6.0 RISK ANALYSIS

6.1 PREAMBLE

Naphtha produced in CDU & Hydrocracker Unit is presently used for production of MS & rest is used as fuel in Gas Turbine and in Reformer as feed and fuel. M/s NRL want to replace the use of Naphtha as fuel in GT as well as in Reformer once Natural Gas is available. Hence, there will be surplus Naphtha available once Natural Gas is available. M/s NRL have committed to supply 1,60,000 MT of Naphtha (of specific composition) to M/s BCPL which will be the feed to their Hydrocracker. Hence, Naphtha Splitter Unit had to be conceived which is primarily a distillation unit using feed as straight run Naphtha and Hydrocracker Naphtha.

6.2 OBJECTIVE

As the unit will handle Naphtha which has got potential of fire / explosion hazard, it is necessary to evaluate risk from different units. Accordingly, M/s Projects & Development India Limited (PDIL) has been retained by M/s NRL as consultant to carryout Risk Analysis study of Naphtha Splitter Unit.

6.3 The risk analysis has been carried out in line with the requirements of various statutory bodies -

- Identification of potential hazard areas.
- Identification of representative failure cases.
- Identification of possible initiating events.
- Identification of maximum credible accident scenario.
- Assess overall damage potential of identified hazardous events and impact zones of the accident scenarios.
- Consequence analysis for all possible events.
- Hazard effect of the proposed unit on the existing CDU, VDU units.

Hazard Identification

- Identify potentially hazardous materials that can cause loss of human life/injury, loss of properties and deteriorate the environment due to loss of containment.
- Identify potential scenarios, which can cause loss of containment and consequent hazards like fire, explosion and toxicity.

Consequence Analysis

- Evaluate the magnitude of consequences of different potential hazard scenarios and their effect zones.
- Consequence analysis is a measure of potential hazards and is important for taking precautionary measures for risk reduction as for well as for preparation of Disaster Management Plan.

This report has been prepared by applying the standard techniques of risk assessment & the information provided by NRL. Software used is PHAST RISK of M/s DNV Technica.

6.4 HAZARD IDENTIFICATION

6.4.1 Introduction

Identification of hazards in the proposed project is of primary significance in the analysis, quantification and cost effective control of accidents involving chemicals and process. A classical definition of hazard states that hazard is in fact the characteristic of system/plant/process that presents potential for an accident. Hence, all the components of a system/plant/process need to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

Typical schemes of predictive hazard evaluation and quantitative risk analysis suggest that hazard identification step plays a key role.

Estimation of probability of an unexpected event and its consequences form the basis of quantification of risk in terms of damage to property, environment or personnel. Therefore, the type, quantity, location and conditions of release of a flammable substance have to be identified in order to estimate its damaging effects, the area involved and the possible precautionary measures required to be taken. The following two methods for hazard identification have been employed in the study:

- Identification of hazardous units based on relative ranking technique, viz. Fire-Explosion and Toxicity Index (FE&TI); and
- Maximum Credible Accident Analysis (MCAA).

6.4.2 Classification of Major Hazardous Substance

Hazardous substances may be classified into three main classes namely flammable/explosive substances, unstable substances and toxic substances.

Flammable substances require interaction with air for their hazard to be realized. Under certain circumstances the vapours arising from flammable substances when mixed with air may be explosive especially in confined spaces. However, if present in sufficient quantity such clouds may explode in open air also.

Unstable substances are liquids or solids, which may decompose with such violence so as to give rise to blast waves.

Finally, toxic substances are dangerous and cause substantial damage to life when released into the atmosphere. The ratings for a large number of chemicals based on flammability, reactivity and toxicity are given in NFPA Codes.

6.5 MAXIMUM CREDIBLE ACCIDENT ANALYSIS (MCAA) APPROACH

6.5.1 Introduction

A Maximum Credible Accident (MCA) can be characterized, as an accident with a maximum damage potential, which is still believed to be probable.

MCA analysis does not include quantification of the probability of occurrence of an accident. Moreover, since it is not possible to indicate exactly a level of probability that is still believed to be credible, the selection of MCA is somewhat arbitrary. In practice, the selection of accident scenarios representative for a MCA-Analysis is done on the basis of engineering judgement and expertise in the field of risk analysis studies, especially accident analysis.

Major hazards posed by flammable storage can be identified taking recourse to MCA analysis. MCA analysis encompasses certain techniques to identify the hazards and calculate the consequent effects in terms of damage distances of heat radiation, toxic releases, vapour cloud explosion etc. A host of probable or potential accidents of the major units in the complex arising due to use, storage and handling of the hazardous materials are examined to establish their credibility. Depending upon the effective hazardous attributes and their impact on the event, the maximum effect on the surrounding environment and the respective damage caused can be assessed.

As an initial step in this study, a selection has been made of the processing and storage units and activities, which are believed to represent the highest level or risk for the surroundings in terms of damage distances. For this selection the following factors have been taken into account:

- Type of compound viz. flammable or toxic;
- Quantity of material present in a unit or involved in an activity; and
- Process or storage conditions such as temperature, pressure, flow, mixing and presence of incompatible materials.

In addition to be above factors, the location of a unit or activity with respect to adjacent activities is taken into consideration to account for the potential escalation of an accident. This phenomenon is known as the Domino Effect. The units and activities, which have been selected on the basis of the above factors, are summarized; accident scenarios are established in hazard identification studies, while effect and damage calculations are carried out in Maximum Credible Accident Analysis Studies.

6.5.2 Methodology

Following steps are employed for visualization of MCA scenarios:

- Chemical inventory analysis;
- Identification of chemical release and accident scenarios;
- Analysis of past accidents of similar nature to establish credibility to identified scenarios; and
- Short-listing of MCA scenarios.

6.5.3 Common Causes of Accidents

Based on the analysis of past accident information, common causes of accidents are identified as:

- Poor house keeping;
- Improper use of tools, equipment, facilities;
- Unsafe or defective equipment facilities;
- Lack of proper procedures;
- Improvising unsafe procedures;
- Failure to follow prescribed procedures;
- Jobs not understood;
- Lack of awareness of hazards involved;
- Lack of proper tools, equipment, facilities;
- Lack of guides and safety devices; and
- Lack of protective equipment and clothing.

6.5.4 Failures of Human Systems

An assessment of past accidents reveal human factor to be the cause for over 60% of the accidents while the rest are due to other component failures. This percentage will increase if major accidents alone are considered for analysis. Major causes of human failures reported are due to:

- Stress induced by poor equipment design, unfavourable environmental conditions, fatigue, etc.;
- Lack of training in safety and loss prevention;
- Indecision in critical situations; and
- Inexperienced staff being employed in hazardous situations.

Often, human errors are not analyzed while accident reporting and accident reports only provide information about equipment and/or component failures. Hence, a great deal of uncertainty surrounds analysis of failure of human systems and consequent damages.

6.5.5 Maximum Credible Accident Analysis (MCAA)

Hazardous substances may be released as a result of failures or catastrophes, causing possible damage to the surrounding area. This section deals with the question of how the consequences of the release of such substances and the damage to the surrounding area can be determined by means of models.

It is intended to given an insight into how the physical effects resulting from the release of hazardous substances can be calculated by means of models and how vulnerability models can be used to translate the physical effects in terms of injuries and damage to exposed population and environment. A disastrous situation is general due to outcome of fire, explosion or toxic hazards in addition to other natural causes, which eventually lead to loss of life, property and ecological imbalance.

Major hazards posed by flammable storage and distillation units can be identified taking recourse to MCA analysis. MCA analysis encompasses certain techniques to identify the hazards and calculate the consequent effects in terms of damage distances of heat radiation, toxic release, vapour cloud explosion etc. A host of probable or potential accidents of the major units in the complex arising due to use, storage and handling of the hazardous materials are examined to establish their credibility. Depending upon the effective hazardous attributes and their impact on the event, the maximum effect on the surrounding environment and the respective damage caused can be assessed. The MCA analysis involves ordering & ranking of various sections in terms of potential vulnerability.

6.6 RISK ANALYSIS

6.6.1 Properties of Materials Handled

Naphtha Splitter Unit handles Naphtha from CDU and Hydrocracker Unit. These products are a combination of Hydrocarbons and are highly inflammable. Naphtha is Class-A type petroleum liquid (Flash Point <23°C) according to convention. The products once spilled from the containment will cause fire if they get a contact with an ignition source. Vapours may also cause explosion.

Table - 6.1
PROPERTIES OF NAPHTHA

(1)	Boiling Range (°C)	:	42 - 215
(2)	Density at 15°C	:	~ 0.80
(3)	Flash Point (°C)	:	<18
(4)	Vapour pressure at 38°C (Kg/Cm^{2}abs)	:	~ 73
(5)	Heat of Combustion (BTU/lb)	:	~ 18,800
(6)	Auto Ignition Temperature (°C)	:	~ 280
(7)	LFL (% v/v)	:	1.4
(8)	UFL (% v/v)	:	7.6

6.6.2 Product Specification

Cracker feed Naphtha will have the following specifications:

Table - 6.2
PRODUCT SPECIFICATION

Sl. No.	Description	Unit	Test Method	Specification
01.	Colour	Saybolt	ASTM D-156	+25
02.	Deisity at 15°C	Gm/ml	ASTM D-1298	0.689
03.	Sulphur (Total)	ppm (max)	D-3120 alt UOP-357	500
04.	Total Paraffin	Vol % (min)	PIO NA/D5543 alt D5134 (OC)	70.5
05.	Iso/Normal Paraffin	Vol % (max)	- do -	1.85
06.	Olefins	Vol % (max)	- do -	0.5
07.	Aromatics	Vol % (max)	- do -	6.0
08.	Naphthene	Vol % (max)	- do -	Balance
09.	IBP	°C	ASTM D-86	42
10.	FBP	°C	- do -	145
11.	RVP	Psia (max)	ASTM D-323	10.0
12.	Chlorides	Ppmw (max)	ASTM D-4929-94	1.0
13.	Lead	Ppbw	AAS with graphite furnace	6.0
14.	Mercury	Ppbw (max)	CVAA	30.0

6.7 DOW INDEX

6.7.1 Fire Explosion & Toxicity Index (FE & TI) Approach

Fire, Explosion and Toxicity Indexing (FE & TI) is a rapid ranking method for identifying the degree of hazard. The application of FE&TI would help to make a quick assessment of the nature and quantification of the hazard in these areas. However, this does not provide precise information. Respective Material Factor (RMF), General Hazard Factors (GHF), Special Process Hazard Factors (SPHF) are computed using standard procedure of awarding penalties based on storage handling and reaction parameters. Before hazard indexing can be applied, the installation in question should be subdivided into logical, independent elements or units. In general, a unit can logically be characterized by the nature of the process that takes place in it. In some cases, the unit may consist of a plant element separated from the other elements by space or by protective walls. A plant element may also be an apparatus, instrument, section or system that can cause a specific hazard. For each separate plant process, which contains flammable or toxic substances, a Fire and Explosion Index (F & EI) and/or a Toxicity Index (TI) may be determined in a manner derived from the method for determining a fire and explosion index developed by the Dow Chemical Company.

6.7.2 FE and TI Methodology

Dow's Fire and Explosion Index (F and EI) is a product of Material Factor (MF) and Hazard Factor (F3) while MF represents the flammability and reactivity of the substances, the hazard factor (F3), is itself a product of General Process Hazards (GPH) and Special Process Hazards (SPH). An accurate plot plan of the plant, a process flow sheet and Fire and Explosion Index and Hazard Classification Guide published by Dow Chemical Company are required to estimate the FE & TI of any process plant or a storage unit.

6.7.3 Computations and Evaluation of Fire and Explosion Index

The Fire and Explosion Index (F&EI) is calculated from the following formula:

F & EI = MF x (GPH) x (SPH)

The degree of hazard potential is identified based on the numerical value of F&EI as per the criteria given below:

F & EI Range	Degree of Hazard
0 – 60	Light
61 – 96	Moderate
97 – 127	Intermediate
128 – 158	Heavy
159 – Up	Severe

6.7.4 Toxicity Index (TI)

The toxicity index is primarily based on the index figures for health hazards established by the NFPA in Codes NFPA 704, NFPA 49 and NFPA 345 m. However, the products handled are not toxic.

6.7.5 Classification of Hazard Categories

By comparing the indices F&EI and TI, the unit in question is classified into one of the following three categories established for the purpose (Table - 6.3).

Table - 6.3
FIRE, EXPLOSION AND TOXICITY INDEX

Category	Fire & Explosion Index (F&EI)	Toxicity Index (TI)
I	F&EI, 65	TI < 6
II	65 < or = F&EI < 95	6 < or = TI < 10
III	F&EI > or = 95	TI > or = 10

Certain basic minimum preventive and protective measures are recommended for the three hazard categories.

6.7.6 Calculation of DOW Fire & Explosion Index

Dow Fire & Explosion Index has been calculated for the major equipment in Naphtha Splitter Unit and is given in Table - 6.4.

Table - 6.4
CALCULATION OF DOW FIRE & EXPLOSION INDEX

Equipment	Stored/ Process Material	Material Factor (MF)	General Process Hazard Factor (F_1)	Special Process Hazard Factor (F_2)	Unit Hazard Factor (F_3)	Fire & Explosion Index F&EI = F_3xMF	Exposure Radius Ft.	Degree of Hazard
Naphtha Storage Tank	Naphtha	16	2.3	2.9	6.67	107	90	III
SRN Splitter	Naphtha	16	2.3	2.52	5.796	93	78	II
HCN Splitter	Naphtha	16	2.3	2.91	6.693	107	90	III
Stabilizer	Naphtha	16	2.3	2.58	5.936	95	80	III
SRN Splitter Reflux Drum	Naphtha	16	2.3	2.37	5.45	87	73	II
HCN Splitter Reflux Drum	Naphtha	16	2.3	2.68	6.164	99	83	III
Stabilizer Reflux Drum	Naphtha	16	2.3	2.37	5.45	87	73	II

6.7.7 Hazards of Equipment / Pipeline Handling Petroleum Products

6.7.7.1 The hazard of equipment/pipeline handling petroleum products is the potential loss of integrity of the containment with subsequent release of liquid causing fire. The pipelines carry large quantities of petroleum liquid. A rare pipeline fracture would release large quantities of hydrocarbons. The product would get collected in the neighbourhood of the pipeline and may lead to a fire hazard if it gets source of ignition and proper precautions are not taken.

Catastrophic failure of the shell of a storage tank, distillation column or Reflux Drum is a very rare phenomenon, which may occur due to earthquake or due to aerial bombardment during war. However, vapour coming out through the vent line of fixed roof tank or through vapour seal around the shell in floating roof tanks may be ignited through lightning. However, such cases are also very rare. In such cases the whole tank may be on fire. Corrosion in the tanks, distillation column may cause small holes causing release of petroleum liquid from the tanks. However, in case of storage tank, the oil will be contained in the dyke. In case of oil spill collected on ground an oil pool will be formed. An ignited pool of oil is called Pool Fire. It creates long smoky flames. The wind may tilt the flame towards ground causing secondary fires and damages. Radiation from the flame can be very intense near the fire but falls off rapidly beyond 3-4 pool diameters. Such fires are very destructive within the plant area and near the source of generation.

Explosion is another phenomenon in case of release of Naphtha if vapour from the released liquid gets in contact with ignition source.

6.7.8 Brief Review of Safety Related Facilities

6.7.8.1 Because of the inherent hazard potential of the petroleum products to be handled in the plant, due care is to be taken in the design and installation of the storage tanks, distillation columns and other equipment & pipelines and other associated facilities e.g.

i) Well established code of practice in design and installation.
ii) Well planned layout.
iii) Proper instrumentation & control system.
iv) Provision of weather resistant painting for protection of exposed areas of pipelines, valves and equipment.
v) Provision of dykes and fire walls around storage tanks.
vi) Well planned Fire Fighting Facilities.
vii) Well established organisation entrusted for design, inspection & erection of the facility.

viii) Well trained manpower for operation and maintenance.

6.7.8.2 Fire Fighting Facilities

i] Well planned fixed fire fighting facilities have been considered in the installation e.g.

a) Fire Hydrants and Monitors

Fire Hydrants and monitors shall be provided around the dyke walls of Naphtha Storage Tanks in the Marketing Terminal. They are already provided in the plant where the facilities are coming.

Layout of fire hydrants & monitors and isolation valves have been made in such a way that Fire Tenders can approach to put out fire in any possible area.

b) Spray Protection system

Storage tanks containing Naphtha shall be provided with water spray protection. Perforated spray water pipes shall be provided around the shell of the storage tanks and shall be located at the top of the shell.

Fire Fighting Systems has been designed as per guidelines of OISD-116, OISD-117 and other applicable standards as well as TAC rules.

ii] Fire Station

M/s NRL have arranged fire tenders of various types for combating fire. Well trained personnel are available round the clock for fire fighting operation.

iii] Portable Fire Fighting Apparatus

Suitable types of Fire Extinguishers and other fire fighting apparatus shall be provided in vulnerable areas of the plant, storage facilities, etc. as per OISD guidelines such as DCP extinguishers.

6.7.8.3 Safety Valves

To prevent building of pressure and consequent damage two numbers of pressure vacuum valves shall be provided on the roof of Naphtha Tanks to release pressure.

6.8 RISK ASSESSMENT

6.8.1 Introduction

The Naphtha Splitter Plant of M/s NRL, which includes the facilities for receipt, distillation and storage of petroleum products mainly poses fire hazard due to unwanted and accidental release of hydrocarbons. However, due safeguard is being taken in design, installation and operation of the system to prevent any unwanted release of hydrocarbons from their containment. However, in the event of release of hydrocarbons from their containment, there is a risk of fire. The chances of explosion are less. This section deals with various failure cases leading to various hazard scenarios, analysis of failure modes and consequence analysis.

Consequence analysis is basically a quantitative study of hazard due to various failure scenarios to determine the possible magnitude of damage effects and to determine the distances up-to which the damage may be effected. The reason and purpose for consequence analysis are manifolds like -

- ☞ computation of risk.
- ☞ aid better plant layout.
- ☞ evaluate damage and protective measures necessary for saving properties & human lives.
- ☞ ascertain damage potential to public and evolve protective measures.
- ☞ formulate safe design criteria and protection system.
- ☞ formulate effective Disaster Management Plan.

The results of consequences analysis are useful for getting information about all known and unknown effects that are of importance when failure scenarios occur and to get information about how to deal with possible catastrophic events. It also gives the plant authorities, workers, district authorities and the public living in the area an understanding of the hazard potential and remedial measures to be taken.

6.8.2 Modes of Failure

There are various potential sources of large/small leakages in any installation. The leakages may be in the form of gasket failure in a flanged joint, snapping of small dia pipeline, leakages due to corrosion, weld failure, leakages due to wrong opening of valves

& blinds, pipe bursting due to overpressure, pump mechanical seal failure and any other sources of leakage. Catastrophic failure of distillation column and other vessels / tanks are a rare phenomena and can occur due to earthquake, aerial bombardment during war, etc.

6.8.3 Damage Criteria

The damage effect of all such failures mentioned above are mainly due to thermal radiation from pool fire or jet fire due to ignition of hydrocarbons released since Naphtha is highly inflammable whose flash point is low.

Naphtha released accidentally due to any reason will normally spread on the ground as a pool or released in the form of jet in case of release from a pressurised pipeline through small openings. Light hydrocarbons present in Naphtha will evaporate and may get ignited both in case of jet as well as liquid pool causing jet fire or pool fire. Accidental fire on the storage tanks due to ignition of vapour from the tanks or due to any other reason may also be regarded as pool fire.

Thermal radiation due to pool fire or jet flame may cause various degrees of burns on human bodies. Also its effect on inanimate objects like equipment, piping, building and other objects need to be evaluated. The damage effects due to thermal radiation intensity are elaborated in Table - 6.5.

Table - 6.5
DAMAGE DUE TO INCIDENT THERMAL RADIATION INTENSITY

Incident Thermal Radiation Intensity KW/M^2	Type of Damage
37.5	Can cause heavy damage to process equipment, piping, building etc.
32.0	Maximum Flux level for thermally protected tanks.
12.5	Minimum energy required for piloted ignition of wood.
8.0	Maximum heat flux for uninsulated tanks.
4.5	Sufficient to cause pain to personnel if unable to reach cover within 20 sec. (First Degree Burn).
1.6	Will cause no discomfort to long exposure.
0.7	Equivalent to solar radiation.

Table - 6.6
PHYSIOLOGICAL EFFECTS OF THRESHOLD THERMAL DOSES

Dose Threshold KJ/M^2	Effect
375	3rd Degree Burn.
250	2nd Degree Burn.
125	1st Degree Burn.
65	Threshold of pain, no reddening or blistering of skin caused.

1st Degree Burn ➡ Involve only epidermis, blister may occur; example - sun burn.

2nd Degree Burn ➡ Involve whole of epidermis over the area of burn plus some portion of dermis.

3rd Degree Burn ➡ Involve whole of epidermis and dermis; subcutaneous tissues may also be damaged.

In case of Naphtha having relatively higher vapour pressure, there is a possibility of vapour cloud explosion. Damage effects due to blast over pressure is given in Table - 6.7.

Table - 6.7
DAMAGE EFFECTS DUE TO BLAST OVER PRESSURE

Blast Over Pressure (Bar)	Damage Type
0.30	Major Damage to Structures
0.17	Eardrum Rupture
0.10	Repairable Damage
0.03	Damage of Glass
0.01	Crack of Windows

6.8.4 Dispersion and Stability Class

In calculation of effects due to release of Naphtha dispersion of vapour plays an important role as indicated earlier. The factors which govern dispersion is mainly Wind Velocity, Stability Class, Temperature as well as surface roughness. One of the characteristics of atmosphere is stability, which plays an important role in dispersion of pollutants. Stability is essentially the extent to which it allows vertical motion by suppressing or assisting turbulence. It is generally a function of vertical temperature profile of the atmosphere. The stability factor directly influences the ability of the atmosphere to disperse pollutants emitted into it from sources in the plant. In most dispersion problems relevant atmospheric layer is that nearest to the ground. Turbulence induced by buoyancy forces in the atmosphere is closely related to the vertical temperature profile.

Temperature of the atmospheric air normally decreases with increase in height. The rate of decrease of temperature with height is known as the Lapse Rate. It varies from time to time and place to place. This rate of change of temperature with height under adiabatic, or neutral condition is approximately 1°C per 100 metres. The atmosphere is said to be stable, neutral or unstable according to the lapse rate is less than, equal or greater than dry adiabatic lapse rate i.e. 1°C per 100 metres.

Pasquill has defined six stability classes ranging from A to F –

A = Extremely unstable

B = Moderately unstable

C = Slightly unstable

D = Neutral

E = Stable

F = Highly stable

6.8.5 Selected Failure Cases

The mode of approach adopted for consequence analysis is first to select the probable failure scenarios. The failure scenarios are indicated in Table - 6.8.

Table - 6.8
LIST OF FAILURE CASES

Sl. No.	Failure Scenarios	Likely Consequences	Credible/ Non-credible
1]	Catastrophic failure of - i) SRN Splitter ii) HCN Splitter iii) Stabilizer	Thermal Radiation, Blast Overpressure	Non Credible
2]	Full bore failure of discharge lines of overhead Pumps of - i) SRN Splitter ii) HCN Splitter iii) Stabilizer	- do -	Non Credible
3]	Full bore failure of discharge lines of bottom Pumps of - i) SRN Splitter ii) HCN Splitter iii) Stabilizer	- do -	Non Credible
4]	Gasket failure of discharge lines of overhead Pumps of - i) SRN Splitter ii) HCN Splitter iii) Stabilizer	- do -	Credible
5]	Full bore failure of discharge lines of bottom Pumps of - i) SRN Splitter ii) HCN Splitter iii) Stabilizer	- do -	Non Credible
6]	Mechanical seal failure of overhead Pumps of - i) SRN Splitter ii) HCN Splitter iii) Stabilizer	- do -	Credible
7]	Mechanical seal failure of bottom Pumps of - i) SRN Splitter ii) HCN Splitter iii) Stabilizer	- do -	Credible
8]	Product Naphtha Storage Tank Catastrophic failure	- do -	Non Credible
9]	Product Naphtha Storage Tank on fire	Thermal Radiation	Non Credible

It will be seen that most of the probable cases of failures have been considered for Consequence Analysis.

6.9 CONSEQUENCE ANALYSIS

Consequence Analysis of the selected failure cases have been done to evaluate and identify possible consequences as well as to incorporate suitable measures in operational phase to prevent and mitigate such failure events.

6.9.1 Catastrophic Failure of SRN Splitter, HCN Splitter & Stabilizer

Catastrophic failure of distillation towers is a rare phenomenon. It failure frequency is 6.5 x 10^{-6} per year. However, consequence analysis has been done for such cases. Hold up capacity of SRN Splitter is 3067 Kg, HCN Splitter is 8710 Kg and the same for Stabilizer is 5001 Kg.

In case of failure of SRN Splitter, all the liquid inside the distillation column will come out and fall on the ground and form a pool. The pool may ignite causing pool fire and the vapour formed may be ignited causing unconfined vapour cloud explosion. Hazard distances due to thermal radiation as a result of pool fire and vapour cloud explosion are given in Table - 6.9 and 6.10.

Table - 6.9
HAZARD DISTANCES FOR THERMAL RADIATION DUE TO CATASTROPHIC FAILURE OF DISTILLATION TOWERS

Incident Thermal Radiation Intensity (KW/M^2)	Hazard distances (m) for					
	Day			Night		
	2B	3D	5D	2F	3D	5D
SRN SPLITTER						
37.5	56	62	93	32	39	72
12.5	64	74	104	35	53	88
4.5	71	82	112	50	66	99
HCN SPLITTER						
37.5	NR	NR	NR	NR	NR	NR
12.5	28	30	30	26	29	35
4.5	62	69	81	60	68	80

NR = Not Reached

Table - 6.10
HAZARD DISTANCES TO UNCONFINED VAPOUR CLOUD EXPLOSION DUE TO CATASTROPHIC FAILURE OF DISTILLATION TOWERS

Sl. No.	Wind Speed (m/sec) / Stability Class	Max. distances (m) due to overpressure of			LFL	
		0.3 bar	0.1 bar	0.03 bar	Day	Night
SRN SPLITTER						
01.	2B / 2F	218/210	266/259	413/403	140	126
02.	3D / 3D	222/212	268/257	420/400	144	137
03.	5D / 5D	225/218	268/260	421/415	154	150
HCN SPLITTER						
01.	2B / 2F	229/225	289/282	465/453	143	139
02.	3D / 3D	221/226	276/280	446/452	146	143
03.	5D / 5D	220/222	268/272	436/441	150	148
STABILIZER						
01.	2B / 2F	189/185	207/211	393/396	98	96
02.	3D / 3D	208/213	232/228	408/408	124	121
03.	5D / 5D	246/224	254/251	410/410	149	143

6.9.2 Full Bore Failure of Overhead Pump Discharge Lines of SRN Splitter, HCN Splitter and Stabilizer

Full bore failure of pump discharge lines is a non credible phenomenon. The discharge line sizes for these pumps are –

		Size	Failure Frequency
(i)	SRN Splitter	2" (50 NB)	1.7×10^{-6} / m / year
(ii)	HCN Splitter	4" (100 NB)	2.2×10^{-7} / m / year
(iii)	Stabilizer	3" (80 NB)	2.0×10^{-7} / m / year

Source: DNV Technica, UK

In case of failure of pump discharge lines, Naphtha will fall on the ground and will form a pool. The pool may be ignited if vapour on the pool gets in ignition source pool fire will occur. In case of stabilizer overhead pump full bore failure, jet fire will occur. Thermal radiation due to pool fire / jet fire can cause damage to objects near the pool and can also cause lethality of persons. Hazard distances due to “Pool Fire” is given in Table - 6.11.

Table - 6.11
HAZARD DISTANCES TO POOL FIRE / JET FIRE DUE TO FULL BORE FAILURE OF OVERHEAD PUMP DISCHARGE LINES

Incident Thermal Radiation Intensity (KW/M^2)	Hazard distances (m) for					
	Day			Night		
	2B	3D	5D	2F	3D	5D
SRN SPLITTER OVERHEAD PUMP: Release Rate - 1.93 Kg/Sec.						
37.5	8	8	9	8	8	9
12.5	20	22	25	20	22	25
4.5	33	35	36	35	35	36
HCN SPLITTER OVERHEAD PUMP: Release Rate - 7.48 Kg/Sec.						
37.5	NR	16	16	16	15	16
12.5	24	26	29	24	25	28
4.5	46	49	52	45	48	51
STABILIZER OVERHEAD PUMP: Release Rate - 2.82 Kg/Sec. (Jet Fire)						
37.5	29	27	25	29	27	25
12.5	35	33	31	35	33	31
4.5	43	42	40	44	42	40

NR = Not Reached

Vapours from the pool may disperse downwind and can cause Unconfined Vapour Cloud Explosion if the vapours get an ignition source within the LFL distance. The results of Unconfined Vapour Cloud Explosion are given in Table - 6.12.

Table - 6.12
HAZARD DISTANCES DUE TO UNCONFINED VAPOUR CLOUD EXPLOSION FOR FULL BORE FAILURE OF OVERHEAD PUMP DISCHARGE LINES

Sl. No.	Wind Speed (m/sec) / Stability Class	Max. distances (m) due to overpressure of			LFL	
		0.3 bar	0.1 bar	0.03 bar	Day	Night
SRN SPLITTER OVERHEAD PUMP: Release Rate - 1.93 Kg/Sec.						
01.	2B / 2F	49/53	58/66	82/102	33	32
02.	3D / 3D	49/39	58/58	82/81	31	30
03.	5D / 5D	37/37	44/44	63/62	26	26
HCN SPLITTER OVERHEAD PUMP: Release Rate - 7.48 Kg/Sec.						
01.	2B / 2F	110/105	129/131	182/200	71	70
02.	3D / 3D	101/96	114/113	159/157	67	65
03.	5D / 5D	84/84	98/97	136/134	54	52
STABILIZER OVERHEAD PUMP: Release Rate - 2.82 Kg/Sec.						
01.	2B / 2F	89/94	99/108	126/146	44	55
02.	3D / 3D	79/79	90/89	116/115	44	43
03.	5D / 5D	69/69	78/78	103/103	39	39

6.9.3 Full Bore Failure of Discharge Lines of Bottom Pumps of SRN Splitter, HCN Splitter and Stabilizer

Full bore failure of pump discharges is a non credible phenomenon. The discharge line sizes of bottom pumps are –

		Size	Failure Frequency
(i)	SRN Splitter	2"	1.7×10^{-6} / m / year
(ii)	HCN Splitter	2"	1.7×10^{-6} / m / year
(iii)	Stabilizer	3"	2.0×10^{-7} / m / year

Source: DNV Technica, UK

In case of failure of pump discharge lines, the Naphtha will fall on the ground and will form a pool. The pool may get ignited if the vapour on the pool gets an ignition source and form pool fire. The liquid also comes out a jet and if the jet gets an ignition source form jet fire. The thermal radiation from the pool fire / jet fire can cause various degrees of damage to equipment and pipelines and also cause lethality to persons in the path of heat radiation depending on the distance. Hazard distances due to pool fire are given in Table - 6.13.

Table - 6.13
HAZARD DISTANCES TO JET FIRE DUE TO FULL BORE FAILURE OF BOTTOM PUMP DISCHARGE LINES

Incident Thermal Radiation Intensity (KW/M^2)	Hazard distances (m) for					
	Day			Night		
	2B	3D	5D	2F	3D	5D
SRN SPLITTER BOTTOM PUMP: Release Rate - 1.275 Kg/Sec.						
37.5	18	17	16	19	17	16
12.5	22	21	20	22	21	20
4.5	28	27	25	28	27	26
HCN SPLITTER BOTTOM PUMP: Release Rate - 2.78 Kg/Sec. (Jet Fire)						
37.5	27	25	23	27	25	23
12.5	33	31	29	33	31	29
4.5	41	40	38	41	40	38
STABILIZER BOTTOM PUMP: Release Rate - 2.84 Kg/Sec.						
37.5	26	25	23	26	25	23
12.5	32	30	28	32	30	28
4.5	39	38	36	40	38	36

The vapour from the pool may disperse downwind safely beyond LFL limit if it does not get an ignition source within LFL limit. If the vapour gets an ignition source between LFL limit, unconfined explosion can occur. The results of Unconfined Vapour Cloud Explosion due to full bore failure of bottom pumps of three distillation columns are given in Table - 6.14.

Table - 6.14
HAZARD DISTANCES TO UNCONFINED VAPOUR CLOUD EXPLOSION DUE TO FULL BORE FAILURE OF BOTTOM PUMP DISCHARGE LINES

Sl. No.	Wind Speed (m/sec) / Stability Class	Max. distances (m) due to overpressure of			LFL	
		0.3 bar	0.1 bar	0.03 bar	Day	Night
SRN SPLITTER BOTTOM PUMP: Release Rate - 1.275 Kg/Sec.						
01.	2B / 2F	45/56	50/62	63/78	18	20
02.	3D / 3D	45/45	50/50	63/65	18	18
03.	5D / 5D	35/35	39/39	52/52	17	17
HCN SPLITTER BOTTOM PUMP: Release Rate - 2.78 Kg/Sec.						
01.	2B / 2F	79/92	88/104	113/137	38	47
02.	3D / 3D	79/79	88/88	113/112	38	37
03.	5D / 5D	69/59	77/67	101/90	36	35
STABILIZER BOTTOM PUMP: Release Rate - 2.84 Kg/Sec.						
01.	2B / 2F	78/89	85/98	105/123	29	34
02.	3D / 3D	77/77	85/85	105/105	30	29
03.	5D / 5D	67/67	75/74	95/94	30	30

6.9.4 Gasket Failure of Discharge Lines of Overhead Pumps of SRN Splitter, HCN Splitter and Stabilizer

Gasket failure is a credible phenomenon in plants. The pump discharge line diameters are 2", 4" and 3" in case of SRN Splitter, HCN Splitter and Stabilizer. Failure area of 25% on the perimeter of the gasket and 3 minutes release is considered as it is assumed that action will be taken to stop the release by that time. In case of gasket failure, the liquid discharge will come out as jet. If the jet comes in contact with an ignition source jet fire will occur. The burning jet may impinge any equipment or pipeline causing domino effect. If not it may cause damage to objects due to heat radiation from the flame. Hazard distance due to jet flame from gasket failure of overhead pump discharge lines are given in Table - 6.15.

Table - 6.15
HAZARD DISTANCES TO THERMAL RADIATION DUE TO JET FIRE FROM GASKET FAILURE OF OVERHEAD PUMP DISCHARGE LINES

Incident Thermal Radiation Intensity (KW/M^2)	Hazard distances (m) for					
	Day			Night		
	2B	3D	5D	2F	3D	5D
SRN SPLITTER OVERHEAD PUMP: Release Rate - 1.52 Kg/Sec.						
37.5	23	21	20	23	22	20
12.5	28	26	24	28	26	25
4.5	35	33	32	35	33	32
HCN SPLITTER OVERHEAD PUMP: Release Rate - 2.82 Kg/Sec.						
37.5	31	28	26	31	29	26
12.5	37	35	32	37	35	33
4.5	46	44	42	46	44	42
STABILIZER OVERHEAD PUMP: Release Rate - 1.26 Kg/Sec.						
37.5	20	19	17	20	19	17
12.5	24	23	21	24	23	21
4.5	30	29	27	30	29	27

It is found that first degree burn (Radiation Level 4.5 KW/m^2) will cause up to 35 m, 46 m and 30 m for gasket failure of SRN Splitter Overhead Pump, HCN Splitter Overhead Pump and Stabilizer Overhead Pump respectively.

It is also possible that jet fire did not happen in that case Naphtha will fall on the ground and will evaporate. The vapours may come into contact with ignition source and Unconfined Vapour Cloud Explosion will occur. Overpressure distances due to explosion from Naphtha due to gasket failure of overhead pumps are given in Table - 6.16.

Table - 6.16
HAZARD DISTANCES TO UNCONFINED VAPOUR CLOUD EXPLOSION DUE TO GASKET FAILURE OF OVERHEAD PUMP DISCHARGE LINES

Sl. No.	Wind Speed (m/sec) / Stability Class	Max. distances (m) due to overpressure of			LFL	
		0.3 bar	0.1 bar	0.03 bar	Day	Night
SRN SPLITTER OVERHEAD PUMP						
01.	2B / 2F	59/72	68/87	93/124	39	45
02.	3D / 3D	59/59	68/68	92/92	38	36
03.	5D / 5D	48/48	55/55	76/76	29	29
HCN SPLITTER OVERHEAD PUMP						
01.	2B / 2F	94/100	107/121	143/176	55	61
02.	3D / 3D	83/83	96/96	130/130	52	51
03.	5D / 5D	71/61	82/72	111/100	41	41
STABILIZER OVERHEAD PUMP						
01.	2B / 2F	56/57	61/64	77/85	23	28
02.	3D / 3D	46/46	52/52	68/68	23	23
03.	5D / 5D	45/45	51/51	66/66	22	21

It will be seen from the above table that max. overpressure distances of 0.3 bar (Heavy Damage) extends up to 59 m, 100 m and 57 m due to gasket failure of overhead pump. This may damage other equipment and pipelines. Hence, it is important that there should be no ignition source in the plant which may cause explosion due to gasket failure of overhead pumps.

6.9.5 Gasket Failure of Discharge Lines of Bottom Pumps of SRN Splitter, HCN Splitter and Stabilizer

As already stated that gasket failure is a credible phenomenon in any plant. Hence, Naphtha released may cause damage to pipelines and equipment due to jet fire or Unconfined Vapour Cloud Explosion. Hazard distance to jet fire caused by failure of gaskets of bottom pumps of SRN Splitter, HCN Splitter and Stabilizer is given in Table - 6.17.

Table - 6.17
HAZARD DISTANCES TO THERMAL RADIATION DUE TO JET FIRE FROM GASKET FAILURE OF BOTTOM PUMP DISCHARGE LINES

Incident Thermal Radiation Intensity (KW/M^2)	Hazard distances (m) for					
	Day			Night		
	2B	3D	5D	2F	3D	5D
SRN SPLITTER BOTTOM PUMP: Release Rate - 1.046 Kg/Sec.						
37.5	17	16	14	17	16	14
12.5	20	19	18	20	19	16
4.5	25	24	23	25	24	23
HCN SPLITTER BOTTOM PUMP: Release Rate - 1.18 Kg/Sec.						
37.5	18	17	16	18	17	16
12.5	22	21	20	22	21	20
4.5	28	27	25	28	27	26
STABILIZER BOTTOM PUMP: Release Rate - 1.088 Kg/Sec.						
37.5	17	16	15	17	16	15
12.5	20	19	18	20	19	18
4.5	25	24	23	25	24	23

It will be seen from the above table that distance for first degree burn (Radiation Level 4.5 KW/m^2) will be caused to a max. distance of 25 m, 28 m and 25 m due to gasket failure of bottom pumps of SRN Splitter, HCN Splitter and Stabilizer respectively. Another possibility is explosion if the vapours from Naphtha released due to gasket failure comes into ignition source within LFL limit. The hazard distances to overpressure due to UVCE is given in Table - 6.18.

Table - 6.18
HAZARD DISTANCES TO UNCONFINED VAPOUR CLOUD EXPLOSION DUE TO GASKET FAILURE OF BOTTOM PUMP DISCHARGE LINES

Sl. No.	Wind Speed (m/sec) / Stability Class	Max. distances (m) due to overpressure of			LFL	
		0.3 bar	0.1 bar	0.03 bar	Day	Night
SRN SPLITTER BOTTOM PUMP: Release Rate - 1.046 Kg/Sec.						
01.	2B / 2F	44/45	49/50	61/64	16	17
02.	3D / 3D	34/34	39/39	51/51	16	15
03.	5D / 5D	34/34	38/38	49/49	14	14
HCN SPLITTER BOTTOM PUMP: Release Rate - 1.18 Kg/Sec.						
01.	2B / 2F	45/56	51/62	65/80	19	22
02.	3D / 3D	45/45	51/51	65/65	19	19
03.	5D / 5D	35/35	40/40	53/53	18	18
STABILIZER BOTTOM PUMP: Release Rate - 1.088 Kg/Sec.						
01.	2B / 2F	34/45	38/50	50/50	15	17
02.	3D / 3D	34/34	38/39	50/50	15	15
03.	5D / 5D	33/34	38/38	49/49	14	14

It will be seen from the above table that due to gasket failure of bottom pump heave damage (0.3 bar) distance goes up to 45 m, 56 m and 45 m respectively due to gasket failure of bottom pumps of SRN Splitter, HCN Splitter and Stabilizer. Maximum LFL distances are 17 m, 22 m and 17 m for the bottom pumps of SRN Splitter, HCN Splitter and Stabilizer.

6.9.6 Mechanical Seal Failure of Overhead Pumps of SRN Splitter, HCN Splitter and Stabilizer

Mechanical seal failure of pumps is also a credible phenomenon in a plant although double mechanical seals are used in pumps handling petroleum hydrocarbons. In case of mechanical seal failure Naphtha will come out and spread on ground and can cause pool fire / jet fire / Unconfined Vapour Cloud Explosion. The results are given in Table - 6.19 for pool fire / jet fire and Table - 6.20 for UVCE.

Table - 6.19
HAZARD DISTANCES TO THERMAL RADIATION DUE TO MECHANICAL SEAL FAILURE OF OVERHEAD PUMPS

Incident Thermal Radiation Intensity (KW/M^2)	Hazard distances (m) for					
	Day			Night		
	2B	3D	5D	2F	3D	5D
SRN SPLITTER OVERHEAD PUMP: Release Rate - 1.122 Kg/Sec. (Pool Fire)						
37.5	11	11	12	10	11	12
12.5	20	21	22	20	22	23
4.5	29	29	29	29	29	30
HCN SPLITTER OVERHEAD PUMP: Release Rate - 1.47 Kg/Sec. (Jet Fire)						
37.5	22	21	19	22	21	19
12.5	27	25	23	27	25	23
4.5	33	32	30	33	32	30
STABILIZER OVERHEAD PUMP: Release Rate - 1.096 Kg/Sec. (Jet Fire)						
37.5	19	18	16	19	18	16
12.5	23	22	20	23	22	20
4.5	28	27	26	28	27	26

It will be seen from the above table that due to failure of mechanical seal of overhead pumps, thermal radiation distances of first degree burn (Radiation Level 4.5 KW/m^2) will to up to 29 m, 33 m and 28 m for SRN Splitter, HCN Splitter and Stabilizer overhead pumps.

Overpressure distances due to ignition of vapours from Naphtha released due to mechanical seal failure are given in Table - 6.20.

Table - 6.20
HAZARD DISTANCES TO OVERPRESSURE DUE TO MECHANICAL SEAL FAILURE OF OVERHEAD PUMPS

Sl. No.	Wind Speed (m/sec) / Stability Class	Max. distances (m) due to overpressure of			LFL	
		0.3 bar	0.1 bar	0.03 bar	Day	Night
SRN SPLITTER OVERHEAD PUMP: Release Rate - 1.122 Kg/Sec. (Pool Fire)						
01.	2B / 2F	47/50	55/60	74/86	31	32
02.	3D / 3D	47/48	55/55	75/75	29	28
03.	5D / 5D	36/36	42/42	59/59	23	23
HCN SPLITTER OVERHEAD PUMP: Release Rate - 1.47 Kg/Sec. (Jet Fire)						
01.	2B / 2F	57/71	65/81	85/109	31	40
02.	3D / 3D	57/57	65/65	85/85	32	31
03.	5D / 5D	48/47	54/53	72/72	27	26
STABILIZER OVERHEAD PUMP: Release Rate - 1.096 Kg/Sec. (Jet Fire)						
01.	2B / 2F	46/57	51/64	67/82	22	27
02.	3D / 3D	46/46	51/51	66/66	21	21
03.	5D / 5D	35/35	40/40	54/54	20	20

It will be seen from the above table that overpressure distances for heavy damage (0.3 bar) extends up to 50 m, 71 m and 57 m for the overhead pumps of SRN Splitter, HCN Splitter and Stabilizer.

6.9.7 Mechanical Seal Failure of Bottom Pumps of SRN Splitter, HCN Splitter and Stabilizer

Due to mechanical seal failure of bottom pumps of SRN Splitter, HCN Splitter and Stabilizer, Naphtha will come out from pumps and may cause pool fire / jet fire and UVCE. In case of failure of mechanical seal the pumps must be stopped immediately and valve at the pumps must be closed as early as possible. For consequence analysis, 3 minutes release has been taken. The results of thermal radiation in case of fire and overpressure distance are given in Table - 6.21 and Table - 6.22.

Table - 6.21
HAZARD DISTANCES TO THERMAL RADIATION DUE TO JET FIRE FOR MECHANICAL SEAL FAILURE OF BOTTOM PUMPS

Incident Thermal Radiation Intensity (KW/M2)	Hazard distances (m) for					
	Day			Night		
	2B	3D	5D	2F	3D	5D
SRN SPLITTER BOTTOM PUMP: Release Rate - 0.065 Kg/Sec. (Jet Fire)						
37.5	NR	NR	NR	NR	NR	NR
12.5	NR	NR	NR	NR	NR	NR
4.5	4	4	4	4	4	4
HCN SPLITTER BOTTOM PUMP: Release Rate - 0.92 Kg/Sec. (Jet Fire)						
37.5	17	15	14	17	15	14
12.5	20	19	18	20	19	18
4.5	25	24	23	25	24	23
STABILIZER BOTTOM PUMP: Release Rate - 1.27 Kg/Sec. (Jet Fire)						
37.5	19	17	16	19	17	16
12.5	22	21	20	22	21	20
4.5	28	27	25	29	27	26

NR = Not Reached

It will be seen from the above table that due to mechanical seal failure of bottom pumps, hazard distances to heavy damage (37.5 KW/m2) of equipment and pipelines will extend up to 17 m & 19 m in case of HCN Splitter and Stabilizer. Overpressure distances due to UVCE for mechanical seal failure of above pumps are given in Table - 6.22.

Table - 6.22
HAZARD DISTANCES TO UVCE DUE TO MECHANICAL SEAL FAILURE OF BOTTOM PUMPS

Sl. No.	Wind Speed (m/sec) / Stability Class	Max. distances (m) due to overpressure of			LFL	
		0.3 bar	0.1 bar	0.03 bar	Day	Night
HCN SPLITTER BOTTOM PUMP: Release Rate - 0.92 Kg/Sec.						
01.	2B / 2F	45/46	49/51	62/62	17	19
02.	3D / 3D	35/35	39/39	52/52	16	16
03.	5D / 5D	34/34	38/38	50/50	15	14
STABILIZER BOTTOM PUMP: Release Rate - 1.27 Kg/Sec.						
01.	2B / 2F	45/56	50/61	63/77	18	20
02.	3D / 3D	45/45	50/49	63/62	18	18
03.	5D / 5D	35/35	39/39	51/51	17	17

It will be seen from the above table that due to mechanical seal failure of bottom pumps of HCN Splitter and Stabilizer, overpressure distances for heavy damage will extend up to 46 m, and 56 m respectively.

6.9.8 Product Naphtha Storage Tank Catastrophic Failure

Three Naphtha Tanks of capacity 8400 m^3 (each) will be located in the marketing terminal. Tanks will be having a dyke wall of size 127 m x 51 m x 2 m ht. Catastrophic failure of storage tanks are very rare. However, consequence analysis has been done in this case. In case of catastrophic failure of any one tank, Naphtha will be released and it will be contained inside the dyke. Release of Naphtha from the dyke can catch fire causing pool fire or the vapours dispersing in downwind direction can catch fire within LFL limit causing UVCE. The hazard distances due to dyke fire and UVCE are given in Table - 6.23.

Table - 6.23
HAZARD DISTANCES TO POOL FIRE DUE TO CATASTROPHIC FAILURE OF NAPHTHA STORAGE TANK

Incident Thermal Radiation Intensity (KW/M^2)	Hazard distances (m) for					
	Day			Night		
	2B	3D	5D	2F	3D	5D
37.5	NR	NR	NR	NR	NR	NR
32.0	NR	NR	NR	NR	NR	NR
12.5	43	44	46	44	44	46
8.0	57	62	69	59	64	70
4.5	95	106	120	97	107	122

NR = Not Reached

In case of catastrophic failure of Naphtha Storage Tank and consequent pool fire, other tank inside the dyke as well as nearby equipment will be damaged by fire. Hence, in such case the spilled liquid should be covered by foam as early as possible.

Another possibility is vapour cloud explosion. Hazard distances to UVCE due to vapours coming into contact with ignition source within LFL limit is given in Table - 6.24.

Table - 6.24
HAZARD DISTANCES TO UVCE DUE TO CATASTROPHIC FAILURE OF PRODUCT NAPHTHA STORAGE TANK

Sl. No.	Wind Speed (m/sec) / Stability Class	Max. distances (m) due to overpressure of			LFL	
		0.3 bar	0.1 bar	0.03 bar	Day	Night
01.	2B / 2F	382/384	436/456	673/578	228	241
02.	3D / 3D	396/408	462/476	661/641	254	253
03.	5D / 5D	300/288	350/337	467/484	187	185

It is evident that in case of vapour cloud explosion, heavy damage may occur to nearby equipment and structures. The overpressure distance may go outside the battery limit of the marketing terminal. The overpressure distance of 0.3 bar may extend up to 408 m. However, such failure probability is very low (Failure frequency 3 x 10^{-6} per year).

6.9.9 Product Naphtha Storage Tank on Fire

Three numbers of Storage Tanks of floating roof type will be located in marketing terminal. The Storage Tanks are provided inside a dyke.

A floating roof tank is susceptible to fire hazard, if a static discharge or a spark ignites the vapour released from the rim vent, causing fire. If the fire is not controlled at the initial stage it can lead to collapse of the roof and total liquid becomes exposed to fire. The hazard posed by such failure and subsequent fire is intense heat radiation. The thermal radiation emanating from such tank fire can cause damage to nearby tanks and persons in the vicinity. As per IP code thermally protected facilities and storage tanks can withstand a thermal radiation of 32 KW/m^2 while unprotected tanks and facilities can withstand up to 8 KW/m^2. A radiation intensity of 4.5 KW/m^2 can cause first degree burn if a man is exposed for more than 20 seconds.

Hazard distances due to thermal radiation as a result of fire in Naphtha Storage Tank is given in Table - 6.25.

Table - 6.25
HAZARD DISTANCES DUE TO PRODUCT NAPHTHA TANK ON FIRE
(All distances are from edge of the Tanks)

Incident Thermal Radiation Intensity (KW/M^2)	Hazard distances (m) for					
	Day			Night		
	2B	3D	5D	2F	3D	5D
37.5	NR	NR	NR	NR	NR	NR
32.0	NR	NR	NR	NR	NR	NR
12.5	26	27	29	27	27	30
8.0	38	41	46	39	42	47
4.5	63	71	82	65	72	82

NR = Not Reached

It is seen from the above table that in case of any one tank on fire, thermal radiation level for 8 KW/m^2 will extend up to 46 m. Hence, it is important that all the tanks should be provided with water spray protection. In case of fire in one Storage Tank, cooling of the tank on fire as well as other tanks by water spray should be started quickly through cooling water pipes to avoid failure of other tanks. However, such tank fires are very-very rare.

6.10 RISKS AND FAILURE PROBABILITY

The term Risk involves the quantitative evaluation of likelihood of any undesirable event as well as likelihood of harm of damage being caused to life, property and environment. This harm or damage may only occur due to sudden/ accidental release of any hazardous material from the containment. This sudden/accidental release of hazardous material can occur due to failure of component systems. It is difficult to ascertain the failure probability of any system because it will depend on the components of the system. Even if failure occurs, the probability of fire and the extent of damage will depend on many factors like:

(a) Quantity and physical properties of material released.
(b) Source of ignition.
(c) Wind velocity and direction
(d) Presence of population, properties etc. nearby.

Failure frequency of different components like pipes, valves, instruments, pressure vessels and other equipment manufactured in India are not available nor any statutory authority has tried to collect the information and form an acceptable data bank to be used under Indian condition.

Failure frequency data for some components accepted in U.S.A. and European Countries are given in Table - 6.26.

Table - 6.26
FAILURE FREQUENCY DATA

Sl. No.	Item	Failure Frequency / 10^6 Years
1]	Shell Failure (a) Process/pressure vessel (b) Pressurised Storage Vessel	 3 1
2]	Full Bore Vessel Connection Failure (Diameter mm) < 25 .... 40 .... 50 .... 80 .... 100 .... >150	 30 10 7.5 5 4 3
3]	Full Bore Process Pipeline Failure d <50 mm .... 50 <d <150 mm .... d >150 mm	 0.3 * 0.09 * 0.03 *
4]	Articulated Loading / unloading arm failure	$3x10^{-8}$**

Source: Cramer & Warner, UK

* Failure frequency expressed in (/m/10^6 years)

** Failure frequency expressed in (/hr of operation)

6.11 CONCLUSION AND RECOMMENDATION

As the Naphtha Splitter Unit will be installed in the existing CDU / VDU area with minor revamp job, risk will marginally increase. As such, the installation is safe if it is operated and maintained properly by experienced & trained personnel.

The recommendations as revealed from Risk analysis Study are as follows:

i) The fire fighting system for equipment and vessels in Naphtha Splitter Unit shall be designed conforming to OISD norms. Fire hydrant network should be considered taking into consideration of additional cooling water requirement.

ii) Naphtha Storage Tanks and distillation towers should be provided with cooling water spray protection.

iii) Health check and maintenance of the equipment and pipelines should be done at regular intervals to avoid any major failure.

iv) Instrumentation of the unit should be of latest type.

v) Instruments and trip interlocks should be checked and calibrated at regular intervals to prevent any wrong signalling and consequent failures.

vi) Fire fighting system as well as portable fire-fighting appliances should be always kept in good working condition. Safety appliances should also be checked and kept in good working condition.

vii) Mock Drills should be conducted at regular intervals.

viii) To reduce the failure frequency due care should be taken in design, construction, inspection and operation. Well-established codes of practices should be followed for design, inspection and construction of the facility.

ix) The operation of the unit should be done by experienced and trained operating personnel. They should also have training in fire fighting operation.

x) Smoking should be strictly prohibited inside the installation.

xi) Non -sparking tools should be used for maintenance to avoid any spark.

xii) The equipments including storage tanks and pipelines should be properly earthed to avoid accumulation of static electricity.

xiii) Maintenance of moving equipments should be done regularly as per instruction of the suppliers as well as by experience of NRL.

xiv) Good liaison should be maintained with outside organisation and District Administration, hospitals and nursing homes in the locality as well as in nearby towns.

6.12 RECOMMENDED SAFETY PRECAUTIONS DURING CONSTRUCTION OF THE PROJECT

Since the Naphtha Splitter Unit is to be installed in CDU / VDU area, utmost precaution should be taken during construction of the plant.

Following safety precautions must be taken during construction period:

i) Jobs should be done with proper safety permit.

ii) Jobs to be supervised by experienced personnel as well as safety supervisor of the contractors.

iii) NRL safety personnel should also check periodically whether the jobs are being done as per safe procedure with due precautionary measures.

iv) Welding jobs should preferably be done away from plant area unless absolutely required with proper work permit and proper safety precautions so that it does not endanger the main plant. Welding work inside the main plant should be done during shut down period.

v) During execution of the jobs for construction, proper personal protective equipments must be used by the personnel involved e.g.

   (a) Head protection e.g. Helmet.
   (b) Eye and face protection e.g. eye goggles and face shields.
   (c) Protective foot wear e.g. safety shoes.
   (d) Safety belts while working at height.
   (e) Hand gloves for hand protection during cutting, grinding, welding, etc.

vi) Connection with main plant should be done during shut down period.

vii) Proper housekeeping should be maintained during construction.

viii) Temporary scaffolding required should be rigid enough so that it does not endanger the plant as well as the personnel working on it.

ix) Non sparking tools should be used while working inside the plant.