RAPID RISK ANALYSIS STUDY

OF

NUMALIGARH REFINERY EXPANSION

PROJECT (NREP)

Numaligarh Refinery Limited

NUMALIGARH REFINERY LIMITED
GOLAGHAT, ASSAM

Submitted by:

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PREFACE

Numaligarh Refinery Limited (NRL), a company promoted by M/s Bharat Petroleum Corporation Limited (BPCL), Govt. of Assam and Oil India Limited (OIL) having the shareholding pattern 61.65%, 12.35% and 26.00% respectively is operating a 3.0 MMTPA grass root oil refinery located at Numaligarh, District Golaghat, Assam, India. The overall refinery configuration at NRL consists of Crude and Vacuum Distillation Unit; Full conversion Hydrocracker unit; Delayed Coker unit; MS block comprising Naphtha Hydro-treating unit, Semi-Regenerative Reformer and Iso-merization unit; and other associated facilities such as Hydrogen Generation Unit (HGU), Sulfur Recovery Unit, Sour Water Stripper (SWS) unit etc. The refinery is producing motor spirit (MS) and high speed diesel (HSD) primarily conforming to Euro III/IV specifications by processing of indigenous Assam Mix crude extracted from the upper Assam oil fields by OIL.

In view of the projected demand growth of petroleum products in the country and also to retain its profitability and competitiveness in the long run, NRL intends to install a parallel new train for imported sour crude processing capacity of 6.0 MMTPA.

The various new units/revamp facilities coming under the proposed 6.0 MMTPA refinery project are as follows;

- CDU/VDU
- MS BLOCK (NHT/CCR/ISOM)
- DHT
- FCCU & PRU
- FCC GASOLINE HYDROTREATER
- HGU
- DCU (Revamp)
- RUF
- SRU BLOCK (SWS/ARU/SRU)
- OFFSITE Facilities consisting of Tanks/Bullets and associated pump house
- LPG Loading Gantry

As part of the execution of this Project, Rapid Risk Analysis Study is being done to identify the hazards associated with the "***NEW FACILITIES***" as proposed under this project, analyze the consequences, draw suitable conclusions and provide necessary recommendations to mitigate the hazard/risk associated with the implementation of the new project facilities. It should be noted that impact due to existing hydrocarbon facilities has not been analyzed in this study Report.

This study is based on the information made available at the time of this study and EIL's own data source for similar facilities. EIL has exercised all reasonable skill, care and diligence in carrying out the study. However, this report is not deemed to be any undertaking, warrantee or certificate.

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EXECUTIVE SUMMARY

1.1 INTRODUCTION

Numaligarh Refinery Limited (NRL), a company promoted by M/s Bharat Petroleum Corporation Limited (BPCL), Govt. of Assam and Oil India Limited (OIL) having the shareholding pattern 61.65%, 12.35% and 26.00% respectively is operating a 3.0 MMTPA grass root oil refinery located at Numaligarh, District Golaghat, Assam, India. The overall refinery configuration at NRL consists of Crude and Vacuum Distillation Unit; Full conversion Hydrocracker unit; Delayed Coker unit; MS block comprising Naphtha Hydro-treating unit, Semi-Regenerative Reformer and Iso-merization unit; and other associated facilities such as Hydrogen Generation Unit (HGU), Sulfur Recovery Unit, Sour Water Stripper (SWS) unit etc. The refinery is producing motor spirit (MS) and high speed diesel (HSD) primarily conforming to Euro III/IV specifications by processing of indigenous Assam Mix crude extracted from the upper Assam oil fields by OIL.

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M/s Engineers India Limited (EIL), New Delhi has been appointed by M/s NRL as a Consultant for Environment Clearance of this Project. In this context, Rapid Risk Analysis Study of the new facilities under the proposed project (as mentioned above) is being carried out and the outcome of the study is provided in sections below.

1.2 APPROACH METHODOLOGY

Rapid Risk Analysis study evaluates the consequences of potential failure scenarios, assess extent of damages, based on damage criteria's and suggest suitable measures for mitigating the Hazards.

Risk analysis involves identification of various potential hazards & credible failure scenarios for various systems based on their frequency of occurrence & resulting consequence. Basically two types of failure scenarios are identified spanning across various process facilities;

a. *Cases with high chance of occurrence but having low consequence, e.g., Pin hole leak, flange leak & Instrument Tapping Failure etc.;*

b. *Cases with low chance of occurrence but having high consequences, e.g. Catastrophic Rupture of Pressure Vessels/Large Hole on the outlet of Pressure Vessels and hose rupture etc.*

Effect zones for various outcomes of failure scenarios (i.e. Flash Fire, Jet Fire, Pool Fire, Blast overpressure, toxic release, etc.) are studied and identified in terms of distances on plot plan. Based on effect zones, measures for mitigation of the hazards/risks are suggested.

1.3 MAJOR OBSERVATIONS & RECOMMENDATIONS

The major credible failure scenarios for the facilities under scope of work are modeled in terms of hydrocarbon release rate, dispersion, flammability & toxic characteristics and detailed consequence analysis of the outcome is presented in this Risk Analysis (RA) report.

The summary of major observations & recommendations of RA study for the refinery expansion Project are recorded below. These recommendations are based on analysis of the consequence results due to most credible leak scenario (20 mm leak size) from various process systems under the present project.

A. CDU/VDU

It is observed from the impact contours on GIS map (Figures 1.1.1 to 1.4.4 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios from the process unit that the effect zone of flash fire is by and large limited within the unit and adjoining roads surrounding the unit. Maximum flash fire distance under the considered leak scenarios is ~78 m from the leak point. Further, it is observed that the jet fire radiation intensity of 37.5 kW/m2 is extending up to ~45 m from leak point which may result in damage of the process equipment/tech. structure and adjoining pipe rack located in the northern side of the unit. No major impact is envisaged from pool fire scenario except some minor damage and health issue if action not taken within time. 5 psi overpressure is expected to reach ~89 from the leak point and may impact the pipe rack in the northern side of the unit.

In view of the above observations from various credible failure scenarios in the unit and their possible impact on the surrounding facilities, the following points are recommended to enhance the overall safety of the unit/plant;

- ***a.*** *Consider fire proofing requirement for the pipe rack structure on the northern side of the unit during the detail engg. stage. It is also suggested to ensure availability of active fire protection for the process system impacted by 37.5 kW/m2 radiation intensity.*
- ***b.*** *Ensure adequate nos. of F&G detectors (open path/point type) are installed in the unit based on prevailing wind direction.*
- ***c.*** *Ensure that the crude pump is located as far as possible from the unit B/L during detail engg. stage.*

B. FCCU & PRU

It is observed from the impact contours on GIS map (Figures 2.1.1 to 2.6.3 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios from the process unit that the effect zone of flash fire is by and large limited within the unit and doesn't reach on the ground in some of the cases. Maximum flash fire distance under the considered leak scenarios is ~45 m from the leak point. Further, it is observed that the jet fire radiation intensity of 37.5 kW/m2 is extending up to ~47 m from leak point which may result in damage of the process equipment/tech. structure provided within the unit. No major impact is envisaged from pool fire scenario except some minor damage and health issue if action not taken within time. 5 psi overpressure is expected to reach ~51 from the leak point and may impact the tech structure and furnace.

In view of the above observations from various credible failure scenarios in the unit and their possible impact on the surrounding facilities, the following points are recommended to enhance the overall safety of the unit/plant;

- ***a.*** *Ensure availability of active/Passive fire protection for the process system impacted by 37.5 kW/m2 radiation intensity.*
- ***b.*** *Ensure adequate nos. of F&G detectors (open path/point type) are installed in the unit based prevailing wind direction.*
- ***c.*** *Ensure that SRR of FCCU Block is made blast resistant and positively pressurized.*

C. MS BLOCK (NHT/CCR/ISOM)

It is observed from the impact contours on GIS map (Figures 3.1.1 to 3.5.4, 4.1.1 to 4.4.3 & 5.1.1 to 5.3.4 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios from the process units that the effect zone of flash fire is extending beyond the boundary of the unit. Maximum flash fire distance under the considered leak scenarios is ~91 m from the leak point. Further, it is observed that the jet fire radiation intensity of 37.5 kW/m2 is extending up to ~57 m from leak point which may result in damage of the process equipment and pipe rack provided on the western side of the unit. No major impact is envisaged from pool fire scenario except some minor damage and health issue if action not taken within time. 5 psi overpressure is expected to reach ~112 m from the leak point and may impact the tech. structure and furnace leading to their possible damage. IDLH value of benzene, toluene and H2S is expected to reach up to ~35 m, ~630 m and ~413 m respectively from the leak point.

In view of the above observations from various credible failure scenarios in the units and their possible impact on the surrounding facilities, the following points are recommended to enhance the overall safety of the unit/plant;

- ***a.*** *Ensure availability of active/Passive fire protection for the process system impacted by 37.5 kW/m2 radiation intensity.*
- ***b.*** *Ensure adequate nos. of F&G detectors (open path/point type) are provided in the unit based on prevailing wind direction.*
- ***c.*** *Ensure the availability of assembly point outside the IDLH value (for Toluene) from the unit at a suitable location (beyond~630 m) in upwind direction as the toxic contour is impacting the existing occupied buildings e.g. lab building, medical centre etc.*
- ***d.*** *Relocate MM shelter to a suitable location outside the 2 psi overpressure zone distance, in case the same is an occupied place.*
- ***e.*** *Ensure that SRR of MS Block is made blast resistant and positively pressurized.*

D. DHDT

It is observed from the impact contours on GIS map (Figures 6.1.1 to 6.4.4 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios from the process unit that the effect zone of flash fire is extending beyond the boundary of the unit and in some cases doesn't reach on the ground. Maximum flash fire distance under the considered leak scenarios is ~135 m from the leak point. Further, it is

observed that the jet fire radiation intensity of 37.5 kW/m2 is extending up to ~54 m from leak point which may result in damage of the process equipment and tech. structure within this zone. No major impact is envisaged from pool fire scenario except some minor damage and health issue if action not taken within time. 5 psi overpressure is expected to reach ~155 m from the leak point and may impact the ware house, tech. structure and furnace leading to their possible damage. IDLH value of H2S is expected to reach up to ~552 m from the leak point and extending beyond the plant boundary limit.

As per the attached MOM in Annexure-III, the possibility of retaining the canteen facility in the proposed CA/IG area was studied. It is observed from the various impact contour that the canteen facility is not impacted by the considered failure scenario in the proposed nearby process facility however, the over pressure contour of 2 psi is passing very close to the canteen facility and since the leak point may shift during detail engg. stage hence the possibility of damage to canteen and potential workers/personnel safety hazard cannot be totally overlooked at this stage of the study. In addition, canteen will be a potential ignition source near the process area and hence may be an additional cause of concern during the operation life cycle.

In line with the above observations from various credible failure scenarios in the unit and their possible impact on the surrounding facilities, the following points are recommended to enhance the overall safety of the unit/plant;

a. *Ensure availability of active fire protection for the process system impacted by 37.5 kW/m2 radiation intensity in the unit.*

b. *Ensure adequate nos. of F&G detectors (open path/point type) are installed in the unit based on prevailing wind direction.*

c. *It is suggested to ensure that the plant boundary limit is extended in the southern side to limit the H2S IDLH conc. within the plant boundary. It is further advised to ensure availability of assembly point outside the IDLH value from the unit at a suitable location (beyond~552 m) in upwind direction.*

d. *Explore the possibility of inventory isolation on actuation of F&G detector during engg. phase of the project to minimize inventory release in case of leakage.*

e. *It is advised to relocate MM shelter to a suitable location outside the 2 psi overpressure zone, in case the same is an occupied place.*

f. *Ensure DHDT SRR is positively pressurized to minimize chances of HC/H2S gas ingress in the building.*

g. *Ensure blast resistant design for RUF/HGU/DHT SRR building.*

h. *As proposed in the plot plan, ensure that ware house is shifted to a suitable location outside the unit at a safe location.*

i. *It is suggested to relocate the existing canteen to a safer location away from the process area, as the possibility of damage to canteen building can't be totally ignored at this stage.*

However, if existing canteen is to be retained at present location then ensure that stripper reflux pump of DHDT is located at ~200 m (min.) from the canteen building during detail engg. stage.

The location of canteen building should also be reviewed with respect to QRA study which is suggested to be carried out during detail engg. stage of the project.

E. HGU

It is observed from the impact contours on GIS map (Figures 7.1.1 to 7.2.3 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios from the process unit that the effect zone of flash fire is extending beyond the boundary of the unit. Maximum flash fire distance under the considered leak scenarios is ~61 m from the leak point. Further, it is observed that the jet fire radiation intensity of 37.5 kW/m2 is extending up to ~58 m from leak point which may result in damage of the process equipment and tech. structure falling in its range. No major impact is envisaged from pool fire scenario except some minor damage and health issue if action is not taken within time. 5 psi overpressure is expected to reach ~55 m from the leak point and may impact the HGU SRR, tech. structure and the reactor leading to their possible damage.

In line with the above observations from various credible failure scenarios in the unit and their possible impact on the surrounding facilities, the following points are recommended to enhance the overall safety of the unit/plant;

a. *Ensure HGU SRR building is positively pressurized.*

b. *Ensure blast resistant design for HGU SRR building.*

c. *Ensure H2 and HC gas detectors are provided at suitable location based on prevailing wind direction at the facility.*

d. *As LFL contour is reaching up to the HGU and DHT substation from source of gas release hence it is suggested that subtstation building shall be kept positively pressurised.*

F. SULPHUR BLOCK (SWS/ARU/SRU)

It is observed from the impact contours on GIS map (Figures 8.1.1 to 8.5.1 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak

scenarios from the process units that the effect zone of flash fire, pool fire and overpressure is not realized at the grade level. IDLH conc. of H2S and NH3 are realized above the grade level and the gas disperses below IDLH value before reaching on the ground in case of leakage from respective H2S and NH3 strippers.

An analysis of impact contours due to leakage from Acid Gas KO Drum, H2S Rich Sour Gas KO Drum and NH3 Rich Sour Gas KO Drum shows that IDLH conc. of H2S is reaching up to ~300 m and may extend beyond the southern boundary of the plant. The toxic cloud may reach up to a height of ~12 m before dispersing in the atmosphere below the IDLH conc. Further, IDLH conc. of NH3 is not realized in this scenario.

In view of the above observations from various credible failure scenarios, and their possible impact on the surrounding facilities, the following points are recommended to enhance the overall safety of the unit/plant;

a. *Install H2S detector at suitable locations near the H2S stripper top outlet for early detection of any toxic leakage and thereby ensuring suitable action to be taken by operator within time.*

b. *Install H2S detector at suitable locations near the NH3 stripper top outlet for early detection of any toxic leakage and thereby ensuring suitable action to be taken by operator within time.*

c. *Install H2S detector at suitable locations near the Amine regenerator top outlet for early detection of any toxic gas leakage and thereby ensuring suitable action to be taken by operator on time.*

d. *Install H2S detector at suitable locations near the Acid Gas KOD, H2S Rich Sour Gas KOD and NH3 Rich Sour Gas KOD for early detection of any toxic gas leakage and thereby ensuring suitable action to be taken by operator on time. This scenario shall be also covered in Onsite/Offsite disaster management plan.*

e. *Ensure availability of portable H2S detector with the operator/plant personnel while working near the H2S/NH3 Stripper, Acid Gas/H2S Rich Sour Gas/NH3 Rich Sour Gas KOD and Amine Regenerator.*

f. *Ensure availability of assembly point at a distance ~300 m from the sulphur block in upwind direction for personnel working in Slabbing & Packing & warehouse section. It is advised that personnel/workers should immediately evacuate the area and move to assembly point in case of toxic gas alarm. Assembly point to be identified and marked on the plot plan.*

Further the person working in this area should be adequately trained to response suitably in case of H2S leakage and move to assembly point as identified. This scenario shall be also covered in Onsite/Offsite disaster management plan.

It should be noted that gas retaining wall won't help much in this scenario as dispersion of gas cloud will depend on the prevailing weather condition of the day such scenario happens.

G. RUF

It is observed from the impact contours on GIS map (Figures 9.1.1 to 9.7.4 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios from the process unit that the effect zone of flash fire is by and large limited near the boundary of the unit and adjoining road on the eastern side of the facility. Maximum flash fire distance under the considered leak scenarios is ~67 m from the leak point. Further, it is observed that the jet fire radiation intensity of 37.5 kW/m2 is extending up to ~47 m from leak point which may result in damage of the process equipment and tech. structure falling within this range. Impact zone of 37.5 kW/m2 fire radiation intensity due to pool fire is reaching up to ~53 m from the leak point which may result in damage of tech. structure and process equipment falling within this zone. 5 psi overpressure is expected to reach ~75 m from the leak point and may impact the pipe rack on eastern side of the unit and tech. structure inside the unit leading to their possible damage. It is to be noted that majority of equipment in this unit handles toxic H2S gas along with other hydrocarbon with H2S conc. reaching up to 20 mol% (approx).

The maximum IDLH distance for H2S as reported by the software based on the credible leak scenario is ~714 m.

In view of the above observations from various credible leak scenarios in the unit and their possible impact, the following points are recommended to enhance the overall safety of the plant personnel and population outside the plant boundary;

a. *It is suggested to minimise the potential vulnerable leakage sources like flange joints, small bore pipings in the proces system containing high quantity toxic H2S component during the design. Further explore possibilities to minimize the inventory in the vessel/equipment to the maximum extent during the design. Equipment containing high % of H2S to be located such that they are at maximum distance from plant boundary.*

b. *Assembly point for plant personnel/staffs to be identified to assemble in case of any emergency scenario. Assembly point to be located upwind of the facility and should be marked on the plot plan.*

c. *Install adequate no. of H2S gas detector at suitable locations based on prevailing wind direction for early detection of any leakage from the equipment in order to take necessary action on time by the operator.*

d. *Ensure continuous availability of portable H2S detector with the workers/operators while working in RUF unit.*

H. DCU

It is observed from the impact contours on GIS map (Figures 10.1.1 to 10.4.3 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios from the process unit that the effect zone of flash fire is by and large limited near the boundary of the unit and adjoining road on the eastern, western and southern side of the facility. Maximum flash fire distance under the considered leak scenarios is ~80 m from the leak point. Further, it is observed that the jet fire radiation intensity of 37.5 kW/m2 is extending up to ~47 m from leak point which may result in damage of the process equipment and tech. structure falling within this range. Impact zone of 37.5 kW/m2 fire radiation intensity due to pool fire is reaching up to ~53 m from the leak point which may result in damage of tech. structure and process equipment falling in its zone. 5 psi overpressure is expected to reach ~76 m from the leak point and may impact tech. structure inside the unit and damage to existing crusher house and silos on the eastern side of the unit. The maximum IDLH distance for H2S based on the credible leak scenario is ~348 m and is impacting the existing control room, buildings and offices.

In view of the above observations from various credible failure scenarios, and their possible impact on the surrounding facilities, the following points are recommended to enhance the overall safety of the unit/plant;

a. *Assembly point for plant personnel/staffs to be identified and marked on the plot plan to assemble in case of any emergency scenario. Assembly point to be located upwind of the unit.*

b. *Review shifting of existing silo, Crusher house & MM SHED to a suitable location outide 2 psi over pressure zone in case they are occupied.*

c. *Install HC & H2S gas detector at suitable locations based on prevailing wind direction for early detection of any leakage from the equipment and thereby allowing operator to take necessary action on time.*

I. FCC GASOLINE HDT

It is observed from the impact contours on GIS map (Figures 11.1.1 to 11.3.3 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios from the process unit that the effect zone of flash fire is extending beyond the

boundary of the unit and overlapping the adjacent CDU/VDU, FCCU, FGHT & Utility substation and FCCU, FGHT & CDU/VDU SRR facilities along with the adjoining road on the northern, southern and western side of the facility. Maximum flash fire distance under the considered leak scenarios is ~84 m from the leak point. Further, it is observed that the jet fire radiation intensity of 37.5 kW/m2 is extending up to ~53 m from leak point which may result in damage of the process equipment, tech. structure and pipe rack structure (on the northern side) falling in this range. Impact zone of 37.5 kW/m2 fire radiation intensity due to pool fire is not realized in this scenario. 5 psi overpressure is expected to reach ~168 m from the leak point and may impact tech. structure, furnace inside the unit and damage to proposed FCCU, FGHT, HGU & CDU/VDU SRR buildings.

In view of the above observations from various credible failure scenarios in the unit and their possible impact on the surrounding facilities, the following points are recommended to enhance the overall safety of the unit/plant;

a. *Ensure SRR CDU/VDU, SRR FCCU, SRR HGU and SRR Gasoline HDT buildings are positively pressurized.*

b. *Install F&G detectors based on prevailing wind direction for early detection of any leakage in the unit, so that suitable action can be taken by operator.*

c. *As LFL contour is reaching upto the CDU/VDU, FCCU, FGHT & Utility substation from the source of release hence it is suggested that sub-station building shall be kept positively pressurised.*

J. OFFSITE TANKS/BULLETS

It is observed from the impact contours on GIS map (Figures 12.1.1 to 12.9.3 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios that;

- For crude oil storage tank the effect zone of flash fire is extending beyond the dyke area in the northern side of the facility and impacting the existing operator room (under Bio refinery project). Maximum flash fire distance under the considered leak scenarios is ~44 m from the tank leak point. Further, it is observed that the jet fire radiation intensity of 8 kW/m2 is extending up to ~16 m from leak point. Impact zone of 8 kW/m2 fire radiation intensity due to pool fire is reaching up to ~27 m from the leak point. 5 psi overpressure is expected to reach ~51 m from the leak point and may impact the existing operator room and MCC leading to their possible damage. 2/3 psi overpressure may lead to damage of cooling tower- bay no 6.

In view of the above observations from various credible failure scenarios in the Crude tank and their possible impact on the surrounding facilities, the following points are suggested to mitigate/minimize the hazardous impact;

a. *MCC (if occupied) & Operator room to be of blast proof design and positively pressurized or shall be shifted to a safe location outside the 2 psi overpressure zone.*

b. *Firewall to be considered in the dyke to avoid spread of radiation from one tank to another and the same to be depicted in plot plan/provided in a note.*

c. *Install F&G detectors at suitable locations based on prevailing wind direction for early detection of any leakage in the crude tank dyke area/pipe manifold area.*

d. *Ensure provision of active/Passive fire protection in the design for the crude tanks.*

- For the LPG bullets, installed along with the propylene bullets, effect zone of flash fire is extending beyond the bullet area in the eastern and southern side of the facility. Maximum flash fire distance under the considered leak scenarios is ~49 m from the bullet outlet manifold line. Further, it is observed that the jet fire radiation intensity of 8 kW/m2 is extending up to ~56 m from leak point. 5 psi overpressure is expected to reach ~52 m from the leak point. 2/3/5 psi overpressure may reach up to New Operator cabin (on eastern side) and can lead to its possible damage.

- For Propylene bullets effect zone of flash fire is extending beyond the storage area in the eastern and southern side of the bullets. Maximum flash fire distance under the considered leak scenarios is ~42 m from the bullet outlet line. Further, it is observed that the jet fire radiation intensity of 8 kW/m2 is extending up to ~58 m from leak point. Radiation intensity of 37.5 kW/m2 is reaching up to ~44 m and may impact the pipe rack structure on the western side of the facility. 5 psi overpressure is expected to reach ~50 m from the leak point. 2/3/5 psi overpressure effects may reach up to New Operator cabin (on eastern side) and can lead to its possible damage.

  In view of the above observations from various credible failure scenarios in the LPG and Propylene Bullet area and their possible impact on the surrounding facilities, the following points are suggested to mitigate/minimize the hazardous impact;

a. *Ensure that the new operator room (as mentioned on the Overall Plot plan) at the eastern side of Propylene/LPG bullet is blast resistant or relocate the same to a safe location outside the 2 psi over pressure zone.*

b. *Install suitable no. of F&G detectors based on prevailing wind direction for early detection of any leakage in the Propylene/LPG bullet area/pipe manifold area.*

c. *Ensure fire proofing requirement for pipe rack structure on the western side of the Propylene/LPG mounded bullet.*

- For MS tank, effect zone of flash fire is limited within the dyke area. Maximum flash fire distance under the considered leak scenarios is ~17 m from the tank. Further, it is observed that the jet fire radiation intensity of 8 kW/m2 is extending up to ~11 m from leak point. Impact zone of 8 kW/m2 fire radiation intensity due to pool fire is reaching up to ~27 m from the leak point and can impact the proposed pipe rack at the northern side of the storage tank. 5 psi overpressure is expected to reach ~13 m from the leak point and can possibly lead to pipe rack structure damage.

  In view of the above observations, the following are suggested to mitigate/minimize the hazardous impact;

  a. *Ensure fire proofing requirement for pipe rack structure at the northern side of the storage tank. Ensure adequate distance is maintained between the dyke and the pipe rack as per industry norms.*

  b. *Install adequate nos. of F&G detectors based on prevailing wind direction at the facility for early detection of any leakage in the MS Tank /pipe manifold area.*

K. OFFSITE PUMPS

It is observed from the impact contours on GIS map (Figures 13.1.1 to 13.9.4 in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios that;

- For DHDT Feed pump, the effect zone of flash fire is limited near the pump house. Maximum flash fire distance under the considered leak scenario is ~11 m from the pump. Further, it is observed that the jet fire radiation intensity of 8 kW/m2 is extending up to ~23 m from leak point. Impact zone of 8 kW/m2 fire radiation intensity due to pool fire is reaching up to ~39 m from the leak point and may result in damage of the FCC Feed tank. 5 psi overpressure is expected to reach ~12 m from the leak point.

In view of the above observations, the following are suggested to improve the safety of the unit/plant;

a. *Ensure active fire protection is provided in the design for the FCC Feed tanks.*

b. *Install adequate nos. of F&G detectors based on prevailing wind direction at the facility for early detection of any leakage in the DHDT Feed Pump area.*

- For NHT Feed pump, the effect zone of flash fire is extending up to ~152 from the leak point. Further, it is observed that the jet fire radiation intensity of 8 kW/m2 is extending up to ~38 m from leak point. Impact zone due to pool fire is not realized in this scenario. Blast overpressure of 5 psi is extending up to ~179 m from the leak point and may result in damage to proposed SRR OFFSITE building.

In view of the above observations, the following are suggested to improve the safety of the unit/plant;

a. *Install adequate nos. of F&G detectors based on prevailing wind directiony for early detection of any leakage in the NHT Feed Pump area.*

b. *Ensure SRR Offsite building is blast resistant design and positively pressurized or it is shifted to safe location outside the 2 psi overpressure zone (~203 m).*

- For Reformate pump, the effect zone of flash fire is extending up to ~13 from the leak point. Further, it is observed that the jet fire radiation intensity of 8 kW/m2 is extending up to ~26 m from leak point. Impact zone of 8 kW/m2 fire radiation intensity due to pool fire is reaching up to ~37 m from the leak point and may result in damage of the pipe rack provided at the southern end of the facility. Blast overpressure of 5 psi is extending up to ~12 m from the leak point and may result in damage to existing oil storage facility.

In view of the above observations, the following are suggested to improve the safety of the unit/plant;

a. *Install adequate nos. of F&G detectors based on prevailing wind direction at the facility for early detection of any leakage in the Reformate Pump area.*

b. *Ensure fire proofing requirement in the design for pipe rack structure at the southern side of the reformate pump.*

c. *Relocate the lube oil storage facility near HSD tanks outside the 2 psi over pressure zone, in case the oil storage doesn't have any dyke and there is possibility of fire escalation spreading to nearby process area.*

L. LPG GANTRY

It is observed from the impact contours on GIS map (Figures 14.1.1(a) to 14.2.3(b) in annexure-I) and the tabulated consequence distance as provided in the annexure-II due to various leak scenarios that in case of hose rupture the flash fire zone is extending up to a distance of ~142 m and Jet fire radiation intensity of 8 kW/m2 is extending up to ~63 m from leak point. Additionally, Blast overpressure of 2, 3 and 5 psi is extending up to ~197 m, 182 m and 171 m respectively from the leak point endangering various existing and new buildings on the southern and northern side of the proposed gantry location.

In view of the above observations the following are suggested to mitigate/minimize the hazardous impact on the surrounding area;

a. *Relocate scale room, control room, Main. Building, store, Admin canteen building to a suitable location outside the 2 psi over pressure zone. If shifting of control room is not possible then blast resistant design for control room to be ensured.*

b. *Ensure existing DG Room and substation & new substation Offsite are positively pressurized or shift the same to a non hazardous location outside the flash fire zone.*

c. *Ensure blast resistant design for SRR Offsite building.*

M. GENERAL RECOMMENDATIONS FOR THE PROPOSED PROJECT

a. *Updated safe evacuation plan should be made available for the units based on revised layout as part of Disaster Management Plan and should also be implemented.*

Emergency exit for the new process plant area to be identified and marked on revised plot plan.

b. *Access road around the new hydrocarbon facilities should be classified and restricted for vehicle movement except for handling emergency situation/ crucial maintenance activities.*

c. *Proper checking of personnel at entry gates for inflammable materials to be ensured to avoid presence of any unidentified source of ignition entering into the plant area.*

d. *It is advised to carry portable H2S gas detector while working in the area near the facilities handling high conc. of H2S in the process fluid.*

e. *Instrument tapping, small bore tapping and process equipment should be inspected regularly during operation for integrity check. Periodic health check of equipment, instruments and maintenance of all equipment & piping are required to be ensured. Periodic calibration of instruments and testing of alarms, trips, interlocks should be given due attention under the existing operation & maintenance philosophy of the units.*

f. *As the work will progress in an existing facility, hence it is advised that proper barricading of the construction area to be done prior to installation of the new facilities. It is advised to develop the Barricading Philosophy for this Project and the same to be followed by owner/contractor during various stages of the project execution.*

g. *It is suggested to provide H2S and HC gas detectors along with hooters and alarm along the barricade during construction phase, if there is possibility of gas ingress in the construction area from the process facility operating in the vicinity.*

h. *It is advised to carry out HAZID (Hazard Identification) study of the project facilities and ensure recommendations are implemented suitably.*

i. *SIMOPS study to be carried out for construction/commissioning stage to identify potential hidden hazards associated with the installation of the new facilities and suggest mitigating measures.*

j. *It is suggested to carry out QRA (Quantitative Risk Assessment) Study of the complete facilities (including new one) of the refinery during engg. stage of the Project.*

k. *Mock drills to be organized at organization level to ensure preparedness of the operators/personnel's working in premises for handling any hazardous situation and safe evacuation to identified area.*

l. *It is suggested to ensure that any new gate provided for vehicle entry is round the clock guarded during construction and post-commissioning stages. Any entry/exit to/from the plant area under the proposed project should be properly checked and recorded in the Vehicle/Personnel Movement entry log register.*

In case, these new gates are to be discarded post-commissioning activities of facilities under project then dismantled boundary wall shall again be erected as per existing oil industry norms.

m. *It shall be ensured and checked that all vehicles entering the plant area are provided with spark arrestors at the exhaust.*

n. *It is suggested that periodic (by operators) and in service inspection (by certified inspector) of the hydrocarbon tanks/bullets is carried out on regular basis.*

o. *It is suggested to provide suitable fire protection system as applicable and fire fighting facilities for the new project facilities as per standards.*

p. *It is recommended that all workers, working near the leakage area shall wear special breathing equipment while attending the leak. Workers/Personnel not wearing the special breathing equipment should immediately leave the area and move to safe location. This should be covered under SOP (Standard Operating Procedure) of the facilities.*

q. *It is suggested to install permanent CCTV facilities for better monitoring the new units/furnace areas from control room.*