standards of CPCB.

Concentrations of carbon monoxide (CO) and non-methane hydrocarbons (NMHC) were measured in winter season. The results of the measurements **(Table 4.1.12)** indicated that CO and NMHC concentrations at all the monitoring locations are observed to be varying in the range of 263-1139 $\mu g/m^3$ and BDL – 138 $\mu g/m^3$. Concentrations of CO are well below the stipulated standards of CPCB for residential/rural region.

For the 2007- 08 winter season the SPM, SO_2 & No_X values are given Below,.

SPM:

The Ambient Air Quality Monitoring was carried out by NEERI during winter season (2008) wherein SPM concentration were observed at the border line / more than the average for the area at 15 places out of 24 locations. It may be observed that ;

1) Jamnagar SEZ located in a semi arid area with low green cover and very scanty rainfall in the years which are the main contributing factors for getting more values of Ground Level Concentration of SPM. The very low green cover (only 15%) can be seen from Landuse/land cover pattern satellite image given in EIA Report (Refer EIA Report Page no. 4.60).

2) The main contributing factor for the variation in the SPM values can be co-related with rainfall occurred during that period. The rainfall in 2007-08 season spread is confined to only 3 days. If the rain is spread over the season then moisture content in the soil remains for longer period which is helpful to minimize the dust resuspension and subsequently results in lower SPM value.

3) More SPM values are observed at Moti Khavadi, Arablus, Mungani, Satalus can be attributed because of the higher vehicular traffic, poor road conditions, dirt tracks, cattle movements etc. in the area.

SO2

The average SO2 concentration was observed to be marginally more than 30 µg/m3 at three locations. However, These SO2 concentration are much less than the standards of National Ambient Air Quality Standards (NNAQS) for industrial / residential area.

Cl2

Generally the chloride in the ambient air is found out in the form of sodium chloride in the aerosol type condition typically near the sea coast due to the wind action. However, it will be quite difficult to measure by using the standard high volume sampling method. This is also has been checked in the literature.

As suggested by the honorable members of the committee “the Cl2 concentrations in the above mentioned range very rarely occur in typical urban pollution.

HCl

As in the case of CL2 the results are very erroneous.

Sources of HCL and CL2

There is no source of HCl and Cl_2 emission from refinery, Jamnagar except for chlorination used in the cooling water treatment. Other source for the emission of chlorides is the sea

4.1.7 Ambient Air Quality Concentrations vis-à-vis Stipulated Standards

The comparison of observed levels of air pollutants in winter season with the standards stipulated by CPCB for the residential/rural region was carried out and presented in **Table 4.1.13**. It was observed that the concentrations of SO_2, NOx, NH_3 and CO are well within the stipulated standards at all the ambient air quality monitoring locations whereas SPM and RPM concentrations exceeded the stipulated standards at most of the ambient air quality monitoring locations.

The SPM concentrations at all the AAQM locations were primarily caused by local phenomena including vehicular activities and natural dust getting air borne due to man made activities and blowing wind.

At all the air quality monitoring locations, the 98^{th} percentile values of SO_2 and NOx were observed to be within the ambient air quality standards promulgated by CPCB for residential/rural region. The concentrations of NH_3 were observed to be below the standards stipulated by CPCB, i.e. 400 $\mu g/m^3$.

The concentrations of CO are observed to be below stipulated standard of CPCB for residential area i.e. 2000 $\mu g/m^3$. There is no standard available yet for NMHC in India, however, the concentrations were observed to be comparable with other industrialized locations in India.

It may be pertinent to note that the set-up of the petroleum and petrochemical SEZ in the area would categorize the entire area as 'industrial'. This is because the SEZ has been notified by the Ministry of Industry and Commerce, Government of India, as a petroleum and petrochemical sector specific SEZ. The effect of the emissions from the SEZ on the baseline will have to be compare to the Industrial Standards for ambient environment.

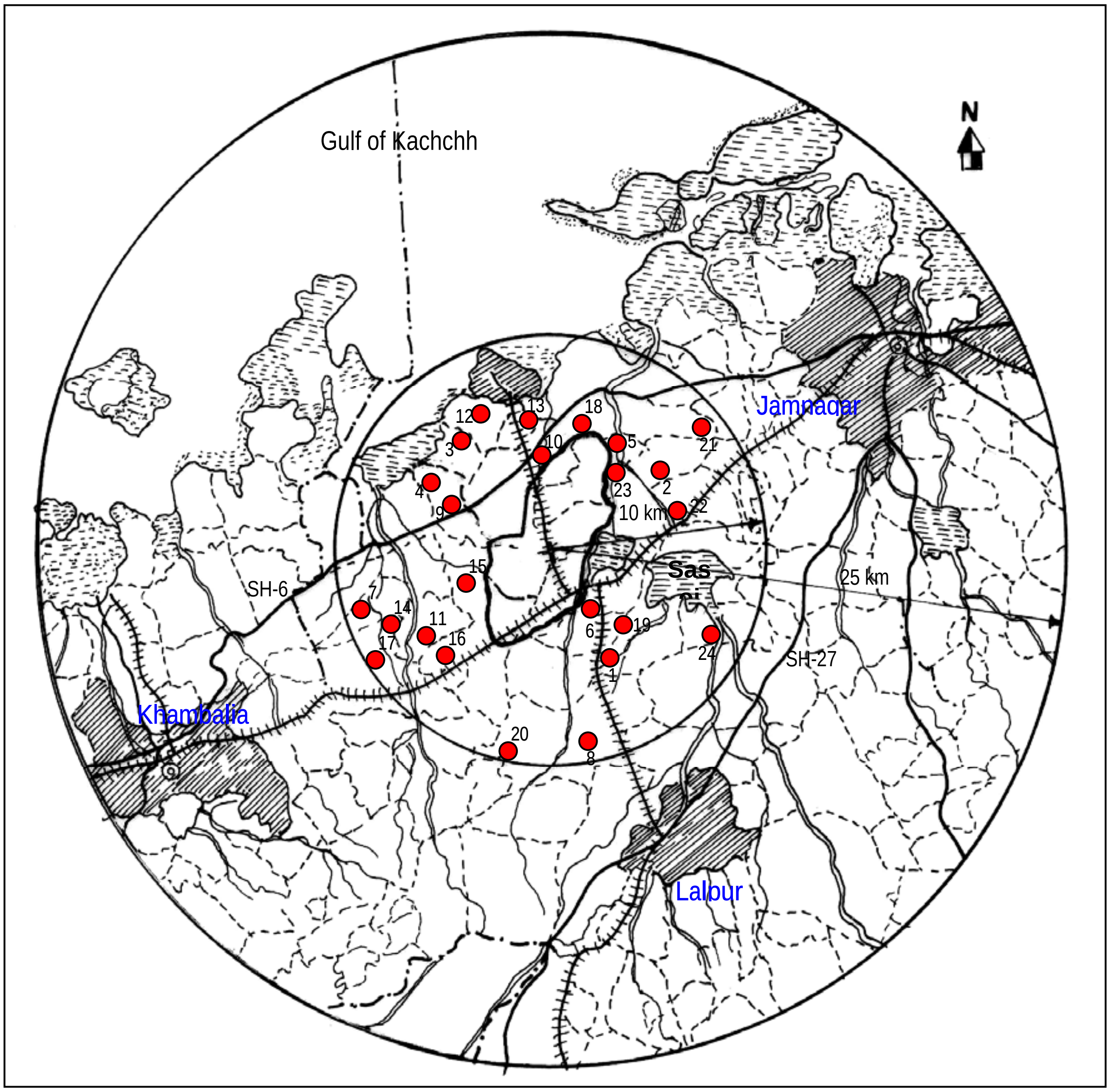


Fig. 4.1.1 : Sampling Location for Ambient Air Quality Monitoring

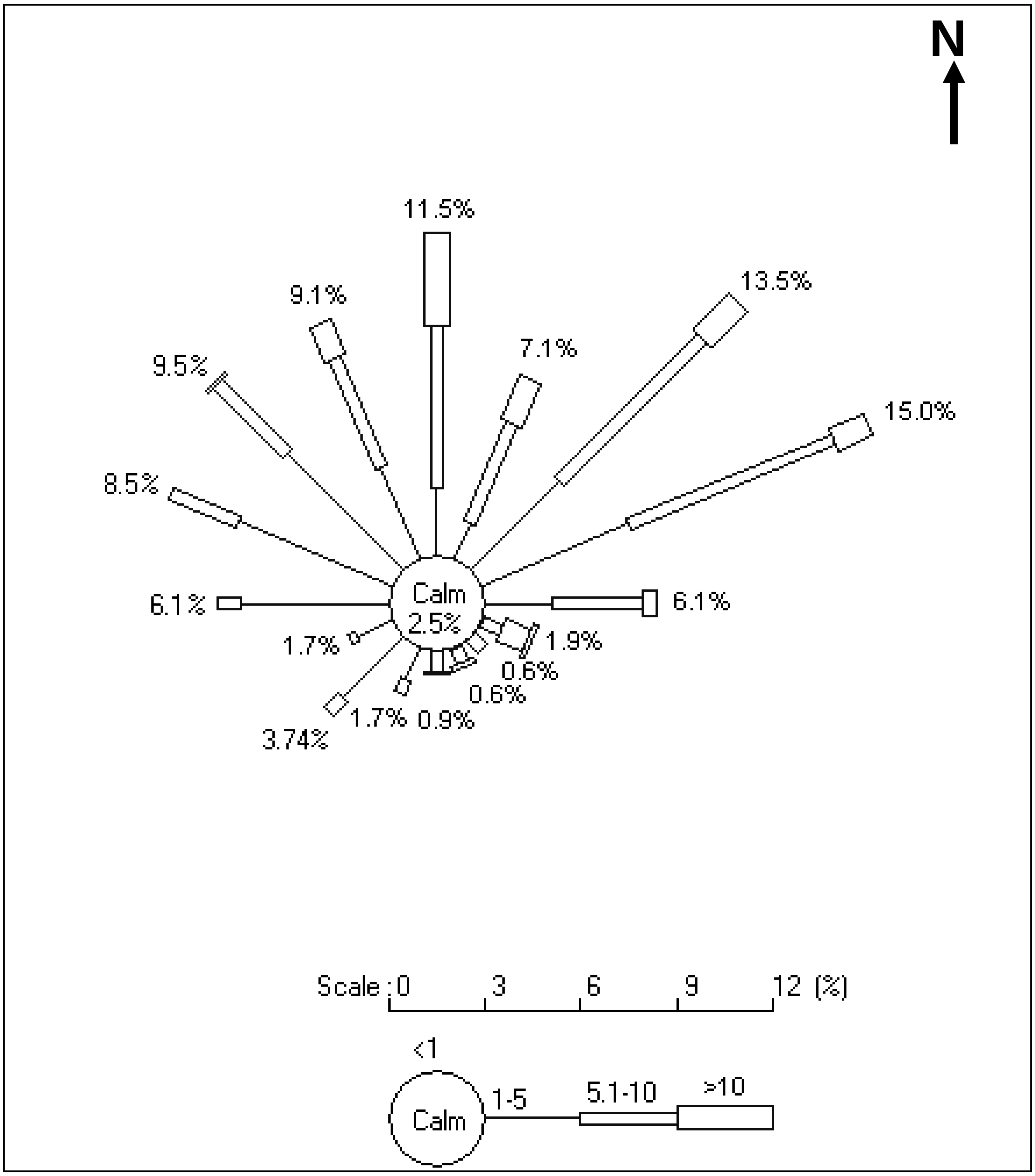


Fig. 4.1.2: Windrose diagram during Winter Season

Table 4.1.1
Environmental Attributes & Frequency of Monitoring

Sr. No	Attribute	Parameters	No. of sampling locations	Frequency of Monitoring/Data collection
1	Ambient air quality	SPM, RPM, SO_2, NOx, NH_3, CO & HC	24	24 hourly samples everyday atleast at 8 locations
2	Meteorology	Wind speed and direction, temperature, relative humidity and rainfall. Mixing Height	1	Data collected during the study period on hourly basis. Historical data also collected from Airport, Jamnagar for corroborating the data and planning the monitoring network.
3	Surface water quality	Physical, chemical and bacteriological parameters.	3	Once during the study period.
4	Groundwater quality	Physical, chemical and bacteriological parameters.	18	Once during the study period.
5	Ecology	Existing flora and fauna.	Study area of 25 kms around SEZ	Through field visit during the study period and substantiated through secondary sources.
6	Noise levels	Noise levels in dBA	29	Hourly observation once during the season in industrial, commercial, residential and silence zones.
7	Soil characteristics	Physical, chemical and biological parameters to assess agricultural and afforestation potential.	9	Sub surface composite samples collected once during the study period.
8	Land use / Land Cover	Land use for different land use classifications.	Study area of 25 kms around SEZ	Land use / Land Cover Analysis using satellite imaging and GIS Technique
9	Socio-economic Environment	Socio-economic characteristics, labour force characteristics, population statistics existing amenities in the study area and quality of life.	Study area of 25 kms around SEZ	Based on field surveys and data collected from secondary sources

Table 4.1.2

Details of Ambient Air Quality Monitoring Locations

Sr. No	Sampling Location
1.	Arablus
2.	Gaduka
3.	Gagva
4.	Jogvad
5.	Kana Chhikari
6.	Kanalus
7.	Khatiya
8.	Macchuberaja
9.	Meghpar
10.	Motikhavdi
11.	Mota Lakhiya
12.	Mungani
13.	Nani khavdi
14.	Nani lakhiya
15.	Padana
16.	Rangpar
17.	Rasangpar
18.	Sapar
19.	Satalus
20.	Sevak Bharudiya
21.	Jivapar
22.	Balambhadi
23.	Dera Chhikari
24.	Meghavadar

Table 4.1.3

Instruments Used For Analysis

Sr. No.	Instrument Name	Make	Parameters
1	Spectrophotometer	HACH	SO_2, NOx, NH_3, H_2S
2	Electronic Balance	Metler	SPM, RPM
3	Gas Chromatograph with FID & ECD	GC-3, VARIAN	CO, HC

Table 4.1.4

Techniques Used for Ambient Air Quality Monitoring

Sr. No.	Parameter	Technique	Technical Protocol	Minimum Detectable Limit ($\mu g/m^3$)
1	Suspended Particulate Matter	Respirable Dust Sampler (Gravimetric method)	IS-5182 & CPCB	3.0
2	Respirable Particulate Matter	Respirable Dust Sampler (Gravimetric method)	IS-5182 & CPCB	3.0
3	Sulphur dioxide	Modified West and Gaeke	IS-5182 & CPCB	3.0
4	Nitrogen Oxide	Jacob & Hochheiser	IS-5182 & CPCB	3.0
5	Ammonia	Nessler Reagent	IS-5182	3.0
6	Hydrogen Sulphide		IS-5182	3.0
7	Carbon Monoxide	Gas Chromatography		125
8	Hydrocarbons	Gas Chromatography		71

Table 4.1.5

Ambient Air Quality Status
(Winter Season)

Unit : μg/m^3 Avg. : 24 hours

Sr. No	Sampling Location	SO_2 Avg	SO_2 SD	SPM Avg	SPM SD	RPM Avg	RPM SD
1.	Arablus	5.33 (4-6)	0.82	202.7 (168-258)	30.4	108.8 (94-120)	10.5
2.	Gaduka	8 (4-18)	5	185 (101-267)	55	83 (43-147)	29
3.	Gagva	22 (13-31)	5	224 (121-359)	64	96 (65-136)	22
4.	Jogvad	21 (10-30)	5	242 (149-348)	99	99 (58-183)	40
5.	Kana Chhikari	6 (3-10)	2	204 (136-297)	56	99 (64-144)	25
6.	Kanalus	5.7 (4-7)	1.03	118.2 (84-141)	21.2	98 (58-143)	12.9
7.	Khatiya	22 (13-29)	5	232 (146-324)	79	114 (77-178)	45
8.	Macchuberaja	9.5 (6-13)	2.7	107 (66-170)	5.02	97.3 (88-105)	6.2
9.	Meghpar	17 (11-26)	5	256 (123-396)	91	114 (63-158)	26
10.	Motikhavdi	15 (10-23)	4	194 (117-252)	58	92 (56-131)	18
11.	Mota Lakhiya	7 (3-15)	3	185 (128-241)	42	91 (68-119)	18
12.	Mungani	16 (10-28)	4	238 (123-345)	60	99 (60-155)	23
13.	Nani khavdi	15 (10-24)	4	206 (113-339)	55	96 (61-136)	19
14.	Nani lakhiya	7 (3-19)	5	217 (108-279)	58	74 (37-106)	22
15.	Padana	6 (0-6)	2	127 (85-161)	30	96 (60-160)	34
16.	Rangpar	11 (6-15)	3	208 (107-298)	65	98 (56-141)	32
17.	Rasangpar	18 (10-32)	7	249 (100-332)	94	83 (55-138)	26

Sr. No	Sampling Location	SO_2		SPM		RPM	
		Avg	SD	Avg	SD	Avg	SD
18.	Sapar	10 (3-25)	6	201 (104-298)	67	72 (40-114)	24
19.	Satalus	8.83 (6-12)	2.23	138.9 (108-164)	20.2	78.3 (60-99)	13.23
20.	Sevak Bharudiya	6.83 (6-8)	0.98	87 (66-100)	14.14	51.5 (38-61)	8.41
21.	Jivapar	4.50 (3-6)	1.38	108.5 (83-126)	17.80	61.7 (50-76)	10.76
22.	Balambhadi	5.17 (3-7)	1.47	95.67 (85-108)	8.62	63.67 (51-97)	17.13
23.	Dera Chhikari	5 (3-6)	1.26	106.67 (91-125)	13.25	67.00 (55-86)	11.98
24.	Meghavadar	8.00 (5-14)	3.29	148.83 (69-238)	59.52	85.33 (41-119)	29.55

Table 4.1.6

Ambient Air Quality Status
(Winter Season)

Unit : $\mu g/m^3$ Avg. : 24 hours

Sr. No	Sampling Location	NOx		NH_3	
		Avg	SD	Avg	SD
1.	Arablus	11.5 (8-15)	5	16.83 (10-31)	7.31
2.	Gaduka	8 (3-17)	4	18 (5-48)	12
3.	Gagva	18 (10-32)	6	36 (10-90)	20
4.	Jogvad	15 (6-29)	6	38 (10-169)	45
5.	Kana Chhikari	13 (4-19)	5	192 (121-281)	48
6.	Kanalus	20.33 (15-26)	4.03	25.83 (15-56)	15.42
7.	Khatiya	8 (3-13)	3	21 (8-50)	13
8.	Macchuberaja	16.67 (12-23)	4.37	14.17 (11-18)	2.32
9.	Meghpar	16 (9-24)	4	21 (3-83)	24
10.	Motikhavdi	16 (11-30)	5	25 (10-48)	12
11.	Mota Lakhiya	6 (3-13)	3	36 (4-76)	19
12.	Mungani	18 (11-30)	5	44 (10-109)	31
13.	Nani khavdi	17 (10-30)	5	28 (11-142)	34
14.	Nani lakhiya	8 (4-20)	5	20 (3-54)	14
15.	Padana	7 (3-11)	3	25 (5-43)	14
16.	Rangpar	6 (3-11)	2	10 (3-35)	16

Sr. No	Sampling Location	NOx		NH_3	
		Avg	SD	Avg	SD
17.	Rasangpar	10 (3-31)	7	24 (9-51)	14
18.	Sapar	16 (3-31)	8	39 (10-78)	21
19.	Satalus	12.33 (7-18)	4.13	19.33 (15-33)	6.89
20.	Sevak Bharudiya	17.83 (13-21)	3.19	13.17 (9-18)	3.66
21.	Jivapar	10.83 (8-15)	3.19	10.83 (7-15)	3.19
22.	Balambhadi	17.50 (15-20)	1.87	17.33 (10-28)	6.56
23.	Dera Chhikari	11.67 (9-16)	2.34	14.17 (10-18)	2.79
24.	Meghavadar	16.50 (14-19)	1.87	29.67 (13-61)	22.21

Table 4.1.7

Cumulative Percentile of SPM (Winter Season)

Unit : µg/m^3 24 hourly average

Sr. No	Sampling Location	Percentiles of SPM			
		25%	50%	75%	98%
1.	Arablus	188.5	199.5	204.5	252.8
2.	Gaduka	134	187	220	266
3.	Gagva	175	207	274	344
4.	Jogvad	189	213	247	336
5.	Kana Chhikari	159	198	237	294
6.	Kanalus	109.75	119	134.25	140.8
7.	Khatiya	180	228	279	320
8.	Macchuberaja	93.75	99.5	100	104.5
9.	Meghpar	194	245	329	396
10.	Motikhavdi	176	192	224	248
11.	Mota Lakhiya	152	188	223	239
12.	Mungani	209	233	285	330
13.	Nani khavdi	168	203	229	325
14.	Nani lakhiya	216	234	235	274
15.	Padana	198	204	230	236
16.	Rangpar	169	198	259	295
17.	Rasangpar	202	234	297	330
18.	Sapar	148	178	276	296
19.	Satalus	128.25	141	148.5	164.4
20.	Sevak Bharudiya	78.25	90	98.75	99.9
21.	Jivapar	95.5	115	121	125.6
22.	Balambhadi	89	97	99.75	107.2
23.	Dera Chhikari	96.75	106.5	114.75	124
24.	Meghavadar	117.25	141.5	180.75	233.3

Table 4.1.8

Cumulative Percentile of RPM (Winter Season)

Unit : µg/m^3 24 hourly average

Sr. No	Sampling Location	Percentiles of RPM			
		25%	50%	75%	98%
1.	Arablus	102.3	109.5	117.5	120
2.	Gaduka	61	74	108	135
3.	Gagva	76.	96	113	132
4.	Jogvad	78	92	104	175
5.	Kana Chhikari	79	97	116	140
6.	Kanalus	65.8	71.5	80.3	84.8
7.	Khatiya	88	100	125	174
8.	Macchuberaja	54.3	56.5	58	62.5
9.	Meghpar	106	115	123	156
10.	Motikhavdi	85	94	100	123
11.	Mota Lakhiya	77	91	102	119
12.	Mungani	85	94	113	149
13.	Nani khavdi	85	93	109	130
14.	Nani lakhiya	73	74	80	104
15.	Padana	92	109	116	119
16.	Rangpar	73	101	121	139
17.	Rasangpar	62	69	96	109
18.	Sapar	54	72	94	134
19.	Satalus	71.5	79.5	82.3	97.4
20.	Sevak Bharudiya	48.3	51.5	57.8	60.8
21.	Jivapar	55.75	66	72.5	75.7
22.	Balambhadi	53.25	58.5	63.75	93.8
23.	Dera Chhikari	58.25	64	73.5	84.9
24.	Meghavadar	70.25	85	108.75	118.6

Table 4.1.9

Cumulative Percentile of SO_2 (Winter Season)

Unit : $\mu g/m^3$ 24 hourly average

Sr. No	Sampling Location	Percentiles of Sox			
		25%	50%	75%	98%
1.	Arablus	5	5.5	6	6
2.	Gaduka	4	5	13	17
3.	Gagva	17	21	27	30
4.	Jogvad	19	22	24	30
5.	Kana Chhikari	4	5	7	10
6.	Kanalus	5.25	6	6	6.9
7.	Khatiya	20	21	23	29
8.	Macchuberaja	8	9	11.5	12.9
9.	Meghpar	13	15	18	25
10.	Motikhavdi	13	14	17	22
11.	Mota Lakhiya	5	6	8	14
12.	Mungani	14	16	18	26
13.	Nani khavdi	12	16	18	23
14.	Nani lakhiya	4	6	9	18
15.	Padana	13	15	16	19
16.	Rangpar	9	13	14	15
17.	Rasangpar	13	15	24	31
18.	Sapar	5	9	12	24
19.	Satalus	7.25	9	10	11.8
20.	Sevak Bharudiya	6	6.5	7.75	8
21.	Jivapar	3.25	4.5	5.75	6
22.	Balambhadi	4.25	5.5	6	6.9
23.	Dera Chhikari	4.25	5.5	6	6
24.	Meghavadar	6	7	8.75	13.5

Table 4.1.10

Cumulative Percentile of NOx (Winter Season)

Unit : μg/m^3 24 hourly average

Sr. No	Sampling Location	Percentiles of NOx			
		25%	50%	75%	98%
1.	Arablus	8.5	11.5	14.5	15
2.	Gaduka	5	8	10	15
3.	Gagva	14	17	21	30
4.	Jogvad	11	14	17	27
5.	Kana Chhikari	10	13	15	19
6.	Kanalus	18	20	22.75	25.7
7.	Khatiya	7	7	10	13
8.	Macchuberaja	13.25	16	19.5	22.7
9.	Meghpar	13	14	18	24
10.	Motikhavdi	12	14	18	27
11.	Mota Lakhiya	4	5	8	13
12.	Mungani	14	17	22	29
13.	Nani khavdi	14	15	19	28
14.	Nani lakhiya	4	5	8	19
15.	Padana	19	21	24	25
16.	Rangpar	5	6	7	10
17.	Rasangpar	5	7.5	11	27
18.	Sapar	9	18	22	30
19.	Satalus	9.25	13.5	14	17.6
20.	Sevak Bharudiya	15.75	19	20	20.9
21.	Jivapar	8	10.5	13	14.8
22.	Balambhadi	16.25	17.5	18.75	19.9
23.	Dera Chhikari	11	11	11.75	15.6
24.	Meghavadar	15.25	16.5	17.75	18.9

Table 4.1.11

Cumulative Percentile of NH_3 (Winter Season)

Unit : $\mu g/m^3$ 24 hourly average

Sr. No	Sampling Location	Percentiles of NH_3			
		25%	50%	75%	98%
1.	Arablus	14	14.5	16.5	31
2.	Gaduka	9	16	21	43
3.	Gagva	20	33	46	88
4.	Jogvad	18	21	25	155
5.	Kana Chhikari	159	188	217	274
6.	Kanalus	18	19	26	56
7.	Khatiya	13	15	24	47
8.	Macchuberaja	13.25	14	14.75	17.7
9.	Meghpar	6	10	21	81
10.	Motikhavdi	17	19	32	47
11.	Mota Lakhiya	24	39	51	69
12.	Mungani	17	30	73	107
13.	Nani khavdi	54	74	111	140
14.	Nani lakhiya	20	28	33	52
15.	Padana	18	24	26	34
16.	Rangpar	6	15	22	34
17.	Rasangpar	14	21	30	50
18.	Sapar	15	43	56	71
19.	Satalus	15.25	17	18.75	31.6
20.	Sevak Bharudiya	10.5	12.5	16	17.9
21.	Jivapar	8.25	12	12	14.7
22.	Balambhadi	12.75	16.5	20.25	27.3
23.	Dera Chhikari	13	14	15.75	17.8
24.	Meghavadar	14	17.5	46.5	60.4

Table 4.1.12

Concentrations of Non-methane Hydrocarbons and Carbon Monoxide (Winter Season)

Spot Sample Unit: $\mu g/m^3$

Sr. No	Sampling Location	CO Concentrations	NMHC Concentrations
1.	Arablus	699	105
2.	Gaduka	263	BDL
3.	Gagva	721	121
4.	Jogvad	641	79
5.	Kana Chhikari	298	83
6.	Kanalus	773	116
7.	Khatiya	469	80
8.	Macchuberaja	486	73
9.	Meghpar	1139	137
10.	Motikhavdi	912	136
11.	Mota Lakhiya	295	BDL
12.	Mungani	568	106
13.	Nani khavdi	835	102
14.	Nani lakhiya	848	138
15.	Padana	358	71
16.	Rangpar	633	93
17.	Rasangpar	581	84
18.	Sapar	642	77
19.	Satalus	752	113
20.	Sevak Bharudiya	551	56
21.	Jivapar	496	74
22.	Balambhadi	468	75
23.	Dera Chhikari	302	BDL
24.	Meghavadar	482	72

Table 4.1.13

Comparison of Ambient Air Quality Levels with Stipulated Standards

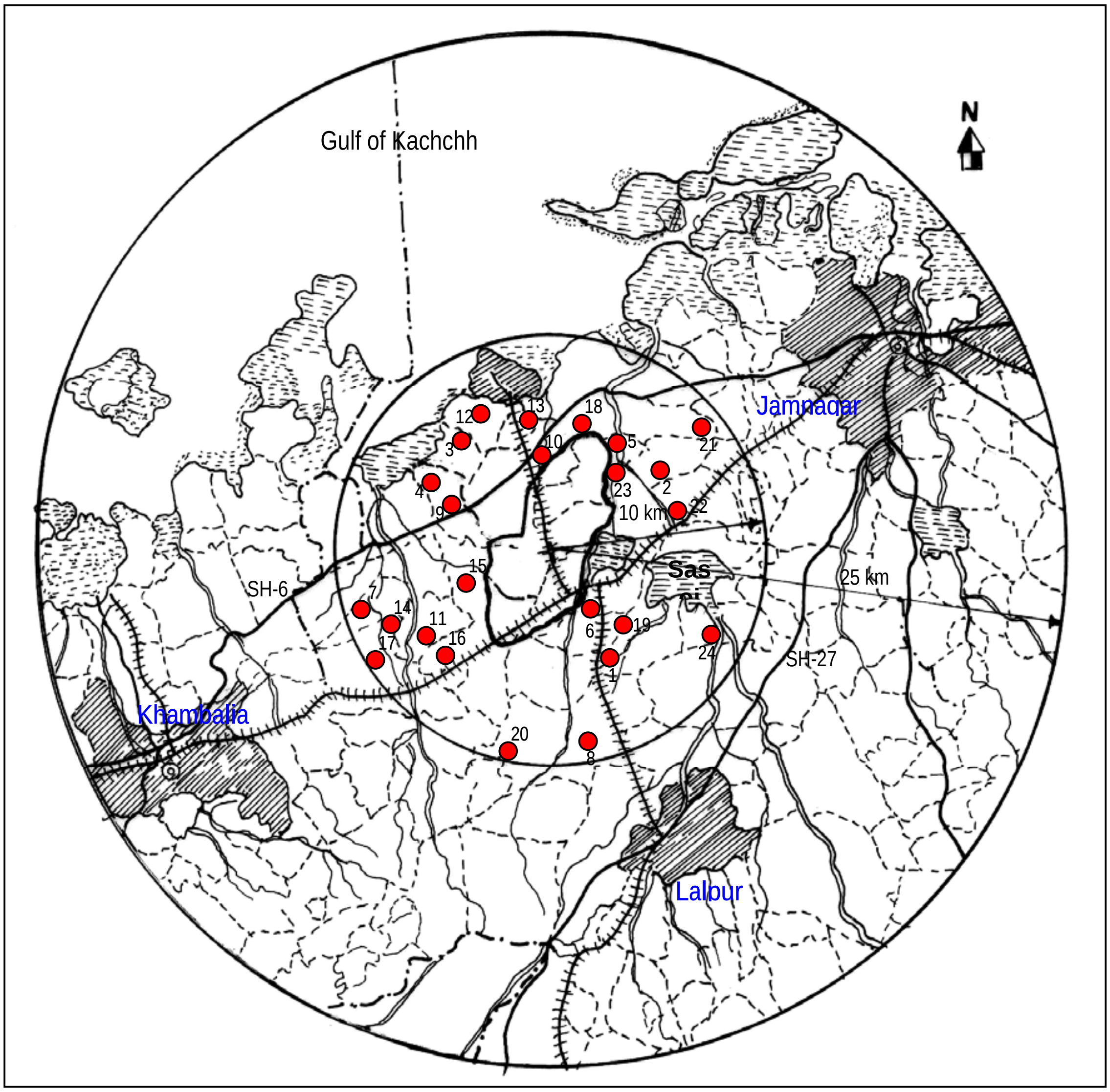
Unit : $\mu g/m^3$ 24 Hourly Average

Pollutants	Winter Season (98th Percentile)	Stipulated Standard of CPCB for Residential Area	Stipulated Standard of CPCB for Industrial Area
SPM	99.9-396	200	500
RPM	60.8-175	80	150
SO_2	6-31	80	120
NOx	10-30	80	120
NH_3	31-274	400	Not Applicable
NMHC	BDL-138	Not Available	Not Available
CO*	263-1139	2000	5000

* 8 hours average

As suggested by MoEF the ambient air quality data collected and for the winter season of 2007-08 is given below

Ambient Air Quality Analysis (Winter 2007- 08)



Sampling Location for Ambient Air Quality Monitoring (2007-08) Winter

Environmental Attributes & Frequency of Monitoring

Sr. No	Attribute	Parameters	No. of sampling locations	Frequency of Monitoring/Data collection
1	Ambient air quality	SPM, RPM, SO_2, NOx, NH_3, CO & HC	24	24 hourly samples everyday atleast at 8 locations
2	Meteorology	Wind speed and direction, temperature, relative humidity and rainfall. Mixing Height	1	Data collected during the study period on hourly basis. Historical data also collected from Airport, Jamnagar for corroborating the data and planning the monitoring network.

Details of Ambient Air Quality Monitoring Locations

Sr. No.	Sampling Location	Direction w. r. RIL	Distance (Km) From RIL	Height above ground Level (m)
1.	Arablus	SEE	5.63	4.0
2.	Gaduka	NE	6.88	4.0
3.	Gagva	NW	5.63	3.5
4.	Jogvad	W	5.31	3.5
5.	Kana Chikari	NE	5.94	3.5
6.	Kanalus	SE	3.44	4.5
7.	Khatiya	S	5.94	4.5
8.	Macchuberaja	SSE	8.44	4.0
9.	Meghpar	SW	4.38	4.5
10.	Moti Khavadi	N	4.06	5.5
11.	Mota Lakhiya	SSW	6.25	4.0
12.	Mungani	NW	6.25	4.0
13.	Nani Kavadi	NNW	5.94	5.5
14.	Nana Lakhiya	SSW	7.19	4.5
15.	Padana	SSW	3.13	5.5
16.	Rangpar	SSW	6.25	5.0
17.	Rasangpar	SWW	5.94	5.0
18.	Sapar	NE	6.25	4.5
19.	Satalus	SE	4.06	4.5
20.	Sevak Bharudiya	S	9.38	4.0
21.	Jivapar	NE	9.38	5.0
22.	Balambhadi	E	6.56	4.5
23.	Dera Chikari	NE	5.31	4.0
24.	Meghavadar	SE	8.75	5.0

Instruments Used For Analysis

Sr. No.	Instrument Name	Make	Parameters
1	Spectrophotometer	HACH	SO_2, NOx, NH_3, H_2S
2	Electronic Balance	Metler	SPM, RPM
3	Gas Chromatograph with FID & ECD	GC-3, VARIAN	CO, HC

Techniques Used for Ambient Air Quality Monitoring

Sr. No.	Parameter	Technique	Technical Protocol	Minimum Detectable Limit ($\mu g/m^3$)
1	Suspended Particulate Matter	Respirable Dust Sampler (Gravimetric method)	IS-5182 & CPCB	3.0
2	Respirable Particulate Matter	Respirable Dust Sampler (Gravimetric method)	IS-5182 & CPCB	3.0
3	Sulphur dioxide	Modified West and Gaeke	IS-5182 & CPCB	3.0
4	Nitrogen Oxide	Jacob & Hochheiser	IS-5182 & CPCB	3.0
5	Ammonia	Nessler Reagent	IS-5182	3.0
6	Hydrogen Sulphide		IS-5182	3.0
7	Carbon Monoxide	Gas Chromatography		125
8	Hydrocarbons	Gas Chromatography		71

Ambient Air Quality Status
(Winter Season 2007 - 2008)

Units: $\mu g/m^3$

Sr. No.	Sampling Location	Avg.: 24 Hrs.					
		SPM	RSPM	SO_2	NOx	HCl	Cl_2
		Avg. + SD					
1.	Arablus	495 ± 90	114 ± 26	17 ± 4	19 ± 6	65 ± 25	13 ± 3
		(99 - 589)	65 -178	(12 - 25)	(9 - 30)	(23 - 99)	(10 - 22)
2.	Gaduka	117 ± 12	73 ± 23	8 ± 2	11 ± 4	54 ± 20	24 ± 4
		(93 - 139)	41 -1 25	(4 - 12)	(5 - 18)	(23 - 99)	(20 - 32)
3.	Gagva	125 ± 18	67± 8	5 ± 1	7 ± 2	43 ± 12	4 ± 2
		(99 - 155)	(53 - 81)	(3 - 8)	(4 -12)	(28 - 64)	(2 - 8)
4.	Jogvad	242 ± 46	97 ± 14	18 ± 5	15 ± 3	59 ± 19	2 ± 1
		(74 - 318)	(76 - 125)	(10 - 28)	(10 - 21)	(25 - 97)	(1 - 4)
5.	Kana Chikari	259 ± 53	103± 18	9 ± 5	31 ± 14	72 ± 14	10 ± 3
		(122 - 361)	(62 - 137)	(3 - 18)	(6 - 66)	(48 - 97)	(5 - 15)
6.	Kanalus	427 ± 114	141± 26	36 ± 16	14 ± 5	75 ± 10	24 ± 6
		(97- 563)	(90 -169)	(14 - 65)	(8 - 29)	(59 - 63)	(8 -32)
7.	Khatiya	189 ± 59	57 ± 18	19 ± 6	12 ± 4	63 ± 17	6 ± 2
		(151 - 266)	(90 ± 111)	(11 - 31)	(6 - 20)	(44 - 97)	(3 - 9)
8.	Macchuberaja	368 ± 142	121± 30	42 ± 19	23 ± 8	49 ± 15	5 ± 2
		(153 - 593)	70 - 166	(8 - 78)	(9 - 36)	(24 - 73)	(2 - 8)
9.	Meghpar	259 ±104	112 ±34	18 ± 3	15 ± 4	40 ± 14	4 ± 2
		(94 - 432)	(45 -149)	(14 - 22)	(9 - 22)	(20 -64)	(2 - 8)
10.	Moti Khavadi	542 ± 37	156 ± 13	14 ± 1	15 ± 5	65 ± 16	6 ± 3
		(311 - 590)	(140 - 176)	(12 - 16)	(8 - 23)	(32 - 83)	(1 - 12)
11.	Mota Lakhiya	181 ± 51	88 ± 17	17 ± 3	12 ± 3	70 ± 15	22 ± 6
		(81 - 270)	62 -120	(12 - 21)	(7 - 17)	(35 - 89)	(12 - 30)
12.	Mungani	386 ± 53	136 ± 18	5 ± 1	17 ± 5	51 ± 22	7 ± 2
		(117 - 488)	(110 -175)	(3 - 8)	(9 - 25)	(18 - 99)	(3 - 12)
13.	Nani Kavadi	150 ± 16	97 ± 19	4 ± 1	17 ± 7	73 ± 20	10 ± 3
		(108 - 165)	(67 - 127)	(3 - 7)	(10 - 34)	(38 - 99)	(7-14)
14.	Nana Lakhiya	212 ± 80	92 ± 26	16 ± 3	13 ± 4	55 ± 16	15 ± 4
		(112 - 377)	44 - 148	(10 - 21)	(7 - 21)	(24 - 85)	(10 - 24)
15.	Padana	207 ± 79	96 ± 27	10 ± 1	12 ± 3	64 ± 23	22 ± 3

Sr. No.	Sampling Location	Avg.: 24 Hrs.					
		SPM	RSPM	SO_2	NOx	HCl	Cl_2
		Avg. + SD					
		(108 - 413)	(59 -145)	(8 -12)	(7-17)	(27- 99)	(18 - 28)
16.	Rangpar	164 ± 59	74 ± 18)	12 ± 4	12 ± 3	41 ± 7	7 ± 2
		(108 - 259)	51 - 124	(5 -18)	(8 -16)	(26 - 55)	(3 - 9)
17.	Rasangpar	186 ± 74	90 ± 25	7 ± 4	10 ± 5	58 ± 12	3 ± 2
		(237 - 364)	(64 -146)	(3 - 16)	(5 - 21)	(38 - 86)	(1 - 8)
18.	Sapar	226 ± 97	88±32	4 ±1	17 ± 10	64 ± 12	13 ± 4
		(122 - 406)	(45 -142)	(3 -6)	(7 - 50)	(45 -88)	(4 - 20)
19.	Satalus	338 ± 126	121± 30	32 ± 13	14 ± 3	60 ± 13	20 ± 3
		(225 - 590)	(77 -157)	(15 - 59)	(7 - 22)	(43 - 92)	(15 - 28)
20.	Sevak Bharudiya	166 ± 68	112 ± 34	13 ± 3	15 ± 3	51 ± 19	3 ± 1
		(86 - 354)	(45 -149)	(9 -18)	(9 -23)	(25 - 88)	(1 - 6)
21.	Jivapar	163 ± 71	79 ± 22	9 ± 3	17 ± 4	52 ± 11	6 ± 3
		(60 - 342)	(36 -119)	(4 - 14)	(11 - 27)	(35 - 84)	(2 -12)
22.	Balambhadi	286 ± 57	107 ± 19	11 ± 4	11 ± 6	66 ± 20	31 ± 18
		(120 - 382)	74 -139	(3 - 17)	(4 - 23)	(35 - 99)	(2 - 58)
23.	Dera Chikari	273 ± 96	104 ± 28	6 ± 2	12 ± 4	75 ± 13	11 ± 5
		(155 - 432)	(49 - 138)	(3 - 10)	(7 - 22)	(54 - 98)	(3 - 19)
24.	Meghavadar	163 ± 51	81 ± 17	10 ± 3	13 ± 3	58 ± 7	6 ± 2
		(60 - 250)	(57 ± 111)	(5 -14)	(9 -18)	(46 -75)	(3 - 8)

Cumulative Percentile of SPM

(Winter Season 2007 - 2008)

Units: µg/m³

Sr. No.	Sampling Location	Min	Percentile				Max
			25th	50th	75th	98th	
1.	Arablus	322	289	330	378	453	471
2.	Gaduka	186	113	118	122	139	139
3.	Gagva	184	110	126	137	154	155
4.	Jogvad	74	232	238	264	313	318
5.	Kana Chikari	122	221	268	292	348	361
6.	Kanalus	97	372	417	520	562	563
7.	Khatiya	151	128	194	244	265	266
8.	Macchuberaja	153	276	304	479	589	593
9.	Meghpar	94	199	269	332	422	432
10.	Moti Khavadi	311	510	536	561	590	590
11.	Mota Lakhiya	81	150	158	209	270	270
12.	Mungani	117	341	383	405	486	488
13.	Nani Kavadi	99	486	519	553	587	589
14.	Nana Lakhiya	112	170	235	254	351	377
15.	Padana	108	142	207	238	379	413
16.	Rangpar	108	129	139	185	260	269
17.	Rasangpar	237	129	146	231	345	364
18.	Sapar	490	150	181	313	392	406
19.	Satalus	225	252	290	434	566	590
20.	Sevak Bharudiya	86	133	148	171	338	354
21.	Jivapar	93	102	159	193	319	342
22.	Balambdi	120	246	267	338	375	382
23.	Dera Chikari	155	228	270	338	423	432
24.	Meghavadar	60	116	169	202	243	250

Cumulative Percentile of RSPM

(Winter Season 2007 - 2008)

Units: µg/m³

Sr. No.	Sampling Location	Min	Percentile				Max
			25th	50th	75th	98th	
1.	Arablus	65	100	109	122	167	178
2.	Gaduka	41	65	69	75	125	125
3.	Gagva	53	62	68	70	80	81
4.	Jogvad	76	90	94	102	123	125
5.	Kana Chikari	62	93	105	112	132	137
6.	Kanalus	90	123	149	159	168	169
7.	Khatiya	57	71	92	101	111	111
8.	Macchuberaja	70	97	114	153	165	166
9.	Meghpar	45	89	122	138	148	149
10.	Moti Khavadi	140	148	149	169	175	176
11.	Mota Lakhiya	62	75	88	99	117	120
12.	Mungani	110	126	136	143	174	175
13.	Nani Kavadi	108	147	157	160	164	165
14.	Nana Lakhiya	44	79	98	111	138	148
15.	Padana	59	71	95	119	141	145
16.	Rangpar	51	63	69	85	114	124
17.	Rasangpar	64	72	75	107	141	146
18.	Sapar	45	66	84	109	141	142
19.	Satalus	77	99	120	151	156	157
20.	Sevak Bharudiya	45	71	76	86	137	144
21.	Jivapar	36	64	79	91	117	110
22.	Balambhadi	74	98	104	118	138	139
23.	Dera Chikari	49	91	110	126	137	138
24.	Meghavadar	57	65	86	93	107	111

Cumulative Percentile of SO_2

(Winter Season 2007 - 2008)

Units: µg/m³

Sr. No.	Sampling Location	Min	Percentile				Max
			25th	50th	75th	98th	
1.	Arablus	12	15	17	20	24	25
2.	Gaduka	4	6	8	10	12	12
3.	Gagva	3	4	5	6	8	8
4.	Jogvad	11	14	16	22	27	28
5.	Kana Chikari	3	6	8	11	18	18
6.	Kanalus	14	20	35	46	64	65
7.	Khatiya	3	15	18	22	30	31
8.	Macchuberaja	8	31	43	53	77	78
9.	Meghpar	14	16	17	20	22	22
10.	Moti Khavadi	12	13	14	14	16	16
11.	Mota Lakhiya	12	15	17	20	21	21
12.	Mungani	3	4	5	5	8	8
13.	Nani Kavadi	3	3	4	5	7	7
14.	Nana Lakhiya	10	14	16	19	21	21
15.	Padana	8	9	10	11	12	12
16.	Rangpar	5	9	11	15	18	18
17.	Rasangpar	3	4	5	6	16	16
18.	Sapar	3	3	4	5	6	6
19.	Satalus	15	22	27	44	57	59
20.	Sevak Bharudiya	9	12	13	15	17	18
21.	Jivapar	4	8	9	10	14	14
22.	Balambhadi	3	9	12	14	17	17
23.	Dera Chikari	3	5	7	7	10	10
24.	Meghavadar	5	8	9	12	14	14

Cumulative Percentile of NOx

(Winter Season 2007 - 2008)

Units:µg/m³

Sr. No.	Sampling Location	Min	Percentile				Max
			25th	50th	75th	98th	
1.	Arablus	9	16	18	20	30	30
2.	Gaduka	5	8	9	14	18	18
3.	Gagva	4	5	7	8	11	12
4.	Jogvad	10	13	16	18	21	21
5.	Kana Chikari	6	24	32	36	59	66
6.	Kanalus	8	10	14	17	26	29
7.	Khatiya	6	9	12	14	19	20
8.	Macchuberaja	9	17	21	28	36	36
9.	Meghpar	9	13	15	16	21	22
10.	Moti Khavadi	8	12	13	20	22	23
11.	Mota Lakhiya	7	10	13	14	17	17
12.	Mungani	9	15	17	20	25	25
13.	Nani Kavadi	10	12	15	18	33	34
14.	Nana Lakhiya	7	11	13	14	21	21
15.	Padana	7	10	12	14	17	17
16.	Rangpar	8	11	12	14	16	16
17.	Rasangpar	5	7	8	10	20	21
18.	Sapar	7	12	17	18	42	50
19.	Satalus	7	12	14	16	21	22
20.	Sevak Bharudiya	9	13	16	17	22	23
21.	Jivapar	11	16	16	19	26	27
22.	Balambhadi	4	7	8	13	22	23
23.	Dera Chikari	7	10	12	13	21	22
24.	Meghaavadar	9	11	13	15	18	18

Cumulative Percentile of HCl

(Winter Season 2007 - 2008)

Units: µg/m³

Sr. No.	Sampling Location	Min	Percentile				Max
			25th	50th	75th	98th	
1.	Arablus	23	51	67	80	99	99
2.	Gaduka	23	42	50	59	98	99
3.	Gagva	28	35	43	52	63	64
4.	Jogvad	25	45	56	65	92	97
5.	Kana Chikari	48	63	71	81	96	97
6.	Kanalus	59	68	74	84	91	93
7.	Khatiya	44	50	59	70	97	97
8.	Macchuberaja	24	43	46	57	73	73
9.	Meghpar	20	28	37	53	62	64
10.	Moti Khavadi	32	60	70	75	83	83
11.	Mota Lakhiya	35	67	71	78	89	89
12.	Mungani	18	35	52	60	95	99
13.	Nani Kavadi	38	57	71	91	99	99
14.	Nana Lakhiya	24	47	55	63	85	85
15.	Padana	27	46	62	86	98	99
16.	Rangpar	26	36	41	44	54	55
17.	Rasangpar	38	51	56	61	85	86
18.	Sapar	45	55	64	74	86	88
19.	Satalus	43	55	58	65	89	92
20.	Sevak Bharudiya	25	36	53	66	82	88
21.	Jivapar	35	46	50	55	79	84
22.	Balambhadi	35	54	57	90	99	99
23.	Dera Chikari	54	67	72	86	98	98
24.	Meghavadar	46	53	56	64	72	75

Cumulative Percentile of Cl_2

(Winter Season 2007 - 2008)

Units: µg/m³

Sr. No.	Sampling Location	Min	Percentile				Max
			25th	50th	75th	98th	
1.	Arablus	10	11	12	14	21	22
2.	Gaduka	20	21	25	26	32	32
3.	Gagva	7	3	4	5	8	8
4.	Jogvad	1	1	2	3	4	4
5.	Kana Chikari	5	8	11	13	15	15
6.	Kanalus	8	23	25	27	32	32
7.	Khatiya	3	5	7	8	9	9
8.	Macchuberaja	2	4	5	6	8	8
9.	Meghpar	2	3	4	5	7	8
10.	Moti Khavadi	1	4	5	7	12	12
11.	Mota Lakhiya	12	17	25	26	30	30
12.	Mungani	3	5	7	8	12	12
13.	Nani Kavadi	11	8	11	12	14	14
14.	Nana Lakhiya	10	12	15	18	23	24
15.	Padana	18	20	22	24	28	28
16.	Rangpar	3	6	7	8	9	9
17.	Rasangpar	1	2	2	3	7	8
18.	Sapar	4	12	13	15	20	20
19.	Satalus	15	18	19	22	27	28
20.	Sevak Bharudiya	1	2	2	3	6	6
21.	Jivapar	2	4	6	7	11	12
22.	Balambhadi	2	18	27	47	57	58
23.	Dera Chikari	3	7	10	16	19	19
24.	Meghavadar	3	5	6	7	8	8

Concentrations of CO, Non-Methane Hydrocarbons and VOC
(Winter Season 2007 - 2008)

Units: µg/m³

Sr. No.	Sampling Location	Spot Sampling						
		CO	NMHC	1-3 Butadine	Benzene	Toluene	Ethyl Benzene	m/p xylene
1.	Arablus	655	111	0	0.1	0.2	0.1	0
2.	Gaduka	300	78	0.2	0.1	0.3	0.1	0
3.	Gagva	750	140	0.1	0.1	0.3	0.1	0
4.	Jogvad	669	80	0	0.1	0.4	0.1	0.05
5.	Kana Chikari	302	85	0.2	0.2	0.5	0.1	0
6.	Kanalus	721	111	0.1	0.1	0.4	0.1	0.05
7.	Khatiya	501	89	0.05	0.2	0.4	0.05	0
8.	Macchuberaja	499	81	0.1	0.1	0.3	0.1	0
9.	Meghpar	999	122	0.2	0.1	0.3	0.1	0
10.	Moti Khavadi	950	142	0.1	0.2	0.5	0.15	0.05
11.	Mota Lakhiya	302	79	0	0.1	0.6	0.1	0
12.	Mungani	612	115	0.2	0.2	0.4	0.1	0
13.	Nani Kavadi	806	109	0.2	0.2	0.5	0.15	0.05
14.	Nana Lakhiya	822	128	0	0.1	0.4	0.1	0
15.	Padana	408	78	0	0.1	0.35	0.1	0
16.	Rangpar	621	90	0.1	0.1	0.4	0.1	0
17.	Rasangpar	558	82	0	0.1	0.4	0.1	0
18.	Sapar	633	72	0	0.1	0.3	0.1	0
19.	Satalus	722	118	0.1	0.1	0.3	0.1	0
20.	Sevak Bharudiya	559	82	0	0.1	0.45	0.1	0
21.	Jivapar	500	79	0.1	0.1	0.3	0.1	0
22.	Balambhadi	453	81	0	0.1	0.4	0.1	0
23.	Dera Chikari	278	BDL	0.1	0.1	0.3	0.1	0
24.	Meghavadar	502	83	0.1	0.1	0.2	0.1	0

A note on ground level concentration for SPM, SO2, HCL and CL2 was high at some of the monitoring locations

The 2008 winter ambient air monitoring data indicates that GLC values of SO_2 were littlie more than the average for the area at a few locations but they were well below the National Ambient Air Quality Standards. However, the SPM concentrations were found to be marginally more than the average at some of the locations.

The predicted average incremental ground level concentrations is in the order of 18 µg/m³ & 22 µg/m³ for SO2 and NOx respectively with a standard deviation of 7 µg/m³and maximum predicted incremental value being 32 µg/m³ and 41 µg/m³ respectively in the SSW direction. All these values indicate GLC are well below the NAAQS.

Co_rrelation between varying SO2 emission rates from the Individual source and Stack Height

It is confirmed and clarified that all the stack height meets the statutory requirements prescribed by the MoEF / CPCB.

We very respectfully submit that, even though generally the SO2 emission and stack height are correlated to minimize ground SOx concentrations, the stack heights are determined by the pressure drop / draft requirements, furnace configuration, thermal efficiency and mechanical considerations. Some heaters have intrinsically higher stack height for the above reasons unrelated to fuel sulphur and SO2 emissions, as highlighted below:

1) The CDU / VDU heater stack height is 72 m in spite of low SO2 emission. The CDU / VDU heaters, have high heater duty, with two radiation chambers, with a common convection section, above. Minimum stack height has to be maintained above the convection section for safety and draft requirement reasons. The stack height is dependent on the heater duty and convection section height and not the SO2 emissions.

2) In case of the Parex unit heater also the stack height is governed by the size and height of the heater, instead of SO2 emissions.

In case of HRSG and boilers the stack height is at 80 meters, though HRSG has lower SO2 emissions than Aux. Boilers. In this case the draft requirements govern the stack height requirement instead of SO2 emission.

4.2 Noise Environment

Monitoring of noise levels in and around the project area was carried out to assess the impact of noise generated due to refinery operations and vehicular traffic on human settlements. Studies pertaining to noise environment were conducted as follows:

- Reconnaissance
- Measurement of noise levels
- Identification and characterization of noise sources
- Impact of noise exposure on community

4.2.1 Reconnaissance

The proposed SEZ is located near the village Kanalus. A fertilizer plant of Gujarat State Fertilizer Corporation (GSFC) is situated in front of the existing Reliance refinery. GSFC township is approximately at a distance of 3 km from the GSFC plant. The residential colony of Reliance Industries Limited is located adjacent to GSFC colony.

The State Highway from Jamnagar to Dwarka has higher vehicular density during the daytime. Approximately 500 vehicles per hour ply on the road during the day and 50-60 vehicles per hour during night. The nearest railway station for goods train is Motikhavadi, which is on the periphery of the existing RIL complex and in the vicinity of the SEZ proposed area.

Jamnagar Airbase is situated about 22 km from the SEZ site. The Indian Airforce aircrafts, which are mainly of supersonic category, fly three hours in the morning and two hours in the afternoon or evening during their routine exercise in this region.

4.2.2 Background Noise

Noise standards have been designated for different types of landuse, i.e. residential, commercial, industrial areas and silence zones, as per 'The Noise Pollution (Regulation and Control) Rules, 2000, Notified by Ministry of Environment and Forests, New Delhi, February 14, 2000'. The ambient noise standards are presented in **Annexure III**. Different standards have been stipulated during daytime (6 am to 10 pm) and nighttime (10 pm to 6 am).

The residential, commercial, industrial areas and silence zones close to the proposed SEZ and in the study area have been identified. These locations have been chosen away from the major roads and major noise sources so as to measure ambient noise levels. Equivalent noise levels (Leq) for a period of about 20 minutes have been measured at each monitoring location during day time and night time.

The background noise levels were measured using Dawe - Lucas Cell Sound Level Meter. The sampling locations are shown in **Fig. 4.2.1** and noise levels during day time and night time are presented in **Table 4.2.1**.

All measurements were carried out when the ambient conditions were unlikely to adversely affect the results as wind speeds were 1-3 m/sec and precipitation was not recorded.

4.2.2.1 Noise Levels in Residential and Commercial Areas

The noise levels in the villages have been monitored within study area of 10 km radial distance from proposed SEZ. Noise monitoring locations are shown in **Fig. 4.2.1**. The noise levels ranged between 43-51.5 dBA during daytime and 33-49 dBA during nighttime.

There is no major commercial activity and market in the study area. The noise levels in commercial areas varied in the range of 53-60 dBA during daytime and 30-40 dBA during nighttime**.**

4.2.2.2 Noise Levels in Industrial Areas

There are other major industrial units viz., Reliance Industries Limited, Refinery, fertilizer plant of Gujarat State Fertilizer Corporation (GSFC), power plant of Gujarat Electricity Board and cement plant of Digvijay Cement Company Limited.

Noise levels were measured in front of these industries during daytime and nighttime and observed to varying in the range of 46-59 dBA during daytime and 42-51 dBA during nighttime.

4.2.2.3 Noise Levels in Silence Zone

Noise levels were also monitored in schools, hospitals and temples in the study area. The noise levels varied from 37-45 dBA during daytime and 31-39 dBA during night time.

The noise levels are observed to be within the stipulated standards of CPCB for the respective zones in the study area.

4.2.3 Traffic Study

The existing refinery has facilities comprising of loading bays for LPG, light & heavy liquid products, sulphur and coke. Approximately 1000 trucks per day are loaded. The present rail gantry has provision to load one LPG rake and two white oil rakes simultaneously. Around 2 MMTPA of products are dispatched through this facility. The utilization of this facility is low due to the availability of rakes.

Traffic Count was made in front of Refinery Gate to account for traffic on SH-25 as well as vehicular movement due to refinery. Traffic survey was undertaken in December, 2005. Traffic survey undertaken indicated hourly traffic of 389 – 561 vehicles during daytime (0600 - 2200 Hrs). The heavy vehicles like trucks and buses form about 20-25% of total traffic count. Traffic count includes tankers transporting products from the adjacent Reliance refinery complex.

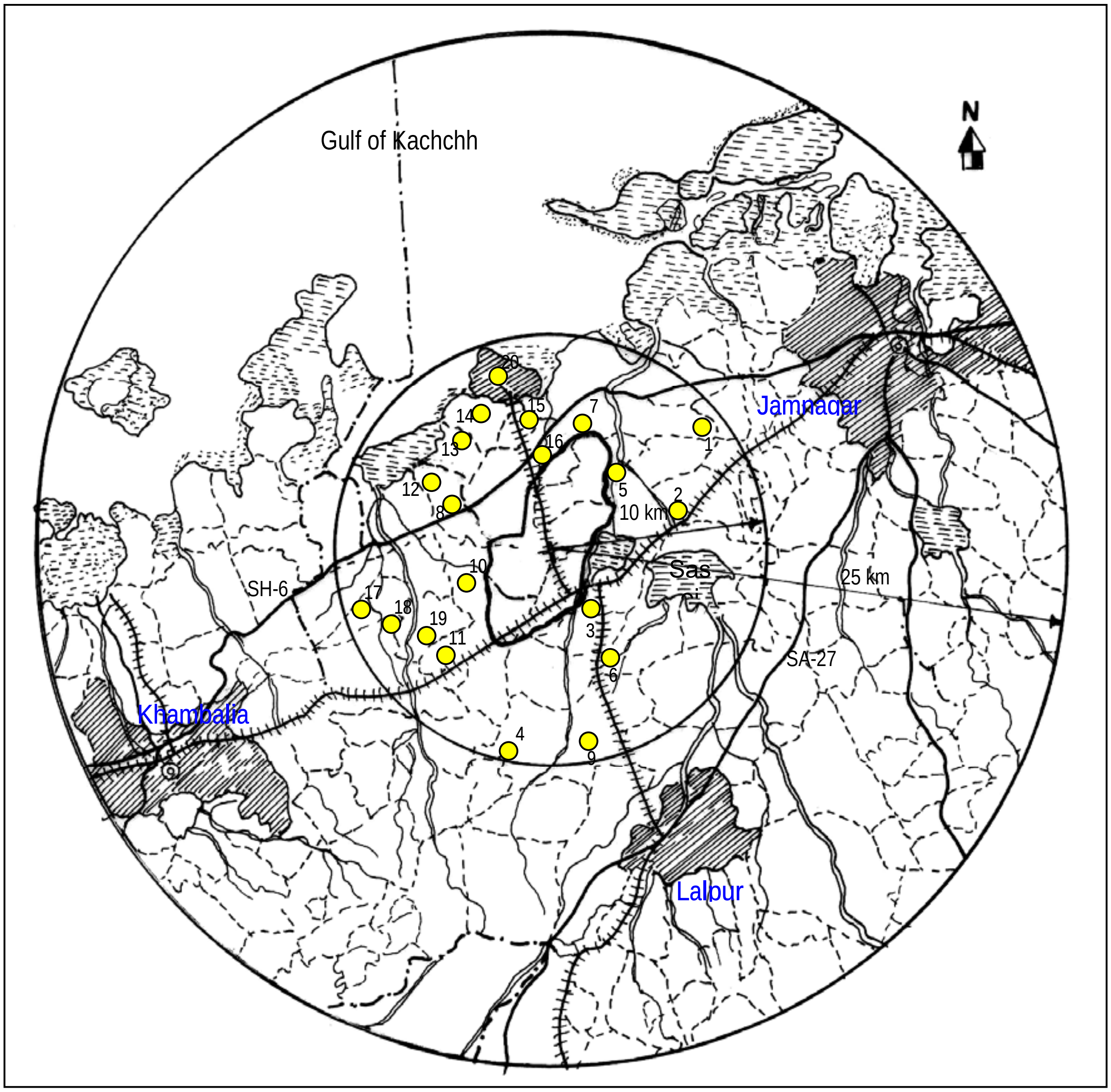


Fig. 4.2.1 : Sampling Location for Noise Monitoring

Table 4.2.1

Background Noise Levels in the Study Area

Sr. No.	Monitoring Locations	Noise Levels in dBA		Remarks
		Day Time (Leq)	Night Time (Leq)	
	Residential/Commercial Area			
1	Jivapar	50.8	42	Residential area
2	Balambhdi	51.4	41.6	Residential area
3	Kanalus	50.2	42	Residential area
4	Sevak bharudiya	44.0	39	Residential area
5	Dera Chikari	51.5	41.8	Residential area
6	Arablus	51.0	43.2	Residential area
7	Sapar	50.2	38	Residential area
8	Meghpar	49.1	48	Residential area
9	Machhu beraja	49.3	42.2	Residential area
10	Padana	46.8	41	Residential area
11	Rangpar	48.2	44.2	Residential area
12	Jogvad	50.2	41	Residential area
13	Gagva	53	30	Commercial area
14	Mungani	49.9	40	Residential area
15	Nani khavdi	48.7	41	Residential area
16	Motikhavdi	60	40	Commercial area
17	Khatiya berja	49	40	Residential area
18	Nana Lakhiya	43	33	Residential area
19	Mota Lakhiya	46	36	Residential area
	Industrial Area			
20	Sikka	57	50	In front of GEB Power Plant – Industrial Area
21	RIL Jetty	46	42	Industrial Area
22	Digvijay Cement Plant Gate	59	51	Industrial Area
23	GSFC Gate	52	44	Industrial Area with no traffic from GSFC

Sr. No.	Monitoring Locations	Noise Levels in dBA		Remarks
		Day Time (Leq)	Night Time (Leq)	
	Silence Zone			
24.	Community medical center, Motikhawadi	45	38	150 m away from main road
25.	Ashapura temple	40	39	
26.	School, Khatia	38	32	
27.	School, Gagva	37	31	
28.	School, Vasai	44	39	25 m away from SH-25
29.	School, Navagam	41	34	25 m away from SH-25

4.3 Water Environment

4.3.1 Reconnaissance

The project is located in Saurashtra region of Gujarat which is known for drought and water scarcity. The annual rainfall in the Jamnagar region is 578.9 mm with 24 rainy days (rainfall above 0.254 cm in day) in the year. May and June are generally the hottest months with a mean maximum temperature of about 36^0C. January is the coldest month with a mean maximum temperature of about 26^0C. The relative humidity is high throughout the year exceeding 70% on an average.

4.3.2 Baseline Data

Physico-chemical parameters alongwith biological indicators of pollution have been used for ascertaining the status of water environment around proposed SEZ. In order to determine the surface and groundwater quality, three sampling locations for surface water, 18 sampling locations for groundwater were identified in the study area. The water quality data collected in winter season 2005-06 were used to establish baseline status of water environment around the SEZ. The sampling locations for surface and ground water around the proposed SEZ are depicted in **Figure 4.3.1** and presented in **Table 4.3.1**.

4.3.2.1 Surface Water Resources

Jamnagar district of Gujarat is divided into two watershed regions by the Madhya Saurashtra plateau. The general slope of these watersheds is towards the Gulf of Kuchchh and the Arabian Sea. Rivers like Sasoi, Und, Sinhan, Bhagedi, Puna etc. flow towards north discharging into the Gulf of Kuchchh, whereas the river Vartu with its tributaries flow to southwest and ultimately meets the Arabian Sea. Dams have been constructed on these rivers to provide the irrigation water in the region. A small percentage of the reservoir water is used for drinking water supply to the nearby towns and villages. Water demand in most of the villages of the region is met from dug wells, hand pumps etc. and partly by river water.

There are three surface water sources in the form of reservoirs in the vicinity of the proposed project site. However, water demand of units in SEZ would be met from the new desalination plant coming up in SEZ and no external water resources will be used for this project . The Narmada Water Supply Project is in the pipeline and could be an added source to the SEZ water demand, if required.

There is no perennial river in the study area. The surface water samples have been collected from Kanalus, Gajana and Apia reservoirs located in the study area.

4.3.2.2 Methodology for Water Quality Assessment

Reconnaissance was undertaken and monitoring locations were decided based on:

- Drainage pattern;
- Location of residential areas representing different activities/likely impact areas and,
- Likely areas, which can represent baseline conditions.

The water samples were analyzed as per the procedures specified in 'Standard Methods for the Examination of Water and Wastewater' published by American Public Health Association (APHA) and 'A Course Manual for Water and Wastewater Analysis' by NEERI, Nagpur.

Samples for chemical analysis were collected in polyethylene carboys. Samples collected for metal content were acidified with HNO_3 acid (conc. 98%). Samples for bacteriological analysis were collected in sterilized glass bottles. Selected physico-chemical and bacteriological parameters have been analyzed for projecting the existing water quality status in the study area. Parameters like temperature, Dissolved Oxygen (DO) and pH were analyzed at the time of sample collection. Standard Operating Procedures (SOP) for water and wastewater sampling and analysis are presented in **Table 4.3.2**. The analytical techniques and the test detectable limits are given in the **Table 4.3.3**.

4.3.2.3 Surface Water Quality

The physico-chemical characteristics of surface water in winter season are summarized in the **Tables 4.3.4 to 4.3.7**. pH varied in the range of 8.6 – 8.8, turbidity 7 - 12 NTU, total dissolved solids (inorganics) 393-510 mg/l, hardness 206-313 mg/l, chloride 112-128 mg/l, and sulphate 25-32 mg/l.

Nutrient values in the form of nitrate-nitrogen and total phosphates are low in the range of 5.0 – 9.0 mg/l and 0.16-0.21 mg/l respectively. The values for demand parameters like DO, COD and BOD are in the range of 5.9 – 7.1 mg/l, 43 – 99 mg/l and 20-40 mg/l respectively. Oil & grease and hydrocarbons are found in non-detectable levels.

The overall water quality indicates that surface water is alkaline in nature having good buffering capacity with marginal inorganic and negligible organic load.

4.3.2.4 Groundwater Resources

The intrusion of seawater has affected the groundwater which has become saline in the areas adjacent to the sea. The major source of water around the area is groundwater. Most of the villages are having public dugwells and handpumps. The hydrogeology of the area is mainly affected by coastal salinity posing its complex pattern and grouped under hard rock, comprising “Deccan Trap”. The top soil cover consists of weathered formation of soft basalt rock of thickness varying from 3 to 4 m followed by rocky strata of basalt/laterite origin.

Water bearing zone in this area is found in the form of intermediate flow of basalt and can be tapped at 30-50 m, 60-65 m and 90-95 m. The rocks in this area do not have any primary porosity in the lower massive portion, but the top vesicular portion has some porosity because of vesicles formed due to escaping gases during cooling of lava. These rocks have no primary permeability as the vesicles are seldom interconnected. Water moving or flowing in the rock is due to fracturing and jointing. It provides passage for infiltration, storage and movement of groundwater. The water level of this area varies from 4 m to 12 m depending upon the rainfall and its duration. The average water level is at 6 m in the area covered right from State Highway-25 to village Gagwa as also in village Mungni, Sikka, Moti Khavadi and Jogwad. During the scarcity period, the water level in this area goes remarkably deep (14-16 m) in open wells. The upper water bearing zones get dry in the summer (after the month of March) and only deeper zones yield water. There is no direct connection observed between these zones and sea. Hence, the capacity of yielding water is also very less.

Small streams and nallahs are recharging the groundwater but have not affected the hydrology of this area. The direction of flow of streams and nallahs of this area is towards north (towards sea). The water quality in this area varies with distance from sea and the depth wise variation shows high dissolved solids having high nitrate but good buffering capacity. From the earlier study the area is demarcated into three zones and groundwater up to a depth of 90 m was found to be potable even during summer season. However, at areas near the coastal zones, pronounced effect of salinity (600-8,000 mg/l) from 30 m to 90 m depth was recorded. It is observed that the rate of intrusion of seawater into groundwater is very low as moved away from the coastal region and vice versa. Since the refinery complex is near to the coastal zone, soil is highly saline in nature and thus bearing high compactness indicating poor permeability and low groundwater discharge pattern as compared to the other zones.

4.3.2.5 Ground Water Quality

Eighteen groundwater samples inclusive of sixteen from tube well and two from dug well were collected in and around refinery complex and analysed. The physico-chemical characteristics of groundwater are presented in **Tables 4.3.4** to **4.3.7**. The groundwater quality showed high mineral contents in the form of total dissolved solids, total hardness, chloride, sulphate and sodium and were found in the range of 477-3024 mg/l, 259-1592 mg/l, 123-1200 mg/l, 42-328 mg/l and 36-500 mg/l respectively. Typical high mineral content in groundwater indicates seawater intrusion in groundwater with depth variation from 30 m to 90 m. The mineral content is high near the coastal areas and decreases with the distance away from the coastline.

4.3.3 Bacteriological Characteristics

Coliform group of organisms and faecal streptococci are indicators of bacterial pollution. The water samples were analysed for estimating total and faecal coliforms deploying membrane filtration techniques. The bacteriological characteristic for winter season is presented in **Table 4.3.8**. The bacteriological characteristics of surface water showed total coliform counts in the range of 220 to 310 CFU/100 ml. Both the reservoirs were found to be faecally contaminated having faecal coliforms in the range of 30-45 CFU/100 ml.

The groundwater in four villages (Gagwa, Kanachikari, Nanikhavdi and Mungni) is found to be faecally contaminated and unfit for human consumption, unless suitably treated.

4.3.4 Biological Characteristics

Studies on biological characteristics of water are important in EIA studies in view of the conservation of environmental quality and safety of natural flora and fauna including human being. As biological community depends on the conditions and resources of its location, it changes according to the changes in the habitat. The impact of pollution in aquatic ecosystem manifests itself first on the biotic aquatic ecosystem communities. The species composition of aquatic organisms in natural communities is directly related to water quality. The response of animals and plants to pollutants when measured quantitatively, gives an insight into the condition of existing aquatic ecosystem.

Because of complex inter-relationship, a change in the ecosystem causes one or more of the pollutants to change and be replaced by others, distinguishable as a different community. The changes in the diversity of biological communities, as a result of pollution in an aquatic ecosystem, can be mathematically expressed as diversity indices. Organic wastes eliminate sensitive organisms and provide food for the surviving tolerant forms. However, with natural stream purification, water quality improves so that the tolerant forms can flourish and subsequently diversity increases. On the other hand, toxic material eliminates sensitive organisms, and because of the restriction of food to that naturally occurring in the stream, numbers of tolerant surviving forms are limited. Very toxic materials may eliminate all organisms below a waste source. Thus, the nature and quality of such biological species in a particular environment is dependent on various physico-chemical characteristics of water and also on the nature of water body.

In fact, estimation with respect to plankton community structure in a water body would indicate its quality as follows:

(a) Indicator Organisms

Organisms have been listed in standard publications according to increasing tropic levels of aquatic environment. Increasing dominance of diatoms, flagellates, ciliates etc. indicate progressively increasing tropic conditions. Presence of euglenophycease indicates highly eutrophic conditions. Also, an increase in the abundance of total rotifers indicates advancing eutrophication.

(b) Diversity

Diversity of planktons depends on physico-chemical characteristics of water especially on trophic levels. In oligotrophic water diversity of plankton is high. While with increasing levels of pollution such as mesotrophic and eutrophic condition diversity of planktons decreases. Shannon Weaver Index is a measure of diversity of planktons, which takes into account the total count, and individual species count in a water sample.

$$d = -\Sigma (ni/n) \log_2 (ni/n)$$

where,

d = Shannon Weaver Diversity Index

ni = number of individual of each individual species in a sample

n = total number of individual and of all species in the sample

It is also noted that the diversity is susceptible to other parameters like turbidity, colour, flow rate etc.

A widely accepted ecological concept is that the communities with large number of species (i.e. with high diversity) will have high stability that can resist adverse environmental factors and thus greater is the structural complexity of the food web. The index values of 3 and above are generally considered healthy conditions of water bodies. The values between 1 and 3 and less than 1 are believed to be for semi and poor-productivity respectively. Systematic ecological monitoring of population dynamics and species composition of relevant parts of the ecosystems in surface water and groundwater around refinery complex was carried out.

The biological characteristics in terms of phytoplankton for surface and groundwater are presented in **Table 4.3.9**. Total counts in surface water and groundwater (dug wells) vary from 846 to 2266 per 100 ml and 987 to 4700 per 100 ml respectively. Phytoplanktons were recorded in four groups, out of which Bacillariophyceae is the dominant group. The Shannon-Weaver Diversity Index for phytoplanktons varies from 2.25-3.79 and from 1.0-2.75 in surface water and groundwater (dug wells) respectively.

The data on zooplankton in surface and groundwater is presented in **Table 4.3.10**. Samples show zooplankton population from 7500 to 18000 no/m^3 and from 267-4500 no/m^3 in surface and groundwater (dug wells) respectively. The Shannon Weaver Diversity Index of zooplanktons which is found to vary in the range of 1.846-2.320 in surface water and 0.918 to 105 in groundwater indicates low to moderate productivity.

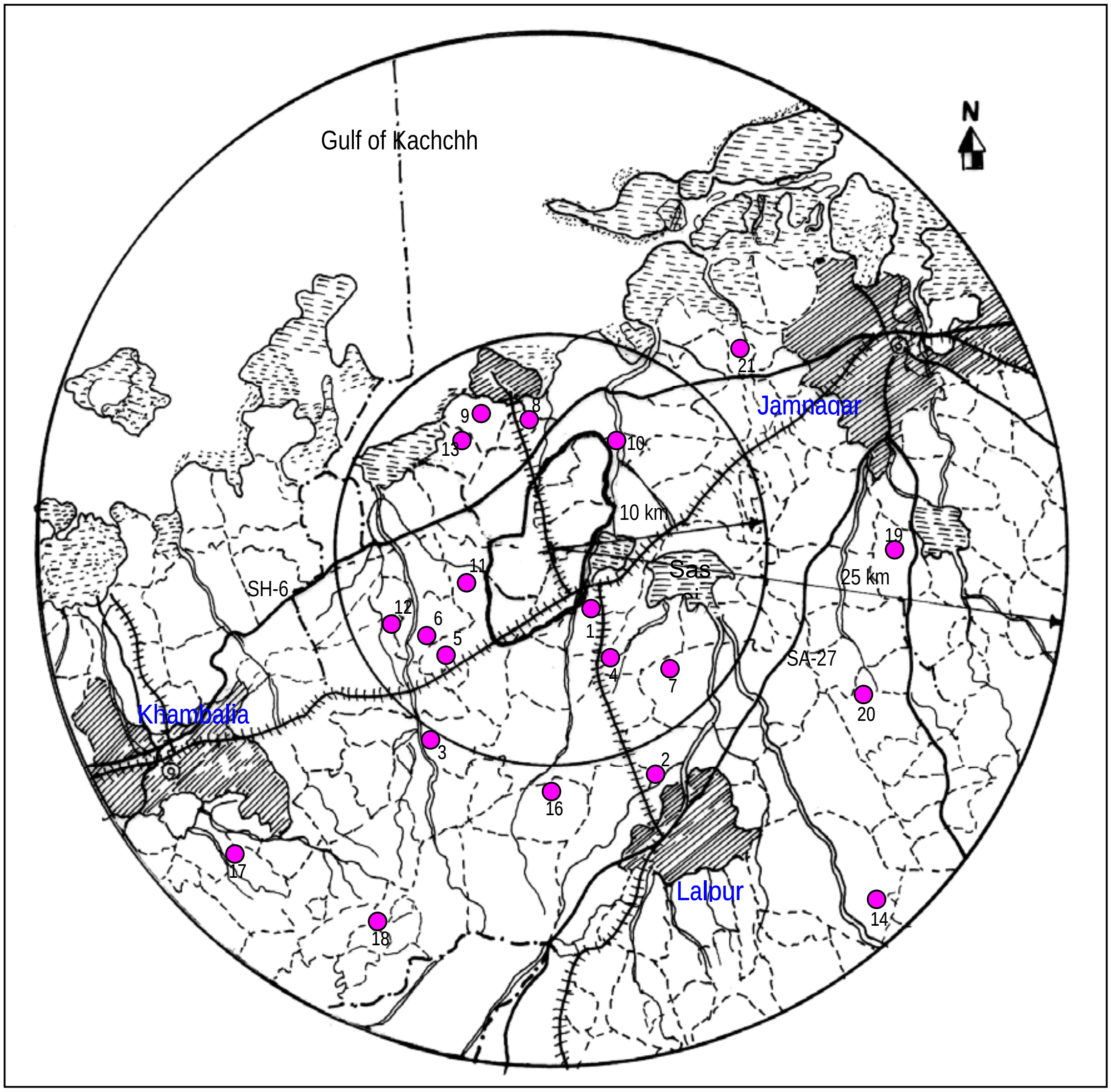


Fig. 4.3.1: Sampling Locations for Water Quality Monitoring (Surface and Ground Water)

Table 4.3.1

Sampling Locations for Water Quality

Sr. No.	Sampling Location
	Surface Water
1.	Kanalus
2.	Gajana
3.	Apla
	Ground Water
	Hand Pump
4.	Arablus
5.	Rangpar
6.	Mota Lakhiya
	Dug Well
7.	Sevak Dhunia
8.	Nanikhavdi
	Bore Well
9.	Mungani
10.	Kana Chhikari
11.	Padana
12.	Nana Lakhiya
13.	Gagva
	Tube Well
14.	Rinzpur
15.	Godavari
16.	Moti Rafudad
17.	Kota
18.	Bajana
19.	Naranpar
20.	Pipartoda
21.	Gordanpar

Table 4.3.2

Standard Operating Procedure for Water and Wastewater Sampling & Analysis

Sr.No.	Parameter	Sample collection	Sample size	Storage/ preservation
1	pH	Grab sampling Plastic /glass container	50 ml	On site analysis
2	Electrical Conductivity	Grab sampling Plastic /glass container	50 ml	On site parameter
3	Total suspended solids	Grab sampling Plastic /glass container	100 ml	Refrigeration, can be stored for 7 days
4	Total Dissolved Solids	Grab sampling Plastic /glass container	100 ml	Refrigeration, can be stored for 7 days
5	Oil & Grease	Wide mouth glass container	500 ml	Add HCl to pH>2, refrigeration, 28 days
6	BOD	Grab sampling Plastic /glass container	500 ml	Refrigeration, 48 hrs
7	COD	Grab sampling Plastic /glass container	100 ml	Add H_2SO_4 to pH>2, refrigeration; 28 days
8	Hardness	Grab sampling Plastic /glass container	100 ml	Add HNO_3 to pH<2, refrigeration; 6 months
9	Chlorides	Grab sampling Plastic /glass container	50 ml	Not required; 28 days
10	Sulphates	Grab sampling Plastic /glass container	100 ml	Refrigeration; 28 days
11	Sodium, Potassium	Plastic container	100 ml	Not required; 6 months
12	Fluorides	Plastic containers only	100 ml	Not required; 28 days
13	Hexavalent Chromium, Cr^{+6}	Plastic/ Glass rinse with 1+1 HNO_3	100 ml	Grab sample; refrigeration; 24 hrs
14	Heavy Metals (Hg, Cd, Cr, Cu, Fe, Zn, Pb etc.)	Plastic/ Glass rinse with 1+1 HNO_3	500 ml	Filter, add HNO_3 to pH>2; Grab sample; 6 months
15	Microbiology	Sterilized bottles	1 lits	Sterilized, Grab sample
16	Pesticides	Silicate glass sample, PTFE-lined cap	1000 ml	Add 1000 mg ascorbic acid/lit of sample; 7 days

Source: Standard methods for the examination of Water and Wastewater, published by APHA, AWWA, wef 21st Edition

Table 4.3.3

Analytical Techniques and Test Detectable Limits for Water and Wastewater Sampling and Analysis

Sr. No.	Parameters	Analytical Method **	Detection Limit
1	pH	4500-H+ B	
2	Color	2120 C	1
3	Temperature	2550 B	0.1°C
4	Conductivity	2510 B	0.5 micro mho/cm
5	Total Dissolved Solids	2540 C	0.5 mg/l
6	Total Suspended Solids	2540 D	0.5 mg/l
7	Dissolved Oxygen	4500-O C	0.1 mg/l
8	B.O.D. (3days at 27^0c)	5210 B	0.5 mg/l
9	C.O.D.	5220 B	0.1 mg/l
10	Total Coliform	9255	1
11	Feacal Coliform	9230	1
12	Total Hardness as $CaCO_3$	2340 C	0.1 mg/l
13	Sodium as Na	3500-Na	0.1 mg/l
14	Potassium as K	3500-K	0.1 mg/l
15	Chlorides as Cl	$4500\text{-}Cl^-$	0.01 mg/l
16	Sulfates as SO_4^2	4500-SO4	0.1 mg/l
17	Fluorides as F	$4500\text{-}F^-$	0.1 mg/l
18	Total Kjeldhal Nitrogen	$4500\text{-}N_{org}$	0.5 mg/l
19	Copper as Cu	3500-Cu	0.01 mg/l
20	Lead as Pb	3500-Pb	0.01 mg/l
21	Manganese as Mn	3500-Mn	0.01 mg/l
22	Iron as Fe	3500-Fe	0.01 mg/l
23	Mercury as Hg	3500-Hg	0.001 mg/l
24	Zinc as Zn	3500-Zn	0.01 mg/l
25	Chromium as Cr	3500-Cr	0.01 mg/l
26	Total Coliform	9255	1

*** Source : Standard methods for the examination of Water and Wastewater, published by APHA, AWWA, wef 21st Edition*

Table 4.3.4

Water Quality - Physical Parameters

S. No.	Sampling Location	pH	Tempe-rature (^{O}C)	Turbidity (NTU)	Total Suspended Solids (mg/l)	Total Dissolved Solids (mg/l)	Conductivity ($\mu S/cm$)
Surface Water							
1.	Kanalus	8.6	28	12	18	400	610
2.	Gajana	8.6	28	8	22	393	595
3.	Apla	8.8	29	7	8	510	749
Ground Water							
Hand Pump							
4.	Arablus	8.5	28	3	1.0	800	1100
5.	Rangpar	8.1	28	2	1.0	1450	2420
6.	Mota Lakhiya	8.0	30	6	2.0	1230	2050
Dug Well							
7.	Sevak Dhunia	8.0	28	2	7	3024	5040
8.	Nanikhavdi	7.5	26	2.3	3.1	1242	2262
				Bore Well			
9.	Mungani	8.1	27	1.6	4.0	612	1140
10.	Kana Chhikari	7.5	29	1.3	3.2	650	1230
11.	Padana	8.1	28	2.1	4.3	1025	1940
12.	Nana Lakhiya	8.0	27	2.1	3.5	930	1650
13.	Gagva	7.6	26	<1	3.	477	850
Tube Well							
14.	Rinzpur	8.4	26	1	11	1290	2150
15.	Godavari	8.4	27	2	2	910	1431
16.	Moti Rafudad	8.6	27	2	1	1000	1567
17.	Kota	8.3	26	2	7	1841	2670
18.	Bajana	8.7	28	3	8	1140	1959
19.	Naranpar	8.6	27	2	1	650	1071
20.	Pipartoda	8.9	27	3	1	756	1145
21.	Gordanpar	8.9	28	1	1	760	1255

Table 4.3.5

Water Quality - Inorganic Parameters

S. No.	Sampling Location	Total alkalinity	Total hardness	Calcium hardness	Chloride	Sulphate	Sodium	Potassium
		(as $CaCO_3$)						
		(mg/l)						
Surface Water								
1	Kanalus	134	206	142	114	32	64	02
2	Gajana	115	235	157	128	25	47	01
3	Apla	213	313	191	112	32	58	01
Ground Water								
Hand Pump								
4	Arablus	156	465	258	278	69	90	01
5	Rangpar	221	667	431	430	135	221	01
6	Mota Lakhiya	223	419	210	450	65	292	03
Dug Well								
7	Sevak Dhunia	538	1592	1113	1200	328	500	05
8	Nanikhavdi	327	777	402	317	278	141	05
Bore Well								
9	Mungani	106	259	160	123	75	59	02
10	Kana Chhikari	192	367	253	164	90	81	01
11	Padana	307	912	509	317	209	111	02
12	Nana Lakhiya	202	432	230	260	249	188	06
13	Gagva	106	259	160	123	75	59	02
Tube Well								
14	Rinzpur	200	694	502	361	122	82	04
15	Godavari	222	585	350	270	100	90	01
16	Moti Rafudad	159	516	400	336	78	145	01
17	Kota	555	861	605	531	155	300	02
18	Bajana	445	752	559	274	142	124	01
19	Naranpar	322	447	234	134	42	70	01
20	Pipartoda	306	563	379	161	68	36	01
21	Gordanpar	247	448	322	202	55	68	02

Table 4.3.6

Water Quality - Nutrient, Demand and Organic Parameters

4S. No.	Sampling Location	Nitrate as N	Total Phosphates	Dissolved Oxygen	Chemical Oxygen Demand	Bio-chemical Oxygen Demand
		(mg/l)				
Surface Water						
1.	Kanalus	5.0	0.20	6.7	48	22
2.	Gajana	5.0	0.16	5.9	43	20
3.	Apla	9.0	0.21	7.1	99	40
Ground Water Hand Pump						
4.	Arablus	11	0.16	2.4	2.0	-
5.	Rangpar	50	0.10	1.4	17	<3
6.	Mota Lakhiya	36	0.10	5.6	10	<3
Dug Well						
7.	Sevak Dhunia	11	0.18	4.6	6.0	-
8.	Nanikhavdi	6.6	0.25	4.3	5.2	<3
Bore Well						
9.	Mungani	6.0	0.31	5.4	5.8	<3
10.	Kana Chhikari	5.6	0.26	4.3	3.8	<3
11.	Padana	6.6	0.30	4.0	3.9	<3
12.	Nana Lakhiya	7.2	0.31	4.1	4.2	<3
13.	Gagva	4.2	0.30	6.1	5.2	<3
Tube Well						
14.	Rinzpur	20	0.16	3.8	30	-
15.	Godavari	11	0.16	2.9	6	-
16.	Moti Rafudad	33	0.15	2.3	2	-
17.	Kota	11	0.24	1.9	22	-
18.	Bajana	11	0.18	2.4	10	-
19.	Naranpar	9	0.20	2.6	27	-
20.	Pipartoda	11	0.17	2.8	32	-
21.	Gordanpar	2	0.14	2.9	51	20

Table 4.3.7

Water Quality - Heavy Metals

S. No.	Sampling Location	Cadmium	Chromium	Copper	Lead	Iron	Manga-nese	Zinc
		mg/l						
Surface Water								
1.	Kanalus	0.013	0.004	0.010	0.214	0.19	0.017	14.45
2.	Gajana	0.017	0.073	0.014	0.406	0.813	0.239	33.45
3.	Apla	0.009	0.004	0.013	0.140	0.178	0.013	0.027
Ground Water Hand Pump								
4.	Arablus	0.029	0.039	0.040	0.432	0.453	0.026	4.93
5.	Rangpar	ND	ND	0.02	ND	ND	ND	7.32
6.	Mota Lakhiya	ND	0.01	ND	ND	0.98	ND	0.63
Dug Well								
7.	Sevak Dhunia	0.025	0.047	0.035	0.390	0.394	0.020	27.45
8.	Nanikhavdi	0.01	ND	ND	ND	0.56	ND	ND
Bore Well								
9.	Mungani	ND	0.15	ND	ND	0.75	ND	ND
10.	Kana Chhikari	ND	0.16	ND	ND	0.15	ND	ND
11.	Padana	0.04	0.03	ND	ND	0.25	0.12	0.19
12.	Nana Lakhiya	0.03	0.08	ND	ND	0.28	0.37	0.48
13.	Gagva	0.02	0.05	ND	ND	0.89	0.15	0.07
Tube Well								
14.	Rinzpur	0.011	0.024	0.012	0.192	0.432	0.014	22.01
15.	Godavari	0.008	0.011	0.014	0.154	0.58	0.05	10.26
16.	Moti Rafudad	0.007	ND	0.008	0.128	ND	0.009	8.12
17.	Kota	0.011	0.026	0.032	0.224	0.875	0.061	16.36
18.	Bajana	0.010	0.037	0.011	0.190	1.475	0.043	7.47
19.	Naranpar	0.008	0.005	0.015	0.162	0.647	0.006	22.16
20.	Pipartoda	0.011	0.029	0.013	0.202	0.273	0.006	62.56
21.	Gordanpar	0.010	0.015	0.014	0.205	1.38	0.017	24.01

ND - Not Detectable

Table 4.3.8

Water Quality - Bacteriological Parameters

Sr. No.	Sampling Location	Total Coliform	Faecal Coliform
		CFU/100 ml	
Surface Water			
1.	Kanalus	230	30
2.	Gajana	220	45
3.	Apla	310	35
Hand Pump			
4.	Arablus	150	40
5.	Rangpar	ND	ND
6.	Mota Lakhiya	70	10
Dug well			
7.	Sevak Dhunia	520	105
8.	Nanalakhiya	484	248
Groundwater			
9.	Mungani	200	238
10.	Kana Chhikari	2030	460
11.	Padana	ND	ND
12.	Nana Lakhiya	358	56
13.	Gagva	5300	460
Tube Well			
14.	Rinzpur	240	30
15.	Godavari	150	30
16.	Moti Rafudad	ND	ND
17.	Kota	ND	ND
18.	Bajana	70	ND
19.	Naranpar	70	ND
20.	Pipartoda	ND	ND
21.	Gordanpar	ND	ND

ND - Not Detectable CFU - Colony Forming Unit

Table 4.3.9

Water Quality – Biological Parameters (Phytoplankton)

Sr. No.	*Sampling Locations*	Total Count no/ 100ml	Percentage of Composition of Algal Groups				Shannon Weaver Diversity Index
			Bacillario-phyceae	Cyano -phyceae	Chloro-phyceae	Eugleo-phyceae	
Surface Water							
1.	Kanalus	846	50	17	-	-	2.25
2.	Gajana	1222	27	18	-	9	3.19
3.	Apla	2266	23	12	-	12	3.79
Hand Pump							
4.	Arablus	ND	-	-	-	-	-
5.	Rangpar	-	-	-	--	-	-
6.	Mota Lakhiya	-	-	-	-	-	-
Dug well							
7.	Sevak Dhunia	987	64	12	12	12	2.75
8.	Nanalakhiya	-	-	-	-	-	-
Groundwater							
9.	Mungani	1880	50	-	50	-	1
10.	Kana Chhikari	-	-	-	--	-	-
11.	Padana	-	-	-	-	-	-
12.	Nana Lakhiya	-	-	-	-	-	-
13.	Gagva	4700	40	-	60	-	1.522
Tube Well							
14.	Rinzpur	ND	-	-	-	-	-
15.	Godavari	ND	-	-	-	-	-
16.	Moti Rafudad	ND	-	-	-	-	-
17.	Kota	ND	-	-	-	-	-
18.	Bajana	ND	-	-	-	-	-
19.	Naranpar	ND	-	-	-	-	-
20.	Pipartoda	ND	-	-	-	-	-
21.	Gordanpar	ND	-	-	-	-	-

\- Not found

Table 4.3.10
Biological Parameter – Zooplankton

Sr No.	*Sampling Locations*	*Total Count no/ m^3*	*Percentage of Organisms in Groups*			
			Protozoa	**Rotifera**	**Cladocera**	**Shannon Weaver Diversity Index**
Surface Water						
1.	Kanalus	7500	-	-	60	2.320
2.	Gajana	18000	-	58	25	2.190
3.	Apla	15000	-	50	10	1.846
	Hand Pump					
4.	Arablus	ND	-	-	-	-
5.	Rangpar	-	-	-	-	-
6.	Mota Lakhiya	-	-	-	-	-
Dug well						
7.	Sevak Dhunia	4500	-	-	-	0.918
8.	Nanalakhiya	-	-	-	-	-
Groundwater						
9.	Mungani	133	50	50	-	1
10.	Kana Chhikari	-	-	-	-	-
11.	Padana	-	-	-	-	-
12.	Nana Lakhiya	-	-	-	-	-
13.	Gagva	267	25	25	50	105
Tube Well						
14.	Rinzpur	ND	-	-	-	-
15.	Godavari	ND	-	-	-	-
16.	Moti Rafudad	ND	-	-	-	-
17.	Kota	ND	-	-	-	-
18.	Bajana	ND	-	-	-	-
19.	Naranpar	ND	-	-	-	-
20.	Pipartoda	ND	-	-	-	-
21.	Gordanpar	ND	-	-	-	-

\- Not found

4.4 Land Environment

4.4.1 Reconnaissance

The study area around SEZ complex covers parts of Saurashtra region. The rainfall brought by south-west monsoon in the region is scanty and irregular with an average rainfall of 470 mm per annum. The detail information regarding the landuse pattern of these villages is also collected.

Eighteen locations were identified for collection of soil samples in study area located at different distances and in different directions from the project site. Sampling locations are shown in **Fig. 4.4.1** and listed in **Table 4.4.1**. Soil samples were analysed for relevant parameters using standard procedures of Soil Chemical Analysis (M.L. Jackson). In some of the villages, water samples were collected to assess their irrigation quality.

4.4.2 Geology at Project Site

The study area is covered by Deccan Trap basalt of cretaceous age. A geological succession of the study area is presented below:

Mesozoic Era	Lower Eocene to Upper Cretaceous Epoch	Deccan Trap Formation

Basalt occurring in this region is dark black, hard and compact, with variations in texture leading to massive, weathered and amygdoloidal types. The traps of this area are invariably jointed. Besides vertical and horizontal joints and sheet joints, horizontal shears occurring at a depth of 40 m below ground level have connection with upper strata through vertical joints or fractures. The fractures are oriented in NE-SE and NW-SW directions.

The top most basalt layer is often weathered with thickness varying from 6 to 12 m below ground level. This formation also has number of open fractures and joints. At places the weathering of this formation has given rise to pale-brown fragmented material with admixture of brownish or pale yellow soil.

Basic dykes are present in the region and could be observed as prominent ridges cris-crossing the entire study area. The lithologs indicate that these dykes are extending upto greater depths.

4.4.3 Baseline Status

Eighteen (18) villages/site were identified for existing soil quality assessment. The locations and names of villages/site of project site are given in **Table 4.4.1** and their relative distribution is depicted in **Fig. 4.4.1**.

Representative soil samples from depth (0-25 cm) were collected from these villages and project site for estimation of the physicochemical characteristics of soil. Standard methods have been followed for the analysis of soil samples.

The international pipette method (Black, 1964) was adopted for determination of particle size analysis. The textural diagram was generated using "SEE soil class 2.0 version based on the United States Department of Agriculture (USDA) classification of soil. Physical parameters such as bulk density, porosity and water holding capacity were determined by KR box method (Keen and Raczkowski, 1921)

The chemical characteristics of soil were determined by preparing soil extract in distilled water in ratio 1:1 (Jackson, 1967). Organic carbon was determined by Walkley and Black method (1972). Fertility status of soil in terms of available nitrogen was determined by Kjeldhal method and available phosphorus was determined by Chlorostannus Reduced Molybdo Phosphorus Blue Colour method (Olsen method). Potassium was determined by flame photometric method (Jackson ML 1967)

Heavy metals in soil were determined by extracting soil will conc. H_2SO_4 conc. HNO_3 followed by analysis on ICP or AAS (APHA, 1995).

4.4.3.1 Physical Characteristics of Soil

For studying soil profile of the region, sampling locations were selected to assess the existing soil conditions around the project area representing various land use conditions. The physical, chemical and heavy metal concentrations were determined along with biological parameters. The samples were collected by ramming an augur into the soil upto a depth of 100 cm. The soil samples were collected during the winter season. The sampling locations have been identified with the following objectives:

1. To determine the baseline soil characteristics of the study area; and
2. To determine the impact of proposed project on soil characteristics.

The soils are Vertic Ustochrepts. They are residual soils predominantly having basaltic trap as a parent material and at some places granite and gneiss as a parent material. They are calcareous in nature with a murum layer below 40 cm depth. The soils are well drained with subangular blockey structure, sticky and hard in consistency. They can be broadly classified into alluvial, black, light brown and alkaline.

Soils were analysed for physical characteristics delineated through specific parameters viz. particle size distribution, bulk density, porosity, water holding capacity and texture. The particle size distribution in terms of percentage of sand, silt and clay is presented in **Table 4.4.2** and shown in **Fig. 4.4.2**. It is observed that soil texture varies from clay to sandy clay. The bulk density of soil of the impact zone is found to be 1.11 - 1.35 gm/cm^3 which is considered to be moderate.

Soil porosity is a measure of air filled pore spaces and provides information about movement of gases, inherent moisture development of root system and strength of soil. The porosity and water holding capacity of soil are in the range of 39-66% and 40-69% respectively. The soils have moderate water holding capacity.

4.4.3.2 Chemical Characteristics

The chemical characteristics of soil, viz. pH, electrical conductivity, soluble anions and cations, cation exchange capacity (CEC), exchangeable cations, exchangeable sodium percentage, nutrients, organic contents and heavy metals are presented in **Tables 4.4.3** to **4.4.8**.

It is observed that pH of soil in the study area are in the range of 6.52 - 8.6. The pH range of soil is found to be favorable for plant growth. Moreover, soil does not indicate acidification due to operation of various industries in the region which emit acidic precursor gases such as SO_2 and NOx. Electrical conductivity, a measure of soluble salts in soil is in the range of 0.27-1.6 mS/cm as presented in Table 4.4.4. It is observed that calcium and magnesium concentrations are in the range of 0.12-3.92 meq/l and 0.02-1.43 meq/l respectively; whereas sodium and potassium are in the range of 0.08-1.03 meq/l and 0.02-0.15 meq/l respectively.

Variations in cation exchange capacity (CEC) of soil in the study area are presented in **Table 4.4.5**. CEC was observed in the range of 40.6-50.2 meq/100 gram. Amongst the exchangeable cations, calcium and magnesium are found in the range of 22.4-30.7 and 11.2-15.2 meq/100 gm of soil respectively. Exchangeable sodium percentage (ESP) is ranged from 2.1-3.18%. The relationship of CEC with productivity and absorptivity is presented in **Tables 4.4.6** - **4.4.7**.

Organic matter present in soil influences its physical and chemical properties and is responsible for stability of soil aggregates. Organic carbon is in the range of 0.1 – 0.82%. Nitrate nitrogen in the available form is very essential nutrient for plant growth and observed in the range of 138.1-197.2 kg/ha of soil **(Table 4.4.8)**.

Fertility status of these soils is given in **Table 4.4.8**. The soils are poor to medium in nitrogen and poor to medium in potassium and phosphorus contents. The presence of organic carbon indicates the soil is rich in organic manure.

Plants require some heavy metals at microgram level for their metabolic activities. These heavy metals are termed as micro-nutrients and their deficiency becomes a limiting factor in plant growth. Levels of heavy metals in soils are presented in **Table 4.4.9**.

4.4.4 Soil Microbiology

Various ecological cycles in rhizosporo of plant depend upon microbial population. The population of bacteria, fungi and actinomycetes are vital components of soil and help in maintaining stability. Characteristics of soil microorganisms are presented in **Table 4.4.10**.

Rhizobium and Azotobactor are symbiotic and non-symbiotic nitrogen fixing microorganisms and improve soil fertility by fixing nitrogen in soil. Fungi also constitute an important part of the microflora at normal soil. Total viable micro-organism population per gram of soil varied from 13 x 10^6 to 94 x 10^6 Colony Forming Units. Different microflora observed per gram of soil were fungi (2x10^4 - 15 x 10^4 CFU), actinomycetes (2 x 10^4 – 10 x 10^4 CFU), rhizobium (2 x 10^4 – 8 x 10^4 CFU), and azotobacter (2 x 10^4 - 16 x 10^4).

4.4.5 Landuse Pattern

The landuse pattern in the study is presented in **Table 4.4.11**. The Unirrigated land is the maximum 50% followed by area not available for cultivation 24%. A pie chart representing landuse pattern is shown in **Fig. 4.4.3**.

4.4.6 Remote Sensing Studies for Land use Analysis

Remote Sensing Studies

Remote Sensing technology has emerged as a powerful tool in providing reliable information on various natural resources at different levels of details in a spatial format. It has played an important role in effective mapping and periodic monitoring of natural resources environment.

With the availability of high resolution remote sensing data, newer areas of remote sensing applications have been identified, techniques of data processing have been improved and computer based image processing systems have become more effective.

Data Used

In order to strengthen the baseline information on existing landuse pattern, the following data at the latitude (22°07'-22°35') N longitude (69°38'-70°08') E (approx.) were used:

A. Remote sensing data

IRS P6 LISS III Scene

Path 90, Row 56 dated 31-Dec-2003; CD format

B. Collateral data

Detailed location map

Methodology

Salient features of Methodology are given below:

- Acquisition of Satellite data
- Data loading
- Data processing
- Geo-referencing Image
- Rectification
- Classification
- Ground Truthing / field Checks using Global Positioning System
- Masking

The spatial resolution and the spectral bands in which the sensor collects the remotely sensed data are two important parameters for any landuse survey. IRS P6 LISS III data offers spatial resolution of 23.5 m with the swath width of 141 x 141 km. The data is collected in four visible bands namely green (Band 2) (0.52-0.59μ), red (Band 3) (0.62-0.69μ), near Infrared (NIR) (Band 4) (0.77-0.89μ), Short wave infrared band (Band 5) (1.55-1.75μ) with orbit repeat period of 24 days (three days revisit). The shapes, sizes, colours, tone and texture of several geomorphic features are visible in IRS data. Four spectral bands provide high degree of measurability through band combination including FCC generation, bands rationing, classification etc. These features of the IRS data are particularly important for better comprehension and delineation of the landuse classes. Hence, IRS P6 LISS-III data has been used for landuse mapping.

The digital image processing was performed on ERDAS IMAGINE 8.7 System on high-configured computer. This software package is a collection of image processing functions necessary for pre-processing, rectification, band combination, filtering, statistics, classification etc. Apart from contrast stretching, there are large numbers of image processing functions that can be performed on this station.

The satellite data from the compact disc is loaded on the hard disk and by studying quick looks (the sampled image of the appropriate area), the sub-scene of the study area is extracted.

Supervised classification using all the spectral bands can separate fairly accurately, the different landuse classes at level II on the basis of the spectral responses, which involve the following three steps:

a) Acquisition of ground truth

b) Calculation of the statistics of training area

c) Classification using maximum likelihood algorithm

The training areas for classification were homogeneous, well spread throughout the scene with bordering pixels excluded in processing. Several training sets have been used through the scene for similar landuse classes. After evaluating the statistical parameters of training sets, the training areas were rectified by deleting no congruous training sets and creating new ones.

Results

Landuse refers to man's activities on land, utilitarian in nature whereas landcover denotes the vegetation cover, water body cover and artificial constructions etc.

The landuse/landcover classification system standardized by Department of Space, for mapping different agro-climatic zones has been adopted. This classification system has six major landuse classes at level I and twenty eight at level II **(Table –4.4.12)**. The six major classes at level I was further enunciated in the following six categories:

a) **Built up land**: This comprises areas of land covered by structures

b) **Agricultural land**: Land used for production of food, fiber, crop and plantation

c) **Forest**: This includes land such as dense or sparse evergreen forests, deciduous Forests and degraded forests.

d) **Wastelands**: Land having potential for development of vegetation cover but not being used due to constraint includes salt affected land, eroded land and water logged areas.

e) **Water bodies:** Area persistently covered by water such as rivers/streams, reservoirs / tanks, lakes / ponds and canals

f) **Others**: Grassland and snow covered land are included in this category.

Landuse / landcover distribution in the study area has been estimated as given below using the above classification system and digital analysis techniques.

Plate I

Plate I is the LISS III Imagery showing 25 Km. radial area around the proposed SEZ at Jamnagar. In the image, vegetation (plantation, shrub, forest) appears red, water bodies and river as blue/dull green. Attributes such as colour, tone, texture, shape and size are used to interpret the image visually. Morphologically the area is a flat terrain as it belongs to the coastal plain. The study area mostly covers vegetation cover, water body and agricultural land. Fallow land is also depicted in the imagery by its light green tone. Saltpan is identified by its typical rectangular pattern and white tone seen along coast. Inland Water bodies are well spread in the vicinity of the study area. Settlements are also well identified by its typical spectral response.

Plate II

It is the colour-coded output of supervised classification of 25 Km. radial area around proposed SEZ at Jamnagar with colours assigned to various classes. In this image, colours are assigned to various classes as given in legend. The landuse / landcover classification indicates 9.3% area covered by water bodies, 39.52% agricultural land (crop land, fallow land, Plantation), and 4.36 % fringe vegetation etc.) **(Table – 4.4.13)**. Fourteen different classes are identified along with corresponding area. Water bodies are mainly seawater and reservoir water. Agricultural activity mostly occurs through out the area. The Yellow colour in the landuse map indicates the agricultural land. The fallow is found to be associated with agricultural lands. The water bodies and seawater is assigned by the blue and light blue colour in the land use map respectively.

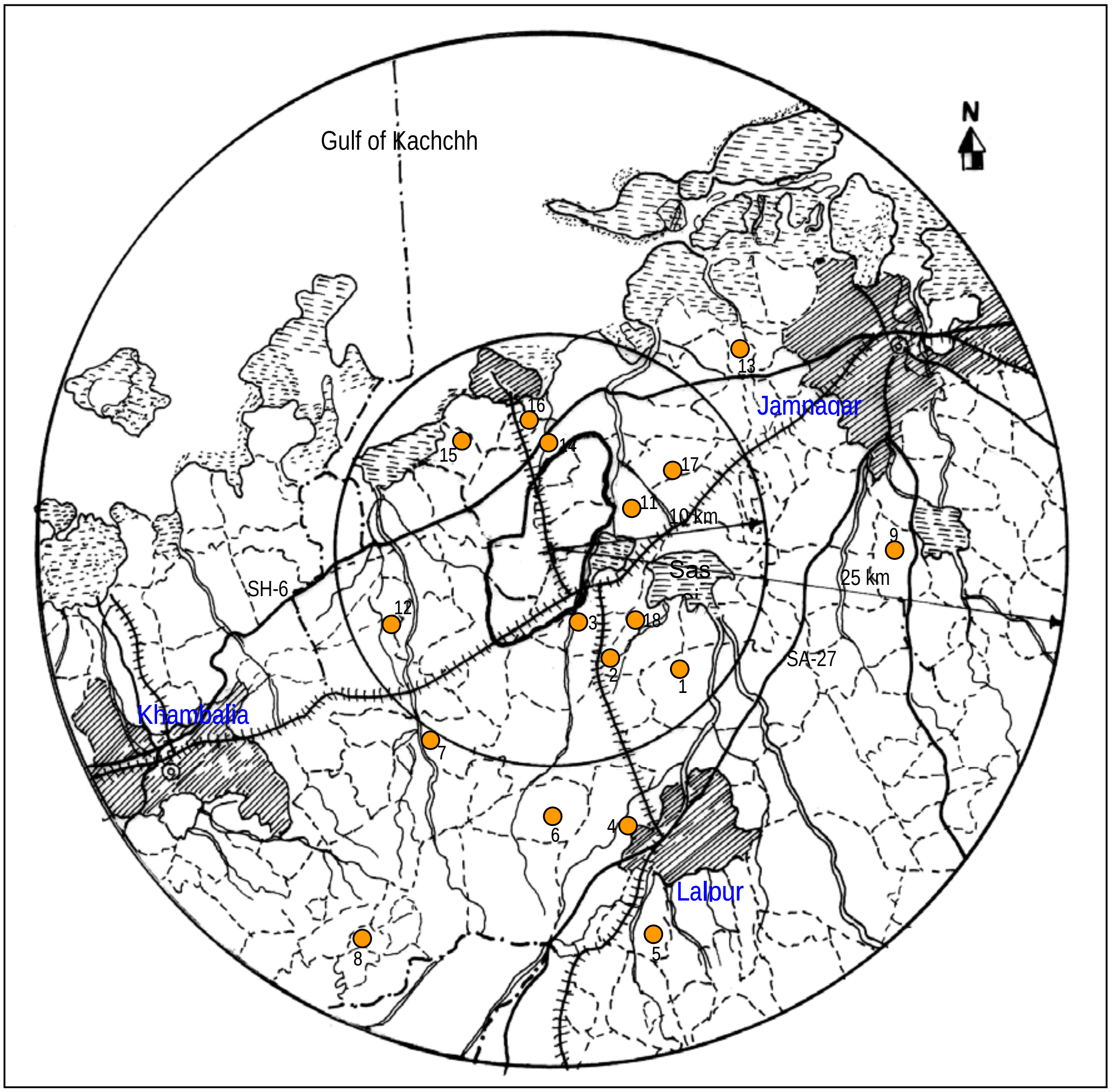


Fig. 4.4.1: Locations Identified for Soil Sampling

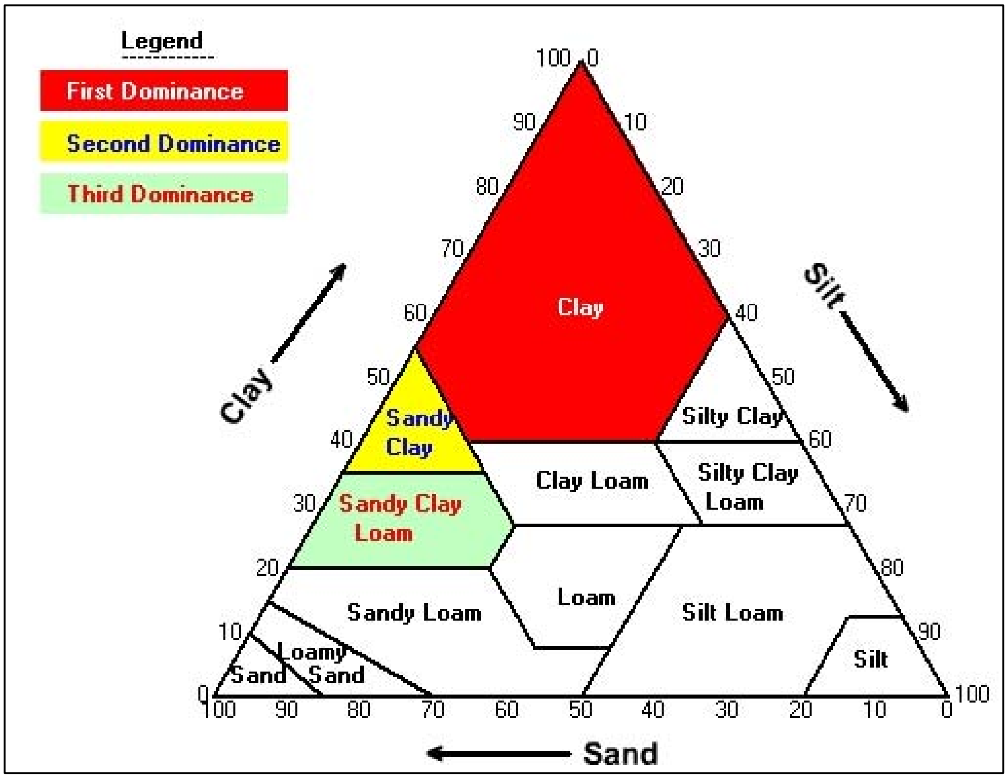


Fig. 4.4.2 : Texture Diagram for Soil Samples

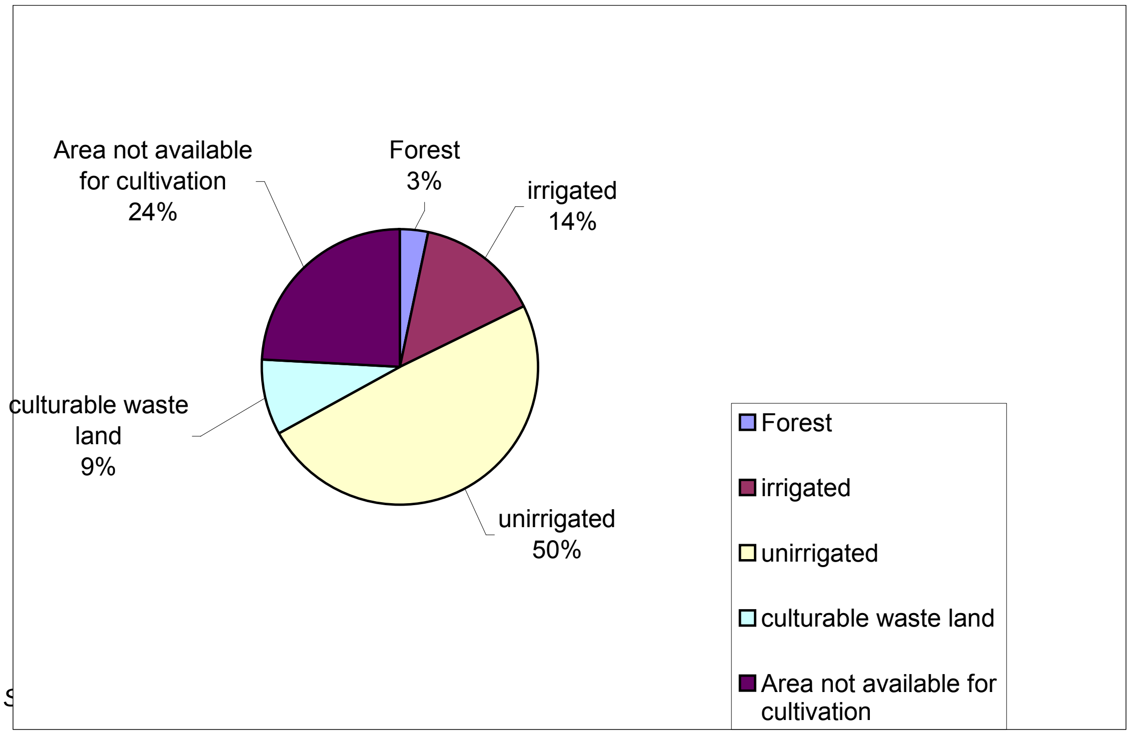
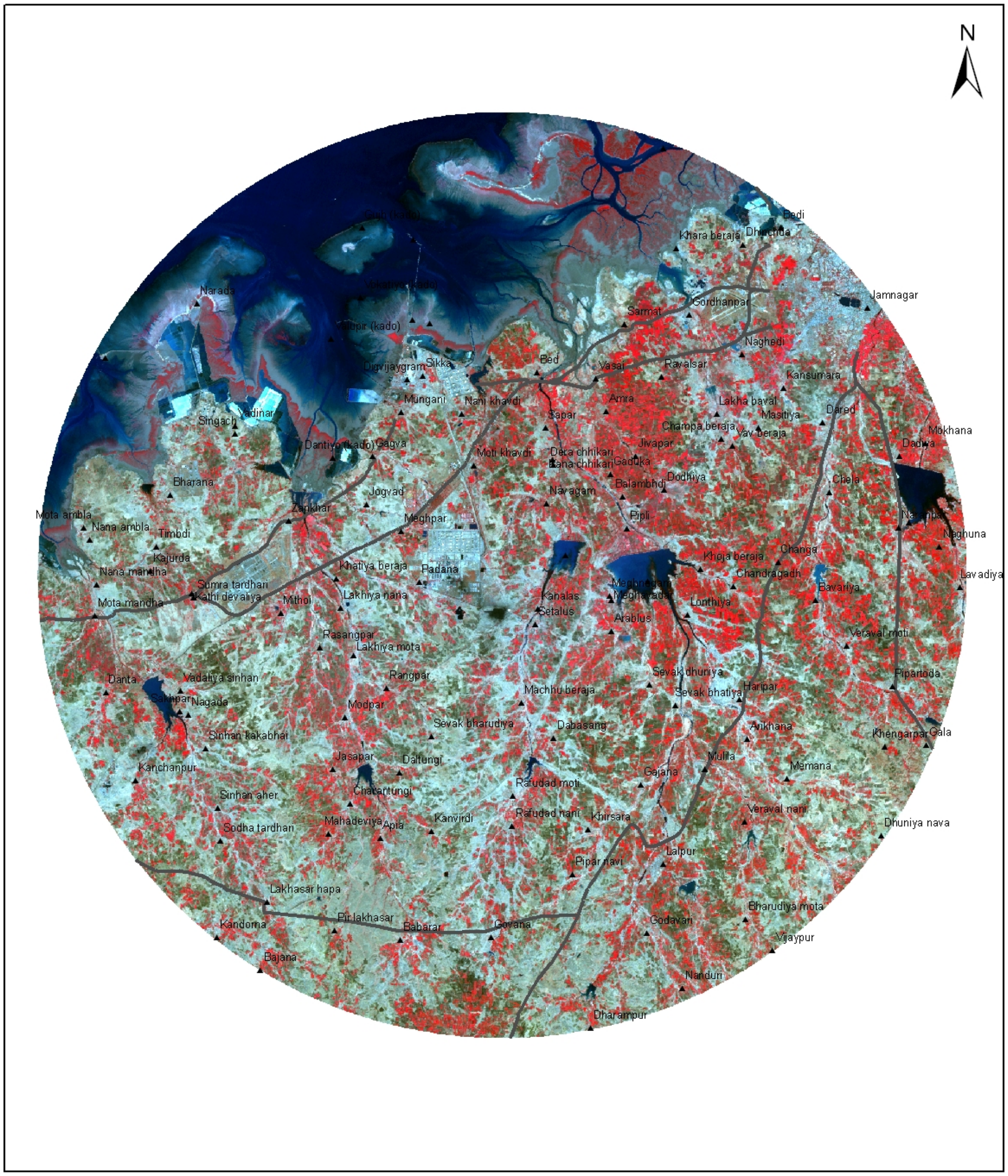


Fig. 4.4.3 : Pie Chart Showing the Land use Pattern in the Study Area



Legend

▲ VillagePoints

State Highways

Scale

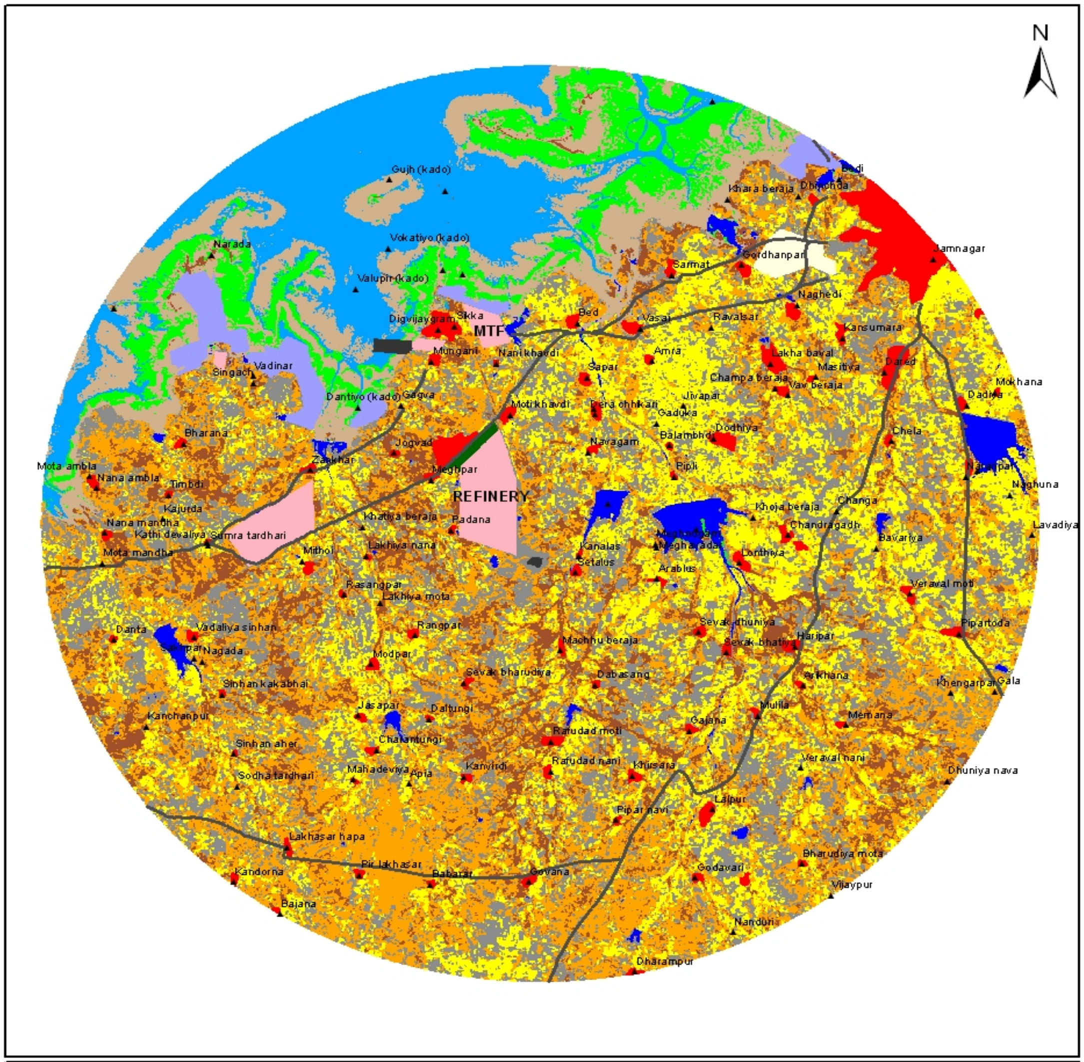
0 2 4 8 12 16 Km

1 : 275,000

Title

LISS III FCC Satellite Imagery dated 31 DEC 2003

Plate I -False Colour Composite of Study area around Proposed SEZ Site at Jamnagar



	JAMNAGAR - AREA STATISTICS (25km Radius)		
	CLASS NAME	AREA (ha)	AREA (%)
	Crop Land	36133.46	18.40
	Fellow Land	41295.46	21.03
	Land With / Without Scrub	49419.19	25.17
	Settlement Area	4898.76	2.50
	Industrial Area	3014.15	1.54
	Plantation	180.12	0.09
	Fringe Vegetation	8564.26	4.36
	Bare Soil	17207.54	8.76
	Mud Flat	13870.54	7.06
	Salt Pan	2618.84	1.33
	Dumping Area	175.74	0.09
	Airport Area	688.03	0.35
	Water Body	2731.51	1.39
	Sea	15533.51	7.91
	TOTAL	196331.10	100.00

▲ VillagePoints

State Highways

Source : LISS III 31 DEC 2003 Satellite Imagery

Scale

0 2 4 8 12 16 Km

1 : 275,000

Title

Landuse/Landcover Status Around Reliance Refinery Jamnagar covering 25 km radius

Plate II – Landuse/Landcover of Study area around Proposed SEZ site at Jamnagar

Table 4.4.1

Soil Sampling Locations

S. No.	Sampling Locations
1.	Sevak Dhunia
2.	Arablus
3.	Kanalus
4.	Lalpur
5.	Godavari
6.	Moti Rafudad
7.	Apla
8.	Bajana
9.	Naranpur
10.	Barwar
11.	Navagam
12.	Padana
13.	Gordanpur
14.	Motikhavdi
15.	Gagva
16.	Nanikhavdi
17.	Gaduka
18.	Satalus

Table 4.4.2

Soil Texture in Study Area

S. No.	Sampling Locations	Particle size distribution (%)				Textural class
		Coarse sand	Fine sand	Silty	Clay	
1.	Sevak Dhunia	20.6	6.2	28.6	44.6	Clay
2.	Arablus	14.4	32.6	11.8	41.2	Sandy Clay
3.	Kanalus	9.8	15.6	30.2	44.4	Clay
4.	Lalpur	10.2	16.2	25.4	48.2	Clay
5.	Godavari	9.8	18.2	25.8	46.2	Clay
6.	Moti Rafudad	30.6	17.2	13.4	38.8	Sandy Clay
7.	Apla	12.2	15.8	28.8	43.2	Clay
8.	Bajana	18.8	28.0	14.6	38.6	Sandy Clay
9.	Naranpur	10.8	15.6	30.2	43.4	Clay
10.	Barwar	9.8	14.4	27.6	48.2	Clay
11.	Navagam	30.2	17.2	13.8	38.8	Sandy Clay
12.	Padana	10.2	13.4	28.2	48.2	Clay
13.	Gordanpur	9.2	15.8	27.4	47.6	Clay
14.	Motikhavdi	9	46	10	35	Sandy Clay Loam
15.	Gagva	18	34	15	33	Sandy Clay Loam
16.	Nanikhavdi	11	32	25	32	Clay Loam
17.	Gaduka	10	30	30	30	Clay Loam
18.	Satalus	12	33	21	34	Sandy Clay Loam

Table 4.4.3

Physical Characteristics of Soil

S. No.	Sampling Locations	Bulk density (gm/cm^3)	Porosity (%)	Water holding capacity (%)
1.	Sevak Dhunia	1.11	43	50
2.	Arablus	1.23	40	45
3.	Kanalus	1.12	42	48
4.	Lalpur	1.12	49	50
5.	Godavari	1.18	47	50
6.	Moti Rafudad	1.32	42	45
7.	Apla	1.26	43	45
8.	Bajana	1.30	39	40
9.	Naranpur	1.28	42	46
10.	Barwar	1.18	49	51
11.	Navagam	1.32	40	41
12.	Padana	1.22	49	50
13.	Gordanpur	1.24	47	50
14.	Motikhavdi	1.35	61	54
15.	Gagva	1.30	66	62
16.	Nanikhavdi	1.19	38	64
17.	Gaduka	1.26	64	69
18.	Satalus	1.23	60	67

Table 4.4.4

Chemical Characteristics of Soil Extract

S. No.	Sampling Locations	pH	EC (mS/cm)	Ca^{++} (meq/l)	Mg^{++} (meq/l)	Na^{+} (meq/l)	K^{+} (meq/l)
1.	Sevak Dhunia	6.54	0.34	0.17	0.06	0.60	0.04
2.	Arablus	6.84	0.44	0.17	0.06	0.89	0.02
3.	Kanalus	6.71	0.53	0.18	0.06	0.55	0.04
4.	Lalpur	7.23	0.55	0.18	0.11	0.93	0.03
5.	Godavari	6.76	0.46	0.12	0.02	0.08	0.10
6.	Moti Rafudad	6.65	0.27	0.14	0.64	0.48	0.02
7.	Apla	6.55	0.90	0.20	0.06	1.01	0.12
8.	Bajana	6.66	0.35	0.17	0.02	0.87	0.03
9.	Naranpur	7.04	0.58	0.19	0.07	0.68	0.12
10.	Barwar	6.66	0.44	0.12	0.03	0.40	0.05
11.	Navagam	6.52	0.36	0.17	0.03	0.74	0.05
12.	Padana	6.62	0.40	0.17	0.06	0.24	0.02
13.	Gordanpur	6.70	0.53	0.17	0.05	0.16	0.03
14.	Motikhavdi	8.2	0.7	1.30	0.49	0.34	0.15
15.	Gagva	8.3	1.0	2.01	1.15	0.56	0.09
16.	Nanikhavdi	8.5	1.6	3.92	1.43	0.96	0.06
17.	Gaduka	8.3	1.0	1.05	0.84	0.8	0.10
18.	Satalus	8.6	0.6	1.25	0.76	1.03	0.09

Table 4.4.5

Cation Exchange Capacity of Soil

S. No.	Sampling Locations	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CEC	ESP
		meq/100 gm					(%)
1.	Sevak Dhunia	28.8	11.2	1.2	1.8	48.8	2.46
2.	Arablus	24.6	11.4	0.98	1.6	42.6	2.3
3.	Kanalus	22.6	14.2	1.1	1.4	46.8	2.35
4.	Lalpur	24.6	14.8	1.6	1.4	50.2	3.18
5.	Godavari	22.4	14.6	1.2	1.8	48.4	2.48
6.	Moti Rafudad	26.2	12.8	1.1	1.6	40.6	2.7
7.	Apla	22.6	14.2	1.1	1.4	45.2	2.43
8.	Bajana	23.4	15.2	0.96	1.2	40.6	2.36
9.	Naranpur	26.4	11.8	1.08	1.4	44.6	2.42
10.	Barwar	25.4	11.2	1.02	1.2	46.7	2.10
11.	Navagam	28.2	14.2	1.2	1.2	47.6	2.52
12.	Padana	30.2	11.6	1.4	1.8	49.2	2.84
13.	Gordanpur	28.8	12.8	1.2	1.6	48.8	2.46
14.	Motikhavdi	26.6	11.3	1.2	1.5	41.2	2.9
15.	Gagva	22.6	12.6	0.95	1.7	44.5	2.1
16.	Nanikhavdi	30.7	13.9	0.97	1.8	45.3	2.1
17.	Gaduka	24.8	13.8	1.22	1.4	40.6	2.7
18.	Satalus	24.7	11.5	1.25	1.5	47.3	2.6

Table 4.4.6

Relationship of CEC with Adsorptivity

CEC	Range in cmol (P+) kg^{-1}	Adsorptivity	Locations (Sr. No)
Limited or low	<10	Low or Limited adsorption	
Moderate	10 – 20	Moderate adsorption	
High	20-30	High adsorption	
Very High	>30	Very high adsorption	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18

Table 4.4.7

Relationship of CEC with Productivity

CEC	Range in cmol (P+) kg^{-1}	Productivity	Locations (Sr. No)
Very low	<10	Very Low	
Low	10 – 20	Low	
Moderate	21 – 50	Moderate	1, 2, 3, 4,5,6,7,8,9,10, 11,12,13,18
High	>50	High	14,15,16,17

Table 4.4.8

Fertility Status of Soils in the Study Area

S. No.	Sample Locations	Total Nutrients			
		Organic Carbon (%)	N	P_2O_5	K_2O
			Kg/ha		
1.	Sevak Dhunia	0.20	138.1	13.1	134.87
2.	Arablus	0.23	165.8	6.3	142.43
3.	Kanalus	0.43	169.9	8.8	144.87
4.	Lalpur	0.57	175.8	13.7	143.65
5.	Godavari	0.82	195.1	22.03	142.19
6.	Moti Rafudad	0.1	140.7	5.2	138.8
7.	Apla	0.50	179.9	12.8	144.63
8.	Bajana	0.36	142.3	9.5	142.51
9.	Naranpur	0.67	178.3	15.6	134.63
10.	Barwar	0.12	163.3	6.1	138.90
11.	Navagam	0.14	150.7	5.6	146.09
12.	Padana	0.04	149.02	5.2	133.30
13.	Gordanpur	0.35	174.1	10.9	138.50
14.	Motikhavdi	0.42	179	14.7	184
15.	Gagva	0.81	192	13.6	107
16.	Nanikhavdi	0.58	178	9.1	146
17.	Gaduka	0.78	172	12.7	136
18.	Satalus	0.82	197.2	15.6	131
Level in poor soil		< 0.5	< 280	< 23	< 133
Level in medium soil		0.5-0.75	280-560	23-57	133-337
Level in fertile soil		> 0.75	> 560.0	> 57.0	> 337.0

Table 4.4.9

Soil Quality - Heavy Metals

S. No.	Sampling Locations	Cd	Cr	Cu	Pb	Mn	Zn	Fe
		mg/kg of soil						
1.	Sevak Dhunia	12.6	88.8	74.4	115.6	729.5	47.2	45548.4
2.	Arablus	12.7	68.4	68.9	116.2	599.6	58.9	44798.4
3.	Kanalus	14.8	81.4	79.9	130.7	999.6	80.4	60742
4.	Lalpur	13.3	77	74.4	117.7	709.6	54.2	53742
5.	Godavari	13.3	71.9	80.4	118.7	704.6	129.9	48398.4
6.	Moti Rafudad	11.9	36.4	43.9	119.2	554.4	37.3	39998.4
7.	Apla	11.4	68.4	65.4	106.7	544.6	86.4	39048.4
8.	Bajana	17.3	70.9	122.9	149.2	824.6	64.4	67492
9.	Naranpur	18.7	206.4	89.4	149.7	034.6	76.9	83492
10.	Barwar	16.1	57.9	96.4	133.2	979.6	75.4	78242
11.	Navagam	17.8	117.9	89.9	152.7	929.6	84.8	81742
12.	Padana	21.2	109.4	121.9	146.2	1069.6	84.9	9549.2
13.	Gordanpur	17.9	74.9	113.9	166.7	1014.6	77.4	70492
14.	Motikhavdi	0.3	5.2	46.3	6.2	578	80.2	7270
15.	Gagva	0.1	4.7	27.3	5.7	790	46.3	9280
16.	Nanikhavdi	0.7	1.8	73.8	10.9	680	93.8	53260
17.	Gaduka	0.8	31.0	69.2	13.7	802	96.8	60280
18.	Satalus	0.8	41.0	54.9	8.1	917.7	126.7	56290

ND - Non detectable

Table 4.4.10

Microbiological Characteristics of Soil

Sr. No.	Sampling Locations	TVC	Fungi	Actinomycetes	Rhizobium	Azotobacter
		(CFU per gram of soil)				
1.	Sevak Dhunia	$16x10^6$	$7 x10^4$	$2 x10^4$	$2 x10^4$	$2 x10^4$
2.	Arablus	$23x10^6$	$5x10^4$	$2 x10^4$	$3 x10^4$	$2 x10^4$
3.	Kanalus	$13x10^6$	$2x10^4$	$4 x10^4$	$8 x10^4$	$7 x10^4$
4.	Lalpur	$44 x10^6$	$12x10^4$	$5 x10^4$	$4 x10^4$	$2 x10^4$
5.	Godavari	$94 x10^6$	$15x10^4$	$7 x10^4$	$8 x10^4$	$16 x10^4$
6.	Moti Rafudad	$52x10^6$	$2x10^4$	$2 x10^4$	$4 x10^4$	$2 x10^4$
7.	Apla	$91x10^6$	$15x10^4$	$4 x10^4$	$4 x10^4$	$13 x10^4$
8.	Bajana	$83x10^6$	$9x10^4$	$5 x10^4$	$2 x10^4$	$7 x10^4$
9.	Naranpur	$62x10^6$	$7x10^4$	$9 x10^4$	$4 x10^4$	$6 x10^4$
10.	Barwar	$58x10^6$	$16x10^4$	$10 x10^4$	$2 x10^4$	$8 x10^4$
11.	Navagam	$22x10^6$	$4x10^4$	$3 x10^4$	$6 x10^4$	$2 x10^4$
12.	Padana	$52x10^6$	$4x10^4$	$4 x10^4$	$3 x10^4$	$11 x10^4$
13.	Gordanpur	$53x10^6$	$7x10^4$	$5 x10^4$	$3 x10^4$	$3 x10^4$
14.	Motikhavdi	$51x10^6$	$7x10^4$	$2 x10^4$	$7 x10^4$	$10 x10^4$
15.	Gagva	$39x10^6$	$5x10^4$	$5 x10^4$	$4 x10^4$	$5 x10^4$
16.	Nanikhavdi	$25x10^6$	$7x10^4$	$4 x10^4$	$8 x10^4$	$9 x10^4$
17.	Gaduka	$27x10^6$	$6x10^4$	$3 x10^4$	$5 x10^4$	$4 x10^4$
18.	Satalus	$62 x10^6$	$13x10^4$	$3 x10^4$	$3 x10^4$	$6 x10^4$

CFU - Colony Forming Unit

TVC - Total Viable Count

Table 4.4.11

Landuse Pattern in Villages of the study Area

Area in hectares

Sr. No.	Name of Village	Total Area	Forest	Irrigated land	Unirrigated land	Culturable waste land including Gouchar and groves	Area not available for cultivation
1.	Jamnagar District						
2.	Vasai	1,565.45	-	GC (203.50) W(17.50) WE(68.50) T(289.50)	827.15	99.95	348.85
3.	Amra	1,432.14	-	GC(243.72) W(36.25) WE(100.00) R(72.96) T(452.93)	727.80	141.00	110.41
4.	Jivapar	596.39	-	GC(262.22) W(71.16) WE(160.00) R(1.62) T(495.00)	12.62	47.08	41.69
5.	Gaduka						
6.	Balambhdi	685.69		GC(296.29) W(9.76) WE(30.00) O(3.05) T(339.10)	207.03	66.07	73.49
7.	Dodhiya	1031.03		GC(49.34) W(43.13) WE(60.00) O(25.30) T(177.74)	582.87	174.00	96.39
8.	Vaw Beraja	716.02	-	W(42.10) WE(50.14) T(92.24)	484.86	60.16	78.76
9.	Chela	2999.68	-	W(300) WE(388.96)T(688.96)	1707.09	351.75	251.88
10.	Harshadpar	1724.35	-	W(73) WE(143.14) T(216.14)	873.64	161.18	473.39
11.	Naranpar	1226.03	-	W(244.41) WE(350.00) T(594.41)	155.17	131.65	344.80
12.	Changa	1858.11	-	W(120) WE(63) T(183)	1494.21	55.63	125.27
13.	Chandragadh	801.66	-	W(85) WE(200.30) T(285.30)	345.82	34.52	136.02
14.	Khoja Beraja	1710.75		GC(64.02) W(121) WE(272.15) R(13.09) T(470.26)	651.90	230.79	357.80
15.	Lonthiya	697.60	-	W(48) WE(106.65) T(154.65)	255.80	28.32	258.83
16.	Bawariya	325.38	-	W(50) WE(21.65) T(71.65)	178.66	33.55	41.52

Sr. No.	Name of Village	Total Area	Forest	Irrigated land	Unirrigated land	Culturable waste land including Gouchar and groves	Area not available for cultivation
17.	Lovadiya	1140.72	-	W(60.22) WE(104) T(164.22)	733.04	155.73	87.73
18.	Mokhana	608.16	-	W(30) WE(51.85) T(81.85)	208.50	249.82	67.99
19.	Dhandha	799.46	-	W(50.60) WE(60.11) T(110.71)	344.95	47.04	296.76
20.	Chandraga	519.01	-	W(50) WE(66.92) T(116.92)	299.52	64.92	37.65
21.	Bed	1895.87		GC(144.84) W(200) WE(254.7) T(599.54)	992.82	266.76	36.75
22.	Mungni	889.78		W(20) WE(15.74) T(35.74)	556.81	158.20	139.03
23.	Gagva	676.82	-	W(14.15) WE(70) T(84.15)	437.49	93.38	61.80
24.	Nanikhavdi	675.89	-	W(83.79) WE(50) T(133.79)	356.48	73.59	112.03
25.	Sapar	609.53		GC(85.18) W(30) WE(71.83) T(187.01)	196.72	93.07	132.73
26.	Champa Beraja	939	-	W(47) WE(20) T(67)	692.56	56.69	122.75
27.	Gordhanpur	493.15		GC(28.39) W(18.30) WE(48.26) T(94.95)	65.69	51.17	281.34
28.	Dhinchda	1235.53	-	W(47.12) WE(90.04) T(137.16)	560.09	73.79	464.49
29.	Moti Khavdi	2605.33		GC(150) W(100) WE(71.39) T(321.39)	1534.66	288.46	460.82
30.	Lakha Baval	1342.89		GC(278.09) W(30) WE(79.23) E(57.18) T(444.50)	464	207.90	226.49
31.	Kansumara	928.67	-	W(60) WE(81.01) T(141.01)	599.52	55.22	132.92
32.	Masitiya	883.47	-	W(11.5) WE(155.56) T(270.56)	457.87	71.62	83.42

	Khambhalia-Taluka						
33.	Khambhalia						
34.	Danta	1764.19	87.66	GC(24.28) W(48.56) WE(20.23) T(93.07)	817.53	80.53	685.40
35.	Bhatgam	532.58	-	W(76.93) WE(4) T(80.93)	338.58	47.83	65.24
36.	Kota	837.79	-	W(52.70) WE(8) T(60.70)	603.70	8.09	165.30

Sr. No.	Name of Village	Total Area	Forest	Irrigated land	Unirrigated land	Culturable waste land including Gouchar and groves	Area not available for cultivation
37.	Kolava	2383.9	202.34	W(60.70) WE(108.93) T(169.63)	1227.59	192.78	591.56
38.	Bhandariya	1407.89	37.58	W(11.15) WE(7.23) T(18.38)	656.35	206.39	489.19
39.	Bajana	2728.46	163.28	W(161.88) WE(242.82) T(404.70)	803.74	174.86	1181.88
40.	Kandorna	1676.68	-	W(68.07) WE(194.63) T(262.70)	670.00	101.69	642.29
41.	Bhadthar	2196.60	-	W(16.30) WE(10.21) T(26.51)	1664.01	7.45	498.63
42.	Sagariya	1187.59	-	W(9.45) WE(3.28) T(12.73)	640.97	15.69	518.20
43.	Mota Mandha	2061.98	-	GC(61) WE(95) T(156)	1382.00	95.98	428
44.	Nana Mandha	1484.71	-	W(263.43) WE(34.07) T(297.52)	596.87	141.75	448.57
45.	Nava Ambla	407.28	-	W(20.43) WE(5.07) T(20.48)	269.37	32.79	79.62
46.	Mota Ambla	881.28	-	W(19.86) T(19.86)	571.07	85.12	205.23
47.	Vadiner	669.79	-	W(10.00) WE(1.10) T(11.10)	450.76	71.04	136.89
48.	Bharana	1849.81	-	W(40.47) WE(20.23) T(60.70)	1385.09	144.46	259.56
49.	Timbdi	967.68	-	W(29.33) WE(8.23) T(37.56)	705.10	80.66	144.36
50.	Kajurda	1150.00	-	W(26.42) WE(12.02) T(38.44)	894.67	74.14	142.75
51.	Haripar	1311.81	-	W(119.23) WE(49.96) T(169.19)	626.85	51.19	464.58
52.	Kanchanpur	639.21	-	W(30.35) WE(17.18) T(47.53)	273.52	85.79	232.37
53.	Sinhan Kakab	974.52	-	W(202.35) WE(214.49) T(416.84)	292.54	121.41	143.73
54.	Lakhasar Hap	1,547.52	87.36	W(51.50) WE(8.93) T(60.43)	798.07	485.10	116.56
55.	Devaliya	1081.02	92.27	W(8.09) WE(12.14) T(20.23)	544.43	16.18	407.91
	Taluka Lalpur						
56.	Lakhiya Nava	437.63	-	W(49.7) WE(81.34) T(131.12)	161.19	41.32	104.00
57.	Lakhiya Mota	1101.12	-	W(93.37) WE(32.37) T(125.74)	748.31	88.84	138.23
58.	Rangpar	979.29	-	W(107.06) WE(36.43) T(143.49)	565.85	122.51	147.44
59.	Veraval Moti	1886.74	-	W(230.36) WE(441.60)	1016.66	161.56	36.56

Sr. No.	Name of Village	Total Area	Forest	Irrigated land	Unirrigated land	Culturable waste land including Gouchar and groves	Area not available for cultivation
				T(671.96)			
60.	Sevak Bhatiya	483.23	-	W(2.43) WE(5.66) T(8.09)	289.20	59.22	126.72
61.	Sevak Dhuniya	1328.02	-	W(4.05) WE(16.18) T(20.23)	964.36	129.56	213.87
62.	Dabasang	1805.88	-	W(75) WE(75) T(150)	1262.53	176.10	217.25
63.	Machhu Beraja	1799.72	-	W(104.30) WE(63.42) T(167.72)	1019.54	92.88	519.58
64.	Sevak Bharwdia	991.74	-	W(101.23) WE(52.10) T(153.33)	516.11	30.24	292.06
65.	Modpar	2559.87	-	GC(100.00) W(50.00) WE(250.00) T(400.00)	1432.58	235.06	492.23
66.	Rafuded Moti	2410.32	-	W(60) WE(60) T(100)	1699.40	159.04	451.88
67.	Gajana	1247.69	-	W(180.06) WE(120.04) T(300.10)	672.13	159.04	451.88
68.	Mulila	697.13	-	W(114.93) WE(48.56) T(163.49)	291.27	65.63	176.74
69.	Piper Nawi	2952.21	232.37	W(100.0) WE(136.0) T(236.0)	1034.00	251.21	1198.63
70.	Kanvirdi	716.45	-	W(45.36) WE(10.07) T(55.43)	308.79	44.64	307.59
71.	Apia	1357.66	476.29	W(40.15) WE(32.10) T(72.25)	509.03	62.77	237.32
72.	Govava	3527.91	323.75	W(73) WE(100) T(173)	1439	206.91	1385.25
73.	Singach	1473.39	-	W(79.18) WE(99.17) T(178.35)	962.84	210.35	121.85
74.	Jasapar	1087.92	-	GC(9.20) W(101.25) WE(35.26) T(145.71)	610.83	51.33	280.05
75.	Veraval Nani	597.61	-	W(36.0) WE(36.0) T(72.0)	350.85	63.04	111.72
76.	Dhuniya Nava	580.63	-	W(40) WE(42) T(82)	260.63	83.0	155.0
77.	Khadba Mota	5273.70	-	W(300.0) WE(500.0) T(800.0)	2342.34	290.79	1840.57
78.	Veraval Nani	597.61	-	W(36.0) WE(36.0) T(72.0)	350.85	63.041	111.72
79.	Godavari	1554.48	300.48	GC(40.17) W(74.56) WE(200.46) TK(15.08) T(330.27)	334.30	127.87	461.56
80.	Nanduri	2092.18	-	W(285.7) WE(325.02) T(610.72)	895.72	313.34	272.4 0
81.	Bharwdiya Mo	808.15	-	W(74.0) WE(100.0) T(174.0)	426.0	97.0	111.15
82.	Vijaypur	285.88	21.26	W(18.0) WE(18.0) T(36.0)	127.0	80.0	21.62

Sr. No.	Name of Village	Total Area	Forest	Irrigated land	Unirrigated land	Culturable waste land including Gouchar and groves	Area not available for cultivation
83.	Raka	810.67	70.33	W(35.00) WE(35.00) T(70.00)	235.0	121.67	313.67
84.	Khatiya	1066.29	588.14	W(40.0) WE(41.0) T(81.0)	191.29	76.0	129.86
85.	Khadba Nana	2404.57	-	W(33.0) WE(100.0) T(133.00)	912.57	245.0	1114.00
86.	Babariya	485.95	51.51	W(25.0) WE(15.0) T(40.0)	71.69	40.39	282.36
87.	Pingpur	1335.29	91.42	W(36.00) WE(100.00) T(136.00)	510.29	394.0	203.58
88.	Tebhada	1741.14	337.83	W(105.09) WE(215.09) T(320.18)	335.50	99.27	698.36
89.	Sanosri	2747.62	265.25	W(100.0) WE(150.0) T(250.0)	1333.20	287.63	611.54
90.	Kathitad	724.51	85.79	W(37.07) T(37.07)	334.83	-	266.82
91.	Sansora	1779.85	253.31	W(191.99) T(191.99)	756.42	-	578.13
92.	Chorbedi	2679.56	613.10	W(175.0) WE(125.0) T(300.0)	506.20	84.81	1175.45
93.	Panchsarom	871.04	-	W(50.0) WE(50.0) T(100.0)	510.0	84.04	177.0
94.	Badhla	866.29	-	W(30.0) WE(46.0) T(76.0)	389.0	102.29	299.0
95.	Vadpanchasa	1022.91	52.83	W(24.28) WE(100.0) T(60.70)	657.15	169.36	82.87
96.	Padama	2967.66	64.35	W(90.35) WE(98.36) T(188.71)	1916.19	167.18	631.23
97.	Navagam	1998.99	29.92	GC(192.06) W(143.93) WE(238.00) T(573.99)	936.73	129.25	329.10
98.	Dera Chikari	228.80	-	GC(2.43) WE(4.04) T(6.47)	167.06	30.0	25.27
99.	Kanechikari	1247.29	-	GC(52.04) WE(180.0) TK(20.0) T(252.04)	482.89	66.55	445.81

Sr. No.	Name of Village	Total Area	Forest	Irrigated land	Unirrigated land	Culturable waste land including Gouchar and groves	Area not available for cultivation
100.	Kanalus	2142.09	-	W(80.94) WE(202.34) T(283.28)	809.17	134.73	914.91
101.	Arblus	1550.84	40.47	W(136.09) WE(83.30) T(219.29)	798.87	63.61	428.50
102.	Meghavadar	657.82	-	W(88.05) WE(57.38) T(145.43)	164.65	91.78	255.96

Source: Census Book of Jamnagar 1991

Table 4.4.12

Land use/Land Cover Classification System

Sr. No.	Level - I		Level – II
1.	Built-up Land	1.1	Built-up land
		1.2	Road
		1.3	Railway
2.	Agricultural Land	2.1	Crop land
		2.2	Fallow (Residual)
3.	Forest	3.1	Evergreen/Semi-evergreen forest
		3.2	Deciduous forest
		3.3	Degraded/Scrub land
		3.4	Forest blank
		3.5	Forest plantation
		3.6	Mangrove
		3.7	Cropland in forest
4.	Wasteland	4.1	Salt affected land
		4.2	Waterlogged land
		4.3	Marshy/Swampy land
		4.4	Gullied/Ravinous land
		4.5	Land with or without scrub
		4.6	Sandy area (coastal and desert)
		4.6	Barren rocky/Stony waste/sheetrock area
5.	Water bodies	5.1	River/Stream
		5.2	Lake/Reservoir
		5.3	Tank/Canal
6.	Others	6.1	Grassland/Grazing land
		6.2	Shifting cultivation
		6.3	Snow cover/Glacial area

Table: 4.4.13

Inventory of Landuse / Landcover

JAMNAGAR-AREA STATISTICS (25 Km.radius)

Sr. No.	CLASS NAME	AREA (ha)	AREA (%)
1	*Crop Land*	36133.46	18.40
2	Fallow Land	41295.46	21.03
3	Land with / without Scrub	49419.19	25.17
4	Settlement Area	4898.76	2.50
5	Industrial Area	3014.15	1.54
6	Plantation	180.12	0.09
7	Fringe Vegetation	8564.26	4.36
8	Bare Soil	17207.54	8.76
9	Mud Flat	13870.54	7.06
10	Salt Pan	2618.84	1.33
11	Dumping Area	175.74	0.09
12	Airport Area	688.03	0.35
13	Water Body	2731.51	1.39
14	Sea	15533.51	7.91
	Total	**196331.10**	**100.00**

4.5 Biological Environment

4.5.1 Introduction

Study of biological environment is one of the most important aspects for Environmental Impact Assessment, in view of the need for conservation of environmental quality and biodiversity. Ecological systems show complex inter-relationships between biotic and abiotic components including dependence, competition and mutualism. Biotic components comprises of both plant and animal communities, which interact not only within and between them but also with the abiotic components viz. physical and chemical components of the environment.

Generally, biological communities are the indicators of climatic and edaphic factors. Studies on biological aspects of ecosystems are important in Environmental Impact Assessment for safety of natural flora and fauna. Information on the impact of environmental stress on the community structure serves as an inexpensive and efficient early warning system to check the damage to a particular ecosystem. The biological environment includes mainly terrestrial ecosystem and aquatic ecosystem.

Biological communities are dependent on environmental conditions and resources of its location. It may change if there is change in the environment. Several variables like temperature, humidity rainfall, soil characteristics, topography etc., are responsible for maintaining the homeostasis of the environment. A change in any one of these variables may lead to stress on the ecosystem. The animal and the plant communities exist in their natural habitats in a well-organized manner. Their natural setting can be disturbed by any externally induced anthropological activities or by naturally induced calamities or disaster. So, once this setting is disturbed it becomes practically impossible or takes a longer time to come to its original state. Plants and animals are more susceptible to environmental stress.

A change in the composition of biotic communities under stress is reflected by a change in the distribution pattern, density, diversity, frequency, dominance and abundance of natural species of flora and fauna existing in the ecosystem. These changes over a span of time can be quantified and related to the existing environmental factors. The sensitivity of animal and plant species to the changes occurring in their existing ecosystem can therefore, be used for monitoring Environmental Impact Assessment studies of any project.

4.5.2 Study Area

The proposed SEZ project site is located near the village Kanalus in Jamnagar District of Gujarat State. The study area is around 25 km radial distance from the proposed project site taking Kanalus as center. In all 30 locations were selected for study on biological aspects.

Selection of sampling locations was made with reference to topography, land use, vegetation pattern, etc. The observations were taken on reserve forest, village forest and non-forest area (agricultural field, catchment area, on hills, in plain areas, village wasteland, etc.) as per the objectives and guidelines of MoEF for Environmental Impact Assessment. All observations were taken in and around sampling locations for quantitative representation of different species.Sampling locations selected for biological environment study are given in **Table 4.5.1** and depicted in **Fig. 4.5.1**. Study area mostly comprises of agriculture and barren land. Most of the vegetation is aggregated on agricultural bunds, near roadside, on degraded village land, canal sides and wastelands.

The study area around the proposed SEZ comprises of terrestrial and marine ecosystems due to nearness to Gulf of Kutch. The region has flat topography with Fulzar and Sasoi rivers flowing in the study area. The coastal zone is predominantly sandy, muddy covered with patches of mangrove vegetation. The terrestrial area was observed to be covered with tropical dry thorn vegetation characterized by the dominance of *Prosopis juliflora* and *Acacia senegal* alongwith agricultural fields and scrub land.

There exist five industries around the proposed project site within 25 km radius. These are Reliance Industries Limited, Essar Oil Limited, Gujarat State Fertilizer Company GEB Power Plant and Digvijay Cement Limited.

The climatic conditions in the study area are severe with hot climate and medium rainfall. Therefore, the terrestrial vegetation consists of thorny, shrubby and xerophytic scrub vegetation. The vegetation is extremely sparse dominated by shrubby growth of *Prosopis juliflora*. However, it has good growth in low-lying areas, by the side of agriculture fields and near villages.

4.5.3 Survey Methodology

Monitoring of biological environment was carried out by random sampling method. The structure and composition of vegetation was studied by taking observations on diverse plant species and their numerical composition at each sampling station. Diversity of plant species was studied by using Simpson's Diversity Index. Simpson's Diversity Index is calculated by following formula:

$$\textbf{Simpson's Diversity Index} = \sum_{i=1}^{n} \frac{ni\,(ni - 1)}{n\,(n - 1)}$$

ni - is the number of individuals of the i^{th} species in the sample and

n - is the total number of individuals in the sample.

Coexistence and competition both are affected directly by the number of individuals in the community. Therefore, it is essential to know the quantitative structure of community. To characterize the community as a whole, certain parameters are used. The parameters like frequency, dominance and Simpson's Diversity Index give a clear picture of community structure in quantitative terms. The values of these parameters are derived from the sampling observations done in the field, which are close to the real value.

To characterize the vegetation in the study area, the data was collected and analyzed for describing the properties of vegetation with reference to species composition and structural attributes. The diversity measurements reflect as to how many diverse species are present, the density measurements indicate number of individuals of a species in a sample plot; the dominance measurements denote which species is largest in terms of its presence; the frequency measurements indicate, how widely a species is distributed or occurred. Species diversity is the best measure of community structure. It is sensitive to environmental stresses that affect the community. Low value of Simpson’s Diversity Index indicates healthy ecosystem and the high value shows that an ecosystem is under environmental stress.

Actual counts of birds were made following the standard survey technique. Observations were made during a walk through in the chosen transect for sighting birds and animals. The number of animals and birds observed in one-kilometer stretch of the site were directly counted and listing was made. The milometer of the car/jeep was used to measure the stretch of the study transect. Birds were noted, counted and identified with the help of binocular and standard field identification guides. Other animals were directly counted from amongst the vegetation, bushes and the roadside fields.

Information was collected on the livestock, fisheries and indigenous fauna of the locality from the State/Central Government Departments. This information has been incorporated in the report wherever essential.

4.5.4 Vegetation Biodiversity in Study Area

According to Champion and Seth, the vegetation in the study area can be classified as Dry Tropical Type, Tropical Dry Thorn type and Littorial and Swamp Type. That can be further classified as Riverian forests, Plain forests and Mangrove forests. The most dominant trees in this region are *Acacia sp., Mangifera indica, Ficus religiosa, Butea monosperma, Terminalia bellerica, Terminalia tomentosa* are found in co-association and phytosociological order with *Syzygium cumini, Azadiracta indica, Bauhinia racemosa, Emblica officinalis,* which are sparse in distribution.

The subdominant species recorded are *Prosopis sp.*, *Capparis sp*., *Euphorbia sp.*, and *Opuntia sp*. *Ficus bengalensis* is observed near villages and by the roadside. Other rare species in this area recorded are *Casuarina, Parkinsonia* and *Cocos nucifera*. Among the shrubs *Euphorbia* sp. and *Opuntia* sp. are abundant followed by *Cassia* sp., *Zizyphus* sp., and *Phoenix* sp., are dominantly observed along with *Cassia siamea and Delonix regia* at some places in villages and on private land. Many tree species are found to be planted in the greenbelt of small and large industries in the area consisting of *Cassia siamea, Delonix regia, Bauhinia, Parkinsonia, Acacia auriculoformis, Eucalyptus, Mangifera indica* etc.

During the floristic survey in study area, a total of 165 plant species were recorded**.** A total of 76 tree species, 28 shrub species, 22 herb species, 23 grasses and 16 climbers were recorded from the study area. The list of total number of different plant species (trees, shrubs and herbs) recorded during field survey is depicted in **Table 4.5.2**.

Study area shows presence of medicinal plants. Out of 165 plants studied, 51 plant species of 25 trees, 10 herbs and 16 shrubs are of medicinal value. However, the scattered distribution and low density of these plants does not allow their commercial use. The Simpson's Diversity Index for trees, shrubs, and herbs of the study area is given in **Table. 4.5.4**.

4.5.5 Floristic Structure and Composition

4.5.5.1 Floristic Characteristic within 15 km radius from the Proposed Project Site

Within 15 km radial distance of Proposed Project site the land is covered by agriculture and fallow land besides built up land and greenbelts developed by Reliance Industries Limited, Essar Oil Refinery and Gujarat State Fertilizer Company. The primary data were collected at around proposed project site, Kanalus, Apia, Ratudad Moti, Padana, Dera Chhikari, Kana Chhikari, Motikhavdi, Navagram, Gavana, Vadaliya Sinhan, Lonthia, Arablus, Veraval Nani, and Sevak Dhuniya.

The floristic study reveals species composition, which represents poor gene pool uniformly spread in restricted vegetation patches around human settlements. Collection of dead and dried branches for fuel, hard wood and local trees for construction purpose, grazing practice on vegetated land is also common. The nature of vegetation cover in this region is mixed, tropicaldry, uneven-aged-deciduous vegetation with marked dominance of *Acacia* sp., *Dalbergia latifolia, Bauhinia purpurea, Ficus racemosa, Mangifera indica, Butea monosperma,* *Sapindus emarginatus,* and *Gmelia arborea*. Most of the vegetation aggregates on agricultural bunds, near roadsides, on degraded village lands, canal sides and wastelands.

The vertical structure of the vegetation shows three distinguished storey i.e. Top, Middle and Ground. *Azadirachta indica, Dalbergia latifolia, Bauhinia purpurea, Ficus racemosa, Mangifera indica, Butea monosperma* etc. comprises top storey of the forest. *Adhatoda vasica, Bougainvellia tochglory, Cassia fistula, Calotropis gigantean, Dalbergia sissoo, Lantana camara, Euphorbia nevulia, Opuntia elator, Prosopis juliflora, Zizyphus rugosa etc. forms middle storey of region. Ground vegetation cover is of Ageratum conizoides, Argemone mexicana, Aloe vera, Dipcadi montanum, Erantemum roseum, Leucas aspera, Phyllanthus niruri, Solanum xanthocarpum, Tinospora cardifolia* etc.

A view of vegetation structure and composition in the study area is shown in **Plate 4.5.1**.

4.5.5.2 Floristic Characteristic within 15-25 km radius from the Proposed Project Site

The region within 15-25km radial distance of the project site has sparse vegetation cover. This includes terrestrial region like Gordhanpur, Kathi devaliya, Kota, Sansora, Tebhada, Chorbedi, Rinzpur, Pipartoda, Naranpar as well as some coastal region near Sikka, Singach, Vadinar, Bharana, Gagva, Mungani, Bed. The composition of vegetation is littorial and swamp, uneven-aged, mixed, moist deciduous natural forests. Vegetation is extremely irregular and varying considerably in condition, composition, and density. Generally trees observed here have low stunted branches, diffuse crown. Dependency of villagers on natural vegetation in this region is more for timber and firewood. Most of the vegetation aggregates near villages mainly composed of *Albizzia chinensis, Bauhinia racemosa, Ficus recimosa, Syzygium cumini, Terminalia tomentosa etc.*

The phyto-ecological structure of vegetation shows three different strata *i.e. Top, Middle and Ground. Top storey covered by, Albizzia chinensis, Bauhinia racemosa, Bombax malabaricum, Butea monosperma, Ficus recemosa, Syzygium cumini, Sapindus emarginatus, Terminalia tomentosa etc. Middle storey in this region comprises Adhatoda vasica, Capparis spinosa, Euphorbia nevulia, Crotolaria retusa, Emblica officinalis, Lantana camara etc. The dominant herbs in ground vegetation are Aegeratum conyzoides, Argemone mexicana, Celosia argentea, Aloe vera, Indigofera tinctoria, Tridax procumbens* etc.

Near the coastal area i.e. near jetty sides, saltpan, mangrove species are found. Mainly six species of mangrove are commonly found in this area are *Avicenia marina, A alba, A. officinalis, Ceriops species, Rhizophora mucronata and Aegiceros corniculata*. The density and vegetation changes with change in locations. A view of mangrove vegetation near Vadinar saltpan area is shown in **Plate 4.5.2**. The area near coastal villages has poor vegetation as compared to other places. Trees species like *Coccos nucifera, Phoenix robusta, Ficus sp, Bahunia racemosa, Cassia fistula, Acacia catechu* and *Azadiracta indica* along with *Prosopis juliflora* are observed in some places. The vegetation is degraded due to the human and live stock interferance in this region. Herbs are abundant only during monsoon. The area is dominated with tree members as compared to shrubs and herbs. The vegetation in this region has been exploitated in the past, therefore the present condition is degraded. *Mangifera indica* and *Azadiracta indica* are the dominant tree species.

Productivity of the agricultural crops in this region is very low because of poor soil quality, infrequent and inadequate rainfall, water scarcity, low consumption of fertilizer, shifting cultivation, lack of improved agricultural technology and improper communication.

4.5.6 Medicinal Plants in Study Area

Ayurveda says “There is no plant on the Earth, which does not possess medicinal property”. This means that each and every plant is equally important for its biological activities, ecology and environment. The conservation of medicinal plants means every species of plant in its actual habitat should be protected and preserved. Conservation of biodiversity is a national and international agenda. Because of continuous exploitation of medicinal plants from their natural habitats, it is required to replant and regenerate them in other areas having similar habitat or environment. Due to over-exploitation of natural resources many of plant species have become extinct from the wild.

The study area shows presence of medicinal plants. Out of total 165 plants studied, 51 plant species including 25 trees, 10 herbs and 16 shrubs are of medicinal value.

Ground floor in study area is covered by herbaceous vegetation, which has many Ayurvedic medicinal plants. In addition, the area abounds in production of many kinds of fruits, flowers, seeds and leaves.

The common herbal medicinal flora of the area is *Adhatoda vasica (*Adulasa*), Acacia catechu* (Khair), *Cassia fistula, Eranthemum roseum* (Dashmuli), *Mangifera indica*, *Vitex nigundo* (Nirgudi), etc. The local people collect the medicinal plants from forest area, but they are not dependent economically on collection of medicinal plants. The list of medicinal plants and their medicinal value is presented in **Table 4.5.3**.

4.5.7 Social Forestry

Social Forestry wing under State Forest Department has carried out plantation in few areas along roadsides, highways and on village lands.

The tree species used in social forestry are *Prosopis, Azadirachta indica, Albizzia lebbeck, Ficus bengalensis, Acacia senegal, Emblica officinalis, etc.* which are native species. *Prosopis* is planted in few villages to develop village forest.

4.5.8 Reserved Forest

Four reserved forests are falling within the radius of 25 km radius from the proposed project site. The names of these reserved forests along with the area are as follows:

Rinzpur reserve forest	:	91.42 ha
Chorbedi reserve forest	:	228.65 ha
Tebhada reserve forest	:	141.00 ha
Sansora reserve forest	:	91.05 ha

These reserved forests are in degraded condition with very poor gene pool of plant species. Plant species mainly comprises of *Prosopis juliflora, Pithecellobium dulce Euphorbia nevulia, Opuntia elatior, Lantana camara, Achyranthes aspera, Celosia argentea, Cassia tora* etc.

Animals found in these reserved forests are mainly comprises of mammal, reptiles and birds. In mammals Nilgai, Wild boar, Common Langur, Bat and Common Fox are found. In reptiles snakes like Cobra, Monitor Lizard, Indian Chamelion while in birds Common Myna, Small Blue Kingfisher, Blue Rock Pegion, Babbler, Black Drongo and Common Peafowl are commonly found. However none of these forest area come in the overall SEZ Development Area.

4.5.9 Threatened Plant Species

National threatened species are those found only in small numbers or those very near to extinction in the country. India has a list of threatened species at the All India level, published by the Botanical Survey of India entitled 'Red Data Book'. Not a single species out of 165 plant species was observed to be threatened in the study area**.** However, there is intense industrial and anthropogenic pressure on flora fauna and forest resources, which are observed to be dwindling.

4.5.10 Agriculture

The staple food of the people in the study region is rice and wheat. The common *Kharif* crops of this region are groundnut, sesamum, cotton, castor, bajra etc. whereas wheat, gram, cumain, ajwan (semi-rabi) are the *Rabi* crops. Productivity of the agriculture crops in this region is medium to low because of low per hectare consumption of fertilizer, illiteracy, lack of improved agricultural technology and improper communication and also due to the weather condition. List of Agricultural crops in the study area is given in **Table 4.5.5**. A view of agriculture (cotton crops) is shown in **Plate 4.5.3**.

4.5.10.1 Agroclimatic Condition of Study Area

Jamnagar district is in North Saurashtra Agroclimatic Zone of State. The typical climate condition is arid and semiarid, with shallow medium black to sandy soil. Study area has coastal climate, which are salt affected soil. Jamnagar district is drought prone area. Ground water table is going down and depleted due to industrial activities in near by area therefore well irrigation is drastically affected.

4.5.11 Assessment of Wildlife and Avifauna

Since animals are capable of movement from one place to another, this makes their study entirely different. Therefore, specific methods were adopted for counting these animals in the field. The on-site information collected during survey was further enriched by the information collected from different secondary sources.

4.5.11.1 Faunal Diversity

a) Wild Animals

The diversity in fauna basically depends upon density and diversity of flora. The richer the diversity among the flora better will be the diversity in fauna. The study area has sparse, dry and thorny vegetation. Present conditions of the area do not support higher mammals. There are animals like hare, mouse, wild boar, fox, wildcat, nilgai, and squirrels. The faunal elements commonly reported in the study area are presented in **Table 4.5.6**.

b) Domestic Animals

The animals in study area mostly consist of domestic species such as camels, cow, buffaloes, sheep, goats, donkeys, horses, dogs and pigs. Animal census data revealed that among domestic animals cattle constituted the most abundant species, followed by buffaloes, goats, sheep and other animals.

4.5.11.2 Avifauna

a) Around Study Area

30 sampling sites were selected at various places in the study area for the assessment of avifauna. The birds were studied by direct observation with the help of 7 – 15 x 35 “Optima Zenith” binocular. A species list was prepared by walking through the areas.

A total number of 20 species of birds were encountered during the survey. (**Table 4.5.6**).

The birds like peafowl, mynas, crows, sparrows, bulbuls, babblers and pigeons are observed in and around villages. In areas with agriculture fields, the grain eating herbivorous species are dominant. These species are doves, sparrows, Cattle egrets, parakeets etc. Insectivorous bird species viz. Bee eaters, *Wagtails, White breasted kingfisher*, Egrets, Swallows, Indian Roller, Larks, are found around water bodies and in low-lying vegitation areas. A view of birds observed in the study area is shown in **Plate 4.5.4**.

b) Around Coastal Areas

Varieties of shore birds are found to nesting and roosting on the coastal area. There are about 190 species available in the Marine National Park (MNP) area, which is spread around an area of 162.89 Sq. Km found in the Gulf of Kutch provides very good grounds for roosting and the mangroves vegetation provides nesting ground to the avifauna. Birds nesting on the island mainly feed in the surrounding reef and mudflats but sometimes they move to nearby islands or coasts during low tide. The birds nesting on the coastal sites collect food from the mudflats, reefs, tidal creeks and channels on the coast. The coastal wetlands in Jamnagar with broad intertidal mudflats, mangroves, coral reefs, salt pans, sand and rock beaches offer a great diversity of habitats for birds to utilize for roosting, nesting and breeding. The area is very rich in the diversity and sheer number of both migratory and residence birds. A number of migratory birds pass through the Gulf of Kachchh and non-breeding adults of many species spend the summer in this region.

4.5.11.3 Rare, Endangered and Vulnerable Faunal Species

A list of rare, endangered and vulnerable species of birds is given in **Table 4.5.7**. Out of 12 species, 2 species i.e. *Eastern knot* and *Eastern little stint* are found to be rare and endangered, 2 species viz. little green herons and black necked stork are found to be endangered and remaining 8 species are found to be vulnerable. Out of birds recorded, only two birds viz. Peafowl and spoonbill are included in Schedule-I. There are no rare and endangered species of birds observed in the project area.

Among animals, Indian cobra (Reptiles), Jungle cat (Mammals) and Jackal (Mammals) are included in Schedule-II of Wildlife Protection Act.

4.5.12 Fishery

As the study area located nearby the coastal belt major fishing activities takes place in sea by the villages of Vadinar, Bharana, Sikka, Mungani, Gagva and Bed. However, some fresh water fishing activities are also done by the local people in dams situated in Lalpur and Khambalia talukas, but in a small scale. Fresh water fishes are mainly comprises of Rohu, Catla and Mrigal.

There are three dams in Khambalia taluka namely Sheda Bhara Thari (275 ha.), Khad Khambalia (48 ha.) and Ghee (405 ha.). These dams are usually given for fresh water fishing activities on lease basis. In Lalpur taluka two dams – Sasoi (1278 ha.) and Panna (363 ha.) are used for fishing activities.

A list of marine fishes found in Jamnagar district and different Prawn species occurring in the Gulf of Kutch are given in **Table 4.5.8** and **Table 4.5.9** respectively**.**

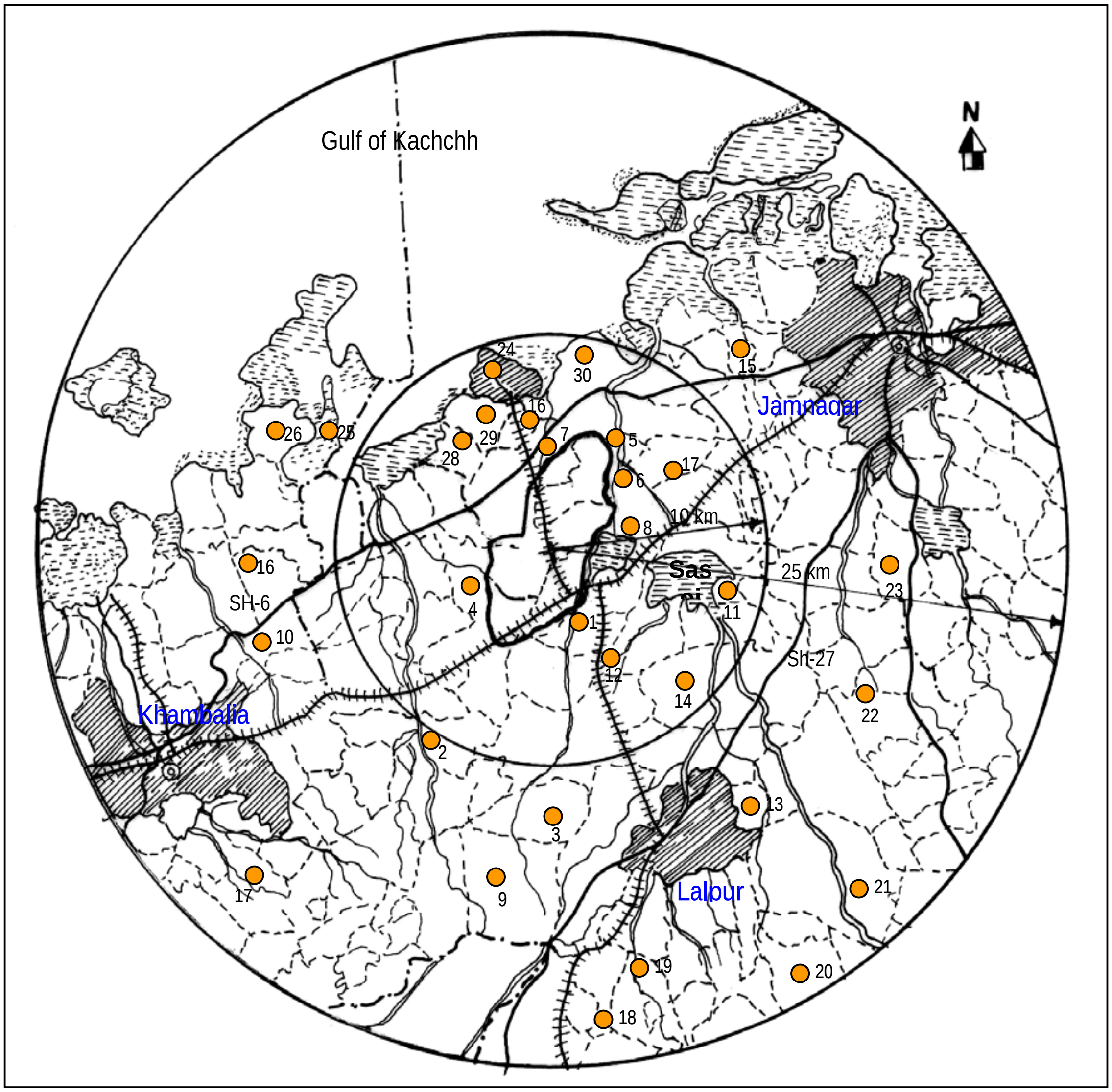


Fig. 4.5.1: Locations Identified for Biological Survey

Plate 4.5.1: A View of Thorny Vegetation near the Tebhada Reserve Forest

Plate 4.5.2: A View of Mangrove Vegetation near Vadinar Village salt pan

Plate 4.5.3: A View of forest observed near the Sansora Reserve Forest

Plate 4.5.4: Reef Heron observed near the Vadinar Jetty

Table 4.5.1

Sampling Locations for Biological Environment Survey in the Study Area

Sr. No.	Name of the Villages
Within 15 km radial distance from the proposed project site	
1.	Kanalus
2.	Apla
3.	Rafudad Moti
4.	Padana
5.	Dera Chhikari
6.	Kana Chhikari
7.	Motikhavdi
8.	Navagam
9.	Gavana
10.	Vadaliya Sinhan
11.	Lonthia
12.	Arablus
13.	Veraval Nani
14.	Sevak Dhuniya
Within 15-25 km radial distance from the proposed project site	
15.	Gordhanpar
16.	Kathi devaliya
17.	Kota
18.	Sansora
19.	Tebhada
20.	Chorbedi
21.	Rinzpur
22.	Pipartoda
23.	Naranpar
24.	Sikka
25.	Singach
26.	Vadinar
27.	Bharana
28.	Gagva
29.	Mungani
30.	Bed

Table 4.5.2

Common Plant Species Present in Jamnagar Dist

Sr. No.	Botanical Name	Local Name	Family
Trees			
1.	*Acacia catechu* *	Khair	Mimoseae
2.	*Acacia ferrugenia*	Kanti	Mimoseae
3.	*Acacia leucophloea*	Hermo	Mimoseae
4.	*Acacia nilotica* *	Baval	Mimoseae
5.	*Acacia planifrons*	Chhatralo baval	Mimoseae
6.	*Acacia senegal* *	Gorad	Mimoseae
7.	*Aegle marmelos* *	Bili	Rutaceae
8.	*Ailanthus excelsa**	Arduso	Simaroubaceae
9.	*Albizia lebbeck* *	Kalo sarsdo	Mimoseae
10.	*Albizia odoratissima*	Dholo sarsado	Mimoseae
11.	*Albizia odoratissima*	Sarasdo	Mimoseae
12.	*Albizia procera* *	Kamai	Mimoseae
13.	*Allangium salivifolium*	Ankol	Alangiaceae
14.	*Annona squamosa* *	Anuri	Annonaceae
15.	*Avicennia officinalis* *	Cher	Avicenniaceae
16.	*Azadirachta indica* *	Limbdo	Meliaceae
17.	*Balanites aegyptiaca*	Ingoriyo	Balanitaceae
18.	*Bauhinia racemosa*	Asundro	Caesalpiniaceae
19.	*Bombax ceiba* *	Semlo	Bombacaceae
20.	*Borassus flabellifer* *	Tad	Arecaceae
21.	*Boswellia serrata*	Saledi	Burseraceae
22.	*Bridelia retusa*	Akal kanto	Euphorbiaceae
23.	*Butea monosperma* *	Khakhro	Fabaceae
24.	*Cassia fistula* *	Garmalo	Caesalpiniaceae
25.	*Cassia siamea* *	Kasid	Caesalpiniaceae
26.	*Casuarina equisetifolia* *	Saru	Casuarinaceae
27.	*Ceriops candolleans*	Kunri	Rhizophoraceae
28.	*Cocos nucifera* *	Narial	Arecaceae
29.	*Commiphora wightii*	Gugal	Burseraceae
30.	*Cordia dichotoma*	Gundi	Ephretiaceae
31.	*Cordia monoica*	Cut gundi	Ehretiaceae
32.	*Dalbergia sissoo* *	Sissoo	Caesalpiniaceae
33.	*Delonix elata*	Sandesaro	Caesalpiniaceae
34.	*Delonix regia* *	Gulmohar	Caesalpiniaceae

Sr. No.	Botanical Name	Local Name	Family
35.	*Diospyros melanoxylon* *	Timru	Ebenaceae
36.	*Emblica officinalis* *	Amla	Euphorbiaceae
37.	*Erythrina variegata*	Jungli khakhro	Fabaceae
38.	*Erythrina variegta*	Panarv	Fabaceae
39.	*Eucalyptus hybrid* *	Nilgiri	Myrtaceae
40.	*Ficus benghalensis* *	Vadlo	Moraceae
41.	*Ficus racemosa* *	Umro	Moraceae
42.	*Ficus religiosa* *	Pipalo	Moraceae
43.	*Ficus tsiela*	Piper	Moraceae
44.	*Garuga pinnata*	Karpati	Burseraceae
45.	*Grewia tiliaefolis*	Dhaman	Tiliaceae
46.	*Holoptelea integrifolia*	Charal	Ulmaceae
47.	*Lannea coromandelica*	Moledi	Anacardiaceae
48.	*Mangifera indica* *	Ambo	Anacardiaceae
49.	*Manilkara hexandra*	Rayan	Sapotaceae
50.	*Melia azedarach* *	Bakan limdo	Meliaceae
51.	*Mellingtonia hortensis*	Akash nim	Bignoniaceae
52.	Mimusops elengi *	Bakul or borsali	Sapotaceae
53.	Mitragyna parvifolia	Kalam	Rubiaceae
54.	*Morinda tinctoria*	Al or rangari	Rubiaceae
55.	*Moringa oleifera*	Saragvo	Moringaceae
56.	*Parkinsonia aculeate* *	Ram baval	Caesalpiniceae
57.	*Phoenix sylvestris* *	Khajuri/Khaleranuzad	Arecaceae
58.	*Pithecellobium dulce**	Goras amli	Mimoseae
59.	*Polyalthia longifolia* *	Asopalav	Annonaceae
60.	*Pongamia pinnata* *	Karanj	Fabaceae
61.	*Prosopis juliflora* *	Gando baval	Mimoseae
62.	*Prosopis spicigera* *	Khijado	Mimoseae
63.	*Rhizophora conjugata* *	Karod	Rhizophoraceae
64.	*Salvadora oleoides*	Mithijar	Salvadoraceae
65.	*Salvadora persica*	Kharijar	Salvadoraceae
66.	*Sapindus emarginatus*	Aritha	Sapindaceae
67.	*Schleichera oleosa*	Kusum ujan	Sapindaceae
68.	*Soymida febrifuga*	Ron	Meliaceae
69.	*Sterculia urens*	Kadayo	Sterculiaceae
70.	*Syzygium cumini* *	Jambudo	Myrtaceae
71.	*Tamarindus indica* *	Amli	Caesalpiniaceae
72.	*Terminalia bellirica* *	Behdo	Combretaceae

Sr. No.	Botanical Name	Local Name	Family
73.	*Terminalia catappa*	Badam	Combretaceae
74.	*Terminalia arjuna* *	Arjun sadad	Combretaceae
75.	*Thespesia populnea*	Paraspipalo	Malvaceae
76.	*Wrightia tinctoria* *	Dudhlo	Apocynaceae
Shrub			
77.	*Abutilon indicum**	Khaper	Malvaceae
78.	*Acacia jacquemontii*	Tal baval	Mimoseae
79.	*Adhatoda vasica* *	Ardushi	Acanthaceae
80.	*Alhagi pseudalhagi*	Dhomso	Fabaceae
81.	*Alysicarpus longifolius*	Ghoda samervo	Fabaceae
82.	*Calotropis gigantea* *	Ankdo moto	Asclepiadaceae
83.	*Capparis deciduas*	Kerdo	Capparidaceae
84.	*Cassia auriculata*	Awal	Caesalpiniaceae
85.	*Commiphora wrightii*	Gugal	Burseraceae
86.	*Cressa cretica*	Lano	Convolvulaceae
87.	*Dichrostachys cinerea*	Majith	Mimoseae
88.	*Euphorbia neriifolia*	Kantalo thor	Euphorbiaceae
89.	*Euphorbia tirucalli*	Karsani thor	Euphorbiaceae
90.	*Euphorbia nevulia* *	Thor	Euphorbiaceae
91.	*Gardenia resinifera*	Dikamali	Rubiaceae
92.	*Hibiscus vitifolius*	Bhindi	Malvaceae
93.	*Lantana camara* *	Danidharia	Verbenaceae
94.	*Lawsonia inermis* *	Mehndi	Lecythidaceae
95.	*Leptadenia spartium*	Khip	Asclepiadaceae
96.	*Ocimum americanum*	Jungli tulsi	Lamiaceae
97.	*Ocimum sanctum* *	Tulsi	Lamiaceae
98.	*Opuntia elatior* *	Hanthalo Thor	Cactaceae
99.	*Tamarix stricta*	Chini	Tamaricaceae
100.	*Thevetia peruviana*	Kaner	Apocynaceae
101.	*Triumfetta rotundifolia*	Zipto	Tiliaceae
102.	*Xanthium stromarium* *	Gadaria	Asteraceae
103.	*Xeromphis spinosa*	Mindhol	Rubiaceae
104.	*Zizyphus nummularia* *	Chanibor	Rhamanaceae
Herb			
105.	*Achyranthes aspera* *	Aghedo	Amaranthaceae
106.	*Agave americana* *	ketki	Agaveceae
107.	*Aloe barbadensis* *	Kunwar	Liliaceae
108.	*Argemone mexicana* *	Darudi	Papveraceae
109.	*Cassia tora* *	Tarota	Caesalpiniaceae

Sr. No.	Botanical Name	Local Name	Family
110.	*Celosia argentea* *	Lamdi	Amarantaceae
111.	*Datura metel* *	Dhaturo	Solanaceae
112.	*Flacourtia occidentalis*	Lodri	Flacourtiaceae
113.	*Haloxylon recurvum*	Kharilani	Chenopodiaceae
114.	*Helicteres isora*	Atedi or marda sing	Sterculiaceae
115.	*Indigofera tinctoria* *	Gali	Fabaceae
116.	*Martynia annua*	Vichhhudo	Martyniaceae
117.	*Maytenus emarginata*	Vikro	Celastraceae
118.	*Pedalium murex*	Ghokharu	Pedaliaceae
119.	*Premna obtusifolia*	Kanther	Verbenaceae
120.	*Pupalia lappacea*	Dhola zipto	Amarantaceae
121.	*Solanum nigram* *	Piludi	Solanaceae
122.	*Solanum suratense* *	Bhoyringani	Solanaceae
123.	*Suaeda fruticosa*	Luno	Chenopodiaceae
124.	*Suaeda nudiflora*	Luni	Chenopodiaceae
125.	*Typha angustata*	Gabajaria	Typhaceae
126.	*Urgenia indica*	Jangli kand	Liliaceae
Bamboo and Grasses			
127.	*Apluda mutica*	Bhangr	Poaceae
128.	*Aristida adscensionis*	Lapdu	Poaceae
129.	*Bambusa bamboos* *	Katis (Vans)	Poaceae
130.	*Bothriochloa inschaemum*	Zinzavo	Poaceae
131.	*Bothriochloo glabra*	Dhrafdo	Poaceae
132.	*Chloris dolichostachya*	Sikaria	Poaceae
133.	*Cymbopogon jwarancusa*	Gandharia	Poaceae
134.	*Cymbopogon martini* *	Rosha	Poaceae
135.	*Cynodon dactylon* *	Dhrub	Poaceae
136.	*Dendrocalamus strictus* *	Mavel (Vans)	Poaceae
137.	*Desmostachya bipinnata*	Darabh	Poaceae
138.	*Dichanthium annulatum*	Jhinvo	Poaceae
139.	*Dinebra retroflexa*	Khariu	Poaceae
140.	*Eragrostis unicloides*	Chaklu	Poaceae
141.	*Heteropogon controtus*	Dabh saliu	Poaceae
142.	*Ischaemum rugosum*	Dholiu	Poaceae
143.	*Iseilema prostratum*	Moshti	Poaceae
144.	*Oplismenus burmanii*	Gandhelu	Poaceae

Sr. No.	Botanical Name	Local Name	Family
145.	*Sehima sulcatum*	Shaniar	Poaceae
146.	*Seteria glauca*	Ziptis ghas	Poaceae
147.	*Sorghum halepense*	Baru	Poaceae
148.	*Sporolobus coromandelianus*	Khario	Poaceae
149.	*Themeda quadrivalve*	Ratad	Poaceae
Climbers			
150.	*Abrus precatorius*	Chanothi	Fabaceae
151.	*Acacia pinnata*	Khirvel	Mimoseae
152.	*Asparagus racemosus*	Satawari	Liliaceae
153.	*Bougainvillea spectabilis* *	Boganvel	Nyctaginaceae
154.	*Capparis sepiaria*	Kanther	Capparidaceae
155.	*Celastrus paniculata*	Malkankani	Celastraceae
156.	*Cissus quadrangularis*	Hadsankal	Vitaceae
157.	*Cocculas villosus*	Vevadi	Menispermaceae
158.	*Combretum ovalifolium*	Malvel	Combretaceae
159.	*Convolvulus microphyllus*	Sankhawali	Convolvulaceae
160.	*Cuscuta reflexa* *	Amarvel	Convolvulaceae
161.	*Ipomoea biloba* *	Rawal patri	Convolvulaceae
162.	*Leptadenia reticulata*	Khirikhodi	Asclepiadaceae
163.	*Pueraria tuberosa*	Vidari	Fabaceae
164.	*Rivea hypocrateriformis*	Fagvel	Convolvulaceae
165.	*Tinospora cordifolia*	Galo	Menispermaceae

Source: State Forest Department, Jamnagar

***These species were observed during the Survey by NEERI Team**

Table 4.5.3

Medicinal Plants in Jamnagar District and their Medicinal Value

Sr. No.	Scientific Name	Common Name	Family	Medicinal Value
Trees				
1.	*Acacia catechu*	Khair	*Fabaceae*	Bark is used in Asthma and bronchites
2.	*Alstonia scholaris*	Saptaparni	*Apocynaceae*	Roots are used in biliousness
3.	*Atlantia racemosa*	Makadi	*Rutaceae*	Antispasmodic (fruit), dyssentry (leaf)
4.	*Bombax malabaricum*	Kate sawar	*Bombacaceae*	Aphrodisiac (root bark), debility (gum)
5.	*Bridelia retusa*	Khaja	*Euphorbiaceae*	Astringent, debility rheum
6.	*Butea monosperma*	Palas	*Fabaceae*	Blood pressure (root bark), diarrhoea, dog bite (flower)
7.	*Careya arborea*	Kumbha	*Myrtaceae*	Cold, cough (calyx), stomache ache (bark, fruit)
8.	*Caryota urens*	Bherali mad	*Palmae*	Laxative (wood sap)
9.	*Cassia fistula*	Bahava	*Fabaceae*	Burns, eczema (leaf), purgative (root), ringworm (leaf)
10.	*Cordia dichotoma*	Bhokar	*Boraginaceae*	Asringent (bark), cough
11.	*Dillenia pentagyna*	Karmal	*Dilleniaceae*	Cold (leaf, root)
12.	*Emblica officinalis*	Awala	*Euphorbiaceae*	Wound maggots (leaf)
13.	*Erythrina stricta*	Pangara	*Fabaceae*	Snakebite (bark), vermicidal leaf
14.	*Ficus racemosa*	Umbar	*Urticaceae*	Dermatites (bark) urinry disease (bark),
15.	*Garcinia indica*	Kokam	*Guttiferae*	Skin diseases (bark)
16.	*Gmelina arborea*	Shivan	*Verbenaceae*	Cholera (bark), rat bite, syphilis, spleen trouble
17.	*Macaranga peltata*	Chandava	*Euphorbiaceae*	Bleeding wounds
18.	*Mallotus phillipinensis*	Shendari	*Euphorbiaceae*	Vermifuge (fruit)
19.	*Mangifera indica*	Am	*Anacardiaceae*	Dysentery (bark)
20.	*Memeceylon umbellanum*	Anjani	*Melastomataceae*	Swell (bark)
21.	*Pongamia pinnata*	Karanj	*Fabaceae*	Diarrhea (leaf), ear

Sr. No.	Scientific Name	Common Name	Family	Medicinal Value
22.	*Sygygium cumini*	Jambhul	*Myrtaceae*	Diabetes (seed, fruit) Fish poison (bark)
23.	*Terminalia bellerica*	Beheda	*Combretaceae*	Asthma (fruits) cholera, cough, measles
24.	*Terminalia chebula*	Hirda	*Combretaceae*	Bronchitis, constipation (fruit bark), purgative (fruit)
25.	*Thespesia populnea*	Ranbhendi	*Malvaceae*	Arthritis, eczema (leaf)
Shrubs				
26.	*Abutilon indicum*	-	*Malvaceae*	Cough (seed), demulcent (leaf), laxative
27.	*Adhatoda vasica*	AduArushalasa	*Acanthaceae*	Rheumatisium
28.	*Barleria prionitis*	Kholeta	*Acanthaceae*	Leucoderma, toothache (leaf)
29.	*Calotropis gigantia*	Rui	*Asclepiadaceae*	Diarrhea, dysentery, skin disease
30.	*Carrisa carandus*	Karwanda	*Apocynaceae*	Skin disease (root)
31.	*Cassia auriculata*	Tarwad	*Fabaceae*	Antifertility (root), labour pain
32.	*Euphorbia nerifolia*	Niwdung	*Euphorbiaceae*	Asthma, earache (leaf)
33.	*Gnidia glauca*	-	*Thymelaeaceae*	Bruises, swell (leaf)
34.	*Helicteres isora*	Murudsheng	*Sterculiaceae*	Cholera, demulcent (fruit), colic,
35.	*Holarrhena pubescens*	Kuda	*Apocyanaceae*	Amoebic dysentery (bark), antitetanic
36.	*Homonoia riparia*	Sherani	*Euphorbiaceae*	Gravel (root)
37.	*Indigofera cassioides*	Chimnati	*Fabaceae*	Piles (leaf)
38.	*Lepidagathis cuspidate*	Kate-adulasa	*Acanthaceae*	Measles (whole plant)
39.	*Murraya koenigii*	Kadhi-patta	*Rutaceae*	Stomach ache (bark root), tonic (leaf)
40.	*Vitex nigundo*	Nirgudi	*Verbenaceae*	Rheumatism, head ache, liver disease
41.	*Woodfordia fruiticosa*	Dhayati	*Lythraceae*	Bleeding, menorrhagia, sprains (flower)
Herbs				
42.	*Alternanthera sessilis*	-	*Amaranthaceae*	Eye complaints (leaf)
43.	*Argemone maxicana*	Dhatura	*Papaveraceae*	Eczema (seed oil),

				jaundice (seed, root) scabies (leaf, root)
44.	*Ascelpias curassavica*	Halad-kunku	*Asclepiadaceae*	Hemorrhage (leaf), piles (root)
45.	*Eranthemum roseum*	Dashmuli	*Acanthaceae*	Leucorrhoea (root)
46.	*Lagascea mollis*	-	*Asteraceae*	Ear complaints (leaf)
47.	*Launaea procumbens*	Pathari	*Asteraceae*	Piles (leaf),
48.	*Polygonum glabra*	Sheral	*Polygonaceae*	Dislocated bone
49.	*Sopubia delphinifolia*	-	*Scrophulariaceae*	Heals sores (whole plant)
50.	*Sphaeranthus indicus*	Gorakhmundi	*Asteraceae*	Digestive disorders (whole plant)
51.	*Tridax procumbens*	Ek dandi	*Asteraceae*	Bruises, cough, cuts, injuries (leaf)

Source: State Forest Department, Jamnagar

Table 4.5.4

Simpson's Diversity Index (SDI) of Flora in the Study Area

Sr. No.	Category of Flora	Simpson's Diversity Index (SDI)
1	**For trees**	**0.1611**
2	**For shrubs**	**0.1935**
3	**For herbs**	**0.2429**

Table 4.5.5
List of Agricultural Crops in Jamnagar District

Sr. No.	Scientific Name	Common Name
Rabi		
Cereals		
1	*Triticum aestivum*	Wheat
2	*Hordeum vulgare*	Barley
Pulses		
3	*Phaseolus*	Gram
4	*Lens culinaris*	Lentil
Oil Seeds		
5	*Brassica juncea*	Mustard
Vegetables		
6	*Coriandrum anum*	Coriander
7	*Allium sativum*	Garlic
8	*Capsicum anum*	Chilly
9	*Solanum tuberosum*	Potato
10	*Daucus carata*	Carrot
11	*Pisum sativum*	Pea
Kharif		
Cereal		
12	*Oryza sativa*	Rice
13	*Zea mays*	Maize
14	*Sorghum vulgare*	Jowar
15	*Millet*	Bajra
Pulses		
16	*Cajanus cajan*	Arhar
17	*Phaseolus angularis*	Urd
18	*Phaseolus mungo*	Moong
Oil seed		
19	*Seasamum*	Til
20	*Arachys hypogea*	Groundnut
21	*Glycine max*	Soyabean
22	*Riccinus communis*	Castor
Others		
23	*Saccharum officinarum*	Sugarcane
24	*Gossipium species.*	Cotton
Vegetables		
25	*Capsicum anum*	Chilly
26	*Zingiber officinale*	Ginger
27	*Piper nigrum*	Pipper

Source: District Agriculture Office, Jamnagar

Table 4.5.6

List of Fauna found in the Jamnagar District

Sr. No.	Scientific Name	Common Name
Animals		
1.	*Axis axis*	Chital
2.	*Boselaphus magocamelus*	Nilgai (Blue bull)
3.	*Canis laureus*	Jackal
4.	*Canis lupus*	Wolf
5.	*Equus hemionus khur*	Indian Wild Ass
6.	*Felis caracal schreber*	Caracal
7.	*Felis chaus*	Jungle Cat
8.	*Felis constantina*	Desert Cat
9.	*Funambulus pennati* *	Squirrel
10.	*Gazelles gazelles benetti*	Chinkara
11.	*Hemiechninas auritus*	Long Eared Hedge Hog
12.	*Anropunctatus* *	Mongoose
13.	*Hyaena hyaena*	Hyaena
14.	*Hystris indica*	Porcupine
15.	*Lepus nigricollis*	Hare
16.	*Manis carassicauta*	Pangolin
17.	*Micro chiroptera* *	Bat
18.	*Panthera pardus*	Panther
19.	*Presbytis entellus* *	Common Langur
20.	*Sus scrofa*	Wild Boar
21.	*Vulpes bengalensis*	Common Fox
22.	*Vulpes bucopus*	Desert Fox
Birds		
23.	*Accipiter badius*	The Shikara
24.	*Acridotheres ginginianus*	Bank Myna
25.	*Acridotheres tristis* *	Common Myna
26.	*Aloedo atthis* *	Small Blue Kingfisher
27.	*Anas clypeatea*	Shoveller Duck
28.	*Andea alba* *	Large Egret
29.	*Anhinga rufa*	Darter
30.	*Anthropoides virgo*	The Demoiselle Crane
31.	*Ardea cinerea**	Grey Heron
32.	*Ardeola grayii* *	Pond Heron
33.	*Athene brama*	Spotted Owlet
34.	*Bubulcus ibis* *	Cattle Egret
35.	*Ceryle rudis*	Pied Kingfisher

Sr. No.	Scientific Name	Common Name
36.	*Chlamydotis undulata*	Houbara Bustard
37.	*Choriotis nigriceps*	The Great Indian Bustard
38.	*Circus aeruginosus*	Marsh Harrier
39.	*Clamator Jacobinus* *	Pied Crested Cuckoo
40.	*Columba livia neglecta* *	Blue Rock Pegion
41.	*Coracias benghalensis* *	Indian Roller
42.	*Corvus macrorhynchos* *	Jungle Crow
43.	*Corvus splendens* *	House Crow
44.	*Cypsiurus parvus*	The Palm Swift
45.	*Dicrurus adsimillis* *	Black Drongo
46.	*Egreta garzetta*	Little Egret
47.	*Egretta gularis**	Reef Heron
48.	*Elanus caeruleus*	Blackwinged Kite
49.	*Eudynamys scolopacea* *	Koel
50.	*Francolinus pondicerianus*	Grey Partridge
51.	*Galerida deva*	Crested Lark
52.	*Gyps bengalensis*	Whitebecked Vulture
53.	*Haliastur indus*	Brahminy Kite
54.	*Himantopus himantopus*	Blackwinged Stilt
55.	*Hydrophasianus*	Pheasant tailed Jacana
56.	*Lanius schach*	Rufousbacked Shrike
57.	*Larus argentatus*	Herring Gull
58.	*Limosa lapponica*	Bartalied Godwit
59.	*Limosa limosa*	Blacktailed Godwit
60.	*Monticola gularis*	Blue Rock Thrush
61.	*Motacilla alba dukhuensis*	White Wagtail
62.	*Motacilla cincerea*	Grey Wagtail
63.	*Mycteria leucorodia* *	Painted Stork
64.	*Nectarinia asiofica brevirostris*	Purple Sunbird
65.	*Neophron percnopterus*	White Scavenger Vulture
66.	*Numenius arquata*	Curlew
67.	*Orthotomus sutocius*	Tailor Bird
68.	*Pandion haliaetus*	Osprey
69.	*Parus major*	Grey Tit
70.	*Pavo cristatus* *	Common Peafowl
71.	*Pelecanus qnocrotalus*	Rosy Pelican
72.	*Perdicula asiatica*	The Jungle Bush Quil
73.	*Phalacrocorax niger* *	Little Cormorant
74.	*Phalacrocorax qarbo* *	Large Cormorant
75.	*Phoenicopterus roseus* *	The Flamingo

Sr. No.	Scientific Name	Common Name
76.	*Platalea leucorodia* *	The Spoonbill
77.	*Pluvialis squatarola*	Grey Plover
78.	*Podiceps raficollis*	Little Grcbe
79.	*Pseudibis papillosa*	Black Ibis
80.	*Psittacula krameri* *	The Roseringed Parakeet
81.	*Recarvirostra avosetta*	Avocet
82.	*Saxicoloides fulicata*	Indian Robbin
83.	*Sterna aurantia*	River Tern
84.	*Strebopelia decaocto*	Ring Dove
85.	*Strebopelia senegalensis* *	Little Brown Dove
86.	*Sturnus pagodarum*	Brahminy Myna
87.	*Sturnus roseus*	Rosy Pastor
88.	*Sypheotides indica*	Lesser Florican
89.	*Tephrodornis pondicerianus*	Common Wood Shrike
90.	*Threskiornis aethiopica*	White Ibis
91.	*Tringa tetanus*	Redshank
92.	*Turdoides striatus*	The Jungle Babbler
93.	*Vanellus indicus*	Redwattled Lapwing
Reptiles		
94.	*Crocodiles palustris*	Crocodile
95.	*Geochelone elegans*	Star Tortoise
96.	*Python molurus*	Python
97.	*Varanus bengalensis* *	Monitar Lizzard
98.	*Varanus salvator*	Water Monitor
99.	*Naja naja*	Indian cobra
100.	*Bungarus caeruleus*	Common Indian Krait
101.	*Vipera russelli*	Russell's Viper
102.	*Calotes versicolor*	Garden lizard

Source: State Forest Department, Jamnagar

*These species were observed during the Survey by NEERI Team

Table 4.5.7

Rare, Endangered and Vulnerable Status of Birds in Jamnagar District

Sr. No.	Scientific Name	Common Name	Status
1	*Ephippiorhynchus Asiaticus*	Black necked stork	Endangered
2	*Haliastur indus*	Brahminy kite	Vulnerable
3	*Anhinga rufa melanogaster*	Darter	Vulnerable
4	*Calidris tenuirostris eastern knot*	Eastern knot	Rare and Endangered
5	*Coruficollis*	Eastern little stint	Rare and Endangered
6	*To nebularia*	Green Shank	Vulnerable
7	*Phalaerocorax fuscicollis*	Indian Shag	Vulnerable
8	*Butorides striatus*	Little Green Heron	Endangered
9	*Falco peregrinus*	Peregrine Falcon	
10	*Asio flammeus*	Shorteared owl	Vulnerable
11	*Tringa erythropus*	Spotted Red Shank	Vulnerable
12	Emberiza striolata	Striolated Bunting	Vulnerable

Source: State Forest Department, Jamnagar

Table 4.5.8

List of Marine Fish Species

Sr. No.	Name of Fish
1.	White pomfret
2.	Black pomfret
3.	Bombay duck
4.	Thread fin
5.	Jew fish
6.	Hilsa
7.	Clupeid
8.	Coilia
9.	Shark
10.	Mullet
11.	Cat fish
12.	Eel
13.	Leather Jacket
14.	Seer fish
15.	Indian salmon
16.	Ribbon fish
17.	Silver bar
18.	Perch
19.	Small Sceindies
20.	Shrimp
21.	Prawn (Medium)
22.	Prawn (Jambo)
23.	Lobster
24.	Crab
25.	Levta
26.	Cuttle/Squids
27.	Miscellaneous

Source: Assistant Director of Fisheries, Jamnagar

Table 4.5.9

Different Prawn Species Found in the Gulf of Kutch

Family	Species
Penacidae	
	1. Penaeus indicus
	2. P. latisulcatus
	3. P. meguiensis
	4. P monodon
	5. Penicillatus
	6. P. semisulcatus
	7. Metapenaeus affinis
	8. M. brevicornis
	9. M. burkenroadi
	10. M. lysianassa
	11. M. lysianassa
	12. M. monoceros
	13. M. stebbingi
	14. Paprpenaeopsis harswickii
	15. P. psculptilis
	16. P. stylifera
	17. Trachypenaeus granulosus
	18. T. pescadoreensis
	19. Solenocera crassicornis
	20. Metapenaeopsis stridulans
Sergestidae	
	1. Acetes indicus
Palaemonidae	
	1. Palaemon semmelinkii
	2. P. styliferus
	3. P. tenuipea
Hippolysmata	
	1. Hippolysmata ensirostris
	2. Saron marmoratus
Alpheus	
	1. Alpheus distinguendus

Source: Marine National Park, Jamnagar

4.6 Socio- economic Environment

4.6.1 Reconnaissance

The study of socio-economic component of environment incorporates various facets viz. demographic structure, availability of basic amenities such as housing, education, health and medical services, occupation, water supply, sanitation, communication and power supply, prevailing diseases in the region as well as features such as places of tourist attraction and monuments of archaeological importance. The study of these parameters helps in identifying, predicting and evaluating the likely impacts due to the proposed project.

The area within 25 km radius from the project site is designated as study area, which includes 115 villages from Jamnagar District covering 3 talukas namely Jamnagar, Khambaliya and Lalpur. The main occupation of the people in the study area is agriculture and its allied activities. These villages surveyed are presented in **Table 4.6.1** alongwith their distance and direction from the project site and the locations is depicted in **Fig. 4.6.1**

The major industrial establishments near the project site include a fertilizer plant of GSFC, power plant of GEB, cement plant of Digvijay Cement Limited, ESSAR Industries Limited and Reliance Industries Limited. It is envisaged that the proposed project would lead to certain impacts on the surrounding area with reference to socio-economic environment. The data on baseline status of the socio-economic profile is collected and the impacts are predicted.

4.6.2 Baseline Status

Baseline information is collected to define the socio-economic profile of the study area. The database thus generated in the process includes the following:

1) Demographic structure
2) Infrastructure base in the study area
3) Economic attributes
4) Health status
5) Socio economic status with reference to Quality of Life
6) Awareness and opinion of the people about the project

The data is generated using secondary sources viz. Census Records, District Statistical Abstract, Primary Health Centers, Official records etc. and primary data collection through field survey as well as field observations.

4.6.2.1 Demographic Structure

The study comprises 115 villages consisting of 38 villages of Jamnagar taluka, 41 villages of Khambaliya Taluka and 36 villages of Lalpur Taluka from Jamnagar district. The summary of a demographic data based on primary census abstract (CD) 2001 of Jamnagar district with reference to population, employment, household, literacy and community structure is presented in **Table 4.6.2** and the summarized information is given in **Table 4.6.3**.

The area is highly dominated by Hindu Community while the other religions group accounts for the very small percentage out of the total population in the study area. The society in the villages is traditionally rooted with old beliefs like patriarchal system and feudalism. Gender differences can also be seen in the study area.

Agriculture is the main occupation of the people in the study area and the major food crops grown in the district are wheat, rice, jowar, bajra and chilies whereas non-food crops grown are cotton and fodder crops.

The significant demographic features are:

- The total no of households in the study area are 216222
- The total population in the study area is 1175132
- Sex ratio (No. of females per 1000 males) is 928
- It is observed that the study area has an average literacy rate of 60.24% and the employment rate is 30.33%

4.6.2.2 Infrastructure Resource Base

The infrastructure resource base with reference to education, medical, water resources, post and telegraph, transportation and power and power supply is abstracted from Household, Assets and Amenities CD-2001 of Jamnagar district, Gujarat and presented in **Table 4.6.4**. However, the information is collected through socio-economic survey about the facilities in the villages is described below:

Education

Anganwadi Center is available in most of the surveyed villages. The figures from survey reported that most of the villages have primary and middle school facility while for further higher education people have to travel to more than 20 km.

The literacy rate of the study area is 60.24%, female literacy rate in the study area is quite low. Maximum educational level of the people in the study area is up to 10th class. The reason behind the low educational level may be due to lack of educational facilities, poor transportation facilities to schools and low motivation level of parents and students.

The scope of higher and technical education is available only at the district and only few people are able to take benefits of these educational institutions.

Medical Facility

Medical facilities in terms of community health workers and medical practitioner are available in most of the villages. The villages devoid of government medical facility avail them from private clinics or RIL center at Motikhavadi or visit to Lalpur and Khambaliya for treatment.

Power Supply

Electricity is available in all the villages for both domestic and agriculture purposes. Electricity connections for irrigation are also very few as the problem of shut down of electricity prevails in the study area.

Water Supply

The rural people from Jamnagar district use untreated well water for drinking purpose. Water supply is available in all villages that include bore wells, water tanks and water tankers provided by panchayats at the time of water scarcity. The quality of water is salty in some villages.

Transport and Communication

Transportation facilities are satisfactory. Bus stop is available in every village and bus visits villages for more than 4-5 times a day. The approach route is either Kuccha or pacca.

Post and communication facilities are extensively available with the PCO, STD and ISD facility. People are satisfied with the communication facilities.

Fuel

Fuel that is mainly used for cooking and other domestic purpose is wood, kerosene and LPG. LPG agencies are available in most of the villages while some people have to fetch it from the villages located more than 5 km.

4.6.2.3 Economic Attributes

The information on economic resource base of the area reveals that the main occupation of the people in the study area is agriculture and its allied activities. As rainfall is scanty and draught is common, agriculture production is not higher in the study area. The main food crops grown are wheat, rice, jowar, bajra, chilies and while the non-food crops grown are cotton and fodder crops. People residing near the coast mainly carry out fishing activity. The salt pans generated, also provides good source of employment for the local people. Local people are also employed in the nearby industries on contract basis. The employment pattern of the study area is shown in **Fig. 4.6.2** and is described below:

- Total main workers in the villages of the study area are 356450 (30.33 %)
- There are 54417(15.27%) workers as cultivators
- There are 21456 (6.01%) agriculture labours

- Non-worker population in the study area is 781603 (66.51%)

4.6.2.4 Health Status

Health of the people is not only a desirable goal, but it is also an essential investment in human resources. As per the National Health Policy, Primary Health Care has been accepted as main instrument for achieving this goal of development and strengthening rural health infrastructure through a three-tier system, viz. sub-centers, primary health center (PHCs) and community health center, which have been established.

Lack of building, shortage of manpower and inadequate provision of drug supplies are hampering the operational activities of these units. The standards to be met according to National health Policy are given below:

Population	Infrastructure	Personnel
3,000 – 5, 000	1 Sub center	1 ANM
25,000 – 30, 000	1 PHC, 6 beds	2 Medical officers
1,00,000	Rural	Medical superintendent

Data regarding health status has been collected from Primary Health Centers; Community Health Center Lalpur and Rural Hospital Khambaliya. From the data collected different health problems are reported to be prevalent in the community. Cases of acute watery diarrhea are reported to be high in the month of August. Other diseases like gastroenteritis and malaria are also highly prevalent in the study area besides common fever and tuberculosis.

The primary health center conducts various health camps and vaccination camps, health awareness programmes such as family welfare camps to motivate people for family planning operations, AIDS awareness programme and regular medical check-up camps are organized by PHC.

4.6.2.5 Cultural and Aesthetic Attributes

The ancient temples of “Krishna” and “Asapura Mata” are situated in villages Khambaliya (21 km) and Jogwad (15 km) from the project site.

4.6.3 Socio-economic Survey

In order to assess and evaluate the likely impacts arising out of any developmental projects on socio-economic environment, it is necessary to gauge the apprehensions of the people in the project area. Socio-economic survey serves as an effective tool for fulfilling this requirement. Socio-economic survey was conducted by NEERI in 18 villages of the study area located in all directions with reference to the project site. Sarpanch of each village and respondents (adults male-female) were chosen for the collection of awareness and opinion, by using judgmental or purposive sampling methods representing various socio-economic sections of the community.

During the socio-economic survey in the 18 villages it was observed that people are facing certain problems. The field observations from each of these villages during survey with reference to critical issues such as expectations from the project and their quality of life is described below:

- In most of the villages, respondent reported that their monthly income is near by Rs. 2000-2500/- unemployment problem are most prevalent in the study area. People are mainly engaged on temporarily or on contract basis in RIL and ESSAR Oil Limited and its associates
- Due to improper planning of drainage system respondents have reported the problems related to mosquito nuisance. Malaria and respiratory diseases are commonly found in study area. Existing medical facility in the surveyed villages are not satisfied
- All the surveyed villages are facing electricity shortage problems. Electricity is available for only 6-8 hours in a day, therefore daily activity mainly agriculture is highly affected. This results in low production and low income affecting economic level of villagers. Most of the villages are not having streetlights
- Primary survey revealed that educational level in the region is relatively low. The status of female literacy is reported to be very low. It was observed that the literacy is reported to be very low. It was observed that the literacy rate in the study area is higher in the younger age group as compared to people above 35 years
- Low educational status in the region has increased the level of unemployment, as people are not able to fulfill the requirement of the job
- People are demanding that technical education must be introduced to locals that may held to create employment opportunities
- People expected construction of infrastructure facilities like school, community hall, temple etc. with the help of SEZ authority
- Villages are facing the problem of pollution due to the near by industries
- Poor and inadequate medical facilities are common complaint in surveyed villages. Some of the villages have no accessibility to health care facilities. People have to go to long distance to access the medical facilities. People expect extension of mobile health van facility in the villages

- Most of the surveyed villages do not have any pucca road. There are only Kuccha roads in the villages. The condition of roads is very poor and maintenance of roads has been not done since long time. People expect periodic maintenance of major roads
- People complained of long distance, lack of proper approach roads and pathways and low motivation level for low enrolment rate in getting higher education

4.6.4 Awareness and Opinion of the People about the Project

Querries were made to the local people regarding awareness about the project. During discussions following observations were recorded:

- Most of the respondents are aware about in the study area proposed project,
- People are expecting that the project will bring new development in the region and may generate jobs for the local population
- People are expecting that project authority will improve the basic infrastructure of the villages and may ultimately help in improving the Quality of Life of the region
- People are expecting medical facilities from proposed project and desire improvement in facilities and extension of the facilities to some more nearby villages

4.6.5 Quality of Life

Quality of life (QoL) is a term, which indicates overall status of socio-economic environment in a given area. Quality of life (QoL) is defined as a function between "objective conditions" and "subjective attitudes" involving a defined "area" of concern.

The "objective conditions" are defined as numerically measurable artifacts of a physical, sociological event or economic event. Objective conditions may be defined as any number, which stands for a given quantity of a variable of interest so long as it is independent of subjective opinion.

"Subjective attitude" is primarily concerned with affective and cognitive dimensions. It is specifically concerned with how aspects of cognition vary with variation in objective conditions.

Once objective measures are obtained for each factor, they are transformed to a normal scale varying from 0 to 1 (value function curve) in which 0 corresponds to the lowest or least satisfactory measure, and 1 corresponds to the highest. The weights are assigned to each factor by ranked-pairwise technique, by the expert group based on the secondary data and general observations.

For each objective measure, a corresponding subjective measure is developed for each individual of the sample population by asking him to rate his satisfaction scale (value function curve). It is used such that 0 corresponds to the lowest level of attitudinal satisfaction and 1 corresponds to the highest level of satisfaction. Weights are assigned to each factor using ranked - pairwise comparison techniques.

The Socio-economic Indicators for QoL Assessment are:

1. Income, Employment and Working Conditions
2. Housing
3. Food
4. Clothing
5. Water Supply and Sanitation
6. Health
7. Energy
8. Transportation and Communication
9. Education
10. Environment and Pollution
11. Recreation
12. Social SecurityHuman Rights

I. Subjective quality of life

$$QoLs = 1/p \sum_{i=1}^{m} \sum_{j=1}^{p} QIij \text{ X } Wi$$

Where,

QoLs	=	Subjective quality of life index
p	=	No. of respondents, j = 1, ..., p
m	=	No. of factors, i = 1, ..., m
QIij	=	Subjective quality index for “i” th factor assigned by jth respondent
∑ Qiij	=	Subjective quality index for ”i” th factor assigned by all respondents in an area
Wi	=	Relative weightage of the “i” th factor

II. Objective quality of life

$$QoLo = \sum_{i=1}^{i=n} QIi \text{ X } Wi$$

Where,

QoLo	=	Objective quality of life index
n	=	No. of QoL Factors
i	=	1, ..., n
QIi	=	Satisfaction level (assigned by the expert group) for the “i” th objective indicator
Wi	=	Normalized weight for “i” th factor

III. Quality of Life (Cumulative Index)

$$QoLc = \frac{QoLo + QoLs}{2}$$

The subjective and objective QoL indices prior to commissioning of the project are presented in **Table 4.6.6.**

The average QoL index values are estimated as:

QoL (s)	=	0.50
QoL (o)	=	0.52
QoL (c)	=	0.51

The average QoL index value for the study area is leaning towards satisfactory level due to good economic status like low income, unemployment and also availability of basic needs, viz. food, clothing, and housing. The area lacking with medical, educational facilities and social security, besides water scarcity, inadequate irrigation, lack of sanitation, which are subjective conditions and are not much satisfactory as compared to objective conditions.

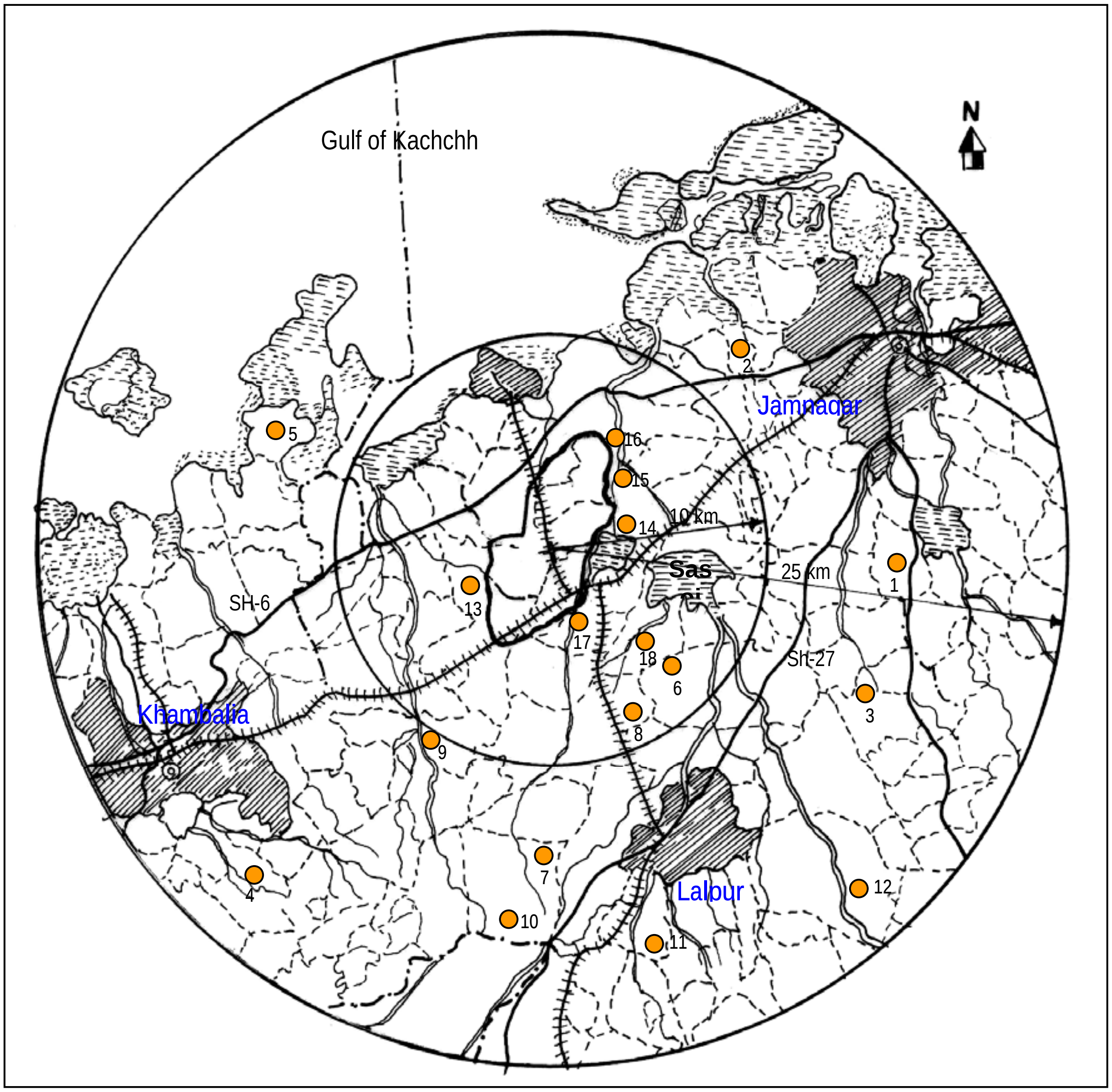


Fig. 4.6.1: Socio-economic in the study area

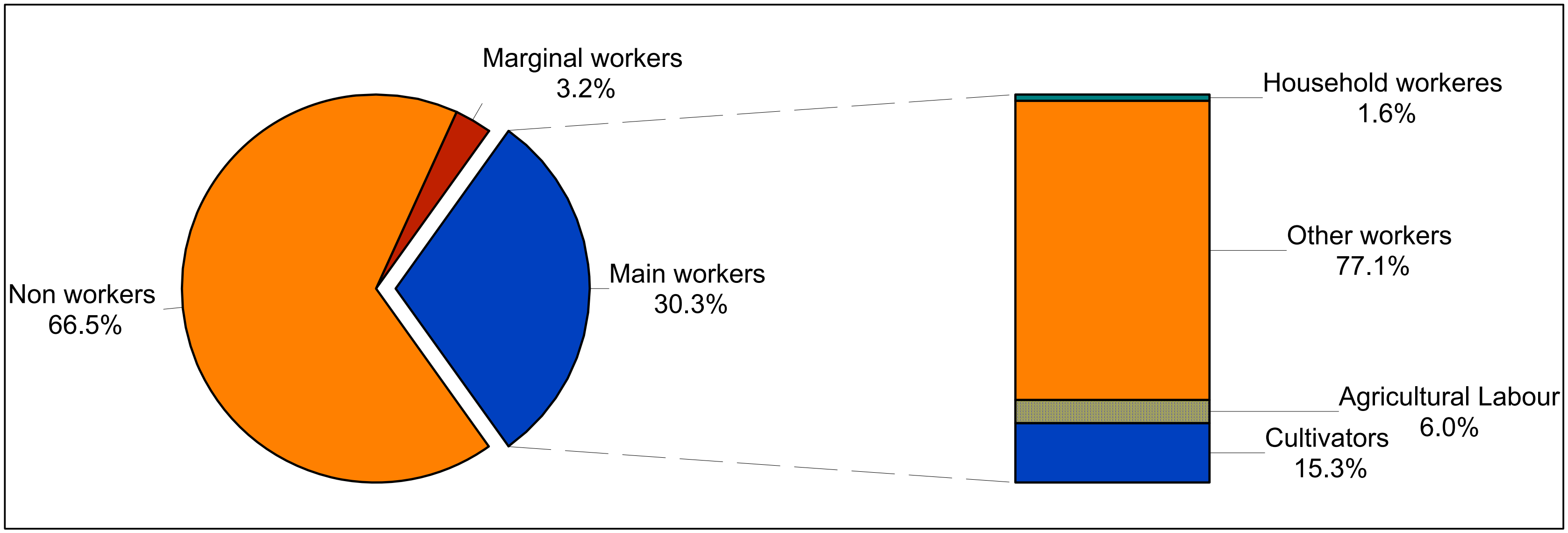


Fig. 4.6.2: Employment pattern in the study area

Table 4.6.1

Distance and Direction of the Villages Surveyed

Sr. No.	Villages	Aerial Distance (km)	Direction
1.	Naranpar	20	ENE
2.	Gordhanpar	20	NNE
3.	Pipartoda	18.3	E
4.	Kota	19	WSW
5.	Vadinar	18.3	NW
6.	Sevak Dhuniya	6.6	E
7.	Rafudad Moti	5	S
8.	Gajana	8	SE
9.	Apia	9	SW
10.	Govana	12.6	S
11.	Godavari	16	SSE
12.	Rinzpur	23.3	SE
13.	Padana	5.6	NW
14.	Navagam	10	NNE
15.	Dera Chhikari	7.3	N
16.	Kana Chhikari	10	N
17.	Kanalus	-	-
18.	Arablus	5.6	NE

Table 4.6.2

Demographic Structure in Study Area

Sr. No.	NAME	No_House hold H	TOT_P	TOT_M	TOT_F	P_SC	P_ST	P_LIT	MAIN_W_P	MR_W_P	NON_W_P
Jamnagar- District											
1.	Jamnagar	156241	836256	435975	400281	68359	4264	537823	244647	14132	577477
2.	Vasai	251	1693	856	837	118	0	377	434	5	1254
3.	Amra	691	4141	2137	2004	165	0	2273	1517	232	2392
4.	Jivapar	446	2405	1223	1182	107	0	1402	1117	58	1230
5.	Gaduka	87	447	229	218	9	0	221	124	75	248
6.	Balambhdi	108	497	253	244	0	0	249	84	102	311
7.	Dodhiya	252	1389	725	664	221	0	781	626	218	545
8.	Vav Beraja	148	775	393	382	7	0	418	302	8	465
9.	Chela	1024	5696	2994	2702	978	67	2556	1989	256	3451
10.	Harshadpar	336	1755	868	887	112	0	1005	837	57	861
11.	Naranpar	302	1886	976	910	180	11	1060	568	21	1297
12.	Changa	265	1531	760	771	190	0	839	558	150	823
13.	Chandragadh	207	1054	520	534	0	0	692	504	7	543
14.	Khoja Beraja	164	871	443	428	91	7	482	346	141	384
15.	Lonthiya	150	795	396	399	11	0	373	359	45	391
16.	Bavariya	37	189	97	92	3	0	104	96	4	89
17.	Lavadiya	226	1398	723	675	144	0	640	581	40	777
18.	Mokhana	222	1234	617	617	123	0	584	333	0	901
19.	Dhandha	76	461	238	223	44	0	246	194	7	260
20.	Chandraga	104	533	265	268	144	0	327	237	64	232
21.	Bed	999	6260	3213	3047	144	0	3187	1926	97	4237
22.	Mungani	450	2644	1361	1283	267	117	1560	584	154	1906

Sr. No.	NAME	No_House hold H	TOT_P	TOT_M	TOT_F	P_SC	P_ST	P_LIT	MAIN_W_P	MR_W_P	NON_W_P
23.	Gagva	157	837	428	409	148	0	425	199	111	527
24.	Nani Khavdi	277	1410	733	677	61	0	901	370	32	1008
25.	Sapar	381	1921	983	938	373	0	1053	798	171	952
26.	Champa Beraja	178	879	462	417	0	7	473	249	34	596
27.	Khoja Beraja	164	871	443	428	91	7	482	346	141	384
28.	Gordhanpar	136	775	399	376	4	0	384	174	51	550
29.	Khara Beraja	97	537	287	250	220	0	213	184	0	353
30.	Dhinchda	493	2790	1448	1342	207	0	1350	749	181	1860
31.	Moti Khavdi	1973	7422	4033	3389	131	9	5098	2356	322	4744
32.	Lakha Baval	607	3504	1791	1713	602	0	1685	1438	49	2017
33.	Kansumara	350	2045	1053	992	267	0	1045	579	85	1381
34.	Haripar	142	704	349	355	0	0	412	257	116	331
35.	Pipartoda	33	138	68	70	0	0	71	65	15	58
36.	Khengarka	200	1148	577	571	243	4	654	354	280	514
37.	Lakha Baval	607	3504	1791	1713	602	0	1685	1438	49	2017
38.	Masitiya	494	3180	1659	1521	0	0	1084	782	57	2341
Khambhalia- Taluka											
39.	Khambhalia	10636	63354	32350	31004	3211	57	31905	16792	1262	45300
40.	Danta	189	1133	583	550	116	31	439	303	1	829
41.	Bhatgam	65	445	247	198	50	0	162	168	16	261
42.	Kota	96	623	334	289	0	0	189	183	7	433
43.	Kolava	313	2018	999	1019	151	0	802	911	145	962
44.	Bhandariya	240	1509	737	772	78	0	709	699	79	731
45.	Bajana	310	2079	1059	1020	102	0	810	714	466	899
46.	Kandorna	180	1062	526	536	49	0	468	500	106	456
47.	Bhadthar	692	3937	2039	1898	313	1	1836	1455	528	1954

Sr. No.	NAME	No_House hold H	TOT_P	TOT_M	TOT_F	P_SC	P_ST	P_LIT	MAIN_W_P	MR_W_P	NON_W_P
48.	Sagariya	74	428	212	216	9	0	202	216	83	129
49.	Mota Mandha	254	1446	732	714	73	0	560	418	172	856
50.	Nana Mandha	216	1330	706	624	99	0	582	247	122	961
51.	Nana Ambla	238	1443	738	705	0	0	436	403	275	765
52.	Mota Ambla	105	594	289	305	14	0	269	167	73	354
53.	Vadinar	1166	6578	3400	3178	742	23	3133	1643	199	4736
54.	Bharana	605	4113	2110	2003	99	0	1211	969	135	3009
55.	Timbdi	155	870	434	436	118	0	436	219	81	570
56.	Kajurda	163	952	483	469	104	0	333	265	143	544
57.	Haripar	147	868	460	408	68	0	541	229	25	614
58.	Kanchanpur	131	626	336	290	6	0	250	159	23	444
59.	Sinhan Kakabhai	124	561	277	284	85	0	248	171	12	378
60.	Lakhasar Hapa	155	1020	514	506	89	3	519	289	130	601
61.	Devaliya	163	1051	514	537	29	0	382	441	86	524
62.	Lakhiya Nana	91	546	287	259	64	0	345	139	25	382
63.	Lakhiya Mota	178	992	495	497	48	0	548	271	154	567
64.	Rangpar	164	954	482	472	95	0	495	353	96	505
65.	Veraval Moti	297	1692	876	816	92	0	1078	732	130	830
66.	Sevak Bhatiya	85	380	181	199	18	0	226	218	4	158
67.	Sevak Dhuniya	163	1006	536	470	113	46	597	300	39	667
68.	Dabasang	256	1298	647	651	246	0	634	340	108	850
69.	Machhu Beraja	273	1626	810	816	38	3	825	610	211	805
70.	Sevak Bharudiya	96	474	241	233	255	43	243	206	68	200
71.	Modpar	475	3193	1600	1593	132	7	1485	1036	61	2096
72.	Rafudad Moti	307	1771	883	888	22	90	956	557	364	850
73.	Gajana	218	1094	589	505	94	0	528	431	108	555

Sr. No.	NAME	No_House hold H	TOT_P	TOT_M	TOT_F	P_SC	P_ST	P_LIT	MAIN_W_P	MR_W_P	NON_W_P
74.	Mulila	203	1196	597	599	40	4	572	517	3	676
75.	Pipar Navi	243	1387	692	695	76	0	696	502	80	805
76.	Rafudad Nani	321	1938	1011	927	151	0	1072	577	528	833
77.	Kanvirdi	77	526	282	244	10	0	282	278	30	218
78.	Apia	168	1011	491	520	56	0	415	533	93	385
79.	Govana	315	1875	953	922	48	0	785	487	408	980
Lalpur-Taluka											
80.	Lalpur	18421	101637	52076	49561	10080	618	53154	35568	8283	57786
81.	Singach	593	3514	1840	1674	152	0	1606	1544	116	1854
82.	Jasapar	214	1376	688	688	21	2	630	497	193	686
83.	Veraval Nani	154	1003	526	477	0	0	437	307	171	525
84.	Dhuniya Nava	89	509	251	258	0	0	235	228	49	232
85.	Khadba Mota	408	2210	1088	1122	323	18	1115	682	476	1052
86.	Jogvad	144	724	397	327	122	0	430	251	74	399
87.	Karana	200	1036	495	541	130	4	549	432	66	538
88.	Dhuniya Nava	89	509	251	258	0	0	235	228	49	232
89.	Khadba Mota	408	2210	1088	1122	323	18	1115	682	476	1052
90.	Veraval Nani	154	1003	526	477	0	0	437	307	171	525
91.	Godavari	197	1202	629	573	74	0	596	371	336	495
92.	Nanduri	470	2659	1355	1304	112	0	1230	848	335	1476
93.	Bharudiya Mota	104	668	349	319	0	0	335	214	10	444
94.	Vijaypur	79	440	223	217	0	0	181	205	2	233
95.	Raka	195	1051	555	496	133	0	534	336	208	507
96.	Khatiya	221	1134	593	541	203	0	644	426	22	686
97.	Khadba Nana	294	1816	920	896	456	84	766	658	38	1120
98.	Babariya	41	282	155	127	0	0	41	84	67	131

Sr. No.	NAME	No_House hold H	TOT_P	TOT_M	TOT_F	P_SC	P_ST	P_LIT	MAIN_W_P	MR_W_P	NON_W_P
99.	Rinzpur	337	2114	1064	1050	86	15	887	697	147	1270
100.	Tebhada	240	1392	739	653	363	0	536	561	171	660
101.	Sanosri	410	2176	1084	1092	298	4	1075	775	257	1144
102.	Kathitad	142	659	371	288	4	9	380	150	52	457
103.	Sansora	245	1540	791	749	116	0	693	398	445	697
104.	Chorbedi	190	1108	577	531	124	0	481	461	135	512
105.	Panchsara Mota	80	375	188	187	36	0	227	173	17	185
106.	Badhla	200	946	486	460	150	0	466	444	0	502
107.	Khadba Nana	294	1816	920	896	456	84	766	658	38	1120
108.	Vadpanchasara	157	846	412	434	133	0	484	296	21	529
109.	Padana	636	3364	1803	1561	489	5	1637	1051	112	2201
110.	Navagam	330	1615	818	797	92	0	854	596	29	990
111.	Dera Chhikari	113	529	265	264	0	0	262	149	18	362
112.	Kana chhikari	118	706	364	342	0	0	300	278	81	347
113.	Kanalus	388	2059	1044	1015	245	9	1075	858	64	1137
114.	Arablus	287	1550	771	779	421	0	800	700	82	768
115.	Meghavadar	158	780	395	385	36	0	393	388	22	370
	Total	216222	1175132	609595	565537	96747	5671	708004	356450	37079	781603

Source : Primary Census Abstract : Jamnagar District CD 2001

Table 4.6.3

Summary of Demographic Structure

Sr. No.	Demographic Parameter	**Details**
1.	No. of District	01
2.	No. of Taluka	03
3.	No. of Villages	115
4.	Total No. of Household	216222
5.	Total Population	1175132
6.	Sex Ratio (No. of female 1000 Males)	928
7.	Scheduled Castes (%)	96747(8.23%)
8.	**Scheduled Tribes (%)**	5671 (0.48%)
9.	Literate (%)	708004 (60.24%)
10.	Main Workers (%)	356450 (30.33%)
11.	Marginal Workers (%)	37079 (3.15%)
12.	Non-workers (%)	781603 (66.51%)

Source: Primary Census Abstract CD (2001) Jamnagar District, Gujarat.

Table 4.6.4

Infrastructure Resource Base of the Study Area

Sr. No.	District	Educational institution	Medical facilities	Power supply	Source Of Drinking Water							
					Tap	Hand pump	Tube well	Well	Tank, pond, lake	River, canal	Spring	Any other
Jamnagar District												
1.	Total	2,629	902	296,004	189,197	60,678	10,919	46,066	1,265	902	185	30,230
2.	Rural	2,074	448	157,963	86,479	40,523	6,345	43,379	1,184	898	183	11,724
3.	Urban	555	454	138,041	102,718	20,155	4,574	2,687	81	4	2	18,506

Source: Housing, Household Amenities & Assets – CD (2001) Jamnagar District, Gujarat.

Table 4.6.5

Mortality Rate of the Study Area

Taluka Name	Year	Birth	Death	IMR
Jamnagar	1999	18389	4439	196
	2000	17549	4604	146
	2001	18338	5292	0
Kambaliya	1999	3965	587	06
	2000	5665	476	10
	2001	4962	500	21
Lalpur	1999	3168	378	27
	2000	3124	389	12
	2001	2822	435	08

Source: Statistical Abstract Book 2002 - 03 Jamnagar District, Gujarat.

Table 4.6.6

Existing Quality of Life in the Study Area

Sr. No.	Villages	QoL (s)	QoL (o)	QoL (c)
1.	Naranpar	0.50	0.52	0.51
2.	Gordhanpar	0.48	0.50	0.51
3.	Pipartoda	0.47	0.49	0.48
4.	Kota	0.49	0.51	0.50
5.	Vadinar	0.49	0.51	0.50
6.	Sevak Dhuniya	0.51	0.53	0.52
7.	Rafudad Moti	0.52	0.54	0.53
8.	Gajana	0.50	0.52	0.51
9.	Apia	0.47	0.49	0.48
10.	Govana	0.52	0.54	0.53
11.	Godavari	0.51	0.53	0.52
12.	Rinzpur	0.53	0.55	0.54
13.	Padana	0.47	0.49	0.48
14.	Navagam	0.52	0.54	0.53
15.	Dera Chhikari	0.48	0.50	0.49
16.	Kana Chhikari	0.49	0.51	0.50
17.	Kanalus	0.53	0.55	0.54
18.	Arablus	0.52	0.54	0.53
	Average	**0.50**	**0.52**	**0.51**

QoL (s) : Subjective Quality of Life
QoL (o) : Objective Quality of Life
QoL (c) : Cumulative Quality of Life

Chapter 5

Identification and Prediction of Environmental Impacts

Impact prediction is a way of ‘mapping’ the environmental consequences of the significant aspects of the project and its alternatives. Several techniques and methodologies are in vogue for predicting anticipated impacts due to projects on natural and social aspects of the environment. These predictions are superimposed over the baseline (pre-project) status of the environment to derive the ultimate scenario of environmental conditions. These conditions are then subsequently evaluated for acceptability by screening them against standards for ambient environmental quality, against toxic effect, thresholds, etc. Based on results of prediction and evaluation, pollution abatement and control measures in order to mitigate the adverse impacts on the environment are delineated in an Environmental Management Plan for further implementation during the construction and commissioning of the proposed activities, as well as during the operational phase.

Impact predictions are made against a 'baseline' established by the existing environment (or by its future state) known as baseline studies, the collection of data on relevant biophysical, social and economic aspects provides a reference point against which the characteristics and parameters of impact-related changes are analysed and evaluated. In many cases, it is likely that the current baseline conditions will still exist when a project is implemented.

The characteristics of environmental impacts to be taken into account in impact prediction and decision-making include:

i) Nature (positive, negative, direct, indirect, cumulative);

ii) Magnitude (severe, moderate, low);

iii) Extent/location (area/volume covered, distribution);

iv) Timing (during construction, operation, decommissioning, immediate, delayed, rate of change);

v) Duration (short term, long term, intermittent, continuous);

vi) Reversibility/irreversibility;

vii) Likelihood (probability, uncertainty or confidence in the prediction); and

viii) Significance (local, regional, global)

The anticipated environmental impacts are predicted and evaluated in terms of the above mentioned characteristics during construction and operation phases of the proposed petroleum and petrochemical units in SEZ.

Various industries in India have been classified as green, orange and red by Central Pollution Control Board (CPCB), a statutory organisation under Ministry of Environment and Forests (MoEF), depending upon pollution potential of these industries. The pollution potential is rated as low, medium and high for green, orange and red category of industries respectively. The industries proposed in SEZ are Refinery and Petrochemicals, which all fall under red category.

Green

i) Non-obnoxious and non-hazardous emitting industries
ii) Do not discharge industrial effluent of polluting nature

Orange

i) Industries with proper environmental assessment and adequate pollution control measures to treat their waste

Red

i) Polluting industries

Prediction of impacts is the most important component in environmental impact assessment process. Several mathematical/statistical techniques and methodologies are available for predicting impacts due to developmental activities on physico-ecological and socio-economic environment. The quantitative prediction of impacts is also essential to delineate pragmatic Environmental Management Plan (pollution abatement and control measures) for implementation during and after the commissioning of proposed activities for minimising the adverse impacts on environmental quality.

Mathematical models are the best tools to quantitatively describe cause-condition-effect relationships between sources of pollution and different components of environment. In case, mathematical models are either not available or it is not possible to identify/validate models for a particular situation, predictions are arrived at through available scientific knowledge and judgments.

The environmental impacts of the proposed project are further categorized into the following:

- During the construction phase which may be regarded as temporary or short term; and
- During the operation phase which would have long-term effects

The construction and operation of the proposed project comprises various activities each of which shall have varied environmental impacts. The impacts identified have been presented in the following sections.

The mathematical models used for carrying out predictions in the present study included, steady state Gaussian Plume Dispersion model designed for multiple point sources for air quality and wave divergence model for noise quality. In case of land, biological and socio-economic environments, the predictions have been made based on the available scientific expertise and judgments.

5.1 Impacts during Construction Phase

The project construction phase (though generally short-term in comparison to the operation phase) can lead to significant environmental impacts. Significant impacts can result through short-term, high-intensity pressures on the physico-chemical environment in relation to air, groundwater, surface water, soils and land. Risks to environment parameters are of particular importance while assessing the construction stage impacts, in addition to hazards and risks posed to construction stage workers.

The stress on infrastructure, socio-cultural incompatibility due to immigration of construction workers and living conditions and consequent public hygiene are also important issues that has been considered while assessing impacts during construction stage.

The prediction of construction stage impacts includes any impacts occurring as a result of project infrastructure setup during construction, (e.g. roads, temporary labor colonies etc.). The waste and refuse generated during construction, and any likely impacts resulting through de-commissioning of temporary structure(s) created during construction phase.

The construction activities will mainly involve:

- Land preparation for proposed project units
- Civil construction and mechanical erection of the facilities
- Internal pipeline laying and development of associated roads

The construction phase activities of any development shall cause short-term and temporary impacts. The various impacts during construction i.e. on air, water, land, soil, biological, social etc. their characteristics are listed in **Table 5.1**.

5.1.1 Air Environment

During the short period of site preparation mechanical shovels and earthmovers will be used for site clearance, cut and fill and other site leveling activities. These activities could generate dust particles which will be mobilised by wind, and affect the ambient air quality. However, these activities will be only temporary and with the sandy nature of the soil, the impact to ambient air quality would be only in areas in close proximity to project site.

During the construction phase, all emission sources will be intermittent which include emissions from heavy equipment used for construction and materials transport, from heavy vehicles on site. The power for construction purpose will be made available from the DG sets. The emissions are temporary and not expected to contribute significantly to the ambient air quality and will be within prescribed limits for industrial regions by CPCB.

The construction phase activities of any development in the SEZ shall mostly cause negative, short-term and temporary impacts. Adjoining proper mitigation measures could minimize these impacts.

i) Air quality and noise level impacts from site clearing, soil excavation, transportation of raw materials, construction activities and trenching on land

ii) Soil erosion to a small extent (flat terrain) due to site clearing, soil excavation, construction activities and trenching on land

iii) Land, soil and aesthetic impacts due to labour camps and land reclamation

iv) Impact on water quality from discharge of wastes from labor camps through sewage treatment units will show turbidity increase due to soil erosion at the project site

v) Marginal loss of flora and fauna due to site clearing

vi) Impacts on socio-economic environment due to employment generation in construction activities

5.1.2 Noise Environment

a) Impacts due to Construction Equipment: The noise due to construction equipment will be a temporary phenomenon. However, noise levels due to construction equipment may result into significant impacts due to operation of several equipment at a time.

b) Noise due to Transportation: The noise impact due to transportation will occur during the construction phase when many trucks (each way) per day will be plying on State Highway due to transportation of construction materials, man and machinery. This will not be a continuous operation but it may last up to 2-3 years. This will add to noise impact as background noise level will increase by 2-3 dBA.

5.1.3 Water Environment

Only temporary and localised impacts on hydrology are expected due to the construction activities. These could arise from temporary obstruction to natural flow of water due to foundation excavation, stacked material etc. There is a low significance of these impacts which can be easily overcome by appropriate construction methodology and practices.

During construction phase, water of appropriate quality is required for the following activities:

- Earth material compaction and stabilization during embankment construction
- In-situ cement concrete preparation for RCC and PCC requirements
- Drinking water needs of construction workers
- Equipment washing and cleaning, especially those involved in earth material compaction and stabilization
- Maintaining the embankment slope landscape, roadside, kerbside, median-side vegetation and compensatory plantation near the completed stretches of road

The water requirement during the construction period is estimated about 500 m^3/hr for construction and campsite requirements. The water will be made available from existing refinery resources (desalination plant) without affecting local water resources as the region is water scarce. The employment of the local people for the unskilled and semi-skilled jobs will ensure minimal temporary construction camp facilities thus minimise the migration of the people. Adequate sanitation facilities will be provided at the campsites.

5.1.4 Land Environment

The SEZ project will require acquisition of additional land; land is being acquired through the Land Acquisition Act and Direct Purchase. Since most of the land is barren no change is anticipated on the landuse due to such activities outside the SEZ boundaries.

The impacts on soil due to land disposal of solid wastes such as construction rubble, campsite garbage and discarded topsoil may impact soil quality. However, the impact is likely to be insignificant as the project authorities will take adequate measures to ensure that all waste generated at the construction site and at the labour camps are collected and disposed off in an appropriate manner in a dump site or recycled or reused where feasible. Moreover, experience gained while setting up RIL refinery will be made use of in handling solid wastes emanated during construction phase.

No quarry material will be required as the land is a gentle slope and mostly even and will not involve major cutting and filling. During the site preparation work, the soil from the higher gradient shall be utilized to level the areas with lower gradient. The amount of cutting and filing is well balanced. The current topography and usage of the area will be used as a basis for the development of a reinstatement plan that will be implemented after the quarry activities have ceased.

5.1.5 Biological Environment

As the project will be developed mainly in barren land therefore there will be very less tree cutting and tree felling. But since the proposed project will acquire a large amount of land it can cause damage to soil micro fauna like earthworms and scavengers which helps in maintaining soil fertility.

There exist five industries around the proposed project site within 25 km radius of the study area. These are Reliance Industries Limited, Essar Oil Limited, Gujarat State Fertilizer Company, GEB Power Plant and Digvijay Cement Limited. Due to these industries and traffic in the region the air pollution and noise pollution causing damage to the environment, due to which the natural habitats of the wild animals (Nilgai, Wild Boar, Fox) are reducing day by day. Because of shortage of food it is learnt that these animals enter the villages and destroy agricultural land.

Minimal vegetation will be cleared for the construction activities. The necessary stockpiles will be maintained within the SEZ complex. The construction labourers will be prohibited from using vegetation for fuel wood. Common kitchens at the camp site will be provided with cooking gas/fuel for this purpose.

The construction phase of the project will not have any impact on the biota freshwater bodies considering its location and operations philosophy.

5.1.6 Socio-economic Environment

The potential impacts of the project construction on local public infrastructure and civic amenities could arise due to pressure on resources (power, water, roads) due to the construction activities and the presence of the construction camps.

The electricity requirement for construction activities will be met from the existing RIL refinery resources and the project proponents' will not source electricity from the State electricity grid supply during the construction activities. No existing resources/water sources (surface/groundwater) which are currently being used by the villagers for the purpose of obtaining drinking water and/or water for irrigation or other purposes will be tapped into. As mentioned previously construction water will be procured by desalinating the saline water. Drinking water requirements during the construction phase will be met from desalination plant of refinery complex.

The SH-25 (Jamnagar – Dwarka) will be the main roadway for transportation of construction equipment and material. About 500 trucks per day are expected to ply on the road. Although such incremental traffic is not likely to cause major impacts on the national highway, any adverse impacts on the road infrastructure shall be adequately addressed. The village roads in the project area, if required, will be widened and strengthened for the use. However any strengthening/widening of any village roads shall not call for resettlement and rehabilitation. After the completion of the project activity village roads in the vicinity of the project area will be repaired for any damage caused by the movement of project related vehicles.

The construction camps will be located on sites acquired by Reliance and no impacts are expected on the local infrastructure in terms of land requirement. Separate arrangements shall be made at the construction camps for water and power supply, sanitation facilities and fuel to ensure that there are no pressures on the local resources.

5.1.7 Impacts on Health & Safety

Given the minimal intrusion into the existing natural resources of the region (land, freshwater sources), adequate measures for dust suppression (the only credible source impacting the air environment) and adequate distance from nearest habitation; minimum adverse health impacts are expected, either during construction or operation phase of the project.

The movement of heavy earthmovers, excavators, transporting vehicles during the construction phase may increase the risk of accidents and injuries. Interaction of local labour with outside labour force during the construction may lead to transference of communicable diseases if left uncontrolled and unchecked. A road safety awareness campaign will be undertaken to better inform the communities about safer road habits. The project proponent proposes to carry out community awareness program in partnership with the local health authorities on communicable sexually transmitted diseases well ahead of the commencement of the construction of project to minimize such risks. Also adequate facilities for the health of construction workers will be provided at the campsite.

Table 5.1

Likely Impacts of Construction Phase

Activity	Environmental Impact	Duration	Reversibility	Primary / Secondary	Significance
Site clearing	Particulate emissions	Short-term	Reversible	Primary	Moderately significant due to high wind speed and large area involved
	Noise generation from earthmovers	Short-term	Reversible	Primary	Moderately Significant to the workers at the site as the noise level generated is about 95-100 dB(A) Insignificant as the silence zone is away from the SEZ site
	Loss of flora and fauna	Short-term	Reversible	Primary	Not significant as land is mostly barren and mangroves are far away
	Increased soil erosion from cleared area	Long-term	Irreversible	Primary	Not significant as the soil has moderate erodibility potential and site sometimes receive heavy rainfall and wind
	Project affected population	Long-term	Irreversible	Primary	Significant as people from 6 villages will be affected
Soil excavation / quarrying	Particulate emissions	Short-term	Reversible	Primary	Moderately significant due to high wind speed and large area involved
	Noise generation from excavating equipment / explosives	Short-term, intermittent	Reversible	Primary	Moderately Significant to the workers at the site as the noise level generated is about 95-100 dB(A) Insignificant as the silence zone is away from the SEZ site
	Turbidity and suspended solids increase in the nearby water body	Interm-ittent	Reversible	Secondary	Moderately significant as creek and sea are nearby and area is prone to heavy rain fall, so runoff effect
Transportation of construction materials	Particulate and gaseous emissions (CO, HC, NOx)	Short-term	Reversible	Primary	Slightly significant/temporary
	Noise generation	Short-term	Reversible	Primary	Insignificant as the silence zone is away from the SEZ site but temporary for locals
Construction activities	Particulate and gaseous (CO, HC, SO_2, NO_x)	Short-term	Reversible	Primary	Moderate

Activity	Environmental Impact	Duration	Reversibility	Primary / Secondary	Significance
	emissions				
	Noise generation	Short-term	Reversible	Primary	Moderately Significant to the workers at the site as the noise level generated is about 95-100 dB(A) Insignificant as the silence zone is away from the SEZ site
	Sewage generation in labour camps	Short-term	Reversible	Primary	Insignificant because sanitation facilities and sewage treatment plant will be provided
	Cutting of trees due to usage of wood as fuel	Long-term	Reversible	Primary	No impact at all as workers will be provided with alternate fuel
DG sets for power generation	Gaseous emissions (SO_2, HC, CO, NO_x)	Short-term	Reversible	Primary	Slightly Significant
Trenching for laying pipelines/sewers/cables	Soil erosion	Short-term	Reversible	Primary	Insignificant as soil will be backfilled within a few days after removal
Land reclamation	Impact on soil quality and erodibility	Long-term	Irreversible	Primary	Insignificant as proper compaction will be undertaken
	Increase in turbidity of water body	Short-term	Reversible	Primary	Insignificant as increase in turbidity will be small and for short duration
Construction activities	Employment generation	Short-term	Reversible	Primary	Significant positive impact

5.2 Impacts during Operation Phase

Every industry during the operational phase has certain emissions, which create an impact to the environment. The operational phase activities due to the proposed SEZ have the potential to cause long-term environmental impacts. A pre-requisite to estimating the potential environmental impacts for the proposed SEZ was the identification and recording of the total project inputs including process technology, raw materials, water and energy. These impacts during the operation phase have been minimized by considering the use of the Best Available Technology, adopting cleaner options, physical and chemical nature of raw materials, precautionary measures, requirements of processing, transportation and handling of any hazardous/toxic /flammable/explosive material(s), usage of any recycled/salvaged material from industrial waste in the process, optimum usage of water, wastewater recycle and reuse etc.

The potential impact identification along with their impact characteristics are presented in **Table 5.2**.

5.2.1 Air Environment

The impacts on air quality from any project depend on various factors like design capacity, configuration, process technology, raw material/fuel used, envisaged emission control measures, operation and maintenance practices. Apart from the above, other activities, viz. transportation of raw materials and products, storage facilities and material handling within the plant may also contribute to air pollution. The air pollutant emission scenarios have been considered for air quality modeling.

5.2.1.1 Air Pollutant Emissions

Emissions due to Existing Refinery

The major air pollutants from the proposed SEZ which will contain refinery and petrochemical units are SO_2 and NOx due to the fuels burnt in the various process units. The fuel gas/liquid fuels in the complex are generated from the various process units and it is hydrotreated so that the fuel has low sulphur content which in turn reduces the emissions from the stacks. The fuel gas and fuel oil are fed to the furnace in a controlled manner so as to have minimum emissions. Natural gas / Synthesis Gas will also be used as a supplementary fuel. The efficient burner management system controls the NOx emissions.

Emissions due to Proposed Project of SEZ

The SEZ complex consists of 9 major units as given in the **Table 5.3.** The emission details of air pollutants due to SEZ is given in the **Table 5.4**.

5.2.1.2 Micro-Meteorology

The micro-meteorological data for the region during winter season indicates the predominant winds from N-E and N-W sectors. Winds from almost all the directions were observed during the study period without significant diurnal shift in wind direction. The sea breeze and land breeze phenomena could not be clearly distinguished due to dominance of synoptic winds. Synoptic winds dominated the wind pattern. The wind speed class of 10-20 km/h dominated the wind pattern. The mixing height details have been given in **Table 5.5.**

The hourly wind speed, solar insulation and total cloudiness during day time and wind speed and total cloudiness during night time were used to determine the hourly atmospheric stability class (Pasquill and Gifford) viz., A to F. The hourly stability was determined based on the technique suggested by Turner.

Turner's system used for determining the stability classes is as follows:

- For day or night: If total cloud cover (TC) = 10/10 and ceiling <7000 ft (2134 m), NR=0
- For night-time (defined as period from one hour before sunset to one hour after sunrise):
  - a) If TC<4/10, use NR = -2
  - b) If TC>4/10, use NR = -1
- For daytime: Determine insulation class number (IN)
  - a) If TC<5/10, use NR=IN
  - b) If TC>5/10, modify IN by the sum of the following applicable criteria
    - i) If ceiling<7000 ft (2134m), modification = -2
    - ii) If ceiling>7000 ft but <16000 ft (4877 m), modification = -1
    - iii) If TC=10/10 and ceiling>7000 ft, modification = -1, and let modified value of IN=NR, except for day-time NR cannot be <+1

All the stability classes were observed to be prevalent during the study period. However, the stability classes B and C were predominant during daytime, whereas stability class F was predominant in the nighttime.

5.2.1.3 Air Quality Modeling

The impact on air quality due to emissions from single source or group of sources is evaluated by use of mathematical models. When air pollutants are emitted into the atmosphere, they are immediately diffused into surrounding atmosphere, transported and diluted due to winds. The air quality models are designed to simulate these processes mathematically and to relate emissions of primary pollutants to the resulting downwind air quality. The inputs include emissions, meteorology and surrounding topographic details to estimate the concentration of conservative air pollutants.

The Industrial Source Complex – Short Term Version 3 (ISCST-3) model has been developed to simulate the effect of emissions from point sources on air quality. The ISCST-3 model was adopted from the USEPA guideline models and routinely used as a regulatory model to simulate plume dispersion and transport from up to 100 point sources and 20000 receptors. ISCST–3 is the state of the art model with USEPA and extensively used for predicting the Ground Level Concentrations (GLCs) of conservative pollutants from point, area and volume sources. The impacts of primary air pollutants are predicted using this air quality model keeping in view the plain terrain at the project site. The micrometeorological data monitored at project site during study period have been used in this model.

The ISCST-3 model is, an hour-by-hour steady state Gaussian plume dispersion model which takes into account the following:

- Terrain adjustments
- Stack-tip downwash
- Gradual plume rise
- Buoyancy-induced dispersion, and
- Complex terrain treatment and consideration of partial reflection
- Plume reflection off elevated terrain
- Building downwash
- Partial penetration of elevated inversions is accounted for
- Hourly source emission rate, exit velocity, and stack gas temperature

The ISCST-3 model thus provides estimates of pollutant concentrations at various receptor locations.

The MoEF sought clarification on data of the data of the ISCST model has been lumped for all the stacks for prediction of environmental GLC. Since there are more than 160 stacks that are envisaged, it is necessary that the exact location of these stacks and their emission rate are included and the GLC then predicted for relevant pollutant including HC

The ISCST3 Model has been used for the air modeling study to predict the pollutant concentration at the ground level. The various stacks, as listed in Table 5.4 of the EIA Report, were marked on the overall plot plan to arrive at their co-ordinates. These co-ordinates were fed into the grid network along with the respective emission rates. In the modeling exercise, each stack has been considered as a point source and the impact of all the point source stacks together has been modeled.

It is clarified that the emissions from all the stacks listed in Table 5.4 of the EIA report have been considered as multi-point sources and not lumped together as a single point source.

The impact of the gaseous emissions from all the 167 stacks has been studied. Each stack has been considered as an individual point source. Accordingly the emissions from 167 point sources have been modeled using the approved ISCST3 air modeling software to arrive at the maximum GLCs in the area. As per the model, the maximum GLCs of SO_2 and NO_X from SEZ emission are estimated to be 57 μg/m3 (4.16 km, SSW Direction) and 56 μg/m3 (4.16 km, SSW Direction) respectively in winter season. The isopleths showing GLCs of SO_2 and NO_X in winter season are presented in **Fig. 5.1** and **Fig. 5.2**. The estimated GLCs after superimposing with the baseline are within the stipulated standards for the industrial areas and is indicated in **Table 5.6.**

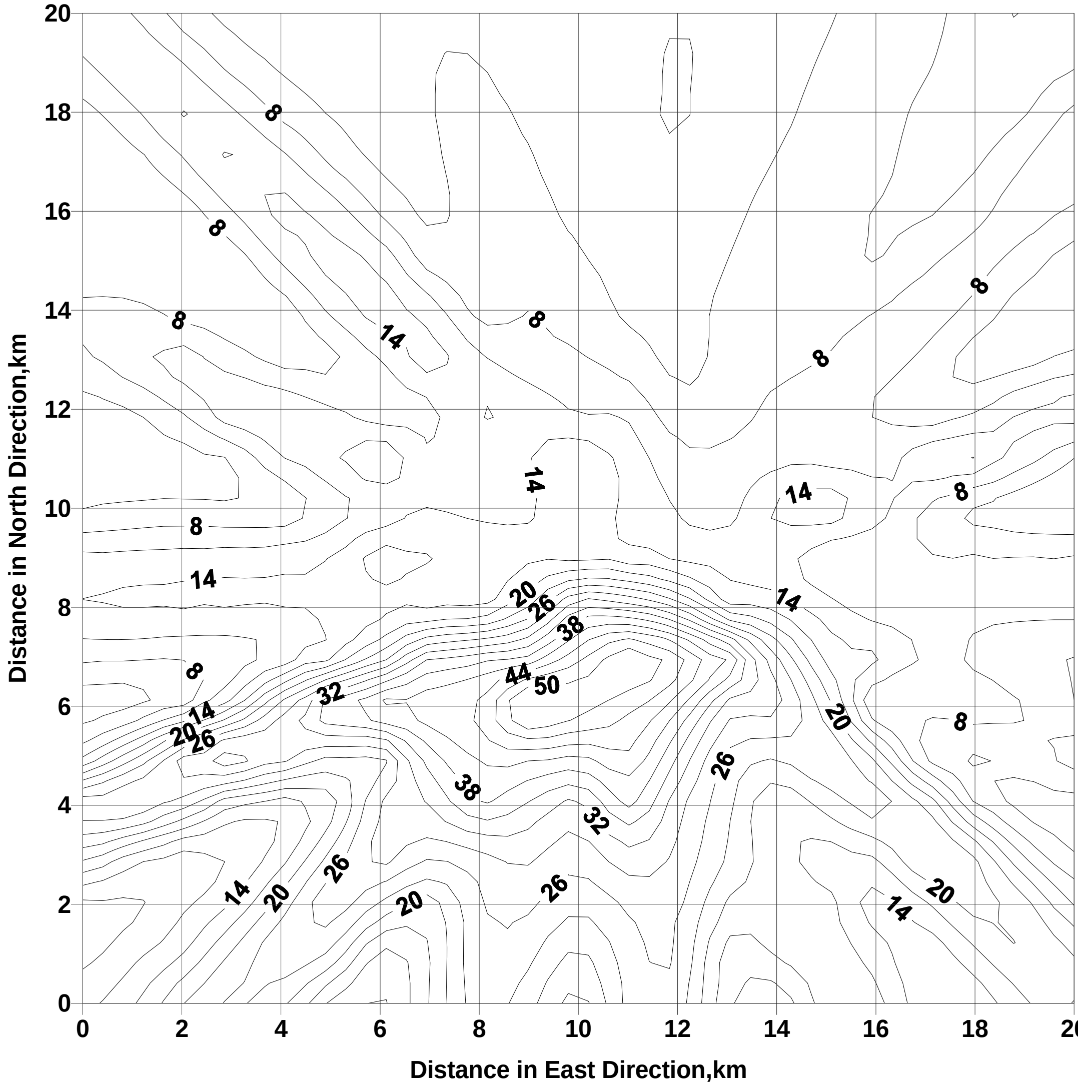
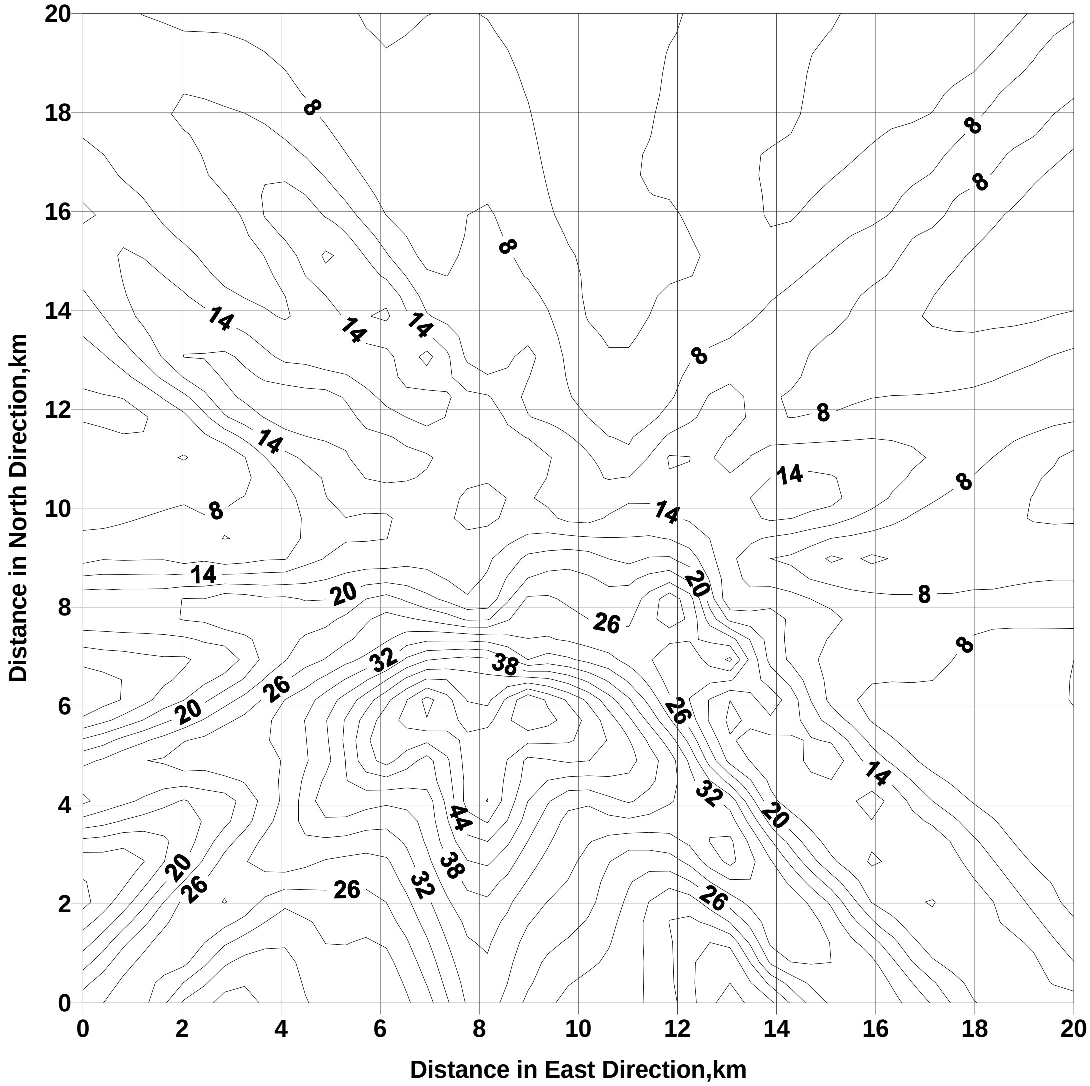


Fig. 5.1 Estimated GLCs of SO2 due to Proposed SEZ in Winter Season



Max. Conc. : 56 µg/m^3
4.16 km, SSW Direction

Fig 5.2: Estimated GLCs of NOx due to Proposed SEZ in Winter Season

Table 5.2
Likely Impacts of Operational Phase

Activity	Environmental Impact	Impact Characteristics				
		Duration	Reversibility	Positive/ Negative	Primary / Secondary	Significance
Transportation of raw materials	Particulate emissions and gaseous emissions (CO, HC, NO_x) during vehicular movement	Long-term	Irreversible	Negative	Primary	Slightly significant
	Noise generation from vehicular movement	Long-term	Irreversible	Negative	Primary	Slightly significant
	Noise generation from power plant	Long-term	Irreversible	Negative	Primary	Can be assessed only after undertaking EIA for power plant
	Water quality impacts from cooling water discharge	Long-term	Irreversible	Negative	Primary	Insignificant as the discharge will be properly designed using diffuser
Resource utilization	Competitive water demand	Long-term	Irreversible	Negative	Primary	Insignificant as large quantity of water will be required though treated sewage will also be used
Product generation	Air emissions from process plant / industry operation	Long-term	Irreversible	Negative	Primary	Slightly significant as predominantly non-polluting industries having cleaner technologies will be set up in SEZ
	Noise generation from process plant / industrial machinery	Long-term	Irreversible	Negative	Primary	Insignificant as silence zone is away from SEZ
	Solid waste generation	Long-term	Reversible	Negative	Secondary	Slightly significant as waste will be segregated, treated and disposed at appropriate landfill sites or incinerated

(Table 5.2 contd….)

Activity	Environmental Impact	Impact Characteristics				
		Duration	Reversibility	Positive/ Negative	Primary / Secondary	Significance
						Industries proposed in SEZ will generate only small quantity of hazardous waste which will be disposed as per the Hazardous Waste Collection, Handling and Disposal Rules at common facility
	Wastewater generation	Long-term	Irreversible	Negative	Secondary	Slightly significant as the wastewater will be appropriately treated and reuse to maximum and excess will be disposed off at locations away from fishing / breeding zones / other beneficial water use areas Treated effluent after recycled to maximum extent will be discharged into the sea
Raw material / product storage	Impact on groundwater quality due to leakage of material during rains	Long-term	Irreversible	Negative	Secondary	Slightly significant as storage tanks will be properly lined
Product distribution	Vehicular emissions during transportation of product to consumers	Long-term	Irreversible	Negative	Primary	Slightly significant
	Noise generation during transportation of product to consumers	Long-term	Irreversible	Negative	Primary	Insignificant as silence zone is away from SEZ
	Traffic congestion	Long-term	Reversible	Negative	Secondary	Slightly significant as the existing road will experience increased volume

Table 5.3

SEZ Units

Sr. No	Proposed Units	
I	**C1 Based Units**	Coke Gasification
		Methanol Synthesis
		Acetic Acid
		Vinyl Acetate Monomer
		Polyvinyl Acetate (PVA)
		Polyvinyl Alcohols (PVOH)
II	**C2 Based Units**	Multifeed Cracker Complex
		Ethylene Oxide Derivatives like Mono Ethylene Glycol (MEG), Di Ethylene Glycol (DEG), Tri Ethylene Glycol (TEG)
		Polyethylene polymers - Linear Low Density Polyethylene (LLDPE), Low / High Density Polyethylene (LDPE / HDPE)
III	**C3 Based Units**	Acrylic Acid & derivatives, Super Absorbent Polymer (SAP)
		n-Butyl Acrylate
		n-butyraldehyde
		n-Butanol
		2-Ethyl Hexanol
		Propylene derivatives like Propylene oxides, cumene, phenol
		Propylene Glycols
		Polyols
		Hydrogen Peroxide (H_2O_2)
		Polypropylene (Non woven)
		Polypropylene (PP)
IV	**C4/C5 Based Units**	Butyl/Halo Butyl Rubber, Emulsion Styrene Butadiene Rubber (ESBR), Styrene Butadiene Rubber (SBR), Poly Butadiene Rubber (PBR), Solution Styrene Butadiene Rubber (SSBR)
		Butene 1
		Maleic Anhydride (MA)
		Fumaric Acid
V	**C6/ C7/ C8 Based Units**	Mono Nitro Benzene, Aniline, Methylene Di Aniline, Phosgene, Methylene Diphenyl Diisocyanate, Toluene Diisocyanate, Benzene
		Styrene
		Paraxylene (PX), Orthoxylene (OX)
		Putrefied Teraphthalic acid (PTA)
		Polyethylene Tera-phthalate (PET)
		Polyesters Complex Polyester Oriented Yarn (POY), Polyester Stable Fiber (PSF)
VI	**Carbon Black**	
VII	**Lube Oil Cum Refinery Complex**	
VIII	**Captive Power Plant**	
IX	**Jamnagar Export Refinery Project**	

Table 5.4

Stack Details for the Refinery, Power Plant and the Petrochemical Units

Unit	Stack name	Diameter (m)	Stack Height (m)	Temp. K	Velocity (m/s)	Emission Rate (g/s)	
						SO_2 (g/s)	NO_X (g/s)
C1 Based Units							
Coke gassification	SRU/TGT Stack	1.7	117.3	595	10.1	11.66	1.69
	SRU/TGT Stack	1.7	117.3	603	10	11.66	1.69
Acetic Acid	Process Stack	0.4	50	320	6.9	0.04	
Methanol	Process Stack	1.2	50	483	7		
	Furnace Stack	1.5	50	468	13.2	0.13	46.07
	Furnace Stack	1.5	50	472	14.1	0.13	46.07
Poly vinyl Acetate	Process Stack	1.2	50	483	7.7		
Poly Vinyl Alcohol	Vent Dryer Stack	1.2	50	480	7.2		
Vinyl Acetate Monomer	Process Stack	0.6	50	458	6.2		
C2 Based Units							
Multifeed cracker	Fresh feed Furnace	1.6	50	437	17	9.73936	3.500083
	Fresh feed Furnace	1.6	50	428	17.6	10.0831	3.623615
	Fresh feed Furnace	1.6	50	429	17.5	10.02581	3.603026
	Fresh feed Furnace	1.6	50	430	17.1	9.796651	3.520671
	Fresh feed Furnace	1.6	50	435	17.5	10.02581	3.603026
	Fresh feed Furnace	1.6	50	433	16.9	9.68207	3.479494
	Fresh feed Furnace	1.6	50	432	17	9.73936	3.500083
	Fresh feed Furnace	1.6	50	437	17.2	9.853941	3.54126
	Fresh feed Furnace	1.6	50	434	17.3	9.911231	3.561849
	Fresh feed Furnace	1.6	50	428	17.6	10.0831	3.623615
	Fresh feed Furnace	1.6	50	429	17.5	10.02581	3.603026
	Fresh feed Furnace	1.6	50	430	17.1	9.796651	3.520671
	Fresh feed Furnace	1.6	50	433	17	9.73936	3.500083
	Fresh feed Furnace	1.6	50	431	16.9	9.68207	3.479494
	Fresh feed Furnace	1.6	50	435	17.4	9.968522	3.582438
	Fresh feed Furnace	1.6	50	433	17	9.73936	3.500083
	Fresh feed Furnace	1.6	50	436	17.3	9.911231	3.561849
	Fresh feed Furnace	1.6	50	432	17.6	10.0831	3.623615
	Fresh feed Furnace	1.6	50	429	17.5	10.02581	3.603026
	Fresh feed Furnace	1.6	50	431	17.4	9.968522	3.582438
	Fresh feed Furnace	1.6	50	427	17.3	9.911231	3.561849
	Fresh feed Furnace	1.6	50	429	17	9.73936	3.500083
	Fresh feed Furnace	1.6	50	433	17.1	9.796651	3.520671
	Fresh feed Furnace	1.6	50	437	16.9	9.68207	3.479494
	Fresh feed Furnace	1.6	50	431	17.1	9.796651	3.520671
	Fresh feed Furnace	1.6	50	429	17.5	10.02581	3.603026
	Fresh feed Furnace	1.6	50	430	17.3	9.911231	3.561849
	Fresh feed Furnace	1.6	50	435	17.5	10.02581	3.603026
	Fresh feed Furnace	1.6	50	438	17.4	9.968522	3.582438
	Fresh feed Furnace	1.6	50	429	17.1	9.796651	3.520671

Unit	Stack name	Diameter (m)	Stack Height (m)	Temp. K	Velocity (m/s)	Emission Rate (g/s)	
						SO_2 (g/s)	NO_X (g/s)
	Fresh feed Furnace	1.6	50	427	17.3	9.911231	3.561849
	Fresh feed Furnace	1.6	50	439	17.6	10.0831	3.623615
	Fresh feed Furnace	1.6	50	433	16.9	9.68207	3.479494
	Fresh feed Furnace	1.6	50	437	17.6	10.0831	3.623615
	Fresh feed Furnace	1.6	50	438	17.4	9.968522	3.582438
	Fresh feed Furnace	1.6	50	428	17	9.73936	3.500083
LLDPE	Process Stack	1.5	50	562	17.06	8.590196	3.087102
MEG+DEG+TEG	CO2 Stripper Vent	0.4	50	320	6.9	0.04039	
	Incinerator	0.44	50	337	7.3	0.126511	0.056831
	CO Vessel Vent	0.5	50	338	7.2	0.062346	
C3 Based Units							
n-Butyraldehyde	Process Stack	0.75	50	460	4.1		
	Process Stack	0.75	50	460	4.1		
PP	Absorber	0.8	50	326	7		
	Vent Absorber	0.96	50	340	7.2		
2 Ethyl Hexanol	Flare Stack	0.5	75				
Propylene derivatives	Process Stack	0.25	50	430	4		
	Flare Stack	0.3	60				
Acrylic acid & derivatives	Flare Stack	0.4	65				
SAP	Process Stack	1.1	50	411	7.6		
C4 / C5 Based Units							
n-Butanol	Flare Stack						
ESBR	Flare Stack	0.5	60				
Butyl /Halo Butyl rubber	Flare Stack	0.7	80				
Poly Butyl rubber	Process Stack	0.2	50	475	2.4		
C6 / C7 / C8 / C9 Based Units							
Mono Nitro Benzene	Flare Stack	0.45	60				
Styrene		3.8	50	414	5.3	0.033333	1.227778
Polyster Complex	DTA Vapouriser	1.2	50	483	7.1	2.288034	0.822262
	DTA Vapouriser	1.2	50	483	7	2.255808	0.810681
	DTA Vapouriser	1.2	50	483	7.3	2.352485	0.845424
	DTA Vapouriser	1.2	50	483	6.9	2.223582	0.7991
	DTA Vapouriser	1.2	50	483	7.2	2.320259	0.833843
	DTA Vapouriser	1.2	50	483	7	2.255808	0.810681
	DTA Vapouriser	1.2	50	483	7.3	2.352485	0.845424
	DTA Vapouriser	1.2	50	483	7.1	2.288034	0.822262
	DTA Vapouriser	1.2	50	483	7.7	2.481389	0.891749
PTA	Vent Scrubber	1.1	50	411	7.6		
	Turbine Expander	1	50	318	23.2	0.683285	0.427053
	Atm. Absorber	0.8	50	335	7.2	0.128827	0.080517
	Incinerator	1	50	361	6.8	1.521775	0.546888
Paraxylene and Orthoxylene	Platforming	4.82	50	489	3.6	3.958333	16.13889
	Xylene	4.43	50	485	4.1	2.183333	1.786111

Unit	Stack name	Diameter (m)	Stack Height (m)	Temp. K	Velocity (m/s)	Emission Rate (g/s)	
						SO_2 (g/s)	NO_X (g/s)
	Xylene	4.43	50	485	4.1	2.183333	1.786111
	Xylene	4.43	50	485	4.1	2.183333	1.786111
	O-Xylene	4.42	50	486	3.7	2.005556	14.025
Carbon black							
	Fuel Stack	2	50	430	7.7	9.25	2.477081
	Fuel Stack	2	50	429	7.5	9.25	2.412741
	Fuel Stack	2	50	432	8	9.25	2.57359
Lube Oil Cum Refinery Complex							
	CDU/VDU	4.5	72	478	4	0.061111	2.697222
	CDU/VDU	4.5	72	473	4.2	0.061111	2.697222
	VHO HT	2.8	50	451	4	0.038889	1.691667
	DHDS-1	3.8	50	491	3.6	0.011111	0.463889
	Hydrogen Plant	2.94	50	456	6.5	0.025	1.15
	Hydrogen Plant	2.94	50	453	6.2	0.025	1.15
	LCO Hydrocracker	1.4	50	588	3.5	0.008333	0.380556
Power Plant (2100 MW)							
	HRSG	3.2	80	468	13.2	0.138889	46.07222
	HRSG	3.2	80	472	14.1	0.138889	46.07222
	HRSG	3.2	80	470	13.8	0.138889	46.07222
	HRSG	3.2	80	469	13.9	0.138889	46.07222
	HRSG	3.2	80	469	14.8	0.138889	46.07222
	HRSG	3.2	80	475	14	0.138889	46.07222
	HRSG	3.2	80	465	14.2	0.138889	46.07222
	HRSG	3.2	80	468	13.6	0.138889	46.07222
	HRSG	3.2	80	473	14.5	0.138889	46.07222
	HRSG	3.2	80	475	13.4	0.138889	46.07222
	HRSG	3.2	80	474	13.3	0.138889	46.07222
	HRSG	3.2	80	469	13.7	0.138889	46.07222
	HRSG	3.2	80	468	14.3	0.138889	46.07222
	HRSG	3.2	80	470	13.5	0.138889	46.07222
	Auxiliary Boilers	2.3	80	423	13.1	23.33333	9.602778
	Auxiliary Boilers	2.3	80	432	13.5	23.33333	9.602778
	Auxiliary Boilers	2.3	80	430	13.6	23.33333	9.602778
	Auxiliary Boilers	2.3	80	423	13.4	23.33333	9.602778
	Auxiliary Boilers	2.3	80	433	14.1	23.33333	9.602778
	Auxiliary Boilers	2.3	80	427	13.7	23.33333	9.602778
	Auxiliary Boilers	2.3	80	425	14	23.33333	9.602778
	Auxiliary Boilers	2.3	80	429	13.9	23.33333	9.602778
JERP							
	Delayed Coker	3.25	54	458	3.7	0.033	1.495
	Delayed Coker	3.25	54	457	3.6	0.033	1.495
	Delayed Coker	3.25	54	458	3.8	0.033	1.495
	Delayed Coker	3.25	54	460	3.6	0.033	1.495
	Styrene 1	3.8	45	411	3.8		0.441667
	Styrene 2	3.8	45	414	3.7	0.011111	0.441667

Unit	Stack name	Diameter (m)	Stack Height (m)	Temp. K	Velocity (m/s)	Emission Rate (g/s)	
						SO_2 (g/s)	NO_X (g/s)
	LCO Hydrocracker	1.4	45	588	3.5	0.008333	0.380556
	MS Quality Upgrader	3.8	45	571	3.6		0.047222
	Alkylation	3.8	45	468	3.3	0.055556	2.452778
	DHDS – 1	3.8	45	491	3.4	0.011111	0.463889
	DHDS –2	3.8	45	498	3.6	0.011111	0.444444
	CDU / VDU	4.5	72	478	3.3	0.061111	2.697222
	CDU / VDU	4.5	72	470	3.5	0.061111	2.697222
	CDU / VDU	3	52	472	3.2	0.061111	2.697222
	VDU	3	52	488	3	0.061111	2.697222
	Bitumen	1	40	471	3.8	0.019444	0.858333
	Mild Hydrocracker	3.8	54	451	3.5	0.038889	1.797222
	Mild Hydrocracker	3.8	54	454	3.6	0.038889	1.797222
	Kero HT	2.2	45	441	3.1	0.005556	0.238889
	VGO HT	2.8	45	451	3.3	0.038889	1.691667
	HNUU	1.6	45	485	3.2	0.016667	0.738889
	Platformer	1.8	55	491	3.5	0.111111	5.047222
	Parex – 1	4.3	73	446	3.3	0.055556	2.558333
	Parex – 2	4.3	73	441	3.5	0.055556	2.558333
	Parex – 3	4.3	73	443	3.4	0.055556	2.558333
	Parex – 4	4.3	73	444	3.5	0.055556	2.558333
	Hydrogen – 1	3.8	45	458	6.5	0.022222	0.952778
	Hydrogen – 2	3.8	45	452	6.3	0.022222	0.952778
	Hydrogen – 3	3.8	45	455	6.4	0.022222	0.952778
	SDA – 1	2	40	430	4	0.036111	1.594444
	SDA – 2	2	40	435	4.2	0.036111	1.594444
	Propane Dehydrogenation	2	40	436	3.9	0.083333	3.691667
	Tatory	2	40	633	3.4	0.002778	0.166667
	Max Olefin FCC	3.45	82	544	19.5	97.22222	68.05556
	SRU – 4	1.7	117.3	593	9.9	9.813889	1.694444
	SRU – 5	1.7	117.3	595	10.1	9.813889	1.694444
	SRU – 6	1.7	117.3	603	10	9.813889	1.694444
Total						**768.5865**	**1138.304**

Table 5.5

Meteorological Data for winter season

Day	Hour	Wind Direction (in degrees)	Wind speed (m/s)	Temp. (^{0}K)	Stability Class	Mixing Height (m)
1	1	337.5	1.5	293.9	6	10
1	2	292.5	1.8	293.3	6	20
1	3	337.5	2.3	293.3	5	100
1	4	67.5	2.6	292.8	5	200
1	5	315	2	292.1	5	250
1	6	67.5	3.5	291	4	400
1	7	315	2.5	289.9	3	500
1	8	45.5	3	291.3	3	550
1	9	360	2.5	293.9	3	600
1	10	45	2	294.8	3	700
1	11	67.5	2.6	295.9	3	800
1	12	45	2.5	296.8	2	900
1	13	315	2.3	297.7	2	1000
1	14	337.5	2.5	298.1	2	1100
1	15	22.5	2.1	298.3	2	1000
1	16	360	1.5	298.6	2	900
1	17	22.5	2	297.7	3	800
1	18	315	2.5	295.9	3	600
1	19	360	3	294.5	4	450
1	20	22.5	3.6	293.8	4	400
1	21	360	3.2	293.3	5	250
1	22	45	4.1	292.9	5	200
1	23	270	3.4	293.3	5	150
1	24	292.5	2.5	292.9	6	50
2	1	337.5	1.5	293.9	6	10
2	2	292.5	1.8	293.3	6	20
2	3	360	2.3	293.3	5	100
2	4	67.5	2.6	292.8	5	200
2	5	45	2	292.1	5	250
2	6	270	3.5	291	4	400
2	7	90	2.5	289.9	3	500
2	8	45.5	3	291.3	3	550
2	9	360	2.5	293.9	3	600
2	10	337.5	2	294.8	3	700
2	11	360	2.6	295.9	3	800
2	12	45	2.5	296.8	2	900
2	13	225	2.3	297.7	2	1000
2	14	337.5	2.2	298.1	2	1100
2	15	22.5	2.4	298.3	2	1000
2	16	360	1.5	298.6	2	900
2	17	22.5	2	297.7	3	800
2	18	315.5	2.5	295.9	3	600
2	19	135	3.2	294.5	4	450
2	20	22.5	3.5	293.8	4	400
2	21	360	3.2	293.3	5	250

Day	Hour	Wind Direction (in degrees)	Wind speed (m/s)	Temp. (^{0}K)	Stability Class	Mixing Height (m)
2	22	45	4.1	292.9	5	200
2	23	90	3.4	293.3	5	150
2	24	292.5	2.2	292.9	6	50
3	1	180	1.5	293.9	6	10
3	2	292.5	1.8	293.3	6	20
3	3	135	2.3	293.3	5	100
3	4	67.5	2.6	292.8	5	200
3	5	202.5	2.3	293.1	5	250
3	6	360	3.5	291	4	400
3	7	90	2.7	289.9	3	500
3	8	45.5	3	290.3	3	550
3	9	360	2.5	293.9	3	600
3	10	337.5	2.2	294.8	3	720
3	11	225	2.6	295.9	3	800
3	12	45	2.5	296.6	2	900
3	13	22.5	2.3	297.7	2	1020
3	14	45	3.5	298.1	2	1150
3	15	67.5	2.4	298.3	2	1060
3	16	360	4.1	299.2	2	900
3	17	22.5	2.3	297.7	3	800
3	18	315.5	2.5	295.9	3	600
3	19	135	3.2	294.5	4	450
3	20	67.5	3.1	293.8	4	400
3	21	360	3.2	293.3	5	250
3	22	45	3.3	292.9	5	200
3	23	90	2.8	293.3	5	100
3	24	315	1.8	292.9	6	50
4	1	292.5	1.2	294	6	10
4	2	67.5	1.5	293.6	6	20
4	3	135	2.4	293.3	5	100
4	4	270	2.2	292.8	5	200
4	5	360	2.4	293.1	5	250
4	6	225	3.3	292	4	350
4	7	135	2.5	289.9	3	480
4	8	45.5	3.2	290.3	3	550
4	9	157.5	2.1	292.9	3	600
4	10	247.5	2.2	293.8	3	720
4	11	315	2.7	294.9	3	830
4	12	292.5	2.3	296.6	2	900
4	13	22.5	2.6	298.7	2	1020
4	14	90	3.5	299.1	2	1150
4	15	45	4.1	299.3	2	1060
4	16	360	4	299.6	3	900
4	17	67.5	2.5	298.7	3	800
4	18	360	2.4	296.9	3	600
4	19	112.5	3.1	295.5	4	450
4	20	90	3	293.8	5	400
4	21	360	3.3	293.3	5	250
4	22	45	3.4	292.9	5	200

Day	Hour	Wind Direction (in degrees)	Wind speed (m/s)	Temp. (^0K)	Stability Class	Mixing Height (m)
4	23	180	2.6	293.3	6	100
4	24	202	2	292.9	6	50
5	1	225	1.2	294	6	10
5	2	45	1.5	293.6	6	20
5	3	337.5	2.4	293.3	5	100
5	4	315	2.2	292.8	5	200
5	5	360	2.4	293.1	5	250
5	6	270	3.3	292	4	350
5	7	67.5	2.5	289.9	3	480
5	8	45.5	3.2	290.3	3	550
5	9	157.5	2.1	292.9	3	600
5	10	22.5	2.2	293.8	3	720
5	11	292.5	2.7	294.9	3	830
5	12	180	2.3	296.6	2	900
5	13	22.5	2.6	298.7	2	1020
5	14	112.5	3.5	299.1	2	1150
5	15	67.5	4.1	299.3	2	1060
5	16	360	4	299.6	3	900
5	17	45	2.5	298.7	3	800
5	18	360	2.4	296.9	3	600
5	19	247.5	3.1	295.5	4	450
5	20	45	3	293.8	5	400
5	21	315	3.3	293.3	5	250
5	22	337.5	3.4	292.9	5	200
5	23	225	2.6	293.3	6	100
5	24	292.5	2	292.9	6	50

Table 5.6

Cumulative Values of GLCs for SO_2 and NOx after Superimposing with the Baseline AAQM Data

Sr. No.	Sampling Location	Cumulative Value SO_2	Cumulative Value NOx
1.	Arablus	26	29
2.	Gadhuka	26	25
3.	Gagwa	42	44
4.	Jogwad	38	43
5.	Kanachikari	18	24
6.	Kanalus	36	49
7.	Khatiya Beraja	38	30
8.	Macchuberaja	21	48
9.	Meghpur	40	48
10.	Motikhavdi	31	38
11.	Motalakhiya	39	36
12.	Mungani	34	38
13.	Nanikhavdi	32	34
14.	Nanalakhiya	39	37
15.	Padana	23	31
16.	Rangpar	26	37
17.	Rasangpar	50	51
18.	Sapar	30	36
19.	Setalus	32	30
20.	Sevak Bharudiya	18	44
21.	Jivapar	14	23
22.	Balambhadi	15	28
23.	Dera Chikari	14	24
24.	Meghavadar	22	33

5.2.2 Noise Environment

5.2.2.1 Impacts due to Stationary Noise Source

Cumulative noise level at a particular location due to noise source can be computed by using Wave Divergence Model as given below:

$$L_{p2} = L_{p1} – 20 \log (r_2/r_1) – Ae_{1,2}$$

Where,

L_{p2} and L_{p1} are the noise levels at the distances r_2 and r_1 respectively from the source and $Ae_{1,2}$ is the excess attenuation along the path r_2-r_1 due to environmental adsorption, scattering and other shielding effects.

Total noise level Lp (Total) due to all sources can be determined as follows :

$$Lp\ (Total) = 10 \log (10^{Lpa/10} + 10^{Lpb/10} + 10^{Lpc/10} + \ldots\ldots\ldots\ldots) \qquad (1)$$

Where,

Lpa, Lpb, Lpc are the noise levels at a given location due to sources A, B, C etc.

Noise levels have been predicted at proposed noise sources in all the process units within the refinery and petrochemical complex.

The major stationary noise generating sources expected at proposed SEZ during operation phase are given in **Table 5.3.** The noise generation from major equipment will be restricted through manufacture specifications like BFPs, GTG, STGs, etc.: 85 dB(A). These sources have been considered for prediction of impact on ambient noise levels at nearby human settlements as well as the occupational exposure to workers within the project premises. Accordingly the net cumulative noise generation due to multiple sources at one location have been derived following standard logarithmic sum (log. Sum) formula.

The cumulative noise impact from different stationary sources at proposed project site has been predicted at 100mx100m grid intervals over an area of 33.52 km x 31.8 km noise impact area mainly covering project premises **Fig. 5.3**. The predicted results of cumulative noise levels at each grid points are used to draw noise contours through Surfer ver.6 graphics package. The predicted noise contours around proposed sources are shown in **Fig. 5.3.** These prediction results are applicable to only present layout plan. In case of any change in layout the distribution/pattern of predicted noise contours are also expected to change accordingly. It is also to be noted these noise contours derived without considering any attenuation factors due to structural interferences or green belt, i.e. the prediction results are conservative. As per the prediction results, the impact of noise out side the proposed project premises would be less than 22 dB(A) (**Fig. 5.3**).

The impact of noise levels from the stationary sources within SEZ is predicted to be below 24 dBA as given in **Table 5.7**. This table also shows the pre-project status and post project status that is prediction of noise impact in the nearby vicinity of the proposed SEZ. The predicted noise level after superimposing the predicted noise levels with the baseline data are well within the stipulated norms of CPCB and is indicated in **Table 5.7**.

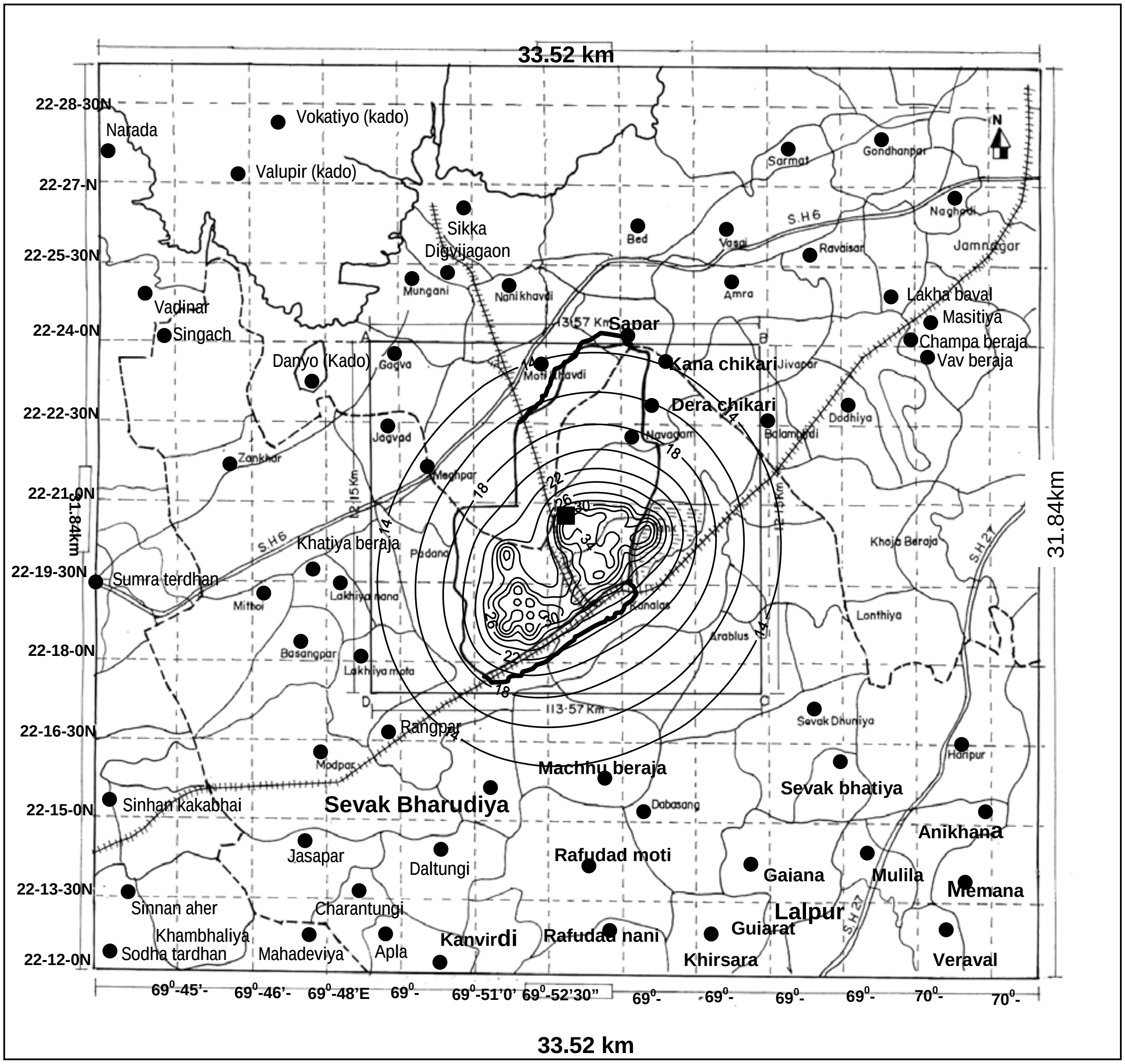


Fig. 5.3 : Predicted Noise Contours due to Proposed U

Note : Contour Units in dB(A)

Table 5.7

Noise Impact from Stationary Sources at SEZ at Nearby Communities

Sr.	Village Name	Pre-project Status (Baseline) dB(A)		Predicted Noise Level from SEZ dB(A)	Post-project Status dB(A)	
		Day	Night		Day	Night
1.	Padana	46.8	41.0	19	46.81	41.02
2.	Motikhavdi	60.0	40.0	15	60.01	40.01
3.	Sapar	50.2	38.0	13	50.21	38.01
4.	Navagam	41.0	34.0	19	41.01	34.01
5.	Kanalus	50.2	42.0	24	50.21	42.02
6.	Dera chikari	51.5	41.8	16	51.5	41.8

5.2.3 Water Environment

5.2.3.1 Water requirement

Considering the water shortage in the region, seawater shall be used for the proposed SEZ after desalination to meet water requirement. The domestic and process water requirements in the SEZ and in township shall be met by desalination of the seawater.

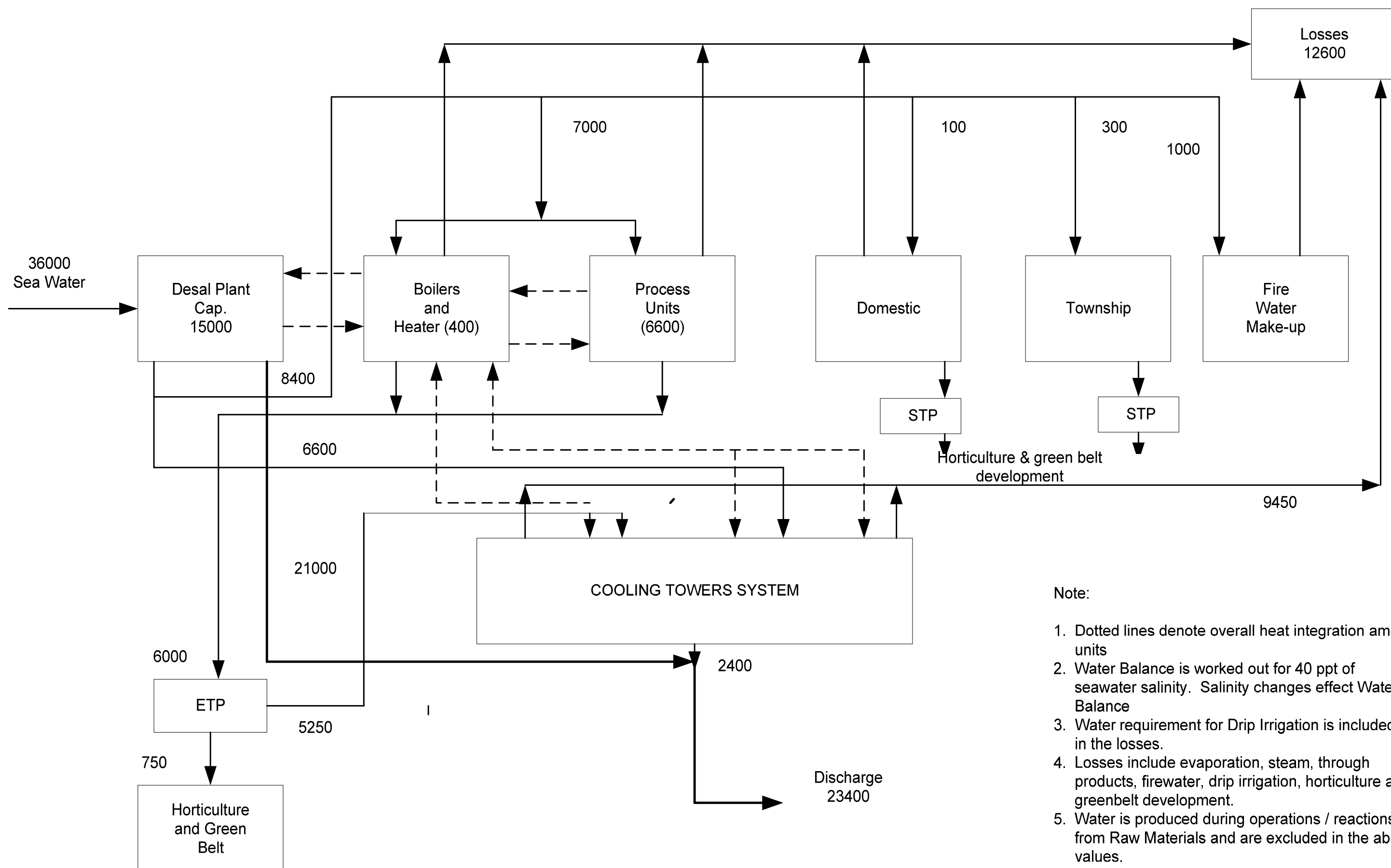
Sea water is the only source of water for the SEZ Project. The energy (heat) requirement for the desalination plant (Desal) shall be met from the waste heat from the processing units. A very low pressure steam (0.7 kg/cm^2 g) shall be used in the Desal Plant. This energy integration eliminates the venting of low pressure and low temperature steam from the process units and / or eliminates the condensation requirements. Water requirement for the SEZ Project and Units therein is estimated at 15000 m^3/hr.

The proposed SEZ project requires water for boilers & heaters, processes, process cooling, utilities cooling, domestic consumption, fire water make up and greenbelt development/horticulture. The entire water requirement will be met from the desalination of seawater. **Thus no fresh water of the region will be used.** However the Narmada supply project is in the pipeline and can be supplementary source, if required.

Total water management system is designed integrating the sea water, desal water, cooling tower and effluent treatment systems using targeted recycle and reuse.

The overall water balance, water requirement and wastewater generation scenario for proposed SEZ project are presented in **Fig. 5.4**.

The water requirement and effluent generation from the each individual unit is provided in Table 5.12 of the EIA report. The total effluent generation from the various complexes and the overall water balance at the intake of the complex is given in the Fig 5.4 of the EIA report



Note:

1. Dotted lines denote overall heat integration among units
2. Water Balance is worked out for 40 ppt of seawater salinity. Salinity changes effect Water Balance
3. Water requirement for Drip Irrigation is included in the losses.
4. Losses include evaporation, steam, through products, firewater, drip irrigation, horticulture and greenbelt development.
5. Water is produced during operations / reactions / from Raw Materials and are excluded in the above values.
6. The quantities are values derived based on ambient atmospheric conditions and changes.
7. Density differences due to temperature, salinity etc. are not taken into account

Fig. 5.4 : WATER BALANCE FOR SEZ (All figures in m3/hr)

5.2.4 Land Environment

5.2.4.1 Land use Pattern

The breakup of land of SEZ complex is presented in section 1.1 of **Chapter 1**. This table indicates that the total land area proposed for the SEZ project is **4,545 Ha** and proposed units would occupy about 2,275 Ha of land apart from 1185 Ha of land utilized for public/semi-public/greenbelt and transportation. The proposed residential complex will be set up in an area of 810 acre. The commercial complex would occupy 275 acre. The change in the landuse/land cover pattern remains insignificant.

5.2.5 Biological Environment

A greenbelt development plan has been recommended by NEERI in **Chapter 6**. The plantation of over 3.0 million trees has already been completed for existing adjacent Reliance refinery. RIL has developed extensive greening of the area in the existing complex using novel technological agricultural methods/techniques using the recycled water. Basing on this experience, a further extensive high-density plantation is proposed to be developed. The impact shall be positive as the greenbelt will be developed on a barren land in and around various units within the SEZ.

5.2.6 Socio-economic Environment

The proposed project will involve employment of workers during the operation phase.

During the socio-economic survey it was observed that the proposed project would create certain beneficial effects as well as adverse effects on the socio economic environment. Some of these impacts would be short-term whereas the others would be of long term in nature.

It is necessary to identify the extent of these impacts for further planning of control measures leading to mitigation of the adverse impacts. The impacts on parameters of human interest have been assessed in terms of positive and negative impacts.

The potential impacts due to the project are presented in **Table 5.8,** whereas the expected change in Subjective Quality of Life is presented in **Table 5.9** and **Table 5.10** respectively. The potential impacts due to the project are presented below:

Positive Impacts

- The proposed project is expected to generate large indirect employment besides marginal direct employment
- Local population will be benefited by the project as the indirect employment opportunities will increase in the region that will help in increasing the economic status of the region

- The project has favorable ranking by majority of the local people and is looked upon as a step for further development of the area
- The proposed project will enhance quality of life of the people in the study area
- Infrastructure will increase due to the project by way of transport and communication and amenities like school, health center, telephone booths and other basic requirements will be generated for working population of the project and village community.
- Local Population may get benefited dew to increased Business activated. viz. Market, trade and commerce

Negative Impacts

The adverse impacts on socio-economic environment due to proposed activities in the region will be :

- During the construction period there will be short-term socio-economic impacts in the study area that may include increase in floating population (contract labourers) which marginally strain on the civic amenities like drinking water, sanitation, road transport and other facilities
- Change in population density and diversity through the immigrants may cause cultural & health related problems in the region.
- Proposed project activity may increase pollution level in the area during the construction and operation period.
- Dust pollution due to transportation in dry areas may cause, poor yield of crops etc.
- Social security problems may in the region due to influx of population

As in the case of previous refinery implementation, the negative effects will be mitigated by extensive socio and health monitoring and support the local population groups in terms of cultural, medical and resource sharing with the people. For eg: Reliance has extended drinking water supply to the Jamnagar and neighbouring communties, whenever there is a shortage of water.

Table 5.8

Prediction of Qualitative Impacts on Socio-economic Environment

Parameter	Local	Regional	Direct	Indirect	Reversible	Irreversible
Employment	+	+	+	+	•	+
Income	+	+	+	+	•	+
Transport	+	+	+	+	•	+
Education	+	•	+	•	•	+
Medical facilities	+	•	+	•	•	+
Communication	+	+	+	•	•	+
Availability of power	-	+	+	•	•	+
Sanitation	-	•	+	•	•	•
Housing	+	+	+	•	•	+
Health	-	•	-	-	-	•
Recreation	+	+	•	+	•	+
Agriculture	-	•	•	-	•	•
Cost of living	+	•	•	-	•	-
Business	+	+	+	•	•	•
Per Capita Income	+	+	+	•	•	•
Pollution	-	•	•	-	•	•

+ : Positive Impact

- : Negative Impact

• : Insignificant

Table 5.9

Expected Change in Subjective Quality of Life

Sr. No.	Villages	QoL (s)	QoL (S) after Implementation of EMP and welfare Measure
1	Naranpar	0.50	0.52
2	Gordhanpar	0.48	0.50
3	Pipartoda	0.47	0.50
4	Kota	0.49	0.51
5	Vadinar	0.49	0.50
6	Sevak Dhuniya	0.51	0.54
7	Rafudad Moti	0.52	0.54
8	Gajana	0.50	0.52
9	Apla	0.47	0.49
10	Gavana	0.52	0.54
11	Godavari	0.51	0.52
12	Rinzpur	0.53	0.55
13	Padana	0.47	0.49
14	Navagam	0.52	0.54
15	Dera Chhikari	0.48	0.50
16	Kana Chhikari	0.49	0.51
17	Kanalus	0.53	0.55
18	Arablus	0.52	0.54
	Average	**0.50**	**0.52**

QOL (s) = Subjective Quality of Life

Table 5.10

Expected Change in Cumulative Quality of Life

Sr. No.	Villages	QoL (s)	QoL (S) after Implementation of EMP and welfare Measure
1	Naranpar	0.51	0.52
2	Gordhanpar	0.51	0.53
3	Pipartoda	0.48	0.50
4	Kota	0.50	0.52
5	Vadinar	0.50	0.53
6	Sevak Dhuniya	0.52	0.54
7	Rafudad Moti	0.53	0.54
8	Gajana	0.51	0.53
9	Apla	0.48	0.50
10	Gavana	0.53	0.55
11	Godavari	0.52	0.55
12	Rinzpur	0.54	0.57
13	Padana	0.48	0.51
14	Navagam	0.53	0.55
15	Dera Chhikari	0.49	0.51
16	Kana Chhikari	0.50	0.52
17	Kanalus	0.54	0.57
18	Arablus	0.53	0.55
	Average	**0.51**	**0.53**

QOL (c) = Cumulative Quality of Life

5.3 Pollution Load

The proposed petroleum and petrochemical complex is composed of different units as listed earlier in this document. The various units will have point sources as emissions and will generate wastewater and solid waste which will contribute to the overall pollution load of the complex. Even though the best possible technology and environment friendly fuel (natural gas & syngas) are proposed to be maximized in the complex, there will be a certain contribution to the pollution load on the environment. The pollution load has been estimated taking into account the CPCBs proposed standards for Refineries and Petrochemical Units. The pollution load also takes into account the World Bank Standards for Refineries and Petrochemical Complexes. The CPCB standards prescribed for the non-criteria pollutants will be incorporated into the design of the various units in the design stage of the project. The pollution load due to each unit proposed in the petroleum and petrochemical complex is tabulated in **Table 5.11**. As seen from the Table, the overall pollution load from the complex in terms of SO_2 and NO_x is estimated at 67 TPD and 99 TPD, respectively. The main source of raw water will be the sea water that will be desalinated for process use. Water management will be implemented to incorporate recycle and reuse. Various Units will have their dedicated Effluent Treatment Plants and methodology for reuse / recycle / disposal of solid and hazardous wastes.

5.4 Public Consultation Summary

The Public Consultation process was conducted by the Gujarat Pollution Control Board in line with Appendix IV of the Environment Clearance Notification dated 14^{th} September 2006. The Public Hearing for the Petroleum and Petrochemical Complex in the SEZ was conducted on 8^{th} January 2008. The entire project including major findings of Environmental Impact Assessment and Risk Assessment reports was presented to the Public and various queries were answered by the project proponent and NEERI. There was overall support for the entire project and no specific objection or comments was raised with respect to the proposed project.

However, the public had some general comments with respect the air emissions, air borne dust, storm water flows and land acquisition issues with respect to the existing facilities. All issues raised by the Public were answered in the Public Hearing and the same have been documented by the Gujarat Pollution Control Board. Various environmental management measures and post project environmental monitoring being conducted for the existing refinery complex were explained to the Public to resolve.

Issues were raised with respect to the benefit of the proposed project to the local community. The Public was informed that the necessary measures would be carried out in consultation with the local governing bodies and Village Gram Panchayat to meet the various requirements of the various villages. It was also mentioned to the villagers that an amount of Rs 1 crore would be spent for environmental and social benefits in each of the villages that would be covered in the SEZ Area.

Employment opportunities were sought by the Public and it was assured that preference would be given to local persons who possess the required skills. Further, the secondary employment generation and potential was also explained with back-up of the existing secondary employment generated due to the existing facilities.

Overall, the Public supported the project and appreciated the various efforts of the project proponent towards community development and participation. The Public Hearing ended with a positive note and the locals are looking forward to industrial development in the region. The proceedings of the Public Consultation process have already been sent by the Gujarat Pollution Control Board to the Ministry of Environment & Forests.

Table 5.11

Pollution Load from Units in Petroleum & Petrochemical Complex

Sr. No.	Plant	Air Emissions			Liquid Effluent	Solid Waste
		SO_2 (TPH)	NOx (TPH)	Other Emissions	(M^3/hr)	
1.	Pet Coke gasification	0.083	0.012	-	150	0.37 MMTPA
2.	Methanol Synthesis	0.0008	0.331	VOC&CO - < 150 mg/Nm^3	25	Catalyst
3.	Acetic Acid	0.00014	-	-	50	None
4.	Vinyl Acetate Monomer	-	-	NMHC - < 150 mg/Nm^3	75	None
5.	Poly Vinyl Acetate	-	-	NMHC - < 150 mg/Nm^3	100	None
6.	Poly Vinyl Alcohol			NMHC - < 150 mg/Nm^3	140	Catalyst
7.	Multifeed Cracker Complex	1.314	0.471		400	Coke
8.	Ethylene Oxide Derivatives – MEG etc.	0.00036		VOC & Stripper Vent - 0.04 Kg/hr CO - 0.44 kg/hr	193	Catalyst
9.	Polyethylene Polymners	0.03	0.011		80	Column residue
10.	Acrylic Acid & derivatives			Purge Gases sent to incinerator	50	Catalyst
11.	Super Absorbent Polymer			Acrylic acid vapours removed with scrubber attached to process stack	300	None
12.	n-Butyl Acrylate			Emissions from process vent - < 150 & Incinerator	75	Catalyst
13.	N-Butraldehyde			NMHC - < 150 mg/Nm^3	60	Catalyst
14.	n-Butanol				75	Catalyst
15.	2-EthylHexanol			Purge gases – Flared NMHC - < 150 mg/Nm^3	75	Catalyst
16.	Propylene Derivatives			NMHC - < 150 mg/Nm^3 and Flare	90	Catalyst
17.	Hydrogen Peroxide H_2O_2			Purge Gases sent to incinerator	150	None
18.	Poly Propylene			Process Flare	20	None
19.	Rubber Projects			Butadiene - 5 mg/Nm^3 Styrene - 100 mg/Nm^3 NMHC – 150 mg/Nm^3	300	1500 TPA
20.	Maleic Anhydride			Particulates 25 mg/Nm^3 & Fuel gas to fuel pool	10	Spent Catalyst
21.	Mono Nitro Benzene			Benzene < 5 mg/Nm^3	10	None
22.	Aniline			H2 blend stream after H2 Separation & Incinerator	300	Catalyst
23.	Phosgene			Stack exhaust < 1 mg/Nm^3		Activated Carbon Catalyst
24.	Methylene Di Anililne				100	Salt

Sr. No.	Plant	Air Emissions			Liquid Effluent	Solid Waste
		SO_2 (TPH)	NOx (TPH)	Other Emissions	(M^3/hr)	
25.	Methylene Diphenyl Diisocyanate			MDI/TDI - < 0.1 mg/Nm^3 Particulate < 25 mg/Nm^3	85	None
26.	Styrene	0.001	0.004	Styrene - 100 mg/Nm^3 Benzene – 5 mg/Nm^3	125	1100 TPA
27.	Paraxylene & Orthoxylene	0.045	0.127	Aromatics/Xylene/toluene - <100 mg/Nm^3	150	2900 TPA
28.	Putrefied Teraphthalic Acid	0.008	0.001		510	Pre-treatment sludge
29.	Polyethylene Tera-phthalic (PET)				125	Spent Pellets
30.	Polyester Complex	0.075	0.031		100	Spent Yarn
31.	Carbon Black	0.099	0.026	Carbon Black – 18 mg/Nm^3	315	None
32.	Lube Oil Refinery Complex	0.0008	0.036		300	Eq. Catalyst
33.	Captive Power Plant	0.678	2.59		Recycled water	None
34.	JERP	0.456	0.47		1200	Eq. Catalyst

Table 5.12

Water Requirement & Effluent generation for the Units in the Complex

Sr.No	Unit	Water Requirment in TPH	Liquid Effluent in TPH
1	Pet Coke Gasification	250	150
2	Methanol	2	25
3	Acetic Acid	2	50
4	Vinyl Acetate Monomer	2	75
5	Poly Vinyl Acetate	4	100
6	Poly vinyl Alcohol	100	140
7	Multifeed Cracker Complex	425	400
8	Ethylene oxide derivatives	250	193
9	Poly ethylene Polymers	150	80
10	Acrylic Acid and Derivatves	115	50
11	SAP	325	300
12	n- Butyl Acrylates	5	75
13	n-butaraldehyde	3	60
14	n-butanol	3	75
15	2- Ethyl Hexanol	2	75
16	Propylene Derivatives	5	90
17	Hydrogen Peroxide	200	150
18	Poly Propylene	50	20
19	Rubber Projects	400	300
20	Maleic Anhydride	40	10
21	Mono Nitro Benzene	50	10
22	Aniline	400	300
23	Methylene Di Aniline	5	100
24	Methylene Diphenyl Diisocynate	100	85
25	Styrene	250	125
26	Paraxylene and Ortho Xylene	280	150
27	PTA	600	510
28	PET	200	125
29	Polyster Complex	180	100
30	Carbon Black	100	315
31	Lube Oil Refinery Complex	500	300
32	RPL Refinery	2000	1200
33	Domestic Consumption / Fire Water Make-Up	1400	
34	CT Make-up	6600	
	Total Water Requirment	**14998**	**5738**

Chapter 6

Environmental Management Plan

The refinery and the petrochemical Special Economic Zone (SEZ), is located near the existing refinery at Jamnagar and at a distance of 28 kms west from Jamnagar in Gujarat State of India. The baseline data for various components of environment i.e. air, noise, water, land, biological and socio-economic aspects has been collected, and the impacts have been predicted and evaluated due to the proposed SEZ on the various environmental components

The Environmental Management Plan (EMP) provides an essential link between predicted impacts and mitigation measures during implementation and operational activities. EMP outlines the mitigation, monitoring and institutional measures to be taken during project design, implementation and operation to avoid or mitigate adverse environmental impacts, and the actions needed to implement these measures.

The EMP prepared is in line with the guidelines prescribed by the MOEF / CPCB. RIL group has got a strong, consistent and committed corporate policy in the Environmental management in all the complexes. The Environmental parameters are internalized into the project planning, design, procurement, constructional and operational aspects. The RIL group as accorded several prestigious environmental management awards for their complexes by national and international agencies.

The design module for the environmental protection for the process, design, engineering, procurement and construction will be a set of specific project environmental specifications for the project planning.

The C1 to C8 petroleum and petrochemical complex the technology providers, licensors, vendors, EPC contractors and possible JV partners will be instructed to follow and implement the project specific project environmental specifications. These are being developed and will incorporate the applicable standards of Govt of India, State government and pollution control boards. The IFC /WB standards and the stipulations of environmental stipulations will also be integrated into the design.

The Environment Management Plan as follows:

- Delineation of mitigation measures for all the identified significant impacts
- Delineation of the unmitigated measures
- Physical planning including work programme and locations for putting mitigation systems in place
- Delineation of financial plan for implementing the mitigation measures in the form of budgetary estimates.

The likely impacts on various components of environment due to the project during developmental activities have been identified and measures for their mitigation are suggested.

Reliance SEZ Jamnagar envisages the following major activities:

- Production of petroleum products such as clean fuels to meet the latest national and international standards
- Production of downstream petrochemical products C1-C8 based units, Carbon Black and Lube Oil Cum Refinery Complex.
- Captive power plant, Desalination Plant, Utilities and infrastructure

The EMP lists all the requirements to ensure effective mitigation of every potential biophysical and socio-economic impact identified in the EIA. For each aspect, or operation, which could otherwise give rise to impact, the following information is presented:

- A comprehensive listing of the mitigation measures
- Parameters that should be monitored to ensure effective implementation of the action
- Timing for implementation of the action to ensure that the objectives of mitigation are fully met

The EMP comprises of a series of components covering direct mitigation plan and environmental monitoring for air, water, noise etc., an outline on the waste management plan. The environmental management plan has been prepared for each of the above developmental activities. M/s Reliance Infrastructure Limited would use the EMP described in the following sections to develop the standard operating procedures for the SEZ and units therein.

6.1 EMP during Construction Phase

6.1.1 Site Preparation

Environmental pollution during construction stage will be limited and for temporary period during the activity.

Directly or indirectly all the environmental components get affected due to construction activity. The following environmental protection and enhancement measures are suggested for implementation by the contractor or the project proponent during the construction activities as applicable.

6.1.2 Air Environment

During the construction phase, the fugitive and gaseous emissions are expected from the heavy machineries deployed during the construction phase. All the other emission sources are intermittent and include emissions from materials transport from heavy vehicles. The gaseous emissions are expected to contribute significantly to the ambient air quality. However, some generic measures should be taken to reduce fugitive and gaseous pollutants emissions during the construction phase, which are as follows:

- The storage and handling of soil, sub-soils, top-soils and materials should be carefully managed to minimize the risk of wind blown material and dust
- Those sections of the working area that are being trafficked over should be damped by controlled application of water sprays (e.g. by water dowsers) as conditions dictate.
- Vehicles or equipment should be checked for pollutant emissions against stipulated norms.
- Transport vehicles and construction machinery should be properly maintained so as keep air emissions in check. Emphasis should be made on EURO II engines
- Idle running of vehicles should be minimized during transport and handling activities
- Engines and exhaust systems of all vehicle and equipment should be maintained so that exhaust emissions do not breach statutory limits (set for that vehicle/equipment type and mode of operation by CPCB), and that all vehicles and equipment are maintained in accordance with manufacturers' guidelines.
- Exhausts of other equipment used for construction (e.g. generators) if any will be positioned at a sufficient height to ensure dispersal of exhaust emissions and

meet the standards set by CPCB.

- Construction material transport to the site should be properly covered to avoid fugitive emissions.
- Regulate vehicle speed to a maximum limit of 40 km/hr within the premises
- Periodic maintenance of vehicle
- Ensure use of good fuel for vehicle. Gas powered or low sulphur diesel and unleaded petrol in conventional vehicles should be used within the project area
- Well maintained construction equipments preferably those with lesser emissions should be preferred.
- During the short period of the site clearing mechanical shovels and earthmovers should be used for site clearance, cutting and filling and other site leveling activities. The site clearance activities could generate dust emissions, which can affect the ambient air quality. The site should be sprayed / sprinkled with water to suppress the dust emissions. The areas where the soils contain large quantities of fine sand, which has a tendency to blow in dry conditions. The Contractor should be made responsible for ensuring that particular attention is paid towards dust suppression.
- A greenbelt should be initiated along the boundary of the project site for improvement of ambient air quality as suggested in the **Section 6.2.5** of this Chapter. Past experience for the development of greenbelt by Reliance could also be utilized.
- Loading/unloading and storage areas should be paved to reduce dust emissions. All main roads (internal and external) to be used by the project authorities should be made ‘pucca’ (either with WBM, concrete or bitumen) to suppress the dust generation along the roads.
- Personnel Protection Equipment (PPE) should be provided to construction workers. Dust masks should be provided to construction workers, while carrying out operations that may entail potential for dust inhalation.
- The construction laborers should be prohibited to use the vegetation for fuel wood.

6.1.3 Noise Environment

The following measures are recommended to mitigate adverse environment during construction phase:

- Onsite workers should be provided with noise protection device muffs wherever necessary.
- Construction activities should be so co-ordinated such that the noise levels should not exceed the ambient noise levels prescribed by CPCB.
- Engines of all the rotating parts, machineries, vehicles should be thoroughly maintained (e.g. oiling & greasing of all the moving parts)
- Earth movers and construction machinery with low noise levels should be used.
- Periodic maintenance of construction machinery and vehicles should be undertaken. Good condition and new machineries should be preferred.
- Green belt should be developed during the construction phase for attenuation of noise, noise levels in the vicinity of the heavy construction equipment will be high due to the running of heavy machines and compressors.
- Acoustic laggings, and silencers should be used in equipment wherever necessary. Either Acoustic barriers / shelter should be developed in noisy workplaces or acoustic enclosures should be provided for the high noise generating equipment.
- Use of DG sets should be enclosed type and should conform to the EP rules prescribed for air and noise emission.

6.1.4 Water Environment

Measures for Supply of Water

- The region being water scarce, the project proponent should not extract water from any water bodies (surface or groundwater) for the construction phase of the project. No existing resources fresh water sources (surface/groundwater) which are currently being used by the villagers for the purpose of obtaining drinking water for irrigation or other purposes should be tapped into. The water shall be supplied from the existing water resources of the adjacent Reliance refinery complex for construction purpose.
- Adequate drinking water of potable quality facilities during the construction phase should be provided to the contractors. This should be met from the

refinery resources to the construction sites.

Mitigation Measures for Prevention of Water Pollution

- The only two credible sources of potential impacts arise from uncontrolled runoffs from the labour camps and accidental spills of oil etc. into surface and ground water bodies. The selected contractor should be obligated to follow the procedures so as not to pollute groundwater.
- Sufficient and appropriate sanitary facilities should be provided in order to maintain hygienic conditions in the labour camps. Adequate precautions should be undertaken so as to avoid sewage into any water body, Sasoi tank in particular. Developmental activities should be in line with the local hydrological pattern.
- Area for maintenance of vehicles should be so located that contamination of Surface water (Sasoi tank) by accidental spillage of oil can be prevented.
- These measures will adequately mitigate the possibility of any negative impacts during construction on terrestrial water quality. The wastes, such as, sanitary wastes should be treated in sewage treatment plant of appropriate size and technology existing facilities available in refinery premises should be extended to construction workers.
- The sludge generated should be collected and disposed in an appropriate manner either at a landfill site or used as compost for horticultural uses.
- The workshop areas should be used for the maintenance of vehicles and construction machineries so as to avoid accidental spills of oil/oily wastes.
- Drains and detention basins should be provided to stabilize slopes and collect run off/sediments
- Storm water management including erosion control and sedimentation measures at the site should be controlled by erosion control methods (Ponds) for the construction phase of the project.
- The storm water drainage system should be designed to be commensurate with the local hydrological pattern of the area. The area being devoid of major rainfall has limited scope for major flows. However, the storm water drains will be culminated in the storm water ponds that should collect the water for reuse. Any excess flow in the ponds will be drained as per the natural hydrological pattern of the area. The storm water ponds should also act as retention ponds for sediment transport and erosion control

- As stated above, the area is mostly even and will not involve major cutting and filling. The site grading should not create any open slopes or dips in the topography that will require slope stabilization. The various storm water ponds etc should be created with the requisite slope stabilization and stone pitching on the sides to retain design volumes of storage and collection. The slope stabilization of storm water pond should also arrest any carrying in or erosion of banks.

6.1.5 Land Environment

- Workers engaged during construction phase should preferably be provided with temporary housing facilities at planned labor colonies located nearer to project site. Haphazard growth of labor camps should be avoided. The labor camps shall be provided with all the essential facilities.
- Labour camps should not disturb local environment.
- On completion of construction works all temporary structures, surplus materials and wastes should be completely removed to avoid future land use incompatibility. Dumping of construction waste should be prohibited on land covered by natural vegetation and stockpiles should be provided with gentle slopes.
- The land acquired for the SEZ project is a barren (arid) land, should be compatible with the surrounding landuse.
- Minimum vegetation should be cleared for the construction activities.
- The solid wastes such as paints, lubricants, oil, diesel containers or any other non-biodegradable wastes that have leaching characteristics should be disposed as per the “Authorization” received from GPCB.
- The nutrient content of topsoil should be recovered from different areas during site grading, prior to construction activities, the topsoil should be placed in the areas where the greenbelt is earmarked for development. If there is any excess topsoil, the same should be handled, stored and piled (max. 3 m height) in demarcated storage area. The storage area should be regularly sprinkled with water to minimize the risk of dust being blown by the wind.
- Stock piles should not be located in the storm water flows.
- The project location is in an arid barren area, which is devoid of any dense vegetation. Sparse vegetation in terms of bushes and shrubs are seen on the

site. These should be cleared, mulched and used in preparation of compost material to be utilized for land application in green belt area.

- The area is mostly even and hence will not involve major cutting and filling. During the site preparation work, the soil from the higher gradient should be utilized to level the areas with lower gradient. Since the overall area is relatively flat, the amount of cutting and filling would be well balanced

Construction Waste Management

- Segregation of waste material should be based on the reusability and recycling potential. Reuse and recycling opportunities shall be systematically investigated.
- Management should ensure that the infrastructure for recycling of construction and demolition materials is in place and operating at the beginning of the project. On-site system should be set-up to collect and sort waste for recycling, or for reuse, and monitor the system consistently throughout all phases of construction.
- Materials and products should be selected with minimal or no packaging, if possible.
- Construction debris from the site and any construction debris in the site areas associated with the projects will be removed on a regular basis by the contractor.
- Workers should be educated on waste prevention goals and the proper handling and storage of materials.
- Separation at source should be implemented e.g. by designating a separate waste disposal area where different types of waste can be brought separated and stored temporarily prior to disposal.
- The solid waste generated should be collected and disposed in an appropriate manner either at a landfill site or used as compost for land application. The existing workshop areas should be used for the maintenance of vehicles and construction machineries so as to avoid accidental spills of oil/oily wastes. Area for maintenance of vehicles should be so located that contamination of groundwater by accidental spillage of oil can be prevented

6.1.6 Biological Environment

The region does not have dense vegetation and landuse suggests agricultural activities in certain areas, which crops for only one season i.e. during the monsoon season. The following measures are recommended to mitigate adverse impacts on biological activities during construction phase:

- There should be minimal removal of vegetation and felling of trees.
- Revegetation should commence at the time when site clearing is being undertaken.
- Reliance should continue with its afforestation programme to replace any vegetation removed during construction.
- A greenbelt of appropriate width should be developed in and around the proposed SEZ.

6.1.7 Socio-economic Environment

- The related developments like construction camps should not be dependent on local resources (power, water), during both construction and operations phase, the only likely impact on infrastructure would be on the roads, especially SH 25 during the construction phase. However, considering the low traffic emanating during construction phase, effective traffic management should not pose any problem. A traffic management scheme should be developed to avoid congestion on the nearby and local roads.
- It is estimated that about 50,000 construction workers on average will be involved for a period of 2-3 years. The total employment during the construction phase will be about 24 lakh man months (both skilled and non-skilled employment). The manpower required for these activities should preferably be employed from nearby villages so that avenues of employment will be open to local people.
- When necessary, it is recommended that the local communities should be engaged in an on-going dialogue during construction period, with an objective to build and maintain a good relationship with the project proponent and contracting companies.
- As an efficient tool for maintaining these good relationships, it is recommended that a grievance mechanism should be operational during the construction period. The mechanism aims at receiving and facilitating resolution of the affected communities concerns and grievances related to the risks and nuisances created by the project. The efforts should be commensurate to the potential impacts of the project, ranging from designating a community liaison officer for maintaining a formal grievance register.

Health and Safety

- The movement of heavy equipment should be done with proper precaution to prevent any accidents on the road.
- Occupational risk should be minimized at the project site through safety measures. Movement of vehicles with 40 km/hr imposed speed limits on village roads should reduce risks of accidents or injuries.
- Safety training should be provided to all construction workers on operation of equipment. Security should also be extended during non-working hours to ensure there is no uncontrolled access to the machinery and equipment.
- The contractors should also be vigilant to detect workers showing symptoms of communicable diseases. All illness and incidents should be reported and recorded.

6.1.8 Energy and Water Use

- Existing Captive Power Plant (CPP) in the adjacent Reliance refinery complex could meet the power requirement for the construction phase, wherever feasible.
- The source of potable and construction water for expansion project during construction should be met by the Desalination units in the existing refinery and storm water collected in the ponds.
- The contractors should be encouraged to conserve the water during the construction
- The lights should be turned off when work is at a halt. Security lighting can run on motions sensors.
- Using of natural material in possible areas that require a low-level of processing, there by reducing energy use and pollution. (Stone, brick Clay tile)

6.2 Environmental Management Plan during Operational Phase

In order to mitigate the impacts due to operation of refinery, power plant and petrochemical complex on various environmental components, the following measures are recommended;

6.2.1 Air Environment

The impact on air quality due to emissions from multiple sources during the continuous operations has been assessed by use of mathematical models.

The incremental predicted GLCs of major air pollutants viz., SO_2 and NO_x due to the proposed SEZ developmental activities over the baseline air quality are within stipulated standards of CPCB for industrial regions, i.e. 120 $\mu g/m^3$. However, measures proposed for mitigating impacts on ambient air quality during the project operations include the following:

- Best Available Control Technology (BACT) should be installed at individual emission sources to minimize the air pollutant emissions.
- Regular record on sulphur emission should be maintained at SEZ units as part of the environmental data records.
- Off gases from proposed units should also be treated in amine absorption units and regeneration unit meant for H_2S removal as already in practice for desulphurization of off gases (fuel gas) in existing Reliance refinery.
- Performance evaluation of Sulfur Recovery Units with Tail Gas Treatment Units should be done on regular basis (at scheduled intervals) through monitoring off gas flow rate.
- In case of any failure in sulfur recovery units appropriate steps should be taken to match the generation with SRU feed
- FCCU should have particulate control systems such as Electrostatic Precipitators/cyclones/wet scrubbers.
- The measures to reduce the SO_2 in furnaces, boilers, gas turbines is by quantifying the contribution of various sources in order to determine the main source, increase in the energy efficiency of the plant, heat recovery, vapor management and change of combustibles.
- All the combustion units should be maintained properly at optimum efficiency.
- All fuel combustion units should be operated with minimum excess air so that fuel consumption is optimized and emission of NO_x is minimized. Low NO_x burners should be implemented in all combustion units of proposed units in SEZ.
- Energy conservation projects/schemes to result into reduction in quantity of fuel should be implemented.
- Port holes and sampling facilities should be provided at proper location for all the

stacks coming up in the SEZ for monitoring of flue gas velocity and flue gas temperature and also for checking concentration of different pollutants at regular intervals.

- The SEZ complex should comply with proposed emission standards of CPCB for stacks located in the SEZ complex.
- Ambient air quality with respect to SPM, SO_2, NO_x, H_2S and CO monitoring shall be done at minimum 4 locations around the SEZ complex. The monitoring stations should be set up in consultation with the GPCB.
- A digital weather station for monitoring wind speed, direction, temperature, relative humidity and rainfall with automatic data logging and analysis facility should be installed at the SEZ complex. The same should be operated continuously for maintaining micrometeorological data record at SEZ site.
- Emission from DG stacks, if used should be comply with the emission standards stipulated by Central Pollution Control Board (CPCB) and GPCB.
- Continuous sources of emissions should be installed with stacks having sufficient height (CPCB norms) to ensure adequate dispersal of pollutants. Further, pollution control systems such as low NO_x burners and low sulphur fuel should be used.
- Gas powered or low sulphur diesel and unleaded petrol in conventional vehicles should be used within the project area and for product evacuation.
- Waste oil should be sold to MoEF /GPCB authorized waste oil recyclers
- Proposed Incinerator design and emissions should be as per the Guidelines of CPCB as given in details later in the **Section 6.2.4.2** of this Chapter.
- Idling of vehicles should also be minimized during transport and handling activities
- Loading/unloading and storage areas should be paved to reduce dust emissions
- All access roads (internal as well external) to be used by the project authorities should be made pucca (either with WBM, concrete or bitumen) to suppress the dust generation along the roads

To control fugitive emissions of VOCs in the SEZ complex, following steps should be taken along with the requirements / conditions notified by MoEF for oil refineries and petrochemicals shall be followed:

- Provision of internal floating roof tanks with flexible double seal for MS and intermediate products.
- Provision of mechanical seals in pumps
- Regular inspection of floating roof seals and proper maintenance of floating roof seals for proposed storage tanks
- Preventive maintenance of valves and other equipment
- Regular skimming of oil from separators/equalization basin in ETP.
- Fugitive VOC emissions should be assessed and minimized whenever possible (vapor recovery systems, joints, pumps, fittings etc.). They shall also be monitored at regular intervals
- Fugitive emissions should be controlled through proper maintainance
- It would be a best practice to avoid burning in flaring stacks and to recover these gases whenever feasible.
- Use of high grade gasket material for packing, provision of motor operated valves for critical services such as high vapour pressure components and chemicals
- Fuel leaks should be prevented from on land equipment. Further implementation of Leak Detection and Repair (LDAR) programme using a portable VOC detection instrument should be done on distribution lines and tanks.
- Inventory of odorous compounds should be maintained and release of such compounds should be prevented.

The following guidelines should be adopted for the units to be developed in the SEZ Complex:

- Each plant may prepare a component inventory as per the data reporting formats
- All leaking equipment may be marked by weatherproof identification till repaired

Pumps:

- Visual inspection should be done every week.
- Changeover to spare pump immediately and repair leaks should be attended to immediately. During the repairs care should be taken to avoid water and soil contamination.
- Sensors should be provided to detect seal system / barrier fluid leaks and should be fitted with an alarm.

Compressors:

- Every compressor in VOC service should be equipped with seal & barrier fluid system to prevent leak to atmosphere.

- Barrier fluid system should be as under:

  - vent/ control system/ fuel systems or back to process
  - sensors should be provided to detect seal system / barrier fluid leaks and should be fitted with an alarm.
- Switch over to leak less / low leak type within next three years.
- The leakages should be attended to immediately
- Compressors having dry sealing systems & having closed vent exhausting vapour from drive shaft seal to control system may be exempted from monitoring.

Pressure Relief Devices:

- Pressure Relief Devices in gas / VOC service should be operated below leak threshold except during pressure release
- Monitoring for confirmation within 5 days of pressure release
- Pressure Relief Devices routed to process / fuel gas system or closed vent system should be exempted from monitoring.
- Pressure Relief devices with upstream rupture disc are exempted from LDAR
- After pressure release, rupture disc should be reinstalled as soon as possible

Sampling Connection Systems:

- Sampling connection system in VOC service should be equipped with closed purge / closed loop / closed vent system, then gases displaced during filling need not be collected
- Closed purge/closed loop/ closed vent system should return purged fluid back to system
- Collect & recycle the purged fluid to process direct or transfer purged fluid to control device
- In-situ sampling systems & sampling without purge are exempted from LDAR monitoring requirement

Open Ended Valves or Lines:

- Each open ended valve or line in VOC service should be equipped with a cap / blind flange / plug or second shut off valve
- Each line equipped with a second valve should be operated so that valve on process side is closed before closing the shut-off valve.
- Open-ended lines designed to open automatically in emergency shutdown system should excluded from LDAR

- Open-ended lines or valves containing materials which will pose serious explosion, over-pressure or other safety hazard if capped, should be excluded from LDAR

Valves:

- Completely closed valves (e.g. bellow seal valves having no external shaft penetrating valve body) are exempted from monitoring provisions.
- Wherever possible, low leakage valves such as non-rising stem/ diaphragm valves with tight sealing system (e.g. metal fabric gasket) may be used.
- Repair to a leaking component should be attended immediately. Conduct monitoring immediately after leak repair as confirmation for satisfactory repair.
- Up to 5% valves may be designated 'inaccessible' & may be exempted from monitoring requirements.

Flanges/Connectors:

- Flanges in organic HAP service should be provided with high quality packing e.g. metal fabric/graff-oil having low leakage values
- Existing Plants should replace flanges in VOC service with high quality packing
- Up to 5% flanges/connectors maybe declared as inaccessible & maybe exempted from monitoring requirements.
- The repair of a leaking flange should be attended immediately. Monitoring should be conducted immediately after leak repair as confirmation for satisfactory repair.

Delay of Repair:

- Conditions under which delay in repair is permissible:
  - Repair not feasible without plant shutdown
  - If existing seal system are to be changed with better/low leakage system requiring change is equipment assemble (e.g. single mechanical seal on pump to be replaced by dual mechanical seal or with a closed vent & control system or change of valve assembly)

Measures for control of phosgene and Safe Management

Phosgene is a transient intermediate in the manufacturing of Methylene Diphenyl Diisocyanate (MDA) & Toluene Diphenyl Isocyanate (TDI). The Phosgene Panel under the American Chemistry Council has delineated the Safe Management Measures for phosgene. The extract of the above refereed document is attached as **Annexure IX**. The most suitable measures for our plant will be selected from those suggested by Phosgene Panel under the American Chemistry Council based on the configuration and size of the equipments. These will be selected during the detailed engineering stage through HAZOP & Risk Analysis studies.

Further, these designs and safety measures will be reviewed by the experts in this field.

Online monitoring of phosgene from the absorber and sensitive detectors would be installed for detection of phosgene.

6.2.2 Noise Environment

The design of the project should be such that the sound pressure level in the work area will not exceed 90 dBA. Restricted areas should be those locations where it is not reasonably practicable to reduce the noise level below the work area limit, Wherever practicable, attempts should be made to reduce the noise level below 85 dB(A). The equipment should be chosen in such a way that the above noise limit is not exceeded. The noise levels at the nearest habitation should be less than the stipulated standards of CPCB. However, as a good operational procedure, the following generic measures should be implemented in addition to the existing green belt:

- Similar measures as proposed in the construction phase for noise making machinery, to ensure practicably low noise levels within the work environment.
- Specification for procuring major noise generating machines/ equipments should include built in design requirements to have minimum noise levels meeting CPCB/MOEF requirements. The monitored noise levels at sensitive locations should be taken to ensure that the impact due to high noise levels is practically minimized.
- Monitor job and location specific noise levels for compliance with HSE regulations by verifying acceptability of noise levels caused by the project activities and comparison with noise criteria
- Conduct periodic audiometric tests for employees working close to high noise levels, such as compressors, DG sets, the loading, unloading sections etc.
- Provision of PPE’s should be done and their proper usage should be ensured for eardrum protection of the workers as well as visitors
- It should be ensured that low noise (generating) equipment are procured wherever feasible
- Acoustic laggings, and silencers should be used in equipment wherever necessary
- Sound proofing /glass paneling should be provided at critical operating stations, and control rooms

- Either Acoustic barriers / shelter should be developed in noisy workplaces or acoustic enclosures should be provided for the high noise generating equipment
- Noise generating sources in the plant areas should be monitored regularly. Monitoring of ambient noise levels should also be carried out regularly both inside the refinery area as well as outside the greenbelt.

6.2.3 Water Environment

- Since fresh water is a scarce resource in the area, only seawater should be used for proposed expansion project. Desalination units should be installed to meet the water requirement of SEZ units. The impact on the ground water/saline intrusion if any should be monitored through the existing network of monitoring wells and piezometers.
- An effluent treatment plant based on the raw wastewater quality and required treated wastewater quality should be designed. However the effluent standards should be well within the prescribed limits of GPCB & CPCB. The performance of ETP should be continuously monitored and any deviation in performance should be corrected on priority
- Reduction in water requirements should be achieved by implementation of closed circuits within the petroleum and petrochemical complex.
- Use of desalinated water as service water should be minimized
- Reuse of effluent should be attempted
- Recycle of pump gland cooling water should be undertaken
- Condensate recovery should be maximized
- Treated effluent should be used for hydrotesting of vessels/tanks/pipelines instead of desalinated water. Treated effluent should also be used for cleaning of columns/vessels during turnaround
- Holding ponds should be provided so that bio-systems of wastewater treatment system should be prevented against shock load
- Dosing of chlorine or biocides as part of advanced cooling water treatment in the cooling water system should be done to take care of biological growth
- The detailed record of raw water intake at refinery (for processes, CT makeup, fire water, green belt development and sanitary and drinking purpose) as well as township complex and wastewater generation from different sources should be

maintained on daily/regular basis w.r.t. flow rates and characteristics. These details should be useful in preparing comprehensive water balance at project site and also for identification and implementation of reuse/recycle practice of treated effluent at project site leading to mitigation of effluent discharges.

- Water flow measurement facilities (metering) should be provided at inlet and outlets of major process units, which should help in minimizing wastage, conserving the water as well as maximizing the recycle/reuse of treated effluent
- Regular monitoring of effluent from different treatment units and also combined final discharge of treated wastewater including outlet of STP at township is recommended. Performance evaluation of effluent treatment plant as well as sewage treatment plant should be undertaken at regular intervals for all relevant parameters covered under this study
- Use of polishing lagoon pond for aquaculture should be explored, where bio-assay tests could be conducted at regular intervals
- The effluents discharged into the sea should be done through the multipore diffuser system designed by the National Institute of Oceanography (NIO). The location of discharge should also be identified by NIO. The diffuser system shall discharge the wastewater generated by the refinery, power plant and the petrochemical units.
- The effluents discharged into the surface water or the natural environment, their physicochemical characteristics after any treatment should comply with the maximum levels defined by the CPCB.
- Regular monitoring of the discharge of the main pollutants is required to ensure that the regulatory maximum levels are complies with. Periodic measurements of the pollutants in the natural environment is considered best practice.

6.2.3.1 Sewerage Management Plan

Following a modular phased development concept in the SEZ, sewerage system should comprise of an integrated sub-system; each catering to a self-contained park/hub, collection system of pipe network, lifting stations (LS), terminal sewage pumping stations (TSPS), sewage treatment plants (STP) and tertiary treatment plant (TTP) before recycling for non-domestic & industrial usages. The whole SEZ territory should be divided into different sewerage catchment zones. Each zone shall be serviced by one sewage treatment plant (STP). Lifting stations should be provided for STPs in order to reduce depth of manholes. Where necessary, the sewage should be pumped through rising mains to traverse higher ground and then flow into the gravity sewer.

Considering the ease of operation and maintenance, power requirement, size of unit, any one of two processes namely UASB or FAB technology may be appropriate for the SEZ area. FAB technology requires very less land, which is a precious item in SEZ area; hence, it is proposed that for secondary treatment of sewage FAB technology (Fluidized Aerobic Bioreactor) may be used. FAB (Fluidized Aerobic Bioreactor) is a biological treatment process employing fluidized bed bioreactors operating at elevated pressures, followed by a dissolved air flotation (DAF) clarifier, which removes suspended solids from the effluent. The DAF unit produces a clear effluent suitable for direct discharge or further polishing, for example, by conventional sand filter or membrane filtration, to yield a final effluent of very high quality**.**

However another alternative, is establishing a Sewage Treatment Plant of high efficiency aerobic treatment schemes based on extended aeration system using fine bubble diffused aeration are proposed. These plants are compact, odor free and have an energy efficient process. STP shall generate water of high quality, suitable for use as process water for industries / warehouses /transportation / horticulture etc.

6.2.3.2 Drainage

A gridiron patterned integrated Drainage system with the sewerage system, to cater the surface run off within the SEZ area should be designed by gravity flow. The storm water discharge points in the form of holding ponds with overflow weirs designed to ensure that excess water, in extreme circumstances should flow out in a controlled manner. These ponds shall act as flood retention as well as surface water storage.

The U-drain system should be constructed of reinforced concrete for the surface run off collection for reasons of easy maintenance and durability. These should be placed along with the main roads. The entire storm water drainage system should be developed according to the layout plan of the area showing industries, roads, residential localities, etc. once the tentative layout is approved. Separate storm water drainage system should be provided to ensure that there is a quick disposal of storm water so that there is no disruption in normal activities.

Type of Drains

The SEZ should have drainage along the four types of roads, viz. local street, collector street, sub-arterial and arterial as drainage is very essential to avoid any water logging which may result in disruption of normal activities in the area. The surface water should be diverted to the drain by bell mouth inlet points or gullies.

Drains are to be designed as per design peak discharge governed by the topography of the area, duration, amount and frequency of rainfall (with 10 and 25 years return period), nature of soil, land use, etc.

Size of the main, trunk, branch and lateral drains should be designed according to the respective area of catchments and design rainfall intensity, as per IRC:50 and CWC flood estimation report.

6.2.3.3 Wastewater treatment plant

The treatment plant should be designed on the following philosophy

- To treat and recycle the effluents from one process to another and also the domestic effluent
- To ensure that the treated effluent is within the stipulated standards or statutory norms of GPCB and CPCB/MOEF.
- Stream wise treatment of wastewater
- To reduce the load on the secondary treatment units

Glycols effluent pre treatment unit

Process effluent like glycol should be kept separately from the other streams because of high BOD/COD. This is due to the presence of glycol in the effluent, which is biodegradable. The effluent from MEG plant is received in to equalisation tank and fed equally on the media of bio tower by rotary distributors. On the surface of the PVC media slime growth takes place and the outlet of the clarifier is taken to the clarifier for the removal of bio sludge. The overflow from the clarifier is taken to the waste recirculation, from where part of the effluent is recycle back to the system and rest is being taken to the equalistion tank II.

Effluent management of mono, di and tri-ethylene glycols

The MEG / DEG / TEG effluent mainly contain corresponding glycols as pollutant. These are very easily biodegradable. This glycol effluent will be pretreated in a biological pretreatment unit to reduce the biodegradable load on the central ETP. The details of the pretreatment are given below.

The effluent from the MEG / DEG / TEG plants will be received in an equalization tank after primary treatment. The requisite nutrients for bacterial metabolism will be added in the equalization pond and the effluent will be fed to the bio-tower. Bio-tower will be filled with PVC media. On the surface of the PVC media slime growth will take place. A rotor distribution arm will be provided on the top of bio-tower to ensure equal distribution of effluent on the PVC packing media surface. Outlet of the bio-tower is taken to the clarifier for the removal of bio sludge from the effluent. Clarifier effluent will then be routed to the Central ETP for further treatment with the other effluent streams.

In the MEG / DEG / TEG plant there will be many pumps, which will be handling organic chemicals like Ethylene Oxide, MEG, DEG, TEG and Poly Glycols. During the maintenance activity these pumps will be decommissioned. During the decommissioning, contents of pumps / suction lines will be drained to separate underground collection pits. These underground pits will be strategically located at various places in the Glycols Plant.

Instead of diverting the content of the underground pits to the ETP, the content of the underground pits will be diverted to a Glycol Slop Tank from where the glycols will be sent to the pretreatment for reprocessing. This system will reduce the organic load on the effluent treatment plant. During the distillation, MEG, DEG & TEG are obtained and the residual glycols are left behind which are usually incinerated in an incinerator. However, there is a potential market for selling this glycol residue, thereby minimizing the generation of waste for disposal. Since this waste can be treated as a product for sale, the emissions contribution from the usual incineration of residual glycol will also be less.

The block flow diagram of the Glycol Effluent pre-treatment unit is shown in Fig 6.4.

PTA Effluent

The concentration of the PTA effluent is very high as it contains organic compounds and acetic acid. The effluent from the PTA is received in to clarifloculator with the aid of poly-electrolyte, where suspended solids are being removed. The overflow of the clarifloculator is fed to the anaerobic digester running either parallel or series. These digesters are combination of up flow sludge blanket and up flow anaerobic filter. The over flow from the digester is taken to the equalisation tank II.

Details of Effluent Characteristics of PFY unit and Effluent treatment

This effluent does not require any separate pre-treatment and will be pumped directly from collection sump to the central ETP for treatment with other effluent streams. The schematic flow diagram of proposed Central Effluent Treatment Plant is shown in fig. 6.1 of the EIA report. Similar practice is already being followed for PFY effluent at one of our petrochemical complex located at Hazira, Gujarat.The Effluent characteristic of Polyester filament yarn unit is enclosed as Table 6.4.

Effluent Treatment Plant

The composite effluent from the rest of the plants mainly consist of oil, grease, organic matter and suspended solids which should be treated in effluent treatment plant consisting of primary, secondary and tertiary facilities.

The primary treatment facilities consist of TPI (Tilted plate inceptor pit) for removal of free oil, equalisation tank and pH Adjustment tank for pH correction, Flocculator followed by Dissolved Air Flotation Unit (DAF) for removal of emulsified oils

The secondary treatment is a combination of the attached growth and suspended growth system consisting of Equalisation tank, Bio tower and Aeration tank and Secondary clarifier followed by Guard pond and polisher

The tertiary treatment facility consists of clarified water sump, Rapid sand filter and Activated carbon filter.

The air is continuously blown from the bottom of the tank so that effluent mixed properly in the tank, due to flowing of air in upward direction it will carry the free oil to the surface, is taken to the slop oil tank via slop oil sump. There is a provision to removal of water from the tank. The equalized effluent should be further treated in Dissolved Air Flotation (DAF) tank for removal of emulsified oils and suspended solids. The oil and scum from the surface should be removed with the help of mechanical skimmer. The scum and oil should then be taken to the sludge pump.

The effluent should be taken to the equalisation tank where PTA effluent after pretreatment. The effluent from the equalisation tank should then pumped into 2 stage biological system compromising of plastic media bio towers as the first stage and a part of the effluent should be taken to the fine bubble diffused aeration system as the second stage.

The overflow of the effluent should then taken to the clarifier for removal of biomass and the overflow from clarifier should be collected in clean clarified sump where chlorine would be added. Then the effluent should be pumped through dual media filters. Then effluent from the filter should be send send to the polishing aeration tank. In this DO level will rise and the effluent from this unit could be used for horticultural purposes and make up water in cooling towers.

The MoEF sought clarification on details of Common Effluent Treatment plant. Some of the plants that have typical effluent characteristics that need pre-treatment will have their own effluent treatment plant within the battery limit of the specific plant. These plant specific ETPs will treat their respective effluent to the specified standard that would be acceptable at the Central ETP.

The composite effluent from the all the plants will mainly consist of oil, grease, organic matter and suspended solids which would be treated in effluent treatment plant consisting of primary, secondary and tertiary facilities.

The primary treatment facilities consist of two stage oil removal – the first being free oil removal and the second would be emulsified oil removal.

The secondary treatment is a combination of the attached growth and suspended growth biological system consisting of Equalisation tank, Bio tower and Aeration tank and Secondary clarifier followed by Guard pond and polisher. The tertiary treatment facility consists of clarified water sump, Rapid sand filter and Activated carbon filter

At the equalisation tank the PTA effluent after pretreatment within the plant will combine.

For further recycle and reuse of the treated wastewater, effluent polishing methods like RO, Ion Exchange columns etc will be explored and implemented. The Schematic Flow Diagram of Proposed Central Effluent Treatment Plant in SEZ is shown in Fig. 6.1.

6.2.4 Land Environment

- Soils in the adjoining areas are sandy loam to silty loam with moderate infiltration rates, amenable to groundwater pollution. Considering this fact, every precaution should be taken to avoid spillage of oils, petroleum and petrochemical products on soils to protect groundwater and to avoid any danger to other soil microbial groups which are sensitive to oil pollution
- Oil is a potential hazardous substance present in wastes generated from refinery and petrochemical complex. Special care should be taken in all the oil removal operations. Disposal of Oily sludge generated from effluent treatment plant through Coker should be practiced.
- The sludge generated from the ETPs' of the petrochemical complex should be disposed off in secured landfill / incinerated. The incinerated ash should be send to the secured landfill.
- The storage, handling, transportation & disposal of the hazardous waste should comply with the Hazardous Waste Management Rules.
- Greenbelt in and around the SEZ units should be developed.
- A record w.r.t quantity, quality and treatment management of solid hazardous waste should be maintained at environmental monitoring cell for different process units (sources)
- Mixers and tank cleaning procedures, which maximize recovery of oil, should be

adopted to reduce tank bottom sludge.

- Recovery of oil from oily sludge using techniques such as centrifuging, thickening and filtration should be undertaken.

The following measures should be practiced at the Coke Storage area by the Reliance:

- Coke piles height should be kept at 3.5 m or less since the wind velocities closer to the ground is less.
- The piles should be aligned with prevailing wind direction to minimize the carry over with the wind.
- Regular water sprinkling should be carried out over the piles and truck movement area. Three / four water tankers should be exclusively used for this purpose round the clock.
- Rows of Casuarinas trees should be planted on the boundary of the storage area as windbreakers.
- Storm water channels should be provided around the piles storage area to collect and route the rainwater to two coke fines settling ponds. Coagulant addition facilities are also to be provided in these ponds for improving the settling.
- The outlet drains two nos of hay filters should be provided in series.
- Down stream of the hay filters a check dam should be constructed near the boundary for creating a large water storage area. This will further increase the residence time for the settling of remaining coke fines.
- It is recommended that above measures should be continued for the project and take further steps of improving/increasing the hay filters.

6.2.4.1 Hazardous /Solid Waste Management

Solid waste disposal and management is a prime concern in the SEZ as it not only comprises of the household waste but also the industrial waste. The domestic waste with assumed solid waste generated of 0.5 kg / capita / day solid waste will be generated in the SEZ township. The hazardous waste generation from each Unit has been tabulated in Table 5.11 of the EIA report. However, the catalyst waste generation frequency varies based on the type of catalyst and its frequency of regeneration. The combined hazardous waste generation and proposed disposal methodology from the Petroleum and Petrochemical Complex has been tabulated in Table 6.1 of the EIA Report.

Proposed Solid waste management system

In the short-term, the trash collection areas should be designed for collection of recyclables and should have a used oil collection tank or a rack on which to store containers of used oil. In the short-term, this oil should then be exported off-site to a refinery for recycling or to a facility where it could undergo proper disposal.

This emphasizes the need of on-site recycling of oil, which is an upcoming concept.

There are two main uses for recycled oil:

- It can be re-refined in the refinery and then used in combustion engines and as a lubricant, or
- It can be burned as fuel, if the proper procedures and equipment are used.

For this facility, the oil collection service transport should collect the oil to an onsite facility for treatment. Ideally, this facility should be located near or in conjunction with SEZ's petroleum, oil, and lubricant facility.

For most of the collected oil, a simple oil separation and storage apparatus should suffice. The used oil should be emulsified; however, a more advanced system called "ultra filtration" is required. If high levels of metals or other contaminants are present, a chemical or reverse osmosis unit may be necessary. In both ultra filtration and osmosis, the waste water that is removed during separation is clean enough to be used directly for gray water and should go to the proposed gray water collection area.

Once treated, the oil should be utilized within SEZ industries with oil boilers for use as a fuel source. The treated oil is actually a preferred fuel source for many industrial facilities. Many of the industries in the SEZ can be potential candidates for this treated oil.

For the residential township, the effective solid waste management systems are needed to ensure better human health and safety. They should be safe for workers and safeguard public health by preventing the spread of disease. In addition to these prerequisites, an effective system of solid waste management should be both environmentally and economically sustainable. Clearly it is difficult to minimize the two variables, cost and environmental impact, simultaneously. There will always be a trade off. The balance that needs to be struck should reduce the overall environmental impacts of the waste management system as far as possible, within an acceptable level of cost.

It is proposed that mechanical composting process be adopted, which is eco-friendly and also some revenue can be generated by the sale of compost.

Recycling turns materials that would otherwise become waste into valuable resources. Materials like glass, metal, plastics and paper are collected, separated and sent to facilities that can process them into new material.

All biodegradable municipal solid waste should be mixed with sewage sludge to undergo composting to produce saleable fertilizer. Composting is another form of recycling. Non-biodegradable waste should be brought together with the industrial waste to the landfill for ultimate disposal. Although source reduction, reused, recycling and composting can divert large portions of municipal solid waste from disposal, non-biodegradable waste should be collected in landfills. Landfills within the SEZ should be well-engineered facilities that are to be located, designed, operated, monitored, closed, and cared for after closure, cleaned up when necessary to protect human health and the environment.

Different processes have different catalyst, which have to be replaced at different intervals. Based on the process, the spent catalyst will be deactivated based on the methods prescribed by the catalyst suppliers. The spent deactivated catalyst will either be taken back by the catalyst supplier for regeneration or the catalyst with available activity can be sold to other processing units. Spent Catalyst containing precious metals can be sold to authorized processors for precious metal recovery. The management and disposal of catalyst will be in line with the requirements of the Hazardous Waste (Management and Handling) Rules.

Segregation and Storage at source

It will be necessary to segregate the solid waste generated at every household as well as in the commercial premises. The segregation will entirely depend upon its source of generation, it should be segregated as biodegradable as well as non-biodegradable and accordingly, it should be stored in different containers or bags with different color codes.

There will be another types of solid waste termed as Bio-medical waste, which will be generated at the medical centre. It will also be of hazardous and non-hazardous type, and hence required to be segregated and collected in separate containers provided at individual medical centers.

Control of contamination risk linked to the storage of toxic or hazardous waste:

- Water-proofing and installation of containment system for loading and unloading area.
- Installation of chemical storage areas which are linked to containment systems, if possible covered.
- Avoidance of chemical and storage tank drainage systems installed

underground.

Collection and transportation

The refuse collector should collect the bags daily from the container placed in residential areas. Small trucks (dumpers) of capacity 4.5 m^3 is suggested for collection of waste. It should be rear loading type equipped with hydraulic loading and mechanical tipping mechanism. Truck shall be designed for manual loading of bags and mechanical unloading at the storage depot.

Waste collected from the litter bins provided at suitable intervals on the street should be a mixture of biodegradable and non-biodegradable waste. This waste should be emptied in to the closed truck and transported to storage transfer depot. Road sweeping is proposed to be done mechanically. Garden waste should be collected once in three days.

Treatment and Disposal Strategies

Several technologies are recommended for processing, treatment and / or disposal of solid waste. Some of them are Microbial composting, Vermi composting, Incineration, Power generation, Fuel pelletisation etc. Each waste has a separate destination depending on its quality. However a general treatment and disposal strategies as out lined in Municipal Solid wastes (Management and Handling) Rules–2000 that can be adopted is as follows:

- After collection and bringing all the coloured bags at one storage area, the biodegradable waste from residential, commercial areas can be transported on routine basis through the authorized contractors to composting plant, whereas non biodegradable should be disposed off to common land fill site. Due care should be taken to avoid fly nuisance throughout the cycle of collection, transportation, treatment and disposal of biodegradable waste from residential and commercial areas
- The recyclables such as metal canes, plastics etc. should be sold to only authorized vendors.
- Hazardous part of bio-medical wastes should be incinerated at common incineration facilities and the incinerated ash should be disposed in the on-site secured landfill, while non-hazardous wastes should be disposed off on pre-identified landfill site in consultation with local administration body.
- The final designing and modalities may be carried out during construction phase of the project or a tie-up with local administration should be made for entire solid waste disposal, after being collected and segregated at township complex.
- The tank truck loading and unloading area should be sealed and linked to containment facilities.

- Hazardous substance storage area should be contained and when possible, covered to any pollution through run-offs.
- Wastewater and chemical drainage systems must undergo regular inspection for leaks.
- Chemical drainage systems inside the facility and storage tanks should be above ground, unless otherwise recommended for reasons of hygiene and safety.
- It is also recommended that a monitoring programme be implemented to check underground water for any spillage.
- It is the best practice that all necessary measures should be taken in the design and operation of the facility to ensure proper waste treatment through the definitionof procedures which aim to:

  - limit the quantity and toxicity of waste at source.

  - sort, recycle an reuse manufacturing sub-products.

  - ensure the treatment or pre-treatment of toxic waste.

  - ensure storage of final waste in the best possible condition

D*isposal of catalyst used in the different process*

Different processes have different catalyst, which have to be replaced at different intervals. Based on the process, the spent catalyst is deactivated based on the methods prescribed by the catalyst suppliers. The spent deactivated catalyst is either taken back by the catalyst supplier for regeneration or the catalyst with available activity is sold to other processing units. Spent Catalyst containing precious metals will be sold to authorized processors for precious metal recovery. The management and disposal of catalyst will be in line with the requirements of the Hazardous Waste (Management and Handling) Rules.

6.2.4.2 Common Incinerator Facility

The incinerator should be designed for capacity more than 200 kg/hr. Incinerator shall be installed with venturi scrubbing system, which is an air pollution control system. All incinerators, individual or common will be designed as per the CPCB Criteria. The individual incinerator will be a process requirement of respective units and the common incinerator will cater to the incineration of requirement of the complex. The technical details of the common incinerator is given in **Annexure XI**

The size of the opening through which the waste is charged should be larger than the size of the waste bag to be fed. The volume of the primary chamber should be atleast five times the volume of one batch.

The double chamber incinerator should preferably be designed on "controlled-air" incineration principle, as particulate matter emission is low in such incinerator. Minimum 100% excess air should be used for overall design. Air supply in the primary and secondary chamber should be regulated between 30% - 80% and 170% - 120% of stoichiometric amount respectively. Primary air should be admitted near / at the hearth for better contact. Flow meter / suitable flow measurement device shall be provided on the primary & secondary air ducting. The combustion air should be supplied through a separate forced draft fan after accounting for the air supplied through burners.

A minimum negative draft of 1.27 to 2.54 mm of WC (Water Column) should be maintained in the primary chamber to avoid leakage of gaseous emissions from the chamber and for safety reasons. Provision should be made in the primary chamber to measure the Water Column pressure.

The waste should be fed into the incinerator in small batches after the fixed interval of time and continuous charging using appropriate feeding mechanism.

The sides and the top portion of the primary and secondary chambers shall preferably have rounded corner from inside to avoid possibility of formation of black pockets/dead zones.

The size of the secondary chamber should be properly designed so as to facilitate a minimum of one second of residence time to gas flow. For the estimation of residence time in the secondary chamber its volume should be calculated starting from the secondary burner tip to the thermocouple.

The refractory lining of the chamber should be strong enough to sustain minimum temperature of 1000° C in the primary chamber and 1200° C in the secondary chamber. The refractory & insulation bricks shall have minimum 115 mm thickness each & conform to IS:8-1983 & IS:2042-1972 respectively.

The Incinerator shell should be made of mild steel plate of adequate thickness (minimum 5 mm thick) & painted externally with heat resistant aluminum paint suitable to withstand temperature of 250°C with proper surface preparation. Refractory lining of the hot duct should be done with refractory castable (minimum 45 mm thick) & insulating castable (minimum 80 mm thick). Ceramic wool should be used at hot duct flanges & expansion joints.

The thermocouple location should be as follows:

- In Primary chamber - Before admission of secondary air
- In Secondary chamber - At the end of secondary chamber or before admission of dilution medium to cool the gas

There shall be a separate burner each for the Primary & Secondary chamber. The heat input capacity of each burner should be sufficient to raise the temperature in the primary and secondary chambers as 800±50°C and 1050±50°C respectively within maximum of 60 minutes prior to waste charging. The burners should have automatic switching "off/on" control to avoid the fluctuations of temperatures beyond the required temperature range.

- Each burner should be equipped with spark igniter and main burner.
- Proper flame safeguard of the burner should be installed.
- Provide view ports to observe flame of the burner.
- Flame of the primary burner

  - should be pointing towards the centre of the hearth.

  - should be having a length such that it touches the waste but does not impinge directly on the refractory floor or wall

The secondary burner should be positioned in such a way that the flue gas passes through the flame.

There should not be any manual handling during charging of waste in to the primary chamber of the incinerator. The waste should be charged in bags through automatic feeding device at the manufacturer's recommended intervals ensuring no direct exposure of furnace atmosphere to the operator. The device should prevent leakage of the hot flue gas & any backfire. The waste should be introduced on the hearth in such a way so as to prevent the heap formation. Suitable raking arrangement should be provided for uniform spreading of waste on the hearth.

A tamper-proof PLC(Programmable Logic Control) based control system should be installed to prevent:

- Wastes charging until the required temperature in the chambers are attained during beginning of the operation of the incinerator.
- Waste charging unless primary & secondary chambers are maintained at the specified temperature range.
- Waste charging in case of any unsafe conditions such as - very high temperature in the primary & secondary chambers; failure of the combustion air fan, ID fan, recirculation pump; low water pressure & high temperature of the flue gas at the outlet of air pollution control device.

The incineration system should have an emergency vent. The emergency vent should remain closed i.e it shall not emit flue gases during normal operation of the incinerator.

Each incineration system should have graphic or computer recording devices, which shall automatically and continuously monitor and record dates, time of day, batch sequential number and operating parameters such as temperatures in both the chambers. CO, CO2, and O2 in gaseous emission shall also be measured

The possibility of providing heat recovery system/heat exchanger with the incinerator should also be considered wherever possible.

Structural design of the chimney / stack should be as per IS:6533-1989. The chimney/stack should be lined from inside with minimum of 3 mm thick natural hard rubber suitable for the duty conditions and should also conform to IS:4682 Part I-1968 to avoid corrosion due to oxygen and acids in the flue gas.

The location and specification of porthole, platform ladder etc. should be as per the Emission Regulations, Part-3 (COINDS/20/1984-85), published by CPCB.

Incinerator room and waste storage room

- The incinerator structure should be built in a room with proper roofing and cross ventilation. There should be minimum of 1.5 m clear distance in all the directions from the incinerator structure to the wall of the incinerator room.
- Adjacent to the incinerator room, there should be a waste storage area. It should be properly ventilated and so designed that waste can be stored in racks and washing can be done very easily. The waste storage room should be washed and chemically disinfected daily.
- The floor and inner wall of the incinerator and storage rooms should have outer covering of impervious and glazed material so as to avoid retention of moisture and for easy cleaning.

The incineration ash should be stored in a closed sturdy container in a masonry room to avoid any pilferage. Finally, the ash should be disposed in a secured landfill.

6.2.4.3 Common Secured Landfill Facility

Selection of Landfill Site

The Hazardous Waste Disposal Facility will be designed and constructed as per the CPCB Guidelines. The ETP sludge, oily sludge, spent clay, incinerator ash etc. should be disposed in a common captive landfill site proposed to be located in the proposed SEZ. The landfill site should be chosen based on following considerations:

- *Minimise health risks*
- *Minimise adverse environmental impacts*
- Minimise costs
- Maximise public acceptability

The site characterization and identification is very important aspect. Prior to assessment of health and environmental impacts of any landfill site, detailed analysis of hydrological, atmospheric and chemical features of the site should be carried out. Accordingly, the selected site for landfill is screened on the basis of following criteria :

- Geology and hydrology of the area
- Soil quality of the region
- Ground water quality
- Ambient air quality

During scrutinizing the selected site, the following areas are eliminated which fail to meet additional socio-economic and environmental concerns as well as additional geologic and hydrologic factors:

- Existing zones of development
- Agricultural land preserves
- Areas of mineral development
- Freshwater wetlands
- Visual corridors of scenic rivers
- Riverine and dam-related flood hazard areas

In addition, following features should also be considered for selection of landfill site:

- Easy access to a road system
- Ease in land acquisition
- Beneficial after use
- Outside a military exclusion zone
- Outside a safe buffer distance (100m) from an existing or planned, quarry, which will undertake blasting with explosives
- Away from areas known to contain collapsing soils

Specifications for landfill site selection

- Landfill site should be large enough to last for 20-25 years
- Landfill site should be away from habitation clusters, forest areas, water bodies, monuments, national parks, wetlands and places of important cultural, historical or religious interest
- A buffer zone of no-development should be maintained around landfill site

Facilities at Landfill Site

The following facilities should be provided at the landfill site:

- Landfill site should be fenced or hedged and provided with proper gate to monitor incoming vehicles or other modes of transportation
- Landfill site should be well protected to prevent entry of unauthorized persons and stray animals
- Approach and other internal roads for free movement of vehicles and other machinery should exist at the landfill site
- Landfill site should have wastes inspection facility to monitor wastes brought in for landfill, office facility for record keeping and shelter for keeping equipment and machinery including pollution monitoring equipments
- Provisions like weigh bridge to measure quantity of waste brought and landfill site, fire protection equipments and other facilities as may be required should be provided
- Utilities such as drinking water (preferably bathing facilities for workers) and lighting arrangements for easy landfill operations when carried out in night hours should be provided
- Safety provisions including health inspections of workers at landfill site should be periodically made

Specifications for Land Filling

- Wastes subjected to land filling should be compacted in thin layers using landfill compactors to achieve high density of the wastes.
- Wastes should be covered immediately or at the end of each working day with minimum 10 cm of soil, inert debris or construction material till such time waste processing facilities for composting or recycling or energy recovery are set up.

- Prior to the commencement of monsoon season, an intermediate cover of 40-65 cm thickness of soil should be placed on the landfill with proper compaction and grading to prevent infiltration during monsoon. Proper drainage berms shall be constructed to divert run-off away from the active cell of the landfill.
- After completion of landfill, a final cover should be designed to minimize infiltration and erosion. The final cover shall meet the following specifications, namely :
    - Final cover should have a barrier soil layer comprising of 60 cm of clay or amended soil with permeability coefficient less that 1 x 10^{-7} cm/sec.
    - On top of the barrier soil layer there should be a drainage layer of 15 cm.
    - On top of the drainage layer there should be a vegetative layer of 45 cm to support natural plant growth and to minimize erosion

Leachate Management

When rain water or run-off water gets into the landfill, the chemical compounds present in the impounded wastes get leached along with water as leachate. The characteristics of the leachate depend upon both composition of the material and on environmental factors.

Solid/hazardous waste landfills should be provided with a system to collect, contain and possibly treat leachate. Typically, at a minimum a double-liner system should be placed at the bottom and side slopes of the facility prior to initial placement of hazardous wastes. This liner system will contain leachate that later may be generated in the deposited wastes and then flow downward by gravity. Leachate that accumulates above the liner should be directed to one or more central collection sumps through a series of perforated plastic collection pipes. From these sumps, leachate is pumped out for pre-treatment (either on or off-site) and ultimate treatment in wastewater treatment plant near CPF.

To facilitate removal of leachate from the liner, the bottom of landfill is sloped, and a sufficient number of drainage pipes are provided so that the leachate depth over the liner does not exceed 0.3 m (1 ft).

Fig. 6.2 and **6.3** illustrate conceptual design of bottom liner and leachate collection system configuration.

Leachate generation is also reduced through the placement of a low-permeability cap over completed portions of the landfill. This cap should have a permeability less than or equal to the permeability of the bottom-liner system.

In some cases, a hazardous waste landfill can be exempted from double-liner requirements for leachate emission control if, among other factors, the hydrogeologic setting would preclude leachate migration to ground or surface water. For example, some hazardous wastes may be minimally prone to leaching or migration. Also, hydrogeologic factors at the site could provide a degree of protection, these include on site soils with a significant attenuative capacity (e.g. certain clays) and/or a substantial thickness of soil situated between the landfill, ground and surface water.

Leachate Collection System

The leachate collection and removal system should consists of a network of drains to collect and remove any accumulation of leachate that might develop in the bottom of the landfill, and it prevents migration of leachate to the subsurface.

Collection drain layer

- Layer permeability not less than 10^{-3} meter/sec; minimum thickness 30 cm; minimum slope 3%

Drain pipe

- Size and hydraulic capacity : large enough to carry-off the collected leachate
- Spacing (as recommended by USEPA)

Surface Water Control

Surface water originating from off-site upstream locations should be directed around or away from the landfill via half-round corrugated metal pipe (CMP) or ditches lined with asphaltic concrete (AC). These ditches should be designed such that off-site peak runon from at least a 25-year storm can be diverted.

On-site surface water should be generally handled as follows:

- Runoff from non-landfilled areas should be diverted directly off-site.
- Runoff from exposed excavation areas should be directed to siltation basins and then discharged off-site.
- Runoff from the active landfill area should be directed to holding sumps where it is sampled for contamination. Uncontaminated water should be directed off-site, and contaminated water should be treated on-site and then discharged off-site or conveyed by truck or pipe for treatment off-site.
- Runoff from completed landfill surfaces should be directed to holding sumps (different sumps than used for runoff from active landfill areas since the runoff volume will be greater and the runoff less likely to be contaminated), where it is

sampled for contamination. Uncontaminated water is directed off site and contaminated water is treated on–or– off–site.

Drainage ditches located on non-landfilled areas are generally earth ditches, half-round CMP, or AC- or gunite-lined earth ditches.

Temporary earth berms and drainage ditches should be used to divert on-site runoff away from active landfilling areas. Permanent drainage ditches located on the landfill must be able to accommodate some differential settlement, and are thus frequently constructed of half-round or whole CMP or plastic pipes with overlapping flexible joints: riprap-lined earth ditches are also commonly used.

Ground Water Monitoring

The monitoring of groundwater is the most important tool to test the efficiency of landfill performance. This is indispensable as it provides detection of the presence of waste constituents in groundwater in case of leachate migration. In this programme, water samples are taken at a predetermined interval and analysed for specific pollutant expected to be in the leachate. However, if any contamination is detected in the existing wells which are located about 500m away from landfill, it can be concluded that considerable damage has already occurred in the liner system provided in the landfill site to prevent further damage to groundwater sources. For early detection of leachate migration, it is suggested to construct Piezometers around the landfill.

In addition to Piezometers, monitoring wells should be installed to a depth of atleast 3 meters below the maximum historic groundwater depth. Based on assumptions and data about the characteristics of leachate to be generated, approximate permeability of soils in the zone of aeration, and direction and velocities of groundwater flow, the maximum probable aerial extent of contaminant migration can be estimated as a basis for establishing the position of monitoring wells.

A minimum of two ground monitoring wells should be typically installed at a disposal facility: one up-gradient well and one down-gradient well. It is suggested to collect water samples and analyse. Records of analysis should be maintained.

Operation and Maintenance Programme

To achieve effective performance of a landfill disposal facility operation and maintenance of the landfill form key element.

Factors involved in the operational stage are summarized below:

- Wastes acceptability

- Details of wastes arrived at secure landfill facility
- Segregation of wastes according to design methods
- Random checking of waste for its characteristics
- Filling as per specification

In addition to the operational procedures outlined above, following maintenance schedule should be adhered:

- Proper care should be taken to check for erosion due to rain and vehicular movements
- Drainage system should be checked periodically for blockage
- A log book should be maintained to account for the quantity of waste disposed/dumped
- If any vegetative growth on the embankment and near landfill area should be removed, an equal area should be planted elsewhere in the same area.

Closure and Postclosure

a) Closure

Upon final closure of the landfill or upon completion of a cell, a final cover is applied that is constructed to:

- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present in order to minimize long-term migration of liquids through the closed landfill's surface
- Function with minimum maintenance
- Promote drainage and minimize erosion abrasion of the cover
- Accommodate settling and subsidence so that the cover's integrity is maintained

For lanfills with all or a portion of the wastes in above grade cell, final side slopes are generally up to 3:1 horizontal to vertical. A 4.6-to 6.1-m wide (15 to 20ft) slope bench is placed every 7.6 to 9.1 m (25 to 30 ft) of vertical rise to minimize slope erosion and increase slope stability. Top surface slopes generally are at minimum 5 percent to promote runoff and to accommodate some degree of future settling of the landfill.

b) Postclosure

After final closure of a disposal facility, the following postclosure maintenance and monitoring activities are conducted throughout the postclosure care period:

- Perform routine final cover maintenance. The integrity and effectiveness of the final cover is regularly maintained by filling and regrading depressions in the cover and surface as necessary to correct adverse effects such as settling, subsidence, erosion, and animal burrowing. Also, drainage and flood control channels should be kept clear of accumulated debris. Dead vegetation should also be replaced
- Prevent runon and runoff of precipitation from eroding or otherwise damaging the final cover
- Protect and maintain surveyed benchmarks
- Maintain the environmental monitoring facilities
- Obtain samples from monitoring facilities and analyze and report the results in accordance with applicable permit requirements

Postclosure monitoring during the first 12 to 18 months will generally involve relatively frequent site inspections and sampling (e.g. once per month). Monitoring frequencies can generally be reduced after this period if no problems are encountered during that time.

6.2.5 Biological Environment

Following measures are recommended to mitigate adverse impacts on biological activities during **operation phase**:

- Development of green belt with carefully selected plant species is of prime importance due to their capacity to reduce noise and air pollution impacts by attenuation/assimilation and for providing food and habitat for local macro and micro fauna. This not only overcomes the problem but also enhances the beauty of area that will attract bird and insect species and by this way ecology of the area will maintain to great extent.
- For developing the greenbelt in and around proposed project site care need to be taken to plant the evergreen species. The planting of evergreen species may have certain advantages that may reduce the environmental pollution.
- Survival rate of the planted trees should be closely monitored and the trees which could not survive should be counted. Equal number of trees should be

replaced and their survival should be closely monitored.

- The rainwater harvesting should be done. Treated sewage and effluent in the best combination should be used for greenbelt development. Water scarcity should not be the reason for not expanding and strengthening greenbelt. Provision for irrigation water should be made as part of proposed project

6.2.5.1 Preparation of greenbelt plan keeping in view the selected plant species

The proposed greenbelt development in SEZ should be of a suitable width along the periphery of SEZ area including residential complex, space between the units located within the SEZ, along the roads, railway sidings, the hazardous waste disposal facility, storage areas, loading / unloading areas of products etc.

Criteria for selection of species for greenbelt

The plant species suitable for green belt development should be selected based on the following characteristics.

- It should have thick canopy cover
- They should be perennial and evergreen
- They should have high sink potential for pollutants
- They should be efficient in absorbing pollutants without significantly affecting their growth.

6.2.5.2 Guidelines for plantation

The plant species identified for greenbelt development should be planted using pitting technique. The pit size should be either 45 cm x 45 cm x 45 cm or 60 cm x 60 cm x 60 cm. Bigger pit size is prepared on marginal and poor quality soil. Soil used for filling the pit should be mixed with well decomposed farm yard manure or sewage sludge at the rate of 2.5 kg (on dry weight basis) and 3.6 kg (on dry weight basis) for 45cm x 45 cm x 45 cm and 60 cm x 60 cm x 60 cm size pits respectively. The filling of soil should be completed at least 5-10 days before actual plantation. Healthy sappling of identified species should be planted in each pit.

Roadside Plantation

Roadside plantation plays a very important role for greening the area, increasing the shady area, increasing aesthetic value and for eco-development of the area. The approach roads to project site, colony, hospitals, etc. should be planted with flowering trees. Reliance SEZ should encourage plantation outside the plant boundary. Adequate care should be taken to encourage greenbelt development on the road side, however to uplift the regional ecosystem of the area by greenbelt development, all the voluntary organizations should take initiative to encourage massive plantation along the roadside Trees should be planted to increase aesthetic value as well as shady area along the roads.

The list of selected evergreen plants species for development of green belt is given in **Table 6.2**.

6.2.6 Socio-economic Environment

In order to mitigate the impacts likely to arise out of the proposed project and also to maintain good will of local people for the proposed project, it is necessary to take steps for improving the social environment. Necessary social welfare measures by the industry shall be useful in gaining public confidence depending on local requirement.

The EMP measures are suggested for smooth functioning of the activities are given below:

- SEZ should continue to undertaken social welfare programes for the betterment of the Quality of Life of villages around in collaboration with the local bodies.
- Some basic amenities, viz. education, safe drinking water supply to the nearby villages may be taken up
- Regular medical check up should be continued on routine basis in the villages around the SEZ and also by providing mobile hospital services
- SEZ shall in collaboration with local government improve the road infrastructure in the vicinity
- Formal and informal training to provide direct and indirect employment to the affected villagers due to the project shall be taken up on priority
- Entrepreneurship Development programme (EMP) should be undertaken for both male and female group irrespective of their age and education, qualification
- Job oriented skill training, courses may be organized. Through industrial/technical training institutions for educational youth (both for male and female), like home need appliances, tailoring, plumbing, light & heavy vehicles driving

6.2.7 Health and Safety

- Personal protective facilities like helmets, safety (gas) mask/safety dress, shoes etc. be ensured for all workers, engaged in operation of process units within the refinery complex
- The health checkups (diagnostic) for all regular employees at the refinery complex at scheduled intervals to be maintained along with the corresponding

health records.

6.2.8 A note on Occupational Health and Surveillance and safety measures

The design of the plants will be based on the relevant API, ASTM standards / codes and the best engineering practices followed internationally. Further, HAZOP studies will be carried out while detailed engineering is done and P&IDs are developed to ensure that all process control measures are adequate for safe operation of the plants. In case of chemicals like phosgene the guidelines issued by American Chemistry Council will be followed and approval from the concerned agencies will be obtained.

The unit operations manual will include a chapter on HSE issues related to the operation of the particular unit.

A note on the Safety Management System being followed in the present Refinery complex is enclosed as **Annexure XII** .Similar Safety Management System will be developed for the new complex before its commissioning.

The fire safety measures for the petroleum and petrochemical complex have been elaborated Chapter 6 & 7 of the Risk assessment Report.

6.3 Capital / Recurring Expenditure on Environmental Management

The details on proposed refinery expansion project cost and capital / recurring expenditure on environmental management.

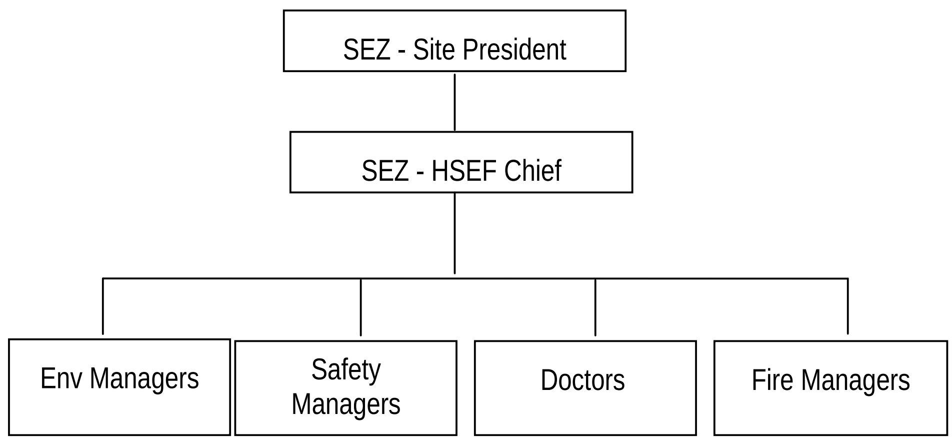
Project Cost	:	Rs. 60,000 crores
Cost for pollution control facilities	:	Rs. 1,800 crores
Recurring budget (Annual Maint @ 2%)	:	Rs. 36.0 crores

6.4 Proposed Environment Monitoring

Since the SEZ Complex is big enough, each industry should have senior executives who shall report to their respective Site President. The SEZ complex will have an Environment Cell for the entire SEZ and units therein. The Environment cell should consists of environmental professionals with experience in various aspects of Environment Management ranging from 7 years to 20 years. This cell should be set up during the construction of the SEZ itself and they should have adequate expertise and competency in handling and implementing the Environment Management systems and practices. The Environment Cell should monitor and measure the environmental performance of each industry in terms of efficiency of pollution control devices, and conduct regular energy and water audits. The cell should also on a regular basis also coordinate third party Environmental Audits. Members of the Environment Cell shall participate in National Task Forces under CREP (Charter for Corporate Responsibility for

Environmental Protection) and in committees for reviewing National Standards for the petroleum and petrochemical industry. The Corporate Environment Cell at the Headquarters shall be an advisory body on all environmental related issues and support the Environment Cell at the SEZ.

Every industry within the SEZ should in due time aim to be certified for ISO 14001 standards. The Environment cell in each industry should be responsible for implementing and maintaining environment management systems. These industry should co-ordinate with the Environmental Management Cell of SEZ for establishing and monitoring the compliance of ISO 14001. The Management Systems should be established in compliance with the ISO 14001 standards which should be audited internally by qualified internal auditors and externally by the certifying body as per the stipulated frequency.



It is recommended that the parameters as provided in **Table 6.3** should be monitored by strengthening the existing environmental monitoring programme. The frequency of monitoring is also presented in **Table 6.3**. In addition, parameters as specified by CPCB, GPCB, MoEF and in CREP should also be monitored at specified locations with recommended frequency.

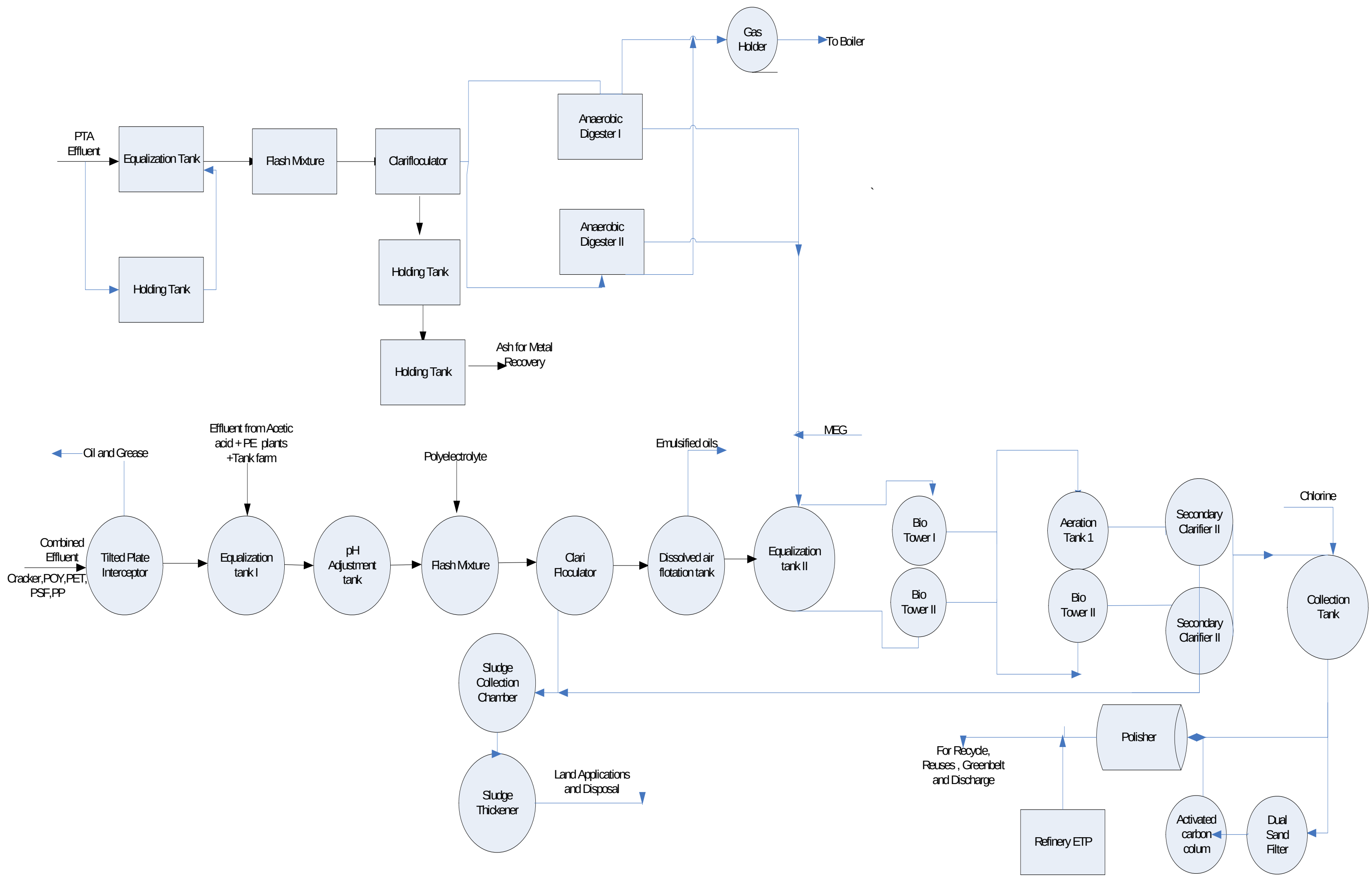


Fig. : 6.1 Schematic Flow Diagram of Proposed Central Effluent Treatment Plant in SEZ

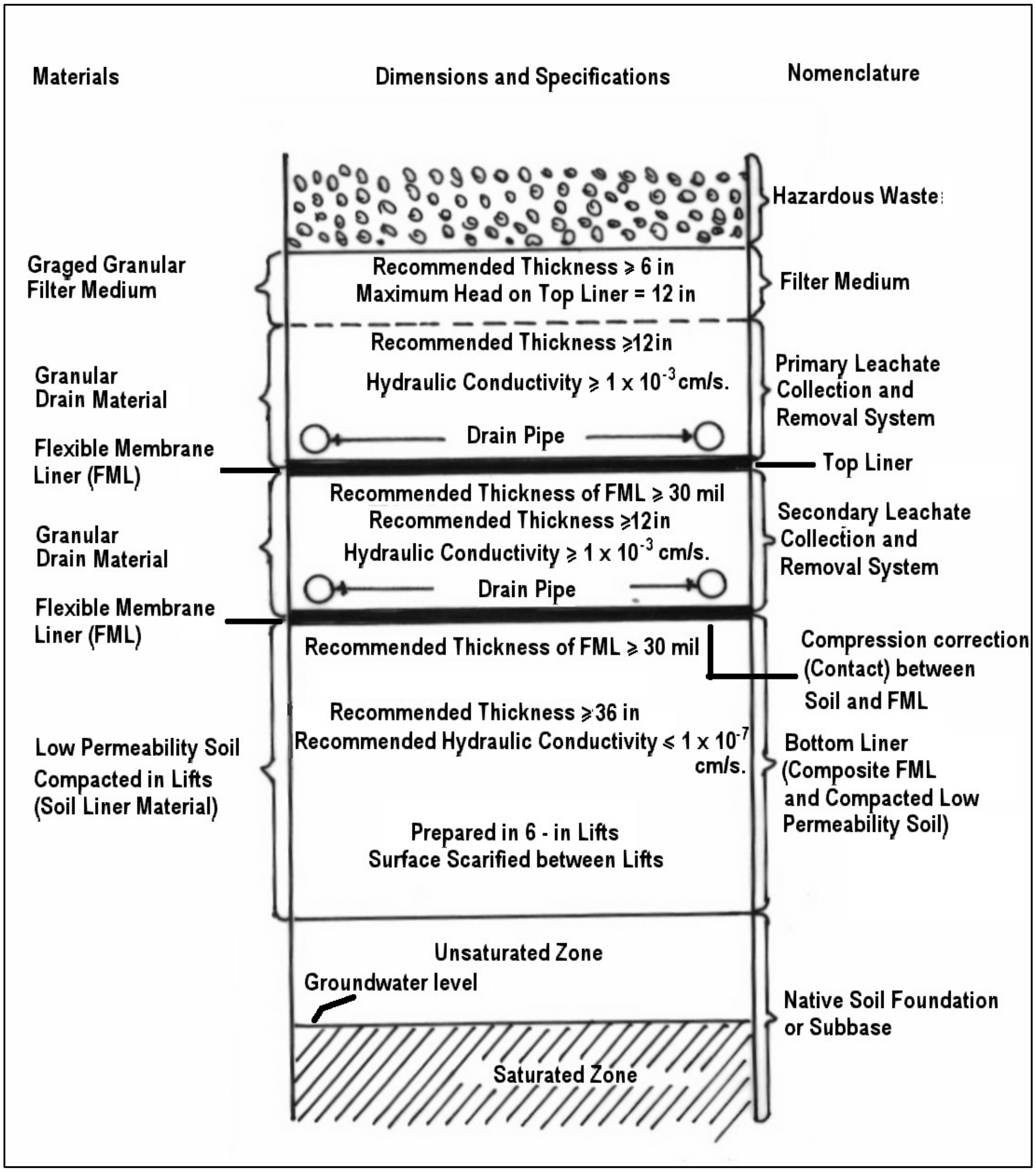


Fig. 6.2: **Schematic Profile of an FML Plus Composite Double Liner System for a Landfill**

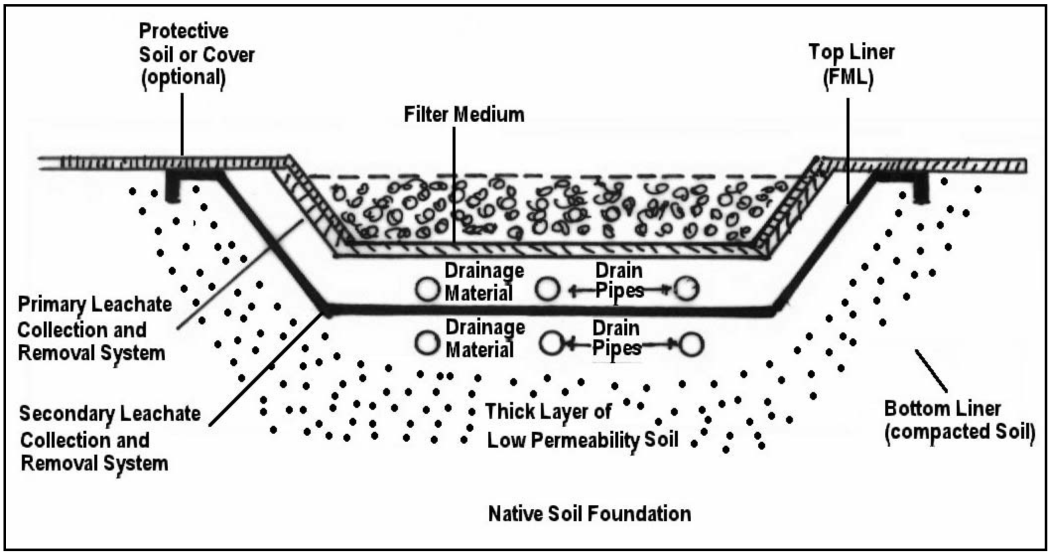
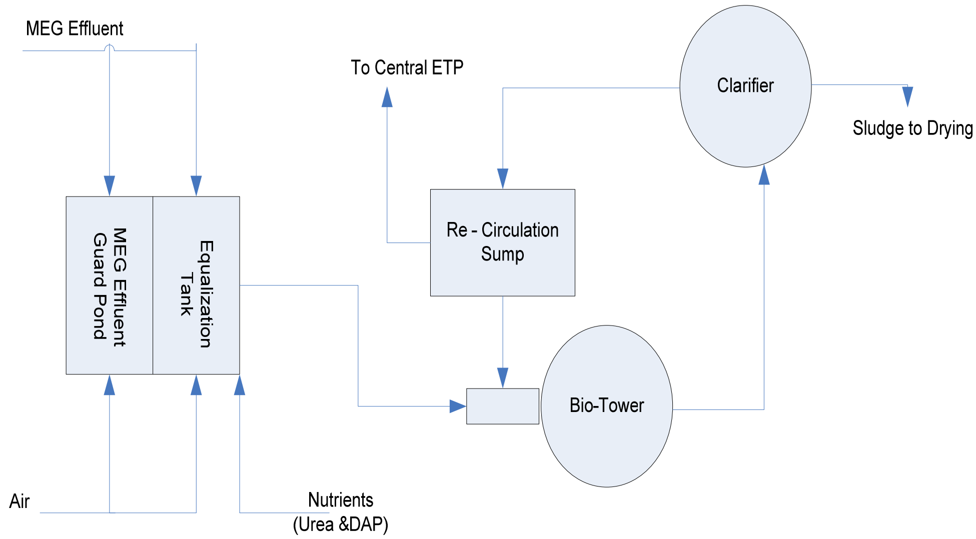


Fig. 6.3 : Schematic of an FML plus Composite Double-liner System for a Landfill



Block Diagram MEG Effluent Pre-Treatment Plant

Fig: 6.4: Block Flow diagram of MEG Effluent Pre Treatment Plant

Table 6.1

Hazardous Waste Quantity and Mode of Disposal

Sr. No	Waste	Qty generated /Yr	Mode of Storage and Disposal
A	**Hazardous waste**		
1	Oil sludge from ETP	14256 M^3	Internal recycle in Delayed Coker unit and Converted into coke.
2	Slop Oil	12000M^3	Internal recycle by reprocessing in the process units
3	Oil Rags, Oil contaminated cotton waste /contaminated packing	450M^3	Stored In the drums and drums are stored on impermiable concrete platform during storage period. It is praposed to be disposed in the secured landfill facility being developed in the SEZ area or Incinarated using well designed incinarator
4	Waste lubrican oil and Used oil	1500 KL	Stored in MS drums. MS drums are stored on impermiable concreate platform during storage period.Waste lubricating oil is sold to certified waste lubricating oil processor.
5	Spent catalyst from other units like Platformer.isomer and tatory	2750 tons*	As per the contracts with catalyst suppliers , the catalyst will be taken back to the suppliers.
6	Oil sludge generated while cleaning of heavy tanks	As and when these tanks are taken for cleaning , so Estimation of quantity is not possible	Will be treated through sludge melting pit for the maximum recovery of hydrocarbon. After that it will be disposed off in the secured landfill..
7	Empty drums	15000 nos	Sold after decontamination.

Sr. No	Waste	Qty generated /Yr	Mode of Storage and Disposal
8	Spent Clays	5500 Tons	Throughly purged and made hydrocarbon free and disposed in landfill area.
9	Incinerator Ash	100 Tons	Secured landfill
B	**Process Related Waste**		
1	Equilibrium catalyst	14000 tons	Sold to other refineries.
2	Biological sludge	250 tons	Composting& use as mannure in Greenbelt .
3	Activated Carbon	4800 Tons	Mixed with petcoke .
4	Molecular Sieves	4000 tons	Sold to firebrick manufacturers.
5	Slag from Coke gasification unit	0.128 to 0.37 MM tons	Sold to Cement manufacturing units/ metal recovery
C	**Non processing waste**		
1	Scrap metal	7500 tons	Sold
2	Wooden and Electrical scrap	3600 tons	Sold
3	Plastic Bags	600 tons	Sold/Reused after cleaning
4	Scrape carton box and Paper	900 Tons	Sold
5	Used Tyres	330 Nos	Sold
6	Glass	90 Tons	Sold
7	Nylon&Fibre scrap	240 tons	Sold

Sr. No	Waste	Qty generated /Yr	Mode of Storage and Disposal
8	Waste cable Scrap	1200 tons	Sold
9	Battary Scrap	330 tons	Sold

Table 6.2

List of Plant Species suggested for Green belt

Sr. No.	Article I. Name of Plants Species
Trees	
1.	*Acacia auriculoformis (16 m)*
2.	*Acacia nilotica (8 m)*
3.	*Achras sapota(10m)*
4.	*Aegle marmelos (12 m)*
5.	*Annona squamosa (10 m)*
6.	*Annona reticulata (10 m)*
7.	*Albizia moluccana(20 m)*
8.	*Azdirachta indica (20 m)*
9.	*Cassia siamea (10-12m)*
10.	*Casuarina equisetifolia (10 m)*
11.	*Dalbergia sisoo (10 m)*
12.	*Derris indica (10 m)*
13.	*Ficus bengalensis (20 m)*
14.	*Ficus religiosa (20 m)*
15.	*Mangifera indica (15 m)*
16.	*Mimusops elengi (10 m)*
17.	*Peltophorum pterocarpum (10m)*
18.	*Pithecellobium dulce (8 m)*
19.	*Psidium guayava (15 m)*
20.	*Saraca asoka (5 m)*
21.	*Syzygium cumini (20 m)*
22.	*Tamarindus indica (20 m)*
23.	*Zizyphus mauritiana (10 m)*
Shrubs	
1.	*Bougainvillea spectabillis (8 m)*
2.	*Citrus lemon (3 m)*
3.	*Hibiscus rosa-sinensis (3 m)*
4.	*Lawsonia inermis (5 m)*
5.	*Nerium indicum (5 m)*
6.	*Sesbania sesban (6 m)*
7.	*Thevetia peruviana (6 m)*

Table 6.3

Post-project Environmental Monitoring Plan

Component	Project Stage	Parameters	Standard	Location	Frequency	Duration	Institutional Responsibility
Air Quality	Construction	SPM, RPM, SO_2, NOx,	NAAQS of CPCB	6 locations with minimum 1 locations in upwind side, more sites in downwind side / impact zone on land only.	Once a month	24 hr/day for 2 consecutive days	Agency/ In-house
Air Quality	Operation	SPM, RPM, SO_2, NOx, CO, HC (non-methane), Mercaptans, benzene, vinyl chloride, NH_3, 1,2-dichloroethane	NAAQS of CPCB and PPAH (World bank)	Minimum 6 locations in each field with one on upwind side, two on downwind and one on lateral side.	Twice a week	Consecutive working days in a week SPM, RPM, SO_2 and NO_x - 24 hrs CO - Grab HC - Grab	Agency/ In-house
Air Quality	Operation	Particulates, SO_2, NOx, CO, HC (non-methane), Ni, Va, H_2S, HCl, Benzene, NH_3, 1,2-dichloroethane	Emission standards of CPCB/GPCB and PPAH (World bank)	Each stack	Once in 15 days	As per the recommendations of GPCB for existing stacks	Agency/In-house

Component	Project Stage	Parameters	Standard	Location	Frequency	Duration	Institutional Responsibility
Noise level	Construction	L_{eq} day, L_{eq} night, dB(A)	CPCB noise standards	2 to 4 locations representing different receptors/land use	Once every season- Summer, Winter, Post-monsoon during construction period	24 hour reading with a frequency of 10 minutes every hour for 2 non-consecutive days per week for 2 weeks per season	Agency/ In-house
Noise level	Operation	L_{eq} day, L_{eq} night, L10, L50, L90 dB(A)	CPCB noise standards	Near major sources in refinery complex and along the highway	Once every season- Summer, Winter, Post-monsoon	24 hour reading with a frequency of 10 minutes per hour for 2 non-consecutive days per week for 2 weeks per season	Agency/ In-house

Water quality	Construction/ Operation	Physico-chemical parameters, Nutrients and Organic parameters, heavy metals	Relevant water quality standards of CPCB and PPAH (World Bank)	10-20 groundwater samples around refinery	Once every season – Summer, Winter, Post-monsoon.	One grab samples from each groundwater source	Agency/In-house
Water quality	Operation	Physico-chemical parameters, Nutrients and Organic parameters, heavy metals	Same as above	Inlet and outlet of each ETP units	Once in 15 days.	Composite flow-weighted sampling	Agency/ In-house

Component	Project Stage	Parameters	Standard	Location	Frequency	Duration	Institutional Responsibility
Soil Quality	Construction	Particle size distribution, Texture, pH, Electrical conductivity, CEC, Alkali metals, SAR, Permeability, Water holding capacity, Porosity	Contaminant threshold level given by USEPA	- At all stockyard locations, construction machinery parking/refuelling/maintenance locations	At the start and end of construction activity at the relevant location	Sample every season till construction phase is complete	Agency/In-house
Solid/hazardous wastes	Operation	Depending on type of wastes	Contaminant threshold level given by USEPA	- At accidental spill sites – Solid waste disposal location	- In the event of an accident - Once during each season	- One time sample	Agency/In-house

Ecology	Pre-construction	Monitoring of tree felling	Number to be felled as laid out in project detail design	At all locations/sections where tree is felled	During tree felling	-	Agency/In-house
	Operation	Survival rate of plantation	-	At locations of compensatory plantation and landscaping	Annually	For 3 years after operation starts	Agency/In-house
Traffic Volume	Construction	Road Traffic volume, characteristics and speed	As per relevant IRC specifications	At all artery roads leading to construction site	1 day hourly counts	Thrice in a year marking peak, medium and low construction activity at the site	Agency/In-house

Table 6.4

Effluent Characteristics of PFY

WATER ANALYSIS REPORT

M/s RELIANCE INDUSTRIES LTD.

Surat, Gujarat

MONTH : April 2009

Date of Sampling : 18-04-09

Sr. No.	Parameters	POY Plant Process Water
1	pH	6.85
2	Suspended Solids, mg/l	22
3	Dissolved Solids, mg/l	356
4	TKN, mg/l	8.96
5	Ammonical Nitrogen, mg/l	6.37
6	BOD (3 days at 27^{0}C), mg/l	28
7	COD, mg/l	648
8	Oil and grease, mg/l	2.9
9	Sulphate (as SO4), mg/l	219.38
10	Chloride, mg/l	111.67
11	Sulphide, mg/l	<0.1
12	Fluoride (as F), mg/l	<0.1
13	Cyanide (as CN), mg/l	<0.1
14	Phosphate, mg/l	7.3
15	Phenols (as C6H5OH), mg/l	<0.1
16	Copper (as Cu), mg/l	<0.01
17	Mercury (as Hg), mg/l	<0.01
18	Zinc (as Zn), mg/l	0.033
19	Lead (as Pb), mg/l	1.017
20	Nickel (as Ni), mg/l	0.425
21	Total Chromium (as Cr), mg/l	<0.01
22	Chromium (Cr+6), mg/l	<0.01
23	Sodium, mg/l	35.07

Chapter 7

Rehabilitation and Resettlement Plan

A detailed planning is necessary for the resettlement of project-affected people with a development strategy and package that may aim at improving or at least restoring the economic base of the project affected persons (PAPs). Preference must be given to land-based resettlement strategies for people dislocated from agricultural settings. If suitable land is not available, non land-based strategies must be planned that may provide opportunities for employment or self-employment. Resettlement action plan is being prepared according to the provisions mentioned in National Rehabilitation and Resettlement Policy 2003 in carrying out resettlement and rehabilitation plans for any developmental project.

7.1 Socio Economic Survey

7.1.1 Demographic Profile of Project affected People

As per the information gathered during the socio-economic survey by NEERI, there are about five project affected villages namely Navagam, Kanalus, Kana chikari, Dera chikari and Padana from where land is going to be acquired for the proposed SEZ project. The total land acquisition for the project is about 4544.76 Hectares out of which 2629.84 hectares of land is private, 1338.27 hectare is Government land and 576.63 hectare is Lease land. The socio-economic survey of the Project Affected Persons (PAPs) was undertaken to know the opinion and expectations of the project affected people.

Village wise distribution of Land Acquired by SEZ

Sr. No.	Name of Village	Area Acquired	
		Private	Govt.
1	Navagam	107-81-76	368-58-97
2	Kanalus	888-62-00	599-25-01
3	Kana Chhikari	439-17-80	321-18-06
4	Dera Chhikari	24-33-19	0-05-06
5	Padana	202-89-96	48-20-83
	Total	**2629-84-71**	**1338-27-93**

Source: Information provided by Project Authority

Details of Land Acquired

Sr. No.	Type of Land	Ha, Are, Sq. Mtrs
1	Private land	2629-84-71
2	Government Land	1338-27-93
3	Lease land	576-63-59
	Total	**4544-76-23**

Source: Information provided by Project Authority

Navagam

The village has a population of about 1615. The education level of the people of Navagam is only up to secondary school as there is no higher education facility in the village. Unemployment level is high in the region, during the survey it was observed that most of the people were having expectation of being employed by Project Proponents.

Kanalus

Kanalus village is having the population of around 2059. All the required, basic facilities are available in the village. Sanitation and drainage facilities are poor in the village, which leads to various diseases. Therefore people are demanding improvement in the sanitation and drainage facility. From this village, land has already been acquired for the project. People have high aspirations regarding employment and compensation. People expect construction of community hall in the villages.

Dera Chikari

People of Dera chikari village reported that water is polluted and saline and due to this health status of villages is badly affected. Common health problems like skin itching gastroenteritis and breathlessness in highly prevalent in the region. People are expecting mobile health facility at this village. People of Dera Chikari are also expecting that employment should be given to the local population by SEZ authorities. People are expecting that SEZ authorities must construct Radhakrishna temple in the village. People are complaining about the air pollution problem in the region.

Kana Chikari

Most of the project affected people of Kana Chikari village are aware about the project and have favorable opinion towards the project; but people are expecting that SEZ authorities must provide job opportunities to the local population and are also demanding that technical training institute must be introduced for the local people so that it may help to create employment opportunities. Villagers are mainly facing the problem of water and electricity. People opined that SEZ authorities should extend welfare activities in the villages

Padana

The village has a population of around 3364. The common diseases reported are gastroenteritis, malaria, skin infection and common fever particularly during rainy season. Frequent power failure and power shut down for 16 hours is reported in the village that hampers the irrigation facility in the region. Agricultural land from Padana village was earlier acquired for the different project operating in the study area. People were unsatisfied with the compensation given to them for the acquisition of the land and are demanding adequate compensation from SEZ and they have high aspirations regarding employment and compensation. People are expecting that SEZ authorities must develop certain infrastructure facilities like school, medical center, community hall, temple etc. in the village. As the village is near to the SEZ people have common complain of air and non availability of potable water.

During the survey it was observed that the quality of life of the surveyed villages is satisfactory. People opined that the implementation of social welfare schemes should be based on priority need of the local people and these needs must be considered after the consultation with the villagers.

7.1.2 Recommendations from National Rehabilitation and Resettlement Plan

Resettlement and Rehabilitation Strategy

The Gujarat government has no specific R&R policy at state level; however they have adopted National Policy on Resettlement and Rehabilitation for Project Affected Families – 2003. The National Policy does not cover any R&R plan in the form of purely cash compensation to project affected people. It addresses only compensatory land allotment and some additional financial assistance as part of compensation for shifting to new location and the transit period losses. The summary of R&R plans based on the provisions under the National Policy on Resettlement and Rehabilitation of Project Affected Persons (PAPs), without affecting their social and economic life have been described below:

- Each PAF owning agricultural land in the affected zone and whose entire land has been acquired may be allotted agricultural land or cultivable wasteland to the extent of actual land loss subject to a maximum of one hectare of irrigated land or two hectares of un-irrigated land/cultivable wasteland subject to availability of Government land in the districts.
- Each PAF owning agricultural land in the affected zone and whose entire land has been acquired shall get one-time financial assistance equivalent to 750 days minimum agricultural wages for “loss of livelihood” where neither agricultural land nor regular employment to one member of the PAF has been provided.
- Each PAF owning agricultural land in the affected zone and whose entire land has not been acquired and consequently he becomes a marginal farmer shall get one time financial assistance equivalent to 500 days minimum agricultural wages.
- Stamp duty and other fees payable for registration shall be borne by the requiring body.
- The Land allotted shall be free from all encumbrances. The Land allotted may be in the joint names of wife and husband of PAF.
- In case of allotment of wasteland/degraded land in lieu of acquired land, each PAF shall get financial assistance of Rs. 10000/- per hectare for land development. In case of allotment of agricultural land, a one-time financial assistance of Rs. 5000/- per PAF for agricultural production shall be given.
- The state government should provide irrigation facilities to the irrigable land at the relocation sites

- According to the government resolutions on R&R policy, each landed oustee shall be entitled to be allotted irrigable land in the state which they choose to resettle, of equal size to that type which they own prior to their resettlement provided, however that in those cases where the oustees owned less than 2 hectares of land, such oustee shall be entitled to at least 2 hectares of irrigable land acceptable to them
- Each PAF belonging to the category of ‘agricultural labourer’, or ‘non-agricultural labourer’ shall be provided a one time financial assistance equivalent to 625 days of the minimum agricultural wages.
- The Project Affected Families shall be provided necessary training facilities for development of entrepreneurship to take up self-employment projects at the resettlement zone as part of R&R benefits.
- Only those oustee who own land shall be considered eligible for the allotment of agriculture land of their own choice
- For the loss of trees, crops, perennials and Sharecroppers compensation should be given at the market value

R&R benefits for project affected families of scheduled tribes

- Each Project Affected Family of ST category shall be given preference in allotment of land.
- Each tribal PAF shall be entitled to get R&R benefits mentioned in above Paras under the Policy.
- Each Tribal PAF shall get additional financial assistance equivalent to 500 days minimum agriculture wages for loss of customary rights/usages of forest produce.
- The Tribal Land alienated in violation of the laws and regulations in force on the subject would be treated as null and void and the R&R benefits would be available only to the original tribal landowner.
- The Tribals families residing in the Project Affected Areas having fishing rights in the river/pond/dam shall be given fishing rights in the reservoir area.
- Tribal PAFs enjoying reservation benefits in the affected zone shall be entitled to get the reservation benefits at the resettlement zone.

Estimation of Cost of Land

- Aspects to be considered while preparing R & R Plan

- Total land to be acquired
- Nature of the land and cropping pattern
- Market value of the land
- Net annual productions of the land
- Net profit from the land

The resettlement plan must include land allocation or culturally acceptable alternative income- earning strategies to protect the livelihood of the landless, semi-landless and households headed by females.

7.2 Recommendations

The recommendations for smooth implementation of the Resettlement and Rehabilitation Plan are delineated below :

- ♦ Compensation should be provided earlier enough before commencement of project construction to the PAP, for the loss of their agricultural land
- ♦ Project authorities should ensure frequent meetings with the implementation and monitoring committee and also with the local project affected people and teams for the smooth implementation of all relief measures
- ♦ Project authorities should seek advice and help of local administration sarpanch, Block development officer and other local leaders] in the area. Their participation and involvement in the proposed development schemes shall be helpful in confidence building. This would also help in conflict resolution if any such, situation arises.
- ♦ The quality of the land must be considered as it may not hinder the economic status of the project affected people and affects their quality of life
- ♦ If the desirable quality of land required is not available, then the net annual income of the project affected people and the net profit from the land income must be considered and that amount of money is to be provided to the project affected people
- ♦ At the time of land acquisition, compensation must also be given for the standing crops, perennials to the PAP
- ♦ Essential cash compensation must be given for the existing infrastructures on the agricultural land like well, small huts etc. for the reconstruction of the infrastructure

Access to Training, Employment and Credit

a) Employment

The Project Authorities should provide preference in employment for project-affected families in the category of unskilled and skilled workmen as per the need of the project. Every affected family must be helped in starting some gainful occupation/getting training to facilitate secondary employment in the region. The project authorities must construct shopping complexes in which a limited number of small shops/stalls will be earmarked. Eligible persons must be allotted employment after considering their skills and capabilities and wages should be provided to them as fixed by the corporation. Some members of the project-affected families may qualify to go for vocational training courses, like ITI etc.

b) Training

Majority of household have small landholdings and their occupation is agriculture. Special training must be imparted to the affected people for supporting their economic activities in various forms. The oustee must be given training on dairy farming, carpet weaving, carpentry etc. Promotional activities for improvement of agricultural and horticulture yields in the area will be encouraged by providing training to the project affected people.

c) Financial Assistance

For starting an income generation scheme/self employment the Project Authority should provide financial grant in the case of shops allotted to the land PAFs. Certain financial assistance must be given to the eligible project affected families for generating self employment.

The Project authorities must consider awarding petty contracts to the Co-operatives of eligible families on preferential basis so that some of them may be engaged in such jobs also.

7.3 R&R Programme Monitoring and Reporting Procedure

R&R committee meetings should be held in every three months in order to ensure incorporation of preference of the PAFs and resolve logistic problems in implementation of R&R Plans. The project co-ordinator with team members must meet every PAF to ensure the implementation of project from time to time. Six-month progress reports must be submitted to project proponent. Planning Department, for evaluation and disbursement of finance. The Potential Evaluation Indicators for monitoring would be:

- Task completion as per schedule
- Identification of conflict among stakeholders, and its resolution
- Awareness of PAFs and their involvement in overall development and improvement in their quality of life

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Annexure - I

National Ambient Air Quality Standards (NAAQS) (1994, 1998)

Pollutant	Time weighted average	Concentration in ambient air: Industrial area	Residential, Rural & other areas	Sensitive area	Method of measurement
1	2	3	4	5	6
Sulphur dioxide (SO_2)	Annual average* 24 hours**	80 $\mu g/m^3$ 120 $\mu g/m^3$	60 $\mu g/m^3$ 80 $\mu g/m^3$	15 $\mu g/m^3$ 30 $\mu g/m^3$	- Improved West & Geake method - Ultraviolet fluorescence
Oxides of Nitrogen (as NO_2)	Annual average* 24 hours**	80 $\mu g/m^3$ 120 $\mu g/m^3$	60 $\mu g/m^3$ 80 $\mu g/m^3$	15 $\mu g/m^3$ 30 $\mu g/m^3$	- Jacob & Hochheiser (Na-Arsenite) method - Gas phase chemiluminescence
Suspended Particulate Matter (SPM)	Annual average* 24 hours**	360 $\mu g/m^3$ 500 $\mu g/m^3$	140 $\mu g/m^3$ 200 $\mu g/m^3$	70 $\mu g/m^3$ 100 $\mu g/m^3$	- High volume sampling (average flow rate not less than 1.1 m^3/min)
Respirable Particulate Matter (size less than 10 μm) (RPM)	Annual average* 24 hours**	120 $\mu g/m^3$ 150 $\mu g/m^3$	60 $\mu g/m^3$ 100 $\mu g/m^3$	50 $\mu g/m^3$ 75 $\mu g/m^3$	- Respirable particulate matter sampler
Lead (Pb)	Annual average* 24 hours**	1.0 $\mu g/m^3$ 1.5 $\mu g/m^3$	0.75 $\mu g/m^3$ 1.00 $\mu g/m^3$	0.50 $\mu g/m^3$ 0.75 $\mu g/m^3$	- AAS method after sampling using EPM 2000 or equivalent filter paper
Carbon Monoxide (CO)	8 hours** 1 hour	5.0 mg/m^3 10.0 mg/m^3	2.0 mg/m^3 4.0 mg/m^3	1.00 mg/m^3 2.00 mg/m^3	- Non-dispersive infrared spectroscopy
Ammonia (NH_3)	Annual average* 24 hours**	-- --	100 $\mu g/m^3$ 400 $\mu g/m^3$	-- --	- --

* Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time it may exceed but not on two consecutive days

NOTE

1. National Ambient Air Quality Standard : The levels of air quality necessary with an adequate margin of safety, to protect the public health, vegetation and property.
2. Whenever and wherever two consecutive values exceeds the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigations.
3. The State Government/State Board shall notify the sensitive and other areas in the respective states within a period of six months from the date of Notification of National Ambient Air Quality Standards.

Annexure - II

Damage Risk Criteria for Hearing Loss
Occupational Safety & Health Administration (OSHA)

Maximum Allowable Duration Per Day, h	Noise Level dBA (Slow Response)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Annexure – III

Ambient Air Quality Standards in Respect of Noise

Area Code	Category of Area/Zone	Limits in dB(A) Leq*	
		Day Time	Night Time
(A)	Industrial Area	75	70
(B)	Commercial Area	65	55
(C)	Residential Area	55	45
(D)	Silence Zone	50	40

Notes :

1. Day time shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 a.m.
3. Silence zone is defined as an area comprising not less than 100 meters around Hospitals, Educational Institutions and courts. The silence zones are zones which are declared as such by the competent authority.
4. Mixed categories of areas may be declared as one of the four abovementioned categories by the Component Authority.

* dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is related to human hearing

"A", in dB(A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of human ear

Leq : It is an energy mean of the noise level over a specified period

Annexure - IV

Classification of Inland Surface Water
(CPCB Standards)

	Characteristics	A@	B@	C@	D@	E@
1.	Dissolved oxygen, mg/l,Min	6	5	4	4	-
2.	Biochemical oxygen demand, mg/l. Max	2	3	3	-	-
3.	Total Coliform organisms,* MPN/100 ml, max	50	500	5000	-	-
4.	Total Dissolved Solids,mg/l, Max.	500	-	1500	-	2100
5.	Chlorides(as Cl), mg/l, Max.	250	-	600	-	600
6.	Colour, Hazen units, Max.	10	300	300	-	-
7.	Sodium absorption ratio, Max.	-	-	-	-	26
8.	Boron (as B) \, mg/l, Max.	-	-	-	-	2
9.	Sulphates (as SO_4),mg/l, Max	400	-	400	-	1000
10.	Nitrates (as NO_3),mg/l, Max.	20	-	50	-	-
11.	Free Ammonia (as N), mg/l, Max.	-	-	-	1.2	-
12.	Conductivity at 25^{o}C, micromhos/cm, Max.	-	-	-	1.0	2.25
13.	pH value	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.0-8.0
14.	Arsenic (as As),mg/l, Max.	0.05	0.2	0.2	-	-
15.	Iron (as Fe) mg/l, Max.	0.3	-	50.0	-	-
16.	Fluorides (as F), Mg/l, Max.	1.5	1.5	1.5	-	-
17.	Lead (as Pb),mg/l, Max.	0.1	-	0.1	-	-
18.	Copper (as Cu), mg/l, Max.	1.5	-	1.5	-	-
19.	Zinc (as Zn), mg/l, Max.	15.0	-	15.0	-	-

✸ If the coliform count is found to be more than the prescribed tolerance limits, the criteria for coliforms shall be satisfied if not more than 20 percent of samples show more than the tolerance limits specified, and not more than 5 percent of samples show values more than 4 times the tolerance limits. Further, the fecal coliform should not be more than 20 percent of the coliform. Source: Indian Standard (IS:229 - 1982).

@ A - Drinking water source without conventional treatment but after disinfection
B - Outdoor bathing (organised)
C - Drinking water source with conventional treatment followed by disinfection
D - Propagation of Wildlife, Fisheries
E - Irrigation, Industrial cooling, Controlled waste disposal

Annexure - V

General Standards for Discharge of Environmental Pollutants - Effluents (Gazette Notification of MoEF, May 1993)

S. No.	Parameter	Standards			
		Inland surface water	Public sewers	Land for irrigation	Marine coastal areas
		(a)	(b)	(c)	(d)
1.	Colour and odour	---	----	---	---
2.	Suspended solids mg/l, Max.	100	600	200	a) For process waste water-100 b) For cooling water effluent 10 percent above total suspended matter of influent
3.	Particular size of suspended solids	Shall pass 850 micron IS Sieve	---		a) Floatable solids, max. 3 mm b) Settleable solids, max 850 microns
4.	***	*	---	***	---
5.	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
6.	Temperature	Shall not exceed 5^{o}C above the receiving water temperature	---	---	Shall not exceed 5^{o}C above the receiving water temperature
7.	Oil and grease mg/l Max.	10	20	10	20
8.	Total residual chlorine mg/l Max.	1.0	---	---	1.0
9.	Ammonical nitrogen (as N), mg/l Max.	50	50	---	50

1. Schedule : VI inserted by Rule 2(d) of the Environment (Protection), Second Amendment Rules, 1993 notified vide G.S.R. 422(E) dated 19.05.1993, published in the Gazette No. 174 dated 19.05.1993.

S. No.	Parameter	Standards			
		Inland surface water (a)	Public sewers (b)	Land for irrigation (c)	Marine coastal areas (d)
10.	Total Kjeldahl nitrogen (as NH_3) mg/l, Max	100	-	-	100
11.	Free ammonia (as NH_3) mg/l, Max	5.0	-	-	5.0
12.	Biochemical Oxygen demand (5 days at 20^oC) mg/l Max.	30	350	100	100
13.	Chemical Oxygen demand, mg/l Max.	250	-	-	250
14.	Arsenic (as As), mg/l Max.	0.2	0.2	0.2	0.2
15.	Mercury (As Hg.) mg/l Max.	0.01	0.01	-	0.01
16.	Lead (as Pb) mg/l, Max.	0.1	1.0	-	2.0
17.	Cadmium (as Cd) mg/l, Max.	2.0	1.0	-	2.0
18.	Hexavalent chromium (as Cr^+6), mg/l, Max.	0.1	2.0	-	2.0
19.	Total chromium (as Cr) mg/l, Max.	2.0	2.0	-	2.0
20.	Copper (as Cu) mg/l, Max.	3.0	3.0	-	3.0
21.	Zinc (as Zn.) mg/l Max.	5.0	15	-	15
22.	Selenium (as Se.) mg/l, Max.	0.05	0.05	-	0.05

S. No.	Parameter	Standards			
		Inland surface water	Public sewers	Land for irrigation	Marine coastal areas
		(a)	(b)	(c)	(d)
23.	Nickel (as Ni) mg/l, Max.	3.0	3.0	-	5.0
[2]24.	***	*	*	*	*
[2]25.	***	*	*	*	*
[2]26.	***	*	*	*	*
27.	Cyanide (as CN) mg/l Max.	0.2	2.0	0.2	0.2
[2]28.	***	*	*	*	*
29.	Fluoride (as F) mg/l Max.	2.0	15	-	15
30.	Dissolved phosphates (as P), mg/l Max.	5.0	-	-	-
[2]31.	***	*	*	*	*
32.	Sulphide (as S) mg/l Max.	2.0	-	-	5.0
33.	Phenolic compounds (as C_6H_5OH) mg/l Max.	1.0	5.0	-	5.0
34.	Radioactive materials				
	(a) Alpha emitter micro curie/ml	10^{-7}	10^{-7}	10^{-8}	10^{-7}
	(b) Beta emitter micro curie/ml	10^{-6}	10^{-6}	10^{-7}	10^{-6}
35.	Bio-assay test	90%survival of fish after 96 hours in 100% effluent	90%survival of fish after 96 hours in 100% effluent	90%survival of fish after 96 hours in 100% effluent	90%survival of fish after 96 hours in 100% effluent

S. No.	Parameter	Standards			
		Inland surface water	Public sewers	Land for irrigation	Marine coastal areas
		(a)	(b)	(c)	(d)
36.	Manganese (as Mn.) mg/l	2	2	-	2
37.	Iron (as Fe) mg/l	3	3	-	3
38.	Vanadium (as V)	0.2	0.2	-	0.2
39.	Nitrate Nitrogen mg/l	10	-	-	20
[2]40.	***	*	*	*	*

2. Omitted by Rule 2(d)(i) of the Environment (Protection) Third Amendment Rules, 1993 vide Notification No. G.S.R. 801 (E) dated 31.12.1993

Annexure VI

Procedure for Environmental Clearance of the project

The Ministry of Environment and Forests (MoEF), Government of India, is the governing body that issues the Environmental Clearance (EC) for a project. The procedures for obtaining the EC for a project is specified in Figure 1.

The EC process will compromise of a maximum of four stages, of which screening may not apply for cases such as i.e. refinery, petrochemical complex, SEZ, etc. These four stages in sequential order are given below:

1. Screening
2. Scoping
3. Public Consultation
4. Appraisal

Scoping

The applicant has to submit an application seeking prior EC made in the prescribed format, pre feasibility report and a comprehensive Terms of Reference (TOR) of the proposed project addressing all the environmental concerns for the preparation of the Environment Impact Assessment (EIA) & Risk Assessment (RA) to the Expert Appraisal Committee (EAC) under the MoEF. The EAC shall determine and convey to the applicant the TOR within 60 days of the receipt of the documents. This TOR will be on the basis of information furnished by the applicant including the TOR proposed by the applicant, site visit by EAC (if required) and the other information available. These TOR shall be deemed as the final TOR for EIA, which will be displayed on the MoEF website.

The applicant/ third party shall prepare the Draft EIA and RA study report in line with the final TOR for the proposed project.

Public Consultation

Once the draft EIA and RA is ready, the applicant shall make a request for Public Hearing (PH) to State Pollution Control Board (SPCB). The SPCB shall advertise the same in one national daily and one regional vernacular daily intimating the date, time, venue, the offices where the public could access the Draft EIA Report and the Summary of the EIA report before the PH. The SPCB shall arrange to video film the entire proceedings. Once the public hearing is completed, a Final EIA is prepared by incorporating the public hearing comments before submission for Appraisal.

On completion of the PH, the SPCB representatives will prepare the minutes of the meeting and compile the documentation pertaining to the PH which will include the press notice, queries, responses, attendance sheets and comments/suggestions made at the PH, which will be submitted to the MoEF.

No Objection Certificate (NOC) / Consent for Establishment (CFE)

As per the requirements of the Air Act and Water Act, the project proponent will file an application with the respective State Pollution Control Board for the Consent for Establishment. The project will be appraised by the technical committee of the SPCB wherein the project proponent has to respond to all the queries based on the documentation submitted and furnish any additional information, as required. On satisfactory completion of the technical committee review, the SPCB issues the No Objection Certificate (Consent for Establishment) of the project.

Appraisal by EAC

The draft EIA will be finalized incorporating the comments of the Public Consultation process. The final EIA will be submitted to the MoEF along with the outcome of the public consultations. The MoEF will then scrutinize the documents (EIA Report, video tape of the PH, final layout plan, Project feasibility report) with reference to the TOR and the inadequacies noted shall be communicated to the EAC enclosing a copy of the EIA documents, the PH proceedings, public responses along with Form – I and scheduled dated of the EAC meeting for considering the proposal. The appraisal of an application (EIA report and other documents) shall be completed by the EAC and the recommendation on grant of EC shall be conveyed to the MoEF. The MoEF shall consider the decision of recommendations of the EAC and convey its decision on EC to the applicant.

Post Environmental Clearance Monitoring

The Project management shall submit half yearly compliance reports in respect to the stipulated EC terms and conditions in hard and soft copies to the regulatory authorities.

Transferability of the EC

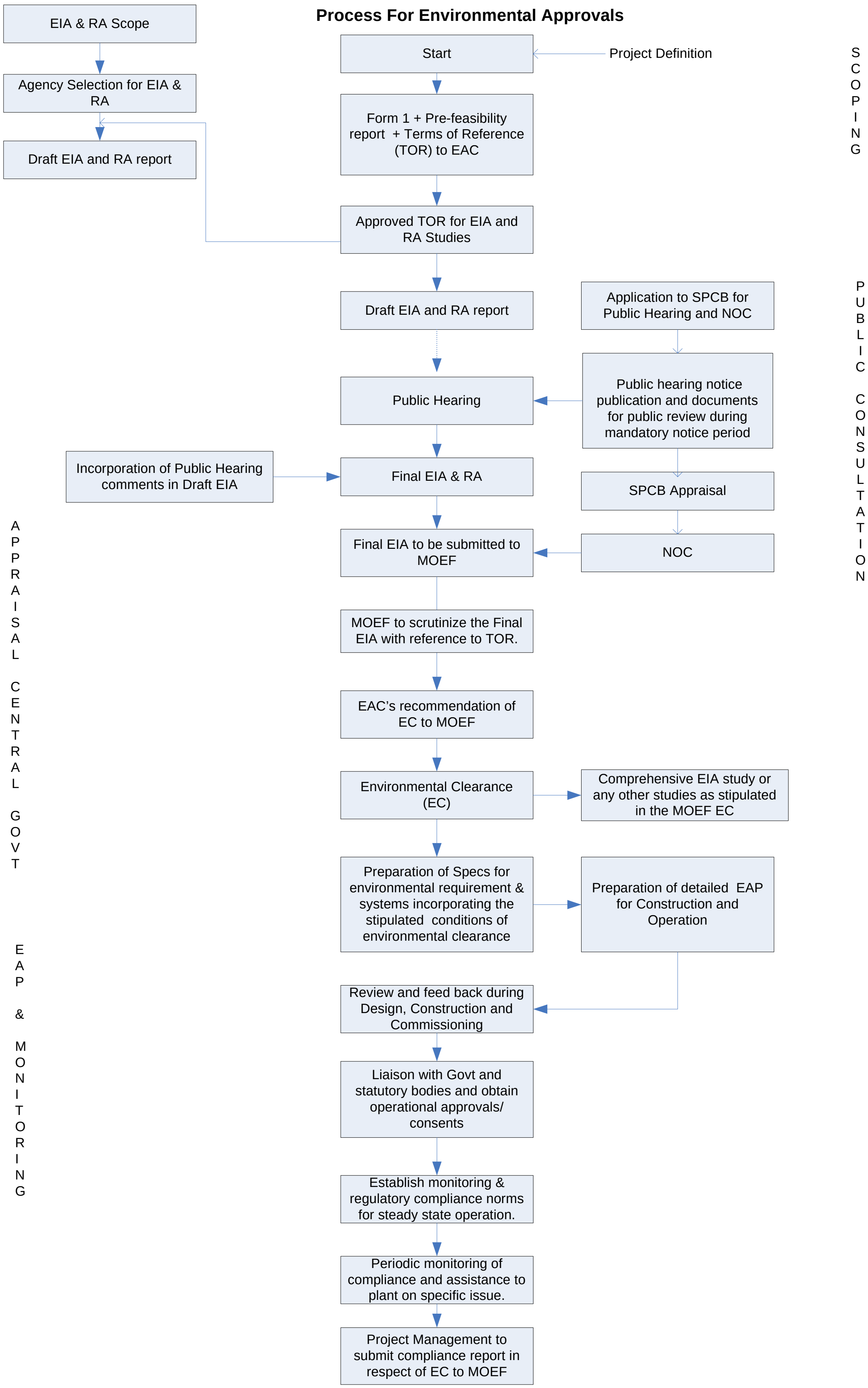
A prior EC granted for a specific project to an applicant may be transferred during its validity to another legal person entitled to undertake the project on application by the transferor or by the transferee with a written ‘no objection’ by the transferor, to, and by the regulatory authority concerned, on the same terms and conditions under which the prior EC was initially granted.

Consent to Operate, Environmental Action Plan and Monitoring

Prior to the commissioning of the project, the project proponent shall apply to the SPCB for Consent to Operate in the prescribed format. All the operational details based on the final design of the project are mentioned on this application and after ensuring compliance to all the conditions specified by the SPCB in the CFE and the conditions specified in the EC. The SPCB will issue consent to operate.

The compliance to various conditions that are specified in the statutory approvals is monitored by the SPCB and MOEF. The post project environmental plan as specified in EIA is to be practiced and periodic reports are to be sent to the MOEF and SPCB of monitoring division. Further an annual environmental audit report is to be submitted to the relevant statutory authorities.

Process For Environmental Approvals



Pollution Prevention and Abatement Handbook
WORLD BANK GROUP
Effective July 1998

Petrochemicals Manufacturing

Industry Description and Practices

Natural gas and crude distillates such as naphtha from petroleum refining are used as feedstocks to manufacture a wide variety of petrochemicals that are in turn used in the manufacture of consumer goods. The description of petrochemical processes and products presented here is for illustrative purposes only. The basic petrochemicals manufactured by cracking, reforming, and other processes include olefins (such as ethylene, propylene, butylenes, and butadiene) and aromatics (such as benzene, toluene, and xylenes). The capacity of naphtha crackers is generally of the order of 250,000–750,000 metric tons per year (tpy) of ethylene production. Some petrochemical plants also have alcohol and oxo-compound manufacturing units on site. The base petrochemicals or products derived from them, along with other raw materials, are converted to a wide range of products. Among them are:

- Resins and plastics such as low-density polyethylene (LDPE), high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), polypropylene, polystyrene, and polyvinyl chloride (PVC)
- Synthetic fibers such as polyester and acrylic
- Engineering polymers such as acrylonitrile butadiene styrene (ABS)
- Rubbers, including styrene butadiene rubber (SBR) and polybutadiene rubber (PBR)
- Solvents
- Industrial chemicals, including those used for the manufacture of detergents such as linear alkyl benzene (LAB) and of coatings, dyestuffs, agrochemicals, pharmaceuticals, and explosives.

A number of alternative methods for manufacturing the desired products are available. Details on typical processes and products are provided in the Annex.

Waste Characteristics

Fugitive air emissions from pumps, valves, flanges, storage tanks, loading and unloading operations, and wastewater treatment are of greatest concern. Some of the compounds released to air are carcinogenic or toxic. Ethylene and propylene emissions are of concern because their release can lead to the formation of extremely toxic oxides. Compounds considered carcinogenic that may be present in air emissions include benzene, butadiene, 1,2-dichloroethane, and vinyl chloride. A typical naphtha cracker at a petrochemical complex may release annually about 2,500 metric tons of alkenes, such as propylenes and ethylene, in producing 500,000 metric tons of ethylene. Boilers, process heaters, flares, and other process equipment (which in some cases may include catalyst regenerators) are responsible for the emission of particulates, carbon monoxide, nitrogen oxides (200 tpy), based on 500,000 tpy of ethylene capacity, and sulfur oxides (600 tpy).

The release of volatile organic compounds (VOCs) into the air depends on the products handled at the plant. VOCs released may include acetaldehyde, acetone, benzene, toluene, trichloroethylene, trichlorotoluene, and xylene. VOC emissions are mostly fugitive and depend on the production processes, materials-handling and effluent-treatment procedures, equipment maintenance, and climatic conditions. VOC emissions from a naphtha cracker range from 0.6 to 10 kilograms per metric ton (kg/t) of ethylene produced. Of these emissions, 75% consists of alkanes, 20% of unsaturated hydrocarbons, about half of which is ethylene, and 5% of aromatics. For a vinyl chloride plant, VOC emissions are 0.02–2.5 kg/t of product; 45% is ethylene dichloride, 20% vinyl chloride, and 15% chlorinated organics; for an SBR plant, VOC emissions are 3–10 kg/t of product; for an ethyl benzene plant, 0.1-2 kg/t of product; for an ABS plant, 1.4–27 kg/t of product; for a styrene plant, 0.25–18 kg/t of product; and for a polystyrene plant, 0.2–5 kg/t of product. Petrochemical units generate wastewaters from process operations such as vapor condensation, from cooling tower blowdown, and from stormwater runoff. Process wastewaters are generated at a rate of about 15 cubic meters per hour (m^3/hr), based on 500,000 tpy ethylene production, and may contain biochemical oxygen demand (BOD) levels of 100 mg/l, as well as chemical oxygen demand (COD) of 1,500–6,000 mg/l, suspended solids of 100–400 mg/l, and oil and grease of 30–600 mg/l. Phenol levels of up to 200 mg/l and benzene levels of up to 100 mg/l may also be present.

Petrochemical plants generate solid wastes and sludges, some of which may be considered hazardous because of the presence of toxic organics and heavy metals. Spent caustic and other hazardous wastes may be generated in significant quantities; examples are distillation residues associated with units handling acetaldehyde, acetonitrile, benzyl chloride, carbon tetrachloride, cumene, phthallic anhydride, nitrobenzene, methyl ethyl pyridine, toluene diisocyanate, trichloroethane, trichloroethylene, perchloroethylene, aniline, chlorobenzenes, dimethyl hydrazine, ethylene dibromide, toluenediamine, epichlorohydrin, ethyl chloride, ethylene dichloride, and vinyl chloride.

Accidental discharges as a result of abnormal operation, especially from polyethylene and ethylene-oxide-glycol plants in a petrochemical complex, can be a major environmental hazard, releasing large quantities of pollutants and products into the environment. Plant safety and fire prevention and control procedures should be in place.

Pollution Prevention and Control

Petrochemical plants are typically large and complex, and the combination and sequence of processes are usually specific to the characteristics of the products manufactured. Specific pollution prevention or source reduction measures are best determined by technical staff. However, there are a number of broad areas where improvements are often possible, and site-specific emission reduction measures in these areas should be designed into the plant and targeted by plant management. Areas where efforts should be concentrated are discussed below.

Reduction of Air Emissions

- Minimize leakages of volatile organics, including benzene, vinyl chloride, and ethylene oxide, from valves, pump glands (through use of mechanical seals), flanges, and other process equipment by following good design practices and equipment maintenance procedures.
- Use mechanical seals where appropriate.
- Minimize losses from storage tanks, product transfer areas, and other process areas by adopting methods such as vapor recovery systems and double seals (for floating roof tanks).
- Recover catalysts and reduce particulate emissions.
- Reduce nitrogen oxide (NO_x) emissions by using low-NO_x burners. Optimize fuel usage.

In some cases, organics that cannot be recovered are effectively destroyed by routing them to flares and other combustion devices.

Elimination or Reduction of Pollutants

- Use nonchrome-based additives in cooling water.
- Use long-life catalysts and regeneration to extend the cycle.

Recycling and Reuse

- Recycle cooling water and treated wastewater to the extent feasible.
- Recover and reuse spent solvents and other chemicals to the extent feasible.

Improved Operating Procedures

- Segregate process wastewaters from stormwater systems.

- Optimize the frequency of tank and equipment cleaning.
- Prevent solids and oily wastes from entering the drainage system.
- Establish and maintain an emergency preparedness and response plan.

Target Pollution Loads

Implementation of cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following production-related targets can be achieved by measures such as those described in the previous section. The figures relate to the production processes before the addition of pollution control measures.

A good practice target for petrochemical complex is to reduce total organic emissions (including VOCs) from the process units to 0.6% of the throughput. Target maximum levels for air releases, per ton of product, are, for ethylene, 0.06 kg; for ethylene oxide, 0.02 kg; for vinyl chloride, 0.2 kg; and for 1,2-dichloroethane, 0.4 kg. Methods of estimating these figures include ambient and emissions monitoring, emission factors, and inventories of emissions sources. Design assumptions should be recorded to allow for subsequent computation and reduction of losses.

Vapor recovery systems to control losses of VOCs from storage tanks and loading areas should achieve close to 100% recovery.

A wastewater generation rate of 15 cubic meters per 100 tons of ethylene produced is achievable with good design and operation; and new petrochemical complexes should strive to achieve this.

Treatment Technologies

Air Emissions

Control of air emissions normally includes the capturing and recycling or combustion of emissions from vents, product transfer points, storage tanks, and other handling equipment.

Catalytic cracking units should be provided with particulate removal devices. Particulate removal technologies include fabric filters, ceramic filters, wet scrubbers, and electrostatic precipitators. Gaseous releases are minimized by condensation, absorption, adsorption (using activated carbon, silica gel, activated alumina, and zeolites), and, in some cases, biofiltration and bioscrubbing (using peat or heather, bark, composts, and bioflora to treat biodegradable organics), and thermal decomposition.

Liquid Effluents

Petrochemical wastewaters often require a combination of treatment methods to remove oil and other contaminants before discharge. Separation of different streams (such as stormwater) is essential to minimize treatment requirements. Oil is recovered using separation techniques. For heavy metals, a combination of oxidation/reduction, precipitation, and filtration is used. For organics, a combination of air or steam stripping, granular activated carbon, wet oxidation, ion exchange, reverse osmosis, and electrodialysis is used. A typical system may include neutralization, coagulation/flocculation, flotation/sedimentation/filtration, biodegradation (trickling filter, anaerobic, aerated lagoon, rotating biological contactor, and activated sludge), and clarification. A final polishing step using filtration, ozonation, activated carbon, or chemical treatment may also be required. Examples of pollutant loads that can be achieved are: COD, less than 1 kg per 100 tons of ethylene produced; suspended solids, less than 0.4 kg/100 t; and dichloroethane, than 0.001 kg/100 t.

Solid and Hazardous Wastes

Combustion (preceded in some cases by solvent extraction) of toxic organics is considered an effective treatment technology for petrochemical organic wastes. Steam stripping and oxidation are also used for treating organic waste streams. Spent catalysts are generally sent back to the suppliers. In some cases, the solid wastes may require stabilization to reduce the leachability of toxic metals before disposal of in an approved, secure landfill.

Emissions Guidelines

Emissions levels for the design and operation of each project must be established through the environmental assessment (EA) process on the basis of country legislation and the *Pollution Prevention and Abatement Handbook*, as applied to local conditions. The emissions levels selected must be justified in the EA and acceptable to the World Bank Group.

The guidelines given below present emissions levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance. Any deviations from these levels must be described in the World Bank Group project documentation. The emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable. All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

Air Emissions

The emissions levels presented in Table 1 should be achieved.

Liquid Effluents

The effluent levels presented in Table 2 should be achieved.

Table 1. Emissions from Petrochemicals Manufacturing and Target Ambient Levels
(milligrams per normal cubic meter)

Parameter	*Maximum value*
PM	20
Nitrogen oxides	300
Hydrogen chloride	10
Sulfur oxides	500
Benzene	5 mg/m³ for emissions; 0.1 ppb at the plant fence
1,2-dichloroethane	5 mg/m³ for emissions; 1.0 ppb at the plant fence
Vinyl chloride	5 mg/m³ for emissions; 0.4 ppb at the plant fence
Ammonia	15 mg/m³

Note: Maximum ambient levels for ethylene oxide are 0.3 parts per billion (ppb) at the plant fence. Maximum total emissions of the VOCs acetaldehyde, acrylic acid, benzyl chloride, carbon tetrachloride, chlorofluorocarbons, ethyl acrylate, halons, maleic anhydride, 1, 1, 1 trichlorethane, trichloroethylene, and trichlorotoluene are 20 mg/Nm³. Maximum total heavy metals emissions are 1.5 mg/Nm³.

Table 2. Effluents from Petrochemicals Manufacturing
(milligrams per liter, except for pH and temperature)

Parameter	*Maximum value*
pH	6–9
BOD	30
COD	150
TSS	30
Oil and grease	10
Cadmium	0.1
Chromium (hexavalent)	0.1
Copper	0.5
Phenol	0.5
Benzene	0.05
Vinyl chloride	0.05
Sulfide	1
Nitrogen (total)	10
Temperature increase	≤ 3°C[a]

Note: Effluent requirements are for direct discharge to surface waters.
a. The effluent should result in a temperature increase of no more than 3° C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 meters from the point of discharge.

Solid Wastes and Sludges

Wherever possible, generation of sludges should be minimized. Sludges must be treated to reduce toxic organics to nondetectable levels. Wastes containing toxic metals should be stabilized before disposal.

Ambient Noise

Noise abatement measures should achieve either the levels given below or a maximum increase in background levels of 3 decibels (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

	Maximum allowable log equivalent (hourly measurements), in dB(A)	
Receptor	*Day (07:00–22:00)*	*Night (22:00–07:00)*
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Monitoring and Reporting

Frequent sampling may be required during start-up and upset conditions. Once a record of consistent performance has been established, sampling for the parameters listed in this document should be as described below.

Air emissions from stacks should be visually monitored for opacity at least once every eight hours. Annual emissions monitoring of combustion sources should be carried out for sulfur oxides, nitrogen oxides, and the organics listed above, with fuel sulfur content and excess oxygen maintained at acceptable levels during normal operations. Leakages should be visually checked every eight hours and at least once a week using leak detection equipment.

Liquid effluents should be monitored at least once every eight hours for all the parameters cited above except metals, which should be monitored at least monthly.

Each shipment of solid waste going for disposal should be monitored for toxics.

Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. The results should be reported to the responsible authorities and relevant parties, as required.

Key Issues

The key production and control practices that will lead to compliance with emissions guidelines can be summarized as follows:

- Implement an equipment maintenance program that minimizes releases of volatile organics, including ethylene oxide, benzene, vinyl chloride, and 1,2-dichloroethane.
- Install vapor recovery systems to reduce VOC emissions.
- Use low-NO_x burners.
- Optimize fuel usage.
- Regenerate and reuse spent catalysts, solvents, and other solutions to the extent feasible.
- Recycle cooling water and reuse wastewaters.
- Segregate stormwater from process wastewater.
- Use nonchrome-based additives in cooling water.
- Design and practice emergency preparedness and prevention measures.

Annex. Typical Processes and Products in Petrochemical Manufacturing

C_1 compounds (with one carbon atom in their molecule) manufactured at petrochemical plants include methanol, formaldehyde, and halogenated hydrocarbons. Formaldehyde is used in the manufacture of plastic resins, including phenolic, urea, and melamine resins. Halogenated hydrocarbons are used in the manufacture of silicone, solvents, refrigerants, and degreasing agents.

Olefins (organics having at least one double bond for carbon atoms) are typically manufactured from the steam cracking of hydrocarbons such as naphtha. Major olefins manufactured include ethylene (C_2, since it has two carbon atoms), propylene (C_3), butadiene (C_4), and acetylene. The olefins manufactured are used in the manufacture of polyethylene, including low-density polyethylene (LDPE) and high-density polyethylene (HDPE), and for polystyrene, polyvinyl chloride, ethylene glycol (used along with dimethyl terphthalate, DMT, as feedstock to the polyester manufacturing process), ethanolamines (used as solvents), polyvinyl acetate (used in plastics), polyisoprene (used for synthetic rubber manufacture), polypropylene, acetone (used as a solvent and in cosmetics), isopropanol (used as a solvent and in pharmaceuticals manufacturing), acrylonitrile (used in the manufacture of acrylic fibers and nitrile rubber), propylene glycol (used in pharmaceuticals manufacturing), and polyurethane.

Butadiene is used in the manufacture of polybutadiene rubber (PBR) and styrene butadiene rubber (SBR). Other C_4 compounds manufactured include butanol, which is used in the manufacture of solvents such as methyl ethyl ketone.

The major aromatics (organics having at least one ring structure with six carbon atoms) manufactured include benzene, toluene, xylene, and naphthalene. Other aromatics manufactured include phenol, chlorobenzene, styrene, phthalic and maleic anhydride, nitrobenzene, and aniline. Benzene is generally recovered from cracker streams at petrochemical plants and is used for the manufacture of phenol, styrene, aniline, nitrobenzene, sulfonated detergents, pesticides such as hexachlorobenzene, cyclohexane (an important intermediate in synthetic fiber manufacture), and caprolactam, used in the manufacture of nylon. Benzene is also used as a solvent.

The main uses of toluene are as a solvent in paints, rubber, and plastic cements and as a feedstock in the manufacture of organic chemicals, explosives, detergents, and polyurethane foams. Xylenes (which exist as three isomers) are used in the manufacture of DMT, alkyd resins, and plasticizers. Naphthalene is mainly used in the manufacture of dyes, pharmaceuticals, insect repellents, and phthalic anhydride (used in the manufacture of alkyd resins, plasticizers, and polyester).

The largest user of phenol in the form of thermosetting resins is the plastics industry. Phenol is also used as a solvent and in the manufacture of intermediates for pesticides, pharmaceuticals, and dyestuffs. Styrene is used in the manufacture of synthetic rubber and polystyrene resins. Phthalic anhydride is used in the manufacture of DMT, alkyd resins, and plasticizers such as phthalates. Maleic anhydride is used in the manufacture of polyesters and, to some extent, for alkyd resins. Minor uses include the manufacture of malathion and soil conditioners. Nitrobenzene is used in the manufacture of aniline, benzidine, and dyestuffs and as a solvent in polishes. Aniline is used in the manufacture of dyes, including azo dyes, and rubber chemicals such as vulcanization accelerators and antioxidants.

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Petroleum Refining

Industry Description and Practices

The petroleum industry is organized into four broad sectors: exploration and production of crude oil and natural gas; transport; refining; and marketing and distribution. This document addresses only petroleum refining.

Crude oil is fractionated into liquefied petroleum gas, naphtha (used to produce gasoline by blending with octane boosters), kerosene/aviation turbine fuel, diesel oil, and residual fuel oil. Catalytic cracking and reforming, thermal cracking, and other secondary processes are used to achieve the desired product specifications. Certain refineries also produce feedstocks for the manufacture of lubricating oils and bitumens. Some refineries also manufacture coke.

Waste Characteristics

Boilers, process heaters, and other process equipment are responsible for the emission of particulates, carbon monoxide, nitrogen oxides (NO_x), sulfur oxides (SO_x), and carbon dioxide. Catalyst changeovers and cokers release particulates. Volatile organic compounds (VOCs) such as benzene, toluene, and xylene are released from storage, product loading and handling facilities, and oil-water separation systems and as fugitive emissions from flanges, valves, seals, and drains. For each ton of crude processed, emissions from refineries may be approximately as follows:

- Particulate matter: 0.8 kilograms (kg), ranging from less than 0.1 to 3 kg.
- Sulfur oxides: 1.3 kg, ranging 0.2–06 kg; 0.1 kg with the Claus sulfur recovery process.
- Nitrogen oxides: 0.3 kg, ranging 0.06–0.5 kg.
- Benzene, toluene, and xylene (BTX): 2.5 grams (g), ranging 0.75 to 6 g; 1 g with the Claus sulfur recovery process. Of this, about 0.14 g benzene, 0.55 g toluene, and 1.8 g xylene may be released per ton of crude processed.
- VOC emissions depend on the production techniques, emissions control techniques, equipment maintenance, and climate conditions and may be 1 kg per ton of crude processed (ranging from 0.5 to 6 kg/t of crude).

Petroleum refineries use relatively large volumes of water, especially for cooling systems. Surface water runoff and sanitary wastewaters are also generated. The quantity of wastewaters generated and their characteristics depend on the process configuration. As a general guide, approximately 3.5–5 cubic meters (m^3) of wastewater per ton of crude are generated when cooling water is recycled. Refineries generate polluted wastewaters, containing biochemical oxygen demand (BOD) and chemical oxygen demand (COD) levels of approximately 150–250 milligrams per liter (mg/l) and 300–600 mg/l, respectively; phenol levels of 20–200 mg/l; oil levels of 100–300 mg/l in desalter water and up to 5,000 mg/l in tank bottoms; benzene levels of 1–100 mg/l; benzo(a)pyrene levels of less than 1 to 100 mg/l; heavy metals levels of 0.1–100 mg/l for chrome and 0.2–10 mg/l for lead; and other pollutants. Refineries also generate solid wastes and sludges (ranging from 3 to 5 kg per ton of crude processed), 80% of which may be considered hazardous because of the presence of toxic organics and heavy metals.

Accidental discharges of large quantities of pollutants can occur as a result of abnormal operation in a refinery and potentially pose a major local environmental hazard.

Pollution Prevention and Control

Petroleum refineries are complex plants, and the combination and sequence of processes is usually very specific to the characteristics of the raw materials (crude oil) and the products. Specific pollution prevention or source reduction measures can often be determined only by the technical staff. However, there are a number of broad areas where improvements are often possible, and site-specific waste reduction measures in these areas should be designed into the plant and targeted by management of operating plants. Areas where efforts should be concentrated are discussed here.

Reduction of Air Emissions

- Minimize losses from storage tanks and product transfer areas by methods such as vapor recovery systems and double seals.
- Minimize SO_x emissions either through desulfurization of fuels, to the extent feasible, or by directing the use of high-sulfur fuels to units equipped with SO_x emissions controls.
- Recover sulfur from tail gases in high-efficiency sulfur recovery units.
- Recover non-silica-based (i.e., metallic) catalysts and reduce particulate emissions.
- Use low-NO_x burners to reduce nitrogen oxide emissions.
- Avoid and limit fugitive emissions by proper process design and maintenance.
- Keep fuel usage to a minimum.

Elimination or Reduction of Pollutants

- Consider reformate and other octane boosters instead of tetraethyl lead and other organic lead compounds for octane boosting.
- Use non-chrome-based inhibitors in cooling water, where inhibitors are needed.
- Use long-life catalysts and regenerate to extend the catalysts' life cycle.

Recycling and Reuse

- Recycle cooling water and, where cost-effective, treated wastewater.
- Maximize recovery of oil from oily wastewaters and sludges. Minimize losses of oil to the effluent system.
- Recover and reuse phenols, caustics, and solvents from their spent solutions.
- Return oily sludges to coking units or crude distillation units.

Operating Procedures

- Segregate oily wastewaters from stormwater systems.
- Reduce oil losses during tank drainage carried out to remove water before product dispatch.
- Optimize frequency of tank and equipment cleaning to avoid accumulating residue at the bottom of the tanks.
- Prevent solids and oily wastes from entering the drainage system.
- Institute dry sweeping instead of washdown to reduce wastewater volumes.
- Establish and maintain an emergency preparedness and response plan and carry out frequent training.
- Practice corrosion monitoring, prevention, and control in underground piping and tank bottoms.
- Establish leak detection and repair programs.

Target Pollution Loads

Implementation of pollution prevention measures can yield both economic and environmental benefits. However, a balance on energy usage and environmental impacts may have to be struck. The production-related targets described below can be achieved by measures such as those detailed in the previous section. The values relate to the production processes before the addition of pollution control measures.

New refineries should be designed to maximize energy conservation and reduce hydrocarbon losses. A good practice target for simple refineries (i.e., refineries with distillation, catalytic reforming, hydrotreating, and offsite facilities) is that the total quantity of oil consumed as fuel and lost in production operations should not exceed 3.5% of the throughput. For refineries with secondary conversion units (i.e., hydrocrackers or lubricating oil units), the target should be 5–6% (and, in some cases, up to 10%) of the throughput. Fugitive VOC emissions from the process units can be reduced to 0.05% of the throughput, with total VOC emissions of less than 1 kg per ton of crude (or 0.1% of throughput). Methods of estimating these figures include emissions monitoring, mass balance, and inventories of emissions sources. Design assumptions should be recorded to allow for subsequent computation and reduction of losses.

Vapor recovery systems to control losses of VOCs from storage tanks and loading areas should achieve 90–100% recovery.

Plant operators should aim at using fuel with less than 0.5% sulfur (or an emissions level corresponding to 0.5% sulfur in fuel). High-sulfur fuels should be directed to units equipped with SO_x controls. Fuel blending is another option. A sulfur recovery system that achieves at least 97% (but preferably over 99%) sulfur recovery should be used when the hydrogen sulfide concentration in tail gases exceeds 230 mg/Nm^3. The total release of sulfur dioxide should be below 0.5 kg per ton for a hydroskimming refinery and below 1 kg per ton for a conversion refinery.

A wastewater generation rate of 0.4 m^3/t of crude processed is achievable with good design and operation, and new refineries should achieve this target as a minimum.

The generation rate of solid wastes and sludges should be less than 0.5% of the crude processed, with a target of 0.3%.

Treatment Technologies

Air Emissions

Control of air emissions normally includes the capture and recycling or combustion of emissions from vents, product transfer points, storage tanks, and other handling equipment. Boilers, heaters, other combustion devices, cokers, and catalytic units may require particulate matter controls. Use of a carbon monoxide boiler is normally a standard practice in the fluidized catalytic cracking units. Catalytic cracking units should be provided with particular removal devices. Steam injection in flaring stacks can reduce particulate matter emissions.

Liquid Effluents

Refinery wastewaters often require a combination of treatment methods to remove oil and contaminants before discharge. Separation of different streams, such as stormwater, cooling water, process water, sanitary, sewage, etc., is essential for minimizing treatment requirements. A typical system may include sour water stripper, gravity separation of oil and water, dissolved air flotation, biological treatment, and clarification. A final polishing step using filtration, activated carbon, or chemical treatment may also be required. Achievable pollutant loads per ton of crude processed include BOD, 6 g; COD, 50 g; suspended solids, 10 g; and oil and grease, 2 g.

Solid and Hazardous Wastes

Sludge treatment is usually performed using land application (bioremediation) or solvent extraction followed by combustion of the residue or by use for asphalt, where feasible. In some cases, the residue may require stabilization prior to disposal to reduce the leachability of toxic metals.

Oil is recovered from slops using separation techniques such as gravity separators and centrifuges.

Emissions Guidelines

Emissions levels for the design and operation of each project must be established through the environmental assessment (EA) process on the basis of country legislation and the ***Pollution Prevention and Abatement Handbook***, as applied to local conditions. The emissions levels selected must be justified in the EA and acceptable to the World Bank Group.

The guidelines given below present emissions levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance. Any deviations from these levels must be described in the World Bank Group project documentation. The emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable.

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

Air Emissions

The emissions levels presented in Table 1 should be achieved.

Liquid Effluents

The emissions levels presented in Table 2 should be achieved.

Effluent requirements are for direct discharge to surface waters. Discharge to an offsite wastewater treatment plant should meet applicable pretreatment requirements.

Solid Wastes and Sludges

Wherever possible, generation of sludges should be minimized to 0.3 kg per ton of crude processed, with a maximum of 0.5 kg per ton of crude processed. Sludges must be treated and stabilized to reduce concentrations of toxics (such as benzene and lead) in leachate to acceptable levels, for example, below 0.05 milligram per kg.

Ambient Noise

Noise abatement measures should achieve either the levels given below or a maximum increase in background levels of 3 decibels (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

Receptor	Maximum allowable log equivalent (hourly measurements), in dB(A) Day (07:00–22:00)	Night (22:00–07:00)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Table 1. Emissions from the Petroleum Industry
(milligrams per normal cubic meter)

Parameter	*Maximum value*
PM	50
Nitrogen oxides[a]	460
Sulfur oxides	150 for sulfur recovery units; 500 for other units
Nickel and vanadium (combined)	2
Hydrogen sulfide	152

a. Excludes NO_x emissions from catalytic units.

Table 2. Effluents from the Petroleum Industry
(milligrams per liter)

Parameter	*Maximum value*
pH	6–9
BOD	30
COD	150
TSS	30
Oil and grease	10
Chromium	
Hexavalent	0.1
Total	0.5
Lead	0.1
Phenol	0.5
Benzene	0.05
Benzo(a)pyrene	0.05
Sulfide	1
Nitrogen (total)[a]	10
Temperature increase	≤ 3°C[b]

a. The maximum effluent concentration of nitrogen (total) may be up to 40 mg/l in processes that include hydrogenation.
b. The effluent should result in a temperature increase of no more than 3° C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 meters from the point of discharge, provided there are no sensitive ecosystems within this range.

Monitoring and Reporting

Frequent sampling may be required during start-up and upset conditions. Once a record of consistent performance has been established, sampling for the parameters listed in this document should be as described below.

Air emissions from stacks should be monitored once every shift, if not continuously, for opacity (maximum level, 10%). Air emissions of hydrogen sulfide from a sulfur recovery unit should be monitored on a continuous basis. Annual emissions monitoring of combustion sources should be carried out for sulfur oxides (sulfur content of the fuel monitored on a supply-tank basis) and for nitrogen oxides.

Liquid effluents should be monitored daily for all the parameters listed above, except that metals should be monitored at least monthly.

Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. The results should be reported to the responsible authorities and relevant parties, as required.

Key Issues

The key production and control practices that will lead to compliance with emissions guidelines can be summarized as follows:

- Use vapor recovery systems to reduce VOC emissions.
- Install sulfur recovery systems, where feasible.
- Use low-NO_x burners.
- Maintain fuel and losses to 3.5% for simple refineries and below 6% (with 10% as the maximum) for refineries with secondary processing.
- Recover and recycle oily wastes.
- Regenerate and reuse spent catalysts and solvents.
- Recycle cooling water and minimize wastewaters.
- Segregate storm water from process wastewater.
- Use nonchrome-based inhibitors (use only to the extent needed in cooling water).
- Minimize the generation of sludges.
- Install spill prevention and control measures.

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Annexure VIII

Resettlement & Rehabilitation Plan

Instructions of Government of India (Ministry of Industry) 1988

Thus, “land for land” was the only objective of human resettlement. But there was no clearcut guidelines in achieving this objective. Government of India, in the Ministry of Industry, Department of Public Enterprises, Bureau of Public Enterprises in their Office Memorandum No. 15/13/84 B.P.E (C) dt. 3.2.1986 issued a set of instructions on land acquisition and rehabilitation aspects involved in major projects and alleviation of the difficulties faced by the dispossessed persons. Ministry of Water Resources in their letter No. 6/71/84-P.H dt. 27.5.1986 impressed upon all State Governments to follow the instructions contained in the aforesaid Office Memorandum of Ministry of Industry, Department of Public Enterprises, while formulating projects. The salient features of the Office-Memorandum are the following :

(a) There should be a Rehabilitation Cell in each and every project to identify the persons who are dispossessed of their land following acquisition of their land

(b) Rehabilitation assistance should be given to those who are dispossessed of their land and homestead and provided they were themselves cultivating those lands. Absentee landlords will not be entitled for any rehabilitation assistance

(c) Considering the educational attainment of the oustees, arrangements at project cost will be made to impart suitable-vocational training in available training institutes for employment in the project, subject to availability of vacancy. If suitable training disciplines are not available in existing institutes, such training courses which would equip the candidates for employment should be started and funded by the project. But there will be no started and funded by the project. But there will be no commitment by the project authorities that such training arranged for by the project will ultimately provide employment to the oustee in the project itself or anywhere else. The idea behind such training is only to equip the oustee with necessary ability to compete for employment alongwith others

(d) There will be no assurance for any employment opportunities in the project. But the projects will assist the State, Governments in organising and financing the oustees in taking to useful avocations like poultry, animal husbandry, etc. The basis responsibility of initiating such activities will be that of the State Government ; not the project

(e) The Rehabilitation Cell will monitor the progress of rehabilitation activities

(f) The entire cost of rehabilitation will be a part of the project cost

Eligibility

(a) In fully submerged villages, displaced families losing land and/or houses will get land in rehabilitation area provided they do not have three acres or more land in any adjoining area

(b) Landless and homeless families belonging to the fully submerged villages will also get land

Rehabilitation Policy Relating to Other Projects in the State

1. Training in I.T.I
2. Allotment of shops adjacent to plant approaches and inside township
3. Engagement in agro-based industries
4. Unskilled job in the plant

Determination of Market Value of Land

(a) Preparation of Land Acquisition estimate is not an easy task. For this, the market value of the land proposed to be acquired is to be determined. Normally this is determined after taking into account the sale transactions at the date of publication of notification U/S 4(1) of the L.A. Act. In the event of non-availability of such data, the market value of the land prevailing on or close to the date of submission of the proposal may be taken into consideration

(b) If no such sale transaction data are available, sales of such quality of land in the vicinity within a fairly recent date can be taken into account

(c) If no such statistics as contemplated in (b) above are available, the net annual produce of the land can be taken into account for valuation

(d) Value awarded in previous land acquisition proceedings is also relevant evidence on the question of market value

(e) For determination of market value of agricultural land, the annual letting value is also taken into account. The net profit the tenant derives from the land over a certain number of years is taken as the letting value

(f) While determining the market value of the land, value of trees, houses, wells, tanks, crops, etc., that are standing on the land shall be taken into account

Source : Environmental Impact of Large Reservoir Project on Human Settlement : A.K. Dalua 1993

Annexure IX

SAFE MANAGEMENT MEASURES FOR PHOSGENE

Contents

SAFE MANAGEMENT PRACTICES FOR PHOSGENE

1.0 Introduction

1.1 Preface and Legal Notice

The information on Phosgene Safe Practice Guidelines Document is a presented in this document. The information provided in the document is a guideline to be adopted or followed. The information is intended to provide helpful guidance that the Project Proponent has to consider.

1.2 Company Goals

- Continuous improvement in phosgene production process with respect to safety, health and environmental protection.

- Comply with the 'Chemical Weapons Convention' to which India is a signatory.

- Precautionary information, such as is presented here, should be provided to all persons who will use, handle or otherwise be exposed to phosgene.

2.0 Training and Job Safety

2.1 Employee Education and Training

Phosgene boils at 7.56^{o}C (approximately 46^{o}F) at atmospheric pressure so it is normally in a gaseous state. As a gas, phosgene is poisonous. However, it may be in a liquid state under certain pressure and temperature conditions. Liquid phosgene can cause skin and eye burns. Liquid phosgene will usually have a sufficiently high vapor pressure that handling it presents the same toxicity concerns as handling the gas. The toxicity of phosgene depends on the degree of exposure or dose. The hazards associated with the use and handling of phosgene (that is, the likelihood of significant exposure) can be minimized by proper education and training of employees and contractors before their assignment to operating responsibilities in areas handling this material, as well as by observing proper engineering practice.

Safe handling of phosgene depends to a great extent upon the effectiveness of employee education, proper training in safe practices, the use of safety equipment, and the proper application from the employee of the knowledge and skills learned. Knowledgeable supervision and management support is required to assess and improve on this process.

Before undertaking any employee training on the handling or processing of phosgene, the trainer should be thoroughly familiar with the properties and characteristics of the chemical. While reviewing the information provided in this document to be helpful, users to help ensure that all appropriate recommendations and precautions are followed. Consider whether the training materials include up-to-date information and are presented in a format that is easily understood by all employees. Verification that the employee has understood the material, and documentation of the testing procedure, may be needed. Frequently Material Safety Data Sheets (MSDS) are relied upon to provide up-to-date information on phosgene safety and handling. The National Institute of Occupational Safety and Health's (NIOSH) Criteria Document on phosgene also provides information.

Employee and contractor education and training programs should be thorough and accurate training program covering topics and information are important and beneficial include:

- Exposure symptoms and exposure signs with emphasis on possible delayed effects.

- Phosgene handling training that includes line-breaking practices.

- Phosgene neutralization practices.

- Qualification of workers authorized to approach and contain phosgene leaks.

- Instructions and periodic drills or quizzes regarding items such as:

  - potential emergency scenarios
  - physical characteristics of phosgene
  - health hazards associated with exposure and overexposure to phosgene
  - first response measures
  - personal protective equipment (PPE)
  - occupational exposure limits
  - fire and explosion information
  - gas detection equipment, gas alarms and emergency shutdown equipment such as valves and switches
  - spill and disposal procedures
  - emergency procedures
  - review of previous incidents (if any)

- Instructions on reporting to the proper authority all incidents involving either the inhalation of the vapors of phosgene or direct contact with the liquid, as well as all signs of illness, particularly respiratory distress.

- Instructions on reporting all cases of personal protection equipment failure to the proper authority.

In addition to initial training, periodic re-training of phosgene workers should be carried out on a regular basis to reinforce and update important information. The Company shall also provide training and education programs for maintenance and emergency personnel who may frequent a phosgene area. Informing workers in neighboring areas (villages) of emergency procedures, in the event of phosgene releases or spills can help provide for appropriate actions should an event occur.

Company will find it useful and this may be required by law to maintain a record of those personnel who are instructed, retrained and tested.

2.2 Safety Review

The users must consult the applicable regulatory norms and review all the requirements in their entirety (and to learn of potential updates). After becoming thoroughly familiar with the properties and hazardous characteristics of phosgene, operating procedures must be written and reviewed by appropriate personnel. Once the procedures have been finalized, they should be reviewed by appropriate personnel, especially workers who will be handling phosgene. During the hazard evaluation, the hazards of the process, past incidents, engineering controls, failure consequences, mechanical integrity and facility siting must be considered. The review should not only be concerned with the hazards of contact with or exposure to phosgene, but also with hazards that may be involved in handling containers and using the operating equipment. Other hazards associated with the work should be noted. The need for personal protective equipment, its maintenance and its proper use, as well as its limitations should be determined. Procedures for all reasonably foreseeable emergencies should be established, including determining suitable locations for and the operation of safety showers, fire extinguishers, alarms etc. Both routine and non-routine operations must be considered including the startup and shutdown of a process. Emergency planning and response procedures must be considered.

During safety review of the operations, it may become apparent that some danger points can be eliminated. However, process changes should not be made without following the 'Management of Change' procedures. In chemical processing, even a slight deviation might cause disastrous results.

To increase training effectiveness, all significant hazards can be explained together with precautions to be followed in the standard operating procedures. Safety precautions can be an integral part of the operating instructions.

For example, if specific-level personal protective equipment is required while line-breaking, the standard operating procedure which describes the line-breaking can also make it clear that the specific personal protective equipment is required for that operation. Since each aspect of operation has elements of safety, it is helpful if the manuals and operations documents incorporate safety information for all steps.

Periodic audits are required at least every 3 years. This duration however can be increased or decreased based on the requirements. Periodically checking the employees helps make certain that they are following instructions and precautions as directed. Complete standard operating procedures that embody safety information can help prevent injuries and accidents.

3.0 Health Factors, Industrial Hygiene, Medical Management, First Aid and Protective Equipment

3.1 General

Phosgene is a poisonous gas at atmospheric pressure and room temperature. (It may, however, be in a liquid state under certain temperature and pressure conditions.) However, the hazards of phosgene are greatly reduced if workers follow safe working procedures and are provided with proper safeguards.

The harmful effects of low-level exposure to phosgene are primarily due to irritation but this action may not be immediately apparent in a relatively mild exposure. An exposed person may even breathe the gas deeply into the lungs without being aware of the hazard. This may result in minor and brief irritation to the upper respiratory system with more serious effects in the alveolar portion of the lungs. In heavy exposures, irritation may be apparent at once but even so, because the gas causes little spasm of the air passages, immediate symptoms may subside. However, the effects to the areas of the lung where gas exchange is taking place will continue to occur over the next few hours. Pulmonary edema, indicated by excessive amounts of fluid in the lungs, is the result of overexposure.

Phosgene exposure may also produce irritation of the eyes and headache. Nausea, vomiting and abdominal pain may occur. The important site of action is in the finer air passages of the lungs and the pulmonary capillaries.

3.2 Air Monitoring

Early methods for the detection of phosgene utilizes absorption into a solution which changes color (25% 4(4-nitrobenzyl pyridine) and stabilizes the color (0.5% N-Phenylbenzene). The absorbance is then read on a spectrophotometer. Early colorimetric methods give rise to development of diffusion badges.

Badges that change color upon exposure to phosgene are commercially available. Color change is white to pink (red) or white to blue. Extremely high concentrations (percent not ppm levels) may cause the color to change back to white again. Badge readings may vary depending on the manufacturer of the badge, the reader of the badge, and other conditions and factors. Manufacturers may provide additional details for inclusion in employee training.

Dose is estimated by matching the intensity of color on a badge reader or color wheel (graduated color intensities that correspond to dose (ppm-minutes). The potential for individuals color blindness to reds is a factor that can be addressed in the development of a badge program.

Users can develop written programs including a log of exposures or possibly lack of exposures. Documentation of dose can include details of the event leading to the exposure as well as details of any respiratory protection used. Useful information may include the name of the individual who wears the badge, the person entering the information, and the circumstances of the event in case it should be necessary to provide this information later. During training on the use of the badges, it may be important to stress that all exposures be reported immediately. In most cases, exposures warrant an incident investigation and accompanying documentation of that investigation.

Placement of badges can be an important element in a badge program. More useful and reliable results can be achieved if the badge is placed in the breathing zone of the individual. Badges that are affected by ultraviolet (UV) light and water may be adhered under the front brim of the hard-hat. Alternately, clips can attach the badge to the collar to better secure the badge and still provide representative breathing zone concentration. Wearing badges under additional personal protective equipment (PPE) (slicker suits, bunker gear, etc.) and badges worn on the back of the hard-hat can hinder the badges effectiveness.

Users may also consider including the written program on 'Standard Operating Procedures' or 'Job Safety Information' regarding instructions on the proper use of badges and medical reporting procedures. The badge manufacturer's recommendations for use are also relevant. Since a dose of 48 ppm-min is equivalent to 480 minutes times the TLV of 0.1 ppm, values less than 48 ppm-min do not necessarily constitute an overexposure. This information may be helpful when considering the definition of "first aid" and "recordable injury." A dose of 48 ppm-min can be chosen as reporting through the medical facility; or use a lesser value. It must be emphasized again, however, any phosgene exposure should be given due consideration keeping in mind the TLV and the hazard potential of phosgene.

Badges are also used as leak detection devices, especially in open-air environments where tiny leaks may escape detection using handheld monitors, area monitors or ammonia sprays. Badges may be placed and left for long periods of time (subject to the manufacturer's recommendations for maximum sampling time) to identify low concentrations of phosgene. The lower detectable limit of instrumentation that gives immediate concentration readout (usually 0.01 ppm) may be insufficient for very small leaks.

Other types of portable and fixed monitoring systems also are available which use either electrochemical cell detectors or a version of the color chemistry mentioned above. Instrumentation utilizing paper tape chemistries is usually very specific to phosgene. Electrochemical cell detectors may have cross-sensitivity to a number of contaminants typically found in industrial settings (e.g., sulphur compounds and hydrochloric acid (HCl) gas). Filters can help minimize the problem. It is beneficial to discuss this matter with manufacturers of all these devices, especially where false indication of phosgene could cause harm to employees, neighboring industries or the community.

In some circumstances, it may be necessary to employ instrumentation in the event phosgene is released in areas where it could enter a building (e.g. intake through the heating, ventilating and air-conditioning (HVAC) system, conduit path openings, etc.). Detection of trapped phosgene vapors after a release is important because vapors could pose a threat to building occupants in the vicinity or person downwind of a release.

Remote optical sensing systems can monitor for phosgene down a long path, rather than detecting its presence at a single point. Fourier Transform Infrared (FTIR) systems may be quite useful. Rapid improvements in this technology make this technique state-of-the-art, but therefore may lack of field reliability over time.

3.3 Medical Management

Clinical Procedures

- Adequate self- protection should be ensured before rescuers attempt to aid casualties. Rescuers should wear appropriate protective clothing including respiratory and eye protection. Self contained breathing apparatus and impermeable suits are required to protect against high concentrations.

- The priority is to remove the casualty from further exposure and maintain vital functions. Management of acute phosgene inhalation is symptomatic and supportive.

- Phosgene is a volatile gas and contamination from individuals exposed to gas alone is unlikely. However, in cold environment/weather, phosgene gas can condense and contaminate others dermally, unless they are protected. Exposure to liquid agent will result in off-gassing and a secondary hazard.

- Remove contact lenses if present and easily removable. Irritate eyes with lukewarm water or sodium chloride 0.9% solution. Patients with eye injuries should be referred to an ophthalmologist. If eye tissue is frozen seek urgent specialist advice.

- All clothing should be removed unless covering an area of frostbite. Whenever possible the affected individual should remove contaminated clothing for him/herself

- Phosgene does not remain liquid for long, except in cold climates. Skin decontamination is therefore not usually required following exposure to gas alone. If required, this should be carried out using a rinse-wipe-rinse regime with dilute detergent (10 ml washing up liquid to a 10 litre bucket of water).

- Contaminated clothing should be placed in clear, labeled sealed bags to prevent further contamination. It should be stored in a secure area away from staff and patients.

- Establish and maintain a clear airway and administer supplemental oxygen as required.

Sample collection and monitoring

- There is no analysis available to measure blood phosgene concentrations. Concentration in air may be measured.

- Clinical samples will be required according to patients condition. Consider obtaining arterial blood gases and chest X-rays. These may need to be repeated.

Treatment

In the event of and incident causing release of phosgene, additional resuscitation equipment will be available. This should be requested EARLY in the course of the incident. The ‘trigger’ for obtaining it will be released separately.

The severity or duration of the initial phases does not reliably indicate the potential for sever clinical effects.

If exposure is suspected the patient should be observed for 24 hours.

Those exposed should undertake no exercise – remaining on bed rest as exercise may precipitate oedema and collapse.

Inhalation Management

- Treatment is symptomatic and supportive. Give oxygen for dyspnoea and bronchodilators (e.g. inhaled sulbutamol) for bronchospasm.

- Monitor arterial blood gases and pulmonary function and obtain a chest x-ray.

- Mechanical ventilation with positive end-expiratory pressure may be necessary if non-cardiogenic pulmonary oedema develops.

- Monitor for the development of secondary infection and ARDS.

- The role of prophylactic corticosteriods (inhaled or systemic) is unproven. Antibiotics will be required if pneumonia is unproven.

- Follow up lung function testes should be obtained following recovery from the acute illness.

Dermal Management

- Dermal features usually occur only after exposure to concentrated phosgene gas or contact with liquid phosgene.

- If frostbite has occurred; remove clothing carefully; these may need to be soaked off with tepid water; irrigate the area. Surgical referral may be necessary.

- If frostbite has not occurred; remove any remaining contaminated clothing. Irrigate with copious amounts of water.

- Treat burns symptotically.

- Place any contaminated clothes in double, sealed, clear bags, label and store in a secure area away from patients and staff.

Eye Management

- Remove contact lenses if required. Irrigate eyes immediately. Stain with fluorescein and refer to an ophthalmologist if there is any uptake of the stain.

Oral Management

- Not applicable.

Admission criteria

- If exposure is suspected, the patients must be observed for 24 hours due to the possibility of delayed, potentially fatal, pulmonary oedema occurring. Patients should undertake no exercise and should be placed on strict bed as soon as possible.

Protection of health workers

- All medical staff should wear full personal protective equipment when decontaminating patients.

Laboratory procedures

- There is no analysis available to measure phosgene concentrations. Air sampling at the site of exposure may confirm the nature of exposure. Clinical samples, including blood gases should be taken according to the patients clinical condition.

Public health procedures

Surveillance and detection of deliberate release

- A deliberate release should be considered in the event of any cases where there is no clear history of occupational or other exposure to phosgene. The likelihood of a deliberate release increases with the number of cases, which are linked in time and place.

- Expert advice may be required in order to confirm the occurrence of a covert release and epidemiological investigations may be required to defined exposed zone in time and space.

Case definition

- A record should be kept of all patients attending as the result of phosgene release.

Possible case

- Patient reporting possible exposure with or without mild symptoms, probably not admitted for continuing medical care.

Probable case

- Patient reporting exposure, with some symptoms consistent with exposure, likely to have continuing medical care.

Confirmed case

- Patients reporting exposure, with some symptoms consistent with exposure, likely to have require hospital care.

Confirmed case

- Characteristically symptomatic patient, with history of exposure require hospital care.

Public Health Action

Removal from exposure

- Minimization of harm by removal from exposure is probably the most important public health measure. Evacuation from contaminated area is essential and is likely to be undertaken by the emergency services (or by self evacuation).

Decontamination

- Adequate self-protection should be ensured before rescuers attempt to aid causalities. Rescuers should wear appropriate clothing including respiratory and eye protection. Self-contained breathing apparatus and impermeable suits are required to protect against high concentrations.

- Phosgene is a volatile gas and secondary contamination from exposed individuals is unlikely, though liquid phosgene can contaminate others dermally, unless they are adequately protected. Off-gassing from liquid agent may pose a secondary vapor hazard.

- All clothing should be removed. Phosgene evaporates quickly except in cold weather and therefore tends not to remain liquid for long, except in very cold climates. Skin decontamination may not be required. If required, it should be carried out using a rinse-wipe-rinse regime with dilute detergent (10 ml washing up liquid to a 10-litre bucket of water.

- Contaminated clothing should be placed in clear, labeled, sealed bags to prevent further contamination.

Epidemiological investigation

- It is vitally important to try and obtain epidemiological data on this patient group. A draft questionnaire has been provided to hospital trusts (Hospital Chemical Incident Response) and further advice may be issued. Health authorities may wish to collaborate with acute trusts in collating these data.

Environmental hazard summary

- Phosgene is denser than air and may accumulate in low-lying areas.
- It has a vapor pressure (vapor pressure 1418 mm Hg at 25C).
- Phosgene degrades slowly in atmosphere
- In water phosgene in hydrolyzed and is rapidly lost by volatisation.
- If released into damp soil phosgene will hydrolyze and be lost by volatilization. It has a high Kco and is expected to be highly mobile.
- Drinking Water Standards: no data available. Immiscible with water.
- Soil Guidelines: no data available.
- Air Quality: no data available.

3.4 Personal Protective Equipment (PPE)

3.4.1 General

Because the odor of phosgene may not be noticed and is not unpleasant, establishment of engineering controls and work practices helps protect against potential risks. Phosgene fatalities have occurred from overexposure, sometimes with few, if any, initial symptoms.

Handling phosgene in completely closed processing systems helps minimize exposure. In the event of a release of phosgene, the immediate evacuation of the area, and entering the area only with the use of appropriate respiratory protective equipment reduces potential concerns.

It is beneficial to have several sets of protective equipment available at all times stored outside of, but near to, the area where phosgene is used.

Workers can benefit from instructions on how to avoid or minimize breathing phosgene in areas where they may be exposed to the gas. Other items may include: equipping and instructing in the use of positive pressure self-contained breathing equipment when it is known that phosgene may escape; familiarizing workers with the location, operation and limitations on the duration of use of respiratory protective equipment; and reporting immediately any episode in which the gas was breathed or of contact of the skin or eyes with liquid phosgene.

Personal protective equipment serves to compliment but not substitute for safe working conditions, adequate process control, ventilation and proper conduct by employees working with phosgene (engineering controls). However, in some instances, it is the only practical means of protecting the worker in emergency situations and while performing tasks where engineering controls are not feasible.

An appropriate choice in selection and use of personal protective equipment will normally be dictated by the total situation, rather than by the toxic properties of phosgene alone. These situations may also involve other hazardous materials or normally innocuous materials that can magnify potential concerns associated with phosgene. Therefore, the following information on equipment is to be considered as a potential reference point for general guidance. Users need to select appropriate personal protective equipment based on their specific needs and circumstances. Other chemicals or factors may require the use of additional protection. Except in extreme emergencies, no one should be given personal protective equipment without suitable training in its use.

CAUTION : It is important to consider all the chemicals potentially present with phosgene when selecting PPE.

3.4.2 Availability and Use

Location, care and selection of appropriate PPE are dictated by the proposed use of the equipment. Personnel, facilities and programs have to be assigned for suitable care, decontamination and repair of all equipment.

3.4.3 Training

Provide training so that employees using PPE in phosgene service are extensively experienced in the use of the relevant PPE prior to its use in phosgene service. Consult the manufacturer recommendations where provided.

3.4.4 Personal Protective Equipment

Some of the Personal Protective Equipment to be provided will be as follows:

- Protective clothing
- Foot protection
- Hand protection
- Eye protection
- Respiratory protection
- Head protection
- Storage of PPE for phosgene service
- Maintenance of PPE for phosgene service
- Decontamination of contaminated clothing

4.0 Emergency Response

4.1 Emergency Response Plan

4.1.1 General

Elements of an emergency response plan. The requirements dictate that the employer develop an emergency response plan that shall address, as a minimum, the following items to the extent that they are not addressed elsewhere:

a. Pre-emergency planning and coordination with outside parties.
b. Personal roles, lines of authority, training and communication
c. Emergency recognition and prevention
d. Safe distances and places of refuge
e. Site security and control
f. Evacuation routes and procedures
g. Decontamination
h. Emergency medical treatment and first aid
i. Emergency alerting and response procedures.
j. Critique of response and follow-up.
k. PPE and emergency equipment

Additional items for Emergency Response Plans

The following items may also be included or considered as part of emergency response planning. Depending on specific circumstances, alternative or additional items may be required for emergency response plan development

- Key company personnel evaluate the feasibility of including alternate personnel and how to contact those individuals if the need arose (e.g. phone, pager). Automatic pager calls and phone ring-down systems are available and may be helpful especially where large numbers of people must be contacted quickly.

- Key outside personnel may be contacted directly or by automatic ring-down, and messaging systems may be incorporated to speed the process and document that the calls were made.

- Titles of individuals as they function in Emergency Response activities and their associated duties before, during and after the emergency can be explained in the plan.

- A description of the facility, layout and chemical inventory will aid in communicating with outside agencies and mutual aid groups.

- Preplanning the location and staffing of the incident command team, management and staging areas, including a possible location offsite should a catastrophic emergency arise, can facilitate response actions.

- It is beneficial to have training and drills simulate real situations and have personnel trained to act as if the activity was not a mere preparation exercise. Drills should include the actual use of respirators including escape respirators. Smoke bombs to be used to make drills more or realistic and to display air patterns.

- Alarm systems such as directional sirens, strobes or public announcement systems to be included. Evaluate whether alarm systems have sufficient volume to reach all affected personnel.

- Evacuation/Shelter-in-Place: Establishing procedures that include communication equipment inside the safe shelter in the event it becomes necessary for persons to evacuate the safe shelter or for occupants to communicate information back to the On Scene Incident Commander (OSIC)

- Downwind or perimeter monitoring has been used to better draw boundaries for personnel protection. Detection instruments help to determine when concentrations have dropped and the "all clear" can be safely given. Consideration may be given to any structures downwind that are or could be occupied by personnel. Phosgene can be "trapped" in buildings where it dissipates slowly. Keep in mind that IDLH conditions will affect the staffing requirements for the downwind/perimeter monitoring person.

- Personnel and PPE decontamination procedures have to be included in emergency plans. Before wearing PPE, the use of badges or direct reading phosgene analyzers help evaluate whether phosgene is present.

- Given the frequency of personnel turnover at hospital emergency rooms, addressing medical procedures for offsite personnel can be useful.

- The incident and drill critiques generate action items that can be resolved in a timely manner.

- When developing written plans consider past incidents, near misses and credible emergency situations that could arise. A detailed plan for phosgene may be incorporated into the general site emergency plan. Other practices that benefit response plants include: familiarizing all employees in the phosgene process with the plan; reviewing the plan on a periodic basis; and training the plant emergency responders to handle phosgene emergencies.

Emergency Response Plan

a. The owner or operator shall develop and implement an emergency response program for the purpose of protecting public health and the environment. Such programs shall include the following elements:

   1. An emergency response plan which shall be maintained at the stationary source and contain at least the following elements:

      (i) Procedures for informing the public and local emergency response agencies about accidental releases;

      (ii) Documentation of proper first-aid and emergency medical treatment necessary to treat accidental human exposures; and

      (iii) Procedures and measures for emergency response after an accidental release of a regulated substance.

   2. Procedures for the use of emergency response equipment and for its inspection, testing and maintenance;

   3. Training for all employees in relevant procedures; and

   4. Procedures to review and update, as appropriate, the emergency response plans to reflect changes at the stationary source and ensure that employees are informed of changes.

b. A written plan that complies with other contingency plan regulations or is consistent with the approach in the National Response Team's Integrated Contingency Plan Guidance ("One Plan")

4.2 Fire

Phosgene is nonflammable. At temperatures above 250°C (482°F), phosgene decomposes to form mixtures of carbon monoxide (CO), chlorine (Cl_2), carbon dioxide (CO_2) and carbon tetrachloride (CCl_4). In the presence of oxygen, the carbon monoxide may burn to form carbon dioxide.

In case of fire and in the absence of phosgene leaks, the removal of cylinders from the fire zone and immediately shutting off phosgene sources reduces some potential risks. When containers cannot be moved and if no phosgene is escaping , water has been sprayed on containers and piping to keep them cool.

Vessels and piping containing phosgene can be cooled with water spray. In such cases, cooling may be imperative because boiling of the phosgene and subsequent explosion of the vessel could create an extremely hazardous situation.

The selection of sprinkler systems, firewater monitors or portable firewater supplies is based on factors including the quantity of phosgene and the requirements of the insurer and local fire marshal. Structural fireproofing where phosgene is stored, piped and used may affect the requirements.

In case of fire associated with phosgene, it may critical to keep all authorized persons upwind a safe distance from the phosgene area and all other personnel evacuated from the area. Firefighting personnel may need respiratory protection available.

4.3 Gaseous Leaks

As soon as there is any indication of phosgene present in the environment, immediate steps to evaluate include stopping the release of gas/liquid and simultaneously protecting personnel downwind including the community. Indication of phosgene's presence in the environment may come from personnel or area monitoring systems, process control indicators or other sources.

Authorized, trained personnel equipped with suitable protective equipment should conduct the investigation. It is prudent to assume that Immediately Dangerous to Life and Health (IDLH) conditions exist when responding to emergencies.

Procedures for IDLH atmospheres. For all IDLH atmospheres, the employer shall ensure that:

i. One employee or when needed, more than one employee is located outside the IDLH atmosphere.

ii. Visual, voice or, signal line communication is maintained between the employee(s) in the IDLH atmosphere and the employee(s) located outside the IDLH atmosphere.

iii. The employee(s) located outside the IDLH atmosphere are trained and equipped to provide effective emergency rescue.

iv. The employer or designee authorized to do so by the employer, once notified, provides necessary assistance appropriate to the situation.

v. Employee(s) located outside the IDLH atmospheres are equipped with:

   (A) Pressure demand or other positive pressure SCBA's or a pressure demand or other positive pressure supplied-air respirator with auxiliary SCBA and either

   (B) Appropriate retrieval equipment for removing the employee(s) who enter(s) these hazardous atmospheres where retrieval equipment would contribute to the rescue of the employee(s) and would not increase the overall risk resulting from entry or

   (C) Equivalent means for rescue where retrieval equipment is not required.

If the leak or spill is extensive or uncontained, sounding an evacuation alarm and warning all persons in the path of the gas helps prevent further concerns. Pre-arranged meeting points, crosswind or upwind, can be planned and used in practice to help ensure everyone is accounted for. Gaseous phosgene often lies close to the ground because it is heavier than air. Wind socks and instrumentation indicating wind speed and direction can provide important information for communication to those in the immediate area.

Relevant regulatory and community organizations should be notified as appropriate.

The use of Safe Shelters sometimes provides a safer alternative to evacuation. These designated buildings can provide greater safety by constructing them to be relatively air-tight and under positive pressure, assuming the air intake is in a phosgene-free area or can be filtered. These locations may be labeled, and direction given to the occupants about procedures to follow when the Safe Shelter is downwind as well as upwind. Persons entering a Safe Shelter downwind of a release have been known to contaminate the building with phosgene.

Anyone critical to the orderly shutdown of a process system that could be downwind of the release, may require respiratory protection.

In case of fire and if only gaseous phosgene is leaking, water can be sprayed on containers and piping to keep them cool. Water applied to the point of leak may cause enlargement of the leaking opening because of corrosion. Consider removing cylinders from the fire zone if possible and shutting off phosgene sources immediately. Water fog may not be very effective in neutralizing phosgene vapor, but can help reduce concentration in the air. Aqueous ammonia spray may be more effective in neutralizing phosgene vapor, but should be used with caution due to hazards associated with breathing high concentrations of ammonia.

4.4 Liquid Spills

In case of fire and if liquid phosgene is leaking, firefighting foams have to be used to cover the liquid spill until disposal. Water for firefighting should be used with caution so as to avoid adding water to the liquid pool if at all possible. Liquid phosgene reacts slowly with water to form carbon dioxide and hydrochloric acid. The heat of reaction increases the vaporization rate of the liquid phosgene and therefore may increase the potential hazard to personnel. Subject to such issues and depending on overall circumstances, it still may be useful to spray containers with water to keep them cool.

All of the requirements and considerations for handling gaseous phosgene leaks also apply for liquid phosgene spills.

4.5 Mutual Aid.

Industrial plants in vicinity can help one another by establishing plans and an organization for rendering mutual aid in the event of an emergency or disaster such as phosgene spill or fire. As part of these efforts, making mutual aid organizations thoroughly aware of the presence of phosgene in a facility facilitates proper response and training. Staging areas (including alternates) may be designated during the planning stage.

Phosgene emergency procedures that may involve persons outside the plant can be incorporated in Mutual Aid Instructions and Public Department Procedures.

Written provisions may be included in the Mutual Aid-Private Industry Agreement to allow for reimbursement for damages to equipment, manpower, etc.

4.6 Public Departments

In the absence of a structured Mutual Aid Organization or where local emergency responders do not participate, including local emergency groups in any emergency plan may provide useful assistance. This inclusion would become especially critical during a catastrophic event.

5.0 Design of Facilities

5.1 Plant Layout & Siting

The design layout of the phosgene plant is an important factor to be considered for new construction. Aspects relevant to design layout include being located near populated buildings, other operations and off site populations.

"Siting" means conducting a review of the location of equipment and piping with regards to: 1) possible impact on human or environmental receptors, or 2) where other plant operations could have impact on the phosgene equipment. In case one, for example, design layout might consider such items as predominant wind direction and populated areas down wind. In case two, the considerations might include items such as any flammable or potential explosive processes, which – if an event occurred – could have impact on the phosgene equipment.

The following section on Plant Siting and Layout Guidelines provides information relevant to the design and layout of new or revised facilities. It is important to note that the following criteria represent considerations often used by facilities handling hazardous materials. However, given the highly toxic nature of phosgene, during the construction of new phosgene handling facilities, or significant modifications to existing facilities, facilities should also consider what secondary mitigation measures may also be necessary or appropriate to address the potential risk to local populations resulting from significant loss of containment.

Items to consider may include:

A) Plant Siting

- Locating phosgene containing units with consideration of prevailing wind direction as far as possible from the general community outside the site boundaries.

- Protecting on-site buildings occupied by a large number of people through a combination of engineering controls, administrative procedures and/or distance.

- Locating phosgene generating and processing plants close together within a site to minimize the spread of phosgene containing areas.

- Locating phosgene containing units away from other processes which have potential for explosion of fire, or events which may impact or damage equipment containing phosgene.

- Incorporating additional safety and loss prevention precautions if phosgene must be transported across plant boundaries either by pipeline or in pressurized container.

B) Plant Layout

- Providing that all sections of the plant are easily accessible for maintenance and emergency response purposes.

- Locating phosgene generating or processing sections in plant areas with low traffic density whenever possible and minimizing phosgene containing pipelines.

- Having additional engineering controls for prevention and mitigation of leaks from the equipment where plant sections have special process conditions, or where because of the surrounding situation, other controls may be needed. Refer to those parts for additional information. Designs that incorporate "layers of protection" rather than relying on a single method of control are relevant in this capacity.

- Selecting the location of the control buildings in relation to the phosgene containing sections and with considerations of the prevailing wind direction. The selected location, having an elevated fresh air intake in the control building and maintaining the building under positive pressure have been used to minimize infiltration of phosgene in the event of a release.

5.2 Materials of Construction

Carbon steel is often used. Austenitic stainless steel, duplex stainless steel, and high nickel alloys have also been used.

5.2.1 General Design Considerations

In this section, the design of process equipment for pure phosgene is discussed. Unless otherwise specified, the information provided below applies to the design of storage and non-storage vessels.

Phosgene processing equipment has been sited earlier above or below ground depending on local conditions. Influencing factors include:

- Consequence of a major spill on the locality (e.g., the local population and the weather conditions).

- Venting, draining, etc. of the immediate area if a major spill occurs.

- Risk from falling objects and accidental damage from other sources (e.g., traffic).

- Risks from external vessel corrosion, (e.g., environment and ground conditions if sited in a buried storage).

- Accessibility for vessel inspection (external as well as internal).

- Approachability to the vessel from all directions to allow access during emergency conditions.

Above ground vessels may, however, be a desirable choice for future installations unless special environmental conditions dictate otherwise.

Containment of Spills

Development of a containment area around phosgene processing equipment can be used to help prevent an uncontrollable spread should a leak occur. This area might be bounded by retaining walls with facilities for the addition of absorbing chemicals, or be fitted with special drains leading to vessels containing neutralization facilities and fume extraction or any other measure that addresses potential conditions. The area might also be fitted with a storm water drainage system that could be manually controlled to lift water out of the containment area. The purpose of this arrangement is to keep inadvertently released chemicals out of the effluent system.

Trenches and Drains

To help prevent the spread of fire into a phosgene process area, maintain an appropriate distance between the equipment and a service trench. A similar distance should be considered between a drain and the processing equipment unless the drain system is completely isolated from any other drains that could transport flammable liquids.

Vessel Design

Consider required pressure rating, operating temperature, and absolute vacuum conditions within the vessel during design. A corrosion allowance may also be incorporated into the design.

Users can take steps to help ensure that the vessels are protected against over pressurization. High-pressure alarms serve in this capacity. Set the alarm approximately mid-way between normal operating and the burst disc failure pressure to give warning of a potentially dangerous occurrence.

Extra protective devices may be required as a function of the site chosen for the vessel. For example, the vessel may be double walled to reduce the risk of damage from falling objects, corrosion and subsequent leaks.

5.3 Piping Items and Valves

5.3.1 Piping

Particular consideration should be provided with regard to the following activities.

- Thoroughly purging all piping of phosgene prior to any welding. Dry phosgene can support combustion of carbon steel and other metals, and may pose a safety risk to personnel performing the welding.

- Protecting piping (and valves and instruments) from over pressurization when liquid phosgene can be trapped between closed valves.

- Protecting phosgene systems from the intrusion of moisture. Moisture can react with phosgene and cause severe corrosion and failure.

- Taking measures so that the phosgene systems are thoroughly cleaned, dried, and devoid of all oils, greases and other materials that would react with phosgene to cause fire, corrosion, pressure increase or harmful deposits.

- Inspecting all phosgene-piping systems at regular intervals for signs of leakage, internal or external corrosion, and insulation failure. Note that because piping supports can be subject to corrosion and can create opportunity for other system integrity problems, including piping supports within the inspection plan helps reduce risk.

- Where stainless steel materials are employed, inspections and testing may include an assessment of stress corrosion cracking caused by exposure to chlorides. Atmospheric exposure from the outside, as well as process exposure from the inside can cause stress corrosion cracking.

- Considering fugitive emission issues when designing piping systems for phosgene.

- Adequately protecting liquid phosgene piping from liquid hammer damage. Phosgene liquid has a high density that can result in large hydraulic shock forces.

Selection

When making design decisions, the designer should consider such items as variable operating conditions, including start-ups, upsets, shutdowns and system evacuation.

The use of threaded joints in piping systems creates increased potential for leaks, and the fittings are necessarily thinner because of the requirement to taper the joints for threading. As a result, threaded fittings tend to be generally avoided, if possible, but where threaded connections cannot be avoided, the use of a chemically compatible thread sealant helps reduce some risks of leakage. Employ fluoropolymer-based thread sealants in phosgene service.

5.3.2 Valves

Types of Valves

Valves commonly employed in dry phosgene service are the globe, ball, plug and butterfly types. Each valve is available in several basic body patterns, employing different design features often suited to a particular service and/or specific application.

5.3.3 Other Components

Other components such as instrument items, relief devices, decontamination hoses, temporary items, cylinders and expansion chambers are described in their respective sections.

Expansion Joints

It is important to consider whether phosgene piping systems have sufficient flexibility to prevent failure of the piping system due to thermal expansion or contraction. When flexibility cannot be introduced into the system through pipe routing, bellows expansion joints have been employed to absorb the differential expansion while containing the system pressure.

Hoses

It is not often that either metallic or non-metallic hoses are used in permanent piping systems, and their use in permanent piping connections may increase opportunity for leakage. When hoses are required for temporary connections, give due consideration to the design, fabrication, testing and certification of all the components. British Standard BS6501 Flexible Metallic Hose Assemblies is one available source for additional information regarding the hoses.

One approach has been to adopt using a hose that is consistent with Chlorine Institute criteria, for phosgene cylinder connections to rigid piping with a PTFE liner. These hoses are typically used in well ventilated areas due to the potential permeability of the fluoropolymer liner. Non-reconstituted (virgin) PTFE reduces the likelihood of permeability. Contact the Chlorine Institute for further information on its approval specification.

5.3.4 Piping Layout and Design

Good piping layout will enhance safety, reduce maintenance costs and provide an efficient operation.

General Layout Considerations

- It is important to avoid trapping liquid phosgene between valves and to provide expansion chambers or pressure relief.

- Arrange and support piping to permit removal of process equipment and components.

- Installing phosgene lines next to steam lines, acid lines, etc. can increase risk of corrosion. Protect phosgene piping from risks of excessive heat or fire.

- Consider limiting the use of vent and drain connections in a phosgene pipeline to the minimum strictly necessary for removal of dirt, liquid or gas. However, company may wish to provide that all sections that can be blocked in have sufficient connections for clearing the phosgene.

- Consider providing for linear thermal expansion by routing or pipe loops.

- Piping design can incorporate a means to minimize the possibility of liquid hammer. Phosgene liquid has a high density that can result in large hydraulic shock forces.

- It may be desirable to blind all dead-ended valves/openings.

- Layout of both process equipment and piping should consider potential safety benefits resulting from minimizing the length and diameter of piping in phosgene service and reduced phosgene inventory

Clearances

Road and walkway clearances can be set to minimize the potential for impact damages. Barriers or guardrails may be useful. Railroad and roadway clearances may be regulated by state or local laws. If phosgene piping must pass through a wall or bulkhead, the maintenance of proper side clearances is important.

Supports

Use supports to prevent pipe sagging. It may be necessary to avoid hanging other piping from phosgene lines and conversely, to avoid hanging phosgene lines from other piping. Piping has been supported with hangers, pipe shoes or other items that do not allow metal to wear or corrode. If located in an area where seismic activity can be significant, local codes may require special design considerations.

Routing

Route phosgene piping for the shortest distance practical with consideration given to the flexibility, line expansion and good engineering practice. Piping can be designed to avoid pocketing.

Valving

- Locate valves and controls in areas with adequate accessibility.

- Consider locating block valves as close to equipment as possible, also in branch lines at the main header and, where practical, to allow lines to drain away from the valves.

- Minimizing the use of valving can reduce some potential risks.

Tracing

Condensation can occur in gas lines when the temperature drops below the pressure-temperature equilibrium. To help prevent this action, the lines can be traced. Installation of tracing can be such so as to minimize corrosion or decomposition of the piping system.

Electric tracing is a useful tracing method. Care must be taken to monitor the condition of the electric tracing system to ensure localized hotspots do not develop in the event of a wiring or control system failure.

Insulation

A key function of insulation is to provide a sufficient moisture barrier to prevent corrosion under the insulation. Engineered access methods, which do not compromise the system moisture barrier, have been used to accommodate thickness testing or external inspection.

Miscellaneous

- Connectors have been used in lieu of flange joints.
- Confusion can be reduced by readily identifying phosgene lines.
- Consider keeping the use of flange joints to a minimum.
- Elastomers, which have been used in piping components, should be selected based on factors including relevant service and service conditions.

5.3.5 Preparation For Use

Cleaning

Since phosgene can react with foreign materials, clean all portions of phosgene systems before use. Care must be taken in cleaning procedures to remove all residues because phosgene also reacts with water. To this end, any equipment received in an oily condition should be appropriately cleaned and thoroughly dried before use.

5.3.6 Leak Testing

Develop leak-testing procedures tailored to a particular need and circumstance. Additional information on leak testing, such as ASME B31.3, is available.

5.3.7 Drying

It is important to consider whether the phosgene piping systems are adequately dried before being placed in service. Even if water has not been purposely introduced into the system for hydrostatic testing or cleaning, moisture may enter the system from the atmosphere or other sources. Where steam has been used for cleaning, introduce nitrogen or dry air directly after steaming. Heating the purge gas aids considerably in the drying process. The temperature must be limited based on the equipment and insulation type, but for general reference purposes, 200°F (93°C) has been a temperature previously used in some situations.

Vacuum dehydration can also be considered after the majority of phased water has been purged from the system. This may be particularly effective following the steam heating / nitrogen purge step, and can also be used for leak checking the system.

Valves

Valves require special attention. Consideration should be given to valve removal for disassembly and drying if water has entered the piping system. Most valves, regardless of style, have pockets where water can be trapped, especially if the valve is fully open. It can be important that valves left in the piping system are fixed in the half-open position when the system is being dried. To help ensure that water or moisture is not trapped in a cavity,a check can be run on valves removed temporarily from the system during the drying operation. These valves are thoroughly dried prior to replacement in the piping system if they are not dried with the rest of the system. Personal responsible for drying the system should be familiar with valve construction and aware of places where water or moisture can be trapped.

5.3.8 Preventative Inspection & Maintenance

Preventative Maintenance

As part of an over-all preventative maintenance program, consider whether items, such as the following have been checked periodically and corrected as needed.

- flange bolt condition and tightness
- valve packing leaks
- valve bonnet leaks

- valve operation
- threaded joints
- insulation condition
- tubing connections
- paint condition
- condition of supports
- external corrosion

Repainting on a regular basis will help maximize pipe life and minimize leaks by reducing external corrosion. Timing for this activity is determined by individual site conditions.

Periodic Inspections

Inspecting phosgene-piping systems on a regular basis reduces potential risks. Methods include those such as visual inspections, ultrasonic thickness checks and non-destructive radiography checks. In many situations, the visual inspection is by far the most important inspection that can be done with other methods used to supplement. Documenting the results of all inspections helps provide for a thorough and consistent maintenance program.

Visual

Part of a visual inspection may encompass a leak check of all flanges, valves and other fittings and attachments. Particular areas of concern may include items such as pipe supports and areas with paint or insulation damage. Where insulation is damaged, further inspection is often warranted. Special note may be taken of weld areas as these areas corrode more quickly. Any significant observed pitting or wall loss merits further investigation and correction as necessary.

Non-Destructive Testing

Non-destructive testing methods measure pipe walls thickness, pit depths, and internal and external erosion/corrosion. These methods include ultrasonic thickness measurements and radiographic measurements.

Routine testing will indicate corrosion rates typical for the system so that the timing of major reports can be estimated. Consideration should be given to checking areas of high fluid velocity more frequently due to possible internal erosion.

Radiographic techniques are available to check pipe wall thickness through insulation. This approach permits checking piping systems without breaking the vapor barrier of the insulation. If test methods are used which require the removal of insulation, care must be taken to address whether the insulation vapor barrier integrity has been properly restored.

5.4 Pumps

5.4.1 General Guidelines

All pumping equipment should be designed to provide reliable operation and a high certainty of containment. The information set out in the following identified sections also provides general guidelines relevant to the specification and design of the pumping system: 5.2 Materials of Construction; 5.3 Piping Items and Valves; and 5.5 Instruments. Additional information is included in Section 5.4.5.

Several common options available to pump phosgene are addressed here. As with other sections of the Manual, users have an independent obligation to conduct their own analysis for their specific circumstances as alternative or additional considerations may be required.

5.4.2 Mechanically Sealed Pumps

Where mechanical seals are employed for containment, a double seal with some type of pressurized barrier fluid should be considered. The use of protective systems helps ensure that the seal and pump function correctly. Local and remote indications are more useful than no monitoring or local monitoring only.

Evaluate whether all gasket and O-ring materials are compatible with the process fluids. Concerns have been raised over graphite being more permeable than other gasket materials. The resulting leakage over time combined with atmospheric moisture has caused corrosion to take place on bolts where it is difficult to monitor.

Screwed connections are more prone to leaks. They also appear weaker in resisting pipe strain and external forces because of concentrated stresses in their thread roots. Threaded connections in phosgene service may be undesirable.

Casing drains can reduce or eliminate trapped phosgene in equipment that must be serviced. Installing a sufficient quantity at the proper location can allow almost complete draining of the pump prior to decontamination and maintenance.

Many manufacturers offer hydro testing as a method of testing their casings, and pumps to be used in phosgene service can use this service. Vessels have been tested to 1.5 times their working pressure and this reference may offer a useful pressure for these pump parts as well. Documentation of the hydro test, for record keeping, can reduce potential difficulties. Additional inspections to help ensure the integrity of the casing include dye penetrant, x-ray or helium leak tests. Other casting specifications can be added that will also require additional testing.

Pumps function most efficiently and reliably if they are operated near their design flow.

For pump protection, instruments are available that measure, monitor or indicate some of or all of the following:

- Suction pressure
- Discharge pressure
- Seal fluid pressure
- Seal fluid flow
- Seal fluid level
- Vibration
- Minimum flow protection
- Supply level trip
- Power level

5.4.3 Differential Pressure

Where practical, phosgene can be moved via differential pressure.

When possible, as with a new design, a combination of differential pressure, and gas only, may reduce the possibility of leaks, save maintenance efforts, and reduce the quantity that can be released.

5.5 Instruments

5.5.1 Introduction

The Instruments section provides a general description of instruments and control systems utilized in phosgene service. It also provides tips regarding operation and maintenance, as well as information regarding less than successful applications employed in the past.

5.5.2 General Description

Phosgene producing or phosgene processing units should be operated in a manner that provides protection for personnel and the environment. Instrumentation complements piping and mechanical systems to help provide for safe and reliable operation.

It is expected that the process will be controlled and remain within the vessels, equipment, piping, instruments and/or analyzer systems. A goal of the instrument design effort is to eliminate or minimize potential leakage points. This is often accomplished by minimizing leak paths in instrument installations, frequently with the use of inline instrument devices.

Other goal of instrument design efforts for phosgene service include providing for the reliability of instrument systems and devices, utilizing reliable technologies and methods, and providing for safe access and maintainability of the instrument system and devices to minimize personnel exposure to phosgene.

The goal of providing safe access for maintainability of the instrument system may sometimes create inconsistencies with the goal of minimizing leak paths. Maintainability is often enhanced with the use of flush/purge fittings or devices. These installations tend to add more valves and fittings, and hence possible leak paths. “Minimizing leak paths” without maintainability will often require removal of an instrument device with a small “controlled” release to a recovery system. Individual company policies and/or practices will provide guidance for achieving these seemingly conflicting goals.

The design/application of inline instrument devices or hardware utilized in phosgene service should consider all the process conditions and other materials in the process stream in selecting the most suitable/appropriate materials of construction for the instrument device or hardware. Material selection for instruments in contact with phosgene varies depending on overall process stream requirements and other specific factors.

5.5.3 General Design Installation Issues

As part of evaluation the following have to be considered:

- Evaluation the use of inline devices whenever possible.

- Eliminating (minimizing) leakage points to the atmosphere for instruments in phosgene service.

- Minimizing screwed (national pipe thread, NPT) process connections and tubing and fittings in contact with phosgene or its reactants as non-threaded process connections provide less potential for leaks (i.e. evaluate the use of welded or flanged connections whenever possible).

- Evaluating common Mode Failure possibilities and taking steps to eliminate as many as possible.

- Utilizing “fail-safe” components and methods whenever possible to drive the process to a safe on loss of energy.

- The use of a process isolation valve for all instrument devices in phosgene service that are not of inline design may allow for safe removal of instruments for maintenance.

- Histories of reliability should be reviewed in technology selection. The use of smart transmitters, valves with smart positioners, etc., may assist online diagnostics and maintenance.

- Instrument devices are often installed to allow flushing and decontamination, purging and/or venting before removal of equipment for calibration and/or repair.

- Redundant systems, when used, often include redundant elements from sensor to control processing to final control elements.

- Support for instrument devices and their auxiliaries are designed to protect against mechanical damage. One example is a small bore extended branch trees with extended moment arms.

- Incorporating self-monitoring and/or error reporting elements ("smart instruments") into phosgene indication, control, interlocking, and/or alarming strategies can help identify some potential problems.

- Periodic checks, calibration procedures (including function check), and reporting methods have been used for instrument devices deemed critical to safety to the process (as identified by PHA analysis or other method).

- Instrument devices are often specified and installed with consideration given to maintenance, calibration and testing requirements, both on line and off line.

- Transmitter specified for phosgene applications can be designed to handle vacuum service required for equipment evacuation.

5.6 Relief Devices

5.6.1 Introduction

Relief devices are used to help prevent a catastrophic failure of equipment and/or minimize the effects of any unanticipated or uncontrolled events. As such, relief devices generally serve as emergency devices not used for normal process control. Relief devices are used for individualized equipment as well as equipment assembled as part of a chemical process. Relief devices are designed to protect a vessel or system from excess pressure by removing or relieving fluid from that vessel or system. Relief devices however are not the only method for over-pressure protection. Equipment and/or process designers also consider the causes of over-pressure as well as the appropriate pressure disposal system during the process design stage. Some considerations during this stage may include:

- Design of process equipment such that there are no credible scenarios, which exceed the maximum allowable working pressure of the equipment, possibly eliminating the need for an over-pressure protection device.

- Design of process equipment to minimize the venting / relief rate through the over-pressure protection device, possibly reducing the size of both the relief device and the connected disposal system.

- Design of process equipment such that a single common over-pressure protection device protects several pieces of equipment, possibly reducing the number of relief devices.

5.7 Secondary Containment

5.7.1 Introduction

Proper design and installation of phosgene handling equipment is essential in preventing phosgene leaks and accidents. Proper design installation, along with an effective maintenance program and operator training, enhances the safety of phosgene operations.

However, to further increase the safety level of the operation, employ “secondary containment” systems. The purpose of these secondary systems is to provide a “safety net” in order to prevent chemical releases to the open atmosphere. Examples of secondary containment include double walled construction, structural airtight enclosures, dump tanks and containment vaults. A description of each type follows:

5.7.2 Double Walled Construction

These types of systems are often called a “pipe within a pipe” or “wall within a wall”. The design concept is essentially a two-layer approach where the inside layer or inside wall is in contact with the chemical and the outside layer and the outside layer or outside wall surrounds the inner layer. The void or plenum area between the walls is often monitored for chemical leakage. Sometimes this area is filled with a gas such as nitrogen to prevent moisture build-up.

Double walled systems also provide protection against foreign object impingement or contact. The same principle is sometimes used in the transportation industry for railcars and barges.

5.7.3 Structural Enclosures

Structural enclosures can be described as a sealed building or box. From the outside, these enclosures may appear similar to other buildings in the operational process. However, they will normally have special features, such as an air tight seal, possibly maintained under vacuum with ventilation to a scrubber, controlled access, and dedicated leak detection monitors.

The material of construction can vary from standard concrete blocks to special “cocoon” sealed corrugated metal to fully welded steel sheets. No matter what the materials of construction, the success of the enclosure or box depends upon its ability to fully contain any phosgene leaks and direct them to a safe neutralization system.

Some cautions when using enclosures involve the possible containment of process flammables such as carbon monoxide or hydrocarbons and the possible need to use of PPE when entering a sealed enclosure. These factors are considered in the design of the enclosure as well as in development of procedures and special steps for maintenance activities inside an enclosure.

5.7.4 Dump Tanks

Dump tanks can be used to transfer a liquid mixture from the process vessel to an emergency holding or containment vessel. In most cases, dump tanks are not used for any other purpose. They are sized to contain the largest applicable operating volume and normally remain empty. Transfer to the dump tank can be either manual or automatic and by either process pressure or with nitrogen pressure. Due to the special nature of most phosgene processes, dump tanks are not routinely used.

5.7.5 Containment Vaults

A vault can be described as an underground pit designed to contain a liquid spill. The spill would be directed into the valve vault where it would be contained and vented or purged to a neutralization unit. Most vaults remain water or moisture free. Also vaults have limitations are not usually effective for gas release containment.

Because of the special nature of most phosgene processes, vaults are not routinely used.

	Pluses	**Minuses**
Double Walled	▪ Excellent impact protection ▪ Easy to maintain ▪ Reliability of containment	▪ Sometimes extremely difficult to locate point of leak ▪ Difficult to repair internal wall

	▪ Capable of continuous leak monitoring of plenum area	▪ Focused secondary containment
Enclosures	▪ Reliability of containment ▪ Can encompass large processing sections ▪ Quick detection of leaks possible	▪ Operational & maintenance cost ▪ Special personnel procedures used ▪ Extends maintenance duration
Dump Tanks	▪ Provide focused containment	▪ Dedicated for liquid processes ▪ Limited purpose.
Vaults	▪ Provide focused containment	▪ Underground ▪ Limited purpose ▪ Must remain moisture free

5.8 Mitigation Systems

Mitigation methods are used to reduce the overall impact of an accidental release. The methods listed below provide varying degrees of mitigation success from complete mitigation to unquantified partial mitigation methods. Mitigation of phosgene is difficult because of the chemical properties of phosgene

In relative terms, phosgene is slow to hydrolyze when exposed to water whereas other halogen compounds tend to react very quickly with water. This characteristics represents a key understanding for emergency response and HAZMAT personnel's awareness.

Another concern is that hazardous concentrations of phosgene may not be visible because the vapor tends to be transparent unless the concentration is very high. This issue depends on the atmospheric conditions at the time of the release.

Phosgene also tends to accumulate in low-lying areas. For instance, phosgene will often be found in drainage systems located in affected areas of release.

5.8.1 Fugitive Collection Systems

5.8.1.1 Vacuum Systems

Generally, there are two different types of vacuum systems employed for handling of fugitive phosgene emissions

5.8.1.1.1 Spot Ventilation Systems

A spot ventilation system typically consists of a circuit or header of "elephant trunk" drops connected to a large volume-blower and discharges to a phosgene mitigation device. The flexible hose of an elephant trunk drop is positioned near the fugitive source, pulling the emission away to a mitigation device. This type of system can serve the following purposes:

- Capture, contain, and mitigate low levels of fugitive phosgene resulting from a minor loss of containment event (e.g., a small valve-packing leak).

- Capture, contain, and mitigate low levels of fugitive phosgene which may result during the process of verifying equipment is clear prior to any maintenance breaking and entering activity.

5.8.1.1.2 Permanent Ventilation Systems

The second vacuum system is typically associated with clearing contaminated process equipment prior to any maintenance disassembly activities. This vacuum system has consisted of either temporary or permanent piping connected to process equipment, with a vacuum pump capable of pulling deeper vacuum. As part of the overall strategy for clearing and maintenance preparation, phosgene and other contaminants are vaporized under a deep vacuum, captured in the vacuum system and discharged to a phosgene mitigation device.

5.8.2 Phosgene Neutralization Systems

5.8.2.1 Caustic Scrubbers

Caustic scrubbers provide a method for mitigation of a phosgene release. Within the category of caustic scrubbers, there are several different types of scrubbing towers.

The basic caustic scrubbing system is comprised of a caustic source feeding a scrubbing tower. The tower is either an open contact type tower or a packed tower.

Key operating parameters for operation of a caustic scrubber include: the maximum flow rate of phosgene expected from the process; the maximum duration of the release to the scrubber; the concentration of caustic available for scrubbing; and the circulation or flow rate of caustic into the scrubbing tower.

5.8.2.1.2 Dispersion Stacks

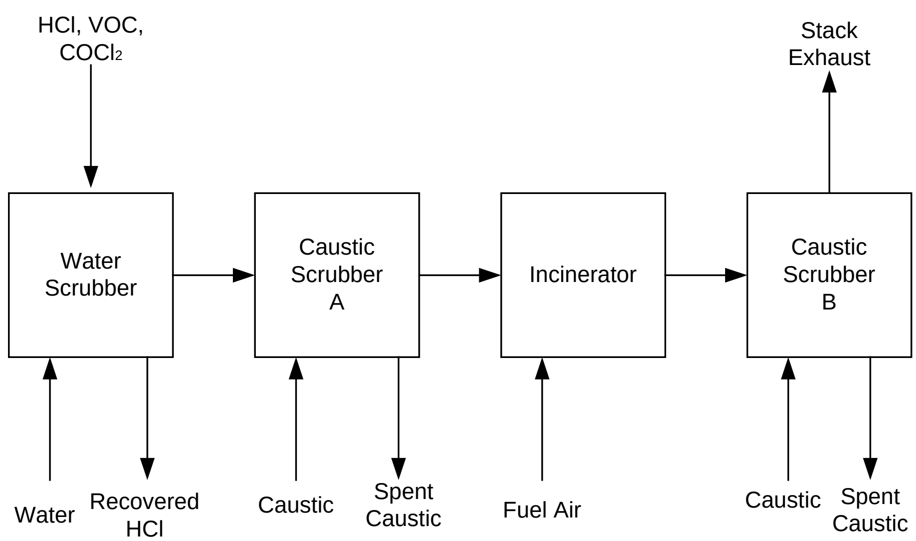
A robust phosgene destruction system design, installation, and operating procedures represent the primary option of controlling phosgene emissions. However, an elevated dispersion stack may be used to provide an additional layer of defense in the event of phosgene breakthrough from the primary phosgene destruction system. In the event the destruction system is unable to completely neutralize the phosgene, the exit gas can be dispersed at an elevated location with the intention of reducing the risk to personnel in the general vicinity. A high volume air blower can be used to elevate the gas velocity through the stack, enhancing the dispersion capability. Dispersion modeling software can be employed to estimate any potential impact of a fugitive phosgene emission, taking into consideration the environmental conditions, such as wind speed and direction. Materials capable of withstanding corrosion resulting from mixing phosgene with moisture in the air are available for dispersion stacks and related equipment.

In addition, an online phosgene analyzer can be used to help ensure appropriate regulatory limits are not exceeded.

5.8.2.1.3 Emissions and Controls

Potential process emissions from the production of isocyanate include phosgene, hydrogen chloride, aromatic and aliphatic solvents, aromatic amines, aromatic nitrogen compounds, isocyanates, nitrogen oxides and sulphur oxides. Because these emissions include a number of toxic and corrosive chemicals, controls are necessary (as shown in figure given below) would include:

1. A water scrubber to remove and recover hydrogen-chloride.
2. A caustic scrubber to provide removal of VOC and $CoCl_2$ from the water scrubber as well as to remove VOC from the nitration and distillation processes.
3. An incinerator for volatile organic compound
4. A second caustic scrubber for treatment of the incinerator exhaust to remove residues from the combustion of chlorinated hydrocarbons.



5.9 Inspection & Testing

Maintaining the integrity of phosgene handling systems is of the utmost importance. This section outlines common practices for inspecting and testing phosgene system equipment, piping and vessels. The objective of inspection and testing practices is to eliminate phosgene releases by preventing failures in these components.

5.9.1 Inspection & Testing During Operation

This section outlines techniques commonly used to inspect and test phosgene-containing process equipment while in operation. The methodologies and frequencies listed are to be considered only as references for additional consideration. Users must develop their own inspection methodologies and frequencies based on their specific needs and circumstances. Local regulations, design codes, and plant history are among the factors that must also be considered in developing appropriate inspection methodologies and frequencies.

Inspection Methodologies and Frequencies During Operation		
Equipment Type	**Sample Methodology**	**Sample Frequency**
Process Equipment	Visual inspection has to be used for observing the signs of corrosion, leaks, condition of paint, and condition of structural support (e.g., pipe hangers, I-beams, etc.)	Annually
Rotating Equipment	Testing that has to be performed: ▪ Vibration measurement	Vibration – Monthly to semi-

Inspection Methodologies and Frequencies During Operation		
Equipment Type	**Sample Methodology**	**Sample Frequency**
	▪ Fugitive emission testing of seals, tubing, and flanged connections	annual Emissions Quarterly to Yearly
Piping	Thickness measurements (TMs) have to be performed to check integrity and estimate corrosion rates. The thickness measurements have to be done using ultrasonic or radiographic methods. Areas frequently checked for thickness include elbows, downstream of valves and welds, branches, turbulent areas, dead legs, injection points and the small end of reducers Piping including connections and flanges, has to be visually inspected for installation of the correct gasket, gasket condition, signs of leakage, paint condition, and the presence of corrosion under insulation (CUI). Profile radiography has to be used to identify corrosion insulation without having to remove the insulation. Suspect areas for corrosion under insulation have included low points on	Thickness measurements – intervals from 1 to 5 years, based on remaining life and corrosion rates Visual - Annually

Inspection Methodologies and Frequencies During Operation		
Equipment Type	**Sample Methodology**	**Sample Frequency**
	vertical piping runs, areas where insulation is altered to fit valves, branches, fittings or areas where insulation is damaged/uncovered. Areas of operating temperatures between 140^{o}F to 280^{o}F (60^{o}C to 137.7^{o}C) and intermittent operation have also warranted focus.	
Relief Devices	Visual inspection has to be used to inspect for signs of leakage or corrosion of bolts, holders, etc.	Annually
Vessels, Pressure & Low/No Pressure	Thickness measurements have to be used to check integrity and estimate corrosion rates. The thickness measurements have to be done using ultrasonic or radiographic methods. (Note: Be sure that the diameter size of the vessel does not exceed the capability of the radiographic methodology. Consider appropriate locations for establishing specific thickness measurements) Visual inspections and profile radiography (on small vessels) have to be used to identify corrosion under insulation. Suspect areas for corrosion under insulation have to be	Thickness measurements – based on remaining life Visual – Annually

Inspection Methodologies and Frequencies During Operation		
Equipment Type	**Sample Methodology**	**Sample Frequency**
	included vessel skirts, insulation support rings, and areas where insulation is altered to fit valves, fittings etc. Areas of operating temperatures between 140^{o}F to 280^{o}F (60^{o}C to 137.7^{o}C) and intermittent operation have also warranted focus. The seam between tank bottom and support pad has also to be visually inspected for damage to the sealer	
Valves, Flanges, Fittings, & Tubing	Visual inspections have to be used for the following: ▪ Gasket and bolt condition ▪ Packing condition ▪ Paint condition ▪ Support condition ▪ Abrasion and crimping (tubing) ▪ Sign of leakage Connections, flanges, fittings, and valve packing have also to be tested for fugitive emissions. Profile radiography has to be used on certain valves to determine if there is erosion or corrosion. This can help identify items to repair prior to turnarounds. (Note check whether the	Visual – Annually Emission - Quarterly

Inspection Methodologies and Frequencies During Operation		
Equipment Type	**Sample Methodology**	**Sample Frequency**
	size of the valve exceeds the capability of the radiography methodology	

5.9.2 Inspection & Testing During Maintenance / Turnarounds

This section outlines commonly used techniques to inspect and test phosgene-containing process equipment during maintenance and turnarounds. The methodologies and frequencies listed are to be considered only as references for additional consideration and are based on historical data from major phosgene manufacturers. Users must develop their own inspection methodologies and frequencies based on their specific needs and circumstances. Local regulations, design codes, and plant history are among the factors that must also be considered in developing appropriate inspection methodologies and frequencies.

Inspection Methodologies and Frequencies During Maintenance / Turnarounds		
Equipment Type	**Sample Methodology**	**Sample Frequency**
All process Equipment	Visual inspection to be used observing for signs of corrosion, leaks, condition of paint, and condition of structural support (e.g., pipe hangers, I-beams, etc).	At each repair or turnaround
Rotating Equipment	Testing that has to be performed: ▪ Coupling inspection & alignment	At each repair or turnaround

Inspection Methodologies and Frequencies During Maintenance / Turnarounds		
Equipment Type	**Sample Methodology**	**Sample Frequency**
	▪ Leak testing of seals, tubing and flanged connections ▪ Internal inspection for casing erosion and corrosion	
Piping	Thickness measurements have to be performed to check integrity and estimate corrosion rates. The thickness measurements have to be done using ultrasonic or radiographic methods. Common areas checked for thickness have included elbows, downstream of valves and welds, branches, turbulent areas, dead legs, injection points and the small end of reducers. Piping including connections and flanges, has to be visually inspected for installation of the correct gasket, gasket condition, signs of leakage, paint condition, and the presence of corrosion under insulation (CUI). Profile radiography has to be used to identify corrosion insulation without having to remove the insulation. Suspect areas for corrosion under insulation have included low points on vertical piping runs, areas where	At each repair or turnaround

Inspection Methodologies and Frequencies During Maintenance / Turnarounds		
Equipment Type	**Sample Methodology**	**Sample Frequency**
	insulation is altered to fit valves, branches, fittings or areas where insulation is damaged/uncovered. Areas of operating temperatures between 140°F to 280°F (60°C to 137.7°C) and intermittent operation have also warranted focus. Inspection tools such as a boroscope have to be used to internally inspect piping for signs or corrosion or erosion Welds have to be inspected for stress cracking using dye penetrant or eddy current. Areas of concern have included welds that experience high loading or high vibration.	
Relief Devices (including rupture disks and pressure / vacuum relief valves)	Activities of rupture disks have to be included: ▪ Inspect holder & bolts for corrosion ▪ Inspect disk for corrosion or other mechanical defects to check correct material selection ▪ Check piping for blockage ▪ Replace disk Activities for pressure or vacuum relief valves have been included:	1 to 2 year intervals

Inspection Methodologies and Frequencies During Maintenance / Turnarounds		
Equipment Type	**Sample Methodology**	**Sample Frequency**
	▪ Tested set pressure (not while installed) ▪ Inspected packing, seats, bolts, and gasket surfaces for corrosion or other mechanical defects ▪ Checked piping for blockage ▪ Looked for signs of leakage	
Vessels, Pressure & Low/No Pressure	Thickness measurements have to be performed to check integrity and estimate corrosion rates. The thickness measurements have to be done using ultrasonic or radiographic methods. Consider appropriate locations for establishing specific thickness measurements. Eddy current has to be used to check integrity of tubes. Visual inspections and profile radiography (on small vessels) have to be used to identify corrosion under insulation. Suspect areas for corrosion under insulation have to be included for vessel skirts, insulation support rings, and areas where insulation is altered to fit valves, fittings etc. Areas of operating temperatures between 140^{o}F to 280^{o}F	External – ¼ of remaining

Inspection Methodologies and Frequencies During Maintenance / Turnarounds		
Equipment Type	**Sample Methodology**	**Sample Frequency**
	(60^oC to 137.7^oC) and intermittent operation have also warranted focus. Internal inspections have to be used to visually identify pitting of the base metal and condition of the welds. Stainless steel alloy welds have to be inspected to dye penetrate or eddy current to identify stress corrosion cracking. Welds that experience high loading or high vibration have often to be areas of concern. Examples include piping connections, seam welds, and tray supports. The internal inspection has also to be used to check the integrity of tank bottoms that cannot be externally inspected. Thickness measurements have been taken to identify areas of thinning or corrosion between the tank bottom and tank pad.	
Valves, Flanges, Fittings, & Tubing	Critical isolation valves and valves in solids or high velocity service have to be internally inspected to check for corrosion/erosion and seat condition. These isolation valves have also to be pressure-tested to check sealing	As with other timetables, frequency varies with previous experience. Areas of high

Inspection Methodologies and Frequencies During Maintenance / Turnarounds		
Equipment Type	**Sample Methodology**	**Sample Frequency**
	integrity. Profile radiography has to be used on certain valves to determine if there is erosion or corrosion. This can help identify items to repair prior to turnarounds. Check whether the size of the valve exceeds the capability of the radiography methodology.	solids or erosion may be checked more frequently.

5.9.3 Commissioning Equipment

This section includes common techniques for checking system integrity prior to and following installation, repair, or turnaround of equipment and systems. Local regulations may require a combination of several of these techniques or alternative methods.

An inspection of equipment and valves prior to installation can help prevent future failures and leaks. This inspection frequently consists of verifying appropriate materials of construction, gasket material, and lubricants. During the installation or assembly process, proper bolt torquing is important to ensure the integrity of connections.

Once installation or repair work is complete, a visual inspection can be used to help verify system integrity. This visual inspection evaluates that correct gaskets are used, all flanges and connections are tight, instrumentation is installed, and that no open connections or drains exist. The visual inspection is often followed by cleaning or flushing to remove trash and debris. This cleaning has been done with compressed gas (e.g. nitrogen or air) or with a fluid. One benefit to using a fluid wash is that some instrumentation can be functionally tested. An acid flush may be necessary for carbon steel equipment to reduce iron content in the product. Draining and blowing the system clear following a fluid wash removes free-standing liquid and minimizes corrosion.

The procedures described above help prepare the system for a rigorous integrity test. The integrity tests are commonly referred to as "pressure tests" or " leak tests." Available integrity tests for piping and equipment systems include: (a) hydrostatic tests, (b) pneumatic tests, and (c) sensitive leak tests. Generally, a hydrostatic or pneumatic test is performed on repaired or new piping and vessels, and then a sensitive leak test is performed on equipment that was opened or repaired during the maintenance / turnaround. Each test method will be described in more detail below.

Hydrostatic Testing

A hydrostatic test is frequently performed on new or repaired piping and vessels. In this test method, the vessel and/or piping is pressurized with a fluid (e.g. water) up to or slightly above design pressure. A hydrostatic test helps verify that the repaired or new vessels and piping can withstand the design pressures.

A hydrostatic test does not provide many clues as to the actual condition of the vessel. Unknown factors such as flaws, corrosion, metal loss in heat affected zones of the welds, poor weld fusion or lack of penetration, cracks in weld seams, or de-lamination of plates are, for the most part, undetected by hydrostatic testing.

Repeated hydrostatic testing can shorten the fatigue life of the vessel because it applies close to yield level stresses to small cracks or flaws that may be developed over time by cyclic stresses. Thus, the hydrostatic test method is not often used for routine inspections. As discussed above, in many cases, it is only performed on new or repaired piping and vessels to help ensure the integrity of welds and connections.

Also, careful development of the test procedure helps prevent damaging equipment due to over pressure. American Society of Mechanical Engineers Code B31.3 provides further information relating to the test parameters. Questions often considered include:

- Is other equipment to be tested at the same time or to be included in the same test? If no, then has the equipment been properly isolated for the test?
- Will the testing exceed the maximum allowable working pressure (MAWP) of the equipment?
- What are the test-acceptance criteria, including duration and gauge errors?
- Who needs to witness the test?
- Is overpressure protection required?
- Are redundant gauges installed?
- What measures are in place to ensure that all air is purged through high point vents to prevent equipment damage or personal injury?

Note: The chemistry of the fluid used in the hydrostatic test is important in preventing corrosion of carbon steel and stress cracking of stainless steel.

Pneumatic Testing

The use of pneumatic testing requires special consideration because of the potential dangers associated with the stored energy of the compressed gas involved in the test. Pneumatic testing is often only used when hydrostatic test is undesirable because of concerns over moisture in the piping and vessels. A pneumatic test involves pressuring the vessel and/or piping with a compressed gas up to or slightly above design pressures.

Like hydrostatic testing, pneumatic testing can shorten fatigue life, or damage equipment and injure people if performed improperly. Thus, it is often only performed on new or repaired equipment to help verify the integrity of welds and connections. The precautions listed in the Hydrostatic Testing discussion above are commonly considered in pneumatic testing a well.

Sensitive Leak Testing

Sensitive leak tests are commonly used in phosgene services because they can detect very small leaks that may go undetected during hydrostatic or pneumatic leak tests. Examples of sensitive leak tests include helium leak tests, ultrasonic leak tests, and anhydrous hydrochloric acid (HCl) tests.

Helium leak testing consists of adding a small volume of helium to the system, followed by a larger quantity of nitrogen. A helium mass spectrometer is then used to detect for leaks.

Advantages of helium testing:

- Very little fatigue on the equipment.
- Helium testing is a more sensitive test. It can identify more leaks than water or air.
- The equipment is portable
- Decreased risk to health or environment

Disadvantages of helium testing:

- Operators must be properly trained.
- The test can be very slow, as you must wait for helium to travel through the vessel.
- Equipment and/or contractors can be costly.

Ultrasonic testing consists of pressuring up the system with nitrogen or compressed air and then using a high frequency sonic leak detection device to detect leaks. The sonic leak detector is used to detect leaks at welds, seams, joints, and any other areas of possible leakage. Sonic leak detectors with a detection frequency range of 20 kHz to 100 kHz have been used previously.

Advantages of ultrasonic testing:

- Simplicity.
- Little fatigue on the equipment.
- High sensitivity relative to hydrostatic or pneumatic tests.
- Low costs.

Disadvantages of ultrasonic testing:

- Not as effective in finding leaks in large systems.
- Sensitive to environmental conditions, especially wind.

Anhydrous HCl testing consists of adding bottled anhydrous HCl into the piping/equipment to a low pressure. Once this is complete, the system pressure is raised using a solution of ammonia water. This should create smoke at the connection if the HCl is leaking from the pressurized system.

Advantages of HCl testing:

- Little fatigue on the equipment
- HCl testing is a sensitive test and provides visual indication of the leak.
- The bottled HCl is portable

Disadvantages with HCl testing:

- Operators must be properly trained.
- Hazardous properties of anhydrous HCl.

Before Startup

After testing, it is important to dry the equipment before returning to service. If the equipment is not dried, HCl will be formed and corrosion may occur.

5.9.4 Certification & Training Requirements for Non Destructive Testing (NDT) Inspectors.

It is important to consider training and qualifications when selecting an inspector. Properly qualified inspectors can help in developing an inspection plan and interpreting the results. The American Society for Nondestructive Testing (ANST) offers information on testing personnel qualifications and certifications. Local regulations may also define specific requirements.

5.9.5 Record keeping

Maintaining accurate inspection records for vessels, piping, and equipment facilitates inspection and testing operations, and is often required by local regulations. These records can be used to determine future inspection intervals and repair methods. Information often kept in these records includes:

- Original design details of the equipment (e.g., design code, fabrication drawings, materials of construction, capacity, chemical service, operating conditions)
- Procedures for safely and effectively performing external and internal inspections, including preferred inspection methods.
- Results of previous inspections and corresponding repair recommendations.

- Procedures and details of any vessel repairs or changes of chemical service.

Local regulation may define record retention rules. Frequently, these records are retained for the life of the equipment or longer.

6.0 Equipment Cleaning and Repair

6.1 General

Because phosgene is a highly toxic material, extraordinary caution is required when working on or entering equipment used in phosgene service. Cleaning and maintenance are potentially hazardous activities that should be performed only by workers who are thoroughly familiar with the dangers involved and the precautions necessary for safe performance of the work. For this reason, the importance of proper training, an understanding of hazard recognition, and a soundly planned approach to each job cannot be overemphasized.

The following sections provide an overview of procedures and techniques used to prepare phosgene equipment for maintenance and return the equipment to service, and offer information on issues that might arise during the repair work itself.

6.2 Preparation for Inspection or Repair

When a phosgene system is to be cleaned or repaired, empty the system of process liquids and gases containing phosgene. Following equipment shutdown, remaining liquids and gases should be transferred to other process equipment in the plant either by pumping or by pressuring off with a dry, inert gas, such as nitrogen, supplied at a pressure higher than that on the equipment to be cleared. Once this has been accomplished, it is useful to valve the system and vent the remaining pressure to a destruction or decomposition device, such as a caustic scrubber. During depressurization, the frosting of piping, etc., which has been in liquid phosgene service, indicates it still contains liquid. External application of heat can expedite the clearing process and may be a necessity when cold weather retards or even prevents evaporation of phosgene at atmospheric pressure. However, heating a closed system containing liquid phosgene may produce excessive pressure so close monitoring helps protect against potential risks.

After the equipment has been depressurized and is liquid-free, pull the equipment under vacuum and install steel slip blinds at the isolation points to prevent phosgene from leaking back through the blocked valves from other parts of the system (note: if plans call for the use of purging for clearing purposes, the vent line would be left unblended). Consider locating the blinds as close as possible to the isolating block valves because a leaking valve may fill the space between the blind and the valve with liquid phosgene, which will then be released when the blind is removed. It may be advantageous to connect the vacuum to a high point on the system, but not at a drain valve if at all possible, because low points are prone to pluggage. When removing full face blinds or plugs located on bleed valves where the vacuum connection would be made, exercise appropriate caution because liquid phosgene can be trapped behind them. Before installing blinds, it may be important to verify that the system is under vacuum by reading an appropriately ranged pressure gauge or by cracking open a bleed valve.

` After blinds are installed, use a dry, inert gas to purge the remaining phosgene vapors to the vent system. For larger systems, which are solid-free, the use of heated inert gas can sometimes be more effective at purging. Once the system is clear, the vent line itself can be blinded to help complete the isolation. For difficult-to-clear equipment, additional options for consideration include flushing with water, weak aqueous ammonia, caustic or anhydrous ammonia (only done after the blinds have been installed and the system vented). Water flushing, following the use of ammonia or caustic, serves an important function to help eliminate those contaminants. Dispose of the resulting vent or waste stream in an environmentally responsible manner consistent with relevant requirements.

Safety should always be the primary consideration when clearing phosgene process equipment. The use of air-supplied respiratory protection is necessary for any activity where exposure to phosgene is a concern. Clear appropriate areas of unprotected personnel whenever performing work requiring breathing air.

Prior to beginning maintenance work, plant operations personnel can help verify that the equipment has been cleared of phosgene by cracking open a bleed valve and checking for the presence of phosgene using a detection badge or other hand-held detection device. The system may need a slight positive pressure in order to check for the presence of phosgene. It is important that the system is depressurized completely before maintenance loosens the first bolt.

As part of the evaluation, keep in mind that process solids that come into contact with, or are suspected of coming into contact with, phosgene may contain trapped phosgene. When solids are agitated, crushed, or blasted, there is potential for phosgene to be released.

The preceding information on clearing relates to equipment being removed from service for relatively major repairs expected to take a considerable amount of time. Aspects of the information may be useful to address minor repairs, such as gasket replacements, instrument replacements, leaking plugs and valve packing, as well as some valve replacements. Even after the equipment has been cleared of liquid, depressurized, and pulled under vacuum, use appropriate precautions during the performance of repair work.

If phosgene equipment requires welding or burning, evaluate use of special preparation procedures because phosgene impregnated into the surface of the metal can be liberated by the high localized temperatures produced. This process can involve washing out the equipment with hot water and/or steaming it out to remove the residual vapors.

In preparation for vessel entry, clear the inert gas used for purging by flushing with atmospheric air. For example, an air horn or similar air-moving device has been used. Flexible ducts connected to a vacuum source discharging to a destruct system may be useful if the existing air is contaminated.

6.3 Equipment Repairs

The repair of equipment that has been in phosgene service merits special precautions to avoid accidental exposure. Due to the increased possibility of accidental releases, it is beneficial to avoid attempting repairs while the equipment is still in operation unless authorized to do so using appropriate safe work procedures. Even after clearing, it is possible for phosgene vapors or liquid to remain trapped in gaskets and valve packing, behind pluggage in piping, inside damaged level displacers or agitator gearboxes, etc. This phosgene can be released during disassembly for repairs or, for example, simply by operating a valve. For this reason, performing repairs using appropriate PPE even on “cleared” equipment reduces potential risks.

At times, equipment that is still contaminated must be transported from the unit to another location for decontamination. In such cases, consider the feasibility of blinding off or plugging all process-exposed sections. If this is not possible, another option is to transport the equipment by a person wearing appropriate PPE and clearing all other personnel from the route.

If equipment must be taken to the facility’s shop or sent out of the plant for repair, consider decontaminating the equipment as soon as possible using special procedures to eliminate the possibility of an unexpected release. The procedures may require disassembly and cleaning using steam, hot water or other cleaning agents as appropriate. Vendors who handle such equipment must be thoroughly knowledgeable of the hazards of handling phosgene and with the decontamination procedures used.

Sometimes welding on phosgene equipment has to be done in the field without benefit of complete decontamination. If so, review whether the welder has air-supplied respiratory protection and whether the area has been cleared of unprotected personnel.

After welding on piping or equipment in phosgene service, risks can be reduced by evaluating whether the work was done properly and will not result in premature or unexpected failures. To this end, all welds can be tested prior to placing the piping or equipment in service.

All parts and materials to be used in phosgene service are designed and specifically approved for such use. A detailed procedure for cleaning and packaging repaired valves for phosgene service serves an important function because failure of these valves to properly seal when required could have significant consequences.

Threaded fittings used in phosgene service (e.g. plugs, pressure gauge nipples) create increased potential for leaks and are necessarily thinner because of the requirement to taper the joints for threading. As a result , threaded fittings tend to be generally avoided if at all possible, but when they must be used, some risks can be reduced by coating the threaded fitting with approved pipe sealant before being installed in order help avoid leakage. As one example, employ fluoropolymer-based thread sealants in the phosgene service.

If a vessel used in phosgene service must be inspected or repaired internally, OSHA guidelines for vessel entry are available. If the vessel has been cleared by dry-gas purging only and has not been washed out, evaluate appropriate PPE to protect against the possible presence of ferric chloride and hydrochloric acid coating the interior surfaces.

6.4 Preparation for Service

A phosgene system that has been open to the atmosphere needs to be extensively dried before being returned to service. Severe internal corrosion to steel piping and other equipment can result if significant moisture is allowed to remain inside the system. Drying the system's return to practice helps prevent this possibility. Drying has been done using a purge of dry inert gas, such as nitrogen. Heating the purge gas will facilitate the procedure. If a steam exchanger is used, consider whether the gas pressure is higher than the steam pressure on the exchanger. This action will help prevent moisture from contaminating the purge gas if the exchanger leaks. To aid evaporation, consider keeping the phosgene system maintained as close to atmospheric pressure as possible (or slight vacuum) during the drying process. External heating of the equipment being dried can help aid in the drying process. Nitrogen bleeds have been established at dead legs, including instruments such as pressure transmitters and differential pressure flow transmitters. Dew points can be taken at a number of different locations to help ensure the entire system has reached the desired dew point.

Equipment that has undergone minor repairs using the vacuum method described in the previous sections may contain a small amount of atmospheric moisture. It may not be practical or possible to purge this moisture from the system or, if it can be purged, to obtain a dew point due to contamination with phosgene. Such equipment can sometimes be returned to service without problems. However, to keep the frequency of this type of repair to a minimum and to do whatever drying is possible under the circumstances because some corrosion and sludging are likely.

Small sections of piping which need to be dried before installation have for example been flushed with acetone and then nitrogen purged. Another method has been to steam purge internally until the piping is very hot then purge immediately with nitrogen.

Note the importance of removing grease, oil and other foreign material from lines and equipment before returning to service. Piping components contaminated with oil, grease, or other hydrocarbons are potentially reactive with phosgene. Products of reaction could lead to unexpected pressure buildup in a closed system.

When drying is complete, consider whether all atmospheric bleeds have been plugged, capped or blinded to prevent phosgene leakage or a release due to accidental valve operation. To reduce risks, the system can be checked for leaks (after removing any blinds) by first pressurizing it with a dry, inert gas to operating pressure, blocking it in, and watching for a pressure drop. This process will help indicate any large leaks, but small leaks might only be found through other methods. Options that have been used include those such as checking each flange, etc. with a soap and water solution and watching for bubbles or by charging the system with a sensitive gas such as helium or helium/nitrogen combination and then leak detection device. After all leaks have been repaired and the equipment passes pressure tests, it can typically be depressurized and returned to service.

It is possible for leaks to occur after equipment has been returned to service, especially if the equipment is in liquid phosgene service. Frequent equipment checks (using phosgene badges or handheld phosgene monitors for example) for several hours after startup help identify such leaks. The use of special washers such as disk spring to prevent loosening of bolting due to thermal cycles on the equipment can be helpful in preventing leakage. A desirable attribute of an appropriate disc spring is that it should apply clamping pressure along a continuous arc pattern, rather than concentrating it at one point.

Annexure X

<u>**Multi-Feed Cracker**</u>

Cracking Furnaces

The plant will be equipped with Ultra Selective Conversion (USC) furnaces which feature high yield, long run length, low maintenance and high reliability.

Thirty-six USC furnaces will be provided with thirty USC main furnaces and six USC recycle furnaces. The recycle C_2 and C_3 will be cracked in the six USC recycle furnaces and can be co-cracked in the other main furnaces.

The Cracker will be a multi-feed cracker and can use different feeds for the cracking process. The naphtha feedstock will be preheated by quench water before entering the convection section hydrocarbon preheat bank. Natural Gasoline Liquid (NGL), if used, will be preheated by quench water and steam. Dilution steam will be superheated in the convection section and will mix with the partially vaporized hydrocarbon external to the furnace. This technique will ensure complete feed vaporization without convection tube fouling. The steam hydrocarbon mixture will further be heated to a suitable crossover temperature in the HC + steam convection section, entering the radiant coil and will pyrolize to form olefins and by- products.

The radiant coil outlet temperature will be controlled to achieve the desired ethylene and propylene yield. The furnace effluent will be rapidly quenched in double pipe exchangers. Super high-pressure steam produced in the exchangers will be superheated in the cracking furnace convection section. The effluent from exchangers will be further quenched in quench fittings by direct contact with quench oil before entering the Quench Oil Tower.

Boiler feed water will be heated in the top bank of the convection section and will feed the steam drum. The stack flue gas temperature of 160°C in main furnaces corresponds to an overall furnace efficiency of approximately 94%. Recycle C_2 and C_3 feed stock will be preheated using quench water before entering the preheat convection back. Preheated recycle feed stock will be mixed with dilution steam and then preheated to a suitable crossover temperature. Then the mixture enters radiant coil where it pyrolizes to from olefins and byproducts. Quench system of USC recycle furnace consists of four exchangers per furnace.

Primary Fractionation

The cracked gas from quench fittings will then be sent to the Quench Oil Tower where it will be cooled by circulating quench oil. This tower separates gasoline and lighter components from fuel oil product besides cooling the furnace effluent products.

The bottom section of the Quench Oil Tower will be a direct contact cooler with cooled quench oil as the cooling medium. Hot quench oil tower bottoms will be circulated and cooled by generating dilution steam. A small stream from middle section of the Quench Oil Tower will be sent to a fuel oil stripper (LFO stripper) to control OF product flash point. A slipstream of hot quench oil will be fed by USC recycle furnace quench fittings and the combined stream will flow into the Heavy fuel oil stripper.

The cracked gas overhead from Quench Oil Tower will be further cooled in the Quench Water Tower by direct contact with circulating quench water, condensing much of the cracked gasoline and most of the dilution steam. The gasoline and process water are separated in the oil/water separator at the bottom of the tower. A portion of the gasoline will be used to reflux the Quench Oil Tower, and the net product gasoline will be Debutanized in the Distillate Stripper and sent to the gas hydrogenation unit (GHU).

The separated quench water will be used for various process heating service and returned to the top of the Quench Tower. Net condensate, representing condensed dilution steam, which was fed in the furnace along with the feed, is sent to the dilution steam generation system.

Dilution Steam Strippers (DSS)
Solids and entrained hydrocarbons are removed from the quench water in a filter/coalescer system. Dissolved light hydrocarbons are stripped from the process water by dilution steam in the LP water stripper. After pumping and preheating, the water is sent to the dilution steam generators for vaporization by quench oil and low medium pressure (LMP) steam in DSS reboilers. Phenols, styrenes and other contaminants are stripped from the water cooled, resulting in an environmentally acceptable blowdown. Additional DSS with steam reboilers are provided to meet excess requirements.

Cracked Gas Compression
The cracked gas from the Quench Water Tower is compressed in a four stage centrifugal compressor. The effluent from each stage passes through an aftercooler and then to a separator drum. Liquid condensate is flashed back to the previous drum, with the vapour going to the next stage of compression. The hydrocarbon condensate from the second stage suction drum is pumped to the distillate stripper. The process water from this drum flows to 1st stage suction drum from where it is pumped to Quench water tower.

Acid gases are removed between the third and fourth stages of compression in Caustic wash tower with non-fouling ripple trays. A water wash section at the top of this tower removes any caustic entertainment.

Cracked gas from the fourth stage discharge is water cooled and sent to a separator drum. Vapor from this drum is sent to the cracked gas rectifier, which fractionates the heavy ends from the feed gas flowing to the demethanizer system. Reflux for this tower is condensed against high-level propylene refrigeration. The cracked gas rectifier effectively reduces cracked gas compressor interstage recycle, minimizing compressor horsepower and further reducing fouling. Wash water is injected into the compressor blades to reduce fouling of blades with polymers during compression.

Acid Gas Removal
Cracked gas from the third stage discharge drum is fed to the caustic tower where it is washed with circulating weak and strong caustic solutions and finally with water. The bottom circulating weak caustic solution is heated by quench water to ensure that

hydrocarbons do not condense in the tower. The strong caustic solution is maintained at 10% NaOH with fresh caustic solution make-up. The strength of the weak caustic solution is maintained by letdown from the more concentrated solution.

Spent caustic from the base of the tower of 1% concentration is routed to the spent caustic deoiling drum where it is contacted with aromatic gasoline to remove hydrocarbons and polymers. The spent caustic is sent to the degassing drum. After degassing spent caustic is stripped with steam to remove hydrocarbons like benzene, before entering the spent caustic oxidation unit for further treatment.

Spent Caustic Oxidation

Spent Caustic from Stripper flows to SCO fed surge from where it is pumped to the first reactor after preheating against reactor vent gas. There are three reactors operating in series. These reactors are fed with air from air compressor after filtration.

Each reactor operates nearly full of liquid at 130°C and is divided into two zones by a perforated plate. The spent caustic flows slowly upward in contact with a stream of fine air bubbles. The reactor pressures are individually controlled to allow the flow of spent caustic through each reactor under level control. On the spent caustic stream from each reactor a filter is provided for removal of possible agglomerated polymer. The residence time in each reactor is approximately 4 hours at the maximum design rate.

Oxidized spent caustic from last reactor is filtered, cooled and diverted to effluent surge drum. From this drum spent caustic is pumped to the effluent treatment plant. During this process, COD of the spent caustic is reduced to acceptable limits for treatments in ETP.

Condensate Stripper

Liquid hydrocarbon bottoms from the cracked gas rectifier are flashed into fourth stage suction drum. Liquid hydrocarbon from this drum is warmed against quench water and flashed into the condensate stripper. This tower function as a deethanizer, further reducing compressor recycle and allowing much of the C_3 and heavier hydrocarbons to bypass the cold fractionation system, with a savings in refrigeration horsepower. Also this ensures that the C_2 spec. in the bottom stream is satisfied.

Cracked Gas Dehydration

The cracked gas from the rectifier reflux drum is dried in the cracked gas dehydrators. Two vessels are provided, one operating, the other regenerating or on standby. Molecular sieve desiccant is utilized with a moisture analyzer strategically placed to monitor for water breakthrough. The desiccant is regenerated with residue gas from the demethanizer overhead system. The regeneration gas is heated in a feed/effluent exchanger followed by a high-pressure steam heater. Saturated regeneration gas is cooled before feeding a separator drum. The condensed water is sent to the quench water tower and the residue gas flows to the fuel gas system.

Demethanizer System
The dried cracked gas is cooled against propylene refrigerant and demethanizer bottoms before separating vapor and liquid in the prestripper feed drums. The liquid is sent to the demethanizer prestripper, while the vapor is further cooled against recycle ethane and propylene refrigerant. Liquid from the second prestripper feed drums is sent to the demethanizer prestripper.

The prestripper is a demethanizing tower, which reduces the energy requirements of the fractionation system. The overhead vapor is the bottom feed to the demethanizer. The prestripper bottoms are sent to the deethanizer. Reboil heat is provided by quench water.

The vapor from demethanizer feed drum No. 1 is cooled in stages against demethanizer overhead streams and ethylene refrigerant. The vapor from demethanizer parallel feed drum No. 1 is cooled against stages of ethylene refrigerant. Liquid vapor provides liquid for the second and third demethanizer feeds.

Vapor from the last demethanizer feed drum is cooled against demethanizer overhead streams and sent to the residue gas rectifier. This small tower effectively eliminates ethylene loss in the residue gas. The rectifier bottom stream is reheated and enters the demethanizer as the top feed. The rectifier overhead vapor is further chilled against residue gas and sent to the overhead separator. Liquid from the separator is returned to the rectifier as reflux.

The net rectifier vapor from the reflux drum is further chilled against the coldest residue gas and sent to the hydrogen drum. Net vapor from this drum of 95-mol percent minimum hydrogen purity is reheated and sent to the PSA system for CO removal. Liquid from this drum is normally flashed to low pressure, reheated and compressed back to fuel gas pressure using fuel gas compressor. If fuel gas compressor is down, hydrogen is injected into the methane stream to achieve low temperature by reducing methane partial pressure.

A standard Pressure Swing Adsorption (PSA) system is used to remove carbon monoxide, which would poison the hydrogenation catalyst. The demethanizer overhead is condensed against lowest level ethylene refrigerant to provide tower reflux. The net tower overhead after partial reheat is sent to the methane expander-recompressor system for cooling the incoming CG feed beds and then to the fuel gas system after regenerating the CG dehydrator.

Reboil heat for condensing intermediate level propylene refrigerant provides the demethanizer. Additional chilling of the CG is performed in the parallel chilling train.

Deethanizer
The dual-feed deethanizer separates the demethanizer and demethanizer prestripper bottom streams into C_2 overhead and C_3 and heavier bottom streams. The bottom stream is sent to the depropanizer. The net vapor overhead stream feeds the acetylene hydrogenation system. Reboil heat is provided by circulating quench water.

Acetylene Hydrogenation System

The acetylene is catalytically hydrogenated to ethane and ethylene over palladium catalyst. The deethanizer vapor overhead stream is heated to reaction temperature and sent to the primary C_2 hydrogenation reactor. Two primary reactors with intermediate cooling are provided, one operating, the second for regeneration or on standby.

The effluent from the primary reactor is cooled and enters the first secondary adiabatic reactor. The effluent from this reactor is cooled and sent to the second guard adiabatic reactor. A third adiabatic reactor is either on regeneration or standby.

The acetylene - free effluent from the secondary adiabatic reactors is cooled and sent to the green oil knockout drum. The separated green oil is sent to the primary fractionator. The gas flows to the secondary dehydrator where molecular sieve desiccant removes traces of water.

Ethylene Fractionation

The ethylene - ethane vapor from the secondary dehydrator feeds the ethylene tower. Reflux is condensed against low level propylene refrigerant. The ethylene product is withdrawn as a liquid a few trays below the top of the tower. Light impurities are eliminated by pasteurization with a small vent stream from the reflux drum recycling to the cracked gas compressor system. Condensing propylene refrigerant vapor provides bottom reboiler heat. Condensing ethylene refrigerant compressor discharge vapors provides the side reboiler load.

Provision is made to send a low pressure and high pressure ambient temperature ethylene vapor product to battery limits by pumping vaporizing and superheating the side draw - off liquid product stored in OSBL spheres. Provision is also made to sub - cool this liquid to approximately - 100°C for transfer to atmospheric storage.

Depropanizer

The deethanizer and condensate stripper bottom streams feed the depropanizer. The C_3 fraction is totally condensed against propylene refrigerant, producing reflux and a liquid overhead stream, which is pumped into the C_3 bydrogenaton system. The bottom stream flows to the debutanizer.

C_3 Hydrogenation

Methylactylene and propadiene are catalytically converted to propylene and propane in two liquid - phase reactors in parallel with after cooling. A separator drum after the cooler vents gas to the cracked gas compression system. MAPD concentration in the feed is controlled by recycling reactors is being regenerated. Third reactor is kept as standby.

Secondary and Tertiary Deethanizers

The effluent from the C_3 hydrogenation system feeds the secondary and tertiary deethanizers operating in series. These towers remove traces of C_2's, carbon dioxide water which are recycled to the cracked gas compression system. These towers are reboiled with quench water. Reflux is condensed with cooling water.

Propylene Fractionation System
The bottom stream from the seondary/tertiary deethanizer feeds the propylene fractionation system, which consists of the propylene stripper and rectifier, in series. The overhead stream from the rectifier is totally condensed against cooling water, producing reflux and a liquid propylene product. The bottom stream, which is primarily propane, is vaporized and is recycled to the cracking furnaces.

Debutanizer
The debutanizer produces a mixed C_4 distillate product. The bottom stream is combined with the distillate stripper bottoms and sent to raw pyrolysis gasoline unit. The Debutanizer is reboiled with L.P. steam and condensed with cooling water.

Refrigeration
The cascaded refrigeration system has three levels of ethylene refrigeration and four levels of propylene refrigeration. The ethylene refrigerant is condensed against various levels of propylene refrigeration. The propylene refrigerant is condensed with cooling water. Refrigerant makeup is supplied by propylene/ethylene product.

C_4 Hydrogenation
The C_4 hydrogenation system is a liquid - phase catalytic process. The butadiene in the debutanizer net overhead - is selectively converted to n-butanes. Recycled back for cracking or used for separating various C_4 components in C_4 complex.

Gasoline Hydrogenation Unit (GHU)
The GHU consists of two stages. This process produces a feedstock for downstream aromatic recovery by selectively hydrogenating the diolefins in the first stage and the olefins in the second stage. The feedstock hydrodesulfurization also takes place during second stage.

The liquid feed from debutanizer bottoms is pumped under flow control to the unit and mixed with fresh makeup hydrogen. The mixed stream enters the 1st stage reactor after heating. The reactions (diolefins and styrene hydrogenation) occur in a mixed phase on the fixed bed type of reactor with two beds. Quench liquid injection between the bed limits the temperature increase.

The reactor effluent enters 1st stage hot separator. The vapor phase from the hot separator is cooled and partly condensed and then it enters the cold separator drum. The liquid from this drum with liquid from hot separator drum flows to the Depentaniser. The purpose of dependaiser is to stabilize the reaction liquid products by eliminating the light components, which have been dissolved under pressure. The second purpose is to separate C_5 cut from C_6 + cut.

C_5 cut is drawn as a side stream from the column and sent to battery limits after cooling. This C_5 stream is recycled back to furnace for further cracking with Naphtha/NGL. C_6 - stream flows to deoctaniser, which operates at slight vacuum, created by LMP steam ejector. Overheads from this column are partly condensed and fed to second stage

hydrogenation reactor. Wash oil is drawn as a side product and sent to wash oil tank after condensation and cooling for internal consumption. Bottoms from the column is C_9 + steam, which is sent to Battery Limits.
The feed to second stage is mixed with hydrogen from 2^{nd} stage recycle compressor & vaporized to reaction temperature prior to reactor entry. The reactions (hydrogenation of olefins and desulfurization) occur in the vapor phase on a fixed bed type reactor.

Ni - Mo type catalyst is used for hydrogenation and Co - Mo catalyst is used for desulfurization. The quench is provided between the two stages for temperature control of second bed. The effluents from the reactor are flashed in the second stage separator after cooling. The net liquid from separator is sent to stripper.

The stripper eliminates H_2S and light components dissolved at high pressure in the C_6 - C_8 cut. The bottoms are sent to battery limits after cooling as C_6 - C_8 cut product, which is further pumped for aromatics, recovery.

The double chamber incinerator will be designed on "controlled-air" incineration principle, as particulate matter emission is low in such incinerator. Minimum 100% excess air will be used for overall design. Air supply in the primary and secondary chamber will be regulated between 30% - 80% and 170% - 120% of stoichiometric amount respectively. The combustion air will be supplied through a separate forced draft fan after accounting for the air supplied through burners.

A minimum negative draft of 1.27 to 2.54 mm of WC (Water Column) will be maintained in the primary chamber to avoid leakage of gaseous emissions from the chamber and for safety reasons. Provision will be made in the primary chamber to measure the Water Column pressure.

The waste will be fed into the incinerator in small batches after the fixed interval of time and continuous charging using appropriate feeding mechanism.

The sides and the top portion of the primary and secondary chambers will preferably have rounded corner from inside to avoid possibility of formation of black pockets/dead zones.

The size of the secondary chamber will be properly designed so as to facilitate a minimum of one second of residence time to gas flow. For the estimation of residence time in the secondary chamber its volume will be calculated starting from the secondary burner tip to the thermocouple.

The refractory lining of the chamber will be strong enough to sustain minimum temperature of 1000° C in the primary chamber and 1200° C in the secondary chamber. The refractory & insulation bricks will have minimum 115 mm thickness each & conform to IS:8-1983 & IS:2042-1972 respectively.

The Incinerator shell will be made of mild steel plate of adequate thickness (minimum 5 mm thick) & painted externally with heat resistant aluminium paint suitable to withstand temperature of 250°C with proper surface preparation. Refractory lining of the hot duct will be done with refractory castable (minimum 45 mm thick) & insulating castable (minimum 80 mm thick). Ceramic wool will be used at hot duct flanges & expansion joints.

The thermocouple location will be as follows:

- In Primary chamber - Before admission of secondary air
- In Secondary chamber - At the end of secondary chamber or before admission of dilution medium to cool the gas

There will be a separate burner each for the Primary & Secondary chamber. The heat input capacity of each burner will be sufficient to raise the temperature in the primary and secondary chambers as 800±50°C and 1050±50°C respectively within maximum of 60 minutes prior to waste charging. The burners will have automatic switching "off/on" control to avoid the fluctuations of temperatures beyond the required temperature range.

- Each burner will be equipped with spark igniter and main burner.
- Proper flame safeguard of the burner will be installed.
- Provide view ports to observe flame of the burner.
- Flame of the primary burner
  - will be pointing towards the centre of the hearth.
  - will be having a length such that it touches the waste but does not impinge directly on the refractory floor or wall

The secondary burner will be positioned in such a way that the flue gas passes through the flame.

The waste will be charged in bags through automatic feeding device at the manufacturer's recommended intervals ensuring no direct exposure of furnace atmosphere to the operator. The device will prevent leakage of the hot flue gas & any backfire. The waste will be introduced on the hearth in such a way so as to prevent the heap formation. Suitable raking arrangement will be provided for uniform spreading of waste on the hearth.

A tamper-proof PLC (Programmable Logic Controller) based control system will be installed to prevent:

- Wastes charging until the required temperature in the chambers are attained during beginning of the operation of the incinerator.
- Waste charging unless primary & secondary chambers are maintained at the specified temperature range.
- Waste charging in case of any unsafe conditions such as - very high temperature in the primary & secondary chambers; failure of the combustion air fan, ID fan, recirculation pump; low water pressure & high temperature of the flue gas at the outlet of air pollution control device.

The incineration system will have an emergency vent. The emergency vent will remain closed i.e it shall not emit flue gases during normal operation of the incinerator.

Structural design of the chimney / stack will be as per IS:6533-1989. The chimney/stack will be lined from inside with minimum of 3 mm thick natural hard rubber suitable for the duty conditions and will also conform to IS:4682 Part I-1968 to avoid corrosion due to oxygen and acids in the flue gas.

The location and specification of porthole, platform ladder etc. will be as per the Emission Regulations, Part-3 (COINDS/20/1984-85), published by CPCB. The incineration ash will be disposed in a secured landfill.

Annexure XII

OCCUPATIONAL HEALTH SURVEILLANCE AT RELIANCE JAMNAGAR

1.Introduction

Reliance Industries Limited, Refinery division is a mega petroleum refinery comple located 30 K.M. from Jamnagar, where large number of employees and contractors ar working round the clock. Approximate population of company's township (Relianc Greens) is about 16,000. Apart from providing Occupational Health services to employee and contract workers, company also provide routine medical care to employees, thei family member's and guests. The refinery has been provided with medical facilities t attend to illnesses. The occupational health centre has been set up both in the refinery an township. These facilities/services will be utilized for the proposed SEZ, as well and wi be augmented as required.

2. Facilities / Equipments

Existing Occupational health centre is located in Reliance Greens (Township), having tot area of 52736 sq. ft. To cover occupational and family illness the following facilities ar available at Occupational Health Centre:

- OPD (Out Patient Dept.)

  Full time services of In-house physician, surgeon, gynaecologist, pediatrician an anesthetist; Round the clock services of Medical officer; Services c physiotherapist, dentist; Services of visiting consultants in various specialties
- IPD (In Patient Dept.)

  Total 20 beds: 8 single occupancy, 6 double occupancy, 3 ICU beds and 1 NICU bed
- ICU with multipara monitoring, central monitoring, defibrillator, ventilato syringe infusion pumps etc.
- Neonatal Intensive care unit (NICU) with warmer, phototherapy etc.
- Labour room: with foetal monitoring.
- Central oxygen, suction, compressed air and nitrogen supply.
- CSSD (Central Sterile Supply Dept.): with autoclave, water disinfector, ultrasoni cleaner, drier and ETO sterilizer.

- Titmus Vision Tester for eye checking.
- Laboratory services: with Randox auto analyser for bio-chemistry, Cell Dyne for hematology, Gas chromatography for urine phenol monitoring. Laboratory tests for all including blood sugar estimation, lipid profiles, liver and kidney profiles etc. can be performed with state-of-the-art equipment like Automatic Blood cell counter & Auto-analyzer.
- Other facilities: X-Ray, TMT (Tread Meal Test), 4D-USG with Colour Doppler for Sonography and 2-D Echo, ECG, Spirometer for Pulmonary function test, Audiometry booth and audiometer (for evaluating hearing loss), 24 hrs chemist and Fully equipped ICU ambulance, Nebuliser, Defibrillator-cum Cardiac Monitor, Pulse Oxymeter, Minor Operation Theatre, Ventilator, Separate decontamination room and observation beds with facility of online oxygen for each bed.
- Industrial Hygiene Cell**:** - To bridge a link between safety, health and environment, a separate industrial hygiene cell is established. A qualified industrial hygienist looks after personal monitoring of various health hazards, by walk through surveys, quantitative analysis etc. Various instruments to measure the same are procured, e.g. Wet Bulb Globe Temperature(WBGT) meter, noise level meter, noise dosimeter, air sampler, indoor air quality monitoring equipment, and illumination meter etc.

3. Occupational Health Monitoring

The main purpose of health monitoring is to detect possible onset of an occupational disease, to identify as early as possible any adverse health effects caused by work practices or exposure to potential hazards, to monitor personal exposure with the help of biological monitoring, for checking the effectiveness of preventive and control measures, for identifying possible health effects of changes in the working practices, technology or substances used in the refinery, to ensure right man for the right job, to prevent spread of communicable diseases through food handlers. Health examinations helps to identify conditions, which may make workers more susceptible to the effects of hazardous agents and to detect the early signs of health impairment caused by these agents.

Medical Monitoring at Reliance includes:-

- Pre-employment Medical Examination
- Periodic Medical Examination
- Special Medical Examination

3.1 Pre-Employment Medical Examination

Pre-employment medical examination is a statutory requirement and its conduction is an important function of an occupational health service. The purpose of pre-employment assessment is to ensure that a person has no pre-existing ill health or disability that may make the performance in the proposed job difficult or unsafe for the individual, co-workers, other employees and for the third parties like the visitors or customers, also to ensure that the proposed job does not cause a danger to health of the person himself/herself by aggravating his/her pre-existing health condition. The assessment is also used to provide baseline data for future comparison during Periodic Medical Examinations (PMEs). All prospective candidates are called to OH&FWC for pre-employment medical examination. Based on all reports, his/her fitness certificate is prepared and sent to HR.

3.2 Periodic Medical Examination

The purpose of periodic medical examination is to monitor the health of employees during the course of their employment. It aims at verifying fitness in relation to their jobs and early detection of any signs of ill health. It will be supplemented by other examinations in accordance with the nature of hazards observed for e.g. persons working in hazardous processes undergo half yearly medical examination; annual audiometry test is performed to those who are exposed to high noise areas. Periodic medical examination of all employees joined or transferred to site on or before 31st March is done irrespective of their cadre or type of job. A separate mail of PME Observation & Recommendation is sent to employees with their findings. A Health Card with brief details of PME is sent to individual employee through internal courier to their residential address

3.3 Special Medical Examination

Those employees who are exposed to either hazardous chemicals or processes will require more frequent medical examination than the others, with specific attention to certain parameters. Similarly some specific groups like food handlers, bus drivers and paramedical staff will also need more frequent medical examination. Special Medical examinations are carried out for following groups:-

3.3.1 Persons exposed to Hazardous Chemicals

Some persons may be exposed to hazardous substances (liquid/gaseous) like hydrogen sulfide, benzene, methanol, petroleum coke, crude oil etc during different processes in refinery. In addition to periodic medical examination they will be subjected to special examination of target organs like Respiratory system, Nervous system, Gastro-intestinal system, Optic nerve & Retina, Skin, Lungs, Bladder, and Hemophiliac etc depending upon the type of chemical exposure. Frequency of this check-up will be six monthly. Every six months data generated will be reviewed and appropriate steps will be taken. For e.g. all personnel handling benzene are monitored for benzene exposure. Based on shift schedule, a monthly schedule is made for urine sample collection by medical center and their urine samples are collected at the end of week shift. Urine phenol estimation and tt-MA (Trans, trans-Muconic Acid test) is done at medical laboratory.

3.3.2 Persons working in Noisy areas

In refinery there are certain areas where personnel are exposed to continuous noise. Though different measures have been taken during designing of the plant, and various protective devices are issued, occupational health hazards due to noise cannot be completely ruled out. In addition to periodic medical examination, employees exposed to continuous noise are subjected to audiometry test every year.

3.3.3 Employees >45 years of age

The likelihood of cardiac problems, hypertension, diabetes, increases progressively with age, hence special attention, including a more detailed investigation is required in this age group. More emphasis is given to: Eye sight and its problems, Status of heart, Stress test, Audiometry. Frequency will be once a year.

3.3.4 Food-Handlers

This group of workers is catering to a large number of employees. They may be one of the prime sources for spreading different communicable diseases, especially those food or water borne. The Health-card will be issued to the workers found fit. The worker will keep the card with him while on duty and will have to display it as and when required.

3.3.5 Drivers of Company Owned Cars / Hired Vehicles

This specific group of workers drives vehicles for the organization (both passenger and goods). Accidents put the employees and property at risk. To avoid such untoward incidents, their medical examination is done. Emphasis is given to vision (Colour & distant), hearing, history or signs of Heart Diseases, epilepsy, and any drug addiction. Crane operators also undergo task specific annual medical examination.

3.3.6 Paramedical Staff

While discharging their duties this group of workers is exposed to different communicable diseases, similarly if they are suffering from communicable disease they may pass it to the patient. Hence it is utmost important to screen them at regular intervals.

4.0 Curative Medical Care

Health Care during Construction

The construction of new Refinery complex is in progress where in thousands of workers are involved. It is of upmost importance to render medical services – both emergency and routine to take care of health of construction workers. All construction workers are examined for communicable diseases before assigning the job at the site as well as providing the accommodation in labour camps. The First Aid medical centres are provided in all labour camps and at the site with necessary required facility, 24 hrs a day. Dust masks are provided to construction workers, while carrying out operations that may entail potential for dust inhalation.

4.1 Project Medical Centre (PMC):

PMC is manned round the clock with availability of doctor, male nurse and an ambulance. PMC is equipped with emergency medical equipment and medicines to give primary medical treatment for any type of injury /acute illness. All medical data are entered in MDMS (Medical Data Management System). 3 additional ambulances are stationed at different locations at construction site to minimize the response time to an emergency call. These ambulances are equipped with basic life saving instruments and medicines. One male nurse along with walkie-talkie is deployed round the clock in these ambulances.

Pre- Placement screening

Contractor supervisors bring / direct new contract workers to Medical Inspection (MI) room, located at Shramik Swagat Kendra & before proceeding for safety induction. Contract workers are screened for any major communicable disease and referred to Moti Khavadi Medical Centre (MKMC) /Project Medical Centre (PMC) for further examination to determine his fitness by doctor. Based on doctor's fitness certificate, security pass is issued. Contractor's supervisor also ensures that such workers are seen by Labour Colony Medial Center (LCMC) medical officer before allocating him a room in labour colony. Workers free from communicable disease, are certified for the same by putting a stamp on a format submitted by contract agency and will proceed for further formalities.

4.2 Labour Colony Medical Center (LCMC)

Sufficient number of labour colonies is provided for workers and each labour colony have one medical centre with doctor, paramedic and necessary equipments. In addition to this, there is one medical centre at project site. It is important to provide medical services to all workers during their stay at labour colony as well as while on the job.

<u>Facilities Available</u>

- All routine medicines
- All emergency injections
- Treatment room: dressing table, oxygen cylinder, suction machine, laryngoscope with tube, autoclave machine, dressing material, suture material etc.
- Observation beds **–** nos. of bed will depend on strength of labour colony.
- Round the clock availability of paramedics
- Part time/Full time doctor
- Ambulance with necessary equipment (Major colonies will have their own ambulance. Smaller colonies will have Camp vehicle to shift patient)

5.0 Health Awareness & Training

CASHe (Change Agents for Safety, Health & Environment)

Reliance Management is always striving for excellence in each and every field. Hence to fulfill this dream, the CASHe Project (Change Agents for Safety, Health & Environment) was initiated as amongst many other initiatives to strengthen the HSE management system and culture. CASHe activities are in place since 2003. The biggest gain by the project was inculcating strong occupational health culture in the plant working area.

Various innovative ideas have come up from the shop floor workers in process design change, modification in PPE's etc. Implementation of various engineering controls and administrative controls have helped in reduction in exposure to majority of occupational health hazards like noise, heat, dust, chemical, vibration, illumination as well as ergonomics. Training and awareness drive is reflected in attitudinal change among workers regarding occupational health, safety and environment. CASHe activities at Jamnagar complex are recognized globally in terms of presentations in conferences and publication in international journal. Swedish experts on OS&H from the National Institute for Working Life (Stockholm) visited the CASHe Project areas. They appreciated the high level of OSH awareness and commended our achievements. Jamnagar site has won "**Dhirubhai Ambani Trophy for Excellence in Occupational Health**" for consecutive two years in a row. Won "**Golden Peacock Award for Occupational Health and Safety Award**" instituted by World Environment Foundation

First aid

A two days training under basic first aid training is given every month in which employees are taught on basics of emergency first aid and basic life support. Aim is to train all employees in basic first aid. Almost 500 employees are trained in a calendar year. Members of auxiliary fire squad are also trained in basic first aid. One day refresher training is given after 3 years. All electrical personnel are also trained for Cardio-pulmonary Resuscitation (CPR). A volunteers' group from first aiders – Auxiliary Medical Squad - is given practical training at medical centre.

Ergonomics

Ergonomics training is given to employees and contract workers wherein how to identify symptoms, workstation design & various exercises are taught to them.

Other Training

Life style management, stress management, understanding of health card, awareness of occupational health hazards etc. are some of training modules in which participants are informed about the specific subject. Health tips are published on intranet, house magazines. Every year in month of July, occupational health week is observed in which various health related activities are carried out for a week

Hygiene and Sanitation

The main objective for hygiene and sanitation is to protect employees, their dependants and labour from different water/ food borne diseases, to prevent epidemics of communicable diseases, to keep all workers healthy, to monitor potability of drinking water all over the project and the township. Pest control measures are taken at different places in Refinery and Township. For effective control of water-borne diseases, sanitary Inspector will randomly collect water samples every month for biological and chemical analysis. All canteens are also inspected once in a month.

6.0 Community Services

The Reliance, Jamnagar Complex processes as much as 30 million tons of Crude and associated Hydrocarbon products per annum. It employs several hundred personnel to work in various capacities in the plant. As a part of corporate social responsibility services, a community medical centre was established in nearby village – Moti Khavdi during the pre-commissioning stage of refinery well back in 1995. This Community Medical Centre caters free of cost, round the clock, comprehensive health services. All the above services will continue for proposed SEZ and the same will be augmented as and when required.

Mobile Van Clinic

The health centre operates "Health on wheels" through Mobile van clinic. One doctor accompanied by one nurse visits five villages namely Nani Khavdi, Meghpar, Gagva, Gagva gate & Padana – each twice a week. Patients are examined & free of cost medicines is dispensed. A step ahead health centre contributes in various national health programmes in its own way. Following is a summary of activities carried out.

REPRODUCTIVE & CHILD HEALTH ACTIVITIES

Family planning clinic

Target couples are advised to adopt either temporary or permanent family planning methods. Free distribution of condoms, oral pills & copper-T insertion is carried out here.

Antenatal clinic

On 1st Thursdays of every month antenatal mothers are examined thoroughly. Iron, calcium & folic acid are supplemented. Inj. Tetanus Toxoid is given & laboratory tests are done. All antenatal mothers having pregnancy of more than 5 months screened for gestational diabetes. To prevent neonatal tetanus in new born, safe delivery kit is given to all expecting mothers in case of home delivery. Health quiz for village ladies are organized time to time

Postnatal clinic

Postnatal mothers are given iron & calcium supplementation, pre-vaginal examination done for stitches. Breast feeding is promoted to lactating mothers.

Vaccination clinic

First Wednesdays of every month is fixed for vaccination in children against Vaccine Preventable Diseases like TB, polio, diphtheria, whooping cough, measles & tetanus. To prevent night blindness in children, syrup Vitamin –A is given to all children from 9 months to 5 yrs. of age

Pulse Polio Drive

Under National Pulse Polio Immunization programme, all children staying at Moti Khavdi Village, nearby villages, labour colonies, Township and surrounding vicinity are immunized with polio drops. With help of mass awareness campaign, group meetings, posters, audio- visual aids etc. 100% target (approx. 3500 eligible children in each round) is achieved for all the rounds.

Other

To be fathers are counseled (Couple counseling) to take care of their better half to restrict physical activities & dietary supplementation during antenatal & postnatal periods. “Saas Bahu samelan” (Mother in law & Daughter in law meeting), are organized to reduce barrier between two generations regarding gender bias & family planning.

CAMPS & OTHER ACTIVITIES

Blindness prevention programme.

- Vitamin A supplementation is given to all children in age group of 9 months to 5 yrs 6 monthly.
- Started cataract surgery to the patients free of cost.
- Eye care clinic is started in which renowned eye specialist renders her services.

School health check up camp

Every year school children are examined for refractive eye error, congenital defects, night blindness, etc.

Community Reproductive Child Health (RCH) Clinic.

A weekly clinic is started at nearby Primary health centre (PHC) at Village Padana, where eminent gynecologist and pediatrician give medical services to the village women and children. Medicines are also distributed free of cost.

Multi-diagnostic camp

Every year one multi-disciplinary diagnostic & treatment camp is organized for community people in which large no. of patients are treated. Eye camps, dental camp, Thallassemia screening camp are also done regularly in which free diagnosis, treatment, cataract surgery, spectacles are provided.

Audiovisual camps

On various topics e.g. Hygiene, diarrhea & diet, antenatal care, family planning, AIDS, Tuberculosis etc. are carried out.

De-addiction camp

Tobacco, panmasala is an addiction in school going children & villagers.

First aid training

The programme is designed to create awareness among the villagers & to make them aware of actions to be taken during emergency situations. Till date villagers from Moti Khavdi, Sikka, Padana, Meghpar and Setalus are trained in safety and first aid.

Directly Observed Therapy (DOT) & HIV / AIDS CENTRE, Motikhavdi

At Moti Khavdi Community Medical Centre (MKMC), DOT & HIV/AIDS centre has became functional from 1st October, 2004 Since inception of DOT center (Oct 2004) and HIV/AIDS awareness Drive (Sep 2004), more than 23,000 people are contacted one to one. Total 26 street plays, 231 group meetings are conducted till date. By rapid method, 367 persons are examined for HIV, of which 5 are found positive. They are directed to Guru GovindSingh Hospital (GGH) for further management. In the clinic, 569 patients are treated for Sexually Transmitted Diseases. Of 2423 patient examined for sputum, 32 were detected for TB. Total 33 (including from transferred from other DOTs) have already completed the treatment. The center has organized lectures, seminars, and street plays for the migrant labor, truck drivers etc. Large quantities of condoms and literature have been distributed.

7.0 Emergency and Admission Services

Emergency Department at Occupational Health & Family Welfare Centre is one with facilities of international standards. The emergency department is staffed round the clock medical officers and registered nurses. They provide care using state-of-the-art equipments and advanced patient monitoring systems to respond to any medical situation.

Emergency Services are applicable to:-

- All work related accidents involving employees, agency staff, contractors and company's guests.
- All domestic accidents and non-accidental medical emergencies like- cardiac, acute abdomen, Heart Attack, surgical emergencies, Status Asthmaticus (severe form of Bronchial asthma), etc. of employees, their dependents, their relatives, and residents of township other than employees.
- As a part of community service, Reliance provides emergency medical care to the victims of roadside accidents occurring in the neighbourhood of the refinery, where the other hospitals/ medical facilities may be far-off.

8.0 Proposed Occupational Health Surveillance for SEZ

As can be seen a well established infrastructure with experienced doctors, paramedics, occupational health personnel and systems are already in place to cater to the existing refinery complex and the new refinery complex under construction. The same approach and systems will be used for occupational health surveillance in the proposed petrochemical SEZ also. This will call for suitable augmentation of the existing infrastructure and manpower. As the expertise is already available with Reliance in this area, augmentation can be carried out to remain best in the industry.

Annexure XIII

Safety Management System

Introduction

We at Reliance believe that good HSEF performance is an integral part of efficient and profitable business management. Therefore, at Reliance we tend to improve our Health, Safety, Environment and Fire protection performance on a continuous basis and in a sustainable way i.e. meeting needs of present without compromising the ability of future generations to meet their needs. Our commitment to these values and beliefs is reflected in the guidelines laid down in our policy statement.

RIL has established a well-structured system, policy and procedure that govern Health, safety, environment and fire protection functions at Reliance Jamnagar Complex. The document covers the planning, organization, implementation and control of the health, Safety environment and fire protection functions. Environment Management System in line with the ISO 14001 Standards. Safety management system is in line with the OHSAS-18001.

Hazard Identification and risk assessment of various activities in each section of the refinery and their interaction with the different risks related to work place environment was carried out systematically as per guidelines of OHSAS-18001. Hazard Identification of all activities was carried out and the risks related to each activity were evaluated. Based on the evaluation and the criteria decided, all the risk were rated as high, medium or low. The objective was to determine the priority base for action to reduce the risk to as low as reasonably practicable. Additional safety controls were implemented and safety procedures developed to reduce the risk level to low. Safety Management programmes has been developed for critical activities.

Training and awareness programs are conducted for all employees and contractors on the various aspects of the OHSAS-18001 by external (M/s LRQA) and internal faculties. All operators and junior management grade undergo Refresher training on yearly basis and middle management and top management level undergo once in two year as a rule.

Plans and Procedures

A large number of industrial accidents and mishaps have occurred all over the world due to human errors and the main cause of these errors has been the lack of written procedures and/or non-compliance of the same. Keeping this in view number of procedures have been written, approved and documented for compliance in the complex. These procedures are developed broadly based on process safety management system (PSM), which is a well-known framework of HSE management all over the world. The procedures developed by us address the main elements of PSM as listed below:

- Process technology / information
- Process hazards analysis
- Operating procedures
- Work permit system
- Management of change
- Personnel training and validation
- Contractor safety
- Incident investigation and communication
- Emergency planning and response
- Auditing
- Pre - startup safety review
- Risk Assessment

Documents developed by HSEF Department

Various procedures, plans and policies concerning health, safety, environment and fire protection activities prepared for complex are documented in the HSE manual which consists of four parts,

- Management Systems & Plans
- Occupational Health and Environment
- Safety
- Fire Protection

In addition to the above four parts of HSEF Manual, Major Emergency Management Plan (Onsite Emergency Plan) Oil Spill Response Plan and Emergency Plan for War or Warlike Situations have also been prepared. Some of the procedures prepared are listed below:

Management Systems and Plans

HSE Management System	HSE - S 101
HSE Training Plan	HSE - S 104
Environment Management Plan	HSE - E 101
HSE Awards Policy	HSE – S 105

Safety

Basic safety rules for Employees, Contractors &Visitors	HSE - S 103
Safety Districts and Committees	HSE - S 106
Safe Work Permit System	HSE - S 201
Pre-start up safety review	HSE - S 202
Safety Audits	HSE - S 203

Safe Transportation of Hazardous Materials by Road	HSE – S 204
Personal protective equipment	HSE - S 205
Safe handling of hazardous substances	HSE - S 206
Management of plant changes	HSE - S 210
Procedure for PHA / HAZOP	HSE - S 211
Incident reporting & Investigation	HSE – S 213
Safe use of Hoses	HSE – S 216
Electrical safety	HSE – S 220
Ionization Radiation safety	HSE – S 221
Traffic safety	HSE – S 222
Safety of Contractor Personnel	HSE – S 223

Emergency Plans

Emergency Response and Control Procedure (On-site Emergency Plan)	HSE – S 229
Oil Spill Response Plan	HSE – E 102
Emergency Plan for War or Warlike Situation	HSE – S 240

HSEF Audits

Periodically, Health, Safety, Environmental programs and Fire Protection including management systems, require a thorough audit to exercise proper control. Audits are conducted periodically on the systems, procedures, and operational aspects to ensure that a desired level of health, safety and environmental standards are maintained as per the requirements of company policy and statutory norms.

Major objectives of the audits are:

- Ensure that all statutory requirements are met fully and extended to new facilities and changes.
- Ensure that set procedures are complete, up-to-date and compliant with applicable standards, codes, company policies, good engineering, and process safety practices.
- Ensure that the management systems in place are effective in assuring that the company and plant policies and procedures are being implemented.
- Identify opportunities where the systems and procedures can be strengthened.
- To check on training and preparedness for handling emergencies
- Cater to public opinion and concern for safe environment.

Various safety audits like two member and Procedure Compliance audits are conducted by an independent two member and three member teams in all plants in order to verify the compliance to Work Permit system, Contractor Safety, Scaffoldings, Portable electrical tools, Personal Protective Equipment and Housekeeping. Mobile crane safety audit also started as a part of the procedure compliance audit. The ratings in the audits are counted for quarterly safety performance competitions.

HSE Committees

Committees are excellent forums to promote health, safety and environment in any type of organization. These committees play a vital role in making health, safety and environment activities an integral part of operating policies and practices. HSE committees help the employees to recognize that their co-operation is essential for safe operation of the complex.

Considering the nature and magnitude of the operations, three tier HSE committees have been set up in our organization. These are:

- Apex Committee
- Central Safety Committee
- District Safety Committees (24 nos.)

The objective of these committees is to promote co-operation among the employees and the management in maintaining proper safety, health and environment at work and to review periodically the measures taken for improving the same. Document HSE - S 106, 'Safety districts and committees', provides the guidelines on formation, scope, composition, responsibilities and functioning of these committees.

Apex Committee

Apex Committee is the highest body of the management of Reliance Industries Limited. Daily Apex meetings in Management Control Cockpit (MCC) are started with review of previous day's HSEF incidents, Fire & Gas alarms, reliability issues, etc. The meeting is chaired by the Site President, coordinated by Site Shift Manager and is attended by Chief of HSEF.

Central Safety Committee

Central Safety committee is the body consisting of senior management personnel from Operations, Manufacturing Services and Support Services which advises the management on all aspects of Health, Safety, Environment and Fire Protection. Regular meetings are held to review the Health, Safety Environment and Fire Protection performances in the whole complex.

District Safety Committees

Each safety district shall have a District Safety Committee which consists of representatives from both management and employees. The District Safety Committee is an advisory body on the safety, health and environmental issues related to the particular district. This committee also fulfils the goal of employee's participation in safety management as envisioned in Factories (Amendment) Act; 1987.These committees play a vital role in highlighting the problems that are specific to the respective districts.

HSEF Promotional activities

Health, Safety Environment and Fire Protection promotion activities are planned to improve the awareness of Health, Safety, Environment and Fire Protection programs among the employees and to clearly exhibit management's commitment and concern towards Health, Safety, Environment and Fire Protection issues. Following are the few activities that are carried out on a regular basis to promote awareness on health, safety and environment issues.

- Celebration of National Safety Day - 4th March
- Celebration of Fire Services Day - 14th - 17th April
- Celebration of World Environment Day - 5th June
- Celebration of Traffic Safety Week - 2nd Week of March
- Celebration of World AIDS prevention Day
- Safety Competitions like, Slogan writing, Poster painting, Essay writing, Case Study Presentation, etc.
- Health and fitness camps / campaigns.

Special HSEF learning Programmes / Self Development Modules

Self Development Module is the concept to identify and improve the individuals learning needs and upgrade their knowledge in various elements. Some of the HSEF knowledge elements have been identified for each job position under this system. The individual employees will identify their learning needs of HSEF elements. Therefore to enhance the knowledge of the employees under the SDM system and also to give focus on special issues need based Learning programmes have been identified and made.

Safety Initiatives

- In line with the Reliance Commitment, **"Reliance shall strive to be a leader in the field of management of Health, Safety and Environment",** Jamnagar site has taken several initiatives to improve its safety performance to move towards the adoption of the best practices and the ultimate achievement of a zero incident safety performance. The Safety management improvement program is one of such initiatives which is focused on improving the procedures and culture of the organization. A prioritized schedule has been prepared which, to begin with, focuses on the key areas of Incident investigation, corrective actions tracking, contractor safety management, major hazard management and safety audit.

- Reliance group has engaged ***DuPont Safety Resources*** as a strategic partner in our pursuit of excellence in Health, Safety and Environment. As a part of this engagement for creating **World class Safety Culture,** restructuring of the Central HSEF Committee was being done through formation of various Sub-committees which focuses on specific safety functions/aspects.

- A project titled **"Change Agents for Safety, Health and Environment (CASHe)"** was initiated in all the units of Jamnagar refinery complex. This pilot project is meant to promote a culture of addressing all occupational health issues (i.e. noise, heat stress, ergonomics and dust) at the plant level by plant personnel themselves.

- **HSEF training** remains a major forte at Reliance, Jamnagar to further the cause of safety. All personnel joining the Jamnagar Refinery Complex undergo intensive fire & safety training. Regular refresher training is also conducted for all employees every year. Continuous, systematic education of Company's contractors and transporters personnel is done for ensuring safe work practices. Special awareness and training programs are also conducted before taking up a major shutdown, in the areas of job specific risk assessment, hazards of toxic gases and pyrophoric material, mechanical isolation and scaffolding. Work permit workshop which was started last year was continued for permit issuers / acceptors. External faculty is also invited to give specialized inputs in Process Safety, Noise Monitoring and Traffic Safety.

- To ensure all critical factors involved in an incident are determined through scientific investigation and key factors are identified to derive the corrective steps which will eliminate recurrences. With a special focus that all incidents are reported and investigated within the stipulated time at RIL Jamnagar ***on- line system named as "iRIL"*** has been developed and made effective for reporting incidents including near misses from April 2008.

- Developed and implemented structured Reliance Safety observation Process (ReSOP) with intent of capturing the safe and unsafe observations. ***ReSOP Portal*** was developed which enables tracking of all such observations with effective from Feb 2008.

- A document driven ***Process Technology Portal (PT) portal*** has been developed for easy retrieval and tracking of process safety documents from June 2008. This portal covers major areas of process Safety viz. Hazards, Process Design and Equipment Design etc.

- In order to enhance the safety skills within the management executives, two batches of HSE line management workshop was organized. Several senior management personnel attended the program which was conducted by Shell Safety expert.

- **Control Of Substances hazardous to health (COSHH)-** In bid to help employees to effectively control exposure of hazardous substances in the work places, COSHH assessment for various chemicals has been carried out. Simple advice in form of Do's & Don'ts in the workplace has been displayed at all location where chemical is being handled.

  An intranet portal titled "CHIP"-Chemical Hazard Information Portal has been developed in-house and launched. This portal is readily accessible to all Reliance Jamnagar site employees & other Reliance group companies. It contains various safety information for over 400 hazardous chemical handled at Jamnagar. This includes one page MSDS, standard MSDS, COSHH assessment sheet, First Aid, Do's and Don'ts, TREM Card, COSHH risk Criteria etc., for ready reference and use.

- **Safety issues** are continuously communicated to all employees at all levels through the use of printed news letters and electronic media in the form of HSE flash, HSE vision, Reliance News, What Went Wrong, Learning from incidents , Chemical Incident Report Centre, etc.

- **Community awareness** programs are conducted regularly in nearby villages, covering topics such as, safety in LPG cylinder handling; basic fire fighting & first aid; actions to be taken in case of a gas leak etc. More than 500 persons were have benefited form the training so far.

AWARDS

- British Safety Council Five Star Audit was conducted in the year 2003. The site was conferred with prestigious **"Five Star "** rating for its Health and Safety Management System.

- The Baroda Productivity Council also conferred the **"Best House Keeping Trophy"** for the excellent house keeping efforts for the year 2002-03, 2004-05 and 2006-07.

- British Safety Council awarded the "**International Safety Award 2004**" to Reliance, Jamnagar for its firm & demonstrated commitment to health & safety plans for making safety an important feature of every day work practice.

- Reliance Jamnagar site recertified for **OHSAS-18001** by LRQA for its Occupational health and Safety management system compliance in Sept'2008.

- Greentech Golden Safety Award 2005-06 by Greentech Foundation, New Delhi

- Golden Peacock Award for Occupational Health and Safety by World Environment Foundation, New Delhi for Year 2007

Abbreviations

EIA	Environmental Impact Assessment
SEZ	Special Economic Zone
PVA	Poly Vinyl Acetate
JERP	Jamnagar Export Refinery Project
MEG	Mono Ethylene Glycol
DEG	Di Ethylene Glycol
TEG	Tri Ethylene Glycol
LLDPE	Linear Low Density Polyethylene
SAP	Super Absorbent Polymer
PP	Polypropylene
SBR	Styrene Butadiene Rubber
PBR	Poly Butadiene Rubber
MA	Maleic Anhydride
PX	Paraxylene
OX	Orthoxylene
PTA	Putrefied Teraphthalic acid
PET	Polyethylene Tera-phthalate
POY	Polyesters Complex Polyester Oriented Yarn
PSF	Polyester Stable Fiber
HRSG	Heat recovery steam generation
AAQM	Ambient Air Quality Monitoring
SPM	Single Point Mooring
ATF	Aviation Turbine Fuel
MMTPA	Million Tons per Annum

FCC	Fluid Catalytic Cracker
CCR	Continuous Catalytic Regeneration
SWS	Sour Water Stripper
STGs	Steam turbine generators
MTF	Marine Tank Farm
NMHC	non-methane hydrocarbons
HTDS	High Total Dissolved Solids
LTDS	Low Total Dissolved Solids
VLCC	Very Large Crude Carriers
GPCB	Gujarat Pollution Control Board
MoEF	Ministry of Environment and Forests
IEA	International Energy Association
MoPNG	Ministry of Petroleum and Natural Gas
MBPD	Million Barrel Per Day
APM	Administered Price Mechanism
GSFC	Gujarat State Fertilizer Corporation
GEB	Gujarat Electricity Board
RCO	Reduced Crude Oil
GAIL	Gas Authority of India Limited
TIS	Tank Information System
BOSS	Blending, Optimisation and Supervisory System
DCS	Digital Control Systems
LRS	Lloyds Register of Shipping
TAC	Tariff Advisory Committee
EMP	Environmental Management Plan
GT	Gas Turbines
OMIS	Oil Movement Information System
CPCB	Central Pollution Control Board

NMHC	Non-Methane Hydrocarbons
CBDS	Closed Blow Down System
IRS	Indian Remote Sensing
NOAA	National Oceanic and Atmospheric Administration
UNEP	United Nations Environmental Programme
USGS	United States Geological Survey
LISS	Linear Imaging Self Scanner
FAO	Food and Agriculture Organization of United Nations
IAS	Image Analysis System
GIS	Geographic Information System
UNEP/EAP-AP)	UNEP Environmental Assessment Programme for Asia and the Pacific
NRSA	National Remote Sensing Agency
SOI	Survey of India
DIP	Digital Image Processing
NIR	Near Infra Red
SWIR	Short Wave Infra Red
NEERI	National Environmental Engineering Research Institute
SMML	Sulakshani Mines and Minerals Limited
GPS	Global Positioning System
CSIR	Council of Scientific and Industrial Research
EIRA	Environmental Impact and Risk Assessment
ITDA	Integrated Tribal Development Authority
RJIL	Reliance Jamnagar Infrastructure Limited
JERP	Jamnagar Export Refinery Project