INDIAN OIL CORPORATION LIMITED

Rapid Risk Assessment (RRA) Report

For

Implementation of BGR INDMAX project associated with
BGR crude processing capacity enhancement from 2.35 to 2.7 MMTPA,
DHDT capacity enhancement from 1.2 to 1.8 MMTPA,
CRU-MSQ revamp & Implementation of SDS unit
At
Tehsil : Sidli (PT-II), PO: Dhaligaon, District: Chirang, Assam.

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AN ISO ISO 9001:2008, ISO14001:2004 & OHSAS 18001:2007 certified
Environmental Engineering and Consultancy Organization
(NABL Accredited & MoEF Recognised Environment Laboratory)
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Introduction

Chapter 1

INTRODUCTION

1. Introduction

Bongaigaon Refinery (BGR) is the eighth operating refinery of IOCL, formed upon the amalgamation of Bongaigaon Refinery & Petrochemicals Limited (BRPL) with Indian Oil Corporation Ltd. (IOCL) on March 25, 2009. Bongaigaon refinery is situated at Dhaligaon in Chirang district of Assam, 200 km west of Guwahati.

Bongaigaon Refinery (erstwhile BRPL) was commissioned in year 1979 with crude processing capacity of 1.00 Million Metric Ton Per Annum (MMTPA). The crude processing capacity was further increased to 1.35 MMTPA in 1986. Presently, the Refinery has two Crude Distillation Units (CDU) having total crude processing capacity of 2.35 MMTPA, two Delayed Coker Units (DCU) and a Coke Calcination Unit (CCU). The refinery has implemented Diesel Hydrotreatment (DHDT) project and MS Quality Improvement (MSQ) project in the year 2011. For the first time in India, technology indigenously developed by M/s IOCL (R&D) and Engineers India Limited (EIL) was adopted for these two projects.

As per the declaration of Government of India dated 6th January,2016, it was proposed to implement BS-VI grade fuel in the entire country w.e.f. 1st April 2020 i.e. by switching over directly from BS-IV grade fuels to BS-VI grade fuel. Thus, it is imperative to upgrade the Refinery for the production of BS-VI grade fuels by inducting suitable new units and revamp of exiting units.

The present crude processing capacity of BGR is 2,350,000 TPA of Assam Crude Oil and Low Sulphur Imported Crude Oil. In view of the Auto-Fuel Policy Vision 2025, the Refineries will be required to supply fuels meeting the BS-IV specification fuels by 1st April 2017 and BS-V/VI specification by 1st April, 2019.

In order to meet the requirement of BS VI Fuel demand, following projects at BGR are proposed for implementation.

- Crude processing capacity enhancement from 2.35 MMTPA to 2.7 MMTPA
- DHDT capacity enhancement from 1,200 TMTPA to 1,800 TMTPA to meet BS-VI HSD specification.
- HGU revamp for capacity augmentation by 25% (75 TMTPA to 94 TMTPA)
- CRU-MSQ revamp to meet BS-VI MS specification.
- INDMAX Project along with Indmax Gasoline De-Sulphurisation Unit.
- MSQ NHT
- Selective Desulphurisation (SDS) Unit.
- Amine regeneration unit (ARU)
- Sulfur recovery unit

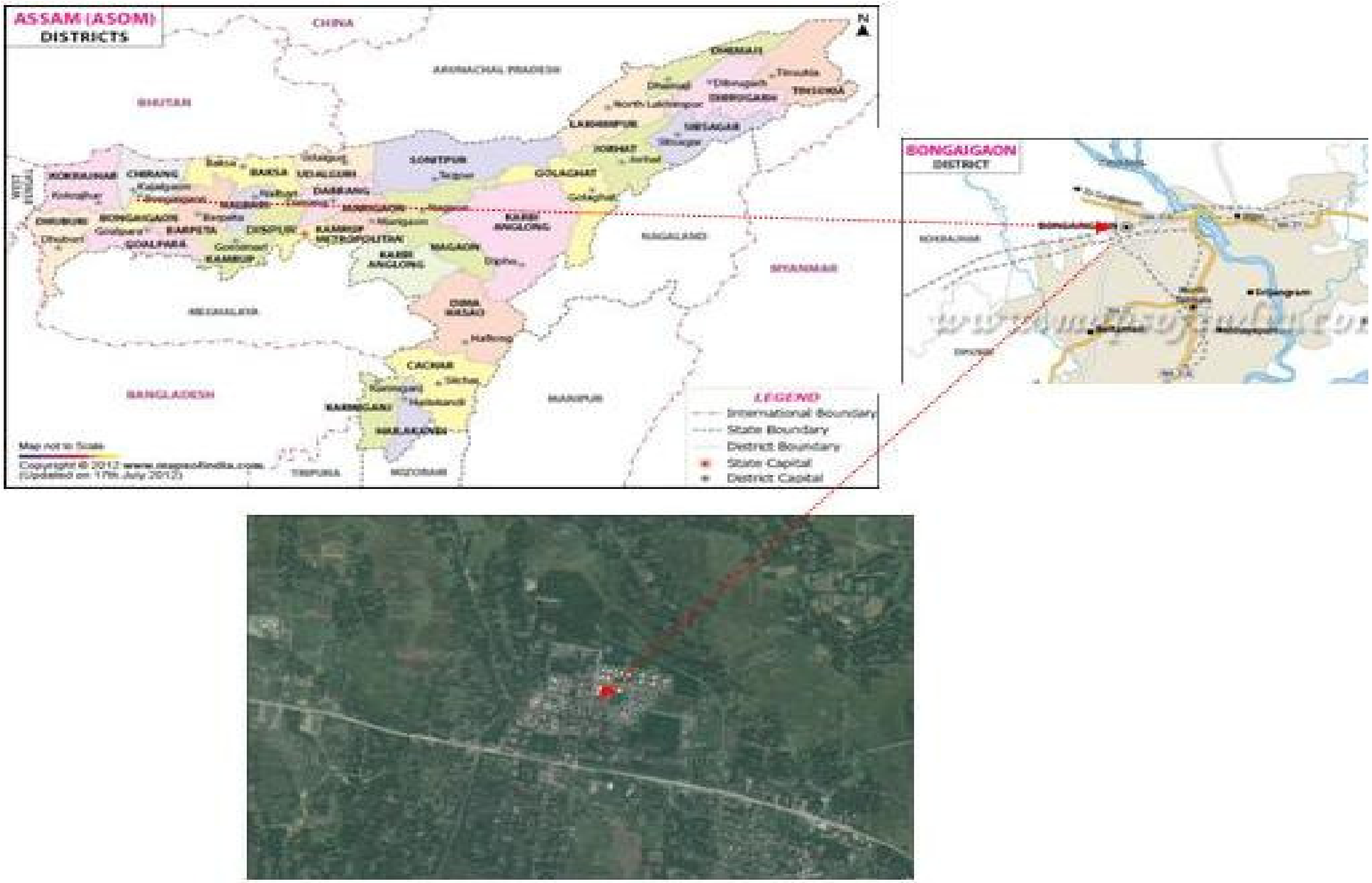

Figure 1: Location Map of the project site

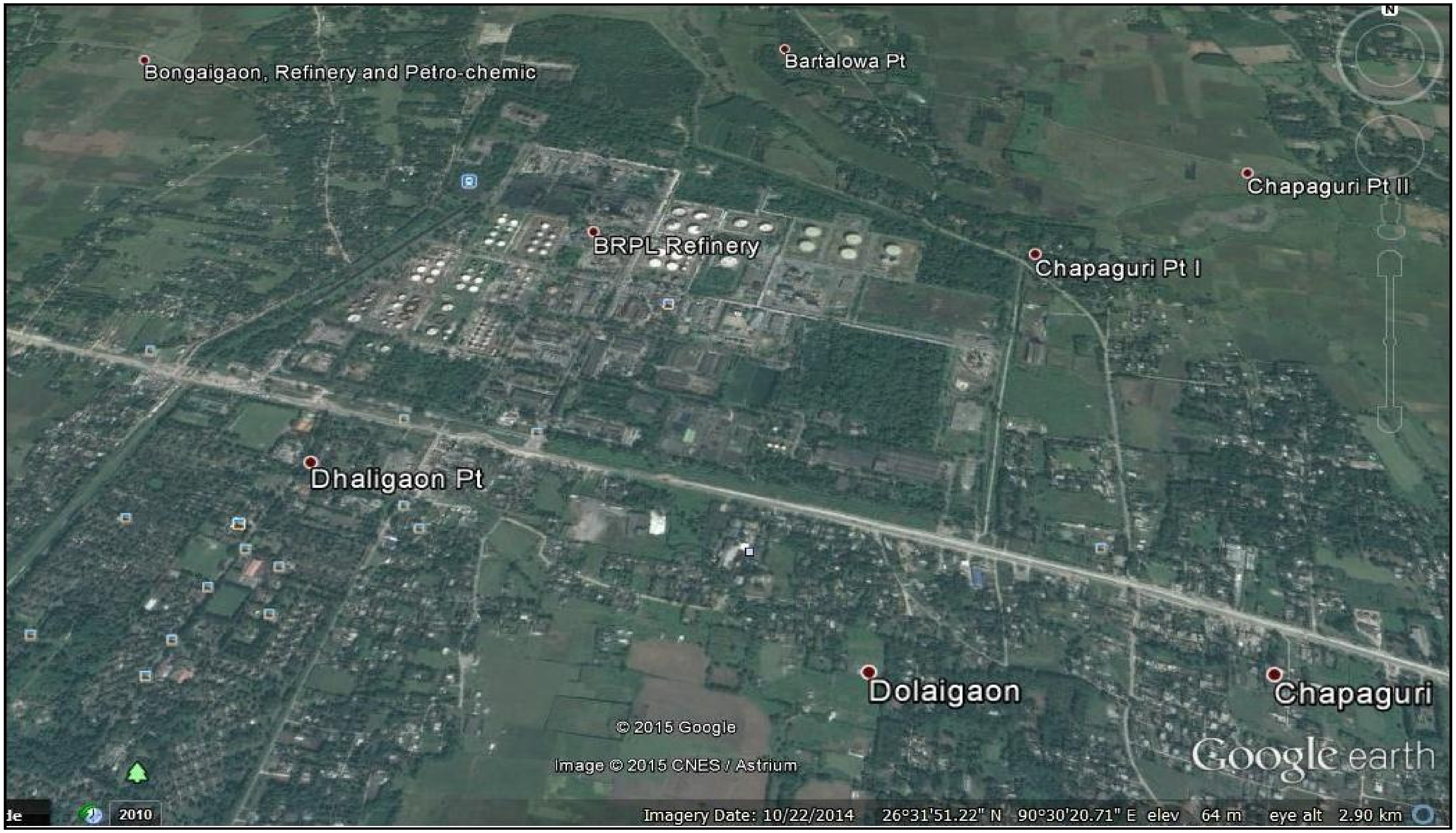

Figure 2: Satellite Image of the BGR Refinery

Chapter 2

Process Description

Chapter 2

PROCESS DESCRIPTION

2.1 Introduction

As per the declaration of Government of India dated 6th Jan'16, it has been proposed to implement BS-VI grade fuel in the entire country w.e.f. 1st April 2020 i.e. switching over directly from BS-IV grade fuels to BS-VI grade fuel. Thus it is imperative that the refinery up gradation should consider the production of BS-VI grade fuels by inducting suitable new units and revamp of exiting units. In this regards BGR is expanding, revamping its units.

The above proposed plant capacity enhancement are mentioned below:

- Crude processing capacity enhancement from 2.35 MMTPA to 2.7 MMTPA
- DHDT capacity enhancement from 1,200 TMTPA to 1,800 TMTPA to meet BS-VI HSD specification.
- HGU revamp for capacity augmentation by 25% (75 TMTPA to 94 TMTPA)
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- INDMAX Project along with Indmax Gasoline De-Sulphurisation Unit.
- MSQ NHT
- Selective Desulphurisation (SDS) Unit.
- Amine regeneration unit (ARU)
- Sulfur recovery unit

2.2 Needs of Capacity Enhancement

The present crude processing capacity is 2,350,000 TPA of Assam Crude Oil and Low Sulphur Imported Crude Oil. In view of the Auto-Fuel Policy Vision 2025, the Refineries will be required to supply fuels meeting the BS-IV specification fuels by 1st April 2017 and BS-V specification by 1st April, 2020.

The project being proposed is important in view of the demand of HSD. The BS-VI will bring down the Nitrogen Oxide emissions from diesel cars by 68 % and 25% from petrol engine cars. Cancer causing particulate matter emissions from diesel engine cars will also come down by a phenomenal 80 %. Therefore this project has national importance and will also contribute to the socio economic development the region. IOCL has proposed to implement new technology, revamp and enhance capacity of the units.

2.3 Project Location

The location of capacity enhancement project on Google satellite image and surrounding area is shown in Figure -1 and Figure -2

IOCL Bongaigaon Refinery, is located at Tehsil: Sidli Part II, Revenue survey no. 450, Dhaligaon, Chirang District, Assam State, India. The Plot plan is shown ahead.

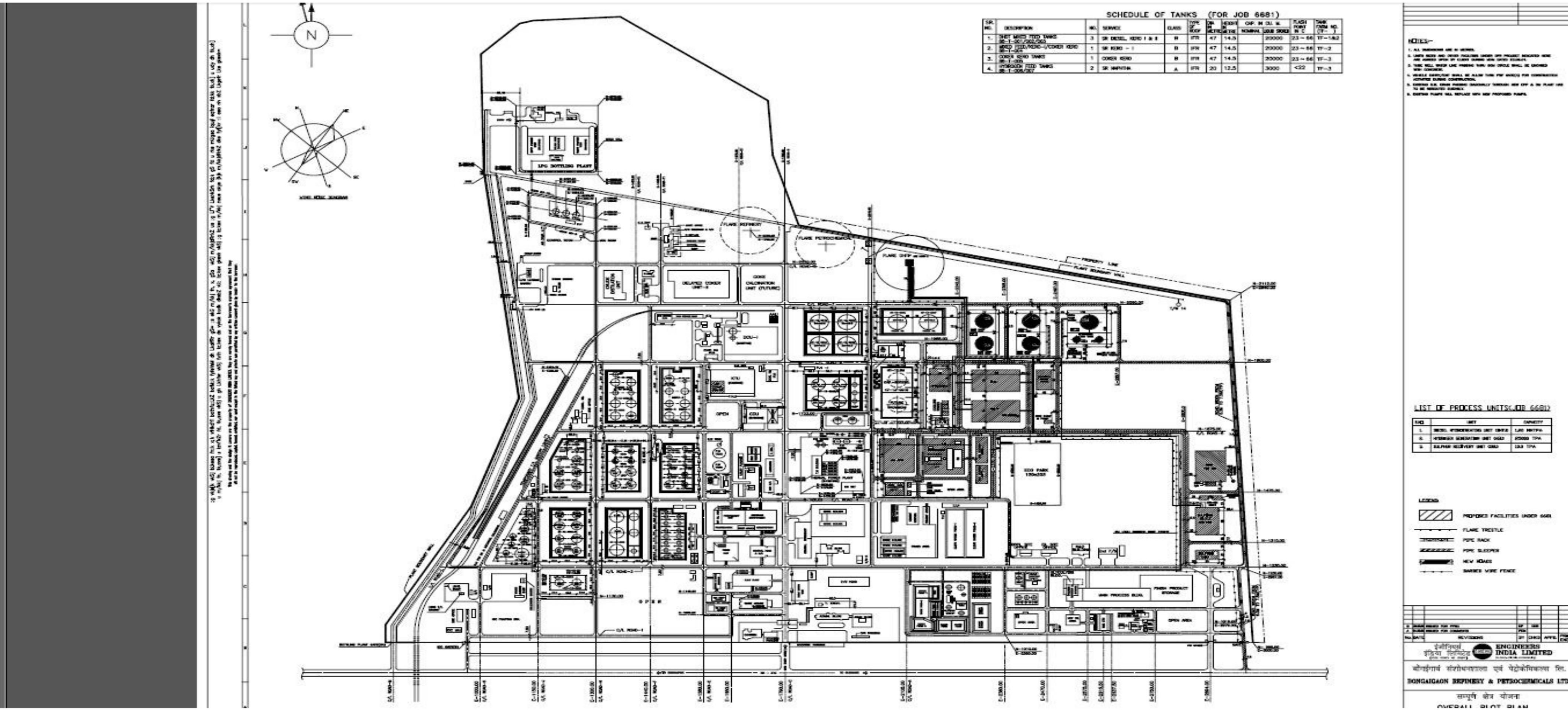

Figure 2.2: Plot Plan of Bongaigaon Refinery

2.4 Manufacturing Process Details

2.4.1

[I] <u>Crude Processing Capacity Enhancement:</u>

Presently crude processing capacity of BGR is 2.35 MMTPA having two Crude Distillation Units (CDU)

- CDU-I having nameplate capacity of 1.35 MMTPA
- CDU-II having nameplate capacity of 1.00 MMTPA

-

After OIL crude pipeline HBCPL capacity enhancement from 7.5 to 9.2 MMTPA, crude availability to BGR will be 2.7 MMTPA.

To process crude of 2.7 MMTPA at BGR, it is proposed to increase the nameplate capacity of CDU-II unit from 1.0 MMTPA to 1.35 MMPTA. No additional facility is required for this project.

2.4.2

[II] <u>DHDT Capacity enhancement project to meet BS-VI HSD specification:</u>

Bongaigaon Refinery proposes DHDT Capacity enhancement to implement Project” (from capacity of 1,200 TMTPA to 1,800 TMTPA) at its existing refinery complex. BGR can supply BS-IV HSD as per the deadline of the Auto Fuel Policy. However, in order to supply BS-IV HSD at the same quantity of HSD being produced presently may not be possible due to reduction in back blending of HSD components due to capacity limitation of the existing DHDT unit.

Salient features of the proposed project:
Project objectives: The objectives of the project are as follows:

- The refinery has to produce BS-VI HSD at the current level of BS-III HSD production without reducing crude throughout

Facilities: The following changes are envisaged in the capacity expansion of DHDT unit.

a) Additional feed pump
b) Additional feed effluent exchangers
c) Revamp of recycle gas compressor
d) Furnace tube size change from existing 6" to higher size to reduce the high pressure drop. Changes in the firing side of the furnace is not anticipated as the furnace thermal loading was only around 65% at 126% load
e) Change of around 12 control valves to higher sizes.
f) Change in internals of stripper & stabilizer columns
g) Change in over head exchangers of stripper & stabilizer.
h) Change in piping can be estimated during detailed engineering.
i) One new fractionating column for continuous production of ATF & HSD from the present blocked out mode operation.
j) Partial change of catalyst with a bed of hydro-cracking catalyst in the last reactor to have

improvement in 95% recovery

k) Offsite transfer pumps
l) Installation of Hot Separator.

The DHDT unit of BGR is designed to process 1,200 TMTPA of HDT feed with balance 25- 30 % directly back blended to HSD. The diesel produced ex-DHDT unit meets BS-V specification, specially the stringent sulfur specification of 10 ppm. However, in BS-VI regime, the total quantity of HSD feed streams will have to be processed via DHDT unit to meet the sulphur and Cetane specification of BS-VI HSD.

In order to sustain HSD production at the existing level under BS-VI scenario, the capacity of the DHDT plant is required to be increased to 150% of the existing capacity i.e. to 1,800 TMTPA from the existing level of 1,200 TMTPA to process all available diesel feed streams.
In order to have clarity the HSD specifications for BS-III, BS-IV & BS-VI HSD is tabulated below:

Table no.2.1: Specification of Diesel

SPECIFICATIONS OF DIESEL					
S. No.	**Attribute**	**Unit**	**BS-III**	**BS-IV**	**BS-VI**
1	Density @15°C	kg/m^3, max	820-845	820-845	820-860
2	Distillation T95	°C Max	360	360	370
3	Sulphur	ppm max	350	50	10
4	Cetane No	min	51	51	51 (For NE states, CN requirement till 1st April 2023 shall be min 48)
5	Cetane Index	min	46	46	46
6	Flash Point	°C min	35	35	42
7	Viscosity @ 40°C	cSt	2.0-4.5	2.0-4.5	2.0-4.5
8	PAH	% wt max	11	11	11
9	Total Contaminants	mg/Kg max	24	24	24
10	RCR on 10% Residue	% wt max	0.3	0.3	0.3
11	Water Content	mg/Kg max	200	200	200
12	Lubricity, Corrected Wear Scar Diameter (WSD) @ 60°C	Microns, max	460	460	460
13	Ash	% wt max	0.01	0.01	0.01
14	Cold Filter Plugging point				
14 a)	Summer Max	°C	18	18	18
14b)	Winter Max	°C	6	6	6
15	Oxidation Stability	g/m^3 max	25	25	25
16	Copper Strip corrosion for 3hrs @ 50°C, max	Rating	Class 1	Class 1	Class 1

2.4.3

[III] CRU-MSQ Revamp to meet the BS-VI MS specification:

Bongaigaon Refinery proposes to implement the CRU-MSQ “revamp project”. In order to meet the aromatic limit of 35 vol% in MS, the Light Naphtha ISOM unit will have to be revamped with a new catalyst along with re-orientation of process configuration to produce Isomerate of RON 90 from the present level of 85. Possibility of RON improvement by changing the catalyst from present zeolite based catalyst to Sulfated Zirconia based catalyst has been discussed with Licensors.

Further to meet Sulphur level of < 10 ppm in BS-VI MS a new Naphtha Hydrotreater will have to be installed for hydrodesulphurization of the straight run naphtha.

A detailed study of the Light Naphtha Isom units required to be carried out for identifying the modifications and for preparation of the feasibility report. In order to absorb all the naptha into MS, the capacity revamp of the CRU unit is required to be increased from the present 160 TMTPA to around 200 TMTPA.

Further, BGR is exploring the option of revamping the existing Isomerisation unit with an additional reactor for improving Isomerate RON from present 84-85 to 90 -91 for which, M/s GTC Technologies is being consulted for putting up an additional reactor with Sulfated Zirconia based catalyst.

Salient features of the proposed project:
Project objectives: The refinery has to produce BS-VI MS

2.4.4 Revamp of Light Naphtha Isomerisation Unit:

The changes envisaged in the Isomerisation Unit are:

- Installation of a new naphtha hydrotreatment unit to reduce sulfur from present level of 50-100 ppm to < 8ppm
- Change of catalyst
- Changing the existing reactors, feed effluent exchangers, trim coolers
- New makeup gas compressor

2.4.5 Capacity expansion of Catalytic Reformer Unit:

In order to sustain MS production at the present levels RON barrel has to be increased which can be achieved by expanding of the CRU unit by processing a wider cut of RFN.
The following modifications are envisaged

- Additional feed pump,
- Furnace modification (increase of tube dia from 4”to 6”, increase of tube length and increase in number of burners from one to three in each furnace) to accommodate the pressure drop of higher hydraulic load,
- Change of compressor (Reciprocating to centrifugal)- optional
- Changing column internals of Stabilizer and Reformate Splitter,
- Installing marginally higher capacity reactors on the same foundations
- Loading of high performance catalyst for enhanced performance at lower space velocities.

2.4.6

[IV] Indmax project:

Bongaigaon Refinery proposes to implement the "Indmax FCC unit along with Indmax Gasoline De-Sulphurisation Unit) at its existing refinery complex at Dhaligaon to eliminate production of demand limited black oils (LDO, LVFO & LSHS) and Naphtha and produce high value products like LPG and Motor Spirit (MS) conforming to BS- VI specifications.

Salient features of the proposed Indmax Project:

Project objectives: The objectives of the Indmax Project are as follows:

- Eliminate production of demand limited Black Oil and Naphtha
- Maximize production of high value LPG
- Maximize production of high value Motor Spirit (BS-VI)

Facilities:

The Indmax Project will consist of the following facilities:

- INDMAX FCC unit with a design capacity of 740,000 MTPA. The INDMAX process has been developed and patented by IOCL (R&D). IOCL (R&D) and Lummus Technology Inc., USA will be the joint licensors for the unit.
- LPG treatment facility as part of the INDMAX FCC Unit.
- Indmax Gasoline De-Sulphurisation Unit with a design capacity of 312,000 MTPA to reduce Sulphur content in Indmax Gasoline so to meet BS-VI equivalent specifications for Motor Spirit.

Existing utilities & Offsite facilities will be utilized for the Indmax project with the following additional facilities:

- Additional storage and transfer facilities for LPG to match with the requirement as per the production
- One additional cooling water circulating pump of 2,600 m^3/hr capacity
- One cell in DM water plant.

Indmax Unit Process:

Presently, Coker Naphtha and Coker Gas Oil & Coker Fuel Oil from Delayed Coker Unit are being blended and evacuated as BS-II Motor Spirit (MS) and LDO & LVFO respectively. With the implementation of Euro-III equivalent fuel norms effective from 2010, it will not be possible to blend Coker Naphtha in the MS pool and will surplus as Naphtha. Also, increasing availability and demand of Natural Gas, the demand of Naphtha and LDO/LVFO (Black Oil) are decreasing day by day.

In view of the above, BGR is implementing INDMAX Unit of 740 TMT per annum capacity at BGR to process Coker Naphtha, Coker Heavy Gasoil (CHGO), Reduced Crude Oil (RCO) and Black Oil components and thereby to increase value added products LPG and MS.

The feed to the INDMAX Unit of BGR comprises of Coker Naphtha (CN), Coker Heavy Gasoil (CHGO) and Coker Fuel Oil (CFO) from Delayed Coker units & Reduced Crude Oil (RCO) ex Crude Distillation units.

INDMAX is proprietary process developed and patented by IOCL (R&D) similar to Residue Fluid Catalytic Cracking (RFCC) process except that the catalyst system and operating conditions are different. With the optimum catalyst formulation, very high catalytic conversion and maximum LPG and light olefin yields are ensured, while making the lowest dry gas and coke yield. INDMAX catalyst demonstrates an exceptionally high vanadium tolerance (21000 ppm on eCat), which is twice that of a conventional RFCC catalyst.

Main features of the process are:

- Feed CCR limitation is 4.0 wt%. The total Ni/V on feed should be less than 80/40 ppm respectively.
- Higher conversion yields higher LPG and light olefin due to the excellent dry gas and coke selectivity of the proprietary catalyst.
- Produces very high octane gasoline (RON: 95-104) compared to that of 89-92 in conventional FCCU.
- Improved coke selectivity permits a very high cat/oil ratio (15-25), as compared to the other state-of-the art processes.
- Significantly higher catalyst to oil ratio provides very efficient heat transportation from the regenerator to the riser.
- Employs higher riser temperature (560 ^{O}C), and a relatively high dilution steam rate (15-20 wt% of feed).

The products from the proposed INDMAX Unit and their routings will be as below:

[A] Fuel Gas: The off gas from INDMAX Unit (approx 7.7 wt% of INDMAX feed) will be treated to remove H2S and the treated off gas will be utilized internally as Fuel Gas. Utilization of off gas as FG will reduce Fuel Oil consumption in the refinery.

[B] LPG: The LPG components produced in the INDMAX Unit (approx 29.5 wt% of INDMAX feed) will be treated within INDMAX Unit to conform meet LPG quality as per IS: 4576-1999 and sent to Storage.

[C] Gasoline: There will be two gasoline streams from INDMAX Unit –Light Indmax Gasoline (C5-15 ^{O}C) and Heavy Indmax Gasoline (150-210 ^{O}C). With the INDMAX Gasoline blended to MS pool, the MS pool would only meet the quality specifications of MS conforming to BS-VI equivalent norms with respect to Sulphur. In view of the above, both Lt and Hy Indmax gasoline will be routed to INDMAX Gasoline De-Sulphurisation Unit before routing to the refinery MP pool conforming to BS-VI equivalent specifications.

[D] Light Cycle Oil (LCO): The Light Cycle Oil will be partly routed to refinery Diesel pool conforming to BS- VI equivalent norms and partly will be consumed as IFO.

[E] Clarified Oil (CLO): The Clarified Oil will be processed in Delayed Coker Unit for production of Needle Coke. With processing of CLO in DCU, RCO will be surplus and the surplus RCO will be fed to the INDMAX Unit.

Coke: Approx 7.8 wt% of feed will be deposited on the catalyst as coke which will be burnt during regeneration of catalyst and thereby steam will be generated in waste heat boiler. With this generation of steam in INDMAX Unit, load to CPP/GTG will reduce and thereby fuel consumption will reduce. It is to be noted that care has been taken in design of INDMAX Unit to minimize emission/pollution from the regenerator.

Indmax Gasoline De-Sulphurisation Unit process:

[F] The Indmax Gasoline if blended in refinery MS pool, the MS pool would not meet the Euro-IV with the refinery MS
equivalent MS specs with respect to Sulphur. The objective of the Indmax Gasoline De-Sulphurisation Unit is to de-sulphurise Light and Heavy Indmax Gasoline so that when blended pool, the MS pool meets the BS-VI equivalent MS specs. The technology Licensor for the Indmax Gasoline De-Sulphurisation Unit will be selected on competitive bidding basis.

In the Indmax Gasoline De-Sulphurisation Unit, the both Light Indmax Gasoline and Heavy Indmax Gasoline will be processed in Selective Hydrogenation Unit (SHU).

The required Hydrogen for the process will be supplied from the Hydrogen Generation Unit (HGU) implemented along with ongoing DHDT project.

The stream ex-SHU reactor will be split in splitter section into two cuts namely LCN (C_5-100 ^{O}C cut) and HCN (100-150 ^{O}C cut).

The LCN (C5-100˚C) from the Splitter top will directly be routed to Stabilizer.

The HCN (100-150 ^{O}C cut) from the Splitter bottom will be first treated in Di-olefin and then will be hydro-treated in HDS reactor to remove Sulphur. Then it will be routed to stabilizer.
The stream ex-stabilizer will be having sulfur content of 8 ppm to meet the BS-VI MS specification and it will be routed to MS blend pool reactor

2.4.7

[V] <u>Selective Desulfurisation (SDS) project:</u>

Bongaigaon Refinery proposes Selective Desulfurisation (SDS) to implement Project" at its existing refinery complex. In BS-VI MS production scenario, Coker Naphtha cannot be blended to MS pool due to high sulfur content. In order to remove sulfur from coker naphtha without drop in octane of coker naphtha, BGR Proposes to install Indselect unit, a selective Desulphurisation process developed by IOC R&D.

Salient features of the proposed Selective Desulfurisation (SDS) Project:
Project objectives: The objectives of the project are as follows:

- To reduce sulphur content of Coker naphtha so that it can be blended to MS in BS-VI scenario.

SDS is a trickle bed reactor system with single stage once through down flow configuration. The hydrogen consumption is very low and the reduction in sulfur is very negligible. The SDS reactor is filled with proprietary catalyst developed by IOC R&D and the conventional guard bed at the top sufficient enough to handle silica rich Coker streams. The key functionality of the catalyst is to selectively saturate the diolefins and shift low molecular weight sulfur compounds to high molecular weight sulfur compounds.

These diolefins are selectively removed under very mild conditions of hydrotreating in SDS Reactor. Sulfur Shift mechanism, the low boiling sulfur compounds are converted to high boiling sulfur compounds by combination of low boiling sulfur compounds with olefins. Due to this reaction, it is possible to segregate the light boiling range gasoline from full range gasoline by distillation before hydrodesulfurization, since all of its sulfur are shifted to high boiling region.

The diolefins treated & sulfur shifted stream is separated in to light & heavy cut through a conventional splitter. The lighter cut which is olefins rich (octane potential) & low sulfur stream is taken to gasoline pool for blending without any post treatment. In this stream, the sulfur content is low due to the sulfur shift mechanism, all low boiling sulfur compounds are ended up in the heavy cut.

Facilities: The SDS Project will consist of the following facilities:

- Coker naphtha Feed
- pump Feed effluent
- exchangers SDS reactor
- Stripper with reboiler, cooler and reflux drum

2.4.8

Hydrogen Generation Unit (HGU):

The estimate of H2 consumption has been carried out considering existing infrastructure and there is shortfall of around 25% which needs to be made from existing HGU unit.

2.4.9

SRU:

The sulphur balance has been developed for the post INDMAX project. As per the calculations the refinery requires a New SRU of 10 TPD for post INDMAX / Post BS VI implementation.

2.4.10

MSQ-NHT:

To reomove the sulphur content of Isom feed to < 10 ppm so as to meet BS-VI MS spec , a new NHT unit will be installed.

2.5 Power Requirement:

Power Requirement for various utilities is in different forms of Electricity, Steam and Fuel as mentioned below:

Table no. 2.2: Power Requirement

S. No	Particular	CDU-II	DHDT	CRU-MSQ	INDMAX FCC Unit	IGHDS Unit	SDS Unit	Total
1	**POWER (KW)**	No Change	300	No change	3620	225	45	4220

2	**STEAM (MT/hr)** Net SL steam Net MP steam Net HP steam	No Change	No Change	No Change	4.5 34.4 (0.3)	- 8.8 -		4.5 43.2 (0.3)
3	**FUEL,** fuel gas **(MMKcal/hr)**	0.63	0.44	0.17	-	0.9	-	2.14

There is no direct requirement of Fuel for INDMAX and SDS unit.

2.6 Water Requirement and Waste Water Generation

Total water consumption will be 370 m^3/hr, where 330 m^3/hr was required daily and after the installation of INDMAX unit additional 40 m^3/hr of fresh water will be required. The water demand will be met from the existing facility. No additional raw water will be required for CDU-II, DHDT, SDS & CRU-MSQ. The plant has installed a 400 m3/hr capacity Tertiary Treatment Plant. The treated effluent water will be reused as make up water for cooling tower and green belt development.

2.7 Environmental mitigation measures of the project:

Table no.2.3: Environmental mitigation measures

Particulars	Stack	Fugitives	Liquid	Solid	Noise
Crude processing capacity enhancement	No additional impact on emissions	No additional impact on emissions	No additional impact on emissions	No additional impact on emissions	No additional impact on emissions
DHDT capacity enhancement	The existing stack is constructed as per CPCB guidelines and it is adequate for marginal changes in stack emissions due to the DHDT capacity enhancement.	Appropriate storage tank, equipment, pumps, valve seals and packing would be specified during detailed engineering.	The existing facility is constructed as per CPCB guidelines and it is adequate for marginal changes.	Only spent catalysts are the solid waste generated from the project. Spent catalyst will be collected and disposed to CPCB approved recyclers.	All rotary equipment shall be of low noise type.
CRU-MSQ revamp	The existing stack is constructed as per CPCB guidelines and it is adequate for marginal changes In	Appropriate storage tank, equipment, pumps, valve seals and packing would be specified	The existing facility is constructed as per CPCB guidelines and it is adequate for marginal	Only spent catalysts are the solid waste generated from the project. Spent catalyst will be collected and	All rotary equipment shall be of low noise type.

	stack emissions due to the DHDT capacity enhancement.	during detailed engineering.	changes.	disposed to CPCB approved recyclers.	
Selective Desulphurisation (SDS) Unit	No stack emission as the Unit does not have a furnace	Appropriate storage tank, equipment, pumps, valve seals and packing would be specified during detailed engineering.	The liquid effluent generated from the process (30.2 m3/hr.) will be treated in the Waste Water Treatment Plant (WWTP) and Tertiary Treatment Plant (TTP). The treated effluent will be reused to the maximum extent possible to reduce discharge to outside.	Only equilibrium catalysts / spent catalysts are the solid waste generated from the project. Spent catalyst will be collected and disposed to CPCB approved recyclers.	All rotary equipment shall be of low noise type.
INDMAX Project	The total SOx and NOx emissions as a consequence of the proposed project are well within the proposed CPCB norms. The stack height will be designed as per CPCB guideline, i.e. H = 14 x (Q) 0.3 or 60 meters,	Appropriate storage tank, equipment, pumps, valve seals and packing would be specified during detailed engineering.	The liquid effluent generated from the process will be treated in the Waste Water Treatment Plant (WWTP) and Tertiary Treatment Plant (TTP). The treated effluent will be reused to the maximum	Only equilibrium catalysts / spent catalysts are the solid waste generated from the project. Spent catalyst will be collected and disposed to CPCB approved recyclers.	All rotary equipment shall be of low noise type.

	whichever is more (Q is the Sulphur load)		extent possible to reduce discharge to outside.		

Chapter 3

Rapid Risk Assessment

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Rapid Risk Assessment

3.1 Need of Risk Assessment

Industrial plants deal with materials, which are generally hazardous in nature by virtue of their intrinsic chemical properties or their temperature or pressure of operation or a combination of these. Fire, explosion, hazardous release or a combination of these are the hazards associated with industrial plants. These have resulted in the development of more comprehensive, systematic and sophisticated methods of safety engineering such as hazard analysis and risk assessment to improve upon the integrity, reliability and safety of industrial plants.

The primary emphasis in safety engineering is to reduce risk to human life and environment. The broad tools attempt to minimize the chances of accidents occurring. Yet, there always exists, no matter how remote, that small probability of a major accident occurring. If the accident involves highly hazardous materials in sufficient large quantities, the consequences may be serious to the plant, to surrounding areas and the populations therein.

3.2 Risk Assessment & Hazard Identification

Risk is defined as the unwanted consequences of a particular activity in relation to the likelihood that this may occur. Risk assessment thus comprises of two variables, magnitude of consequences and the probability of occurrence of accident.

The first step in risk assessment is identification of hazards. Hazard is defined as a physical or chemical condition with the potential of accident which can cause damage to people, property or the environment. Hazards are identified by careful review of plant operation and nature of materials used. The various scenarios by which an accident can occur are then determined, concurrently study of both probability and the consequences of an accident is carried out and finally risk assessment is made. If this risk is acceptable then the study is complete. If the risk is unacceptable then the system must be modified and the procedure is restarted.

3.3 Scope of Risk Analysis

The scope of risk analysis study includes:

1) Identify potential hazard sections of the plant, which are likely to cause damage to the plant, operating staff and the surrounding communities in case of any accident due to the proposed plant facilities.
2) Assess overall damage potential of the hazardous events in relation to main plant and environment.
3) Assessment of total individual risk.
4) Recommended emergency preparedness plan to mitigate the effects of any accident.

3.4 Risk Analysis

Risk Analysis of any plant / installation handling hazardous materials includes –

Hazard Identification

A. Identify potentially hazardous materials that can cause loss of human life/injury, loss of properties and deteriorate the environment due to loss of containment.

B. Identify potential scenarios, which can cause loss of containment and consequent hazards like fire, explosion and toxicity.

Consequence Analysis

A. Analysis of magnitude of consequences of different potential hazard scenarios and their effect zones.

B. Consequence analysis is a measure of potential hazards and is important for taking precautionary measures for risk reduction as for well as mitigation of effect in case of such accidents happening.

This RRA report has been prepared by applying the standard techniques of risk assessment and the information provided by IOCL. Based on the Risk Assessment, Disaster Management Plan (DMP) has been prepared.

3.5 Glossary of Terms used in Risk Assessment

The common terms used in Risk Assessment and Disaster Management are elaborated below:

"Risk" is defined as a likelihood of an undesired event (accident, injury or death) occurring within a specified period or under specified circumstances. This may be either a frequency or a probability depending on the circumstances.

"Hazard" is defined as a physical situation, which may cause human injury, damage to property or the environment or some combination of these criteria.

"Hazardous Substance" means any substance or preparation, which by reason of its chemical or physico-chemical properties or handling is liable to cause harm to human beings, other living creatures, plants, micro-organisms, property or the environment.

"Hazardous Process" is defined as any process or activity in relation to an industry, which may cause impairment to the health of the persons engaged or connected therewith or which may result in pollution of the general environment.

"Disaster" is defined as a catastrophic situation that causes damage, economic disruptions, loss of human life and deterioration of health and health services on a scale sufficient to warrant an extraordinary response from outside the affected area or community. Disaster occasioned by man is factory fire, explosions and release of toxic gases or chemical substances etc.

"Accident" is an unplanned event, which has a probability of causing personal injury or property damage or both.

"Emergency" is defined as a situation where the demand exceeds the resources. This highlights the typical nature of emergency "It will be after experience that enough is not enough in emergency situations. Situations of this nature are avoidable but it is not possible to avoid them always."

"Emergency Preparedness" is one of the key activities in the overall Management. Preparedness, though largely dependent upon the response capability of the persons engaged in direct action, will require support from others in the organization before, during and after an emergency.

3.6 Rapid Risk Assessment at Bongaigaon Refinery Plant

RRA study identifies the hazards associated with the proposed project, analyses the consequences, draws suitable conclusions and provides necessary recommendations to mitigate the hazard/ risk.

Now BONGAIGAON REFINERY PLANT is enhancing the capacity, revamping and installing new technology at the plant. The changes are as follows:

- Crude processing capacity enhancement from 2.35 MMTPA to 2.7 MMTPA
- DHDT capacity enhancement from 1,200 TMTPA to 1,800 TMTPA to meet BS-VI HSD specification.
- CRU-MSQ revamp to meet BS- VI MS specification.
- INDMAX Project along with Indmax Gasoline De-Sulphurisation Unit.
- Selective Desulphurisation (SDS) Unit.
-

This RRA study is based on the information made available in the process design basis of the CDU, DHDT, CRU-MSQ, INDMAX and SDS units.

3.6.1 Objective and Scope of Study

The main objective of the rapid risk analysis study is to identify the potential hazard scenarios and assess the impact of major accidental hazards from the proposed Diesel Hydro Treatment Project on the population and property within and outside the battery limit of the facilities. The results are also useful in developing a meaningful emergency plan and to serve as a powerful training tool.

The following facilities are within the scope of study;

- Crude Distillation unit (CDU-II unit 1.35 MMTPA)
- Diesel Hydro Treatment Facilities (DHDT Unit 1.8 MMTPA)
- CRU unit (200 TMTPA)
- MSQ unit (224 TMTPA)
- INDMAX FCC unit along gasoline desulphurisation unit (312 TMTPA)

General:

Description of Facilities:

3.7 Diesel Hydrotreating Unit

The objective of Diesel Hydrotreatment Unit (DHDT) is to treat and upgrade the existing quality of HSD to meet the stringent new quality specifications of HSD with respect to sulphur content, cetane number, Cetane index, poly aromatics content, stability, etc. Bongaigaon Refinery Plant proposes to improve the quality of HSD with respect to sulphur content from the present level of 0.17 to as low a figure as 0.005 wt%, cetane number from the present level of 45 to 51.

The process flow scheme of DHDT can be split into four main sections:

(i) Feed section
(ii) Reactor circuit section
(iii) Separator/compression section
(iv) Fractionation section

(i) Feed Section

Feed comes from storage and passes through the Feed Filter and then followed by Feed Coalescer. The Feed Filter removes any carry over rust & polymeric components and Feed Coalescer and Surge drums are vessels designed to remove entrained water and provide surge volume to even out fluctuations in feed entering the unit. Feed from the Feed Surge Drum enters the Feed Pumps where its pressure is raised to allow the feed to enter the reactor circuit. Feed from the Feed Pumps first preheated in the Feed/Reactor effluent exchangers and recycle gas including make-up gas from respective compressors are preheated in the Recycle Gas/Reactor eflluent exchangers before mixing with preheated feed stream. The combined feed is directed to the Charge Heater where it is heated to the reaction temperature.

(ii) Reactor Circuit Section

Combined feed from the feed section is heated to reaction temperature in the Charge Heater. The feed/Recycle gas is then sent to the Reactors. The Reactors contain catalyst, chosen for its ability to absorb metals in the feed and provide the proper level of desulfurization required to meet the specified diesel product properties. Reactors have multiple beds with intermediate quench points to control the reactor temperature. Reactor material is cooled in the Recycle gas/ Hot Reactor Effluent Exchanger, the Feed/Reactor Effluent Exchanger, the Stripper Feed/Effluent Exchanger, Feed/ Reactor Effluent Exchanger, Recycle gas/Reactor Effluent Exchanger, Feed/Reactor Effluent Exchanger and then in the separator condenser. After cooling to the appropriate temperature, reactor effluent material is separated in the Separator. The Separator is utilized to separate the vapour and liquid hydrocarbon phase and to decant the sour water phase. The vapour from the separator enters the recycle gas K.O. drum from where it is compressed by the Recycle Gas Compressor and routed to the heat exchange network and quench lines.

(iii) Separator/Compressor Section

Make-up gas is compressed from the hydrogen header to the unit operating pressure in a Make-up Gas Compressor. Hydrocarbon liquid from the Separator is sent to the LP Flash Drum and then routed to Stripper Feed/Bottoms Exchanger and the Stripper Feed/Reactor Effluent Exchanger before entering the Stripper. Sour Water from the Separator is sent to the Sour Water Stripping Unit.

(iv) Fractionation Section

The purpose of the Stripper is to remove from the diesel product, the hydrogen sulphide and light hydrocarbons produced in the Diesel Hydrotreating Unit. An appropriate amount of steam is added at the bottom of the Stripper to strip the hydrogen sulphide from the liquid leaving the column bottom. Overhead vapours from the Stripper are condensed by the water cooled Stripper Overhead Condenser and routed to the Stripper Receiver. The Stripper Receiver separates the non-condensable vapours, hydrocarbon liquid and sour water. The stripper overhead vapours are routed to the Sour Fuel gas Amine Absorber. Part of the overhead liquid is refluxed back to the Stripper. Balance stripper overhead liquid is unstablised and is sent to the Naphtha Stabilizer. Sour water from the receiver is sent to the Sour water Stripping Unit.

Strippe bottom liquid is used to heat Stripper feed in the Stripper Feed Bottom Exchanger and then cooled in the Air cooled Diesel Product Cooler followed by Water cooled Diesel Product Cooler. Dissolved water present in the diesel product separates as it is cooled. The majority of this water is removed in the Diesel Product Coalescer. The Hydrotreated diesel product is routed to the storage.

The unstabilised naphtha from the stripper receiver after getting preheated by the stabiliser bottoms in the stabiliser feed/bottoms exchanger is feed to the naphtha stabiliser. The light ends and H_2S leave the stabiliser from the top. The naphtha stabiliser is reboiled by the stabiliser reboiler. The stabilised naphtha from the bottom of the stabiliser is cooled in the stabiliser feed/ bottoms exchanger.

3.8 CATALYTIC REFORMING UNIT

Hydrotreated Naphtha feed to a Catalytic Reformer unit typically contains C6 to C10 paraffins, naphthenes and aromatics. This Hydrotreated naphtha feed has a poor octane number and the purpose of catalytic reformer unit is to get a high octane gasoline.
Reaction section

The Hydrotreated naphtha pumped by reformer feed pumps and mixed with recycle hydrogen gas compressed in Recycle Gas Compressor. The mixture of naphtha feed and recycled hydrogen is preheated in reformer feed and effluent exchanger which is a vertical true counter current (Texas Tower) exchanger. The feed naphtha and the recycled hydrogen recovers heat in the fourth reactor effluent stream and is further heated to 498 ^{O}C in the reformer preheater. The preheated feed enters the reformer 1st reactor which is loaded with RG-682 catalyst. The reactions are predominantly endothermic in the first reactor and therefore the reactor effluent is reheated in the reformer 1stinterheater. The inlet temperature to all the four reactors is about 498 degC. The reactions in the 2nd reactor are less endothermic but the reactor effluent still requires reheating using the interheater. The reactions in the third reactor is much less endothermic as mostly undesired reactions like hydrocracking reactions takes place in the reactor. The main reactions viz. dehydrocyclization and isomerization are endothermic in nature while hydrocracking reactions are exothermic in nature. The effluent from third reactor is heated to the required temperature and sent to fourth reactor. The heat of fourth reactor effluent is used to preheat the reforming feed in feed/effluent exchanger, and is then condensed in the reactor effluent air cooler and reactor effluent cooler before being collected in the reformer separator.

The separated vapor phase hydrogen rich gas is recycled to the compressor suction, via reformer recycle compressor KO drum. The hydrogen rich gas is partly mixed with the Hydrotreated naphtha and is recycled back to the reaction loop. The remaining hydrogen rich gas from compressor discharge is distributed as hydrogen make-up gas to naphtha pretreater unit and isomerisation unit. The remaining is sent to fuel gas network and stored in bullets.

3.9 STABILIZATION SECTION

The separated liquid from the separator is then sent to the stabilizer column under level-flow control cascaded to the flow control. The stabilizer feed is heated in stabilizer feed/bottoms exchanger and introduced in the stabilizer column.

Overheads from the stabilizer are partly condensed in the stabilizer condenser and collected in stabilizer reflux drum. The vapors from the reflux drum are routed to the fuel gas network under pressure control. The condensed hydrocarbons are sent back to the column as reflux. C5 reformate from stabilizer bottom is directed to the battery limit under level/flow control after heat integration with stabilizer feed/ bottom exchanger, and finally cooling to the desired temperature (40°C) in reformate cooler.

3.10 SULPHUR RECOVERY UNIT (SRU)

The objective of sulphur recovery unit is to recover sulphur from H_2S present in acid gas stream from Amine Regeneration Unit and sour gas from Sour Water Stripping Unit. The process design of SRU is based on 3 stage modified Claus process. The process consists of:

A. Thermal stage (Main Combustion chamber)
B. Two catalytic stages (Catalytic Converters)
C. Hydrogenation Reactor with TGT unit Thermal incineration

98% (min.) sulphur recovery is achievable from this configuration.

A. Thermal Stage (main Combustion Chamber)

Acid gas from SRU is introduced via Acid gas knockout drum and sour gas from SWSU is introduced via sour gas knockout drum. Sour water from sour gas knock out drum and condensate from Acid gas knock out drum are collected in the condensate collection drum. The air to the main burner is supplied by main air blowers. In order to maximize SO2 a controlled amount of air mixed with acid gas and sour gas is fed to the burner where 1/3rd of H2S in the feed is converted to SO2. The SO2 so formed combines with major percentage of residual H2S to form sulphur. The hot reaction furnace effluent gases enter waste heat boiler (WHB) where heat is recovered by producing LP steam. Sulphur produced in reaction furnace condenses and separates in the outlet channel of the WHB and flows to sulphur pit via sulphur seal pot. Then, the process gas is introduced into the first condenser in which it is further cooled, sulfur vapour condenses & separates from gas & flows to sulphur pit.

B. Two Catalytic Stages (Catalytic Converters)

The effluent vapour ex condenser-I is reheated in Electric Reheater-I. This hot process gas flows to Claus converter-I where additional conversion to sulphur takes place. The reaction gas from the converter-I is cooled in sulphur condenser-II. The produced sulphur condenses and flows to sulphur pit via sulphur seal pot. The sulphur condenser-II effluent vapour is reheated in electric rehater-II and flows to Claus converter-II for further conversion. The reaction gases from converter-II is cooled in sulphur condenser-III. The product sulphur condenses and flows to sulphur pit via sulphur seal pot. The gases leaving condenser-II flow to the Tail gas Treating unit (TGTU) where essentially all sulphur compounds will be converted to H2S & returned to the Claus unit for further sulphur recovery. The hot gas from the highly exothermic reaction is cooled in TGU WHB & quenched in a water quench tower to ambient temperature. Finally, H2S is selectively absorbed in alkanolamine solution i.e. MDEA. Vent gas from the absorber is to be incinerated before discharging to atmosphere. Rich amine is stripped in common Amine Regenerator & H2S rich stream recycled back to Claus section.

The sulphur drained to the pit is maintained in liquid state using pit-heating coils. During storage of sulphur H2S dissolved in sulphur gets liberated gradually. Hence a constant sweet air circulation is maintained over liquid sulphur using pit ejectors. Mixture of air and stream from pit ejectors containing H2S called as sweet gas is routed to thermal incinerator. Liquid sulphur from pit is pumped by sulphur pumps to sulphur yard where it is solidified by spraying cold water on it.

3.11 Thermal Incineration

In the thermal incineration combustible components in the tail gas from the tail gas coalesce and sweet gas from sulphur pit is thermally oxidized using excess of air in the thermal incinerator. The thermal incinerator converts all the H2S and other sulphur species in the tail gas to sulphur dioxide.

3.12 INDMAX Unit

INDMAX employs circulating fluidized bed Riser-Reactor-Stripper configuration similar to conventional FCC technology along with single stage full combustion Regenerator system. The catalyst system and operating conditions employed in INDMAX process are tailor-made and different from the conventional FCC technology. The specially designed catalyst of the INDMAX process consists of various synergistic components for upgradation of heavy molecules maximising conversion with higher light olefins selectivity.

Salient Features

1) Employs high riser outlet temp (ROT) of more than 540°C and high catalyst to oil ratio (C/O) of more than 12.
2) Employs proprietary catalyst system with low coke and dry gas make, higher metal tolerance and selectivity towards light olefins.
3) Excellent heat integration - Single stage full burn Regenerator; use of catalyst cooler for feed with higher CCR (>6 wt%).
4) Highly efficient hardware components
5) MicroJet^{TM} Feed injector
6) Proprietary SCT riser reactor design
7) High efficiency Modular Grid– stripper design
8) Direct-coupled cyclone separator
9) Efficient catalyst regeneration system (multi zone pipe grid distributor with MSO nozzle)
10) Advanced catalyst cooler design

3.13 Modes of Failure

There are various potential sources of large leakage, which may release hazardous chemicals and hydrocarbon materials into the atmosphere. These could be in form of gasket failure in flanged joints, bleeder valve left open inadvertently, an instrument tubing giving way, pump seal failure, guillotine failure of equipment/ pipeline or any other source of leakage. Operating experience can identify lots of these sources and their modes of failure. A list of general equipment and pipeline failure mechanisms is as follows:

I. Material/Construction Defects

- Incorrect selection or supply of materials of construction
- Incorrect use of design codes
- Weld failures
- Failure of inadequate pipeline supports

II. Pre-Operational Failures

- Failure induced during delivery at site
- Failure induced during installation
- Pressure and temperature effects
- Overpressure
- Temperature expansion/contraction (improper stress analysis and support design)
- Low temperature brittle fracture (if metallurgy is incorrect)
- Fatigue loading (cycling and mechanical vibration)

III. Corrosion Failures

- Internal corrosion (e.g. ingress of moisture)
- External corrosion
- Cladding/insulation failure (e.g. ingress of moisture)
- Cathodic protection failure, if provided

IV. Failures due to Operational Errors

- Human error
- Failure to inspect regularly and identify any defects

V. External Impact Induced Failures

- Dropped objects
- Impact from transport such as construction traffic
- Vandalism
- Subsidence
- Strong winds

VI. Failure due to Fire

- External fire impinging on pipeline or equipment
- Rapid vaporization of cold liquid in contact with hot surfaces

3.14 Hazards Associated in Refinery

Refinery complex handles a number of hazardous materials like LPG, Hydrogen, Naphtha, Benzene, Toluene and other hydrocarbons which have a potential to cause fire and explosion hazards. The toxic chemicals like Benzene, Ammonia, Chlorine and Hydrogen sulfide are also being handled in the Refinery. This Risk assessment report describes in brief the hazards associated with these materials.

- **Hazards Associated with Flammable Hydrocarbons**

Below mentioned are the properties and risks associated with the handling of chemicals at BGR

(i) Liquefied Petroleum Gas (LPG)

LPG is a colourless liquefied gas that is heavier than air and may have a foul smelling odorant added to it. It is a flammable gas and may cause flash fire and delayed ignition. LPG is incompatible to oxidizing and combustible materials. It is stable at normal temperatures and pressure. If it is released at temperatures higher than the normal boiling point it can flash significantly and would lead to high entrainment of gas phase in the liquid phase. High entrainment of gas phase in the liquid phase can lead to jet fires. On the other hand negligible flashing i.e. release of LPG at temperatures near boiling points would lead to formation of pools and then pool fire. LPG releases may also lead to explosion in case of delayed ignition.

Inhalation of LPG vapors by human beings in considerable concentration may affect the central nervous system and lead to depression. Inhalation of extremely high concentration of LPG may lead to death due to suffocation from lack of oxygen. Contact with LPG may cause frostbite.

Refer Table below for properties of LPG.

S.No	Properties (LPG)	Values
1	LFL (% v/v)	1.7
2	UFL (% v/v)	9.0
3	Auto ignition temperature (°C)	420-540
4	Heat of combustion (Kcal/Kg)	10960
5	Normal Boiling point (°C)	-20 to -27
6	Flash point (°C)	-60

(ii) Hydrogen

Hydrogen (H_2) is a gas lighter than air at normal temperature and pressure. It is highly flammable and explosive. It has the widest range of flammable concentrations in air among all common gaseous fuels. This flammable range of Hydrogen varies from 4% by volume (lower flammable limit) to 75% by volume (upper flammable limit). Hydrogen flame (or fire) is nearly invisible even though the flame temperature is higher than that of hydrocarbon fires and hence poses greater hazards to persons in the vicinity. Constant exposure of certain types of ferritic steels to hydrogen results in the embrittlement of the metals. Leakage can be caused by such embrittlement in pipes, welds, and metal gaskets.

In terms of toxicity, hydrogen is a simple asphyxiant. Exposure to high concentrations may exclude an adequate supply of oxygen to the lungs. No significant effect to human through dermal absorption and ingestion is reported. Refer to Table 8 for properties of hydrogen.

S.No	Properties (H_2)	Values
1	LFL (% v/v)	4.12
2	UFL (% v/v)	74.2
3	Auto igniton temperature (°C)	500
4	Heat of combustion (Kcal/Kg)	28700
5	Normal Boiling point (°C)	-252

6	Flash point (°C)	NA

(iii) Naphtha and Other Heavier Hydrocarbon

The major hazards from these types of hydrocarbons are fire and radiation. Any spillage or loss of containment of heavier hydrocarbons may create a highly flammable pool of liquid around the source of release.

If it is released at temperatures higher than the normal boiling point it can flash significantly and would lead to high entrainment of gas phase in the liquid phase. High entrainment of gas phase in the liquid phase can lead to jet fires. On the other hand negligible flashing i.e. release at temperatures near boiling points would lead to formation of pools and then pool fire. Spillage of comparatively lighter hydrocarbons like Naphtha may result in formation of vapor cloud. Flash fire/ explosion can occur in case of ignition. Refer to Table below for properties of Naphtha.

S.No	Properties (Naptha/other HCs)	Values
1	LFL (% v/v)	0.8
2	UFL (% v/v)	5.0
3	Auto ignition temperature (°C)	228
4	Heat of combustion (Kcal/Kg)	10100
5	Normal Boiling point (°C)	130 -155
6	Flash point (°C)	38-42

3.14.1 Hazard Associated with Toxic/Carcinogenic materials

I. Hydrogen Sulfide

Hydrogen sulfide is a known toxic gas and has harmful physiological effects. Accidental release of hydrocarbons containing hydrogen sulfide poses toxic hazards to exposed population. Refer Table below for hazardous properties of Hydrogen Sulfide.

S.No	Threshold Limits (H_2S)	Concentration (ppm)
1	Odour threshold	0.0047
2	Threshold Limit Value (TLV) 10	10
3	Short Term Exposure Limit STEL (15 minutes)	15
4	Immediately Dangerous to life and Health (IDLH) level (for 30 minutes exposure)	100

II. Chlorine

Chlorine is required in a refinery complex for water treatment. Chlorine tonner is therefore located near the Cooling water system. Chlorine gas is not flammable but highly poisonous in nature. Its routes of entry into the human body are through inhalation, ingestion, skin and eyes. An exposure to chlorine can cause eye irritation, sneezing, restlessness. Exposure to high concentration of chlorine can cause respiratory distress and violent coughing. Lethal effects of inhalation depend not only on the concentration of the gas to which people are exposed, but also on the duration of exposure. The toxic effects of chlorine are listed in Table below:

S.No	Properties (Cl)	Values
1	Short Term Exposure Limit STEL (15 minutes)	2
2	Immediately Dangerous to life and Health (IDLH) level (for 30 minutes exposure)	10

III. Ammonia

Ammonia may be release from failure of connection tube of ammonia cylinder used in Atmospheric unit (AU). Ammonia is also likely to be present in sour gas produced from Sour water stripper unit (SWSU). The hazard associated with ammonia is both toxic and flammable hazards. Toxic hazards being more pronounced. Vapors of ammonia may cause severe eye or throat irritation and permanent injury may result. Contact with the liquid freezes skin and produces a caustic burn. Table below indicates the toxic properties of ammonia.

S.No	Properties (NH_3)	Values
1	Threshold Limit Value (TLV) 10	25
2	Short Term Exposure Limit STEL (15 minutes)	35
3	Immediately Dangerous to life and Health (IDLH) level (for 30 minutes exposure)	300

3.15 Characterising of failures:

(i) Hazards from Petroleum Products Storage and Handling

Accidental release of flammable or toxic vapors can result in severe consequences. Delayed ignition of flammable vapors can result in blast overpressures covering large areas. This may lead to extensive loss of life and property. Toxic clouds may cover yet larger distances due to the lower threshold values in relation to those in case of explosive clouds (the lower explosive limits). In contrast, fires have localized consequences. Fires can be put out or contained in most cases; there are few mitigating actions one can take once a vapor cloud is released.

In a petroleum marketing installation such as the plant in question, the main hazard arises due to the possibility of leakage of petroleum products during decanting (number of hose connections, tank lorry movement etc.), storage, filling and transportation. To formulate a structured approach to identification of hazards an understanding of contributory factors is essential

(ii) Operating Parameters

a. Inventory

Inventory Analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role in regard to the potential hazard. Larger the inventory of a vessel or a system, larger the quantity of potential release. A practice commonly used to generate an incident list is to consider potential leaks and major releases from fractures of pipelines and vessels containing sizable inventories. Each section is then characterized by the following parameters required for consequence modeling:

- Mass of flammable material in the process/storage section (oil/gas)
- Pressure, Temperature and composition of the material
- Hole size for release

b. Loss of Containment

Plant inventory can get discharged to Environment due to Loss of Containment. Various causes and modes for such an eventuality have been described. Certain features of materials to be handled at the plant need to the clearly understood to firstly list out all significant release cases and then to short list release scenarios for a detailed examination.

c. Liquid Outflow from a vessel/ line

Liquid release can be either instantaneous or continuous. Failure of a vessel leading to an instantaneous outflow assumes the sudden appearance of such a major crack that practically all of the contents above the crack shall be released in a very short time. The flow rate will depend on the size of the hole as well as on the pressure in front of the hole, prior to the accident. Such pressure is basically dependent on the pressure in the vessel.

d. Vaporization

The vaporization of released liquid depends on the vapor pressure and weather conditions. Such consideration and others have been kept in mind both during the initial listing as well as during the short listing procedure. Initial listing of all significant inventories in the process plants was carried out. This ensured no emission through inadvertence.

Based on the methodology discussed above a set of appropriate scenarios was generated to carryout Risk Analysis calculations for Pool fire, fire ball, source strength, toxic threat zone, flammability threat zone, overpressure (blast force) from vapor cloud explosion.

3.16 Consequence Analysis

Consequence analysis involves the application of the mathematical, analytical and computer models for calculation of the effects and damages subsequent to a hydrocarbon / toxic release accident. Computer models are used to predict the physical behavior of hazardous incidents. The model uses below mentioned techniques to assess the consequences of identified scenarios:

- Modeling of discharge rates when holes develop in process equipment/pipe work.
- Modeling of the size & shape of the flammable/toxic gas clouds from releases in the atmosphere.
- Modeling of the flame and radiation field of the releases that are ignited and burn as jet fire, pool fire and flash fire.
- Modeling of the explosion fields of releases which are ignited away from the point of release.

The different consequences (Flash fire, Pool fire, Jet fire and Explosion effects) of loss of containment accidents depend on the sequence of events & properties of material released leading to the either toxic vapor dispersion, fire or explosion or both.

3.16 Consequence Analysis Modeling

a. Discharge Rate

The initial rate of release through a leak depends mainly on the pressure inside the equipment, size of the hole and phase of the release (liquid, gas or two-phase). The release rate decreases with time as the equipment depressurizes. This reduction depends mainly on the inventory and the action taken to isolate the leak and blow-down the equipment.

b. Dispersion

Releases of gas into the open air form clouds whose dispersion is governed by the wind, by turbulence around the site, the density of the gas and initial momentum of the release. In case of flammable materials the sizes of these gas clouds above their Lower Flammable Limit (LFL) are important in determining whether the release will ignite. In this study, the results of dispersion modeling for flammable materials are presented LFL quantity.

c. Flash Fire

A flash fire occurs when a cloud of vapors/gas burns without generating any significant overpressure. The cloud is typically ignited on its edge, remote from- the leak source. The combustion zone moves through the cloud away from the ignition point. The duration of the flash fire is relatively short but it may stabilize as a continuous jet fire from the leak source. For flash fires, an approximate estimate for the extent of the total effect zone is the area over which the cloud is above the LFL.

d. Jet Fire

Jet fires are burning jets of gas or atomized liquid whose shape is dominated by the momentum of the release. The jet flame stabilizes on or close to the point of release and continues until the release is stopped. Jet fire can be realized, if the leakage is immediately ignited. The effect of jet flame impingement is severe as it may cut through equipment, pipeline or structure. The damage effect of thermal radiation is depended on both the level of thermal radiation and duration of exposure.

e. Pool Fire

A cylindrical shape of the pool fire is presumed. Pool-fire calculations are then carried out as part of an accidental scenario, e.g. in case a hydrocarbon liquid leak from a vessel leads to the formation of an ignitable liquid pool. First no ignition is assumed, and pool evaporation and dispersion calculations are being carried out. Subsequently late pool fires (ignition following spreading of liquid pool) are considered. If the release is bounded, the diameter is given by the size of the bund. If there is no bund, then the diameter is that which corresponds with a minimum pool thickness, set by the type of surface on which the pool is spreading.

While modeling cases of lighter hydrocarbons in the range of naphtha and MS wherein the rainout fraction have been minimal (not leading to pool formation) due to the horizontal direction of release, downward impingement has been considered for studying the effects of pool fire for consequence analysis only. Pool fires occur when spilled hydrocarbons burn in the form of large diffusion flames. Calculating the incident flux to an observer involves four steps, namely

- Characterizing the flame geometry
- Estimation of the flame radiation properties
- Computation of the geometric view factors
- Estimation of flame attenuation coefficients and computation of geometric view factors between observer and flame.

The size of the flame will depend upon the spill surface and the thermo chemical properties of the spilled liquid. In particular, the diameter of the fire, the visible height of the flame, the tilt and drag of the flame etc. The radioactive output of the flame will depend upon the fire size, the extent of mixing with air and the flame temperature. Some fraction of the thermal radiation is absorbed by the carbon dioxide and water vapor in the intervening atmosphere. In addition, large hydrocarbon fires produce thick smoke which significantly obscure flame radiation

The calculations for radiation damage distances start with estimation of the burning velocity:

$Y= 92.6\ e - 0.0043T_bMw10^{-7}/(x\ 6)$
Where y= burning velocity in m/s
Mw= molecular weight in kg/kg mol
T_b= normal boiling point

The next step involves calculation of the equivalent diameter for the spreading pool- this depends upon the duration of the spill (continuous, instantaneous, finite duration etc.). This is calculated using expressions like:
$D_{eq}. =2(V/3.142y)^{1/2}$

Where D_{eq}. Is the steady state diameter of the pool in
m V= liquid spill rate in m^3/s
Y= Liquid burning rate in m/s
In the absence of frictional resistance during spreading, the equilibrium diameter is reached over a time given by: **$T_{eq}.= 0.949\ D_{eq}./(\Delta y\ X\ D_{eq}.)^{1/3}$**
The visible flame height is given by;
$H_{flame}= 42D_p\ ((BvD/D_a(gD_p)1/2)^{0.61}$
Where H_{flame} = flame height in
m D= density in kg/m3
Da= air density in kg/m^3
g = gravitational acceleration or 9.81 m/s^2

The emissive power of a large turbulent fire is a function of the black body emissive power and the flame emissivity. The black body emissive power can be computed by Planck's law of radiation. The general equation used for the calculation is:
$E_P= -0.313T_b+117$
Where Ep is the effective emissive power in
kw/m^2 Tb= normal boiling point of the liquid in °F

Materials with a boiling point above 30 °F typically burn with sooty flames-the emissive power from the sooty section is about 20 kW /m2. The incident flux at any given location is given by the equation:

$Q_{incident}$ = EP * t * V F

Where $Q_{incident}$ = incident flux in kw/m^2

t= transmitivity (a function of path length, relative humidity and flame temperature) often taken as 1 and the attenuation of thermal flux due to atmospheric absorption ignored.

V_F= geometric view factor

The view factor defines the fraction of the flame that is seen by a given observer.

V F= 1.143 (R_p/X) 1.757

Where X= distance from the flame centre in m

R_p= pool radius in m

Based on the radiation received, the fatality levels are calculated from Probit equation, which for protected clothing is given by:

Pr.= -37.23 + 2.56 ln (t X $Q^{4/3}$)

Where Pr. = Probit

No. t= time in seconds

Q heat radiation in w/m2

f. Blast Overpressures

Blast Overpressures depend upon the reactivity class of material and the amount of gas between two explosive limits. MS could give rise to a VCE due to their vapor pressures - however, as the results will indicate, the cloud flammable masses are quite small due to the high boiling point and low vapor pressures. In addition, unless there is sufficient extent of confinement, it is unlikely to result in any major explosion. Examples where flammable mixtures could be found are within storage tanks and road tankers. Open-air explosions are unlikely. As a result, damage would be limited Equations governing the formation of overpressures in an explosion are given later. Blast overpressures are calculated based on comparison of combustion energy per unit mass of a vapour cloud with that of TNT and taking into account that only a fraction of the energy will contribute to the explosion. Overpressure data compiled from measurements on TNT are used to relate overpressure data to distance from explosions. The equivalent mass of TNT is calculated using the equations:

M_{TNT}= (M_{cloud} X ($\Delta H_{c.}$)/1155 X Y_f)

Where M_{TNT} is the TNT equivalent mass

(lb) ΔHc = Heat of combustion is in

Kcals/kg M_{cloud} is mass in cloud in lbs

Y_f is the yield factor

The distance to a given overpressure is calculated from the general equation:

X=M_{TNT} 1/3 exp (3.5031-0.7241 ln (O_p) + 0.0398 (ln O_p)$)^2$

Where X is the distance to a given overpressure in feet Op is the peak overpressure

3.17 Toxic Realease in Air:

The aim of the toxic risk study is to determine whether the operators in the plant, people occupied buildings and the public are likely to be affected by toxic substances. Toxic gas cloud e.g. H2S, chlorine, etc was undertaken to the Immediately Dangerous to Life and Health concentration (IDLH) limit to determine the extent of the toxic hazard created as the result of loss of containment of a toxic substance.

I. Size and duration of release

Leak size considered for selected failure cases are as listed below:

S.No	Failure Description	Leak Size
1	Pump Seal Failure	6 mm hole size
2	Flange gasket failure	10 mm hole size
3	Instrument tapping failure	19 mm hole size
4	Small hole	20 mm hole size
5	Large hole	50 mm hole size
6	Catastrophic failure	Complete rupture of pressure vessel

The duration of release is a very important input to the consequence analysis as this directly dictates the quantity of material released. General basis for deciding the duration of release is given in the Table below-

S.No	Blocking System Configuration	Isolation Time (M)
1	Fully automatic blocking system(including automatic detection and closure of block valves)	2
2	For remote operated blocking systems (detection is automatic, but control room operator must validate alarm signal and close block valve remotely)	10
3	For hand-operated blocking systems (detection is automatic, but control room operator must validate alarm, go to field and manually close block valve)	30

II. Damage Criteria

In order to appreciate the damage effect produced by various scenarios, physiological/physical effects of the blast wave, thermal radiation or toxic vapor exposition are discussed.

III. LFL or Flash Fire

Hydrocarbon vapor released accidentally will spread out in the direction of wind. If a source of ignition finds an ignition source before being dispersed below lower flammability limit (LFL), a flash fire is likely to occur and the flame will travel back to the source of leak. Any person caught in the flash fire is likely to suffer fatal burn injury. Therefore, in consequence analysis, the distance of LFL value is usually taken to indicate the area, which may be affected by the flash fire.

Flash fire (LFL) events are considered to cause direct harm to the population present within the flammability range of the cloud. Fire escalation from flash fire such that process or storage equipment or building may be affected is considered unlikely.

IV. Thermal Hazard Due to Pool Fire, Jet Fire

Thermal radiation due to pool fire, jet fire or fire ball may cause various degree of burn on human body and process equipment. The following table details the damage caused by various thermal radiation intensity.

S.No	Incident Radiation (kW/m^2)	Type of Damage
1	0.7	Equivalent to Solar Radiation
2	1.6	No discomfort for long exposure
3	4.0	Sufficient to cause pain within 20 sec. Blistering of skin (first degree burns are likely)
4	9.5	Pain threshold reached after 8 sec. Second degree burns after 20 sec.
5	12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing etc.
6	25	Minimum energy required to ignite wood at indefinitely long exposure
7	37.5	Sufficient to cause damage to process equipment

V. Vapour Cloud

In the event of explosion taking place within the plant, the resultant blast wave will have damaging effects on equipment, structures, building and piping falling within the overpressure distances of the blast. Tanks, buildings, structures etc. can only tolerate low level of overpressure. Human body, by comparison, can withstand higher overpressure. But injury or fatality can be inflicted by collapse of building of structures.

The following table illustrates the damage effect of blast overpressure.

S.No	Peak Overpressure	Damage Type
1	12.04 psi	Total Damage
2	4.35 psi	Heavy Damage
3	1.45 psi	Moderate Damage
4	0.44 psi	Significant Damage
5	0.15 psi	Minor Damage

3.18 Risk Assessment of INDMAX:

In order to achieve the objective of rapid risk analysis study, following activities are carried out:

- Identification of all probable major accident cases.

- Analysis of consequences of the above to find out various hazard distances and impact zones.
- Suggest mitigating measures to eliminate/reduce above hazards

Risk is defined as the unwanted consequences of a particular activity in relation to the likelihood that this may occur. Risk assessment thus comprises of two variables, magnitude of consequences and the probability of occurrence of accident.

The first step in risk assessment is identification of hazards. Hazard is defined as a physical or chemical condition with the potential of accident which can cause damage to people, property or the environment. Hazards are identified by careful review of plant operation and nature of materials used. The various scenarios by which an accident can occur are then determined, concurrently study of both probability and the consequences of an accident is carried out and finally risk assessment is made. If this risk is acceptable then the study is complete. If the risk is unacceptable then the system must be modified and the procedure is restarted.

Individual risks are the key measure of risk acceptability for this type of study, where it is proposed that:

- Risks to the public can be considered to be broadly acceptable (or negligible) if below 10-6 per year (one in 1 million years). Although risks of up to 10-4 per year (1 in 10,000 years) may be considered acceptable if shown to be As Low As Reasonably Practicable (ALARP), it is recommended that 10-5 per year (1 in 100,000 years) is adopted for this study as the maximum tolerable criterion.

- Risks to workers can be considered to be broadly acceptable (or negligible) if below 10-5 per year and where risks of up to 10-3 per year (1 in 1000 years) may be considered acceptable if ALARP.

The highest LSIR (location specific individual risk) location at INDMAX unit is 1E-05 per year. The maximum LSIR in the units are listed below:

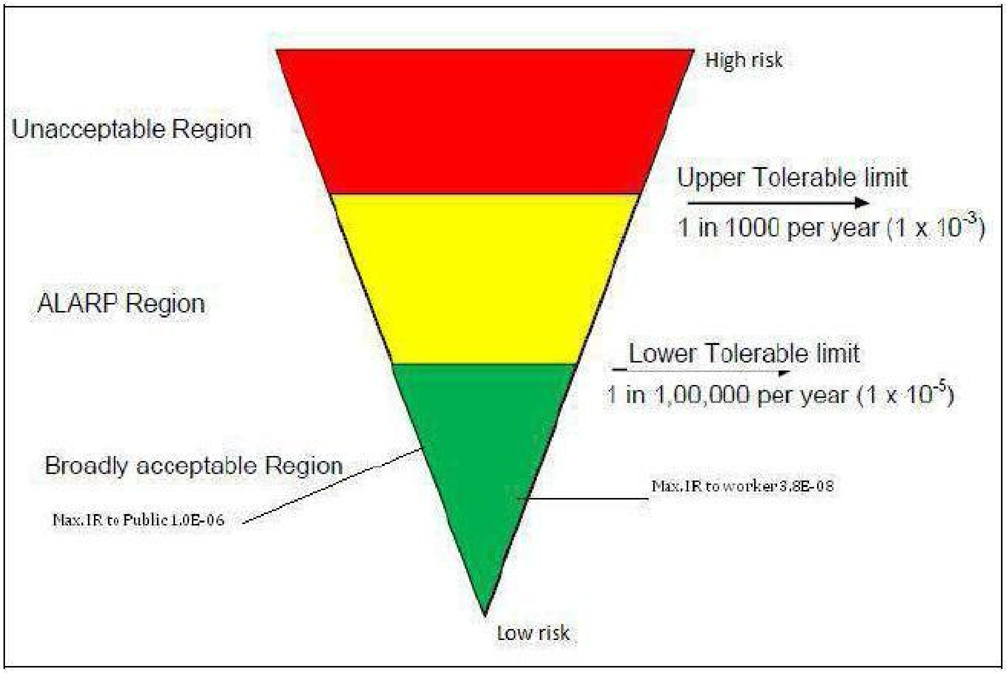
S.No	Unit	Maximum LSIR
1	HDT/HGU field operator room	6.57 E-08
2	SRU block field operator room	2.31 E-08
3	INDMAX field operator room	1.14 E-07

3.19 Individual Risk to worker at INDMAX Unit (ISIR):

The location specific individual risk (LSIR) is risk to a person who is standing at that point 365 days a year and 24 hours a day. The personnel in INDMAX unit are expected to work 8 hour shift as well as general shift. The actual risk to a person i.e. “Individual Specific Individual Risk” would be far less after accounting for the time fraction a person is expected to spend at a location

ISIR Area = LSIR x (8/24) (8 hours shift) x (Time spent by and individual/8 hours) The maximum ISIR in the units are listed below:

S.No	Unit	Maximum LSIR
1	HDT/HGU field operator room	2.19 E-08
2	SRU block field operator room	7.7 E-09
3	INDMAX field operator room	3.8 E-08



Societal Risk are also proposed, although these should be used as guidance only. A criterion of 10^{-4} per year is recommended for determining design against the fire and explosion loads that occur with a frequency of 1 in 10,000 years. The societal risk parameters for INDMAX unit is shown in figure below in the form of FN curve. The result from the FN curve show that the societal risk due to INDMAX Unit is below the ALARP region which is broadly acceptable or negligible risk.

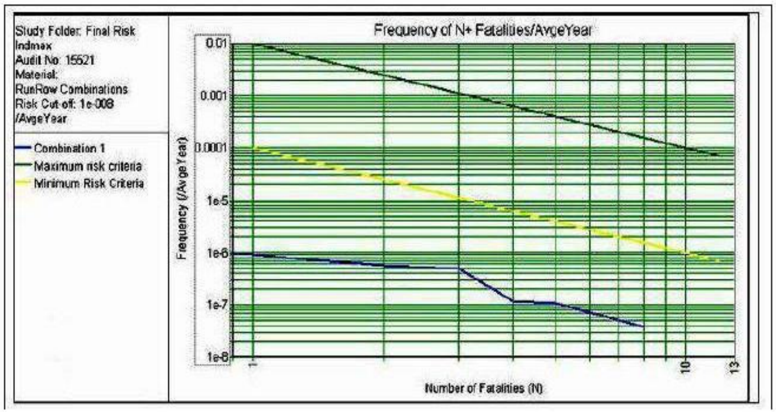


Figure: FN curve for societal risk at INDMAX unit at BONGAIGAON REFINERY PLANT

The significant risk contributions from INDMAX unit is based on result available from PHAST show below:

Top Risk Contributors at INDMAX unit:

S.No	Scenario	Societal risk contribution
1	Rupture in the inlet line to stabilizer /debutanizer	52.09
2	Rupture from shell side of Stripper feed exchanger	22.34
3	Leak from shell side of Stripper feed exchanger	11.72
4	Rupture in line to main fractionator column	2.22
5	Leak in discharge line of LPG R/D Pump	1.01

Chapter 4

Disaster Management Plan

CHAPTER 4

DISASTER MANAGEMENT PLAN

4.1 Disaster Scenarios

Based on the Risk Analysis done for BONGAIGAON REFINERY PLANT and various scenarios of industrial accidents in the refining sector, following scenarios have been identified for finalising detailed action plan for Off-Site Emergency situation.

1. Fire in storage tanks & tank farm area (major fire) in SRU, due to gasket failure.
2. Fires and explosions in the unit area
3. Boiler explosion in captive power plant
4. Un-confined vapour cloud explosion (LPG)
5. Profuse naphtha leak in cooling water system
6. Large oil spillage flowing out of the refinery
7. Chlorine gas leak from cylinder (s)
8. LPG cylinders explosions in LPG bottling plant (BGR plant)
9. H_2s leakage from acid gas knock out drum top line

In addition to the above, any emergency, which goes beyond the control of BONGAIGAON REFINERY PLANT and may affect the outside population, will be considered as off-site disaster.

4.2 CLASSIFICATION OF EMERGENCIES

(1) Emergencies can be categorized into three broad levels on the basis of seriousness and response requirements;

(a) Level 1 : This is an emergency or an incident which

(i) Can be effectively and safely managed, and contained within the site, location or installation by the available resources
(ii) Has no impact outside the site, location or installation
(iii) Is unlikely to be danger to life, the environment or to company assets or reputation

(b) Level 2 : This is an emergency or an incident which

(i) Cannot be effectively and safely managed or contained at the site, location or installation by available resource and additional support is required

(ii) Is having, or has the potential to have an effect beyond the site, location or installation and where external support of mutual aid partner may be involved

(iii) Is likely to be danger to life, to the environment, to company assets or reputation

(c) Level 3: This is an emergency or an incident which is catastrophic and is likely to affect the population, property and environment inside and outside the installation, and management & control is done by District Administration. Although the level-III emergency falls under the purview of District Authority but till they step in, it shall be responsibility of the unit to manage the emergency.

Note: Level-I & Level-II shall normally be grouped as onsite emergency and Level-III as off-site emergency. Off-site Disaster Management Plan will be activated in case of Level 3 emergency situation

4.3 Types of Disaster:

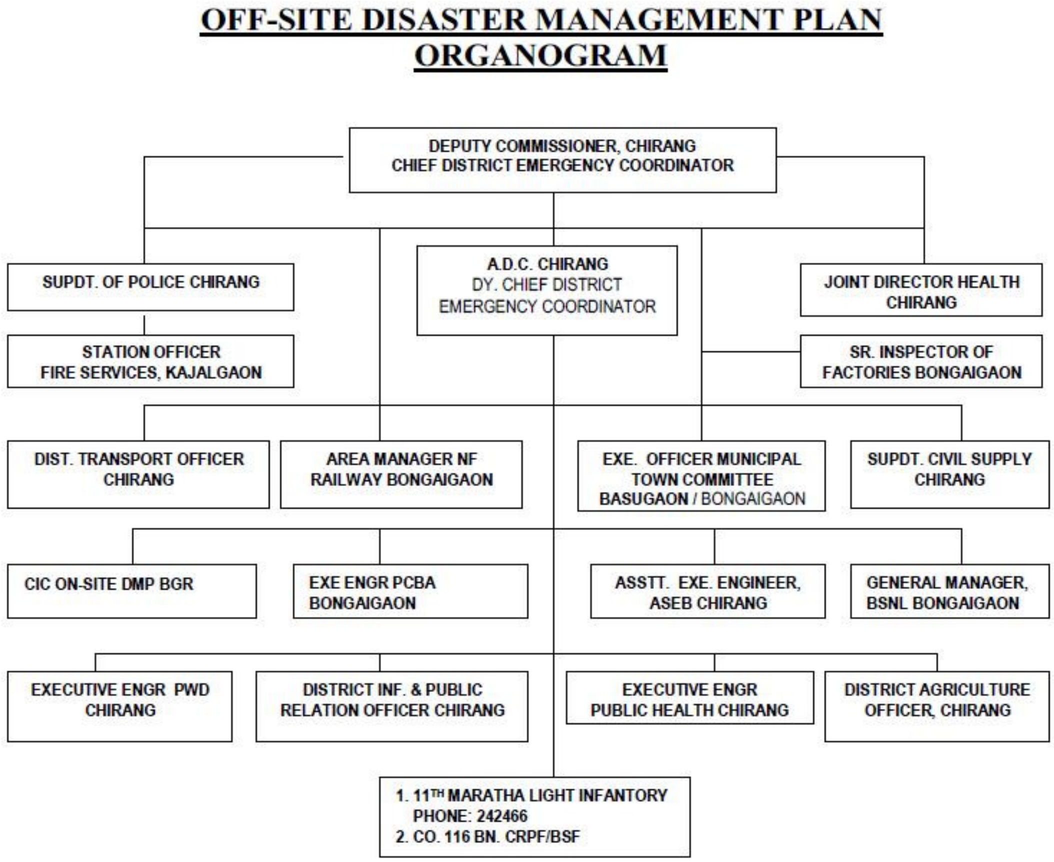
- Fire & Explosion in Tank Farm Area.
- Major Fire/Explosion in Unit Area.
- Accidental release of Toxic Gas in to atmosphere
- Large Oil Spillage which can escape from the Complex.
- Vapour Cloud Explosion/BLEVE

4.4 Causes of Disaster

S.No	Man made	Natural	Extraneous
1	Heavy leakage	Flood	Riots/Civil disorder/
2	Fire	Earthquake	Mob attack/ Terrorism
3	Explosion	Cyclone	Bomb Threat
4	Failure of Critical Control system	Breakout of disease	War hit by missiles
5	Design deficiency	Excessive rains	Abduction
6	Unsafe acts		Food water poisoning
7	In-adequate maintenance		

4.5 Off -site Disaster Management Plan

The Deputy Commissioner (DC), Chirang District will be the Chief District Emergency Coordinator (CDEC) for operating the Off-Site Disaster Management Plan. Additional Deputy Commissioner (ADC) will be Dy. Chief District Emergency Coordinator (DCDEC). The CDEC will be the overall in charge of all off-site emergency activities. He will coordinate various activities in co-ordination with the onsite Chief Incident Controller (CIC), BONGAIGAON REFINERY PLANT. CDEC will also be the authority to order evacuation wherever necessary. He will co-ordinate with various service agencies such as Police, Fire Brigade, Medical, Transport, Railways, Civil Defence, Army (as and when required), Factory Inspectorate, Pollution Control Board etc.



4.6 Notification of Disaster and all clear signal (Normalcy)

The CDEC will make an assessment of the nature of the incident and its potential impact on life, property or the environment and declare a DISASTER if required by –

- Public announcement over mobile PA system.
- Using the air raid siren system of the civil defense Organization.
- Using Sirens of Railways, BONGAIGAON REFINERY PLANT or other industries.

The CDEC will declare a "Return-to Normal"/All clear, after ensuring that cause of disaster and its effects are over.

4.6.1 Siren Code of BGR Plant

Siren code will be as follows:

1. SMALL FIRE: No siren
2. MAJOR FIRE: A wailing siren for two minutes (30 sec.+ gap 15 sec +30sec +gap 15 sec +30 sec)
3. DISASTER: Same type of siren as in case of Major Fire but the same will be sounded for three times at the interval of *one* minute i.e.*(wailing siren 2 min + gap 1 min + wailing siren 2 min + gap 1min + wailing siren 2 min) total duration of Disaster siren to be eight minutes*.
4. ALL CLEAR (For fire): Straight run siren for two minutes.
5. TEST: Straight run siren for 30 seconds at 12 noon and 12.45 PM every day.

4.6.2 Responsibilities of CDEC/DCEC

1. Establishing the Crisis control Room near BONGAIGAON REFINERY PLANT premises at any of the following locations.
    - DC Office, Chirang PH: 241992
    - Police Station, Dhaligaon PH: 241262
    - Guest House, BONGAIGAON REFINERY PLANT (Deoshri) PH: 4585
    - Disaster Control Centre BONGAIGAON REFINERY PLANT PH: 241345 / 3336 / 3337
    - Any other place so decided by CDEC.
    - A Crisis Control Room will be established in the Conference Hall of DC’s Office which will work 24 hours a day and throughout the year.

2. Establishing communication linkage at the control room.
3. Requisition fire fighting services from Bongaigaon and NF Railways, if the situation demands.
4. Coordinate the rescue operation with police.
5. Arrangement for announcement through PA system to the affected population around, action to be taken by them and advising for evacuation, if required.
6. Identify places of safe shelters where the evacuated population has to belodged and arrange tents etc. for shelters in open area/Public hall/Schools.
7. Requisitioning all possible modes of transport for shifting them to predetermined shelters if required.
8. Ensure supply of food, drinking water and proper sanitation to the evacuated persons kept in various shelter locations.
9. Organise necessary medical aid through district health authorities and other voluntary institutions.
10. Arrange for protection of property of the evacuated persons during their absence.
11. Monitoring the shelter camps and the evacuated localities till the normalcy is restored.
12. Making public announcements from time to time in the shelter camps and in the neighbouring city areas and coordinating media persons.
13. Transportation of the evacuated persons back to their localities after the emergency has been controlled.

4.6.3 Establishing of Central Crisis Control Room (CCR)

The CDEC/DCDEC will coordinate the activities from the CCR identified already for the purpose near the refinery premises. It is desirable to have 2 CCRs so that if one is affected by the incident, then the other one is available for use.

4.6.4 Communication System

The following communication system should be available connecting the CCR with the refinery and emergency services:

* Telephone
* Wireless Communication System
* Portable Public Addressing System

4.6.5 Checklist of items in CCR

Following items shall be provisioned for in the CCRs. The agency / authority responsible for provisioning is also indicated below:

a. Checklist of actions to be taken by CIC BONGAIGAON REFINERY PLANT **– By CIC, BONGAIGAON REFINERY PLANT**

b. A complete list of areas showing population densities to plan for people to be evacuated, if required and pick-up points for evacuation. – **By CDEC**

c. A copy of Off-Site Disaster Management Plan- **By CIC, BONGAIGAON REFINERY PLANT**

d. Emergency power supply and lights- **By CIC, BONGAIGAON REFINERY PLANT**

e. Personal Protective Equipments such as Self Contained Breathing Apparatus, dust filters, PVC suits/hand gloves, Safety Goggles, helmets, gum boots etc.-**By CIC, BONGAIGAON REFINERY PLANT**

f. Latest/updated list of resources available to mitigate the emergency:

By CIC, BONGAIGAON REFINERY PLANT for resource at BONGAIGAON REFINERY PLANT and ADC for other resources in the district.

g. Adequate manpower equipped with various emergency services/facilities as and when needed on demand. : **By CDEC**

h. List of organisations and specialists available to handle the emergency as contained in the Offsite DMP **By CDEC**

i. A copy of Map/plot plan of Chirang/Bongaigaon District. **–By CDEC**

j. Latest/updated BSNL Telephone Directory: **- By CDEC**

4.6.6 RESPONSIBILITIES OF ON-SITE CHIEF INCIDENT CONTROLLER (CIC) BONGAIGAON REFINERY PLANT

On-site Chief Incident Controller is the overall in-charge of all activities at the site of the incident inside the BONGAIGAON REFINERY PLANT. He will act according to the on-site emergency plan. He is also responsible to inform CDEC in case of a major emergency /disaster at BONGAIGAON REFINERY PLANT which is likely to have effect outside of the complex. He shall:

1) Provide full details to CDEC about the nature and magnitude of the emergency and the area likely to be effected.
2) Coordinate internal functions of BONGAIGAON REFINERY PLANT
3) Organise technical back up to the CDEC
4) Advise CDEC for evacuation. Also to suggest location for rehabilitation, if pertinent.
5) Alert CDEC in case of contamination in effluent.
6) Provide administrative and hardware support to the Disaster Crisis Control Room.eg. Blow off all clear siren on the advice of CDEC.

On Site Disaster Organisation

Chief Incident Controller (BONGAIGAON REFINERY PLANT)

Name & Authority	House No.	Tel (O)	Tel (R)	Mobile
Mr. R.K. Sharma,GM(PJ)	Bangalow-5	241338	241226	9435499800
Mr. G.C. Sikder, GM(T)	Bungalow-2	241206	243318	9435139681
Mr. A Kalita, GM(TS&HSE)	D-154	241334	241392	9435482605

Nodal Officer

Name & Authority	Bungalow no.	Tel (O)	Tel (R)	Mobile
Executive Director BONGAIGAON REFINERY	1	241030	241241	120814

Conclusions and Recommendations:

A rapid risk analysis study for the proposed CDU, CRU-MSQ unit, DHDT, INDMAX SDS units of BONGAIGAON REFINERY PLANT, at Bongaigaon was carried out to evaluate consequence due to identified potential failure scenarios. Based on the results and discussions, the principal conclusions and recommendations are detailed below. The relevant sections of the report should be referred to for further details.

For DHDT:

1. At the offsites, tanks are provided for storage of HGU feed, Diesel and Coker Kero product. In the event of tank on fire the thermal hazard distance for 8kw/m^2 was estimated to be about 16m, 17m and 17m respectively and observed to be restricted to the respective tank area. The hazard distances due to 32Kw/m^2 are not realised. It can therefore be stated that the inter tank distances are adequate and fire-fighting facilities should be provided as per the applicable standards. Also, the standard operation practices to include the mode of dyke valve operation to OWS or to storm sewer.

2. For CPP expansion day tanks for HSD, LSHS & Naphtha shall be provided for fuel supply. Therefore, an event of “tank fire” cases for HSD and Naphtha day tanks were considered to estimate the thermal hazard to facilities in the vicinity. It was estimated that at tank level 32 kW/m2 radiation hazard distances extend to about 5m and 6m, respectively for 1F weather conditions and are restricted to the tank periphery. The 8kW/m_2 radiation hazard distance estimated to be 13m in case of HSD tanks would affect the adjacent LSHS tank. It is also observed that at ground level, the thermal radiation hazard zone due to HSD tank fire extends to a distance of 12m for 8 kW/m^2 radiation intensity.

It is recommended to increase the inter tank distances such that the adjacent tanks are outside the 8 kW/m2 radiation hazard zone or the tanks are to be provided with cooling facilities. Alternatively, since these fuel day tanks are low height and low capacity tanks, vessels for storage of the fuel instead of tanks should be considered.

3. In the DHDT area the LFL plume due to HP Separator bottom line failure is likely to envelop HGU, cooling tower, substation, OWS sump & pump house and partially affect the existing control room, nitrogen block, ecopark, CPP and the control room. It is therefore, recommended to consider provision of adequate measures such as facility for remote isolation of the separator and installing HC detectors at strategic locations in the unit for early detection of leakage and prevention of major releases.

4. In the DHDT area catastrophic failure of stabilizer reflux drum is considered. It is estimated that the 5-psi and 2-psi blast wave overpressure distance would extend to84m and 106m, respectively at 1F weather condition. The 2-psi blast overpressure effect zone is likely to affect partially the HGU block, substation, pipe sleepers and the nearby road while 5-psi blast wave may approach these areas.

Due to presence of H_2S in the stabilizer reflux drum feed toxic hazards are also evaluated due to catastrophic failure of stabilizer. Accordingly, toxic hazard distances for IDLH (100 ppm) concentration were estimated to be about 108m for 1F weather conditions and observed to envelope the DHDT block and extends to substation, HGU area and nearby roads. While, the 1%, 5% and 50% fatality affect zone lie within the DHDT battery limit. It is however, recommended to consider installation of hydrocarbon/H_2S detectors at strategic location in the process unit.

5. In the HGU a large hole in tubular reformer outlet line is considered. In the event of immediate ignition of the released material a jet flame may result. The jet flame is likelyto damage any equipment coming in its path and may lead to domino effects. It is recommended to provide hydrocarbon/hydrogen detectors in appropriate location inside the unit.

6. In the SRU failure scenario of accidental release of H_2S due to Acid Gas KOD top line flange gasket failure is considered. In the ARU a failure scenario of Amine regenerator reflux drum top line flange gasket failure is considered. The toxic hazard distances for IDLH (100 ppm) concentration and concentration causing 1%, 5% and 50% fatality are estimated. It is observed that at 1F weather conditions the H_2S cloud at IDLH Concentration would envelope the control room near the SRU block.

It is therefore, recommended to provide adequate number of H_2S detectors inappropriate location of the plant and at the control room air handling intake to warn the operators/supervisors for initiating shut down of air handling unit of control room. Control room should be air pressurised to prevent the infiltration of the flammable/toxic gas incase of accidental release. Air sucked for pressurisation should be from a safe location. Breather apparatus in healthy condition should be readily available in case of detection of accidental release of H_2S for escape/isolation of the leak source.

In case of acid gas KOD flange gasket failure it is observed that the IDLH cloud would travel about 180m beyond the plant boundary therefore it suggested that any human settlements within 200m of the plant boundary near the sulphur block should be avoided.

7. In the naphtha pre-treatment unit, two failure scenarios viz. naphtha feed pump mechanical seal failure and sulphur guard bottom line flange gasket failure are considered. It is estimated that flash fire distances would extend to 11 m and 25 m respectively and are restricted within the unit battery limit. The thermal hazard zone due to 12.5 kW/m^2 radiation intensity extends to about 13m and 15m respectively, and approach the adjacent hot oil area and fractionation section area. It is therefore recommended to provide hydrocarbon detectors at strategic location near the unit.

8. In the CRU events of reformer feed pump mechanical seal failure and reformer recycle gas compressor discharge line flange gasket failure have been considered. The flash fire distances are estimated to be about 29 m and 6 m for 1F weather condition. The thermal hazard zone due to 12.5 kW/m^2 radiation intensity extends to 14m and 17m for 1F weather condition and are mostly restricted to the unit battery limit. However in case offeed pump mechanical seal failure the thermal hazard zone due to 12.5kw/m^2 radiations may approach the compressor area. It is recommended the pump should be located such that compressor area is outside the thermal hazard zone of 12.5kw/m^2.

9. Thermal radiation hazard from pool fire due to seal leakage of the pumps handling light hydrocarbons (stripper overhead pump) is likely to affect the adjacent equipment. It is recommended to consider double mechanical seal pumps and also installation of hydrocarbon detectors near the pump seals along with appropriate deluge systems as per OISD guidelines.

10. Fired heaters are the potential ignition source in the process plant. Released gases due to failure of seal of pumps handling light hydrocarbon/failure of compressor gland/gasket leak is likely to be ignited in presence of ignition source. It is recommended that the location of heaters should be in upwind direction in order to reduce the ignition probability of the released gas.

11. Periodic health check and maintenance of all equipment and plant piping are required to be ensured. Periodic calibration and testing of alarms, trips, and interlocks should be given attention. It is also suggested to use minimum number of joints with proper gasket for all joints. Gaskets should be replaced by new ones everytime the flange joints are opened.

For INDMAX:

Although the results of this Risk analysis show that the risks to the public are broadly acceptable (or negligible), they will be sensitive to the specific design and/or modelling assumptions used. The maximum risk to persons working in the INDMAX unit is 3.8×10^{-8} per year which is below the unacceptable level and is in the lower part of ALARP triangle. It is observed that the iso-risk contour of 1×10^{-5} per year is within the INDMAX unit and the risk contour of 1×10^{-6} per year extended to the adjoining facilities on South East direction which have storage tankage and SRU unit.

The high risk contributors in the INDMAX unit are Stabilizer/Debutanizer stripper Feed exchanger. The major conclusions and recommendations based on the risk analysis of the identified representative failure scenarios are summarized below:

- The individual risk from all scenarios is found below the ALARP region for Employee and Public for INDMAX unit.
- The INDMAX unit of refinery is covered in the process safety management system of refinery.
- Mitigate the risk by preventing toxic cloud travelling beyond the plant boundary in South West side but the concentration of Hydrocarbons beyond the boundary is very low, therefore no specific mitigation measures are required for that point.
- Gas detectors are provided at critical locations. Operators are well trained about the fire and gas detection systems.
- Emergency stop of critical equipment's are available in control room.
- CCTV coverage with perimeter monitoring available.
- The vehicles entering the refinery should be fitted with spark arrestors.
- Routine checks to be done to ensure and prevent the presence of ignition sources in the immediate vicinity of the refinery (near boundaries).
- Clearly defined escape routes shall be developed for each individual plots and section of the INDMAX unit taking into account the impairment of escape by hazardous releases and sign boards be erected in places to guide personnel in case of an emergency.
- Well defined muster stations in safe locations shall be identified for personnel in case of an emergency.

- Windsocks existing in all prominent locations with clear visibility.
- Identification of critical equipment's done & inspection of methodologies existing for inspection during shutdown.
- The active protection devices like fire water sprinklers and other protective devices shall be tested at regular intervals.

- SOP should be established for clarity of actions to be taken in case of fire/leak emergency.

General conclusion and Recommendations:

1. In case of tanks on fire the heat radiations from the tank on fires will slightly affect the INDMAX Unit but the intensity is not so high to cause major damage to the unit. Fixed water sprays system is available on all nearest tanks, irrespective of diameter where inter distances between tanks in a dyke and/or within dykes are not meeting the requirements of OISD-STD-118.
2. Ensure that combustible flammable material is not placed near the Critical instrument of the INDMAX Unit. These could include oil filled cloths, wooden supports, oil buckets etc. these must be put away and the areas kept permanently clean and free from any combustibles. Secondary fire probability would be greatly reduced as a result of these simple but effective measures.
3. Sprinklers and foam pourers provided. Monitors & hydrants located at a distance more than 15 meters.
4. ROSOV and Hydrocarbon detectors to be provided with the nearest tank of the INDMAX unit.
5. Since Refinery operation is being done 24 hourly. Lighting arrangements are available in line.