RISK ASSESSMENT

Introduction

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

Hazard and risk analysis, involves very extensive studies and require a very detailed design and engineering information.

Assessment of risks the neighboring populations are exposed to as a result of hazards present. This requires a thorough knowledge of failure probability, credible accident scenario, vulnerability of population etc. Much of this information is difficult to get or generate. Consequently, the risk analysis is often confined to maximum credible accident studies. The common terms used in Risk Assessment and Disaster Management are elaborated below:

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

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

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

environment.

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

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

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

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

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

In the sections below, the identification of various hazards, probable risks in the Power plant, maximum credible accident analysis, consequence analysis are addressed, which gives a broad identification of risks involved in the power plant. Based on the risk estimation for fuel and chemical storage, disaster management plan has been also been present.

Identification of Major Hazard Installations Based on GOI Rules. 1989

Following accidents in the chemical industry in India over a few decades, a specific legislation covering major hazard activities has been enforced by Govt. of India in 1989 in conjunction with Environment Protection Act, 1986. This is referred here as GOI rules 1989. For the purpose of identifying major hazard installations the rules employ certain criteria based on toxic, flammable and explosive properties of chemicals.

Analysis of Units of Different Processes

A systematic analysis of the fuels/chemicals and their quantities of storage has been carried out, to determine threshold quantities as notified by GOI Rules, 1989 and the applicable rules are identified.

Uttar Pradesh Rajya Vidhyut Utpadan Nigam Limited (hence forth UPRVUNL) has proposed to set up one units of 660 MW power plant at its existing thermal plant site at Panki, District Kanpur, Uttar Pradesh. The existing plant has two thermal power units comprising of:

- 2 units of 32 MW each
- 2 units of 105 MW each

Out of these 2 x 32 MW units have been closed and 2 X 110 MW units have been derated to 2 X 105 MW & are currently generating power.

Coal based thermal power plant does not involve any hazardous chemical process which can create potential risk to personnel and property at the site and surroundings. However, few hazardous materials and gases will be handled and stored at the coal based power plant. These can create potential hazardous situations in the unlikely event of an accidental release. For identification of hazards and to enhance the safety, risk assessment studies has been carried out for the proposed coal based power plant.

Approach to the Study

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

Preliminary Hazard Assessment

Preliminary hazard assessment was performed through examination of proposed layout plan for the proposed coal fired power plant. The data on quantities of toxic and flammable chemicals proposed to be stored in the plant was obtained from the project proponent for subjective assessment of hazards involved in the operations of the proposed plant.

Hazard Identification

Based on the site visits and the information available, the principal hazards were identified, which include accidents due to mechanical and electrical failures, pipeline failures, storage tanks ruptures/leakages, release /spillage of toxic gases/chemicals.

Hazard Analysis

A detailed analysis of the likely hazards associated with risks due to failure of electrical and mechanical systems, the storage, transfer and use of LDO/HSD, storage was conducted. Also identified from the plant design information, are likely scenarios of accidents due to failure of mechanical and electrical systems.

Consequence Analysis

The risks associated with the proposed project are small and, to a large extent, localized. The number of exposed persons on-site and off-site would also be small.

Little data on failure probability applicable to Indian conditions is available for the type of operations proposed by SPGCL. While it may be possible to use data derived from western experience, in the absence of any criteria for acceptable risk in India from industrial operations, this will not provide any meaningful analysis. This limits the use of a quantitative risk analysis for the proposed project

Description of Major Hazardous Activities

Construction Hazards

The main hazard during construction results from lack of attention to safety aspects particularly fire protection and prevention throughout construction areas. The transportation of high value items to sometimes remote areas can also result in significant loss incidents.

Operational Hazards

Fire and explosion represent the greatest hazards due to significant amounts of flammable and combustible materials contained as well as heat used in the process. The potential for loss applies particularly during early commissioning and subsequent operation of the plant and equipment, especially if it is a new or innovative design and is not based on a well established and proven type. Fire can affect all areas of the production area particularly around the boilers and steam turbines where it can be made worse by the high heat levels present in the process. Explosion within the boiler itself can be due to pressure parts failure or as a result of an uncontrolled explosion of the primary fuel. Fire can also affect the coal and fuel oil storage areas.

Machinery used in the process can be subjected to high operational stresses due to temperature, pressure or rotational speed and these represent a significant hazard. Tolerances in plant and equipment to maintain efficiency can be close, which can result in major incidents as a result of breakage or detachment.

The fuel oil (HFO/LSHS/HPS) shall be used for initial start up, coal flame stabilization and low load operation of the steam generator while firing coal. Considering the fact that quantities of stored flammable and toxic chemicals are low, the effects of release of chlorine or thermal radiation due to tank fire will be localized and disaster potential is low.

Hazard Identification

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

Estimation of probability of an unexpected event and its consequences form the basis of quantification of risk in terms of damage to property, environment or personnel. Therefore, the type, quantity, location and conditions of release of a toxic or flammable substance have to be identified in order to estimate its damaging effects, the area involved, and the possible precautionary measures required to be taken.

Identification of Major Hazardous Units

Hazardous substances may be classified into Flammable substances, Unstable substances and Toxic substances. Flammable substances require interaction with air for their hazard to be realized. Under certain circumstances the vapor arising from flammable substances when mixed with air may be explosive, especially in confined spaces. However, if present in sufficient quantity such clouds may explode in open air also. Unstable substances are liquids or solids, which may decompose with such violence so as to give rise to blast waves. Finally toxic substances are dangerous and cause substantial damage to life when released into the atmosphere. The ratings for a large number of chemicals based on flammability, reactivity and toxicity have been given in NFPA Codes 49 and 345 M.

Identification of Major Hazard Installations Based on GOI Rules

Following accidents in the chemical industry in India over a few decades, a specific legislation covering major hazard activities has been enforced by Govt. of India in conjunction with Environment Protection Act, 1986. This is referred here as Hazardous Chemicals Rules. For the purpose of identifying major hazard installations the rules employ certain criteria based on toxic, flammable and explosive properties of chemicals.

Hazard Analysis

Hazards analysis is based on the philosophy "PREVENTION IS BETTER THAN CURE". How safe are the operations ? Safety is relative and implies freedom from danger or injury. But there is always some element of danger or risk in anything we do or build. When a process facility is considered safe? This calls for identification of hazards, quantification of risk and further suggests hazard mitigating measures, if necessary.

Hence hazards analysis is more relevant when a plant is at design/construction stage. This technique, applied early in the project life cycle, helps to eliminate hazards and, thus to avoid costly design modifications later. This analysis fortifies the proposed process design by incorporating additional safety factors into the design criteria.

Methodology

An assessment of the conceptual design is conducted for the purpose of identifying and examining hazards related to feed stock materials, major process components, utility and support systems, environmental factors, proposed operations, facilities, and safeguards.

Preliminary Hazard Analysis (PHA)

In the proposed Thermal Power Project, coal and air mixture is burnt to convert chemical energy into heat. The liberated heat generates steam at high temperature and pressure, which in turns drives the turbo generator to generate electrical power. Small quantities of LDO oil are used for flame stabilization during start up and low load operation.

Risks due to failure of mechanical system

Turbine : For the protection of turbine, the following devices will be provided

- Over speed device
- Bearing temperature sensors
- Exhaust gas temperature sensors

The operation of the turbine and the generators will be fully automatic through a DCS. Annunciation panels will be provided in the control room for the operators to monitor the operations.

Piping & Valves : The piping of the power plant will be low-pressure utility and cooling water piping and hence do not pose any major risks. The water piping will be made of carbon steel and designed as per IS : 1239/IS : 3589 . The air pipelines will be of galvanized carbon steel and designed as per IS 1239. The design, material, construction, manufacture, inspection and testing of valves shall comply with all currently applicable standards and regulations and API/ANSI/AWWA or BS codes.

Piping Insulation : There is a risk to burn injuries in case of personnel coming in contact with pipelines carrying high temperature fluids. To avoid this, all piping systems having working temperature equal to or more than 60ºC as per ASTM C 533 shall be provided with adequate insulation to conserve energy and protect personnel.

Lifting Tools and Tackles : The plant will have lifting tools and tackles like hoists, EOT cranes etc. The risks associated with these equipment are accidental release of the load due to failure of chain/rope. The criteria for selecting the crane will be based on maximum load and the raising and lowering heights of assembly. The design of the EOT will be as per IS 3177/IS 607. The design of the hoists will be as per IS 3938. Annual load testing and certification by a competent authority for safe working loads will be done as per Factories Act 1948 – Section 28 & Section 29 (2).

HVAC systems : The risks involved in HVAC system are fires due to overloading of electrical cables/panels and leakage's of refrigerant from the system. The HVAC system will be designed as per the following codes :

- Safety code for air conditioning : IS 669
- Safety code for mechanical refrigeration : IS 660

Risks due to failure of Electrical Systems

The electrical installation is prone to fires due to short circuits, overloads, sparking, poor earthling etc.

Generator Protection : For the protection of the generators and associated transformers following precautions will be provided **:**

a. Generator differential protection
b. Protection of Generator against accidental back energisation.
c. Stator earth fault protection
d. Stator stand-by earth fault protection
e. Rotor earth fault protection
f. Loss of excitation protection
g. Voltage controlled over current relay
h. Low forward power/reverse power relay
i. Stand by Low forward power/ reverse relay
j. Over voltage alarm for generator
k. Under frequency & over frequency protection with alarm & stage tripping
l. Generator Transformer REF protection
m. Generator over fluxing protection
n. Generator Transformer over fluxing protection
o. Generator Transformer differential protection
p. Generator transformer start up earth fault protection
q. Generator Breaker failure relay
r. Back up earth fault protection for Generator transformer
s. Unit auxiliary transformer differential protection
t. Unit aux. Transformer back up over current protection on HV side
u. Unit aux. Transformer restricted earth fault protection on LV neutral
v. Unit aux. Transformer back up earth fault protection on LV neutral

In addition, the generators would have winding temperature recorders and instruments for measuring coolant temperature, flow pressure etc. with alarm and trip contacts as necessary. Rotor over current and under excitation protections would be included in the automatic voltage regulator. Two sets of hand reset trip relays would be provided for each generator. Additional one set shall be provided for generator. Necessary relays would be provided in switchgear panels for protections of auxiliary power system including LT transformers and motors.

The generator would be connected with its step up generator transformers through isolated phase bus ducts. The bus ducts shall be continuous enclosure self cooled type and shall be equipped with air pressurization system. It will be of aluminum construction.

Necessary current and voltage transformers shall be provided in the bus duct for excitation control, performance testing, metering protection and synchronizing. Surge protection equipment and a generator neutral grounding cubicle with distribution transformer and secondary resistor will also be provided.

220 KV Bus Bar Protection : Bus bars would be protected by three high speed, high stability circulating current type differential protection having operate & restrain characteristics which can be set as per requirements along with bus wires supervisions and hand set trip relays. Local breaker back up protection could be connected with each 220 KV breaker and would be connected to de-energies that effected breaker from both sides. Each set of trip coil would be connected to separately fused DC circuits for greater reliability.

Generator Transformer : Generator transformer each for Steam Turbine shall be 3 phase with OFAF cooling and vector group of Ynd11. It shall step up the generation voltage to 220 KV. OFF Load Tap Changer shall be provided on the generator transformer and the tap range shall be ± 5% in steps of 2.5%.

LT Transformers: The power distribution at 415 V will be created by the 6.6/0.433 KV transformers. All the above transformers will be delta connected on the HT side and star connected on the LT side. The LT star point will be solidly earthed. These transformers will be mineral oil filled, suitable for outdoor service or dry type in case of indoor installation. HT side shall be suitable for cable termination. LT side of transformers shall be connected to 415 V switch gears either by bus trunking or by XPLE cables.

HT Switchgears : Power received at 6.6 KV station transformer will be connected to the 6.6 KV switchgear for further distribution. All auxiliary motors rated 160 KW & above shall be connected to the 6.6 KV system and motors below 160 KW to the 415 V system.

All 6.6 KV motors will be of direct-on-line starting having the breaker provided with requisite protection for the individual equipment. The interrupting capacity of 6.6 KV breakers shall be suitable for maximum possible system fault contribution and that of the motor during fault condition. The 6.6 KV switchgear shall be indoor, metal clad, draw-out type with SF/6 or vacuum breakers.

LT Switchgear : The source of supply for 415 V will be taken from 6.6 KV switchgear through transformer of 6.6 KV/433 V step down transformers. The 415 V system will have duplicate incomer and bus coupling arrangements so that a changeover can be made from either of the two step down transformers to restore power in case of failure of one of the above two transformers. Each transformer shall be rated for 100% capacity. Motors having a capacity of 100 KW & above would be controlled by breakers from respective MCC and that of lower capacity by contractor.

Control and Instrumentation System : The Control & Instrumentation system shall be microprocessor based Distributed Digital Control Monitoring and Information system (DDCMIS) to provide centralized, automated and efficient operation of the plant under various modes of operation i.e. start up, shut down, normal and emergency operation with due consideration to the safety, reliability and availability of the plant.

System Design Requirements : The DDCMIS shall perform the functions of closed loop controls. Open loop controls including sequence interlock and equipment protection as well as plant monitoring and information functions. The functions of closed and open loop controls shall be achieved through redundant multi-function controllers in hot stand by configuration. The main protection shall be provided with adequate redundancy at sensor and channel voting logic level ensuring safety of the equipment under all the operating conditions for the safety of the plant. It shall be ensured that the basic interlock and protection functions are available even during the failure of the man controller under open loop control. The control system sensor levels enhance system availability and reliability. Facility shall be provided for control system configuration tuning, programme development/ modification and system maintenance including system documentation functions. Due importance shall be given to the features of self diagnostics and self surveillance to facilitate maintenance in minimum possible time. An on line sequence of events recording system (SERS) with a resolution of millisecond is also envisaged for analyzing the tripping, which may be stand alone or a part of the plant DDCMIS.

It is proposed to start-up/ shut down, control monitor and operate the entire combined cycle plant in all regimes through work station based operator consoles supported by other peripherals. Back up, hardware push buttons stations/trip switches for critical drives shall be provided for start up/shut down of the plant. Further hardwired at to manual stations due to drives are also envisaged. Back up with system mimic shall also be provided.

Central Control Room : The Plant shall be monitored, operated controlled in all regimes from Central Control Room (CCR) located inside the plant. The CCR shall house control desks panels with work station based operator consoles and other peripherals like printers etc. Vertical panels housing conventional hardwired devices viz. push. button stations, trip switches, auto manual stations indicators/ records, annunciation facia shall also be suitably located in the CCR. The electrical control panels for operation of various breakers, isolators etc. shall be also be located in CCR.

The Control hardware cabinets shall be located in Control Equipment Room (CER), adjacent to CCR with due consideration for ease of maintenance.

Other Electrical Systems and Equipment

Power and Control Cables : Main factors which are considered for selection of power cable sizes will be as follows :

- System short circuit withstand time
- De-rating factors due to higher ambient temperature and grouping
- Continuous current rating
- Voltage drop during starting and under continuous operation
- 6.6 KV cables will be with standard aluminum conductor with XLPE insulation, conductor and insulation shall have extruded semi-conducting screen.
- 11/6.6 KV cables shall also have copper screen rated for earth fault current for 2 seconds
- The cables will have overall PVC sheath, each core screened on conductor as well as on insulation , armoured and overall FRLS PVC sheathed.
- All LT power cables power cables will be 1100V grade , PVC cable with

stranded aluminum conductor XLPE or PVC insulated, extruded PVC inner sheathed, armoured and overall FRLS PVC sheathed.

- Control cables would be with stranded copper conductor, multicore, 1100 Volt grade PVC insulated , PVC sheathed , armoured and overall FRLS PVC sheathed.

Motors : All motors and other electrical fittings will be of flame-proof type wherever required.

Lightning Protection : Lightning protection system will be installed for protection of the buildings/structures and equipment against lightning discharge. The lighting arrestors shall conform to IEC-99. This will be achieved by providing lightning masts, down conductors on buildings /structures, towers in switchyard and connecting these with ground grid. Also, for outdoor equipment exposed to atmosphere, protection against lightning surges will be provided with lightning surge arresters at suitable locations, over and above the shielding wires and lightning masts to safeguard the equipment.

Maximum Credible Accident Analysis (MCAA)

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

A disastrous situation is general due to outcome of fire, explosion or toxic hazards in addition to other natural causes, which eventually lead to loss of life, property and ecological imbalance.

MCA analysis encompasses certain techniques to identify the hazards and calculate the consequent effects. A host of probable or potential accidents of the major units in the complex arising due to use, storage and handling of the hazardous materials are examined to establish their credibility.

Depending upon the effective hazardous attributes and their impact and even the maximum effect on the surrounding environment alongwith the respective damage caused can be assessed.

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

Methodology

Following steps are employed for visualization of MCA scenarios :

- Chemical inventory analysis
- Identification of hazardous processes in individual units
- Identification of chemical release and accident scenarios
- Analysis of past accidents of similar nature to establish credibility to identified scenarios
- Short listing of MCA Scenarios.

Common Causes of Accidents

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

- Poor house keeping
- Improper use of tools, equipment, facilities

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

Failures of Human Systems

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

Major causes of human failures reported are due to :

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

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

The proposed power plant mainly poses flammable and explosion hazards due to unwanted release of hydrocarbons. Consequence analysis is basically a study of quantitative analysis of hazards due to various failure scenarios. It is that part of risk analysis, which considers failure cases and the damage caused by these failure cases. It is done in order to form and opinion on potentially serious hazardous outcome of accidents and their possible consequences. The reason and purpose of consequence analysis are many folds like :

- Part of Risk Assessment
- Plant Layout/Code Requirements
- Protection of other plants
- Protection of the public
- Emergency Planning
- Design Criteria

The results of consequence analysis are useful far getting information about all known and unknown effects that are of importance when same failure scenario occurs in the plant and also to get information as haw to deal with the possible catastrophic events. It also gives the workers in the plant and people living in the vicinity of the plant, an understanding of their personal situation.

Modes of Failure

There are various potential sources of large leakage, which may release hydrocarbon into atmosphere. This could be in the form of small gasket failure in a flanged joint, or a bleeder valve left open inadvertently, or an instrument tubing giving way or a guillotine failure of a pipeline, or any of many other sources of leakage. Operating experience can identify lots of these sources and their modes of failure.

Damage Criteria

The fuels and chemical storage at the plant may lead to fire, toxic and explosion hazards. The damage criteria due to an accidental release of any hydrocarbon arise from fire and explosion. Contamination of soil or water is not expected as these fuels will vaporize slowly and would not leave any residue as it happens with spillage of crude oil. The vapors of these fuels are not toxic and hence no effects of toxicity are expected. Similarly, fixed roof tanks are provided for LDO storage. Similarly storage of Hydrogen pose hazards related to fireball formation and explosion. Storage of Chlorine may mainly pose toxicity effects on the workers and neighboring population.

Tank fire would occur if the radiation intensity is high on the peripheral surface of the tank leading to increase in internal tank pressure. Pool fire would occur when fuel oil collected in the dyke due to leakage gets ignited.

Fire Damage

A flammable liquid in a pool will burn with a large turbulent diffusion flame. This release heat based on the heat of combustion and the burning rate of the liquid. A part of the heat is radiated while the rest is convected away by rising as hot air and combustion products. The radiation can heat the contents of a nearby storage or process unit to above its ignition temperature and thus result in a spread of fire. The radiation can also cause severe burns or fatalities of workers or fire fighters located within a certain distance. Hence, it will be important to know beforehand the damage potential of a flammable liquid pool likely to be created due to leakage or catastrophic failure of a storage or process vessel. This will help to decide the location of other storage/process vessels, decide the type of protective clothing the workers/fire fighters need, the duration of time for which they can be in the zone, the fire extinguishing measures needed and the protection methods needed for the nearby storage/process vessels. **Table 1.1** tabulated the damage effect on equipment and people due to thermal radiation intensity.

Table 1.1

Damage Due to Incident Radiation Intensities

S.N.	Incident Radiation (kW/m^2)	Type of Damage Intensity	
		Damage to Equipment	Damage to People
1.	37.5	Damage to process equipment	100% lethality in 1 min. 1% lethality in 10 sec.
2.	25.0	Minimum energy required to ignite wood at indefinitely long exposure without a flame	50% Lethality in 1 min. Significant injury in 10 sec.
3.	4.5	--	Causes pain if duration is longer than 20 sec, however blistering is un-likely (First degree burns)
4.	1.6	--	Causes no discomfort on long exposures

Scenarios Considered for MCA Analysis

Coal Handling Plant - Dust Explosion

Coal dust when dispersed in air and ignited would explode. Crusher Houses and conveyor systems are most susceptible to this hazard. To be explosive, the dust mixture should have :

- Particles dispersed in the air with minimum size (typical figure is 400 microns)
- Dust concentrations must be reasonably uniform
- Minimum explosive concentration for coal dust (33 % volatiles) is 50 grams/m^3.

Failure of dust extraction and suppression systems may lead to abnormal conditions and increasing the concentration of coal dust to the explosive limits. Sources of ignition present are incandescent bulbs with the glasses of bulkhead fittings missing, electric equipment and cables, friction, spontaneous combustion in accumulated dust.

Dust explosions may occur without any warnings with Maximum Explosion Pressure upto 6.4 bar. Another dangerous characteristic of dust explosions is that it sets off secondary explosions after the occurrence of the initial dust explosion. Many times the secondary explosions are more damaging than primary ones.

The dust explosions are powerful enough to destroy structures, kill or injure people and set dangerous fires likely to damage a large portion of the Coal Handling Plant including collapse of its steel structure which may cripple the life line of the power plant.

Stockpile areas shall be provided with automatic garden type sprinklers for dust suppression as well as to reduce spontaneous ignition of the coal stockpiles. Necessary water distribution network for drinking and service water with pumps, piping, tanks, valves etc. will be provided for distributing water at all transfer points, crusher house, control rooms etc.

A centralized control room with microprocessor based control system (PLC) has been envisaged for operation of the coal handling plant. Except locally control equipment like travelling tripper, dust extraction/ dust suppression / ventilation equipment, sump pumps, water distribution system etc., all other in-line equipment will have provision for local control as well. All necessary interlocks, control panels, MCC's, mimic diagrams etc. will be provided for safe and reliable operation of the coal handling plant.

Control Measures for Coal Yards

The total quantity of coal will be stored in separate stack piles, with proper drains around to collect washouts during monsoon season.

Water sprinkling system will be installed on stocks of coal in required scales to prevent spontaneous combustion and consequent fire hazards. The stack geometry is being adopted to maintain minimum exposure of stock pile areas towards predominant wind direction. Temperature monitoring of the stock piles is done to detect in time any abnormal rise in temperature inside the stock piles to enable prompt control of the same through necessary steps.

Turbo Generator Buildings

Turbo-Generator Buildings are separate, however both are exposed to risks due to similar hazards given below :

1. As per the summary of study of losses in United States for a period of 50 years, the probability of fire in Turbo-Generators is one-in 185 unit years. Therefore, there is a probability of fire/explosion in Turbo-Generator Set once in about 30 years. The likely time however cannot be predicted. The hazardous areas are :

- Lubrication oil system
- Hydrogen system

2. Apart from the Turbo-Generator sets, other major hazardous areas in Turbo Generator Buildings are :

- Cable Galleries
- Control Rooms
- Switch-gears
- Oil drums stored at Ground Floor level
- Battery Rooms

PVC cables may also cause fire. Such fires are known to propagate at speeds up to 20 m/min. Hence there is a possibility of starting fresh fires in all directions wherever cable runs cross each other or bifurcate. On combustion, every kilogram of PVC compound produces 1000 m^3 of highly dense smoke, which mainly contains hydrogen chloride fumes sufficient to produce 1 liter of Hydrochloric acid, which may condense on cooler metallic parts and instruments in presence of moisture damaging them severely.

Apart from PVC cables, the oil installation is large one for Turbo-Generator sets and can burn furiously spreading fires to Cable Galleries and other places.
The rapidity of spread of fire may create problems such as safe shutdown of units not involved initially in fire and safe evacuation of personnel, particularly operators and engineers working in control rooms.

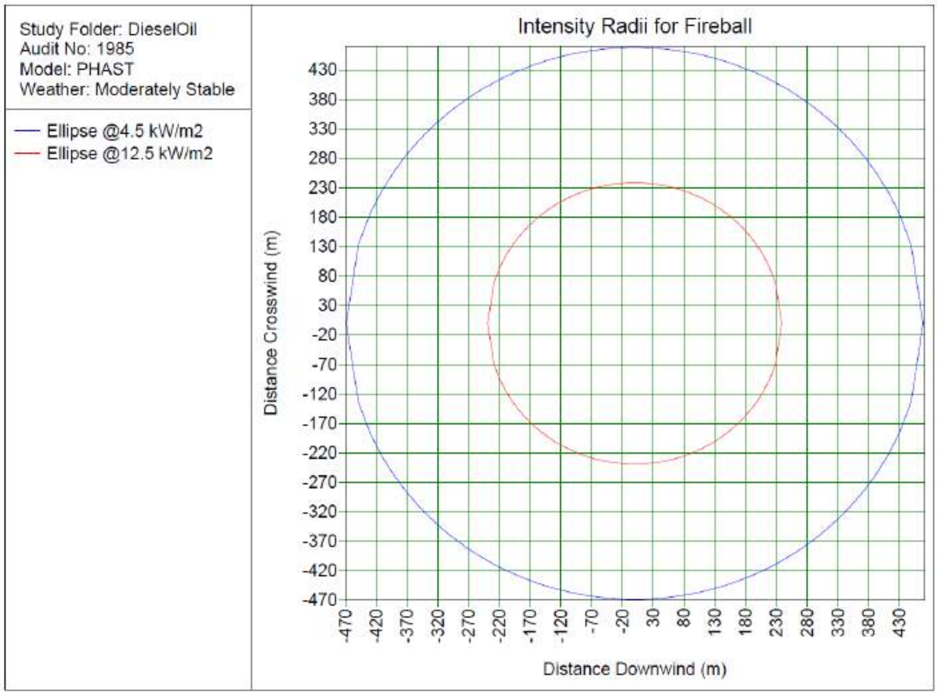
Turbo-Generator building hall is a steel structure with no insulation, and in case of a major fire, may collapse as the strength of steel would get reduced by half at temperature of 550°C (yield point of steel) and above.

Fuel Storage

Total two numbers of storage tanks of 500 KL capacity each will be provided to store LDO. In case of tank or fuel released in the dyke area catching fire, a steady state fire will ensue. Failures in pipeline may occur due to corrosion and mechanical defect. Failure of pipeline due to external interference is not considered as this area is licensed area and all the work within this area is closely supervised with trained personnel.

Risk Contours

The risk contours for LDO / Diesel storage is given below:



It may be observed from the figures above that the radiation intensity of 4.5 KW/m^2 {which may causes pain if duration is longer than 20 sec, however blistering is un-likely (First degree burns)} will be observed upto a distance of about 460 m.