7. HAZARD IDENTIFICATION AND RISK ASSESSMENT

7.1 Introduction

Identification of hazards in the proposed Heat Traced Pipeline 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 toxic or 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.

A list of general Heat Traced Pipeline failure mechanisms is as follows:

- Material/Construction Defects
  - Incorrect use of design codes;
  - Weld failures; and
  - Failure of inadequate Heat Traced Pipeline supports.
- Pre-Operational Failures
  - Failure induced during delivery at site;
  - Failure induced during installation;
  - Pressure and temperature effects;
  - Overpressure;
  - Temperature expansion/contraction (improper stress analysis and support design);
  - Low temperature brittle fracture (if metallurgy is incorrect); and
  - Fatigue loading (cycling and mechanical vibration).
- Corrosion Failures
  - Internal corrosion (e.g. ingress of moisture);
  - External corrosion;
  - Cladding/insulation failure (e.g. ingress of moisture); and

- Cathodic protection failure, if provided.

➢ Failures due to Operational Errors
  - Human error; and
  - Failure to inspect regularly and identify any defects.

➢ External Impact Induced Failures
  - Dropped objects;
  - Impact from transport such as construction traffic;
  - Vandalism;
  - Subsidence; and
  - Strong winds.

➢ Failure due to Fire
  - External fire impinging on Heat Traced Pipeline or equipment

➢ Control philosophy
  - During normal operation the system shall operate in auto mode only

Maximum Credible Accident Analysis (MCAA) has been employed in the study for hazard identification.

7.2 Classification of Major Hazardous Substance

Hazardous substances may be classified into three main classes namely Flammable 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 specially 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 49 and 345 M.

MSDS of LSHS, HSVR are provided as **Annexure IV** .

7.3 Criteria of Risk Assessment

Hazard analysis involves the identification and quantification of the various hazards (unsafe conditions) that exist in the proposed pipeline. On the other hand, risk analysis deals with the identification and quantification of risks, the equipment and personnel are exposed to, due to accidents resulting from the hazards.

Hazard and risk analysis involves very extensive studies and require a very detailed design and engineering information. The various hazard analysis techniques that may be applied are hazard and operability studies, fault-tree analysis, event-tree analysis and failure and effects mode analysis.

Risk analysis follows an extensive hazard analysis. It involves the identification and assessment of risks the neighboring marine life is exposed to as a result of hazards present. This requires a thorough knowledge of failure probability, credible accident scenario, vulnerability of marine life etc. Much of this information is difficult to get or generate. Consequently, the risk analysis is often confined to maximum credible accident studies.

7.4 Glossary of Terms Used in Risk Assessment

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

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

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

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

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

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

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

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

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

7.5 Scope of the Study

The risk assessment has been carried out in line with the requirements of MoEF for similar type of projects:

- Identification of potential hazard areas;
- Identification of representative failure cases;
- Identification of possible initiating events;
- Assess the overall damage potential of the identified hazardous events and the impact zones from the accidental scenarios;
- Development of event trees from the initiating events for a particular hazard;
- Consequence analysis for all the possible events;
- Assess the overall suitability of the site from hazard minimization and disaster mitigation points of view; and
- Furnish specific recommendations on the minimization of the worst accident possibilities.

7.6 Risk Modelling with Phast 6.7

Phast is a consequence modelling package that can be used to assess situations which present potential hazards to life, property and the environment and to quantify their severity. Phast examines the progress of a potential incident from the initial release to far-field dispersion including modelling of pool spreading and evaporation, and flammable and toxic effects. The results from the analysis can be displayed in tabular & graphical form, so the extent of the impact can be seen, and the effect of the release on the population and/or workforce and environment can be assessed. Validation of software is important to obtain reliable results, and Phast is amongst the world's most validated consequence modelling software packages, using comparisons with observations during both experiments and real life incidents.

* PHAST: Process Hazard Analysis Software Tools

7.7 System Definition, Hazard Identification & Failure Scenarios

This stage of the study involves a review of the facilities in order to define the failure cases. The failure cases in the facilities are defined in terms of LoC scenarios, i.e. accidental releases of process fluids into the atmosphere. This may include various sizes of process leaks, full bore rupture of process piping and catastrophic rupture of storages. Range of release sizes and the representative sizes applied for this study are outlined in assumption register.

The failure cases are defined by sectionalising equipment in the process units. The following steps apply:

- Identify isolatable segments, based on isolation facilities and physical location.
- Identify sections with different physical nature of the hazardous materials being handled (i.e. fluid phase, pressure and temperature) within each isolatable segment.
- Identify generic failure cases in term of release sizes in each section.

All facilities which normally containing hazardous material has been considered in defining the failure cases. Details of failure cases identified and consequence effects for existing facilities are summarised in consequence tables.

For each failure case, the release rate and the release duration of release is then defined. This will determine the amount of material being released to the atmosphere, and hence the potential impact of the failure scenario.

The duration of a release is dependent on the time to detect the released fluids, time to isolate the leaking segment and the time to discharge remaining inventory in the segment. The total release duration is the sum of these three periods.

Further it can be argued that the time to detect depends on:

- Monitoring of process conditions, which may indicate any leak in process and/or pipeline sections.
- Availability of a fire and gas detection system and/or leak detection system in a pipeline.
- Surveillance of the Receiving and Loading area, either by operator routine patrol or by a remote surveillance system.
- While the time to isolate is determined by the availability of ESD system, which includes:
- ESD activation logic (i.e. manual or automatic),
- Remote or local activation (push button location) for manual intervention, and
- Location of the isolatable segment.

Release durations applied in this study are outlined in Assumptions (Release Characteristics).

7.8 Consequence Modelling / Phast Software

Phast calculates wide range of possible consequences from the LoC events, including:

- Pool Fire, causing thermal radiation impact.
- Flash Fire, causing thermal radiation impact within the flammable cloud envelope.

Various factors affecting the extent of consequence are also considered within the Phast model (applied values of these factors are discussed in Assumption Register), which include:

- Atmospheric conditions, including solar radiation flux, ambient temperature, humidity and wind speed/direction as well as weather stability.
- Release location.
- Release orientation.
- Bund / dike existence.

Detailed findings of the consequence analysis for selected failure cases are presented in Consequence tables.

The qualitative levels of explosion and heat radiation effects are described in the below tables respectively are used to assess the likelihood of harm to people or the likelihood of further loss of containment and escalation.

TABLE 1 : EXPLOSION OVERPRESSURE EFFECTS

Overpressure (bar)	Effects Within Zone
0.02	10% window glass broken

Overpressure (bar)	Effects Within Zone
0.05	Window glass damage causing injury
0.1	Repairable damage to buildings and house facades
0.2	Structural damage to buildings
0.35	Heavy damage to buildings and process equipment

TABLE 2 : EFFECTS OF THERMAL RADIATION

Radiation Intensity (kW/m2)	Observed Effect
37.5	Sufficient to cause damage to process equipment
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing
4	Sufficient to cause pain to personnel if unable to reach cover within 20 s, however blistering of the skin (second degree burns) is likely; 0% lethality

Various probability factors which will determine the route of event within the event trees are also determined in the Phast model. These include:

1. ***Immediate ignition;*** This is directly specified and will be different depending on the size of the release.
2. ***Fireball / flash fire / explosion probability*** *in the event of immediate ignition* of instantaneous release. This is directly specified.
3. ***Flash fire / explosion probability*** in the event of delayed ignition. This is also directly specified in Phast.
4. ***Toxic Hazards:*** The release of toxic chemicals into the atmospheric results in dispersion of a toxic cloud in downwind direction. The variation in time of the concentration will depend on both the release characteristics (continuous, finite-duration, instantaneous or time-varying release) and the effects of wind meander. The selection of the average time should be appropriate for the calculation of the toxic effect for an average human, who is located at a fixed location and observes a concentration C (ppm) as function of time.

7.9 Consequence Analysis

Since the material involved in this study is toxic as well as flammable, the possible scenarios are toxic impacts, pool fire, flash fire, dispersion and Jet fire. Orange colour in the pictures shows predominant effect due to wind direction. All the pictures provide cumulative effect due to the existing and proposed storage tanks.

7.9.1 Approach to the Study

Risk involves the occurrence or potential occurrence of some accident consisting of an event or sequence of events. The description of the tasks of the various phases involved in risk analysis are detailed below.

Phase I: Hazard Identification

The technique employed for the Hazard Identification is MCA analysis. MCA stands for Maximum Credible Accident or in other words, an accident with maximum damage distance, which is believed to be probable. MCA analysis does not include quantification of the probability of occurrence of an accident. In practice, the selection of accident scenarios for MCA analysis is carried out on the basis of engineering judgment and expertise in the field of risk analysis especially in accident analysis. Process information study and relevant data would help in the identification of hazard prone section of the plant. Inventory analysis and Fire and Explosion and Toxicity Indices and following Manufacture, Storage and Transport of Hazard Chemicals Rules of Government of India (GOI Rules, 2000) are also the methods used in hazard identification.

Release of chemicals in the atmosphere from the storage section is then studied by building scenarios on the basis of the properties of the chemicals and the consequences are calculated in terms of damage distances.

Phase II: Hazard Assessment and Evaluation

Ranking of each unit in hazard prone sections are done based on the Fire and Explosion Index (F & EI), Toxicity Index (TI) and Inventory Analysis. Safety of hazard prone section is studied using Preliminary Hazard Analysis.

A Preliminary Hazard Analysis (PHA) is a part of the U.S. Military Standard System Safety Program requirements. The main purpose of this analysis is to recognize hazards early, thus saving time and cost which could result from major plant redesigns, if hazards are discovered at a later stage. Many companies use a similar procedure under a different name. It is generally applied during concept or early development phase of a process plant and can be very useful in site selection. PHA is a precursor to further hazard analysis and is intended for use only in the preliminary phase of plant development for cases where past experience provides little or no insight into any potential safety problems, e.g. a plant with a new process. The PHA focuses on the hazardous materials and major plant elements since few details on the plant design are available and there is likely not to be any information available on procedures. The PHA is sometimes considered to be a review where energy can be released in an uncontrolled manner. The PHA consists of formulating a list of hazards related to:

- Heat Traced Pipeline equipments;
- Interface among system components;

- Operative environment;
- Operations (tests, maintenance, etc.);
- Facility; and
- Safety equipment.

The results include recommendations to reduce or eliminate hazards in the subsequent plant design phase. The PHA is followed by evaluation of MCA and Consequence analysis.

7.10 Maximum Credible Accident Analysis (MCAA) Approach

7.10.1 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 an 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 to represent the highest level of 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; and
- Other conditions such as temperature, pressure, flow, mixing and presence of incompatible materials.

7.10.2 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.

7.10.3 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, unfavorable 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.

7.10.4 Short Listing of MCA Scenarios

Based on the storage quantities and properties of the chemicals, the hazard identification has been done and given as follows for carrying out MCA analysis studies.

- Vapour Cloud Explosion due topipeline leake;
- Pool fire due to rupture/leakage and accumulation;
- Flash fire due to leakage; and
- General fire hazards.

7.10.5 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 give 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 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. The MCA analysis involves ordering and ranking of various sections in terms of potential vulnerability.

7.10.6 Scenario Considered for MCA Analysis

Although the Heat Traced Pipeline will be buried minimum 1 m below underground, the Heat Traced Pipeline rupture scenario with various pin hole sizes are considered as a worst case. The chances of Heat Traced Pipeline rupture will be remote and there is no past evidence of such occurrences in India, hence not considered.

Based on the information so far gathered from Fire and Explosion Index and past accident analysis the following accident cases are identified:

- Failure/rupture of valve/nozzle/pipeline of various sizes.

The following failure scenarios have been identified for the transportation of crude oil products for MCA analysis and are presented in **Table-34.**

TABLE 3 : SCENARIOS CONSIDERED FOR MODELING

Sr. No.	Product	Flow rate (TPH)*
1	LSHS	400
2	HSVR	648
3	VGO	997

*Note: Flow rate indicated is tentative, and will be finalised during detailed engineering.

A perusal of **Table34** indicates that the material storage and transportation are flammable liquids. Fires could occur due to presence of ignition source at or near the source of leak or could occur due to flashback upon ignition of the traveling vapor cloud.

For the present study, the scenarios under consideration assume that the peak level of radiation intensity will not occur suddenly. For radiation calculations, pool fire have been considered. From the above considerations, the criteria of 4.5 kW/m^2 is selected to judge the acceptability of the scenarios. The assumptions for calculations are:

- It is not continuous exposure;
- It is assumed that no fire detection and mitigation measures are initiated;
- There is not enough time available for warning the public and initiating emergency action;
- Secondary fire at public road and building is not likely to happen;
- The effect of smoke on reduction of source radiation intensity has not been considered; therefore hazard distances calculated tend to be conservative; and
- Shielding effect of intervening trees or other structures has not been considered. No lethality is expected from this level of intensity although burn injury takes place depending on time of exposure.

7.10.7 Toxicity

The extent of the consequence of toxicity is represented by the toxicity envelope, i.e. the maximum dispersion distance of the toxic cloud at IDLH concentration. **Table 35** below summarises representative failure cases together with their toxicity consequence results.

TABLE 4 : IMPACT AREA IN TERMS OF TOXICITY

Failure Scenario ID	Hole Size	Maximum Dispersion Distance to equivalent toxic dose for Various Weather Cases (m)	
		3AB	5D

Failure Scenario ID	Hole Size	Maximum Dispersion Distance to equivalent toxic dose for Various Weather Cases (m)	
		3AB	5D
LSHS	10mm	0.987	0.988
	20mm	1.34	1.36
	50mm	2.51	2.52
HSVR	10mm	0.991	0.992
	20mm	1.56	1.57
	50mm	3.64	3.85
VGO	10mm	0.863	0.864
	20mm	1.23	1.24
	50mm	2.43	2.44

7.10.8 Pool Fire

When a non-boiling liquid spills, it spreads into a pool. The size of the pool depends on the availability of the bund and obstacles. If there are no obstacles or bund, it can spread into a thin film on flat land/floor. In general, a cylindrical flame approximates the flame geometry. Radiation levels at various distances are calculated taking into account atmospheric transmission coefficient, geometric view factor and the radiation intensity in terms of surface heat flux of the flame. Depending upon the conditions, there are several ways in which these can occur, ultimately causing damage due to heat radiation.

Effects of Pool Fire

Pool fire may result when bulk storage tanks of fuel will leak/burst, and the material released is ignited. If the tanks are provided with dike walls to contain the leak and avoid spreading of flammable material, the pool fire will be confined to the dike area only. However, the effects of radiation may be felt to larger area depending upon the size of the pool and quantity of material involved.

Thermal radiation due to pool fire may cause various degrees of burns on human bodies. Moreover, their effects on objects like piping, equipment are severe depending upon the radiant heat intensity.

The extent of the consequence of a Pool fire is represented by the thermal radiation envelope. Three levels of radiation are presented in this report, i.e.:

- 4 kW/m2; this level is sufficient to cause personnel if unable to reach cover within 20s; however blistering of the skin (second degree burn) is likely; 0: lethality
- 12.5 kW/m2; this level will cause extreme pain within 20 seconds and movement to a safer place is instinctive. This level indicates around 6% fatality for 20 seconds exposure

- 37.5 kW/m2; this level of radiation is assumed to give 100% fatality

Table 36 below summarises representative failure cases with the associated pool fire consequence results.

TABLE 5 : IMPACT AREA IN TERMS OF HEAT RADIATION FROM POOL FIRES

Failure Scenario ID	Hole Size	Thermal Radiation Distances for various Weather Cases (m)					
		4 kW/m^2		12.5 kW/m^2		37.5 kW/m^2	
		3AB	5D	3AB	5D	3AB	5D
LSHS	10mm	5.96	6.21	3.98	3.99	0.89	0.92
	20mm	12.12	12.13	7.89	8.12	1.59	1.62
	50mm	30.9	31.66	18.51	20.27	8.3	8.33
HSVR	10mm	6.89	6.99	4.93	4.94	2.16	2.18
	20mm	13.63	13.64	8.69	8.98	2.92	2.93
	50mm	31.92	32.96	19.21	21.23	8.9	8.43
VGO	10mm	5.91	5.92	2.97	2.98	0.86	0.87
	20mm	11.93	11.94	6.93	6.94	1.32	1.33
	50mm	28.6	29.63	17.21	19.62	7.31	7.38

7.10.9 Jet Fire

The extent of the consequence of a Jet fire is represented by the thermal radiation envelope. Three levels of radiation are presented in this report, i.e.:

- 4 kW/m2; this level is sufficient to cause personnel if unable to reach cover within 20s; however blistering of the skin (second degree burn) is likely; 0: lethality, as outlined in Assumptions.
- 12.5 kW/m2; this level will cause extreme pain within 20 seconds and movement to a safer place is instinctive. This level indicates around 6% fatality for 20 seconds exposure, as outlined in Assumptions.
- 37.5 kW/m2; this level of radiation is assumed to give 100% fatality as outlined in the same section above.

Table 37 below summarises representative failure cases with the associated jet fire consequence results.

TABLE 6 : IMPACT AREA IN TERMS OF HEAT RADIATION FROM JET FIRES

Failure Scenario ID	Hole Size	Thermal Radiation Distances for various Weather Cases (m)					
		4 kW/m2		12.5 kW/m2		37.5 kW/m2	
		3AB	5D	3AB	5D	3AB	5D

Failure Scenario ID	Hole Size	Thermal Radiation Distances for various Weather Cases (m)					
		4 kW/m2		12.5 kW/m2		37.5 kW/m2	
		3AB	5D	3AB	5D	3AB	5D
LSHS	10mm	1.24	1.25	0.95	0.96	0.34	0.35
	20mm	4.62	4.81	2.08	2.09	1.62	1.65
	50mm	9.57	10.05	4.77	6.35	3.58	4.51
HSVR	10mm	2.91	2.93	1.22	1.23	0.53	0.54
	20mm	5.89	5.92	3.21	3.22	1.89	1.92
	50mm	11.9	12.1	5.63	7.21	5.93	6.28
VGO	10mm	1.22	1.23	0.83	0.84	0.21	0.22
	20mm	4.53	4.62	1.93	1.94	1.60	1.61
	50mm	8.96	8.97	4.63	6.21	3.25	3.26

7.10.10 Flash Fire

The extent of the consequence of a flash fire is represented by the flash fire envelope, i.e. the maximum dispersion distance of the flammable cloud at LFL concentration.

38 below summarises representative failure cases together with their flash fire consequence results.

TABLE 7 : IMPACT AREA IN TERMS OF HEAT RADIATION FROM FLASH FIRES

Failure Scenario ID	Hole Size	Maximum Dispersion Distance of Flammable Cloud @ LFL Concentration for Various Weather Cases (m)	
		3AB	5D
LSHS	10mm	1.3	1.4
	20mm	2.8	2.9
	50mm	5.9	6.0
HSVR	10mm	1.6	1.7
	20mm	3.1	3.2
	50mm	6.8	6.9
VGO	10mm	1.2	1.3
	20mm	2.7	2.8
	50mm	5.7	5.9

7.11 Conclusion

- The pipeline traverses through one town and 2 muncipal Corporations. The number of dwellings in the vicinity of the pipeline is more and the overall risk is within the As Low As Reasonablely Possible (ALARP) region.
- The impact of thermal radiation on adjacent buried pipelines will not have potential impact due to adequate soil cover and separation distance.
- The pool fire distance is reaching to maximum distance of 31.6 m for a 4 kW/m2 of 50 mm leak.
- Emergency Shut Down (ESD) System shall be incorporated in design of Pump Station for isolation of leaked section immediately within 90 Secs) and evacuation so that the duration of radiation effect is considerably reduced thereby ensuring safety and integrity.
- As a safety measure BPCL can implement Pipeline Intrusion Detection System (PIDS) which will alert the Pipeline Operator about any third party activity within the RoU viz. excavation etc. for ensuring integrity of the pipeline. The system can supplement PAS for confirming leak in the cross country pipeline. Supervisory Control and Data Acquisition (SCADA) system, dedicated optical fibre cable based telecommunication system, leak detection system / pipeline application software.
- The adjacent population is to be made aware of the risk associated with the proposed pipeline and the mitigation measures to be taken in case of Emergency.

7.12 Disaster Management Plan

7.12.1 Objective and Scope

The key objective of this Disaster Management Plan (DMP) is to outline the management, organizational arrangements and available facilities that will be utilized by BPCL in the event of an emergency. BPCL is having very well developed Disaster Management Plan which will be utilised in case of Emergency.