1.1. Risk Assessment Study

Environmental risk involves the occurrence or potential occurrence of some accident consisting of an event or sequence of events resulting into fire, explosion or toxic hazards to human health and environment. Risk Assessment (RA) provides a numerical measure of the risk that a particular facility poses to the public. It begins with the identification of probable potential hazardous events at an industry and categorization as per the predetermined criteria.

1.1.1. Objectives

Following are the objectives of Risk Assessment studies:

- Generation of release scenarios for proposed project
- Estimation of damage distances for the accidental release of hazardous chemicals based on different scenarios
- Suggestion of risk mitigation measures for well blow out scenarios, diesel storage, mud system and falling objects
- Approach to Disaster Management Plan

1.1.2. Scope of Work

The scope of this study is to carry out risk assessment for Expansion for development and production of Uber-2 well and Group Gathering Station, Jambusar, Gujarat. Standard industry practices of risk assessment are considered in the study. The hazard potential of various fuels/chemicals and estimation of consequences in case of accidental release are the issues of immediate relevance to be considered.

1.1.3. Identification of Risks Hazards

Taking into account the applicability of different risk aspects of the drilling operations to be undertaken in the major categories of hazards that can be associated with proposed project has been dealt with in detail. They are as follows:

Table-5.1: Major hazards and risks of Oil/Gas well drilling

Sl. No	**Hazards**	**Risks**
1.	Blow out	Fire, Oil spill
2.	Oil Spill	Fire, Environmental damage
3.	Presence of H2S	Loss of life

All the above mentioned hazards are significant and will have major consequences. All the causative factors have been evaluated and through risk ranking criteria detailed below and the risk reduction measures existing and residual risks of these have been evaluated.

The following risk ranking matrix has been used for assessing the risks of various activities of drilling. All the risks and hazards have been evaluated based on the likelihood of occurrence and magnitude of consequences. The significance of the risk is expressed as the product of likelihood and the consequence of the risk event, expressed as follows: Significance = Likelihood X Consequence in three regions that identify the limit of risk acceptability according to the policy and the strategic objectives of ONGC is given in Table-5.2. Depending on the position of the intersection of a column with a row in the risk matrix, hazard prone activities have been classified as low, medium and high thereby qualifying for a set of risk reduction / mitigation strategies.

Table 5.2: Criteria for the Risk Ranking

Severity of incident (or consequences)	**FATAL / HIGH POTENTIAL MAJOR**	**MAJOR**	**MINOR**	**SIGNIFICANT**	**RECORDABLE**
	Personnel • Fatality or permanently disabling injury • **Environmental-** • significant release with serious off-site impact and more likely than not to cause immediate or long term health effect **Property Damage** • Blowout/ Explosion / Major Fire	**Personnel** • one or more serious injury/disabling injury • man hour loss more than 500 hrs **Environmental-** • significant release with serious off-site impact **Property Damage** • Vessel Collision **Cost(Equipment damage)-** • major damage to process areas; estimated at a cost more than Rs	**Personnel** • not severe injury resulting in more than one day off **Environmental-** • release which results in agency notification or permit violation **Cost(Equipment damage)-** • some equipment damage at an estimated cost > Rs 5000/- (Five thousand) up to Rs 1,00,000/- (One lakh) **Shut Down –** • More than 06 hours.	**Personnel** • less than one day off **Environmental-** • environmentally reportable event with no agency notification or permit violation **Cost(Equipment damage)-** • Minimal equipment damage at a minimal cost up to Rs 5000 (Five thousand) Public image: • Confined to installation. Fire: • Up to 2 mins	**Personnel** First aid incidents **Environmental** environmentally recordable event **Cost(Equipment damage)-** No recordable equipment damage

	Cost (Equipment damage)- major or total destruction to process areas estimated at a cost more than Rs 5,00,000/- (Five lakhs) **Shut Down –** • More than 24 hours down time	1,00,000/- (one lakh) up to Rs 5,00,000/- (Five lakhs) **Shut Down / Failure** • Critical Equipment • More than 12 hours. **Fire:** • 15 mins and above • Explosion	• **Fire:** • Less than 15 mins		
SCORE	5	4	3	2	1
Prob. of occurrence (or likelihood)	**Negligible**	**Low**	**Medium**	**High**	**Frequent**
Grade	A	B	C	D	E

RISK MATRIX						**Likelihood**				
						Negligible	**Low**	**Medium**	**High**	**Frequent**
						No known occurrences in the industry	**Known to have occurred in the industry**	**Occurs in the company**	**Occurs in the Asset/Drilling Services**	**Occurs on the Rig**
SEVERITY		**People**	**Asset**	**Environment**		**A**	**B**	**C**	**D**	**E**
	Recordable	First aid incidents	No recordable equipment damage	environmentally recordable event	1					
	Significant	Less than one day off	Minimal equipment damage at a minimal cost up to Rs 5000 (Five thousand)	Significant Environmentally Incident	2					

	Minor	not severe injury resulting in more than one day off	Cost (Equipment damage) • Damage cost Rs 5000-1,00,000/- Shut Down • More than 06 hours. • Fire: less than 15 minutes	Release which results in agency notification or permit violation	3					

	Major	• One or more serious injury/disabling injury • Man hour loss more than 500 hrs	Cost(Equipment damage)- • major damage to rig estimated at a cost more than Rs 1,00,000/- (one lakh) up to Rs 5,00,000/- (Five lakhs) Shut Down / Failure • Critical Equipment • More than 12 hours. Fire: • 15 mins and above	Significant release with serious off-site impact	4					

	Fatal/High Potential Major	Fatality or permanently disabling injury	Cost (Equipment damage) major or total destruction to process areas estimated at a cost more than Rs 5,00,000/- (Five lakhs) Shut Down More than 24 hours down time	Significant release with serious off-site impact and more likely than not to cause immediate or long term health effect	5					

Table 5.3 Risk Categories and Significance of Criteria

Risk	Criteria Definition
Low (Continuous improvement)	The level of risk is broadly acceptable and no specific control measures are required.
Medium (Risk reduction measures)	The level of risk can be tolerable only once a structured review of risk-reduction measures has been carried out
High (Intolerable risk)	The level of risk is not acceptable and risk control measures are required to move the risk figure to the previous regions.

1.2. Major Hazards

1.2.1. Blowout

A blowout in a hydrocarbon exploration activity can be defined as any uncontrolled flow of formation fluids from the reservoir to the surface, due to formation pressure exceeding the hydrostatic pressure of the mud or fluid column and failure of secondary blowout prevention measures. For an offshore drilling activity, blowout events may occur at the drill ship level or subsea and may result in pool /jet fires, or sometimes may lead to release of toxic gases like Hydrogen Sulphide.

Contributors to blowout are:

a) Primary

- Failure to keep the hole full
- Mud weight too low
- Swabbing during trips

- Lost circulation and
- Failure of differential fill-up equipment.

b) Secondary

- Failure to detect and control a kick as quickly as possible
- Mechanical failure of BOP
- Failure to test BOP equipment properly
- Damage to or failure of wellhead equipment
- Failure of casing; and
- Failure of formation or cement bond around casing.

1.2.2. Blowout Consequences And Effects

A blowout incident can take a variety of different forms, ranging from a minor leak which can be stopped within minutes, to a major release which continues out of control for days or even months. The consequences of a blowout event will to a large extent depend on how the blowout scenario evolves and the following possible scenarios are likely:

- Release of oil, resulting in a slick or spill on the sea release of drilling fluids and resulting spill leading to contamination of marine environment.

- Release of toxic / flammable gas which may have deleterious effect on the personnel

- Ignition of the flammable gas / oil released resulting in a jet fire, pool fire or an explosion

If the hydrostatic head exerted by the column of drilling fluid is allowed to drop below the formation pressure then formation fluids will enter the wellbore (this is known as a kick) and a potential blowout situation has developed. Fast and efficient action by operating personnel in recognizing the above situations and taking precautionary measure can avert a blowout.

1.3. Control Measures for Major Hazards

1.3.1. Blowout

The precautionary and control measures used for blowout prevention are discussed below:

a. Precaution against Blowout

The following control equipment for drilling mud system shall be installed and kept in use during drilling operations to prevent the blowout:

- A tank level indicator registering increase or reduction in the drilling mud volume and shall include a visual and audio –warning device near the driller stand.
- A device to accurately measure the volume of mud required to keep the well filled at all times.
- A gas detector or explosive meter at the primary shale shaker and connected to audible or visual alarm near the driller stand.
- A device to ensure filling of well with mud when the string is being pulled out.
- A control device near driller stand to close the mud pump when well kicks.
- Blowout prevention (BOP) drill shall be carried out once every week near the well during drilling.
- Suitable control valves shall be kept available near the well which can be used in case of emergency to control the well.
- When running in or pulling out tubing, gate valve and tubing hanger shall be pre- assembled and kept readily available at the well.

b. Precaution after Blowout

On appearance of any sign indicating the blowout of well, all persons, other than those whose presence is deemed necessary for controlling blowout, shall be withdrawn from the well. During the whole time while any work of controlling a blowout is in progress, the following precautions shall be taken:

- A competent person shall be present on the spot throughout.

- Area within 500 meters of the well on the down wind direction will be demarcated as danger zone.
- All electrical installations will be de-energized.
- Approved safety lamps or torches will only be used within the danger zone.
- No naked light or vehicular traffic will be permitted within the danger zone.
- A competent person shall ascertain the condition of ventilation and presence of gases with an approved instrument as far as safety of persons is concerned.
- Two approved type of self-containing breathing apparatus or any other breathing apparatus of approved type will be made available for use in an emergency.
- Adequate firefighting equipment will be kept readily available for immediate use.

1.4. Risk Mitigation Measures

Risk involves the occurrence of an accident arising out of an event or sequence of events. Based on risk analysis mitigation measures are recommended which can either prevent an event from occurring or reduce the consequences, if the event occurs. A number of recommendations are made regarding measures that should be taken to reduce the risks of any hazardous event occurring or, if it did, of mitigating the hazards arising. The following risk mitigation measures at various locations are suggested

1.4.1. Drilling Operations

A majority of accidents occur during drilling operation on the drill floor and may be associated with moving heavy tubular, which may strike or crush personnel. Falling and crushing make up maximum occupational risk of fatality due to striking of objects. Mechanical pipe handling, minimizing the requirement of personnel on the drill floor exposed to high level of risk, may be an effective way of reducing injuries and deaths. Good safety management, strict adherence to safety management procedures and competency assurance will reduce the risk. Some of the areas in drilling operations where safety practices are needed to carry out jobs safely &without causing any injury to self, colleagues and system are:

a. Maintenance of Mud Weight

It is very crucial for the safety of drilling well. Drilling Mud Engineer should check the ingoing and out coming mud weight at the drilling well, at regular intervals. If mud weight is found to be less, barites should be added to the circulating mud, to raise it to the desired level. Failure to detect this decrease in level may lead to well kick & furthermore, a well blow out, which can cause loss of equipment & injury to or death of the operating personnel.

b. Monitoring of Active Mud Tank Level

Increase in active tank level indicates partial or total loss of fluid to the well bore. This can lead to well kick. If any increase or decrease in tank level is detected, shift personnel should immediately inform the Shift Drilling Engineer & take necessary actions as directed by him.

c. Monitoring of hole Fill-up / Return Mud Volume during Tripping

During swabbing or pulling out of string from the well bore, the hole is filled with mud for metallic displacement. When this string runs back, the mud returns back to the pit. Both these hole fill up & return mud volumes should be monitored, as they indicate any mud loss or inflow from well bore, which may lead to well kick.

d. Monitoring of Inflow

Any inflow from the well bore during tripping or connection time may lead to well kick. So, it is needed to keep watch on the flow nipple during tripping or connection time.

e. Monitoring of Background / Trip Gas

Increase in background gas or trip gas indicates insufficient mud weight against drilled formation. Such indications should be immediately brought to the notice of the Shift Drilling Engineer.

For total safety of such operations, each team member must religiously follow the safety aspects pertaining to respective operational area. If every team member starts working with this attitude, zero accident rates are not a distant dream.

Drilling operation is a team effort and success of such an operation depends upon the sincerity, efficiency & motivation of all team members. Safety in such operations is not the duty of a single person, but it is everyone's job.

The use of protective fireproof clothing and escape respirators will reduce the risk of being seriously burnt. In addition, adequate fire fighting facilities and first aid facilities should be provided, in case of any emergency.

Risk reducing measures include kick simulation training for personnel, presence of well-trained drillers and mud engineers, and strict adherence to safety management procedures and good well control procedures.

1.4.2. Wells

- Proper insulating joints should be provided on well head
- Co-ordination with local authorities, such as port, police, fire, ambulance, nearby industries should be ensured to meet any eventuality
- The well should be physically inspected regularly

1.4.3. Preventive measures for spillage and accident due to Storage of Chemicals

- Fire is one of the major hazards, which can result due to the spillage from storage tanks. Fire prevention and code enforcement is one of the major areas of responsibility for the fire service. Hence the site should be equipped with:
  -Water supply
  - Fire hydrant and monitor nozzle installation
  - Foam system
  - Water fog and sprinkler system
  - Mobile Fire fighting equipment
  - First aid appliances
- Storages of chemicals should be designed, fabricated, inspected and maintained so that there is no release possibility while it is kept within design conditions. Protective systems of quantified high reliability and availability should be designed to ensure

that these physical conditions are maintained. Impurities should be controlled to obviate abnormal corrosion.

- These measures should be backed up by relief systems such that the combination of design, protection, quality control and relief eliminates the possibility of complete failure. Storages of chemicals should be sited, or given protective barriers such that they are fully protected from external damage
- Surrounding population should be made aware of the safety precautions to be taken in the event of any mishap. This can effectively be done by conducting the training programs
- Safety escape routes should be provided at strategic locations and should be easily accessible
- Grating and vent panels should be provided to minimize Domino Effects
- Fire extinguishers should be tested periodically and should be always kept in operational mode
- Shut off and isolation valves should be easily approachable in emergencies
- The fire protection equipment shall be kept in good operating condition at all time and fire fighting system should be periodically tested for proper functioning and logged for record and corrective actions

1.4.4. Flow Sensor

A flow sensor is provided to detect any change in the rate of flow of mud in the flow line. In case of any sudden increase in the rate of flow, it gives an automatic alarm at the drillers control panel as also at the geologist's instrument cabin

1.4.5. Control Panel

There are two control panels for the BOP stack. One of them is on the derrick floor near the drillers stand, another at the accumulator (Koomy). The accumulator unit is located outside the safety perimeter. The control panel is equipped with pressure and flow indicators and suitable markings for close and open positions.

1.4.6. Instrumentation in Mud System

Continuous monitoring of condition of mud in the well provides information useful for well control. The following instruments and equipment are used in the drilling mud system for this purpose:

- A pit level indicator registering increase or decrease in drilling mud volume. It is connected with an audio-visual alarm near the drillers control panel.
- A trip with float-marking device to accurately measure the volume of mud going in to the well. This is useful to keep the well feed with required quantity of mud at all times.
- A gas detector or explosimeter installed at the primary shale shaker together with an audio-visual alarm at the drillers control panel to indicate the well presence of gas-cut mud in the well. The kick in the well is prevented by keeping the hydrostatic head of the drilling fluid greater than the formation pressure.

The primary control can be lost in the following situations:

- While tripping if the well is not kept full with the required volume of mud.
- If there is reduction in hydrostatic pressure in the well due to swabbing, which may be caused if the drilling string is pulled out too fast or by a balled-up or clogged bit, which is indicated by insufficient filling of mud.
- If the specific gravity of the drilling fluid is not maintained as per the requirement.
- If there is loss of circulation, which may be caused either due to running in too fast, thereby, causing the weak horizons of the well to break or while drilling through a formation with cracks or cavity.

1.4.7. Risks to Personnel

Good safety management, strict adherence to safety management procedures and competency assurance will reduce the risk. Safety practices are needed to carry out jobs safely and without causing any injury to self, colleagues and system. For total safety of any operation, each team member must religiously follow the safety practices / procedures pertaining to

respective operational area. If every team member starts working with this attitude, zero accident rate is not a distant dream.

Any operation is a team effort and its success depends upon the sincerity, efficiency and motivation of all team members. Safety in such operations is not a duty of a single person, but it is everyone's job. Use of protective fireproof clothing and escape respirators will reduce the risk of being seriously burnt. In addition, adequate fire fighting facilities and first aid facilities should be provided, in case of any emergency.

1.4.8. Precautionary Measures for Falling Objects

Following are the mitigation measures suggested to avoid or minimize risk due to falling objects

- Provide safety helmets to protect the workers below against falling objects
- Barriers like a toe boards or mesh guards should be provided to prevent items from slipping or being knocked off the edge of a structure
- Secure objects to the structure like lashing of scaffold boards
- Ensure that there are no loose objects and all tools are properly secured;
- Create an exclusion zone beneath areas where work is taking place.
- Danger areas should be clearly marked with suitable safety signs indicating that access is restricted to essential personnel wearing hard hats while the work is in progress.

1.5. Disaster Management Plan (DMP)

Several Government agencies, both at the Central and State levels, are entrusted with the responsibility of ensuring safety and management of hazardous chemicals under acts and rules made for the purpose. Despite these measures, the possibility of accidents cannot be ruled out. In order to face risk of accidents during drilling operations, a disaster management plan is prepared to mitigate the impact.

1.5.1. Objectives

The DMP is prepared with the objective that ONGC can respond effectively in a rapid and systematic manner to any of the technical or natural calamities related incidents in order to:

- Minimize or eliminate any further danger or risk to individuals
- Minimize or eliminate any further risk to company's operations and asserts
- Minimize or eliminate any adverse publicity and to ensure all external inquiries are handled consistently by a nominated spokes person
- Ensure that all legal aspects of response are considered.

1.5.2. Key Elements

Following are the key elements of Disaster Management Plan:

- Basis of the plan
- Accident / emergency response planning procedures
- Accident Prevention Procedures / Measures for Drilling
- On-site Disaster Management Plan
- Off-site Disaster Management Plan

1.5.3. Basis of the Plan

Identification and assessment of hazards is crucial for on-site emergency planning and it is therefore necessary to identify what emergencies could arise in transportation of hydrocarbons. One of the emergencies is due to hazards from spread of fire or release of flammable chemicals during transportation. Hazard identification is the basis of the Disaster Management Plan to tackle the unforeseen events.

1.5.4. Emergency Planning and Response Procedures

Emergency rarely occurs therefore activities during emergencies require coordination of higher order than for planned activities. To effectively coordinate emergency response activities, an organizational approach to planning is required.

The important areas of emergency planning are organization and responsibilities, procedures, communication, transport, resource requirements and control centre. Offsite emergency requires additional planning over and above those considered under onsite plans, which should be properly integrated to ensure better coordination.

The emergency planning includes anticipatory action for emergency, maintenance and streamlining of emergency preparedness and ability for sudden mobilization of all forces to meet any calamity.

1.5.5. Accident Prevention Procedures / Measures for Drilling

General

OISD standard 174 gives the codes for well control and standard 189 sets out engineering requirement for fire fighting equipment for drilling rigs. Standard Industry practice is to be adopted.

A separate plan is provided to deal with the situations, which necessitate emergencyaction. The emergency response plan includes details of the organizational response to emergencies and the safety precautions to be observed in preventing loss of life and damage to property.

Operation and Maintenance

Oil and Gas industry experiences throughout the world have shown that the main physical dangers that well faces during operation are mechanical damages caused by excavation works adjacent to the well. To guard the well against damage, a system of regular surveillance and inspection to warn of mechanical or corrosion damage is employed.

Following are the main factors, which determine whether the well will stay free of significant defects:

- The well Protection against external interference such as caused by nearby excavations
- Changes in the well environment
- Adequate well markers

1.5.6. Protecting the Well from External Interference

It is essential to protect the well from being struck or damaged by third parties. The primary defence against this occurrence will be:

- Liaisons with third parties likely to excavate near the well. ONGC shall identify, then make them aware of the well and gather advance notifications of their activities
- Regular patrolling of the well to monitor third party activities nearby to the wells.

1.5.7. Fire Prevention Planning and Measures

Fire is one of the major hazards, related to Oil and Natural Gas well. Fire prevention and code enforcement is the area of responsibility of the fire service. Safe operating practices reduce the probability of an accidental fire on a platform. Personnel should understand their duties and responsibilities and be attentive to conditions that might lead to fire. The following precautions are recommended

- There should be provision for safe handling and storage of dirty rags, trash and waste oil. Flammable liquids and chemicals spilled on platform should be immediately cleaned
- Containers of paints and hydrocarbon samples, gas cylinders for welding and cutting should be stored properly. Gas cylinders should be transported in hand-carts
- Cutting and welding operations should be conducted in accordance with safe procedures
- Smoking should be restricted to designated platform areas and “no smoking” areas should be clearly identified by warning signs
- Platform equipment should be maintained in good operating condition and kept free from external accumulation of dust and hydrocarbons. Particular attention should be given to crude oil pump, seals, diesel and gas engines which could be potential source of ignition in the event of a failure

The Disaster Management Plan will address the issue of a fire event at any location on the well and the procedure to be adopted in the very unlikely event of this occurring. If a fire

starts in any well, that section of the well will be isolated by closing the section (block) valves, as quickly as possible and surrounding facilities will be cooled with water.

1.5.8. On-site Disaster Management Plan

On-site and off-site Disaster Management Plan can be extended as a contingency plan for methane explosion. It elaborates emergency procedures in case of fire and explosion due to accidental release of hazardous chemicals.

Purpose

- To inform people at the site about above happening if it is likely to adversely affect them
- To inform authorities including helping agencies in advance, and also at the time of actual happening
- To identify, assess, foresee and work out various kinds of possible hazards, their places, potential and damaging capacity and area in case of above happenings.

Activities

- Preparation of a plan showing therein the areas of various hazards like fire, explosion and toxic releases.
- The fire protection equipment shall be kept in good operating condition at all time and fire fighting system should be periodically tested for people functioning logged for record and corrective action
- The fire fighting training shall be provided to all officers and other employees who are likely to be present in installation
- There should be regular mock fire drills once in a month. Record of such drills shall be maintained
- Assign key personnel and alternate responsible for safety transportation
- Describe risk associated with transportation facility.
- Reporting procedure should be followed according to guidelines

In the event of fire from accidental release of flammable gas or liquid, a person seeing the incident will follow the laid down procedure in the plant and report as follows:

- Will dial the nearest telephone
- Will state his name and exact location of emergency
- Will contact concerned officers on duty
- People reporting the accident will remain near the location to guide emergency crew arriving at the scene
- Report injuries or blood or body fluid exposures to the appropriate supervisor immediately
- Workers should be seen as soon as possible by a health professional.

1.5.9. Off-site Disaster Management Plan

Emergency is a sudden unexpected event, which can cause serious damage to personnel life, property and environment as a whole, which necessitate evolving offsite emergency plan to combat any such eventuality. Emergencies can be handled by an organized multidisciplinary approach. If it becomes necessary to evacuate people, then this can be done in orderly way.

The different agencies involved in evacuation of people are civil administration (both state and central) and police authorities.

Purpose

- To save lives and injuries and to prevent or reduce property losses
- To provide necessary assistance for quick resumption of normal situation or operation
- To make explicit inter related set of actions to be undertaken in the event of an accident posing hazards to the community
- To plan for rescue and recuperation of casualties and injuries. To plan for relief and rehabilitation
- To plan for prevention of harms, total loss and recurrence of disaster. It will be ensured that absolute safety and security is achieved within the shortest time

Following are the activities of the government, Non-Government organizations and concerned personnel involved in off-site disaster management plan:

This will include the safety procedure to be followed during an emergency through posters, talks and mass media in different languages including local language. Leaflets containing do's/ don'ts should be circulated to educate the people in vicinity

Medical Help consisted of doctors and supporting staff for medical help to the injured persons because of disaster should be formed. Functions and duties of the committee include, providing first Said treatment for injured at the spot or at some convenient place and shift those to nearby hospitals for further treatment if required

The police will assist in controlling of the accident site, organizing evacuation and shifting of injured people to nearby hospitals.

The fire brigade shall organize to put out fires other than gas fires and provide assistance as required. Approach roads to accident site and means of escape should be properly identified. Chief fire officer should co-ordinate entire fire control measures. Routine training of fire fighting equipment and special rescue equipment should be carried out. Concerned officer should ensure adequate supply of fire water and fire fighting agents at the site of emergency. Maintenance of standby equipment / personnel for fire fighting should be ready at any given time.

1.5.10. Oil Spill Response Plan

Spills of oil to land require immediate response action to stop the source of the discharge and to limit the spread of material. Immediate response actions and notification procedures shall be developed. Attention must be paid to fire and safety hazards. For terrestrial areas, selection of appropriate control and containment techniques is dependent on the:

- Nature of the substrate,
- Slope of the terrain,
- Amount of product, and
- Time available to implement the response action.

The quantity and time parameters reflect the reality of constructing a barrier of appropriate size in the time available. These factors can only be judged in the field at the time of the incident. Should it be impossible to implement the desired method at a desired location due to a lack of time or access, a new control point would be selected further down the slope. If containment is still impossible and human safety is in question, the threatened area would need to be evacuated.

Spill response strategies would vary significantly attributed by the location of the spill. Herein the spills have been envisaged in two areas as listed below:

- On-site Spills
- Off-site Spills

The various methodologies that can be adopted for spill control is described below:

1.5.11. Response Strategies – Onsite Spills

In case of spills / leaks of hydrocarbons within the fence line of property one of the following techniques could be used for the control of spill.

a. Sorbents and Drip Pans

Sorbent materials, drip pans, and drainage mats are used to isolate and contain small drips or leaks until the source of the leak is repaired. Material handling equipment, such as valves and pumps, often have small leaks and are applications for using sorbents, drip pans, or drainage mats. Although sorbents are usually used to control small isolated spills, they can also be used to contain and collect large volume spills before they reach a watercourse. Sorbents include clay, vermiculite, diatomaceous earth, and man-made materials.

Drip pans are widely used to contain small leaks from product dispensing containers (usually drums), uncoupling of hoses during bulk transfer operations, and for pumps, valves, and fittings. Drip pans are typically 5 to 15 gallons and may be plastic or metal, depending upon the type of chemical handled. They may be single pans for individual dispensing drums or gutter-type continuous pans built into multiple drum dispensing racks. Drip pans must be checked regularly and emptied when necessary so an overflow spill does not occur.

Drainage mats are sometimes used to prevent spilled product from entering into an uncontrolled drainage or sanitary sewer system. The mat is placed over a storm drain, sealing the drain against the entry of spilled material. Drainage mats are especially applicable in areas where constructing a secondary containment or diversion structure is impractical, such as a congested tanker truck unloading area.

Drainage mats are typically made of synthetic rubber materials and can be stored on site or carried on a fuel delivery truck. The use of drainage mats is a low-cost solution to providing a degree of containment; however, it is not as fail-safe as the other containment techniques, since it is dependent upon the operator properly placing the mat.

Materials such as foams and gelling agents are commonly used to contain small spills in areas where physical secondary containment is not available. Foams that solidify to form a physical barrier or dike are highly effective forms of emergency secondary containment.

b. Spill Diversion Ponds or Retention Ponds

Spill diversion or retention ponds should be constructed with an impervious base utilizing HDPE sheets or geo-membranes to prevent soil and / or groundwater contamination. These ponds should not be constructed in areas prone to flooding.

1.5.12. Response Strategies – Off-Site Spills

The objective of surface containment is to prevent the spread of oil on the soil or substrate surface and to prepare it for recovery or treatment. This usually can be achieved using easily available materials (i.e., shovels, earth-moving machinery, trucks, damming materials, sorbents, etc.) to construct berms, dams, barriers, and trenches to divert and contain the flow. Containment and damming to pool the oil are important if the oil is to be pumped and / or sucked up. Several techniques are also discussed to contain and divert subsurface flow.

Strategies

- Act quickly.
- Contain and control as near source as possible.
- Protect resources in oil pathway.

- Prevent oil reaching streams, rivers, or groundwater.
- Use the natural features to contain and control flow whenever possible.

Strategies for Spill Fires - Ground Level

- Operators should determine the source of leakage or spill immediately and stop it, if possible. If is a continuous leakage which cannot stopped, the particular piece of equipment involved should be taken out of service, depressurised and steamed, if necessary.
- Blanket small fires with steam or dry powder but avoid scattering burningmaterials.
- In case of large spill fire, direct high pressure water fog into the source of leakage. Protect surrounding structures with water spray. Maintain the water flow unit the operators control the flow of fuel.
- Apply foam to extinguish fires in oil pools or trenches.
- Maintain adequate drainage of the fire area.
- Avoid working above sewer drains or near fire traps.

1.6. Hydrogen Sulphide (H2S)

Hydrogen Sulphide gas (H2S) is extremely toxic, even very low concentrations can be lethal depending upon the duration of exposure. Without any warning, H2S may render victims unconscious and death can follow shortly afterwards. In addition, it is corrosive and can lead to failure of the drill string or other tubular components in a well. The following safety measures may become necessary as and when H2S is detected while drilling and testing a new well in drilling. The Occupational Safety and Health Act (OSHA regulations) set a 10 ppm ceiling for an eight hourly continuous exposure (TWA limit), a 15 ppm concentration for short term exposure limit for 15 minutes (STEL) and a peak exposure of 50 ppm for 10 minutes.

1.6.1. H2S Gas Detection System

The detection system will be connected to an audio visual (siren and lights) alarm system. This system will be set to be activated at a concentration of 15 ppm H_2S.

The mud logging will have a completely independent detection system which is connected to an alarm in the cabin. This system will be adjusted to sound an alarm at a concentration level of 10 ppm H2S as suggested in the Drilling and Production Safety Code for Onshore Operators issued by The Institute of Petroleum.

A stock of H2S scavenger will be kept at drilling site for emergency use.

a. H2S < 10 ppm

Small levels of H2S (less than 10 ppm) will not activate the well site alarms. Such levels do not create an immediate safety hazard but could be a first indication of high levels of H2S to follow. H_2S will cause a sudden drop of mud pH. The mud man will therefore organize and supervise continuous pH checks while drilling. Checks should be as frequent as possible and always made following a formation change.

Following control measures will be taken in case of small level of detection:

- H2S scavenger will be added to mud.
- H2S levels will be checked at regular intervals for possible increase.
- All personnel of the rig will be informed about the presence of H2S and current wind direction. • Operations will be commenced in pairs.
- Sub base and cellar out-of-bounds will be rendered without further checking levels in this area.
- The workers will be provided with personal H2S detectors along with self-containing breathing apparatus.

b. H2S >10 ppm

Higher levels of H2S (greater than 10 ppm) do not necessarily cause an immediate safety hazard. However some risk does exist and, therefore, any levels greater than 10 ppm should be treated in the same manner. Occurrence of 10 ppm or greater H2S concentration will sound an alarm in the mud logging unit.

If higher levels of H2S greater than 10 ppm are found, following steps will be taken:

- Driller will shut down rotary and pumps, pick-up so that drill pipe in BOP and chain down the break.

- One pre-assigned roughneck will go to doghouse and put on breathing apparatus. All other rig personnel will evacuate the rig and move in up-wind direction to designated muster point.

- Driller and roughneck will return to the rig floor and commence circulating H2S scavenger slowly and reciprocating pipe.

- The level of H2S will be checked in all work areas. H2S scavenger will be added to the mud and circulated. If H2S levels drop, drilling will be continued with scavenger in the mud. Approximately 30 % of hydrogen peroxide (H2O2) solution will neutralize H2S gas in the mud at 20 gallon of H2O2 per 100 barrels of mud.

- The workers will be provided with personal H2S detectors along with self-containing breathing apparatus.

1.7. Fire Fighting Facility

As per Oil Industry Safety Directorate (OISD) guidelines on fire and explosion risk assessment and fire protection system for onshore installations will be provided:

- Fire water system; and
- First aid and fire-fighting system

1.7.1. Fire Water System

Fire water system shall comprise of fire water pumps and distribution piping network along with deluge system, sprinkler system, hose reels, hydrants and monitors, as the main components. Sea water is used for fire extinguishments, fire control, cooling of equipment and for exposure protection of equipment/personnel from heat radiation.

Fire water pumps will be designed to deliver the pressure and flow requirements for the anticipated manual fire-fighting demand (monitors or monitors plus hose streams) as well as

operation of the largest deluge/water spray system if installed. The pump shall able to supply adequate pressure and flow, to the hydraulically most demanding area.

Fire water piping will be designed to deliver the required volume and pressure for all systems, hose streams, and monitors that are reasonably expected to operate simultaneously. One fire water distribution single line with minimum 4 "size pipe/casing will be installed at drilling site.

Recommended fire water hoses will be of diameter 1 in. (25 mm) or 1'/2 in. (38.1 mm) for effective handling by one person. Hose lengths of not more than 100 ft (30.5 m) will be used. The selection of hoses will be made such that that they are resistant to oil, chemical deterioration, mildew, rot and exposure to offshore environment.

1.7.2. Fire Fighting Equipment At Drilling Rig

Portable fire extinguisher will be installed on the drilling rig. The minimum quantities of fire extinguishers at various locations should be provides as per the following:

Table-5.4: Location of the Fire fighting Equipments at Drilling Rig

Sl. No	Type of Area	Portable Fire Extinguisher
1	Drilling Rig floor	. 2 nos. 10 kg DCP type extinguisher
2	Main Engine Area	1 no. 10 kg DCP type extinguisher for each engine
3	Electrical motor/pumps for water circulation for mud pump	1 no. 10 kg DCP type extinguisher
4	Mud gunning pump	1 no.10 kg DCP type extinguisher
5	Electrical Control Room	1 no. 6.8 kg CO2 type extinguisher for each unit
6	Mud mixing tank area	1 no. 10 kg DCP type extinguisher
7	Diesel storage area	1 no. 50 lit mechanical foam
		1 no. 50 kg DCP type extinguisher

		2 nos. 10 kg DCP type extinguisher
		2 nos. sand buckets or ½ sand drum with spade
8	Lube Storage Area	1 no. 10 kg DCP type extinguisher
		1 no. sand bucket
9	Air Compressor area	1 no. 10 kg DCP type extinguisher
10.	Fire pump area	1 no. 10 kg DCP type extinguisher
11.	Near Drill In-charge Office	One fire extinguisher/shed with 3 nos. 10 kg DCP type extinguisher and 2 sand buckets
12.	Fire bell near bunk house	1 no. 10 kg DCP type extinguisher

Points to Remember

- Always pay attention to fire and health hazards.
- Start containment operations immediately to prevent oil from reaching a watercourse, the groundwater, or otherwise sensitive area or object.
- Evaluate logistical factors (safety, access, availability, etc.) to assess feasibility and to ensure effective and efficient implementation.
- Consider the type of equipment that can be used, as different equipment has different operational capabilities. It is necessary to match planned activities with the available equipment and personnel.
- As much as possible, do not allow vehicles to run over oil-saturated areas.
- Do not flush the oil down clean drains and other inlets.
- Do not use excavators on areas with free oil on the surface.
- Containment is easier on land than on open water.