6

# ADDITIONAL STUDIES

## 6.1 Risk and Hazard Mapping

M/s SLSL has proposal for expansion of sugar cane crushing from 4500 TCD to 7500 TCD, 18 MW to 36 MW cogeneration and establishment of 60KLPD distillery within the existing facility. As per TOR prescribed by MOEF and guidelines for sugar plant we here-by appraise associated risk within project and also due to expansion. Apropos risk therefore need to be responded and hence will be the Disaster Management Plan towards preparedness. This is also statutory requirement as per MSIHC rule 1989 having hazardous material in process as well as in stock exceeding prescribe threshold limit. While preparing this concise text with respect to appraise risk and hazard being associated, we acclimatize with plant operation; lay out, storage, process particularly with respect to hazard and likely impact. It is duly composed on the basis of plant site visit, discussion with stake holders about operations and their understanding with respect to hazard and approach toward mitigation, preparedness as well as planning with to deal with any disaster or untoward incidence.

In our approach for Risk assessment we need to identify the hazards associated within plant and their potential which might result into disaster or any untoward incidence. Hence the criteria for assisting risk within plant  quantity of hazardous material due to its intrinsic properties which may result into fire, explosion or may be toxic or in combo. Other risk areas are pressure equipment, high temp /pressure processes, pipeline, heavy movements etc. Though they are susceptible to potential risk but such systems are customized and equipped with safety gears and has safe operation as well as maintenance operational practices. Hence this assessment may be not appropriate. We therefore assess the associated risk with the Hazardous material quantification.

The raw materials, which will be required to run the plant, are discussed in detail in Chapter-2.0. Bagasse is by product after crushing operation. This is considered as main fuel supplement for power generation in co-gen mode. Apart some chemicals such as Lime, Caustic Soda, Sulphur etc which will be stored in isolation with due care for storage with instruction and written manual for handling. MSDS for all major chemicals are in place with appropriate person to deal with emergent situation.

### 6.1.1 The main hazard potentials in the proposed SLSL are as under

- Material hazards of Bagasse for boiler unit mainly prone to fire due to store in open yard.
- Process hazards due to loss of containment during handling of hazardous materials or processes resulting in fire, explosion, toxicity etc.
- Mechanical hazards –due to mechanical operation such as welding, maintenance, falling objects etc. - basically those NOT connected to hazardous material.
- Electrical hazards: electrocution, high voltage levels, short circuit, etc. Out of these, the material and process hazards are the one with a much wider damage potential as compared to the mechanical and electrical hazards, which are by and large limited to small pockets  local pockets.

## 6.1.2 Type of Disaster

Disaster can occur as on site or off site variety i.e. disaster on campus or disaster in nearby area causing indirect damage to site area & the complex. Disaster may occur due to 2 categories, natural and manmade calamities

- Natural calamities cover Flood, Storm / typhoon, Earthquake, Tsunami, Heavy mist, fog, hail storm, Land slide.
- Man made calamities involve Fire & Explosion, All types of leakages & spillage, Electrocution, excavation, construction, erection, Sabotage, rail & road accidents, mass agitation, Looting, Morcha, war.

The identified hazardous areas in the process are;

- Boiler area - Explosion
- Oil tanks - Fire and spillage
- Turbine section - Explosion
- Electrical rooms - Fire and electrocution
- Transformer area - Fire and electrocution
- Cable - Fire and electrocution
- Storage facilities – Fire / spillage for fuel and alcohol

Considering various probabilities, the management & safety department has to create awareness & preparedness in all employees and people in vicinity area in case of any sort of emergency to occur & a chalked out attempt to surely overcome the disaster in time. This includes preparation of onsite and offsite disaster control plans, mock drills at least 2 times calendar year, reports for the same to DISH & due amendments for the perfect implementation.

## 6.1.3 Level of Accident

If there is any disaster in any part of plant/work place due to any reason the level of accidents from damage point of view may vary. Accordingly safety program will have to be initiated by safety department simultaneously.

## 6.1.4 Critical Targets during Emergency

### a) Level I Accidents

- Under this level disaster may happen due to electrocution, fire explosion, oil spillage and spontaneous ignition of combustible material. This level has probability of occurrence affecting persons inside the plant. Various hazardous areas identified above are to be affected due to level I accidents.

### b) Level II Accidents

- Disaster of this level can occur in case of sabotage and complete failure of all automatic control/warning systems, and also if the fuel oil stored in tank and covered by tank bunds leaks out. However, probability of occurrence of this is very low due to the proposed adequate security training, and education level of plant personnel for the captive power plant.

At SLSL the hazardous inventory as per project data - Storage Capacity

**Table 6.1 Hazardous inventory at SLSL**

| | | |
|---|---|---|
| 1 | RS | $600m^3$ x 2 |
| 2 | ENA | $600m^3$ x 2 |
| 3 | Ethanol | $600m^3$ x 1 |
| 4 | Day tank RS | $65m^3$ x 3 |
| 5 | Day tank ENA | $65m^3$ x 3 |
| 6 | Day tank ethanol | $65m^3$ x 3 |
| 7 | Sulfur | 5 TPD or 150TPM |
| 8 | Bagasse | 1650TPD |

## 6.1.5 Safety Policy and Regulations

Keeping in view of the safety requirement during construction, operation and maintenance phase SLSL has safety policy in place.

### 6.1.5.1 SLSL has formulated safety policy with the following regulations.

- To allocate sufficient resources to maintain safe and healthy policy at work place
- To take steps to ensure that all known safety factor are taken in to account in the design, construction, operation and maintenance of plants, machinery and equipment.
- To ensure that adequate safety instruction are given to all employee
- To provide wherever necessary, protective equipment, safety appliances and clothing and to ensure their proper use.
- To inform employees about materials, equipment or processes used in their work area known to be potentially hazardous to health and safety
- To keep all operations and methods of work under regular review for making necessary changes from the point of view of safety in the light of experience and up to date knowledge.
- To provide appropriate instruction, training and supervision in health and safety, first aid and ensure that adequate publicity is given to these matters.
- To ensure proper implementation of fire prevention and an appropriate fire fighting services together with training facilities for personnel involved in this service.
- To ensure that professional advice is made available wherever potentially hazardous situations exit or might arise.
- To organize collection, analysis & presentation of data on accident, sickness & incident involving personal injury to health with a view of taking corrective, remedial and preventive action
- To promote through the establishment machinery, joint consultation in health & safety matters to ensure effective participation by all employees.
- To publish/ notify regulation, instruction and notice in the common language of employee.
- To prepare separate safety rules for each type of occupation/process involved in a project.
- To ensure regular safety inspection by a component person at suitable intervals of all buildings equipment, work places and operation.

## 6.1.6 An Approach to Risk Assessment

The objectives of Risk assessment is to control, prevent or reduce loss of life, illness, or injury, damage to property and consequential loss and environmental impact.

Before risk can be effectively managed, it must be analyzed. The analysis of risk is a useful tool for:

- Identifying risks and approaches to their solution
- Facilitating objective decisions on the acceptability of risk
- Meeting regulatory requirement

The results of risk assessment can be used by a decision-maker to help to judge the tolerability of risk and aid in choosing between potential risk reduction or avoidance measures. From the decision-makers perspective some of the principal benefits of risk assessment include:

- Systematic identification of potential hazards
- Systematic identification of potential failure modes
- Quantitative risk statements or ranking
- Evaluation of possible modifications to reduce risk or achieve better dependability levels
- Identification of the important contributors to risk and weak links in a system
- Better Understanding of the system and its installation
- Comparison of risks to those of alternative systems or technologies
- Identification and communication of risks and uncertainties
- Help in establishing priorities for improved health and safety
- A basis for preventive maintenance and inspection to be rationalized
- Post-accident investigation and prevention
- Selection between alternatives such as different risk-reduction measures and technologies
- Prevention of economic loss, etc.

All these play an important role in effective risk management.

## 6.1.7 Scope of Work

**(a) Hazard Identification:**

- Study of ongoing operations being carried out at facility and Engineering information, Piping and Instrumentation diagrams (P&ID), plot and layout plans.
- Identification of fire, explosion & other health hazards;
- Analysis of inventories in storage and handling units with recourse to Manufacture, Storage & Import Of Hazardous Chemical Rules, 2000 and Fire- Explosion & Toxicity Index (FE& TI);
- Identification of accident sequences and consequences with recourse to Event Tree Analysis (ETA) and to evaluate propensity of occurrence of the top event through Fault Tree Analysis (FTA);
- Past accident data/information analysis in similar installations to develop the credibility of worst come worst accident scenarios; and
- Visualization of Maximum Credible Accident (MCA) scenarios.

**(b) Analysis of MCA Scenarios:**

Analysis of identified MCA scenarios and quantification of primary effects and to evaluate the domino effects with recourse to computerized mathematical models pertaining to cases of:

- ALCOHOL /ENA/RS outflow and its release
- Spilled Product fire
- Tank on fire and Pool Fire
- Vapour cloud explosion (VCE)
- Fire in bagasse stock piles
- Fire/explosion in Sulfur storage
- Fire/dust explosion in coal yard

Application of damage criteria for heat radiation with recourse to health criteria, dose-response relations and vulnerability models.

**(c) Recommendations based on:**

- Observations on the operational practices & Installation hardware
- Findings of the Risk Analysis & safety review Check-list
- Firefighting& other emergency facilities available
- Observations during the Mock Drill
- Manufacture, Storage & Import of Hazardous Chemicals Rules, 2000
- Relevant OIL Industries Safety Directorate (OISD) Guidelines/PESO guidelines

## 6.2 Inventory of Hazardous Material as per Intrinsic Chemical Property /Flammability Classification and Details of other facilities

Inventory and type of flammable products plays the important role in analysis of risk, hazards and their consequences. To analyze Maximum Credible Accident (MCA) Scenarios, maximum inventory of the STOCK MATERIAL at the along with the road tank trucks present in the vicinity of the site for loading/unloading have been considered. As well as, leakage through pipeline/bursting of line containing in transit.

Maximum storage capacity of Hazardous material according to Flammability class is tabulated as under:

**Table 6.2 Maximum Inventories of SLSL Products (with Flash Points) at SLSL**

| Flammability Class | Flash Point Range $^{o}C$ | Products | Total Capacity |
|---|---|---|---|
| A | FP < 23 | Ethanol/RS/ENA | $600m^3$ x 5<br>$65m^3$ x 9 |

## 6.3 Hazard Identification and Visualization of MCA Scenarios

### 6.3.1 Introduction

“Risk” is loss per unit time and is the product of the consequence of an event and the frequency of its occurrence. All activities involve some risk. In our everyday life, people engaged in an activity frequently perform their own risk assessment often intuitively. The level of risk deemed to be acceptable is highly subjective, varies from person to person, and depends on many factors. Total avoidance of risk (zero risk) is an unattainable goal. Risk can, however, be reduced through the implementation of control measures, engineering design and good management practices.

The starting point of the risk analysis study is the identification of hazards and selection of scenarios which are then addressed for further analysis.

"Hazard" is a characteristic of a system, Installation or processes that present potential for an accident. It is defined as a chemical or physical condition that has the potential for causing damage to people, property or the environment. Therefore, all the relevant aspects of hazardous material storage and handling process have been thoroughly examined to assess their potential for initiating or propagating an unintentional event or sequence of events, which can lead to an accident or disaster. Type, quantity, location & conditions of release of the hazardous material under various scenarios have been examined in order to estimate its damage potential, area affected, and based on that, the precautionary measures needed to be taken are suggested in Independent Heading – “RECOMMENDATIONS”.

## 6.3.2 Hazard potential: Deciding factor

Factors considered to identify and analyze the hazard potential are:

- Flash point & Boiling point of the ALCOHOL/flammable Products as well as intrinsic chemical properties of bagasse and sulfur
- Inventory of the ALCOHOL/flammable, bagasse and sulfur.
- Potential for loss from containment/fire in stock
- Pool size & dyke capacity
- Potential for availability of ignition sources in the vicinity of leakage or spillage

Apart from the characteristics and process of its handling, size & layout of the sugar plant are also analyzed in order to assess the hazard potential.

## 6.3.3 Identification of hazards

Identification of hazards is of primary significance in the analysis, quantification and cost effective control of accidents involving Hazardous stock of material and their Operations.

ALCOHOL/ flammable, bagasse, sulfur require sufficient interaction with air or oxygen for their mixture to form in presence of ignition source and then for occurrence of their hazards associated with them. Under certain circumstances, vapors of the products when mixed with air may be explosive especially in confined spaces. Following methods of hazard identification have been employed in this study:

- All hazardous materials present on the site, and or transported to and from the site are identified
- The properties of these hazardous materials are reviewed in order to categories the possible hazards
- Characterization of major hazardous units based on Manufacture, Storage and Import of Hazardous Chemicals Rules, Government of India, 2000; referred here as MSIHC Rules.
- Identification of hazardous installations based on relative ranking technique, viz. Dow's Fire Explosion Index and Mond's Toxicity Index (FE & TI)

- The site facilities and transport systems are examined to identify where the hazardous materials are present and the conditions under which they are contained

The major hazards in petrochemical, chemical plants and installations are due to substances within the Installations that can be released to cause either:

- Fire
- Explosion
- Toxic effect (Poisoning)

At SLSL, Fire and Explosion are the major hazards due to handling and storage of products. At SLSL Alcohol is the main hazardous flammable material having potential threat to fire and explosion. We therefore consider all possible MCA w.r.t to these inventories. The credible accident scenarios with these materials can be

- Pool fire
- Jet fire
- Spill fire
- Tank on fire
- VCE
- BLEVE
- Pressure waves
- Stock pile fire and other incidental conducive conditions

However each scenario can cause potential damage under favorable conditions. But obvious chances for incidences are remote as all safety gears are in place with due practice. More over all scenarios have been visualized vis-à-vis most credible one. IT can be quantified to assess possible damage and hence planning for preventive as well as protective arrangement also being designed .reviewed .Most of them are not credible scenarios under normal conditions. Their probability of occurrence has been rated lesser then 1 in million yr as per standard prescribe text (TNO GREEN BOOK). Accordingly such scenarios have been considered as acceptable risk. We therefore restricted our estimation of damage potential for spill fire/tank on fire cases for sake of symbolic risk assessment. OISD also prescribe safety measures towards mitigation measures and suggested control as well as fire fighting gears to be in place. Accordingly hydrant lining, monitors, cooling water, water storage static tank, ROV, automation etc have been integrated.

For estimation of damage potential we need to understand intrinsic properties of Hazardous stock. By simulating scenario and thus applying modeling software we can assess extent of damage potential as well as quantum. In our further collation we are compiling those attributes and evaluate the different cases for risk mapping.

### 6.3.4 Physico – Chemical Properties of Alcohol /ENA/RS

We use generic work Alcohol (similar almost RS/ENA) is highly inflammable in their basic character (depending on Flammability class). They are dangerous because of their intrinsic properties, i.e. flash point, ignition energy required, heat of combustion, flammability limits, etc. In addition to such intrinsic properties, extrinsic factors like quantity of storage, Type of storage (A/G or U/G) and operating conditions are also considered for hazard identification. Physico-chemical properties of the alcohol products, to be stored during operation phase of SLSL, are given in table

**Table 6.3 Hazardous Properties of ALCOHOL**

| SN | Properties | Ethanol |
|---|---|---|
| 1 | Physical State | Highly Volatile |
| 2 | ALCOHOL Act/OISD Flammability Class | A |
| 3 | Specific Gravity | 0.79 |
| 4 | Reactive to | - |
| 5 | Flash point ºC (Range) | < 23 |
| 6 | Boiling point ºC | 78.32 |
| 7 | Auto – Ignition Temperature ºC | 422 |
| 8 | Specific Heat (KJ/Kg °K) | 2.13 |
| 9 | Heat of Evaporation (KJ/Kg) | 85.38 |
| 10 | Heat of Combustion (KJ/Kg) | 30624 |

**Table 6.4 Flammability Classification Criteria:**

| SN | Flammability Class | Flash point (°C) |
|---|---|---|
| 1 | Class A Flammable Liquid | FP < 23 |
| 2 | Class B Flammable Liquid | 23 > FP <65 |
| 3 | Class C Flammable Liquid | 65 > FP < 93 |
| 4 | Excluded ALCOHOL | More than 93 |

## 6.3.5 Applicable MSIHC Rules 2000

Major hazard installations in the country have been identified & characterized by MSIHC (Manufacturing, storage and Identification of Hazardous Chemicals) Rules, amended in 2000. The rules employ certain criteria based on flammable, explosive & toxic properties and quantity of the chemicals. Indicative criteria adopted in the MSIHC Rules, 2000 and description of applicable provisions of the rules is given in Appendix I.

As per provisions of the MSIHC Rules, 2000 quantity of ALCOHOL Product Storage at the Installations has been analyzed and the applicable rules are identified based on the type of ALCOHOL products, quantity of storage and the threshold quantity given in the rules. Applicable regulations of MSIHC Rules, 2000 to the Installations are identified in the following Table.

All ALCOHOL products marketing locations fall under the category of isolated storage, which comes under schedule 2 of MSIHC Rules. Threshold quantities and applicability of various rules are as follows:

**Table 6.5 Applicability of MSIHC Rules**

| SN | Product | Storage Capacity | | Threshold Quantity (MT) as per MSIHC Rules* | | Applicable Rules |
|---|---|---|---|---|---|---|
| | Class | In KL | In MT | For Rules 4,5,7 to 9 & 13 to 15 | For Rules 10 to 12 | |
| 1 | Class A | | | 7000 | 7000 | 2(e)(i) & (ii), 2(h)(i), 4,5,7 to 9, 10 to 12 & 13 to 15 |

**Rule 2: Identification for Existence of "Hazardous Chemicals":**

* "Hazardous chemicals" are existing in the SLSL, Installation as per rule 2(e)(i) & 2(e)(ii), ALCOHOL products existing at the Depot are covered under Schedule I(b)(ii)

* "Industrial Activity" carried out in the Depot involves operation / processes having hazardous chemicals and includes their on-site storage & transportation as per Rule 2(h) (i). "Isolated storage" of ALCOHOL products is covered in schedule 2.

**Rule 3: Duties of the Government Authorities:**

* Duties of the Government Authorities as per schedule V.

**Rule 4: General Responsibility of Occupier:**

* As "hazardous chemicals" exist in the project site the occupier has to provide evidence to show that he has:

a) Identified the major accident hazards &
b) Taken adequate steps to:

   i. Prevent such major accidents and to limit their consequences to persons & environment.
   ii. Provide information, training and safety equipments, including antidotes to the persons working on site to ensure their safety

**Rule 5: Notification of Major Accidents:**

* Notification of "Major Accidents" in the format given in Schedule 6 to Chief Inspector of factories and to other authorities as listed in Schedule V.

**Rule 7: Notification of Site:**

* Notification of site and updated information of the modifications to the competent authority as per Schedule VII.

**Rule 8: Updating of the Site Notification Following Changes in the Threshold Quantity:**

* Any change in the "threshold quantity" (storage quantity) is to be notified to the competent authority.

**Rule 9: Transitional Provision:**

* Transitional Provision for the existing activity

**Rule 10: Safety Reports:**

*Preparation of Safety report by the occupier & to carry out an independent safety audit once in a year.

**Rule 11: Updating of report under rule 10:**

*Updating of safety reports based on modification.

**Rule 12: Requirement for further information to be sent to the authority:**

*Further information on safety reports to the authority.

**Rule 13: Preparation to On-sire emergency plan by the occupier:**

*Preparation of onsite emergency plan by the occupier & to conduct mock drill once in every 6 months.

**Rule 14: Preparation of Off-sire emergency plan by the occupier:**

* Preparation of offsite emergency plan by the occupier & to conduct mock drill once in every Year.

**Rule 15: Information to be given to persons liable to be affected by a major accident**

**Rule 17: Collection, Development and Dissemination of Information on "Hazardous Chemicals" Employed by the Occupier**

- Material Safety Data Sheet is to be prepared as per Schedule IX
- Every container of hazardous chemical should be labeled or marked to identify -
    - Contents of the container
    - The name and the address of the manufacturer
    - Physical, Chemical and Toxicological data as per the criteria given in Schedule I: Part I

**Rule 18: Import of Hazardous Chemicals**

- The rule is applicable as “hazardous chemicals” as per Schedule 1 Part I (b) (ii) exist in the Installation.
- To provide timely information to various Govt. Authorities listed in Schedule V:
    - Name & address of the company receiving the consignment in India
    - The port of entry in India
    - Mode of transport from exporting country to India
    - The quantity of chemicals being imported
    - Complete product safety information

## 6.3.6 Fire Explosion Index (FEI) Analysis

The most widely used relative ranking hazard indices are **Dow chemical Company's Fire Explosion Index (FEI) and Mond's Toxicity Index (TI)**. They are commonly together referred to as Fire Explosion and Toxicity Index (FEI & TI).

FEI and TI involve objective evaluation of the realistic fire, explosion, toxicity and reactivity potential of process or storage units. The quantitative methodology relies on the analysis based on historic loss data, the energy content of the chemical under study and the extent to which loss prevention measures are already incorporated. FEI are primarily designed for operations involving storage, handling and processing of flammable, combustible and reactive chemicals.

**Table 6.6 Fire & Explosion Index & Category:**

| SN | Fire & Explosion Index (FEI) | Category |
|---|---|---|
| 1 | FEI <60 | Light |
| 2 | 61> FEI <96 | Moderate |
| 3 | 97>FEI <127 | Intermediate |
| 4 | 128 >FEI <158 | Heavy |
| 5 | 159 and more | Severe |

Computations of FEI for storage units of SUGAR PLANT are computed in the following Table. The approach for FEI calculations is shown in Appendix V. Here only FEI is computed, because ALCOHOL is inflammable in nature and not toxic. Toxic effect is left just momentary and hence not dangerous as other real toxic chemicals e.g. Chlorine.

**Table 6.7 Fire Explosion Index for Storage Units**

| SN | Product | Product Capacity ($m^3$) | Material Factor | | | | Penalties | | Fire & Explosion | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | NH | NF | NR | MF | GPH | SPH | Index | Category |
| 1 | Ethanol | **600** | 0 | 3 | 0 | 16 | 0.5 | 1.67 | 64.14 | Moderate |

Ethanol Storage Tanks (Coming under Moderate), all other Storage Tanks falls under light category

## 6.3.7 Visualization of MCA Scenarios

### 6.3.7.1 Introduction

A Maximum Credible Accident (MCA) can be characterized as an accident with a maximum damage potential, which is believed to be credible. For selection of a MCA scenario following factors have been taken into account.

- Flammability of the ALCOHOL Products
- Quantity of Products present in the tank
- Process or storage conditions such as temperature, pressure, flow, mixing and presence of incompatible materials

In addition to the above factors, location of the unit with respect to adjacent establishment has been taken into consideration to account for the potential of escalation of an accident. This phenomenon is known as the domino or secondary effect. In order to visualize MCA scenarios Chemical Inventory Analysis, Event Tree Analysis and Past Accident Review have been employed.

### 6.3.7.2 Chemical Inventory Analysis

Maximum inventory of ALCOHOL Products, bagasse, sulfur, in pipeline/transit sections, storage units and handling equipments has been considered. Diagram showing accidental release of chemicals is shown as figure.

### 6.3.7.3 Identification of Chemical Release & Accident Scenarios

Credible accident scenarios for the Depot have been divided into following categories according to the mode of release of ALCOHOL products, physical effects and the resulting damages:

- Jet fire (leakage of ALCOHOL products from a tank/pipe/pump/joints and the products stream catching fire in case of Ethanol)
- Spilled product Fire (Release of ALCOHOL products from valve joints, loose connections, etc.)
- Pool fire (release of ALCOHOL products from a tank, rupture of pipeline sections, etc. forming a pool within the area thereafter catching fire)
- Tank On Fire (due to external heat, joints of roof of tank get loose and it get thrown outside and if the surface of tank catches fire, it is termed as tank on fire)
- Unconfined Vapor Cloud Explosion (UVCE) as a secondary effect of above mentioned scenarios
- Fire in stock pile of bagasse ,sulfur under favorable conditions

Even Tree Analysis (ETA) to define outcome of release

Different outcomes of a leakage or catastrophic failure are possible depending on if and when ignition occurs and the consequences thereupon. ETA considers various possibilities such as immediate or delayed ignition for the different outcomes to occur.

ETA diagram for various modes of failures of storage tank/ pump/ pipe/ joints for atmospheric storage of ALCOHOL products have been developed for conditions such as overfilling, over-pressure and remote incidents like missile, lightening or bomb attack and earthquake. The resultant ruptures of vessels or leak incidents have been identified with possible outcomes of such incidents. Even tree Analysis for SLSL is shown in Figure.

Scenarios pertaining to leakage & spillage are most credible in such Installation.

**Fault Tree Analysis to Explore Propensity for Occurrence of the Top Event**

In ALCOHOL Installations, it is important to analyze the possible mechanisms of failure and to perform probabilistic analysis for the expected rate of such failures. A technique like Fault Tree Analysis (FTA) can suitably be used for this purpose.

Any system represented by a fault tree has components that operate in series or parallel, with the contribution of the two being most frequent. These components are studied for their failure and the possible causes are linked together through logical gates. Thus a complete network is formed using logical gates for different causes and consequences. This network represents a system for which propensity towards top event is examined.

To construct a fault tree for a present case, Pool fire scenario is designated as the "top event”. Tracing backward, exactly opposite to the forward approach followed in Event Tree Analysis (ETA), all failures that could lead to the top event are found. Then all failures leading to each of those events are identified. The word `event' means conditions, which are deviations from the normal or planned state of operation of a system.

The evaluation of fault tree may be qualitative or quantitative or both depending on the scope of analysis and requirement. The aim of fault tree evaluation is to determine whether an acceptable level of safety has been incorporated in the design of the system or not. Suitable design improvements to minimize the probability of occurrence of top event are found out.

The system safety is upgraded by evaluating the critical events that significantly contribute to the top event and the measures provided to cope with such eventualities.

#### 6.3.7.4 Short listing of MCA scenarios

Based on the hazard identification and comparing the nature of installation with that from past accidents in similar units, a final list of MCA scenarios for the Depot has been made, which is tabulated below. These are the maximum credible accidents, which may occur, in the respective unit.

**Table 6.8 Short Listing of MCA Scenarios for hazardous material**

| SN | Tank No/stock piles. | Hazardous Product | MCA Scenario |
|---|---|---|---|
| 1. | | Ethanol | Pool Fire, Spilled product Fire, Tank on Fire& VCE |
| 2. | Stock | Bagasse/ Sulphur | Stock pile fire/dust explosion |

The above foreseen accident scenarios will have certain adverse effects on the nearby units/structures in the Depot which may lead to escalation of the accident further. Consequences of the entire above maximum credible accident scenarios have been analyzed in detail in the subsequent ***: Consequence Analysis***.

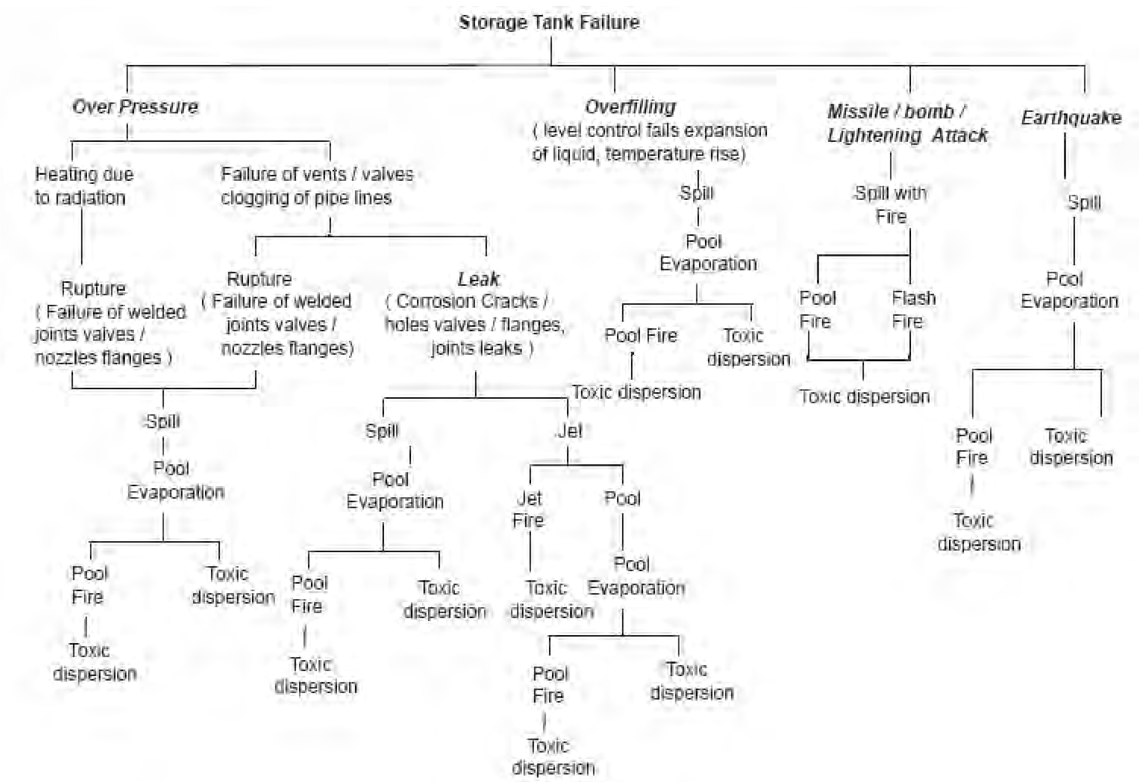



**Fig 6.1 Event Tree Analysis for Atmospheric Storage of Flammable Liquids**

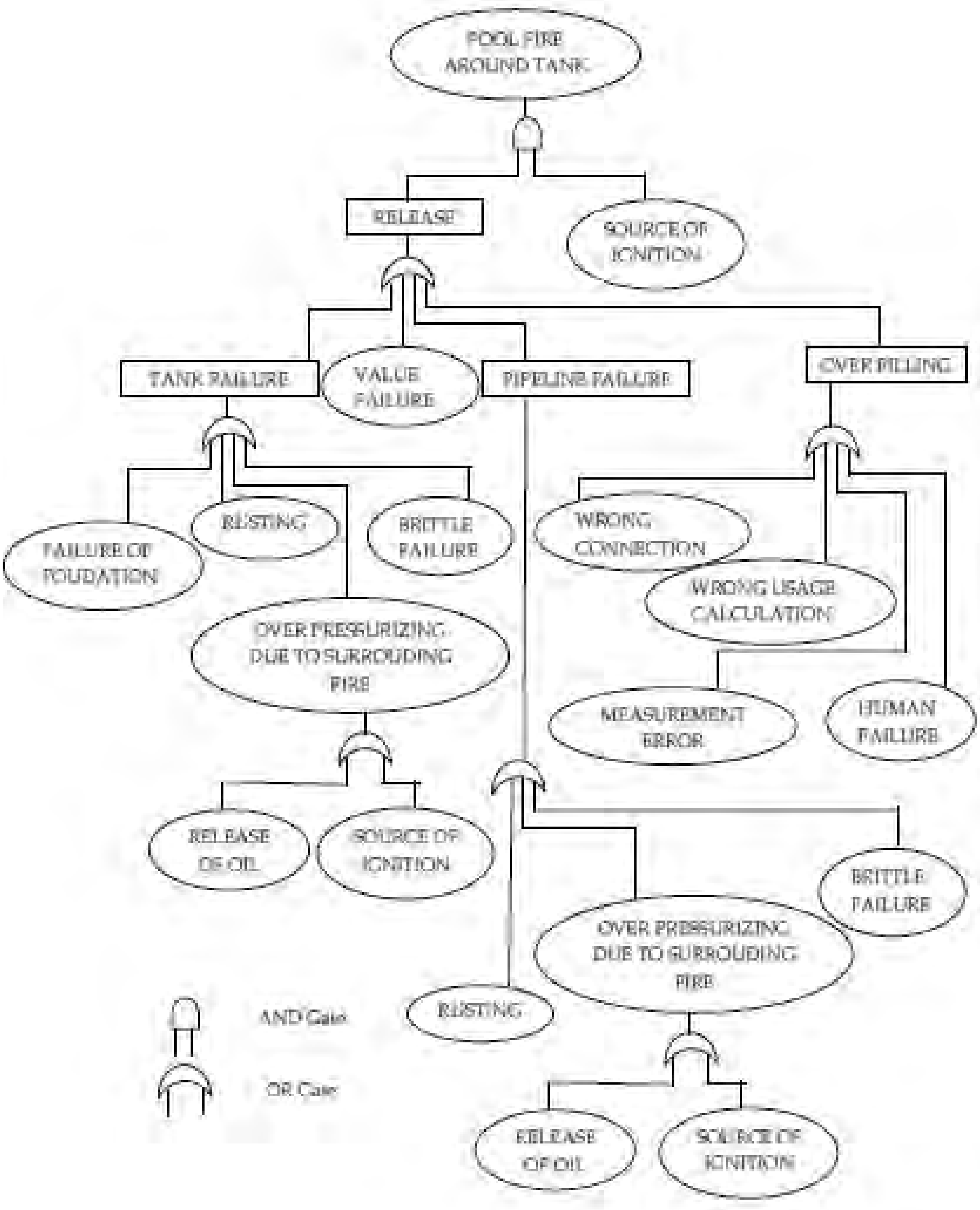



**Fig 6.2 Fault Tree Analysis for Top Event of Pool Fire Scenario**

### 6.3.7.5 Consequence analysis

This chapter deals with the quantification of various effects of release of ALCOHOL /Hazardous material products on the surrounding area by means of mathematical models and internationally recognized Safety software.

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 computerized models and how the vulnerability models can be used to translate the physical effects in terms of injuries and damage to exposed population & environment.

**Table 6.9 Mathematical and Analytical Model for Hazard Analysis**

| SN | Phenomenon | Applicable Models |
|---|---|---|
| 1 | **Outflows:**<br>• Liquid, Two phase<br>• Mixtures, Gas/vapor | Bernoulli flow equation; phase equilibrium; multiphase flow models; orifice/nozzle flow equations; gas laws; critical flow criteria |
| 2 | **Discharges:**<br>• Spreading liquid<br>• Vapor jets<br>• Flashing liquids<br>• Evaporation of liquids on land & water | Spreading rate equation for non-penetrable surfaces based on cylindrical liquid pools<br>Turbulent free jet model<br>Two zone flash vaporization model<br>Spreading, boiling & moving boundary heat transfer models; Film & meta-stable boiling phenomenon; cooling of semi-infinite medium |
| 3 | **Dispersion:**<br>• Heavy Gas<br>• Natural Gas<br>• Atmospheric stability | • Boundary dominated, stable stratified & positive dispersion models (similarity)<br>• 3D Models based on momentum, mass & energy conservation<br>• Gaussian Dispersion models for naturally buoyant plumes<br>• Boundary layer theory (turbulence), Gauss Ian distribution models |
| 4 | **Heat Radiation:**<br>• Liquid pool fires<br>• Jet fires<br>• Fire balls<br>• Stock pile fire | Burning rate, heat radiation & incident heat correlation (semi imperial); Flame propagation behavior models<br>Fire jet dispersion model<br>API fire ball models relating surface heat flux of flame, geometric view factor & transmission coefficients |
| 5 | **Vulnerability:**<br>• Likely damage | Probit functions; Non-Stochastic vulnerability models |

First, attention is paid to the factors, which are decisive for the selection of the models to be used in a particular situation, after which the various effect models are discussed.

Factors which influence the use of physical EFFECT MODEL

In order to calculate the physical effects of the incidental release of hazardous substances the following steps have been carried out in succession:

- Understanding of the form in which the hazardous substance is in existence (i.e. liquid of highly volatile nature in case of ALCOHOL Product)
- Determination of the various ways in which the release can take place
- Determination of the outflow volume or quantity (as a function of time) i.e. estimating rate of evaporation from the pool of liquid;
- Solid hazardous stock like bagasse as well as sulfur

In the case of ALCOHOL Product, quantity of leaked or spilled Product along with pool size has been calculated. Finally, the analysis results in computation of heat radiation intensity ($KW/m^2$) with respect to distance for various MCA scenarios. In this analysis, final effect calculations have been made for pool fire for heat radiation intensity effects with respect to distance from dyke wall. However for stock pile fire black body radiation strength can be computed.

## 6.3.8 Models for determining the source strength for the release of hazardous substances

Source strength of a release means the quantity of the substance released with respect to time. The release may be instantaneous or continuous. In case of instantaneous release, the strength of the source is given in kg whereas in continuous release source strength depends on the outflow time and expressed in kg/s. In order to find the source strength, it is first necessary to determine the state of a substance in a vessel or pipe along with physical properties, viz. vapor pressure & minimum ignition energy required. Phase of ALCOHOL Product at the time of accidental release is also to be determined. This may be gas, gas condensed to liquid or liquid in equilibrium with its vapor.

### 6.3.8.1 Instantaneous Release

In the event of the instantaneous release of a liquid a pool of liquid will form. The evaporation can be calculated on the basis of pool size, volatile nature of the product (i.e. vapor pressure) and meteorological conditions.

### 6.3.8.2 Semi-Continuous Outflow

In the case of a semi continuous outflow, it is again first of all necessary to determine whether it is gas, a gas condensed to liquid or liquid that is flowing out. The following situations can occur here.

**(a) Gas Outflow:**

- The model with which the source strength is determined in the event of a gas outflow is based on the assumption that there is no liquid in the system.

**(b) Liquid Outflow:**

- In case of liquid outflow, discharge due to overall head difference takes place.

## 6.3.9 Model for Evaporation

In application of evaporation models, ALCOHOL product is a case of volatile liquid. From the pool, which has formed, evaporation will take place as a result of the heat flow from the ground and solar radiation. The evaporation model only takes account of the heat flow from the ground since the heat resulting from solar radiation is negligibly small compared with the former. The evaporation rate depends on the kind of liquid and the kind of subsoil.

## 6.3.10 Model for Dispersion

The gas or vapor released either instantaneously or continuously will be spread in the surrounding area under the influence of the atmospheric turbulence. In the case of gas dispersion, a distinction is required to be made between neutral gas dispersion and heavy gas dispersion.

The concentrations of the gas released in the surrounding area can be calculated by means of these dispersion models. These concentrations are important for determining the nature of accidents for example an explosive gas cloud formation injuries will occur in the case of toxic gases.

#### 6.3.10.1 Heavy Gas Dispersion Model

If the gas density is higher than that of air due to higher molecular weight or marked cooling, it will tend to spread in a radial direction because of gravity. This results in a "gas pool" of a particular height and diameter. As a result of this, in contrast to a neutral gas, the gas released may spread against the direction of the wind.

### 6.3.11 Model for Heat Load and Shock Waves

#### 6.3.11.1 Model for Flare

If an out-flowing vapour (in case of class A Products) forms a cloud with concentrations between the lower and upper explosion limit and ignition takes place, momentary/instantaneous/luminous fire film may occur for fraction of seconds. A model with which the length of a torch and the thermal load for the surrounding area can be calculated, assumes an elliptic shaped torch. The volume of the flare in this model is proportional to the outflow. In order to calculate the thermal load, flare is regarded as a point source located at the center of the flare. This center is taken as being half a flare length from the point of outflow.

#### 6.3.11.2 Model for jet fire

In this event, if out-going stream is due to small opening / hole in the storage tank / valve joints having sufficient liquid head may result in jet fire if it catches ignition source.

### 6.3.12 Model For Spilled/Pool Fire/Tank on Fire

The schematic of a pool fire is depicted in **Figure 8**. The heat load on objects outside a burning pool of liquid can be calculated with the heat radiation model. This model uses average radiation intensity, which is dependent on the liquid. Account is also taken of the diameter-to-height ratio of the fire, which depends on the burning liquid. In addition, the heat load is also influenced by the following factors:

- Distance from the fire
- Relative humidity (water vapor has relatively high heat absorbing capacity)
- The orientation i.e. horizontal/vertical of the object irradiated with respect to the fire

### 6.3.13 Vulnerability Model

Vulnerability models or dose response relations, which, are used in order to determine how people are injured by exposure to heat load or a toxic dose. Such models are designed on the basis of animal experiments or on the basis of the analysis of injuries resulting from accidents, which have occurred. Vulnerability models often make use of a Probit function. In a Probit function a link is made between the load and the percentage of people exposed who suffer a particular type of injury. The Probit function is represented as follows:

$Pr = k_1 + k_2 \ln V$

In which,

P = Probit, a measure for the percentage of people exposed who incur a particular injury (relation between percentages & Probit is given in Table.

$k_1$ = A constant depending on the type of injury and type of load

$k_2$ = A constant depending on the type of load

V = Load or dose

**Table 6.10 Relationship between Percentage and Probit**

| Percentage | Probit | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | - | 2.67 | 2.95 | 3.12 | 3.25 | 3.36 | 3.45 | 3.52 | 3.59 | 3.66 |
| 10 | 3.72 | 3.77 | 3.82 | 3.87 | 3.92 | 3.96 | 4.01 | 4.05 | 4.08 | 4.12 |
| 20 | 4.16 | 4.19 | 4.23 | 4.26 | 4.29 | 4.33 | 4.36 | 4.39 | 4.42 | 4.45 |
| 30 | 4.48 | 4.50 | 4.53 | 4.56 | 4.59 | 4.61 | 4.64 | 4.67 | 4.69 | 4.72 |
| 40 | 4.75 | 4.77 | 4.80 | 4.83 | 4.85 | 4.87 | 4.90 | 4.92 | 4.95 | 4.97 |
| 50 | 5.00 | 5.03 | 5.05 | 5.08 | 5.10 | 5.13 | 5.15 | 5.18 | 5.20 | 5.23 |
| 60 | 5.25 | 5.28 | 5.31 | 5.33 | 5.36 | 5.39 | 5.41 | 5.44 | 5.45 | 5.50 |
| 70 | 5.52 | 5.55 | 5.58 | 5.61 | 5.64 | 5.67 | 5.71 | 5.74 | 5.77 | 5.81 |
| 80 | 5.84 | 5.88 | 5.92 | 5.95 | 5.99 | 6.04 | 6.08 | 6.13 | 6.18 | 6.23 |
| 90 | 6.28 | 6.34 | 6.41 | 6.48 | 6.55 | 6.64 | 6.75 | 6.88 | 7.05 | 7.33 |
| - | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| 99 | 7.33 | 7.37 | 7.41 | 7.46 | 7.51 | 7.58 | 7.65 | 7.75 | 7.88 | 8.09 |

### 6.3.13.1 Injuries resulting from flammable liquids and gases

In the case of flammable liquids and gases and immediate ignition a pool fire or a flare will occur depending on the conditions. The injuries in this case are mainly caused by heat radiation.

### 6.3.13.2 Damage models for heat radiation

It is assumed that everyone inside the area covered by the fire ball, a torch, a burning pool or gas cloud will be burned to death or will asphyxiate. The following Probit functions are an example of a method, which can be used to calculate the percentage of lethality, and first-degree burns that will occur at a particular thermal load and period of exposure of an unprotected body.

Lethality: $Pr = -36.83 + 2.56 \ln (t.q^{4/3})$

First degree burn symptoms: $Pr = -39.83 + 3.0186 \text{ in } (t.q^{4/3})$

In which, t = exposure time in seconds and;

q = thermal load $W/m^2$

Two values have been chosen for the exposure time to heat radiation:

* 10 seconds: for exposed persons in populated area it is assumed that they will have found protection from the heat radiation e.g. from a wall, within 10 seconds

* 30 seconds: this pessimistic assumption applies if people do not run away immediately or when no protection is available

Thermal radiations for particular Heat Radiation Intensity (kw/$m^2$) give different impacts. It depends on Intensity of Heat Radiation and surrounding facilities. Following table describes the damage due to particular Heat Intensity.

**Table 6.11 Damages Envisaged at Various Heat Loads**

| Incident Radiation intensity, KW/$m^2$ | Type of damage Intensity | |
|---|---|---|
| | **Damage to Equipment** | **Damage to People** |
| 62.0 | Spontaneous Ignition of Wood | 100% Lethality (severe damage) |
| 37.5 | Sufficient to cause damage to process equipment | 100% lethality in 1 min. and 1% lethality in 10 sec. |
| 25.0 | Minimum energy required to ignite wood, at infinitely long exposure (non-piloted) | 50% Lethality in 1 min. and Significant injury in 10 sec. |
| 19.0 | Maximum thermal radiation intensity allowed on thermally unprotected equipment | ----- |
| 12.5 | Minimum energy required for piloted ignition of wood, melting plastic tubing etc. | 1% lethality in 1 min. |
| 9.5 | ---- | Pain threshold reached after 15 seconds |
| 6.4 | ---- | Pain threshold reached after 8 seconds. Second Degree burns after 20 seconds. |
| 4.5 | ---- | Sufficient to cause pain to personnel if unable to reach cover within 20 seconds, however blistering of skin (first degree burns) is likely |
| 2.0 | PVC insulated cables damaged | ---- |
| 1.6 | ---- | Will cause no discomfort to long exposure. Pain threshold reached after 60 seconds |
| 0.7 | ----- | Equivalent to solar radiation. Exposed skin reddens and burns on prolonged exposure |

*** Source:** Reference Green book “Methods for Determination of Possible Damage”, TNO, Netherlands; World Bank (1988); Technical Report No. 55: Techniques for Assessing Industrial Hazards; D.C.: The World Bank

The level of damage caused is a function of duration of exposure as well as heat flux. This is true both for the effects on buildings and Installation equipment as well as personnel. However, the variation in likely exposure time is much more marked with personnel due to possibility of findings shelter.

The following table gives the relationship between exposure time and heat flux against the fatality probability factors. Fatality Probability due to thermal radiation:

| **Percentage of Fatality** | **10%** | **50%** | **99%** |
|---|---|---|---|
| **Heat Flux ($KW/m^2$)** | **Times in Seconds** | | |
| 1.6 | 500 | 1300 | 3200 |
| 4.0 | 150 | 370 | 930 |
| 12.5 | 30 | 80 | 200 |
| 37.5 | 8 | 20 | 50 |

In general it might be possible to take to a "shelter" within 30-60 seconds. As can be seen from above table, the change between very low to very high fatality probabilities occurs between flux levels of 12.5 $kw/m^2$ and 37.5 $kw/m^2$.

For transient fires like fire ball, the steady state heat flux levels cannot be used to estimate the damage. The degree of thermal radiation in terms of total incident thermal energy dose levels are relevant as shown in table below:

**Table 6.12 Physiological effect of Threshold Thermal Dose**

| **Thermal Threshold Dose ($KJ/m^2$)** | **Effects** |
|---|---|
| 37.5 | 3rd Degree Burns |
| 25.0 | 2nd Degree Burns |
| 12.5 | 1st Degree Burns |
| 6.5 | Threshold of Pain or blistering of skin |

## 6.3.14 Impact of Overpressure

Pressure wave's results due to catastrophic failure or rupture of storage tank/pipeline etc. it results in generation of high pressure waves which have potential to cause damage to property/personnel/equipments/neighboring areas. A peak over pressure of 0.1 bar is taken as the limit for fatal injury and 0.03 bar as the limit for the occurrence of wounds as the result of flying fragments of glass. Following inferences are used to translate an explosion in terms of damage to the surrounding area:

- Everyone within the contours of the exploding gas cloud will die as a result of burns or asphyxiation. Establishments in this zone will be fully destroyed.
- In houses with serious damage it is assumed that one in eight persons present will be killed as a result of the building collapsing. Within the zone with a peak over pressure of 0.3 bar the risk of death in houses is 0.0125, i.e. one in eighty people will be killed.

**Table 6.13 Damage Effects of Blast Overpressure**

| **Peak Overpressure (Bar)** | **Damage Level** |
|---|---|
| 5.0 – 8.0 | Major structural damage (assumed fatal to people inside building or within other structures)<br>100% Lethality |
| 3.5 – 3.0 | Oil storage tank failure<br>50% Lethality |
| 2.0 – 3.0 | Eardrum rupture<br>Threshold Lethality |
| 1.33 - 2.0 | Repairable damage. Pressure vessels intact; light structures collapse |

| Peak Overpressure (Bar) | Damage Level |
|---|---|
| | Severe lung Damage |
| 1.0 – 1.33 | Window breakage, possibly causing some injuries<br>50% eardrum Rupture |
| 0.3 | Heavy (90% Damage) |
| 0.1 | Repairable (10% Damage) |
| 0.03 | Damage of glass |
| 0.01 | Crack of windows |

The summary of damage criteria adopted in the study based on vulnerability models and published health criteria for arriving at damage distances for the identified effects are:

**Table 6.14 Damage Criteria for Pool Flare/Jet Fire**

| SN | Damage | Exposure Time = 10s | | Exposure Time = 3s | |
|---|---|---|---|---|---|
| | | With Protection | Without Protection | With Protection | Without Protection |
| 1 | 100% lethality & severe damage to life & property | Within pool | Within pool | Within pool | Within pool |
| 2 | 1% Lethal Injury (kW/M$^2$) | 21.1 | 16.5 | 9.3 | 7.3 |
| 3 | 1% First Degree Burns (KW/m$^2$) | 8.5 | 6.9 | 4.5 | 3.0 |

## 6.3.15 Result of Maximum Credible Accident Analysis (MCA)

The maximum credible accident scenarios for the **SLSL** have been identified and listed in Table no 6.14 Results of those identified scenarios are tabulated in subsequent headings as under.

## 6.3.16 Spilled Product Fire Scenario

In SLSL, handling of ALCOHOL products (here, Ethanol,) for any leakage or spillage from process and at the Pump House, there will be accumulation of ALCOHOL products. In either of the cases if it catches fire depending on availability of potential ignition source in the vicinity, it will take form of a Spilled Product Fire. But this fire has comparatively less impact on the surrounding area and there are less chances of damaging the other facilities of the plant. Using Software Model, damage distances for Spilled product fire scenario at site area are calculated and tabulated as under:

**Table 6.15 Damage Distances Due to Spilled Product Fire Scenario for considered Areas**

| SN | Name of Product | Maximum Intensity of Heat Radiation Calculated Using Spilled Fire Model (kW/m$^2$) | Damage Distance in meters Calculated For Exposure Time of 10s | | Damage Distance in meters Calculated For Exposure Time of 30s | |
|---|---|---|---|---|---|---|
| | | | 1% Lethality (21.2 kW/m$^2$) | First Degree Burn (8.5 kW/m$^2$) | 1% Lethality (9.3 kW/m$^2$) | First Degree Burn (4.5 kW/m$^2$) |
| 1 | Ethanol | 33 | NR | 1.01 | 0.934 | 1.74 |
| | | | NR | NR | NR | 1.94 |
| | | | NR | NR | NR | 1.3 |

** NR: Not Reachable (Within the area under fire)*

From results of Spilled Product Fire scenario, it is concluded that, the effect of spilled fire will be for a lesser distance & will not affect the nearby facilities properties or surrounding area. Chances of any severe lethality will be least in case of spill fire, however there can be first degree burns to the people if any close to fire area.

*Note: NR in above table represents that radiation of that particular heat intensity will be limited to spilled fire area only.*

## 6.3.17 Pool Fire Scenario

At SLSL, during handling or storage operation of ALCOHOL products (ETHANOL, HSD), if there is a major leakage/total rupture from storage unit within the boundary (due to any reasons), there will be formation of pool within the Dyke wall in case of less volatile or non-volatile liquid. If the liquid does not overflow firebreak wall, then the pool will be limited to the respective unit. However if the liquid overflows the firebreak wall, it may engulf the complete dyke area. In both of the cases if it catches fire depending on availability of potential ignition source in the vicinity, it will take form of Pool fire.

There are dyke walls enclosing tanks of ALCOHOL products. Individual ALCOHOL product for each dyke wall is considered for pool fire study and using software model, results have been obtained for pool fire scenario. In another possible case there can be pipeline failure due to some accidental conditions. In this case pipeline volume and pressure, isolation time through control system and other software requisite were considered to predict damage potential Damage distances for particular heat radiation intensity are being tabulated as under:

**Table 6.16 Results of Pool Fire Scenario for all Dyke walls**

| **SN** | **Dyke No. Considered For Pool Fire** | **Storage tanks enclosed in Dyke wall** | **Name of product** | **Maximum Intensity of Heat Radiation Calculated Using Pool Fire Model (KW/m2)** | **Damage Distance Calculation for Exposure Time of 10 sec** | | **Damage Distance Calculation for Exposure Time of 30 sec** | |
|---|---|---|---|---|---|---|---|---|
| | | | | | **1% Lethality** | **First Degree Burn** | **1% Lethality** | **First Degree Burn** |
| 1 | Dyke | | | | | | | |
| | | 600KL | ETHANOL | 33 | 8.02 | 19.5 | 18.38 | 33.34 |

Damage distances for pool fire scenario of each ALCOHOL product are well within the depot boundary area. Heat radiations may cause burn injury to personnel's and heating of nearby tank. Strict precautions and safe operations need to be carried out by SLSL officials. From above calculations, it is inferred that damage distance (at radiation level 4.5 KW/m2) **36.54 m**. This is well within SLSL plant boundary and as per license limit.

### 6.3.17.1 Tank on fire scenario

Escaping of roof of storage tank due to internal pressure (due to surrounding heat or any other reason) or due to roof structure failure may result in tank on fire if product within the tank catches fire.

Each tank is examined for this scenario and the results were scrutinized. The effect of fire on people and property outside and inside the SLSL is in the form of thermal radiations. A criterion was selected for deciding the maximum level of thermal radiation to which the outside population can be subjected. Thermal radiation levels from fire scenarios of each tank were worked out at various distances and their effects are evaluated against the set criteria.

Thermal radiation due to tank on fire may cause various degrees of burns on exposed to human bodies. Moreover their effects on piping and equipment are to be evaluated to assess their impact. Table gives type of damage due to various heat radiation intensities.

**Table 6.17 Type of damage due to various heat radiation intensities**

| SN | Radiation Load ($kW/m^2$) | Type of Damage |
|---|---|---|
| 1 | 37.5 | Sufficient To Cause Damage to process Equipment |
| 2 | 12.5 | Minimum Energy Required For Piloted Ignition of Wood, Molting of plastic etc. |
| 3 | 4.5 | Sufficient to cause pain to personnel if unable to reach cover within 20 seconds, however blistering of skin ($1^{st}$ Degree Burn) is Likely |

FOR SLSL, each tank is examined for Tank on fire scenario. The results are shown in following table:

**Table 6.18 Damage Distances Due to Tank on Fire Scenario**

| SN | Tank No. | Product | Damage Distance (m) From Tank Surface For Radiation Intensity $KW/m^2$ | | |
|---|---|---|---|---|---|
| | | | $37.5\ KW.m^2$ | $12.5\ KW/m^2$ | $4.5\ KW/m^2$ |
| 1 | - | ETHANOL | 0 | 0.3 | 2.8 |

** NR: Not Reachable*

Analyzing the damage distances and heat radiation intensities for various Tank on fire scenarios it can be inferred that ***there will not be any fatality outside the SLSL premises*** as there will be sufficient time to escape and there is no any habitation or facility. Only burn injuries may occur inside SLSL to personnel. Thus, damage in the plant could be limited to the plant only if any. However, necessary due precautions must be undertaken by plant Personnel to ensure safety within the depot. Frequency of occurrence of such accidents has been found extremely low.

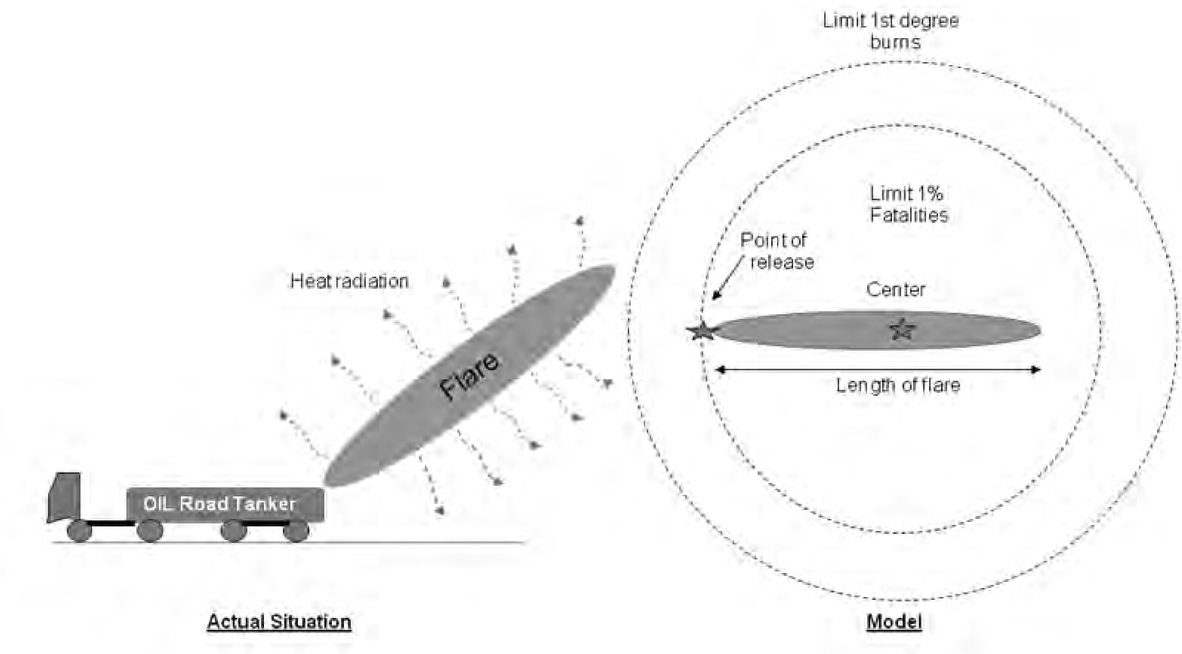



**Fig 6.3 Schematic of a Flare/Jet Fire**

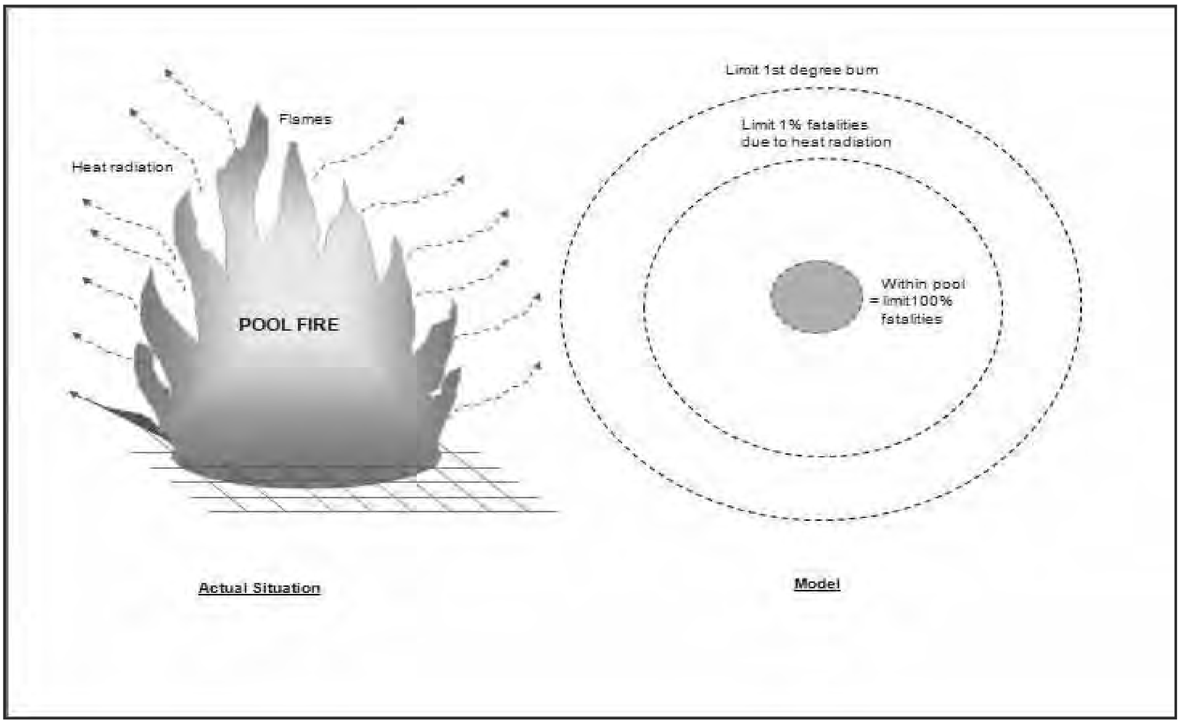
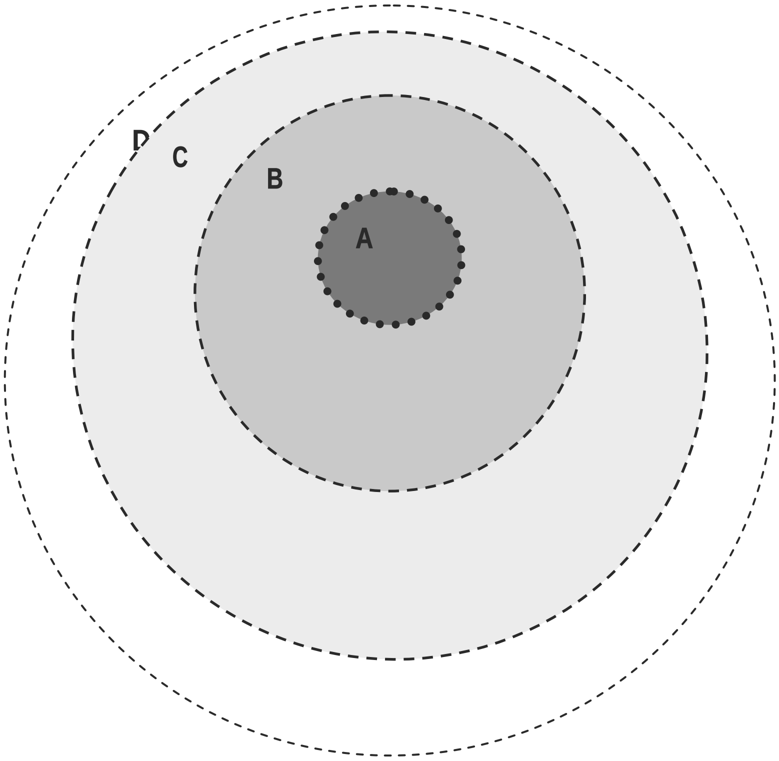


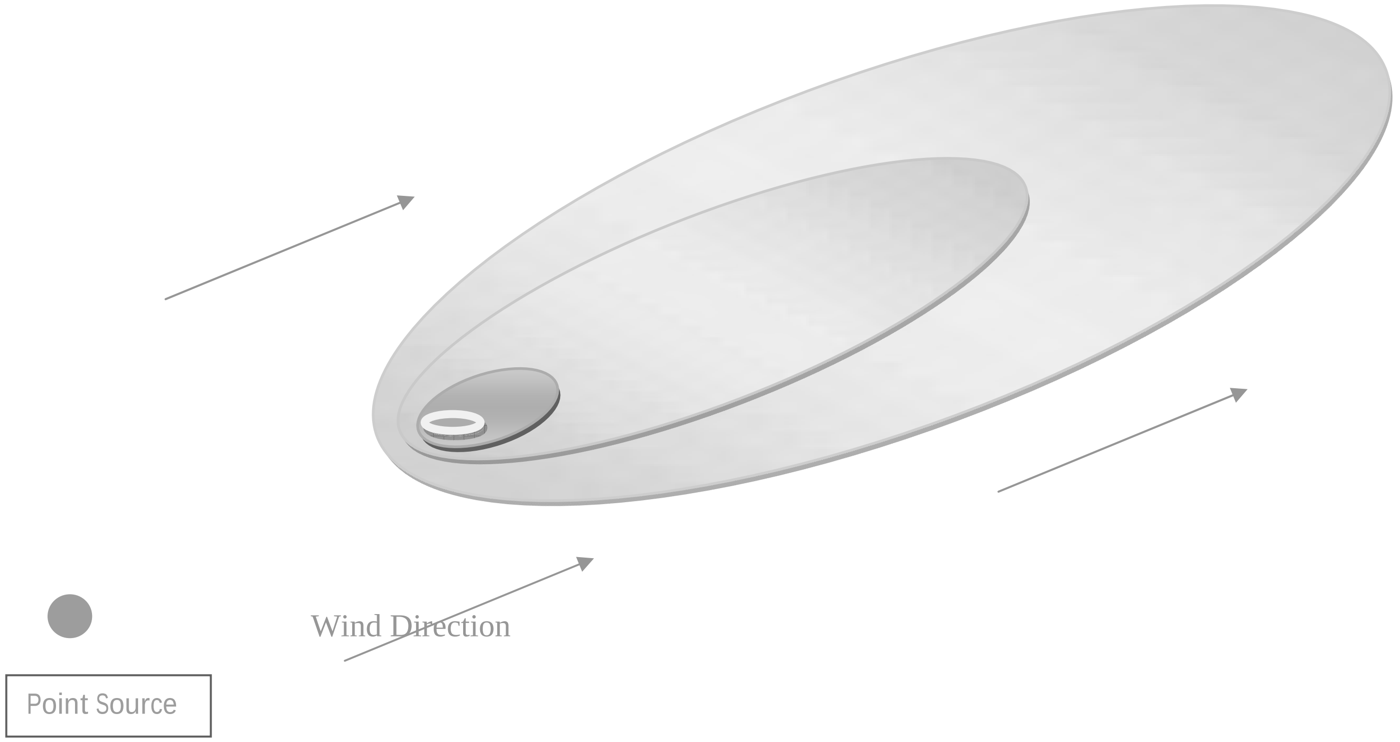

**Fig 6.4 Schematic of a Pool Fire/Spilled Fire**




| | Radiation Intensity KW/M$^2$ | Effect |
|---|---|---|
| **A** | >37.5 | 100% Lethality |
| **B** | 25-37.5 | 50% Lethality |
| **C** | 12.5-25 | 1% Lethality |
| **D** | 4.5-12.5 | First Degree Burns |

**Fig 6.5 Symbolic representation of pool fire and radiation effect from source at center (pool/spill)**

Center represents burning pool. Radiation effect diminishes with distance from pool. Radiation at 12 kw/m$^2$ can be considered as safe distance for burn injury.




### 6.3.18 Vapour Cloud Explosion Scenario

Continuous Alcohol evaporating vapor moves in wind direction and finds ignition source results into this scenario. It may also likely to be dispersed into atmosphere and diluted into it. If continue to drift, it will reach below LEL level sometime and thus there will be no chance of ignition. It will disperse totally .It is not considered as credible scenario.

### 6.3.19 Risk Associated With Solid Hazardous Material Bagasse and Sulphur

Risk Assessment for Bagasse and Sulphur Storage also being identified. The process for manufacturing and refining sugar is a standard process. Areas of concern from hazard and risk points of view in the plant manufacturing of sugar are

1) Bagasse Storage and
2) Sulphur Storage

- Bagasse generation per day will increase to 1680 MTD. Present area reserved for of storage will be increased proportionately.
- Large quantity of bagasse stored poses the serious hazard of fire as it is easily ignitable and fire spreads rapidly. Serious fire accidents have been reported.

# 6.4 Mitigation Measures

## 6.4.1 Following precautions should be taken to minimize risk of fire and for fire fighting to contain fire in case of accident

- It should be ensured while routing high tension voltage lines to avoid storage of bagasse storage below & near high voltage (H.T.) transmission lines.
- Avoid route of electric supply cables & AC cable trenches far away from stored bagasse or bagasse heaps.
- Always keep raw & useful material far away from storage of bagasse area.
- Installation of Fire Hydrant (self auto-mode fire fighting) system around the area of bagasse yard.
- Posting of proper supervision staff with necessary communication facility.
- Hot work, like welding, gas cutting should not be carried out near bagasse storage.
- Daily record of bagasse storage data, proper review of conditions taken by higher authority.
- Training of all the involved staff in normal & emergency operating system.
- Proper planning & installation of fire hydrant system around the bagasse storage yard and not depending exclusively on fire tender for fire fighting.
- Creating awareness among workers about sudden bagasse fire and emergency action plan will definitely avoid risks of heavy fire.

In this way we can save valuable fuel & life of human being working near bagasse handling and storage.

**Design and Installation of Firefighting: Measures suggested:** It is recommended to install fire hydrant piping system around the bagasse storage yard with fire hydrant points considering it as high hazard category [(6.7) of code IS 13039] and installing hydrant point every 30 meters and minimum 5.25 kg/cm sq. pressure should available at the remotest point. Hydrants should be located 15 meters away from the storage area boundary. Also it is recommended to install self auto-mode fire fighting system.

**Sulphur Storage:** 150 MT (1 month stock) of Sulphur will be stored in a closed shed and is transfer manually to the sulphur burner in 30-50 kg bags. Following are the hazards in storage and handling Sulphur.

1. Dust Explosion
2. Fire Dust Explosion

As Sulphur is stored and handled in granular form, there is always some dust formation, which can lead to dust explosion. A dust explosion occurs when a fine dust in suspension in air is ignited, resulting in a very rapid burning, and the release of large quantities of gaseous products. This in turn creates a subsequent pressure rise of explosive force capable of damaging plant and buildings and injuring people. It is generally considered that a dust explosion can only be initiated by dust particles less than 500 microns diameter.

## 6.4.2 Conditions for Dust Explosion

Under the following conditions dust explosion can take place in the industry.

- The dust must be combustible like sulphur, coal

- The dust cloud must be of explosive concentration, i.e. between the lower and upper explosion limits for the dusts.
- There must be sufficient oxygen in the atmosphere to support and sustain combustion.
- A source of ignition must be present.
- The dust must be fine enough to support an explosion.

6.4.2.1 Mitigation Measures:

Explosion Prevention: Dust explosions can be prevented by ensuring that the following conditions are met:

- Formation and Suspensions of Sulphur dust in air are avoided.
- To prevent dust formation during the storage and handling of sulphur, it is necessary to take necessary precautions to avoid spillage and crushing of granular sulphur during bulk loading and unloading in the storage area.
- Storage shed should be constructed with a minimum number of horizontal surfaces to avoid dust accumulation.
- All sources of ignition are excluded.
- Presence of moisture helps in preventing dust explosion

**a) Fire in Sulphur storage**

There is a risk of fire in sulphur storage as ignition temperature is low 190 deg C. Solid and liquid sulphur will burn to produce sulphur dioxide gas, which is extremely irritating and toxic (MSDS of $SO_2$). The effects of the fire hazard itself are slight.

**b) Mitigation Measures**

- Smoking and the use of matches shall be prohibited in all areas where sulphur dust is likely to be present. Prominent NO SMOKING signs shall be placed around such areas.
- Naked flames or lights and the use of gas cutting or welding equipment is prohibited during the normal operation of the plant. Repairs involving the use of flames, heat, or hand or power tools in areas where sulphur may be present shall be made only after getting hot work permit from the authorities.
- Where this is not possible the sulphur shall be wetted down.

## 6.4.3 Safety and Fire Fighting ascribes

- Always use Self Contained Breathing Apparatus (SCBA). Sulphur fires produce hazardous sulphur dioxide gas. Sulphur dioxide gas is heavier than air and will accumulate in the vapour spaces of the rail car.
- Small sulphur fires are easily extinguished by adding more sulphur on top of the burning sulphur. This depletes the oxygen and smothers the fire.
- For larger sulphur fires use a light water fog or $CO_2$ to extinguish. Do not use heavy water streams as this may create sulphur dust which could potentially explode.

Apart from obvious risk from hazardous material inventory other areas like power plant components such as Boiler and turbine are potential hazards. However the system is customized and at times proprietary commodity. It has its own SOP s as well as maintenance strategy with well define documents as well as skilled manning. Hence all hazards and associated risks were already being accounted and ascribed for due care and operation. Just for symbolic representative collation with respect to associated risk being presented as under

## 6.4.4 Risk Classification Screening Table for Boiler and Turbine

**(**Risk acceptance criteria are being adopted from standard referred text “Industrial fire protection“)

**Table 6.19 Risk Classification Screening Table for Boiler and Turbine**

| BOILER HAZARDS | | | | | | |
|---|---|---|---|---|---|---|
| **S N** | **HAZARD DISCRIPTION** | **Initiating event likelihood** | **Unmitigated consequences** | | **Risk class** | **Corrective action** |
| | | | **Life safety** | **Property damage** | | |
| i | Explosion in boiler due to over pressure and temperature | 1 | 4 | 4 | C | maintenance |
| ii | Explosion in boiler due to improper combustion of fuel. | 1 | 4 | 4 | C | Regular inspection, maintenance |
| iii | Burn injury due to hot water and hot steam pipeline leakage | 3 | 3 | 3 | B | Inspection, maintenance |
| iv | Exposure to the hot surface of pipeline or machineries. | 3 | 1 | - | A | Regular inspection, maintenance |
| v | Water tube burst due to Failure in boiler water level control | 2 | - | 4 | C | Continuous monitoring, maintenance |
| vi | Fire in diesel supply line | 3 | 3 | 3 | B | Regular inspection, maintenance |
| vii | Burn injury by hot fly ash | 4 | 1 | - | A | Maintenance, proper exhaust |
| viii | Catches on the moving part of the machinery like F.D. fans or motors | 3 | 2 | 1 | A | Proper fencing on the moving part of turbine |
| ix | Burst of the equipment body due to over pressure and over temperature | 3 | 1 | 4 | A | Regular inspection, maintenance |
| x | Sleep , trip and from the height during routine work, maintenance or inspection | 4 | 4 | 2 | B | Training, proper supervision, PPE’s |

| | | | | | | |
|---|---|---|---|---|---|---|
| **GENERATOR AND TURBINE HAZARD** | | | | | | |
| I | Explosion in turbine due to cooling system failure | 1 | 4 | 5 | C | Regular inspection, maintenance |
| II | Damage on generator due to lack of lubrication in coupling shaft | 2 | 1 | 4 | A | Regular inspection, maintenance |
| III | Fire on cooling oil sources | 3 | 3 | 3 | B | Proper storage, isolation from the ignition |
| IV | Fire and explosion on hydrogen tank | 2 | 5 | 4 | D | Proper storage, isolation from the ignition sources |
| V | High noise level | 1 | 3 | - | B | Ear plug, ear muff should provided |

**Table 6.20 Risk Classification With Respect To Above Reference**

| CLASS | GENERAL DISCRIPTION | ACTION |
|---|---|---|
| A | Low risk events Low risk level | Further risk reduction action required |
| B | Moderate risk events | Required minor risk reduction improvements; generally addressed by codes, standards, company or industry practices |
| C | Moderate-High risk events | Generally required further analysis to determine an optimal risk reduction strategy or reliability analysis of propose risk controls |
| D | High risk events | Risk required immediate risk reduction analysis |

Numbers1. 2. 3. 4 are the ratings of likelihood of occurrences of such events for sake of assigning risk level and required mitigation as well as prescribing safety gears. However cogen power plants has its own tailor made safety manual as well as risk mapping.

In power plant operation, towards safety, it is integrated logically for safe operation to isolate/cut off operation if exceeds limit due to reaching out unintended outcome. Some of them are being mentioned here for gross understanding as under –

## 6.4.5 Fully automated with interlocks, alarms are incorporated in Co-gen plant is being installed and has following standard safety features

- Turbine is interlocked with high and low steam inlet pressure
- Turbine is interlocked with high and low steam inlet high and low pressure
- Turbine is interlocked with high vibration of any bearing of turbine, gear box, and alternator.

- Turbine is interlocked with any bearing high temperature.
- High axial displacement of the rotor
- Turbine is interlocked with high lube oil temperature
- Separate Turbine over speed protection has been provided and interlock has been incorporated for turbine to trip on high speed.
- For reducing noise, all stem out lets have been provided with silencers.
- Pressure safety relief valves have been provided on stem drum and stem lines.
- In addition to mechanical SRVs electrometric safety relief valve is provided.
- Smoke leak detector alarm has been provided with alarm.
- Jockey pump with auto start has been provided for firefighting with low pressure interlock to automatically start main pump on low pressure.

For boiler following safety and interlocks are built in;

- Low drum level interlock,
- Furnace high pressure interlock
- Boiler feed pump interlock
- De aerator level interlock

## 6.4.6 DMP (actual data will be compiled when plant is in full operation after expansion and duties being assigned)

### 6.4.6.1 On-Site Emergency Plan

The on-site emergency plan is supposed to be a dynamic, changing document focusing on continual improvement of emergency response planning and arrangement. A structure working on a plan, does, check and review (PDCR) cycle has been therefore suggested. A person, head of operations or factory in-charge will be deployed who will be in-charge of overall disaster management plan implementation during an emergency.

### 6.4.6.2 Disaster control Management system

Disaster Management group plays an important role in combating emergency in a systematic manner. Schematic representation Emergency Control Management system SLSL is shown in List of team onsite is given in Table No 6.21

**Table 6.21 List of onsite team**

| SR | Name | CONTACT DETAIL |
|---|---|---|
| 1 | Onsite Chief Controller (Executive Director) | Adhik Rao Patil- 9742548893 |
| 2 | Site Incident controller | Prashant M Patil- 9620435008 |
| 3 | Deputy Site Incident controller | |
| 4 | Plant Manager | Santhosh B Chippalakatti - 9060599866 |
| 5 | H.O.D (Personal & Administration) | Prashanth P |
| 6 | Section In charge (unit wise) | Prashanth Patil - 9620435008 |
| 7 | Maintenance Team | |
| 8 | Medical Coordinator | H.S Yadravi- 9880496612 |
| 9 | Govt liaison team coordinator | |

| | | |
|---|---|---|
| 10 | Maintenance Team coordinator | |
| 11 | Fire & Security coordinator | Sanjeev Meenappagal - 8970767068 |
| 12 | Communication Coordinator | |
| 13 | Emergency coordinator | |
| 14 | Personal& Administrative Manager | Balappa B Shindlnimarad - 8884294705 |
| 15 | Transport coordinator | |
| 16 | Site Controller | |
| 17 | Plant Manager | |
| 18 | Section In charge | |
| 19 | Medical Coordinator | |
| 20 | Incident Controller | |
| 21 | Emergency Communication | |
| 22 | Coordinators | |
| 23 | Occupational Safety | Sanjeev Meenappagal - 8970767068 |
| 24 | Transport Coordinators | |
| 25 | Personal /Administrative Manager | |
| 26 | Communication Officer | |
| 27 | Fire & safety Officer | Santhosh C - 9916297006 |
| 28 | H.O.D (Process) | Gurav - 08411888834 |

During operational phase of the expansion, the table will be filled with names and contact number. Currently, the above are present.

## 6.4.7 Onsite DMP - Disaster Control / Management System

### 6.4.7.1 Control Room Facility

**Following are the facilities to be provided at the control room of Soubhagya Laxmi Sugars Ltd to tackle the emergency failure scenarios**

- Fire Detection System is to be installed in the control room VHF base station with a range of 25 km and VHF handsets of range 5 km is to be installed for ready communication in emergency
- Public address System (PAS) is to be installed to ease the communication to various corners of the site
- The duties and responsibilities of different co-ordinators of Onsite Disaster. Management Plan are to be displayed in the Control Room.

### 6.4.7.2Alarm System

A siren shall be provided under the control of Security office in the plant premises to give warning. In case of emergencies this will be used on the instructions to shift in charge that is positioned round the clock. The warning signal for emergency shall be as follows:

- **Emergency Siren:** Waxing and waning sound for 3 minutes.
- **All clear signal:** Continuous siren for one minute.

#### 6.4.7.3 Communication

Walkies & Talkies shall be located at strategic locations; internal telephone system EPBX with external P&T telephones would be provided.

## 6.4.8 Fire Protection System

#### 6.4.8.1 Fire Fighting System

The fire protection system for the unit is to provide for early detection, alarm, containment and suppression of fires. The fire detection and protection system has been planned to meet the above objective. The complete fire protection system will comprise of the following.

**Fire Fighting Facility**: Available in existing unit and will be maintained in future System Description of Fire Fighting System The entire fire safety installation shall be compliant with the most stringent codes /standard for the entire complex to ensure the highest safety standard and uniformity of system. Further, before property is operational, the fire protection shall be fully operated and tested under simulated conditions to demonstrate compliance with the most stringent standards, codes and guidelines.

#### a) Fire pumping system

The fire pumping system shall comprise of independent electrical pumps for hydrant and sprinkler system, diesel engine driven pump & jockey pump for hydrant & sprinkler system. Electrical pump shall provide adequate flow for catering requirement of hydrant system. Diesel engine driven fire pumps shall be provided for ensuring operation & performance of the system in case of total electrical power failure. Jockey pumps shall compensate for pressure drop and line leakage in the hydrant and sprinkler installation. Provision of PRS/ orifice plate shall be made in sprinkler riser to restrict pressure on sprinkler system. Individual suction lines shall be drawn from the fire reserve tanks at the basement level and connected to independent fire suction header. The electric fire pumps, diesel engine driven fire pumps and the jockey pumps shall all draw from this suction header. Delivery lines from various pumps shall also be connected to a common header in order to ensure that maximum standby capacity is available. The sprinkler pump shall be\ isolated from the main discharge header by a non return valve so that the hydrant pump can also act as standby for the sprinkler system. The ring main shall remain pressurized

At all times and Jockey pumps shall make up minor line losses. Automation required to make the system fully functional shall be provided.

#### b) Fire hydrant system

Internal and external standpipe fire hydrant system shall be provided with landing valve, hose reel, first aid hose reels, complete with instantaneous pattern short gunmetal pipe in the Complex.
The internal diameter of inlet connection shall be at least 80 mm. The outlet shall be of instant spring lock type gunmetal ferrule coupling of 63 mm dia. for connecting to hose pipe. Provision of flow switch on riser shall be made for effective zone monitoring. The flow switch shall be wired to FAP and shall indicate water flow on hydrant of the identified zone. Recessed cupboard/ fire hydrant cabinet shall be strategically located for firefighting requirement. Location of cabinets shall be accessed as per compartmentation plan in consultation with the Architect. Provision of fire man’s axe shall be made for internal hydrant. External hydrant shall be located within 2 m to 15 m from the building to be

protected
such that they are accessible and may not be damaged by vehicle movement. A spacing of about 45-50 m between hydrants for the building shall be adopted. Details of fire hydrant system are as follows:

**Piping**: Mild Steel pipes (heavy class) as per IS: 1239 shall be provided throughout the complex. Pipes buried below ground shall be suitably lagged with 2 layers of 400 micron polythene sheet over 2 coats of bitumen.

**External Hydrants:** External hydrants shall be provided all around the Complex. The hydrants shall be controlled by a cast iron sluice valve or butterfly valve. Hydrants shall have instantaneous type 63mm dia outlets. The hydrants shall be double outlet with CI duck foot bend and flanged riser or required height to bring the hydrant to correct level above ground.

- For each external fire hydrant two numbers of 63mm dia. 15 m long controlled percolation hose pipe with gunmetal male and female instantaneous type couplings machine wound with GI wire, gunmetal branch pipe with nozzle shall be provided.
- Each external hydrant hose cabinet shall be provided with a drain in the bottom plate.
- Each hose cabinet shall be conspicuously painted with the letters “FIRE HOSE”.

**Internal Hydrants:** Internal hydrant shall be provided on each landing and other locations as required by NBC with double headed gunmetal landing valve with 100 mm dia inlet, with shut off valves having cast iron wheels. Landing valve shall have flanged inlet and instantaneous type outlets.

Instantaneous outlets for fire hydrants shall be standard pattern and suitable for fire hoses.

- For each internal fire hydrant station two numbers of 63 mm dia. 15 m long rubberized fabric lined hose pipes with gunmetal male and female instantaneous type coupling machine would with GI wire, fire hose reel, gunmetal branch pipe with nozzle shall be provided.
- Standard fire hose reels of 20mm dia high pressure rubber hose 36.5 m long with gunmetal nozzle, all mounted on a circular hose reel of heavy duty mild steel construction having cast iron brackets shall be provided. Hose reel shall be connected directly to the wet riser with an isolating valve. Hose reel shall be mounted vertically.
- Each internal hydrant hose cabinet shall be provided with a drain in the bottom plate. The drain point shall be led away to the nearest general drain.
- Each internal hydrant hose cabinet containing items as above shall also be provided with a nozzle spanner and a Fireman’s Axe. The cabinet shall be recessed in the wall.
- Each hose cabinet shall be conspicuously painted with the letters “FIRE HOSE”.

**Hose Reel:** Hose reel shall be heavy duty, 20 mm dia, length shall be 36.5 metre long fitted with gun metal chromium plated nozzle, mild steel pressed reel drum which can swing up to 170 degree with wall brackets of cast iron finished with red and black enamel complete.

**c) Sprinkler system**

Elaborate automatic sprinkler system shall be provided. The system shall be suitably zoned for its optimum functional performance. The sprinkler system shall be provided with control valves, flow and tamper switches at suitable location and shall be connected to control module of the fire alarm system for its monitoring and annunciation in case of activation. Sprinkler type along with its Quartzite bulbs rating shall be selected based on the requirement of the space and shall be specified accordingly. Inspector’s test valve assembly with sight glass shall be provided at remote end with discharge piped to drain outlet / pipe.

**d) Fire Extinguishers** Portable fire extinguishers of water (gas pressure), Carbon-di-oxide, foam type, Dry Chemical Powder and FM-200 or Clean agent type shall be provided as first aid fire extinguishing appliances. These extinguishers shall be suitably installed in the entire areas as per IS: 2190. The appliances shall be so installed over the entire sections, that a person is not required to travel more than 15 m to reach the nearest extinguisher. These shall be placed or hanged on wall in a group on several suitable places.

**e) Fire Pump** The fire pump shall be horizontally mounted, variable speed type. It shall have a capacity to deliver and developing adequate head so as to ensure a minimum pressure at the highest and the farthest outlet. The pump shall be capable of giving a discharge of not less than 150 per cent of the rated discharge, at a head of not less than 65 per cent of the rated head. The shut off head shall be within 120 per cent of the rated head. The pump casing shall be of cast iron and parts like impeller, shaft sleeve, wearing ring etc. shall be of non-corrosive metal like bronze/brass/gun metal. The shaft shall be of stainless steel. Provision of mechanical seal shall also be made. Bearings of the pump shall be effectively sealed to prevent loss of lubricant or entry of dust or water. The pump shall be provided with a plate indicating the suction lift, delivery head, discharge, speed and number of stages. The pump casing shall be designed to withstand 1.5 times the working pressure.

**f) Foam System For Fire Fighting** Aqueous Film-Forming Foams (AFFF) based on combinations of fluoro-chemical surfactants, hydrocarbon surfactants, and solvents will be used as foam agent. These agents require a very low energy input to produce a high quality fire fighting foam. Foam concentrate will be stored in a bladder tank system. In AFFF systems a bladder tank containing a nylon reinforced elastomeric bladder is used to store the foam concentrate. System water pressure is used to squeeze the bladder providing fire fighting foam concentrate, at the same pressure, to the proportioner. An aqueous film will be formed on the surface of the alcohol by the foam solution as it drains from the foam blanket. This film is very fluid and floats on the surface of most alcohol. This gives the AFFF unequaled speed in fire control and control the spill fire.

**First Aid** A first aid centre with adequate facilities shall be provided. It shall be maintained round the clock by a compounder cum dresser and a doctor. An Ambulance shall also be provided at site to carry affected people to hospital.

**Security**

The security requirements of the company premises shall be taken care of by CSO assisted by a Fire In charge. The team, apart from the normal security functions will manage the role required during a disaster management operation as a part of the crisis control team.

**Safety**

The safety wing led by a Safety Manager will meet the requirement of emergencies round the clock. The required safety appliances shall be distributed at different locations of the plant to meet any eventualities. Poster/placards reflecting safety awareness will be placed at different locations in the plant area.

**Evacuation Procedure** As the major hazard is only due to fire, which has more or less localized impact no mass evacuation, procedures are required. Evacuation would involve only the people working very close to the fire area.

**Personal Protective Equipments (PPE**) This equipment is used mainly for three reasons; to protect personnel from a hazard while performing rescue/accident control operations, to do maintenance and repair work under hazardous conditions, and for escape purposes. The list of Personal Protective Equipment provided at the facility and their locations shall be available in

ECC. Effective command and control accomplish these functions necessitates personal trained in this On–site Disaster Management Plan with adequate facilities and equipments and equipment to carry out their duties and functions. These organizations and the facilities required to support their response are summarized in the following subsections. Personal protective equipments play a vital role in overcoming major disastrous situation saving life during onsite emergency. List of recommended Personal Protective equipment (PPE) is given below in table no 6.22

**Table 6.22: Summary of Recommended Personal Protective Equipment according to specific purpose**

| Hazard onsite Objective | Workplace Hazards | Suggested PPE |
|---|---|---|
| **Eye and face protection** | Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation | Safety glasses with side-shields, protective shades, etc. |
| **Head protection** | Falling objects, inadequate height clearance, and overhead power cords | Plastic helmets with top and side impact protection |
| **Hearing protection** | Noise, ultra-sound Hearing protectors | ear plugs or ear muffs |
| **Foot protection** | Failing or rolling objects, points objects. Corrosive or hot liquids | Safety shoes and boots for protection against moving and failing objects, liquids and chemicals |
| **Hand protection** | Hazardous materials, cuts or lacerations, vibrations, extreme temperatures | Gloves made of rubber or synthetic material (Neoprene), leather, steel, insulation materials, etc |
| **Respiratory protection** | Dust, fogs, fumes, mists, gases, smokes, vapors Facemasks with appropriate filters for dust removal and air purification (chemical, mists, vapors and gases). | Single or multi-gas personal monitors, if available Oxygen deficiency Portable or supplied air (fixed lines). |
| **Onsite rescue equipment** | Body / leg protection Extreme temperatures, hazardous materials, biological agents | cutting and laceration Insulating clothing, body suits, aprons etc. of appropriate materials |

| Objective | Workplace Hazards | Suggested PPE |
|---|---|---|
| SAFETY | Contact with HSD Fuel Oil storage and Fuel Handling | Canister type gas mask. PVC or Rubber. Goggles giving complete protection to eyes. Eye wash fountain |
| SAFETY | Fly Ash Fly ash handling and storage | Wear dust-proof goggles and rubber or PVC gloves.<br>-When using large quantities or where heavy contamination is likely, wear: coveralls. |
| SAAFETY | - At high dust levels | Wear: a Full-face Class P3 (Particulate) or an |

| | | |
|---|---|---|
| | | Air-line respirator where, an inhalation risk exists, wear: a Class P1 (Particulate) respirator. |

**Mock Drill**

As per the Industrial Major Accident Hazard Rules, Mock drills of the on-site emergency plan are conducted every month. A detail report of the mock drill conducted is to be made immediately available to all the concerned authority Also, Major Fire and Minor Fire mock drills are conducted once in three months and one month respectively.

**Training**

On job training to the engineers on various stages of risk analysis and preparedness during emergency to reflect in the operation of terminal, especially from the safety stand point. The fire team belonging to the fire fighting department are to be intensively trained for the use of all equipment and in various fire fighting methods for handling different types of fires.

**Details of Training facilities for**

- Safety- Monthly
- Fire Fighting- Monthly
- Occupational Health & safety-Monthly

**Procedure for Testing & Updating the Plan:** Simulated emergency preparedness exercises and mock fire fighting exercises including mutual aid scheme resources and in conservation with district emergency authority to be carried out time to time. Disclosure of Information to Worker & Public Awareness System in Existence & Anticipated

- Safety awareness among workers by conserving various training programs and Seminars, competition, slogans etc.
- Practical exercise.
- Distribution and practices of safety Instructions.
- Safety Quiz contests.
- Display of Safety Posters & Safety Slogans.
- Developing Safety Instructions for every Job and ensuring these instructions/booklets or manuals by the workers.

## 6.4.9 Off-Site Emergency Planning

The off-site emergency plan is an integral part of any hazard control system. It is based on those accidents identified by the works management, which could affect people and the environment outside the works. Thus, the off-site plan follows logically from the analysis that took place to provide the basis for the on-site plan and the two plans therefore complement each other. The roles of the various parties that may be involved in the implementation of an off-site plan are described below. The responsibility for the off-site plan will be likely to rest either with the works management or with the local authority. Schematic representation of various organization involved during emergency is shown below in Figure & Table shows details with Communication Nos during Offsite Emergency.

**Table 6.23 Local Statutory Government bodies**

| SR NO | Name of Govt. Agency | Phone Nos |
|---|---|---|
| 1 | District collector | 0831-2407200 |
| 2 | Sub Divisional Officer | 0831-2407275 |
| 3 | Factory Inspector of the district | 0831-2428066 |
| 4 | PCB Head Quarters | 08338-272700 |
| 5 | DCP Traffic (HQ/ Control room) | 0831-2405200 |
| 6 | Addnl. Commissioner of Police | 0831-2404007 |
| 7 | Fire brigade | 08332-225011 |
| 8 | Director Ind. Safety & Health | 0831-2466033 |
| 9 | Addl. Director Civil Defense | 0831-2420451 |
| 10 | Fire Advisor | 0831-2429441 |
| 11 | Dy. Chief Controller of Explosive | 0831-2427092 |
| 12 | Govt Hospital(nearest) | 08332-326994 |

Either way, the plan must identify an emergency coordinating officer who would take overall command of the off-site activities. **Consideration of evacuation may include the following factors:**

- In the case of a major fire but without explosion risk (e.g. an oil storage tank), only houses close to the fire are likely to need evacuation
- If fire is escalating very fast it is necessary to evacuate people nearby as soon as possible
- In acute emergency people are advised to stay indoors and shield themselves from the fire.

### 6.4.9.1 Various Organizations Involved During Emergency

- Organizational details of command structure, warning systems, implementation procedures, emergency control centres include name and appointments of incident controller, site main controller, their deputies and other key personnel involved during emergency.
- **Communications**: Identification of personnel involved, communication centre, call signs, network, list of telephone numbers.
- **Special Emergency Equipment**: Details of availability and location of heavy lifting gear, specified fire-fighting equipment, fireboats etc.
- **Voluntary Organizations**: Details of Voluntary organizations, telephone numbers nearby of hospitals, Emergency helpline, resources etc are to be available with chief authorities.
- **Medical Aid**: Local Authority, Environmental Health & Safety Department, District Level Emergency Committee Plant Level Emergency Committee Hazard works Management Fire Department
- **Emergency Control Center** Chief Co -Ordinators, Police/Traffic Department, Public Education

## 6.4.10 EMERGENCY

### 6.4.10.1 Non-governmental Organizations (NGO)

NGO's could provide a valuable source of expertise and information to support emergency response efforts. Members of NGOs could assist response personnel by performing specified tasks, as planned during the emergency planning process.

- Evacuation of personnel from the affected area
- Arrangements at rallying posts and parking yards
- Rehabilitation of evacuated persons

**a) Chemical information**

Details of the hazardous substances (MSDS information) and a summary of the risks associated with them are to be made available at respective site.

**b) Meteorological information**

There are arrangements for obtaining details of weather conditions prevailing at or before the time of accident and weather forecasts updates.

**c) Humanitarian Arrangements**

Transport, evacuation centres, emergency feeding, treatment of injured, first aid, ambulances, temporary mortuaries.

**d) Public Information**

- Dealing with the media-press office Informing relatives, etc.

**e) Assessment**

- Collecting information on the causes of the emergency

Reviewing the efficiency and effectiveness of all aspects of the emergency plan.

### 6.4.10.2 Role of local authority

Local Authorities- like Panchayat, Sabha, Samity, municipalities can help in combating emergency situation after assessing the impact scenario in rescue phase.

- Role of police

The police are to assist in controlling of the accident site, organizing evacuation and removing of any seriously injured people to hospitals. Co-ordination with the transport authorities, civil defense and home guards Co-ordination with army, navy, air force and state fire services Arrange for post mortem of dead bodies

- Establish communication centre with easy contact with ECC

### 6.4.10.3 Role of Fire Brigade

The fire brigade is to be organized to put out fires and provide assistance as required during emergency.

Media

- The media is to have ready and continuous access to designated officials with relevant information, as well as to other sources in order to provide essential and accurate information to public throughout the emergency and to avoid commotion and confusion
- Efforts are made to check the clarity and reliability of information as it becomes available, and before it is communicated to public
- Public health authorities are consulted when issuing statements to the media concerning health aspects of chemical accidents
- Members of the media are to facilitate response efforts by providing means for informing the public with credible information about accidents involving hazardous substances

### 6.4.10.4 Role of health care authorities

Hospitals and doctors must be ready to treat all type of injuries to causalities during emergency. Co-ordinate the activities of Primary Health Centres and Municipal Dispensaries to ensure required quantities of drugs and equipments Securing assistance of medical and paramedical personnel from nearby hospitals/institutions, Temporary mortuary and identification of dead bodies

### 6.4.10.5 Model Output

CALCULATION MODEL: HEAT RADIATION ---alcohol

AMBIENT TEMPERATURE = 40 (°C)
DIAMETER POOL = 30 (M)
INTENSITY OF RADIATION = 32.8 (KW/M²)
RELATIVE HUMIDITY = 50 (%)
THE THERMAL LOAD IS CALCULATED FROM THE EDGE OF THE POOL

| DISTANCE | THERMAL LOAD Q (KW/M²) | | |
|---|---|---|---|
| (M) | Q HOR. | Q VERT. | Q MAX. |
| 1.5 | 11.0 | 13.9 | 17.7 |
| 3.0 | 8.7 | 11.9 | 14.8 |
| 4.5 | 7.3 | 10.6 | 12.8 |
| 6.0 | 6.2 | 9.5 | 11.4 |
| 7.5 | 5.4 | 8.6 | 10.2 |
| 15.0 | 2.8 | 5.6 | 6.3 |
| 30.0 | 0.9 | 2.8 | 2.9 |
| 45.0 | 0.4 | 1.6 | 1.6 |
| 60.0 | 0.2 | 1.0 | 1.0 |
| 135.0 | 0.0 | 0.2 | 0.2 |
| 210.0 | 0.0 | 0.1 | 0.1 |
| 285.0 | 0.0 | 0.1 | 0.1 |

CALCULATION MODEL: HEAT RADIATION ---alcohol tank on fire

AMBIENT TEMPERATURE = 40 (°C)
DIAMETER POOL = 6 (M)
INTENSITY OF RADIATION = 32.8 (KW/M²)
RELATIVE HUMIDITY = 50 (%)
THE THERMAL LOAD IS CALCULATED FROM THE EDGE OF THE POOL

| DISTANCE (M) | THERMAL LOAD Q(KW/M²) Q HOR. | Q VERT. | Q MAX. |
|---|---|---|---|
| 0.3 | 11.9 | 14.9 | 19.0 |
| 0.6 | 10.2 | 13.6 | 17.0 |
| 0.9 | 8.7 | 12.3 | 15.1 |
| 1.2 | 7.6 | 11.1 | 13.4 |
| 1.5 | 6.7 | 10.1 | 12.2 |
| 3.0 | 4.0 | 7.0 | 8.1 |
| 6.0 | 1.8 | 3.9 | 4.3 |
| 9.0 | 0.9 | 2.5 | 2.6 |
| 12.0 | 0.5 | 1.6 | 1.7 |
| 27.0 | 0.1 | 0.4 | 0.4 |
| 42.0 | 0.0 | 0.2 | 0.2 |
| 57.0 | 0.0 | 0.1 | 0.1 |

## 6.5 Environmental Public Hearing

Environmental public hearing was conducted on 19-10-2016 at project site under the Chairmanship of Shri. N Jayram, I.A.S., The deputy Commissioner, Belgaum District.