Risk Assessment

Hazard Identification & Risk Assessment

Hazard analysis involves the identification and quantification of the various hazards (unsafe condition) that exist in the plant during both construction and operation phases. On the other hand, risk analysis deals with the identification and quantification of the risk, the plant equipment and Personnel are exposed to accidents resulting from the hazards present in the plant. Risk analysis involves the identification and assessment of risks to the population which is likely to be exposed to as a result of hazards incidence.

This requires an assessment of failure probability credible accident scenario, vulnerability of population etc. Much of this information is difficult to get or generate consequently, the risk analysis in present case is confined to worst case and maximum credible accident studies and safety and risk aspect related to sulphitation process and plant operations. Detailed Quantitative Risk Assessment (QRA) on potentially more hazardous and risky situations have been carried out in details and presented in the report in the later part.

Methodology

Risk assessment is most essential before preparing any on site or off site emergency plan. Hazards identification involves hazard prone areas, transportation risk, storage risks, pollution risks and air and water pollution etc. Catastrophic risks are due to natural calamities, earthquake, landslide, storm, high wind, flood, scarcity, heavy rain, lightening. Massive infection, heavy fire, heavy explosion, heavy spill, toxic exposures are other areas where risk analysis must address to minimize the damages. Risks from social disturbances, risks from the past accidents must be considered while carrying out risk assessment for a particular area (district) from which the off-site emergency plan is to be prepared.

Scope

Risk analysis deals with the identification and quantification of the risk, the plant equipment and personnel exposed to accidents resulting from the hazards present in the plant. Risk analysis involves identification and assessment of risks to the population exposed to as a result of hazards event. This requires an assessment of failure probability credible accident scenario, vulnerability of population etc. The risk analysis in present case is confined to maximum credible accident studies and safety and risk aspect related to sulphitation process. Activities requiring assessment of risk due to occurrence of most probable instances of hazard and accident are both onsite and off-site.

Detail Risk analysis is carried out considering various scenarios for the operations, raw material handling, production process, and packing of sugar bags etc. Protective measures provided and their effectiveness is delineated as given in following **Table.** To decrease the hazards potential

Identification of hazards areas

Onsite possible Hazardous Locations

Sr. No.	Hazardous Area	Hazard identified
1	Boiler Area	Explosion
2	All over the plant	Lightening
3	Electrocution	Lose fitting
4	Electrical rooms	Fire and electrocution
5	Transformer area	Fire and electrocution
6	Toxic gases	Sulphitation section in sugar factory
7	Storage yard (Bagasse) If boiler is also operated on coal	Fire and Sliding
8	Turbine room	Explosion

On Site Emergency Plan

An emergency may be defined as sudden occurrence of such magnitude so as to bring about a disruption in the normal pattern of activities inside a factory with a potential impact on food safety. The objective on-site emergency plan is to tackle emergencies based on the concept of comprehensive emergency management. The plan must consider managing emergency effectively but also preventing for, respond to and recover from such situations.

When an emergency occurs in the plant, the incident informer (the person) who first sees the mishap should inform about the emergency to the supervisor. The supervisor must inform the same to site coordinator. After confirming the message, chief coordinator will rush to Emergency control centre and alert the plant personnel through warning sounded through the waiving siren for one minute. The emergency coordination will announce the location of the emergency, requesting concerned teams to rush to the spot, and all others to clear the plant site and rush to assembly point. All team members will assemble at the spot to take over their duties under the control of the chief controller. He will give necessary instruction to teams and co-ordinate for combating the emergency. If required he will consult with the Emergency coordinators for safe shutdown/ operation plant/ section. The team leader after getting instruction from chief controller will mobilize their team members to control the emergency.

They will maintain constant communication with the chief controller who will be stationed at the emergency control centre.

An industrial unit is vulnerable to major hazards caused by natural or human caused phenomenon. This includes: a) Fire b) Power shutdown c) Food Poisoning /Hazardous material release d) Flooding e) Medical problem or accident. All the aforesaid situations cannot be anticipated, since there are many factors like nature of situation human error, equipment failure, act of God, environment risk etc. It may be noted that food safety must be given priority other than the rescue operations.

Hazard Identification in Sugar manufacturing plant:

1. Fire Hazard in Bagasse storage Area.
2. Dust and Fire hazard in Sulphur Handling
3. Exposure to SO_2 gas produced by burning Sulphur.

Elimination requires prompt action by operators/workers, emergency staff, e.g. firefighting equipment, emergency shut off valves, water sprays. Minimizing the effects may include rescue, first aid, evacuation, rehabilitation and giving information promptly to people being nearby.

Responsibility of Work Manager:

- Be responsible for all safety activities, including fire prevention during the construction period.
- Submit a safety plan including safety measures for the work to the Safety supervisor prior to commencement of the work.
- Establish, implement and maintain the safety plan through the safety supervisor and workers.
- Conduct independent audits to ensure conformance with the established safety plan and determine the effectiveness of individual elements of the safety plan.

Fire team & Security team:

- Control the emergency by fire fighting. Give a call to mutual aid if required.
- Move people to safe areas specified by safety and engineering teams.
- Control the movement of traffic at Gate.
- Provide time to time information to site incident controller.
- Provide Fire Extinguisher in plant for safety.

First Aid Team

Facilities shall be readily available to all personnel and at all times at site. First Aid training shall be considered for some of the supervisory personnel. Each shift should have TRAINED FIRST AID PERSONNEL.

Regardless of work situations, personnel who are trained and designated for first aid shall be made responsible for taking care of the situation and respond to extend first aid treatment. Primary medical treatment will be considered in addition to the first aid provisions.

OFF Site Emergency Plan

Since the only hazards are expected in the plant unit is fire and is normally contained within a premises no off site emergency plan is needed. However in case hazards spread outside the premises Team shall communicate to the District Magistrate, Commissioner of Police, Control Room and Inform situation as off site emergency.

It shall be the responsibility of declarer/ controller of emergency to inform the Local Panchayat Official regarding the likely hazards from the industry and the steps to be taken when there is an offsite emergency. It is preferable that local Panchayat officials are also trained, on simple protective methods, through demonstration.

Fire & Risk Management

Appropriate measures shall be included for prevention of fire work out the measures for the worst possible conditions from the initial stages of construction planning. The following shall be considered during all site activities such as housekeeping, training, site inspection, daily work instructions, storing of flammable substances, precautions against electrical equipment,. Tool box talks etc. All staff will make every effort to make all workers fully aware of fire prevention and fire fighting drills. Fire fighting equipment shall be provided in an adequate quantity of well maintained extinguisher for each work area and it shall be ensured that workmen are trained in the use of fire extinguisher, understand the basics of fire fighting and become with such usage.

- Always use Self Contained Breathing Apparatus (SCBA). Sulphur fires produce hazardous Sulphur dioxide gas. Sulphur dioxide gas is heavier than air and will accumulate on the ground level.

- 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.
  It is recommended to keep sufficient quantity of sand buckets for extinguishing fire in the initial stage.
- It is recommended to keep minimum four CO_2 fire extinguisher in and near the warehouse.
- These extinguishers should be checked for working and tested annually maintained. It is advisable to maintain the record of testing.

If any fire occurs in the site will have to report to site in-charge and safety Manger/officer .Then, corrective actions shall be determined and taken to prevent recurrence. All workers must be provided training to familiarize with:

- Emergency Plan prepared by organization.
- Your role and responsibility during an emergency.
- Emergency communication system
- Location of fire alarm points nearest to your workplace.
- Location of emergency kits, store well its key items available in it.
- Location of First Aid box and items available in it.
- First Aid procedures.
- Emergency Telephone Nos. of Fire Station, Medical centre and Security (Main Gate).
- Assembly Point.
- Location of fire Extinguishers and its use in case of fire.

Planning For Prevention and Handling of Fire

- Keep fire doors / Shutters, Passages and Exit doors unobstructed.
- Don't obstruct access to fire extinguishers.
- Maintain good housekeeping.
- Don't smoke in "No smoking" areas.
- Use proper containers for flammable liquids.
- Maintain safe distance of flammable liquids from sources of ignition
- Welding and Cutting equipment should be checked before and after use.
- Main electrical equipment should switch off when not in use.
- Be familiar with fire fighting system and with the operation of the fire extinguishers.
- Ensure that you know all escape routes.

If Fire Occurs

- As soon as any fire break observed – Shout " Fire and Activate ' Fire Alarm '
- Be concerned about your own safety as well as that of others.
- If it is small and you know fire fighting, use nearest fire extinguishers to put out the fire without undue personal risk.
- If you cannot extinguish it alone - get help.
- Make certain you know your escape route and assembly point.
- Inform all staff members to meet at the predetermined assembly area
- Verify that all employees are outside the building
- Discard products that have been near a fire. Products exposed to fire can be damaged by the heat of the fire, smoke fumes and chemicals used to fight the fire.
- Utensils & equipments exposed to fire fighting chemicals can be decontaminated by washing in hot soapy water & sanitized using proper sanitizer.

Fire Alarm Sound:

- (Signal: A siren sounded on a continuous wailing basis)
- Stop work immediately.
- Switch off all electrical equipment and welding machines.
- Proceed immediately to assembly area.
- Wait for further instructions from Fire personnel.

Process Hazards / Risks and Control Measures

Bagasse Storage:

This will remain same after the expansion because of increased consumption for increased steam production due to increased capacity of Co-gen generation from 15 Mw to 21 MW.
Major hazard in Bagasse storage is Fire, which can be caused by any source producing spark.

Mitigation Measures:
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.

Following precautions should be taken to minimize risk of fire by eliminating the possibility of spark and any other source of ignition and firefighting measures should be installed to control fire, and minimize damage to life and property, in case of accident-

a. It should be ensured while routing high tension voltage lines to avoid storage of bagasse storage below & near high voltage (H.T.) transmission lines.

b. Avoid route of electric supply cables & cable trenches far away from stored bagasse heaps.
c. Ensure that the area is protected by properly designed and installed lightening arrestors.
d. Always keep raw & useful material far away from storage of bagasse area.
e. Installation of Fire Hydrant (self auto-mode fire fighting) system around the area of bagasse yard.
f. Posting of proper supervision staff with necessary communication facility.
g. Hot work, like welding, gas cutting should not be carried out near bagasse storage.
h. Daily record of bagasse storage data, proper review of conditions taken by higher authority.
i. Training of all the involved staff in normal & emergency operating system.
j. Proper planning & installation of fire hydrant system around the bagasse storage yard and not depending exclusively on fire tender for fire fighting.
k. 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 a valuable fuel & life of human being working near bagasse.
l. Fire hydrant piping has been properly laid around the bagasse storage
m. The drawing showing fire hydrant around the bagasse storage has been provided.

Dust and Fire hazard in Sulphur Handling

The existing plant has a well-fabricated warehouse of 44 m^2 area to store 90 MT of Sulphur. The same warehouse will be used for increased production.

NFPA rating for Sulphur is NH=3 NF=1.

Though Sulphur is stored in granule form, there is always dust present in the atmosphere and there is hazard for worker's health due to dust inhalation.

Mitigation Measures

1) Avoid formation of dust and Workers to use proper breathing mask to avoid inhaling Sulphur dust. Workers to use gloves to avoid skin contact.

Hazard: Dust Explosion in Sulphur Storage

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. Lower explosive limit for Sulphur is reported to be 280 mg/m^3

Following conditions are necessary before a dust explosion can take place.

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

Mitigation Measures:

Dust explosions can be prevented by ensuring when 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 by installation of flameproof lighting in the warehouse
- Presence of moisture helps in preventing dust explosion. Hence, Sulphur heaps can be kept slightly wet by spraying water.

Fire in Sulphur storage

There is a risk of fire in Sulphur storage as ignition temperature is low at 190^O C. Solid and liquid Sulphur will burn to produce Sulphur dioxide gas, which is extremely irritating and toxic.

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.

- Adequate numbers of Fire extinguishers have been provided inside the warehouse.

Cogeneration Plant Operation

Hazards

Boiler operation has hazard of leakage of high pressure steam and explosion and turbine has its associated hazards due to high speed rotation of shift.

Mitigation Measures

All high pressure boilers are designed, operated and maintained as per IBR boiler act and regulations. Steam lines are designed as per IBR rules and fabricated by IBR approved welders.

In addition to this all boilers have following standard built in instrumentation, alarms and interlocks to ensure safe operation

Boiler Alarms & Interlocks

1) Drum level low Alarm
2) Drum level high alarm.
3) Drum level very low, FD & bagasse feeder trip.
4) Dearater level low alarm & boiler feed pump trip.
5) Furnace draft low & high alarm & boiler trip.
6) Mechanical Safety valves for high pressure release.
7) Interlocks for boiler ESP silo levels, RAV trip & TRCC feedback for boiler trip.
8) Boiler feed pump bearing temperature high alarm & very high trip.
9) Boiler feed pump suction DP high alarm & very high feed pump trip.

Turbine Alarm & Interlocks

1) Mechanical & electrical trip for turbine over speed.
2) Turbine trip for very low vacuum.
3) Inlet steam temperature & pressure low alarm & very low turbine trip.
4) Hotwell level low & high alarm. And very high turbine trip.
5) Axial displacement & vibration high alarm & very high trip.
6) Lube. oil & Control oil pressure low alarm & very low trip.
7) Turbine bearing temperature high alarm & very high trip.
8) CEP Discharge pressure low, standby CEP pump started.

Occupational Health & Safety

Standard Medical facilities as required by Factory rule are provided in the OHC for the existing plant, some important are illustrated below:

1. Well equipped First Aid Boxes will be provided in each Section of the factory.
2. In case of need, factory will be having dispensary to give effective medical facility to workers. In dispensary, sufficient stock of medicines will be available to provide to workers in case of any major emergent situation.
3. Ambulance will be made available 24X7 in the factory to deal and take the injured workers to the district hospital, if required as per factory act.
4. The noise levels in critical area shall be monitored regularly and the workers at high noise level generating areas will undergo audiometric tests once in six months.
5. Ensure proper implementation of fire preventive methods and an appropriate firefighting service together training facilities for personnel involved in this service.
6. Publish and notify regulations, instructions and notices in the common language of employees.
7. 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.
8. Provide appropriate facilities for first aid and prompt treatment of injuries and illness at work.
9. Take steps to ensure that all known safety factors are taken into account in the design, construction, operation and maintenance of plants, machinery and equipment.
10. Allocate sufficient resources to maintain safe and healthy conditions to work.
11. Ensure that adequate safety instructions are given to all employees.

Site Specific Studies

Quantitative Risk Analysis (QRA)

QRA is carried out for estimating the SO_2 gas concentration over the distance till concentration is equal to TLV of SO_2 gas, under the most credible scenario of 2 mm and worst case scenario as 5 mm leakage through the flange joint.

Threat zone calculated by using ALOH software are as follows:

2 mm flange leakage		5 mm flange leakage	
Concentration	Distance Meters	Concentration	Distance Meters
IDLH100 ppm	10	IDLH100 ppm	34
10 ppm	16		
TLV 5 ppm	23	TLV 5 ppm	156

Mitigation Measures based on QRA

There is a SOP to shut off the Air compressor in case of leakage or emergency. Following instructions must be displayed for workers to follow:

1) Gas masks and SBA must be available near the generation unit for the workers to attend the leakage in case of emergency
2) All the workers (normally 3) working in that area should vacate the area and go against the wind to a safer location.
3) Assembly point should be designated near the SO_2 production area.
4) Higher authorities should be informed and if the leakage is serious, alarm should be sounded and procedure given in Onsite Emergency Plan should be followed.
5) Detailed Procedure, based on the above should be included in the plan.
6) Procedure for shutting down the generation unit and actions to be taken in case of gas leakage.
7) Clear passage must be available for people to leave the area easily.
8) Before the plant start up and every six months, pressure test and thickness test of all the equipments and piping carrying SO_2 must be carried out to avoid leakage.
9) Provision to sound an alarm must be installed near the operating area, in case, SO_2 leakage is suspected and detected by smell, to warn all workers of the leakage.
10) SO_2 leak detectors may be installed.
11) All operators must be aware of Emergency Shutdown procedure and action to be taken to warn authorities to sound alarm.
12) Emergency Shutdown procedure and action to be taken should be displayed in the SO_2 production area in the local language**.**
13) It should form an important part of mock drill to be carried out as per on-site emergency plan.
14) In case major leakage is envisaged in MCA of flange joint leakage, area around SO_2 production unit and part of the main plant must be vacated immediately.

Failure frequencies for pipe

Above ground pipeline		**Underground pipeline**	
Type of failure	**Failure frequency [/year]**	**Type of failure**	**Failure frequency [/m.year]**
Small leak deq = 0.1 D	2.8 10-7 L/D	**Crack** deq = 10 mm	7.9 10-8
Medium leak deq = 0.15 D	Medium Leak 0.15 D	1.2 10-7 L/D	
Large leak deq = 0.36 D	5.0 10-8 L/D	**Hole** deq = 0.5 D	6.9 10-8
Rupture	2.2 10-8 L/D	**Rupture**	2.8 10-8

L= to pipe length minimum 10 meters

D= inner pipe diameter in mm

For assumed length of 50 meters and 200 mm pipe diameter frequency failure rate calculated for small leak d_{eq} = 0.1 D= 0.1 X 200 = 20 mm

We have done QRA for 2 mm and 5 mm leak.

Failure frequency calculated = $7X\ 10^{-5}$

Another reference quotes frequency failure rate for 4 mm leak in 150 to 300 mm diameter as $1X\ 10^{-6}$

These frequency failure rates are low.