Risk Assessment

1.1 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, alcohol storage 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.

Objective of the Risk and Hazard analysis is to;

1) Identify hazards and nature of hazard in the process, storage and handling of hazardous chemicals.
2) Carry out Qualitative risk analysis for the process and suggest mitigation measures.
3) Carry out Quantitative risk analysis of the storage of hazardous chemicals and estimate the threat zones for Most Credible and Worst case scenarios
4) Suggest mitigation measures to reduce the risk/probability of the accident to the minimum.
5) Incorporate these measures for ensuring safe operations and safe layout and for effective preparation of On-site and Off-site emergency plans
6) Suggest Guidelines for on-site and off - site emergency plan

1.1.1 Methodology

Identify hazards based on;

- Processes description received based.
- Identify Hazardous Chemicals handled and stored.
- Inventory of Hazardous chemicals

1.1.2 Hazard Identification

Identification of types of Hazards in Sugar Industry, and Go-gen and distillery:

The potential general hazardous areas in a factory and the likely accidents with suggested /already in place mitigation measures in the concerned are listed below table;

Table No. 1.1: Onsite possible Hazardous Locations

Sr. No.	Hazardous Area	Hazard identified	Mitigation measures	Mitigation measures in place	Comments/ Additional measures
1	Boiler Area	Explosion	IBR rules for design, maintenance and operation of boilers by certified boiler attendants in mandatory	These measures are in place as the boiler is in operation for the existing capacity.	The same measures will be adopted for the additional boiler capacity of 185 TPH.
2	All over the plant	Lightening	To design and install adequate number of best available lightening arrestors.	Lightening arrestors at critical locations like bagasse yard, Co –gen plant distillery section are installed.	Additional are required for increased area of operations these will be installed. Additional lightening arrestors will be installed in the new distillery area, as per the requirement of electrical rules and guidelines
3	Electrocution	Lose fitting	Regular maintenance, internal safety audit, and external safety audit at regular intervals.	These are in place for the operation of the existing capacity	To be checked and inspected regularly and corrective action to be taken immediately.
4	Electrical rooms MCC rooms	Fire and electrocution	Regular maintenance, internal safety audit, and external safety audit at regular intervals.	These are in place for the operation of the existing capacity	Strictly not to be used as store and/or rest rooms for workers.
5	Transformer area	Fire and electrocution	Regular maintenance, internal safety audit, and external safety	These are in place for the operation of	

Sr. No.	Hazardous Area	Hazard identified	Mitigation measures	Mitigation measures in place	Comments/ Additional measures
			audit at regular intervals.	the existing capacity	
6	Cable tunnel	Fire and electrocution	Regular maintenance, internal safety audit, and external safety audit at regular intervals.	These are in place for the operation of the existing capacity	To be checked and inspected regularly and corrective action to be taken immediately.
7	Bagasse storage area	Fire	Fire hydrant around Bagasse Storage area.	Fire hydrant around the Bagasse storage should be in place.	Other Detailed measures have been suggested in the report, in the later part.
9	Sulphur Storage	Dust Explosion & Fire	Fire extinguishers, water hose connection	Fire extinguishers should be in place	Other detailed mitigation measures are suggested in the report
10	Molasses Storage Tanks	Spillage & Tank Explosion	Dyke walls around the Storage tanks. Or gutter of 2 M width and 3 M depth around the storage tanks for collection of Molasses in case of leakage, in addition to pump for pumping leaked Molasses back to the tank in good condition. Temperature Control	Temperature Control in place. Tans are provided with external cooling arrangements. Company has gutter around the tanks for collection of leakage . This must be improved as suggested.	Dyke walls must be built around the existing tanks and around the additional tanks installed after expansion. Minimum concrete gutter of 2 meter wide 1.5 to 2 meter depth to be provided with concrete pit collection and with a pumping arrangement to pump molasses leaked into the other tank.

Proposed Additional Mitigation Measures to avoid accidents:

(A) Preventive additional Mitigation Measures for eliminating Electricity Hazard:

1. All electrical equipment is to be provided with proper earthing. Earthed electrode are periodically tested and maintained.
2. Emergency lighting is to be available at all critical locations including the operator's room to carry out safe shut down of the plant.
3. Easy accessibility of fire-fighting facilities such as fire water pumps and fire alarm stations is considered.
4. All electrical equipment's to be free from carbon dust, oil deposits, and grease.
5. Use of approved insulated tools, rubber mats, shockproof gloves and boots, tester, fuse tongs, discharge rod, safety belt, hand lamp, wooden or insulated ladder and not wearing metal ring and chain.
6. Flame and shock detectors and central fire announcement system for fire safety are to be provided.
7. Temperature sensitive alarm and protective relays to make alert and disconnect equipment before overheating is to be considered
8. Danger from excess current due to overload or short circuit is to be prevented by providing fuses, circuit breakers, thermal protection

(B) Boiler Section:

1. Presently two boiler of capacity 70 TPH & 40 TPH with 45 kg/cm2 is in working condition. And additional 120 TPH X 02 nos boilers will be installed for Sugar and Co-gen expansion.
2. Boiler ash after the ESP is directly stored and transported to brick manufacturers.
3. It is recommended to avoid manual handling and loading of ash. Or at least the workers should be provided them with proper mask to avoid inhaling of fine ash and soap etc. for cleaning, after their duty.

(C) Establishing a Fire Fighting Group:

1. A small spark of fire may result into loss of lives, machines and the damage by fire may result in high economic losses. This type of losses can be avoided by preventing and controlling the fire instantly for which fire–fighting group will be established.
2. First aid trained and Fire– fighting trained person will be available in every shift.
3. The fire-fighting group would house and keep in readiness, the following types of equipment and arrangements.
    a. CO2 extinguishers
    b. Dry powder chemical extinguishers
    c. 80 mm. spray hoses
    d. Fire brigade

4. Amongst the hazards identified above the area of major concern for fire, explosion and exposure to and release of toxic liquids and gases and there is risk of persons, outside the factory limits getting affected are identified below:

1.1.1.1 Sugar manufacturing section:

- ✓ Bagasse storage: Fire hazard
- ✓ Production and handling of SO2
- ✓ Molasses Storage tanks: Leakage of molasses due to tank failure

- ✓ Bagasse storage: Fire hazard

Present Scenario:

a. At present capacity of 6000 TCD, is stored in a storage yard.
b. Present Bagasse storage area is 14000 Sq. M is provided (110 x 128 x 9 mtr).
c. After expansion same Bagasse yard will be used - 26500 sq. m (151 x 205 x 9 mtr).
d. There is fire hydrant piping laid around the Bagasse storage area.
e. Fire hydrant system is provided and maintained to cover up entire bagasse yard.

Suggested measure:

1. The fire- hydrant system has to be continuously charged with water pressure of 7 Kg/sq.cm.
2. Hydrant points must be always approachable, even during night.
3. Fire hose and boxes have to be in good ready to use condition.
4. Fire Fighting System at SGSL;
    - The company has adequate water storage reserved for fire-fighting, main fire hydrant pump, pump running on HSD, alarm system.
    - Water storage for Firefighting : 1650 Cu. M (Cu. M to be confirmed)
    - Hydrant points : 60 Nos
    - Main Hydrant pump Capacity : 325 Cu. M/Hrs
    - Jockey Pump Capacity : 325 CM/Hrs
    - Jockey pump starts at 7 Kg/cm2 line pressure
    - Jockey Pump stops at 6 kg/cm2 .
    - Main Pump starts at 1.5 Kg/Sq. cm.
    - Diesel pump starts at 1.5 Kg/Sq. cm
    - Stops Manually
    - Booster pump starts at 1.5 Kg/Sq. cm and stops at 7 Kg/ Sq. Cm

Additional Information

1. Factory layout already showing this hydrant piping and hydrant location layout is given in Chapter 2.

2. Fire hydrant piping size 150 mm and hydrant points and distance between hydrant points in 15 meters.
3. Fire hydrant system is designed as per IS for sizing of fire hydrant piping, number of hydrants, location of hydrant points, hose boxes etc.
4. Water storage provision of 1650 Cu. M to be exclusively used for fire-fighting has been made is as per IS 9668.
5. Factory layout drawing is required, which must clearly show the hydrant piping layout and hydrant location.
6. Fire NOC may be required now and/or before distillation plant commissioning.

Mitigation Measures for safe storage:

Following mitigation measures to eliminate the fire hazard are in place and some additional measures are suggested as below:

1. It should be ensured while routing high tension voltage lines to avoid storage of bagasse storage below & near high voltage (H.T.) transmission lines.
2. Avoid routing of electric supply cables & cable trenches near to bagasse storage and if unavoidable locate these as far away from stored bagasse or bagasse heaps.
3. Always keep other raw materials & useful material far away from storage of bagasse area.
4. 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.
5. Posting of proper supervision staff with necessary communication facility.
6. Hot work, like welding, gas cutting should not be carried out near Bagasse storage or only after issue of proper work permit and making necessary arrangements.
7. Daily record of Bagasse storage data must be maintained and proper review of storage conditions must be taken by higher authority.
8. Training of all the involved staff in firefighting in normal & emergency operating system.
9. Proper Planning & Maintenance of the fire hydrant system around the bagasse storage yard and not depending exclusively on fire tender for fire-fighting.
10. 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.
11. Goggle and mask should be provided for workers in bagasse yard to prevent ill effect on eyes and inhalation of fine Bagasse dust on the workers in the area.

- ✓ Production and handling of SO2

Hazard Identification: Sulphur Storage: Dust and Fire hazard in Sulphur Handling:

- The existing plant has a well-fabricated warehouse of 44 M^2 areas to store 90 MT of Sulphur.
- The same warehouse will be used for increased production.
- NFPA rating for Sulphur is NH=3 NF=1.

Health Hazard

- 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 use proper breathing mask to avoid inhaling Sulphur dust. Workers use gloves to void 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

Conditions for Dust Explosion;

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 must 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.

Hazard: Fire in Sulphur storage

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

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 number of Fire extinguishers has been provided inside the warehouse.

Safety & Fire Fighting Tips

1. 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.
2. Small Sulphur fires are easily extinguished by adding more sulphur on top of the burning Sulphur. This depletes the oxygen and smothers the fire.
3. For larger Sulphur fires use a light water fog or CO2 to extinguish. Do not use heavy water streams as this may create Sulphur dust which could potentially explode.
4. It is recommended to keep sufficient quantity of sand buckets for extinguishing fire in the initial stage.
5. It is recommended to keep minimum 4 CO2 fire extinguisher in and near the warehouse.
6. These extinguishers should be checked for working and tested annually maintained. It is advisable to maintain the record of testing.

Hazard: Exposure to SO_2 gas produced by burning Sulphur.

1. SO_2 gas is used for the purification of Sugar juice, in stirred tank closed vessel designed for complete absorption of SO_2 gas.
2. SO_2 gas is produced, in SO_2 gas generators by charging Sulphur granules in the melter and producing SO_2 gas by reacting with air in standard burners, followed by cooling

to around 70 deg C. And gas is supplied for the treatment of Sugar juice. There is practically no intermediate storage of the gas and supplying the gas.

3. The SO_2 gas hold up is the pipeline of 200 mm diameter and length of maximum 30 meters for calculation purpose length of 50 meters is assumed at maximum pressure of 0.5 kg/sq. cm
4. In case of abnormal conditions, air blowers can be switched off.

Quantitative risk analysis

Quantitative risk analysis 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:

Under following assumed atmospheric conditions:

- ✓ **Atmospheric Data: (Manual Input of Data)**

Wind: 5.5 meters/second from W at 3 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: D

No Inversion Height Relative Humidity: 5%

- ✓ **Source Strength:**

Non-flammable gas is escaping from pipe

Pipe Diameter: 20 centimeters Pipe Length: 50 meters

Unbroken end of the pipe is closed off

Pipe Roughness: smooth Hole Area: 1 sq cm (10 mm hole)

Pipe Press: 2.5 atmospheres Pipe Temperature: 60° C

Release Duration: 18 minutes

Max Average Sustained Release Rate: 2.34 kilograms/min

(Averaged over a minute or more)

Total Amount Released: 5.75 kilograms

Table No 1.3 QRA for SO_2

Release Duration	Total Qty Released	Hole area 1 sq. cm		Release Duration	Total Qty Released	Hole Area 2 sq.cm	
18 minutes 5.57 Kgs		Concentration	Distance Meters	9 minutes 5.75		Concentration	Distance Meters
		IDLH100 ppm	68			IDLH100 ppm	85
		25 ppm ERPG	137			25 ppm ERPG	174
		TLV 5 ppm	318			TLV 5 ppm	406

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 added 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 should be clearly displayed on the board, in local language.
7) Clear passage must be available for people to leave the area easily.
8) Before the plant startup and every six months, pressure test and thickness test of all the equipment's 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 with alarm should 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.
15) Failure frequencies for pipe systems

Table No 1.4 QRA for Pipeline

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		1.2 10^{-7} L/D	
Large leak deq = 0.36 D	5.0 10^{-8} L/D	Large Leak d_{eq} =0.5D	6.9X 10^{-8}
Rupture	2.2 X10^{-8} L/D		2.8 X 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 = 7 X 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.

- ✓ **Molasses Storage Tanks:**

Table No. 1.5 Capacities of Molasses Storage Tank

Present Molasses Storage	Molasses Storage expansion
Tank Capacity In Cu. m	Tank Capacity In Cu. m
4000 x 01 Nos	10000 x 04 Nos
6000 x 02 Nos	750 x 01 Nos

Hazard Identification:

There are two areas of concern are:

1. Molasses storage: Heavy leakage of Molasses, total breakage of tank, leading to loss of life and pollution.

Molasses storage:

i. In the present plant 3 numbers of molasses tanks having capacities of 16000 Cu. M are installed for storage of molasses.
ii. Cooling system for tank is provided for safety purpose.
iii. During Expansion, additional 4 number of Molasses tanks of 10000 Cu. M each will be installed.

Mitigation Measures:

It is necessary to take following mitigation measures to prevent bursting of tanks, and heavy leakage and loss of life.

Storage of molasses:

1. Molasses should be stored in good quality and leak proof mild steel tanks.
2. Adequate safety factor should be incorporated into the design of wall thickness considering deterioration that will occur due to corrosion over a period of time.
3. Regular internal and external inspection should be scheduled for checking wall thickness of the tanks.
4. Dyke/ Bund walls should be constructed around the tank or tanks.
5. It must be ensured while finalizing the dyke dimensions and that thickness that clear volume inside the dyke walls is equal or more than 1.2 x volume of tank storage capacity.
6. At least, as suggested gutter around the tanks, with pumping arrangement must be constructed.
7. Continuous mixing of molasses through external pump circulation should be done.
8. If there is increase in temperature beyond 30^0C external cooling of tanks shall be provided by heat exchanger in the circulation line.
9. Frequent Temperature monitoring, manually or by recorder is strongly advised.
   If there is leakage –

a. Leakage should be washed out and diluted and should be recycled as far as possible or must be properly treated in Effluent treatment plant.
b. Replacing of leaky gaskets, joints, should be done strictly by following work permit system.
c. Leakage of pipelines, welding repairs should be attended / carried out outside the plant. The necessary hot work permit should be issued after taking necessary precautions and fire - fighting measures for onsite hot work, by the concerned authority before any hot work in undertaken
d. Leakage through pump gland shall be reduced to the minimum by installing mechanical seals.
e. To attend all major leakage in tanks the following procedure should be followed
   (i) Transfer the material to other tank.
   (ii) Prepare the tank for welding repairs by making sure that it is positively isolated with blinds from other vessels and ensuring that it is free of the chemicals and gases by

purging air and carrying out air analysis before any hot work is undertaken and this should be done by skilled workers. For this purpose safety permit should be given.

1.1.1.2. Co-Generation Plant:

Company has existing 21 MW Co-gen plant. The same will be expanded by additional Co-gen plant of 90 MW to have total 111 MW generations Capacity.

(iii) The company's present plant is standard DCS controlled and operated to take care of all safety related issues with all instrumentations, alarms and interlocks. Details of the same are provided in **Annexure {I}**.
(iv) Similar system will be in place for expansion plant as it is standard.
(v) In addition, all the employees working in this area on the shop floor are provided with ear plugs to prevent ill effects of high noise in this area.

1.1.1.3. New Distillation Plant of 150 KLPD:

i. The company will adopt standard Alcohol production technology, which is described in details in the earlier part of the EIA report.
ii. Separate areas of 2023 sq. Meters have been allocated for this plant. Details of the same are shown in the site layout, in this EIA report.

Suggestion for minimization of Hazard in the process:

i. Major hazard identified in the production unit is release of alcohol vapours and fire.
ii. It is recommended that, the company should insist in the process know –how and basic engineering supply agreement to include HAZOP study. It is desirable to associate technical and production staff in these studies for better understanding of the process and instrumentation philosophy and other technical aspects of the process and plant.
iii. Detailed engineering should ensure that all the recommendations on safety measures are implemented.

Major Hazard in Distillery

Major hazard is leakage and fire in storage of Alcohol.

Following Alcohol storage is planned:

It is confirmed that the following for the Alcohol storage, tank layout, tank-farm layout, pump locations etc will be as per the requirements of PESO latest rules and regulations.

Statutory approvals for the storage of Alcohol will be obtained, before the pant start up.

Table No. 1.6 Alcohol Storage Tank details

Sr. No	Product	No. of Tanks	Each tank capacity in KL	Tank Dimension	Monthly Production in KL
1	Extra Quality Rectified Spirit	3	1500	H-13m, Dia-12.2m	4350
2	Extra Neutral Alcohol	3	1500	H-13m, Dia-12.2m	4350
3	Ethanol	3	1500	H-13m, Dia-12.2m	4350
4	Technical Alcohol	1	1500	H-13m, Dia-12.2m	435
5	IS	1	1500	H-13m, Dia-12.2m	435
6	DS	1	1500	H-13m, Dia-12.2m	--
7	Fusel oil	1	50	H-7m, Dia-3.02m	9

i. All tanks will be provided with flame arrestors, moisture traps, and over head condensers with chilled water for prevention of Alcohol loss and environment protection.
ii. NFPA rating for Alcohol is NH (Health Factor) NF (Fire Factor) NR (Reactivity)
iii. NF= 3, NH = 2 and NR=0, indicating fire as the major hazard in handling and storage of Alcohol

Following storage has been for various grades of alcohol in the existing plant in the unit 1 and 2:

Qualitative Risk analysis:

For the storage of alcohol Fire and Explosion index has been calculated to be 72 based on the Material Factor MF= 16 and storage conditions (Degree of Hazard is rated based on of Fire and explosion index as follows)

Table No. 1.7 Degree of Hazard and F&Ei Index

F&Ei Index Range	Degree Of Hazard
1-60	Light
61-96	Moderate
97-127	Intermediate
128- 158	Heavy
More Than 159	Severe

F&EI index is in the range of moderate

Mitigation measures:

1. Based on standard recommendations for moderate hazard is it is recommended to have alcohol storage tanks should be in open in dyke walls and must have spill collection and control (recycle) arrangement to pump into another tank.
2. As indicated the storage should be in open with dyke walls.

3. If applicable and if storage of alcohol equals or exceeds 5000 kl following must be done.
4. Clear distance between tanks will be provided as per the requirement of petroleum rules table 1 schedule ii.
5. Location of pumps, location of tank farm in the factory should be as per the requirements of peso petroleum rules. Note on Transportation of Class A Solvents given in **Annexure II.**
6. Necessary approval /license from chief controller of explosives will be obtained for the alcohol storage and factory lay out as per the chapter v of peso rules
7. Proper firefighting system, inside the plant and around the storage tanks will be designed as per is or international code. And fire NOC will be obtained.
8. Fire fighting around alcohol storage will be as per IS 117 or equivalent standard with sprinkler system and foam based fire-fighting arrangement as per as per the chapter v.

Quantitative risk analysis:

- ✓ F&ei index can also be used for estimating the damage that would probably result from the accident/fire. And it is converted to radius of exposure by multiplying it by 0.84 to feet. Thus radius of exposure in this case will be 0.84x72= 60 feet or 18 meters

QRA for Alcohol Storage has been calculated and results and conditions assumed are given below:

- **Atmospheric Data: (Manual Input of Data)**

Wind: 5.5 meters/second from W at 3 meters

Ground Roughness: open country Cloud Cover: 0 tenths

Air Temperature: 30° C Stability Class: D

No Inversion Height Relative Humidity: 5%

- **Source strength:**

Tank Diameter: 12.2 meters Tank Length: 13 meters

Tank Volume: 1,520 cubic meters

Tank contains liquid Internal Temperature: 30° C

Chemical Mass in Tank: 950,042 kilograms

Tank is 80% full.

Results are given in the following table

Table No. 1.8 Result of QRA for Alcohol Storage

1 centimeters Opening is 1.30 meters from tank bottom		**THREAT ZONE:**		
Total Amount Burned:	Max Flame Length:	(10.0 kW/(sq m) (potentially lethal within 60 sec)	(5.0 kW/(sq m) (2nd degree burns within 60 sec)	2.0 kW/(sq m) (pain within 60 sec)
209 kgs	**2 meters**	**Less than 10 meters**	**Less than 10 meters**	**Less than 10 meters**
2centimeters Opening is 1.30 meters from tank bottom		(10.0 kW/(sq m) (potentially lethal within 60 sec)	(5.0 kW/(sq m) (2nd degree burns within 60 sec)	2.0 kW/(sq m) (pain within 60 sec)
837 kgs	**3 meters**	**Less than 10 meters**	**Less than 10 meters**	**Less than 10 meters**

This shows the importance of having the clear distance between two tanks as per the PESO rules and to have adequate cooling provision and system to cool the tanks in case of pool fire. Because conditions are catastrophic under BLEVE

BLEVE of flammable liquid in vertical cylindrical tank the results are:

Tank is 80% full

Percentage of Tank Mass in Fireball: 30%

Fireball Diameter: 382 meters Burn Duration: 21 seconds

Pool Fire Diameter: 200 meters Burn Duration: 11 minutes

Flame Length: 76 meters

Threat Zone:

Threat Modeled: Thermal radiation from fireball

Red : 683 meters --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: 976 meters --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: 1.5 kilometers --- (2.0 kW/(sq m) = pain within 60 sec.

In this case DMP will have to be put in action and Government and local authorities will have to be alerted

1.3 On-site Emergency Plan:

- The company has an on-site emergency plan for the existing facilities.
- The same will have to be modified with inclusion of Mitigation measures and quantitative Risk analysis results given above for Sugar manufacturing section and other suggestions.
- This will have to be suitably modified to include distillery safety measures and results of QRA studies to be carried out and modify the same.
- DMP (Disaster Management Plan) and off-site emergency plan will be in place before commissioning of distillery.

Safety Measures during regular and shut-down:

- It must be remembered that shutdown plant are also and sometimes more prone to accidents. Hence it is suggested that all workers, regular and contract workers should be issued proper PPE, like helmet, safety shoes etc. as necessary.
- All work, hot work, working at height etc. during working and shutdown period should be carried out with proper work permit and under proper supervision.

1.4 Occupational Health Aspects and medical provision in the factory:

Effects of Alcohol on health:

- It reacts vigorously with oxidizing materials. TLV for 8 hr. is 1000 ppm (ACGIH). Minimum identifiable concentration has been reported as 350 ppm.
- Exposure to concentrations of 5000 - 10000 ppm results in irritation of eyes and mucous membranes of the upper respiratory tract.
- Effects of exposure to higher concentration of Alcohol in the atmosphere are given in the following Table No. 1.9

Table no. 1.9 Effect of ethyl alcohol

mg/l	Ppm	Effects in human
10-20	5300 – 10,640	Some transient coughing and smarting of eyes and nose, not tolerable
30	15,960	Continuous lacrimation and marked coughing; could be tolerated with discomfort.
40	21,280	Just tolerable for short period
> 40	>21,280	Intolerable

- To prevent injury to workers, standard PPEs will be provided. In addition, sufficient number of Self-contained breathing apparatus will be provided to be used in case of major alcohol leakage to avoid exposure to higher levels of Alcohol.
- All precautionary methods will be adopted by the company to reduce the risk of exposure of employees to occupational safety and health hazards.

1.4.1 Medical check-up: Pre & post medical check-ups will be done of all the employees. Employees will be regularly examined and the medical records will be maintained for each employee. Pulmonary function test and periodical medical checkup shall be done once in every year. The following tests will be conducted for each worker:

- Lung Function Test
- Radiology – X-ray
- Pulmonary Function Test
- Audiometric Test
- General clinical examination with emphasis on respiratory system
- Pre employment examinations
- Periodical medical examinations at the time of employment and after completion of employment.

1.5 Occupational Health Center {OHC}:

- The company has OHC center for the existing sugar plant. The facilities of the present OHC and the periodic tests to be carried out will be modified for distillery workers and officers in view of the above details and in consultation with the registered medical practitioner.
- The location of OHC with dimensions will be clearly shown in the factory layout drawing layout and note on facilities provided will be given.
- It will be ensured that the exiting OHC and other medical facilities at the site as per the factories act, and number of employees. Consulting physician will be retained to attain the factory.
- The same will be augmented before the Distillery start up.
- The company will have OHC and other medical facilities at the site as per the factories act, and number of employees.

Some guide lines are given below:

Under rule 73 W All factories carrying out hazardous processes must have OHC with services and facilities

A) For factories employing up to 50 workers: i) Medical officer on retainer ship basis, ii) minimum 5 workers trained in first aid, at least one shall be available during all working hours. iii) Fully equipped first aid box (What it should contain is also specified later)
B) For factories employee 51 to 200 workers
   i) OHC with min. floor space of 15 sq. meters ii) part time medical officer iii) one qualified and trained dresser-cum- compounder throughout all working hours. iv) equipped first aid box
C) For factories employing more than 200 workers,
   i) Full time medical officer up to 500 workers, and one more full time medical officer for every additional 1000 workers or part thereof
   ii) OHC with 2 rooms
   iii) one compounder and one ward boy 24 by 7 iv) OHC to be equipped all emergencies
D) Requirement of Ambulance van for any factory carrying on hazardous process shall be provided and maintained is defined under 73-X.
E) For factories with less than 200 workers, management must have an arrangement for getting ambulance van at short notice it also details out what facilities ambulance Van should have
F) Other important requirements are: company must have, MSDS for all hazardous chemicals at site,
G) Pre-employment medical checkup and six monthly medical check-up for all employees, including contract workers. And record must be available. Since the operation involve storage and handling of toxic chemicals, affecting liver, kidneys, lounges, medical test must include the specific teats to check functioning of these vital organs.
H) The company carries out medical checkup for workers as per the requirement; the health check-up parameters can be modified in consultation with the qualified medical doctor.
I) Standard Medical facilities as required by Factory rule are expected to have been provided in the OHC for the existing plant, some important are illustrated below:
   i. Well-equipped First Aid Boxes will be provided in each Section of the factory.
   ii. Snake bite Lancet
   iii. 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.
   iv. A vehicle will be always available to shift the sick/injured person to District Hospital.
   v. Ambulance will be made available 24X7 in the factory to deal and take the injured workers to the district hospital.

1.6 EHS policy: The Company has well defined EHS policy and is displayed as per the norms.

Annexure I

Boiler Interlock

Fuel Handling System:-

1) Excess Bagasse Carrier stopped or tripped then MBC, CCSC and RBC tripped.
2) MBC stopped or tripped then CCSC and RBC tripped.
3) CCSC stopped or tripped then RBC tripped.
4) Pole cord switch or belt swa switch act then RBC tripped.

Ash Handling System:-

1) Ash Belt elevator stopped or tripped then all ash belt conveyer and ESP and APH RAV tripped.

FAN Interlock System:-

1) ID FAN stopped or tripped then FD FAN, SA FAN and fuel handling System are tripped.
2) FD FAN stopped or tripped then SA FAN and fuel handling System are tripped.
3) SA FAN stopped or tripped then fuel handlings System are tripped.

Drum Level Interlock:-

1) Drum level greater than 80% or less than 20% then FD Fan tripped.

Bagasse Feeder interlocks:-

1) Screw feeder stopped or tripped then bagasse feeder tripped.
2) SA FAN air pressure for fuel feeding less than 350 mmWc or both SA Fan stopped or tripped.

Feed Pump Interlock :-

1) Deareator level less than 30% or suction pressure less than 1kg/cm^2 or suction valve close or in between feedback or motor bearing temperature 90 ^{0}C or winding temperature greater than 110 ^{0}C or feed pump cooling water pressure less than 2 kg/cm^2. All any above conditions or any one of above conditions occur then feed pump tripped.

ESP Interlock System:-

1) Any of ESP RAV stopped or purge air blower stopped or tripped or ESP inlet flue gas temperature less than 130 ^{0}C or ESP hopper level hi hi alarm then ESP TRCC tripped.

Boiler Alarm

1) ID, FD, SA and BFW bearing temperature greater than 80 ^{0}C .
2) ID, FD, SA and BFW winding temperature greater than 90 ^{0}C .
3) Fuel feeding air pressure for bagasse less than 450 mmWc.
4) ESP inlet Temperature 140 ^{0}C .

5) Main steam pressure less than 80 kg/cm^2 .
6) Main steam Temperature 500 ^{0}C .
7) Main steam pressure greater than 90 kg/cm^2 .
8) Main steam Temperature 529 ^{0}C .
9) Deareator level less than 60%
10) Deareator level greater than 90%
11) Deareator Temperature less than 105 ^{0}C .
12) Deareator Temperature greater than 112 ^{0}C .

Turbine Interlock System

Turbine Tripping Interlock:-

1) Lube oil pressure less than 1.8 kg/cm$^{2.}$
2) Control oil pressure less than 7.8 kg/cm$^{2.}$
3) Oil tank level less than 36.5%.
4) Turbine inlet pressure less than 41.5 kg/cm$^{2.}$
5) Turbine inlet temperature less than 485 ^{0}C.
6) Turbine inlet pressure greater than 99 kg/cm$^{2.}$
7) Turbine inlet temperature greater than 543 ^{0}C.
8) Exhaust steam temperature less than 120^{0}C.
9) Exhaust steam Temp. between 105 ^{0}C and 120 ^{0}C. more than 1hr.
10) Exhaust steam pressure less than -0.763 kg/cm$^{2.}$
11) Hotwell level greater than 92.5%.
12) OHT level less than 94%.
13) Turbine no load more than 1hr.

Pressure Timer:-

Timer T1:

TG inlet pressure in between 87.12 kg/cm$^{2.}$ And 99.56 kg/cm$^{2.}$ Then timer start for counting 12 hr (paused timer). After completion 12 hr then turbine trip.

Timer T2:

Turbine running time 1year after that turbine Trip.

Temperature Timer:

Timer T1 (Retentive Timer):

TG inlet Temp. in Between 523 ^{0}C to 529 ^{0}C then timer start counting 16 day 16 hr (paused timer) after completion 16 day 16 hr then turbine trip.

Timer T2 (Retentive Timer):

Turbine running time 1year after that turbine Trip.

Timer T3 (Retentive Timer):

TG inlet Temp. in Between 529 ^{0}C to 543 ^{0}C then timer start counting 3 day 8 hr (paused timer) after completion 3 day 8 hr then turbine trip.

Timer T1:

TG inlet Temp. in Between 529 ^{0}C to 543 ^{0}C continuously timer start for 15 min (reset timer) after completion 15 min then turbine trip.

Vibration Alarm and Trip Condition (Turbine, gearbox and Alternator):-

SR NO	TAG	Service Name	Alarm H	Trip HH	Alarm L	Alarm LL
1	ZI-801	Axial Displacement	0.4 mm	0.6 mm	-0.4mm	-0.6mm
2	ZI-802	Axial Displacement	0.4 mm	0.6 mm	-0.4mm	-0.6mm
3	YI-801	Turbine Front Bearing Vibration X-axis	76 µ	99 µ		
4	YI-802	Turbine Front Bearing Vibration Y-axis	76 µ	99 µ		
5	YI-803	Turbine Rear Bearing Vibration X-axis	76 µ	99 µ		
6	YI-804	Turbine Rear Bearing Vibration Y-axis	76 µ	99 µ		
7	YI-805	GB High Speed DE Vibration X-axis	65 µ	125 µ		
8	YI-806	GB High Speed DE Vibration Y-axis	65 µ	125 µ		
9	YI-807	GB High Speed NDE Vibration X-axis	65 µ	125 µ		
10	YI-808	GB High Speed NDE Vibration Y-axis	65 µ	125 µ		
11	YI-809	GB Low Speed NDE Vibration X-axis	90 µ	150 µ		
12	YI-810	GB Low Speed NDE Vibration Y-axis	90 µ	150 µ		
13	YI-811	GB Low Speed DE Vibration X-axis	90 µ	150 µ		
14	YI-812	GB Low Speed DE Vibration Y-axis	90 µ	150 µ		
15	YI-813	Alternator Front Vibration X-axis	178 µ	232 µ		
16	YI-814	Alternator Front Vibration Y-axis	178 µ	232 µ		
17	YI-816	Alternator Rear Vibration X-axis	178 µ	232 µ		

18	YI-817	Alternator Rear Vibration Y-axis	178 µ	232 µ		
19	-	Exciter Field Volt	200 V	200 V		
20	-	Exciter Field Current	25 A	25 A		

Bearing Temperature, Alarm and Trip Condition (Turbine, gearbox):-

SR NO	SENSOR	ALARM	TRIP
1	Turbine Thrust active top bearing Temp.	95 ^{0}C.	100 ^{0}C.
2	Turbine Thrust non active top bearing Temp.	95 ^{0}C.	100 ^{0}C.
3	Turbine Front Bearing Temp.	110 ^{0}C.	120 ^{0}C.
4	Turbine Rear Bearing Temp.	110 ^{0}C.	120 ^{0}C.
5	Turbine active bearing Bottom Temp.	95 ^{0}C.	100 ^{0}C.
6	Turbine non active bearing Bottom Temp.	95 ^{0}C.	100 ^{0}C.
7	Gear box High speed front bearing Temp.	100 ^{0}C.	107 ^{0}C.
8	Gear box High speed rear bearing Temp.	100 ^{0}C.	107 ^{0}C.
9	Gear box low speed front bearing Temp.	85 ^{0}C.	90 ^{0}C.
10	Gear box low speed rear bearing Temp.	85 ^{0}C.	90 ^{0}C.

Bearing Temperature, Alarm and Trip Condition (Alternator):-

SR NO	SENSOR	ALARM	TRIP
1	Alternator Front Bearing Temp.	85 ^{0}C.	95 ^{0}C.
2	Alternator Rear Bearing Temp.	85 ^{0}C.	95 ^{0}C.
3	Alternator Winding Temp. (U1)	125 ^{0}C.	130 ^{0}C.
4	Alternator Winding Temp. (V1)	125 ^{0}C.	130 ^{0}C.
5	Alternator Winding Temp. (W1)	125 ^{0}C.	130 ^{0}C.
6	Alternator Winding Temp. (U2)	125 ^{0}C.	130 ^{0}C.
7	Alternator Winding Temp. (V2)	125 ^{0}C.	130 ^{0}C.
8	Alternator Winding Temp. (W2)	125 ^{0}C.	130 ^{0}C.
9	Inlet air Temp.-1 (Not Trip)	50 ^{0}C.	55 ^{0}C.
10	Outlet air Temp.-1 (Not Trip)	80 ^{0}C.	85 ^{0}C.
11	Inlet air Temp.-2 (Not Trip)	50 ^{0}C.	55 ^{0}C.
12	Outlet air Temp.-2 (Not Trip)	80 ^{0}C.	85 ^{0}C.
13	Alternator Core-1 Temp.	125 ^{0}C.	130 ^{0}C.
14	Alternator Core-2 Temp.	125 ^{0}C.	130 ^{0}C.
15	Alternator Core-3 Temp.	125 ^{0}C.	130 ^{0}C.
16	Exciter Field Temp.	125 ^{0}C.	130 ^{0}C.

CEP Interlock System:-

1) Condensate discharge header pressure less than 3.5 kg/cm^2 then CEP auto start.
2) Hotwell level Greater 84.40% then auto start.
3) Hotwell level less than 20% then CEP Pump tripped.

Barring Gear Motor Interlock System:-

1) Lube oil pressure greater than 1.95 kg/cm^2 then barring gear motor start permissive.
2) Turbine RPM less than 250 RPM then barring gear motor start permissive.
3) EOP ready or HOT level greater than 94% barring gear motor start permissive.
4) Turbine speed greater than 350 RPM then barring gear motor auto stopped.

Hood Spray Valve Interlock System:-

1) Exhaust temperature greater than 80 ^{0}C then auto open valve.
2) Exhaust temperature less than 55 ^{0}C then auto close valve.
3) Hood spray valve continuously 1 hr open then auto valve closed.

Vacuum Breaker Valve Interlock System:-

1) Lube oil header pressure less 1.95 kg/cm^2 then auto open.
2) Generator differential relay operated than auto open.
3) Turbine rotor axial movement hi hi.
4) Turbine RPM less than 70% then open.

Turbine Extraction QCNRV Interlock System:-

1) Active Power greater than 6.6 MW then valve open permissive.
2) Active Power less than 5.5 MW then valve auto closed.
3) Turbine Trip then valve auto closed.

Turbine Bleed QCNRV (HP Heater) Interlock System:-

1) TG inlet Steam flow greater than 40 TPH then open permissive.
2) TG inlet Steam flow less than 35 TPH then valve auto closed.
3) Turbine Trip then valve auto closed.

Turbine Bleed QCNRV (MP Process) Interlock System:-

1) TG inlet Steam flow greater than 40 TPH then open permissive.
2) TG inlet Steam flow less than 35 TPH then valve auto closed.
3) Turbine Trip then valve auto closed.

Wonder Bleed Control Valve 101 Interlock System:-

1) TG Steam Flow greater than 40 TPH then valve open permissive.
2) TG Steam Flow less than 35 TPH then valve auto closed.
3) TG Steam Flow greater than 65 TPH then valve auto closed slowly and wonder valve 102 slowly simultaneously opened.
4) Turbine Trip then valve auto closed.

Wonder Bleed Control Valve 102 Interlock System:-

1) TG Steam Flow greater than 65 TPH then valve open permissive.
2) TG Steam Flow less than 60 TPH then valve auto closed.
3) TG Steam Flow greater than 60 TPH then valve auto closed slowly and wonder valve 101 slowly simultaneously opened.
4) Turbine Trip then valve auto closed.

Annexure II

Note on Transportation of Class A Solvents

Transportation of Raw Material/Safety Guidelines for transportation of Solvent & Hazardous Chemicals

Following recommendations will be followed while fixing the transport agency for transporting Class A solvents and other hazardous chemicals:

Recommendations for transport of Class A chemicals and hazardous chemicals

Class A Solvents transport: Rules to be followed and precautions to be taken. The Petroleum Act and the Petroleum rules 2002 clearly specify in PART IV "TRANSPORT ON LAND BY VEHILES" UNDER RULES 62 TO 86 mandatory for the transportation of Class A chemicals.

A. Rule No 63: Chief Controller of Explosive (CCE) Approval required for tank and vehicle used for transportation.
B. Rule No 64: deals with tank capacity limits and solvent filling limits in the tank.
C. Rule No 65: clearly specifies that the vehicle approved for Class A solvent will not be used for transportation of any other purpose.
D. Rule No 69: No other article can be transported in the vehicle transporting Class A chemical.
E. Rule No 70: makes it mandatory to have spark arrestor fitted to the exhaust pipe of the vehicle and engine air intake fitted with effective flame-arrestor.
F. Rule No 71: specifies Electrical installation requirement for the tanker.
G. Rule No 72: specifies that it is mandatory to carry Fire Extinguisher of minimum 10 kg capacity.
H. Rule No 73: specifies that it is mandatory to have at least one person with knowledge attending the vehicle 24X7 during parking.
I. Rule No 74: specifies regarding parking of vehicle in the public place.
J. Rule No 76: specifies for loading and unloading of the tanker.
K. Rule No 78: specifies precautions against static charge, the most important being (7) of the same.
L. Rule No 79: specifies precautions against electrical hazard: No loading or unloading unless the engine is switched off.
M. Rule No 83: specifies tanker loading and unloading to be restricted between sunrise and sunset.
N. Rule No 84: prohibits smoking /open flame etc.

Common Guidelines for transport and handling hazardous chemicals and Class A solvents:

- It will be ensured that during the transportation contents are not spilled. Personnel including the driver and cleaner are properly trained about the hazardous properties of the material being carried and for transport of hazardous material.

- Tanker must be RTO approved and tested and approved by CCE for Class A solvents. Frequently tested for integrity. Certificate must be available.
- Vehicle must have safety equipment/PPEs and antidote if necessary.
- It is mandatory that driver possess a valid driver's license.
- The maximum speed limit is prescribed.
- Driver will be instructed to park the tanker at safe place and they should be available in the near vicinity.
- TREM (Transport Emergency) cards are to be provided to the drivers.