

CHAPTER 7: RISK ASSESSMENT & DISASTER MANAGEMENT PLAN

7.1 INTRODUCTION

Environmental Risk Assessment is a scientific analysis for identification of credible risk and thereafter estimating the safe distances from any hazardous installations/processes in the eventuality of an accident. Estimation of near accurate safe distances is absolutely necessary to protect the public, property and environment.

Development drilling and testing operations of hydrocarbon wells within 3 blocks of Dipling PML are considered hazardous in nature, which can pose risk to life and property in an unlikely event of sudden and violent release of hydrocarbon fluid and hydrogen sulfide (H₂S) gas and due to other unsafe acts and conditions. Therefore, detailed hazard identification, risk assessment have been carried out and disaster management plan has been prepared for prompt response in the event of an emergency.

7.1.1 OBJECTIVE

The objectives of the study are to provide:

- Preliminary identification of hazards and hazardous scenarios that could produce an undesirable consequence arising from the proposed developmental drilling of wells within 3 blocks of Dipling PML.
- Assessment of consequences of hazards from developmental drilling of wells within the facility in terms of ignition, thermal radiation, blowout etc.
- Determination of the magnitude of all major accidents arising due to the proposed developmental drilling of wells within 3 blocks of Dipling PML that have the potential to cause damage to life, property and environment including:
 - ✓ Effects are as where personnel may be located within the proposed developmental drilling of wells within 3 blocks of Dipling PML
 - ✓ Effects on are as external to the development drilling
- Estimation of frequency of occurrence of the hazards.
- Review of safety features (organizational systems & safety equipment)
- Recommendations for prevention, control and mitigation measures for any identified risk

The overall aim of the study is to provide a degree of predictability on the risk of the operation as a result of the proposed developmental drilling of wells within 3 blocks of Dipling PML.

7.1.2 METHODOLOGY & APPROACH EMPLOYED

Risk analysis consists of hazard identification studies to provide an effective means to identify different types of hazard during the operation of the facility. This is followed by an assessment of the impacts of these hazards.

Hazard is present in any system, plant or unit that handles or stores flammable materials. The mere existence of hazards, however, does not automatically imply the existence of risk. Screening & ranking methodologies based on Preliminary Hazard Analysis (PHA) techniques have to be adopted for risk to be evaluated.

The approach and methodology by ABC Techno Labs followed for the Risk Assessment study are described hereunder:

❑ Identification of Hazards Analysis

Various possible hazards will be identified during developmental drilling of wells within 3 blocks of Dipling PML. The release sources and potential accidents scenarios associated with each hazards will be listed. For each selected release sources, several scenarios may be possible depending upon the failure mode causing loss of containment. The criteria used for selection of scenarios for the consequence analysis will be the Maximum Credible Accidental (MCA) scenarios.

❑ Effects & Consequence Estimation

Effects & consequence distance estimation performed to determine the potential for damage or injury from the selected scenarios. The incident outcomes analyzed using release rates, dispersion, combustion, thermal radiation from fire and spill. Damage distance computation based on jet fire, flash fire scenarios, as applicable.

❑ Failure Frequency Analysis

Failure frequency analysis done for Blowout & well release, Structural failure etc. Standard international database referred for estimation of probabilities.

Failure rate data is essentially derived from internationally well known generic databases. The generic failure data base selected for calculating the failure frequencies

and the values in the database are used to reflect the mechanical and process design of the development drilling operations.

❑ Risk Summation

Risk quantification and summation is based on probabilities from standard international database. The risk to personnel will be expressed in terms of Individual Risk (IR) represented by Iso Risk Contours and Group Risk/Societal risk represented by F-N Curves based on risk tolerability criteria.

❑ Risk Mitigation Measures

Based on consequence analysis and risk summation findings, risk mitigation measures will be suggested in view of applicable standards, guidelines and best practices to reduce risk and enhance safety at the proposed developmental drilling of wells within 3 blocks of Dipling PML.

7.2 RISK ASSESSMENT AND HAZARD IDENTIFICATION

Developmental operations and testing operations are generally hazardous in nature by virtue of intrinsic chemical properties of hydrocarbons or their temperature or pressure of operation or a combination of these factors. Fire, explosion due to hazardous release of crude oil, gas, H₂S or a combination of these are the hazards associated with hydrocarbon developmental and testing operations. These have resulted in the development of more comprehensive, systematic and sophisticated methods of safety engineering, such as, hazard identification and risk assessment to improve upon the integrity, reliability and safety of hydrocarbon operations.

The primary emphasis in safety engineering is to reduce risk to human life and environment. The broad tools attempt to minimize the chances of accidents occurring. Yet, there always exists, no matter how remote, that small probability of a major accident occurring. If the accident involves hydrocarbon in sufficient large quantities, the consequences may be serious to the project site, to surrounding area and the population therein.

Derrick floor is the center stage of all the development drilling operations and it is most susceptible to accidents. Safety precaution with utmost care is required to be taken during drilling as per the prevailing regulations and practices so that accidents can be avoided. Due to advancement in technology, numbers of equipment have been developed over a period to cater the need of smooth operation on derrick floor. Various standards

are required to be referred to cover the variety of equipments used for safe operation in drilling and it is desirable to use a properly prepared manual for occupational safety while working or drilling over rig.

The following are the main hazards envisaged during developmental drilling of well.

7.2.1 MINOR OIL SPILL

During development drilling and testing operations, details of classification of possible oil spill scenario(s) and respective activities are as follows:

Table 7.1: Classification of Oil spill during Developmental Drilling

Classification of spill	Extent of spill	Impact	Scenarios	Preventive Measures
Tier 1 Response can be adequately addressed using equipment and materials available at the site.	Spill contained on site.	Minor equipment damage. Brief disruption to operations.	• Diesel fuel refueling (i.e. drill rig hose leaks, overfilling or connection/disconnection incidents). • Drilling fluid (i.e. leaks from tanks, pumps or other associated equipment within the closed loop circuit system). • Drilling fluid chemicals (i.e. chemicals used during drilling; note that the volumes are limited by the storage containers used i.e. 200 L drums etc.). • Hydraulic oil (i.e. leaks from a split hydraulic hose or failed connector; moderate pressure, low volume lines).	One of the following preventive systems or its equivalent shall be used as a minimum for onshore facilities: • Dykes, berms or retaining walls sufficiently impervious to contain spilled oil
Tier 2 Response requires additional oversight expertise, equipment, and materials available	Localized spill with potential for escaping the site or that has escaped the site but is of limited extent	Moderate to major equipment damage/loss. Partial or short-term shutdown of operations.	• Transportation incidents associated with the delivery of diesel fuel to the drill-site (i.e. third party supplier's truck rollover or collision). • Complete failure of an on-site storage tank (e.g. diesel fuel for generators).	
Tier 3 Response requires oversight, expertise, equipment, and materials available	Major incident or a spill that has extended beyond the site.	Extensive equipment damage/loss. Long-term shutdown of operations.	• Uncontrolled fluid flow (blowout) from a well during development drilling in case oil is part of fluid.	

Source: ABC Techno Labs India Pvt. Ltd.

Spill response strategies for combating incidents include:

- **Prevent or reduce further spillage:** One of the first response actions, if safe to do so, is the isolation of the source and prevention of further discharge.
- **Monitoring and evaluation:** Monitoring and evaluation are used to: Determine the location and movement (if any) of the spill, its appearance, its size and quantity, changes in the appearance and distribution of the spill over time and potential threat to the environment and the resources required to combat the spill (i.e. a more effective and coordinated response).
- **Mechanical containment and recovery:** restriction of spill movement through the use of physical barriers (e.g. bunds, booms, diversion swales). Containment would be followed by the physical removal of the spilled material. This may be accomplished using sorbent pads, vacuum trucks, skimmers or other mechanical means appropriate to the material spilled.
- **Protection of sensitive areas:** Bunds or booms will be used to prevent spills from migrating down a watercourse or stream.
- **Clean-up:** This involves earthmoving equipment used to recover the absorbed spill and affected soil. Such operations may involve the collection of significantly greater volumes of material than was originally released.
- Combinations of the above strategies.

Affected area due to oil spill will be isolated. Spilled oil will be recovered and stored. Contaminated earth will be collected and disposed in consultation with Assam Pollution Control Board. Oil contaminated area will be reclaimed using bioremediation technique through oil zapper or other appropriate methods.

7.2.2 BLOWOUT

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 well bore (this is known as a kick) and a potential blowout situation has developed. Blowout means uncontrolled violent escape of hydrocarbon fluids from a well. Blowout followed by ignition, is a major hazard. Major contributors to blowout are:

Primary

- Failure to keep the hole full;
- Too low mud weight;
- Swabbing during trips;
- Lost circulation; and
- Failure of differential fill-up equipment.

Secondary

- Failure to detect and control a kick as quickly as possible;
- Mechanical failure of Blow Out Preventer (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.
- Fast and efficient action by operating personnel in recognizing the above situations and taking precautionary measure can avert a blowout.

❑ *Presence of Sour Gas (Hydrogen Sulphide-H₂S)*

Presence of Sour Gas (H₂S) in hydrocarbon during blowout of well can pose immediate dangers to life and health at and around the rig area. On ignition, H₂S is converted to sulfur dioxide (SO₂) which is also highly toxic. Therefore, a safety system should be in place to monitor H₂S.

Hydrogen Sulphide gas (H₂S) is extremely toxic and even very low concentrations can be lethal depending upon the duration of exposure. Additionally it is corrosive and can lead to failure of the drill string or other tubular components.

Important characteristics of H₂S gas are briefed below:

1. H₂S is a toxic colourless gas heavier than air.
2. In concentrations greater than 100 ppm, it causes loss of senses in 3 to 15 minutes and death within 48 hours.
3. The safe concentration for a normal working period without protection is 10 ppm.
4. It has an odour of rotten eggs.
5. In concentration greater than 10 ppm, the olfactory sense to smell the gas is lost, hence need for detectors is apparent.

6. It dissolves in the blood and attacks through the nervous system.
7. It is very irritating for the eyes as it forms sulphurous acid together with water.
8. It attacks the body through the respiratory organs.
9. The Occupational Safety and Health Act (OSHA) sets a 10 ppm ceiling for an (eight) hour continuous exposure (TWA limit), a limit of 15 ppm for short term exposure limit for 15 minutes (STEL) and a peak exposure concentration of 50 ppm for 10 minutes.
10. The best protection is breathing apparatus, with mask covering the whole face and a bottle containing breathing air.
11. H_2S burns with a blue flame to sulphur dioxide which is also dangerous
12. It forms an explosive mixture with air at concentrations from 4% to 46%.
13. Short exposure of high tensile steel to as little as 1 ppm in aqueous solution can cause failures.
14. Concentrations greater than 15 ppm can cause failure to steel harder than Rockwell C-22. High stress levels and corrosive environments accelerate failures.
15. When pH is above 9 and solubility is relatively high, it is readily soluble in mud and especially in oil mud.
16. A 30% hydrogen peroxide solution will neutralize H_2S gas in the mud or 20 gallons of H_2O_2 per 100 barrels of mud. It occurs together with natural gas in all oil provinces of the world.
17. Coughing, eye burning and pain, throat irritation, and sleepiness are observed from exposure to low concentrations of H_2S .
18. Exposure to high concentrations of H produces systems such as panting, pallor, cramps, paralysis of the pupil and loss of speech. This is generally followed by immediate loss of consciousness. Death may occur quickly from respiratory and cardiac paralysis.

Concentrations	Symptoms/ Effects
100 ppm	Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15-30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours.

Concentrations	Symptoms/ Effects
	Death may occur after 48 hours.
Greater than 100 ppm	Loss of smell (olfactory fatigue or paralysis).
500-700 ppm	Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes.
700-1000 ppm	Rapid unconsciousness, "knockdown" or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes.
1000-2000 ppm	Nearly Instant Death

As per available data, there is no chance of presence of H₂S in the hydrocarbon present within block, however, as a hypothetical case, scenario of presence of 3% H₂S has been considered for consequence analysis.

7.2.3 OTHER HAZARDS DURING DRILLING RIG OPERATIONS

7.2.3.1 HAZARDS DURING PREPARATION FOR SETTING UP THE SUBSTRUCTURE

Equipment(s) are unloaded and positioned at or near the exact location of drilling point. The substructure is assembled, pinned together, leveled, and made ready for other rig components on the floor. Equipping the cellar begins but can be done throughout the rigging up process. This includes welding on a drilling nipple to the conductor pipe and attaching a flow line.

Potential Hazards:

- Being struck by the crane, load, truck.
- Pinched fingers when assembling equipment.
- Burns from cutting and welding on the drilling nipple.
- Temporary eye irritation from welding light flash.
- Falling from heights.

7.2.3.2 HAZARDS DURING SETTING UP THE RIG FLOOR AND MAST OR DERRICK

Once the substructure is set in place, the process of setting up the rig floor begins by installing stairways and guardrails to allow access to the rig floor. Then, the draw works is set in place and secured to the substructure. On mechanical rigs, the engines are set in place and the compound and associated equipment connected to the draw works. On electric rigs, the electric cables (lines) are strung to the draw works.

The bottom of the mast is raised to the rig floor and pinned in place. The crown section is then raised into place on the derrick stand. The "A-legs" are raised and pinned into place.

The monkey board is pinned in place on the mast and all lines and cables are laid out to prevent tangling when the mast is raised. A thorough inspection of the mast should be made before raising the mast/derrick. The mast is now ready to be raised. The engines are started, and the drilling line is spooled onto the draw works drum. Once the mast has been raised and pinned, the remaining floor equipment can be set into place. If the rig has safety guy lines, they must be attached to the anchors and properly tensioned prior to continuing the rigging up process. A derrick emergency escape device is installed on the mast.

Potential Hazards:

- Falling or tripping during rigging up;
- Falling from rig floor;
- Being struck by swinging equipment;
- Being struck by falling tools;
- Being crushed or struck by equipment due to failure or overloading of hoisting equipment;
- Getting entangled in lines during rising of the derrick or mast;
- Failure to properly install derrick emergency escape device; etc

7.2.3.3 HAZARD IN RIGGING UP THE CIRCULATING SYSTEM

While one crew finishes preparing the rig floor, another crew might be rigging up the circulating system. The mud tanks and mud pumps are set into the predetermined location. The mud lines are then connected and electric cords are strung.

Potential Hazards:

- Being struck by or crushed by equipment being set into place;
- Getting caught in pinch points;
- Being struck by crane, load, truck or forklift tipping;
- Being struck by hammer when connecting mud line unions; etc

7.2.3.4 HAZARDS DURING INSTALLING THE AUXILIARY EQUIPMENT

All remaining drilling and auxiliary equipment must be set into place and installed where needed. The catwalk and pipe racks are positioned and the pipe and drill collars are set on the racks.

Potential Hazards:

- Getting struck or pinched by, or caught in between, tubulars being loaded onto racks.
- Having feet pinched or crushed when setting up the pipe racks and catwalk.

7.3 CONSEQUENCE ANALYSIS

The risk presented by a blowout (hydrocarbons release event) is determined by the frequency and consequence of its possible outcomes. The consequence of igniting a hydrocarbon release during blowout depends on the type of material released, the mass release rate, the timing of the ignition, and the environment into which the hydrocarbon is released. Briefly, typical outcomes are:

- **Jet fires:** produced by an ignited jet of gas or liquid spray released under pressure;
- **Pool fires:** produced by ignition of a liquid release that accumulates on the surface and ignites;
- **Flash fires:** produced by igniting a gas cloud so that a fire propagates through the gas cloud (without generating a significant overpressure);
- **Explosions:** produced by igniting a gas cloud in conditions where the resultant accelerating flame front produces a significant overpressure.

Jet fire emanating from the release source may follow a flash fire or explosion.

1. Early Ignition

In the consequence analysis, gas and two-phase events that ignite early are modeled as jet fires. Liquid releases that ignite early are modeled as pool fires.

Briefly, jet fires are modeled as follows:

- Mass release rate is determined (for each representative hole size) based on the operating temperature and pressure at the point of release.
- From the mass release rate, the jet flame length and associated fatality area.

2. Late Ignition

In the event of two-phase releases that ignite late are modeled as explosions.

Delayed ignition is not assumed to occur for oil releases. The consequential effect of a hydrocarbon gas explosion on personnel is determined by a variety of factors, including:

- Direct effects of blast overpressure;
- Whole body translation due to the blast wave;
- Thermal effects on personnel inside the burning gas cloud.

It is assumed that all personnel caught inside the burning gas cloud are likely to be fatally injured due to thermal radiation effects and inhalation of burning gases. Outside the gas cloud, personnel may still suffer from the effects of flash fire.

❑ Thermal Radiation

Thermal radiation from a hydrocarbon fire is a significant hazard to personnel. The degree of injury caused by thermal radiation is related to the intensity of the thermal radiation and the exposure time.

Thermal radiation effect modeling to estimate the likely injury or damage to people and objects due to thermal radiations resulting from incident outcomes is the straightest forward of the three types of physical exposure modeling referred to above. The consequence caused by exposure to heat radiation is a function of:

- The radiation energy onto the human body [kW/m^2];
- The exposure duration [sec];
- The protection of the skin tissue (clothed or naked body).

The following damage distances for thermal radiation have been used for modeling:

37.5 kW/m^2	:	<i>Damage to process equipment. 100% fatality in 1min. 1% fatality in 10sec.</i>
12.5 kW/m^2	:	<i>First degree burn for 10 sec exposure</i>
4.0 kW/m^2	:	<i>First degree burn for 30 sec exposure</i>

❑ Ignition of Blowout

Surprisingly, few surface blowouts ever ignite. Less than 10 blowouts per year ever catch on fire, worldwide. Typically, large formation water flows lifted by the hydrocarbon flow make ignition difficult if not impossible. Water comes into the blowout zone, drawn in by low flowing bottom hole pressure; or adjacent wet zones are exposed to the flow path.

Highly flammable blowouts may never ignite if no ignition source is present and flow is quickly dispersed. Thus, knowledgeable and experienced blowout specialists always restrict blowout access and carefully inspect the area around blowouts for ignition sources, particularly areas within an explosive vapor cloud.

7.3.1 MODEL USED FOR CONSEQUENCE ANALYSIS

PHAST (Version 6.53.1) software of DNV has been used to perform the consequence calculations. PHAST is a consequence and risk assessment software for calculation of physical effects (fire, explosion, atmospheric dispersion) of the escape of hazardous materials. PHAST software allows detailed modeling and quantitative assessment of release of pure and mixtures of liquid and gaseous chemicals.

7.3.2 SCENARIOS WISE FINDINGS OF CONSEQUENCE ANALYSIS

Subsequent to the accidental release of hydrocarbon, the consequence depends on various factors e.g. type and quantity, presence and location of an ignition source, meteorological conditions, etc. The consequence analysis for the selected accident scenarios for hydrocarbon releases have been carried out to estimate the impacted distances and outcomes of same have been described in subsequent sections.

❑ Blowout during Drilling of Well

Formation pressure in hydrocarbon wells is typically may be high, thus conventional BOP stack is used at drilling rig.

Release of Hydrocarbon through 150 mm hole containing 3 % H₂S gas due to Blowout

1. IDLH Concentration of 3 % H₂S

In the event of vertical release of hydrocarbon, IDLH concentration of hydrogen sulphide (H₂S) will not reach to the ground. Therefore, no hazard is anticipated.

IDLH Concentration	IDLH Concentration Distances (m)			
	3 m/s - B	3 m/s - D	2 m/s - E	1 m/s - F
100 ppm	No Hazard	No Hazard	No Hazard	No Hazard

2. UFL and LFL Concentration Distances

In the event of release of hydrocarbon during blow-out, hydrocarbon /fluid gas cloud will be formed, if it is not getting source of ignition. Computed hydrocarbon gas concentrations between UFL and LFL are as per given below:

Concentration	UFL and LFL Concentration Distances (m)			
	1 m/s - B	3 m/s - D	3 m/s - E	2 m/s - F
UFL	0.420653	0.439907	0.296074	0.151806
LFL	4.40103	3.90301	3.72547	3.02901
LFL Fraction (50%)	10.9116	11.8302	11.9041	9.8477

Heights (m) for above distances are given below:

Concentration	Height of cloud (m)			
	1 m/s - B	3 m/s - D	3 m/s - E	2 m/s - F
UFL	14.0123	14.9357	15.9621	16.2453
LFL	39.2846	40.6116	46.8858	54.2279
LFL Fraction (50%)	57.0586	58.7686	59.3760	55.4106

3. Flash Fire Envelope

On ignition of Hydrocarbon gas, flash fire envelope will be formed as per details given below:

Concentration	Distances Fire covered by Flash Envelope (m)			
	1 m/s - B	3 m/s - D	3 m/s - E	2 m/s - F
Furthest	4.40103	3.90301	3.72547	3.02901
Furthest (50%)	10.9116	11.8302	11.9041	9.8477

Heights (m) for flash fire envelope are given below:

Concentration	Height of Flash Fire Envelope (m)			
	1 m/s - B	3 m/s - D	3 m/s - E	2 m/s - F
Furthest	39.2846	40.6116	46.8858	54.2279
Furthest (50%)	57.0586	58.7686	59.3760	55.4106

Flash fire envelope distances are depicted in Figure 7.1.

4. Jet Fire on Immediate Ignition

In the event of ignition of blow out, computed thermal radiation distances resulting from jet fire are as per given hereunder:

Radiation Level	Thermal Radiation Level Distances (m)			
	1 m/s - B	3 m/s - D	3 m/s - E	2 m/s - F
4 kW/m ²	71.6135	70.1652	67.7123	59.3962
12.5 kW/m ²	11.1	Not Reached	Not Reached	Not Reached
37.5 kW/m ²	Not Reached	Not Reached	Not Reached	Not Reached

Thermal radiation distances and intensity radii from jet fire are depicted in Figure 7.2.

7.4 FAILURE FREQUENCY ANALYSIS

The failure frequency analysis aims at estimation of the “probability” of the incident. Failure frequencies may be classified as generic and synthesised for a particular situation, especially for more complex systems. Generic failure frequencies are preferred wherever available, as these reduce variances arising out of analyst judgement in the failure frequency estimation.

The standard method of calculating the failure rate of an isolated section of equipment or a chosen set of equipment items is to count the different items and associated line lengths. The failure rate for a certain item is then broken down into the correct proportions for required release rate bands.

7.4.1 BLOWOUT AND WELL RELEASE FREQUENCIES

The study (*Source: White Rose oilfield development on the Grand Banks, offshore Newfoundland by Husky Oil Operations Limited*) estimates that there have been 51,000 development wells drilled in that period of 1955 to 1988 giving a frequency of $4/51,000 = 7.8\text{E-}05$ blowouts per well drilled.

The frequency of well blowout and well release is discussed in The International Association of Oil & Gas Producers Risk Assessment Data Directory. Table 7.2 shows the expected frequency of such events based on historical data from recent years,

Table 7.2: OGP Blowout and Well Release Frequencies

Operation	Frequency			
Category	Average	Gas	Oil	Unit
Blowout	6.0E-05	7.0E-05	4.8E-05	Per drilled well
Well Release	4.0E-04	5.7E-04	3.9E-04	Per drilled well

Source: OGP - Oil & Gas Producers

Additional correction factors could also be considered based on the likelihood that the wind is blowing in the direction of populated areas. Also for smaller releases it is believed that the well release could be isolated by mechanical means reducing the event duration.

The above estimate is, however, still very conservative for a number of reasons. The data on which the above frequency is based cover several decades.

In past years, drilling technology has improved significantly since that time and the risk of a development drilling blowout will inevitably be lower than the above frequency suggests. Finally, the drilling rig will operate in accordance with stringent operating procedures and these will be in line with the best practice of well drilling operation worldwide.

7.4.2 STRUCTURAL FAILURE FREQUENCIES

Det Norske Veritas (DNV 1997) states that the total structural failure frequency is comprised of:

- ✓ ***Structural failure within design: 2.4E-05 per year;***

✓ *Structural failure due to extreme weather: 1.2E-05 per year;*

✓ *Structural failure due to ballast failures: 1.2E -05 per year;*

Therefore, the total structural failure frequency is 4.8E-05 per year, including failure in design, extreme weather and ballast failures.

7.4.2.1 PROCESS PIPING FAILURE FREQUENCIES

Most data bases of pipe failure rates are not sufficiently detailed to allow a determination of the failure frequency as a function of the size of the release (i.e. size of the hole in the pipe). The data shows that well over 90% of all failure are less than a 1-inch (25 mm) diameter hole and 3% are greater than a 3 inch (75 mm) diameter hole. Since most full rupture of piping system are caused by outside forces, full rupture are expected to occur more frequently on small-diameter pipes.

7.5 RISK REDUCTION MEASURES

This section discusses the measures for risk reduction and enhancement of safety during development drilling operations.

7.5.1 RISK MITIGATION MEASURES TO CONTROL HAZARDS

Occurrence of blowout and sour gas (H₂S) are the two major hazards. Occurrence of H₂S along with oil and gas is the major anticipated hazard during development drilling and production testing (The past experience and historical information available for drilling, production of hydrocarbons in the area reveal that H₂S gas shall not be found in hydrocarbon reserves of the region. However, in the event of occurrence of H₂S during drilling operations, associated hazards and risk are considered for completeness of the study). Control measures for occurrence of blowout and release of H₂S gas are discussed in following sub-sections:

7.5.1.1 BLOWOUT

The risk mitigation measures used for blowout prevention are discussed below:

A. Blowout preventer assembly

- Blowout preventor assembly shall consist of:
 - ✓ One bag type of preventor for closing regardless whether drilling equipment is in the hole or not.
 - ✓ One blind ram preventor closing against an open hole.

- ✓ One pipe ram preventor closing against drill pipe in use in the hole.
- In blow out preventor assembly, two seamless steel pipes at least 50 mm of diameter connected below each set of blow out preventor, (one for bleeding off pressure and the other for killing the well) shall be provided. These pipes shall be straight and lead directly into the well.
- Each pipeline shall consist of component having a working pressure equal to that of the blowout preventer.
- After the surface casing is set in a well, no drilling shall be carried out unless blowout preventor assembly is securely installed and maintained.

B. Blowout Preventer (BOP) Control Units: Location and Conditions

- BOP control units should be located at a distance of nearly 30 m from well center.
- Status of following should be checked and maintained in good condition:
 - ✓ Pressure gauges;
 - ✓ Pressure steel lines/fire resistant hoses;
 - ✓ Level of hydraulic oil;
 - ✓ Charging of unit; and
 - ✓ Availability of sufficient number of charged bottles.

C. Control System for Blowout Preventer

- All manual control for manually operated blowout preventer shall be located at least 0.60 meters outside the derrick substructures. Instructions for operating the controls shall be posted prominently near the control wheel;
- A control of power operated blowout preventer shall be located within easy reach of driller floor;
- A remote control panel for blowout preventer shall also be installed around floor level at a safe distance from the derrick floor;
- All control for blow out preventer shall be clearly identified with suitable markers; etc.

D. Other Preventive Measures

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

- A pit 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 explosimeter 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 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; etc

E. Measures after Blowout

During controlling a blowout, the following precautions shall be taken:

- 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 and a competent person shall be present on the spot throughout;
- An area within the 500 meters of the well on the down wind direction shall be demarcated as danger zone;
- All electrical installations shall be de-energized;

- Approved safety lamps or torches shall only be used within the danger zone;
- No naked light or vehicular traffic shall 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 for use in an emergency shall be available at or near the place. Adequate firefighting equipment shall be kept readily available for immediate use; etc.

7.5.1.2 CONTROL MEASURES FOR H₂S DURING DRILLING

A. H₂S Detection System

A four channels H₂S gas detection system should be provided. Sensors should be positioned at optimum points for detection, actual locations being decided on site but likely to be at or near to:

- ✓ Well Nipple
- ✓ Rig Floor
- ✓ Shaker header tank
- ✓ Substructure cellar

The detection system should be connected to an audio visual (siren and lights) alarm system. This system should be set to be activated at a concentration of 15 ppm H₂S.

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.

B. Small Levels of H₂S

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.

H₂S 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 required depending on ROP and always made following a formation change.

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

- ✓ Add H₂S scavenger to mud.
- ✓ Check H₂S levels at regular intervals for possible increase.
- ✓ Inform all personnel of the rig about the presence of H₂S and current wind direction.
- ✓ Commence operations in pairs.
- ✓ Render sub base and cellar out-of-bounds without further checking levels in this area.

C. High Levels of H₂S

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 to shut down rotary and pumps, pick-up the string so that drill pipe is in the BOP and chain down the break;
- ✓ One pre-assigned roughneck will go to the doghouse and put on the breathing apparatus. All other rig personnel will evacuate the rig and move up wind to designated muster points;
- ✓ Driller and roughneck will return to the rig floor and commence circulating H₂S scavenger slowly and reciprocating the pipe string;
- ✓ 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; etc.

D. Control Measures for H₂S During Testing

H₂S scavenging chemicals (caustic soda solution, calcium hydroxide or iron oxide slurry) will be continuously injected in the recovered gas/oil/formation water after pressure reduction through choke before sending the same to separator.

7.5.2 SAFETY SYSTEM FOR DRILLING RIGS

Operational Safety is the foremost concern while working on drilling rig. Derrick floor is the center stage of all the operations and it is most susceptible to accidents. Safety precaution with utmost care is required to be taken as per the prevailing regulation and practice so that accidents can be avoided. Due to advancement in technology, number of equipment has been developed over a period to cater the need of smooth operation on derrick floor. Various standards are required to be referred to cover the variety of equipment used for safe operation in drilling and become cumbersome at times to refer standards for each equipment as per given hereunder;

- ✓ Twin stop safety device (crown-o-matic and floor-o-matic);
- ✓ Fall prevention device on mast ladder with safety belt;
- ✓ Emergency Escape device for top man;
- ✓ First aid box with Stretcher and Blanket;
- ✓ Fire bell /siren;
- ✓ Emergency vehicle;
- ✓ Fire extinguishers;
- ✓ Flame proof portable hand lamp /safety torch;
- ✓ Railling with toe board;
- ✓ Guards on all moving parts;
- ✓ Breathing apparatus (wherever required);
- ✓ Gas detector for hydrocarbon gas & H₂S gas (if required);
- ✓ Safety lines for power tongs;

- ✓ Rotary brake;
- ✓ Hoisting brake lever with safety chain;
- ✓ Emergency shutoff system for draw works;
- ✓ Safety chain for inclined ramp (to prevent fall of any person);
- ✓ Safety belt for top-man with lane yard;
- ✓ Railing on stair case at mud tank/walkways and derrick floor; etc.

7.5.3 AVAILABILITY AND PROVISIONS BEFORE SPUDDING OF THE WELL

To enhance the safety at the drilling rig during drilling operation following should be ensured:

- ✓ Geo-technical Order (GTO)/drilling program with shift in-charge;
- ✓ PPE for crew;
- ✓ First aid box ;
- ✓ Wash pipe should be greased after every 8 hours or as specified by the manufacturer;
- ✓ Kelly bushes to be greased after every 24 hours or as specified by the manufacturer;
- ✓ Lower & upper kelly cock (its operating lever should be kept at designated place at derrick floor);
- ✓ Kelly saver sub on Kelly;
- ✓ Mud check valve /full opening safety valve;
- ✓ BOP control panel on derrick floor;
- ✓ Before lowering casing, inspect all the instruments such as, weight indicator, pressure gauges, rotary torque, SPM counter, RPM counter mud volume totaliser, flow meter & trip tank;
- ✓ Required Number of drill collars and heavy weight D/Ps;
- ✓ Ensure availability of two mud pumps in good working condition;

- ✓ Rat hole and mouse hole be drilled;
- ✓ Twin stop safety device should be made in working order; etc.

7.5.4 GENERAL SAFE PRACTICES DURING DRILLING OPERATION

- ✓ Penetration rate shall be monitored. In case of any drilling break, stop rotary table, pull out the Kelly, stop mud pump and check for self flow;
- ✓ Different type of drill pipes should not be mixed up during making up the string;
- ✓ Protectors should be used on drill pipes while lifting and laying down the pipes on catwalk;
- ✓ Drill pipe rubber protector should be installed on drill pipes body while being used inside the casing;
- ✓ Before starting drilling, hole should be centered to avoid touching of kelly with casing / wellhead and ensure that no damage is done to well head and BOP;
- ✓ Continuous monitoring of the gain/loss of mud during;
- ✓ BOP mock drill should be carried during drilling / tripping and under mentioned operations;
- ✓ Safe Working Conditions and Practices to be Adopted During Drilling Operations; etc

7.5.5 EMERGENCY PREPAREDNESS

- ✓ BOP drills and trip drills should be done once a week;
- ✓ Deficiency observed in BOP drill should be recorded and corrective measures should be taken; etc

7.5.6 FIRE FIGHTING FACILITY FOR DRILLING RIG

For the drilling rigs following fire fighting system/equipments should be provided:

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

7.5.7 CONTROL OF HYDROCARBON RELEASE AND SUBSEQUENTLY FIRE & EXPLOSION DURING DRILLING AND TESTING

To detect the release of hydrocarbon during drilling and testing, hydrocarbon detectors should be placed, so that control measures may be taken to prevent fire and explosion.

Emergency control measures should also be adopted as per Mines Act 1952, Oil Mines Regulation 1984 and Oil Industry Safety Directorate Standard 2000.

As per Oil Industry Safety Directorate (OISD) Standard, for the drilling rigs and well testing following fire fighting system/equipments should be provided:

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

A temporary closed grid hydrant system with monitors, hydrant points and fire hose boxes may be installed to cover well location, and oil and diesel fuel storage tanks. Portable fire extinguishers of DCP, mechanical foam and CO₂ types of sufficient capacity and in sufficient numbers along with sand buckets should also be placed at strategic locations.

Electrical and manual siren systems should be provided at the Security Gate of the experimental production facility. Electrically operated siren of 500m range along with push buttons at appropriate locations to operate the siren should be installed.

Adequate personal protective equipments including sufficient number of breathing apparatus must also be kept ready in proper working condition.

❑ Fire Water System

- ✓ One water tank/pit of minimum capacity of 50 Kl should be located at the approach of the drilling site.
- ✓ For experimental production testing, one additional tank/pit of 50 Kl should be provided.
- ✓ One diesel engine driven trailer fire pump of capacity 1800 lpm should be placed at the approach area of drilling site.
- ✓ One fire water distribution single line with minimum 4 " size pipe/casing should be installed at drilling site with a minimum distance of 15 m from the well.

❑ First Aid Fire Fighting Equipments at Drilling Rig

Portable fire extinguisher on the drilling rig will be installed in line with IS: 2190 and minimum number requirement is as per details given below:

Table 7.3: Details of Fire fighting equipments

Sl. No.	Type of Area	Portable Fire Extinguisher
1.	Derrick 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 bucket 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 Dill 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

Source: Ramayana Ispat Pvt. Ltd

7.5.8 MEDICAL FACILITIES

First aids facilities should be made available at the core drilling site and a 24 hour standby vehicle (ambulance) should also be available at the well site for quick transfer of any injured personnel to the nearest hospital, in case an accident occurs and medical emergency arises. Prior arrangements should be made with the nearby hospitals to look after the injured persons in case of medical emergency during core hole drilling and experimental production testing operations.

7.6 RECOMMENDATIONS

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. Being struck by objects, falling and crushing usually make up maximum occupational risk of fatality. 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 and without causing any injury to self, colleagues and system are given below:

Maintenance of Mud Weight

It is very crucial for the safety of drilling well. Drilling Mud Engineer should check the in-going & out-coming mud weight at the drilling well, at regular intervals. If mud weight is found to be less, barytes 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 and furthermore, a well blow out, which can cause loss of equipments and injury to or death of the operating personnel.

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 and take necessary actions as directed by him.

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.

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.

7.7 DISASTER MANAGEMENT PLAN

7.7.1 INTRODUCTION

In view of the hazards associated with the Oil Exploration and Production industry, it is essential that a disaster control plan be evolved to effectively deal with the situation utilizing the available resources. There are many agencies involved in the activities associated with a disaster e.g. Government, Fire Service, Medical, Police, Army, Voluntary Organization etc. besides the various departments of the concerned organization itself which requires an organized multi - disciplinary approach to the problem.

The purpose of this DMP is to detail organizational responsibilities, actions, reporting requirements and support resources available to ensure effective and timely management of emergencies at, or affecting RIPL's operations associated in the development block. The overall objectives of DMP are to:

- Ensure safety of people, protect the environment and safeguard commercial considerations
- Immediate response to emergency scene with effective communication network and organized procedures.
- Obtain early warning of emergency conditions so as to prevent impact on personnel, assets and environment;
- Safeguard personnel to prevent injuries or loss of life by protecting personnel from the hazard and evacuating personnel from an installation when necessary
- Minimise the impact of the event on the installation and the environment, by:
 - ✓ Minimizing the hazard as far as possible
 - ✓ Minimizing the potential for escalation
 - ✓ Containing any release.

7.7.2 LEGAL REQUIREMENTS FOR DISASTER PLANNING

Relevant statutory requirements, as given below and as amended from time to time, inter alia, are applicable for emergency response preparedness in E&P industry:

- *Oil Mines Regulation (OMR), 1984;*
- *Central Electricity Authority Regulation, 2010;*

- *Manufacture, Storage and Import of Hazardous Chemicals (MSHIC) Rules, 1989 and amended thereof;*
- *The Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996;*
- *Explosives Rules, 2008;*
- *Atomic Energy (Radiation Protection) Rules, 2004; etc*

Additionally, all statutory requirements notified by the Central Government or States, from time to time, shall be complied with, as applicable. Clause-72 of Oil Mines Regulations (OMR), 1984 requires the Mines owner to formulate a contingency plan for fire and clause-64 requires development of an emergency plan for petroleum pipelines specifying actions to be taken in the event of fire, uncontrolled escape of petroleum from pipelines. Also, Clause - 45(3) requires preparation of emergency plan for blow-out of oil and gas wells. The rules on “Chemical Accidents (Emergency Planning, Preparedness and Response) – 1996 compliments the set of rules on accident prevention and preparedness notified under the Environment (Protection) Act, 1986, in 1989 entitled “Manufacture, Storage and Import of Hazardous Chemicals Rules” and envisages a 4-tier crisis management system in the country. RIPL will follow safety guidelines and emergency response procedures as per the detailed regulations given in the Oil Mines Regulation 1984 and Oil Industry Safety Directorate (OISD) Standard 2000.

7.7.3 OBJECTIVES OF THE PLAN

The objectives of Disaster Management Plan (DMP) are to set out the appropriate course of action to mitigate the impact of an emergency event/incident. The plan provides procedures allowing all those involved to mobilize their resources in an orderly way and to react in time effectively. Disaster, in present context means an occurrence resulting in uncontrolled release of hydrocarbon and other associated developments. Most disasters have three common characteristic features i.e. loss of control, unwanted release of energy and failure to arrest chain of events. These may result in loss of life, damage to property, adverse effect on the environment and ecological imbalance.

This plan therefore aims at:

1. *To visualize the possible emergency scenario that are likely to occur;*
2. *To evolve a pre-planned methodology of carrying out various emergency combating plans;*

3. *To prepare detailed responses for each type of emergencies;*
4. *To train operating personnel by means of mock drills, so as to make them well acquainted with the response action;*
5. *To minimize the damage to the environment during emergency; etc*

The plan therefore, aims at immediate response to an emergency event to prevent escalation and also the response in the event of such escalation.

Generally, the following five phases are involved in an emergency:

1. **Discovery and Notification:** An event with an imminent threat of turning into an accident must first be discovered and the discoverer quickly notifies the same to the safety officer.
2. **Evaluation and Accident Control Initiation:** Based on the evaluation of available information, the safety officer makes a rapid assessment of the severity of the likely accident and initiates the best course of action.
3. **Containment and Counter Measures:** Action is first taken to contain and control the accident by eliminating the causes which may lead to the spread of accident. Measures are also taken to minimize the damage to personnel, property and environment.
4. **Clean-up and Disposal:** After the accident is effectively contained and controlled, the cleanup of the site of the accident and safe disposal of waste generated due to the accident are undertaken.
5. **Documentation:** All aspects of accidents, including the way it started and progressed as well as the steps taken to contain and the extent of the damage and injury, must be documented for subsequent analysis of accident/incident for prevention in future, damage estimation, insurance recovery and compensation payment. It may be noted that some aspects of documentation, such as, photographs of the site of accident and main objects involved in the accident, survey for damage estimation, etc. may have to be completed before the cleanup and disposal phase. However, the effort in all cases is to re-commence the operation as soon as possible.

RIPL will develop site specific on site and off site emergency plan which also includes linkages with local administration, local communities and other operators in the area to

provide necessary support. However, salient features of proposed DMP are summarized below:

7.7.4 EMERGENCY CLASSIFICATION

Severity of accident and its likely impact area will determine the level of emergency and the disaster management plan required for appropriate handling of an emergency. Emergency levels and the action needed for each level are indicated below:

7.7.4.1 LEVEL 1 EMERGENCY

Disaster would be one in which emergency response personnel within the installation would be able to contain and deal effectively with the disaster and its aftermath. In this level of emergency, the response is site specific where site personnel are involved and it takes into account the proposition that the situation is controllable with the help of resources available at site. An installation-specific Emergency Response Procedure (ERP) is available at each installation for this level.

7.7.4.2 LEVEL 2 EMERGENCY

Disaster would require efforts from RIPL resources at the work centers. Level II response is normally activated when the incident Coordinator reaches the site and after an assessment and taking initial actions decides that the situation requires still bigger response by higher authorities of the company, due to severity of the incident, lack of resources or adverse media publicity, community response etc. From this point, the steps of this DMP are applicable.

7.7.4.3 LEVEL 3 EMERGENCY

Disaster would be of such a magnitude that it would be beyond the containing ability of work centres and would require mobilization of resources through local administration, mutual aid agencies and State / Central Govt. assistance. The CEC (Chief Emergency Co-ordinator) then activates the offsite DMP.

An accident involving very serious hazard and with likely impact area extending beyond 500 m from the operational area, that is, drilling area limits, such as, major fire, very large release of inflammable material. Major fires will usually have the triggering effect resulting in the propagation of explosion. In a level 3 emergency, evacuation of population in villages, if any,

adjoining the operational area may sometime become necessary if threatened area extend to populated village area adjoining the site of the primary accident in a direction of maximum impact.

7.7.4.4 LEVEL 4 EMERGENCY

Disaster response is initiated when the Company authorities after implementation and assessment of emergency procedures decides that the local resources are not capable to cope-up with the emergency situation. There are adverse business implications and the situation is worsening and drawing more and more adverse reactions which would require the intervention of Corporate & National level. For such responses, Corporate DMP has been prepared and available at each installation.

Finally, since every emergency situation is unique in characteristics, the exact plan would be decided by the competent authorities. This plan would, at best, serve as guide for drawing the exact plan.

On-site Disaster Management Plan (DMP) will meet the hazards created due to all Level 1 emergencies and most of the Level 2 emergencies. In addition to on-site DMP, off-site DMP may also have to be put into operation for some Level 2 and all Level 3 emergencies.

Luckily the maximum vulnerable zone may not be extended much beyond development drilling and testing area due to blow out and fire around HSD storage area. Therefore, Level 3 Emergency requiring evacuation of surrounding village population is not applicable in case of drilling and testing area. Even the Level 2 emergency is likely to be confined within a limited distance from the drilling site and HSD storage area, the evacuation of personnel only from affected area will be required. Even under the worst accident scenario, evacuation of less than 30 persons may be involved and damage, if any, to nearby installations is expected to remain confined within the operational area.

7.7.5 ON-SITE DISASTER MANAGEMENT PLAN

The On-site Disaster Management plan is activated in case the emergency requires mobilization of resources from the block manager. This plan is activated by the Chief Emergency Coordinator (CEC). Block manager is the CEC at block level and will exercise control through the Basin Emergency Control Room (ECR).

7.7.5.1 EMERGENCY ORGANIZATION

The existence of a well-defined emergency organization is the most vital part of an emergency preparedness plan drawn up to combat any emergency situation. On-site emergency organization chart will be appropriately activated and made functional while combating an emergency situation. The core action group of the emergency organization comprises of the various functionaries of the PML area.

The Project Incharge, Dipling PML is head of the On-site emergency organization and is designated as the Chief Emergency Coordinator (CEC) at Block level. He will exercise control through the Emergency Control Room (ECR). The CEC is assisted by an expert team drawn from various disciplines.

The Chief Emergency Coordinator (CEC) will assume control through the Assistant Emergency Coordinator (AEC). The Chief Emergency Coordinator (CEC) may appoint Head Drilling Services/Head Well Services/Surface Area Manager as Assistant Emergency Coordinator (AEC).

The AEC will have the following expert representatives / services to function under his direct control and provide all the necessary assistance and inputs of men and material.

<i>Chief Emergency Coordinator (CEC)</i>	<i>Project Incharge, Dipling PML</i>
<i>Assistant Emergency Coordinator</i>	<i>Head - Drilling Services / Well Services / Geophysical Services and Surface Area Manager</i>
<i>On-Scene coordinator (OSC)</i>	<i>Shift I/C in the initial phase & Installation Manager</i>
<i>Logistics Coordinator</i>	<i>Manager Logistics</i>
<i>Safety Coordinator</i>	<i>Head- HSE</i>
<i>Material Coordinator</i>	<i>Store Manager</i>
<i>Medical Coordinator</i>	<i>Medical Services</i>
<i>Finance Coordinator</i>	<i>Manager Finance</i>
<i>Security Coordinator</i>	<i>Head- Security</i>
<i>Fire Safety Coordinator</i>	<i>Manager Fire Services</i>
<i>Communication Coordinator</i>	<i>Manager -Personnel</i>
<i>Public Relation Coordinator</i>	<i>Manager -Personnel</i>
<i>Welfare Coordinator</i>	<i>Manager -Personnel</i>

7.7.5.2 ROLE OF CO- ORDINATORS (KEY PERSONNEL)

1. Chief Co- Ordinator

- *Declares Crisis / Emergency situations.*
- *Communicates with MD / Ministry, State Govt. high officials and releases*
- *Information's to press / mass communications media.*
- *Directs main Co-ordinators as deemed necessary arising out of Crisis situations.*

2. Services Co-Ordinator

- *Co- ordinates for fire control measures.*
- *Provision of emergency communication.*
- *Supply of essential services facilities like water, electricity, transport.*
- *Ensures provision of material, repair facilities at workshop.*
- *Provision of temporary accommodation, repair, removal of debris etc.*

3. Administrative & Welfare Co- Ordinator

- *Coordinates for security arrangements.*
- *Liaises with police and district civic authorities.*
- *Co-ordinates with DGM (MS) & DGM (ER) for Rescue, Shelter and Medical relief operations.*
- *Informs the voluntary organizations to assist for rescue and relief operations.*
- *Public relations.*

4. Medical Relief Co- Ordinator

- *Organizes First Aid at the site of incidence.*
- *Arranges Ambulance Services.*
- *Medical relief camp in nearby Hospital and arranges extended services under.*

5. Drilling & Workover Co-Ordinator

- *Assesses damages to drilling/workover installations.*
- *Arranges salvaging of the affected installation.*
- *Act as chief co-ordinator till arrival of MD/Chairman of RIPL as the case may be.*

- *Guide fire Service, security, ambulance at site.*

6. Employee Relations & Welfare Co- Ordinator

- *To participate in rescue and relief operations.*
- *To contact relatives of affected persons and provide Food/ Beverage etc. at reliefcamp.*
- *Contacts Union Officials.*

7. Safety & Environment Co- Ordinator

- *To liaise between the main Co- ordinators.*
- *To liaise with statutory Safety & Environment authorities i.e. Mines Safety*
- *Directorate, Petroleum & Explosive Safety Organisation, State/ Central Pollution Control Board, OISD etc.*

8. Finance Co- Ordinator

- *To give finance support for all activities arranged by Main Co- ordinators.*

9. Operation Group Co- Ordinator

- *To co-ordinate activities of Well control measures in case of impending blow out or Blow out with or without fire.*
- *To liaise with Services Co-ordinator for fire control measures and emergency standby duty.*

7.7.5.3 EMERGENCY CONTROL ROOM

An Emergency Control Room shall be in place from where the operation to handle the Emergency are directed and coordinated. The ECR should be equipped with good communication facilities like Telephone (2 nos.), Radio Equipment, Wall Chart showing Locations of Installations, fire station, copy of the Disaster Management Plan, List of Key personnel, their addresses and telephone numbers, note pads etc.

A plan or plans of the works to show:

- ✓ *Areas where there are large inventories of materials, including oil storage, drilling materials;*
- ✓ *Sources of safety equipment;*

- ✓ *The fire water system and additional sources of water;*
- ✓ *Stocks of other fire extinguishing materials;*
- ✓ *Assembly points, casualty treatment centres;*
- ✓ *Location of the works in relation to the surrounding community; and*
- ✓ *Lorry/ truck parks.*

Additional plans which may be marked up during the emergency to show:

- ✓ *Areas affected or endangered;*
- ✓ *Deployment of emergency vehicles and personnel;*
- ✓ *Areas where particular problems arise;*
- ✓ *Area evacuated; and*
- ✓ *Other relevant information*

7.7.5.4 EMERGENCY REPORTING

- ✓ When witnessing or receiving notification of an emergency, as much information as possible should be taken and/or conveyed to the relevant emergency activation authority. Where possible, all information should be logged in written form with time and date included and provided to the Incident Controller.
- ✓ Personnel working on the field may, at any time, be exposed to an emergency, which could take many forms, for example (but not limited to):

<i>Injuries and/or fatalities</i>	<i>Exposures</i>
<i>Aggressive releases</i>	<i>Fires and/or explosions</i>
<i>Equipment hazards</i>	<i>Impacts</i>
<i>Extreme weather</i>	<i>Adverse environments</i>

- ✓ When an emergency occurs, an appropriate and prompt response is required, providing precise action to control, correct and return the site to a safe condition.
- ✓ Timely action is also required to protect people, the environment and property from harm.

- ✓ Reporting Forms for actions to be considered, when witnessing an emergency or receiving a report of an emergency.
- ✓ All near misses and unsafe acts will be written in logbooks / reported in the 'Near miss, unsafe acts, hazards and sub-standard conditions report' and verbally communicated to the concerned Supervisor / Superintendent / Installation Manager at an appropriate opportunity.
- ✓ All accidents and incidents will be immediately reported to the Project Incharge (Chief Emergency Coordinator), and appropriate forms completed.
- ✓ All accidents and incidents occurring within the Field facilities will be reported to the Production Manager and Head- HSE as per Block operator Incident Reporting and Investigation Procedure. This includes both situations where there is actual damage to health or equipment and also where there has been a threat of danger or a near miss.

7.7.5.5 SAFETY MEASURES FOR DRILLING INSTALLATIONS

❑ Standing Order When Well Kicks And The Duties Of Person Employed On The Rig: Shut-In Procedure

I. While Drilling

1. Stop Rotary.
2. Pick up Kelly to clear tool joint above Rotary table.
3. Stop mud pump and check for inflow. If yes,
 - *Raise Alarm*
 - *Close the Well by any the shut-in method.*

II. While Tripping

1. Raise Alarm
2. Position tool joint above Rotary Table and set pipe on slip
3. Install Full Opening Safety Valve (FOSV) in open position on drill pipe and close.

4. Shut- in Well by any of the method.

III. While Out Of Hole

1. Raise Alarm
2. Close blind or Shear Ram.
3. Close Choke.
4. Open HCR/ Manual valve on Choke line.
5. Record SICP and Pit gain.

Positioning of Crew

Driller / Drilling Engineer/ SIC	- at remote choke control panel
Asst. Drilling Engineer/ Jr. Engineer	- on Floor to assist SIC
Derrick man/ Top man-I	- at Choke manifold
Derrick man/ lop man-II	- at Mud Pump
Floor men/ Rig men	- at Stand pipe/ on Floor
Rig Mechanic/ In- Charge (TS)	- at Rig Engines
Pump Fitter/ Technician	- at Mud Pump
Electrician/ in- Charge (Elect)	- at B.O.P Control Unit
Roustabouts/ Trade men	- at Mud Tanks and Pumps
Mud Chemist/ Operator	- at Shale Shaker tank
Geologist/ Mud logger	- at flow line/ MLU

IV. To effectively kill a kick the end of the string shall be closed to the bottom of the well so that bottom hole pressure can be monitored and use of excess mud weight can be avoided. So if a kick is detected during tripping the D. E. should take the following steps:

1. Sound alarm
2. Make up the internal BOP depending on the severity of the kick; he will take either of the following steps:

Case A - In case the kick is not severe i.e. rate of inflow is negligible:

1. Run in the string to bottom as far as possible, carefully comparing the actual displacement volume against theoretical displacement volume, while running in care shall be bottom to fill up the string with mud.
2. After reaching bottom make up the Kelly cock.
3. Open choke line
4. Close annular B.O.P
5. Slowly close the choke line valve
6. Make up Kelly
7. Take steps to record shut in drill pipe and casing pressures

Case B- If the kick is very severe the D.E. shall take the following steps:

1. Open choke line
2. Close annular preventer
3. Slowly close choke line
4. Record annulus pressure
5. Arrange for stripping the string to bottom

The stripping procedure is briefly described as under:

1. Reduce closing pressure on the annular preventer.
2. Strip into the well bore with B.P.V. on the string. Bleed off required volume of fluid into the trip tank with hand adjustable choke. Drilling fluid volume bleed off shall include volume required for proper gas bubble expansion.
3. After reaching bottom, any standard well killing procedure may be adopted to circulate the kick out. It is to be noted that stripping operation shall always be done under proper guidance and supervision.

V. Standing Order for Workover Well Blowout Shut- In Procedures

When one or more of the warning signs are observed, immediate steps shall be taken to shut- in the well. If there be any doubt, it can always be checked up afterwards as even a small flow turn into big blowout in no time.

A. While Drilling

1. Raise Kelly until the tool joint is above the Rotary table or working platform.
2. Stop pump
3. Close B.O.P.
4. Inform IM
5. Read and record the shut- in tubing pressure, the shut- in casing pressure and the pit gain.

B. While Tripping

1. Set top tool joint on slip (If cut- of-hole run back.)
2. Install and make up shut-in-valve in open position.
3. Close shut-in valve and B.O.P.
4. Pick-up and make circulation gear.
5. Open shut-in-valve.
6. Kill outfit engine.
7. Inform IM
8. Read and record the shut-in tubing pressure, the shut-in casing pressure and the pit gain.

Installing a full opening shut in valve instead of a drop in type valve is advisable as further operation such as running in of wire line tools if become necessary can be done through shut-in valve only.

VI. Responsibilities for Shut-In

Each member of the crew has different responsibilities during various shut-in/killing procedures.

A. While Drilling

❑ Drilling Crews

1. JE-II - At Engine Kill
2. TOPMAN-II - At pump
3. TOPMAN-I - At kill manifold
4. RIGMAN V - At well head
5. RIGMAN I-IV - At Derrick floor/ working platform

❑ Engineering Crews

1. Supervisor/ Fitter - Keep in touch with D.E.
2. Remaining - 2 at pumps + 2 at outfit engine
3. Engine Driver - Electrical Switch Board
4. Chemical Deptt. Crews - At flow line
5. Production Crews - Near the well head

❑ Drilling Engineer

1. Pick up Kelly to above Rotary Table/ Working platform
2. Stop pump
3. Close B.O.P
4. Inform Installation Manager / Higher Official.
5. Read & record shut in, tubing and casing pressures and pit gain.

B. While Tripping

❑ Drilling Crews

1. JE II - Engine Kill
2. Topman II - Double board

3. Topman I - Kill manifold
4. Senior Grade - Well head
5. (I-V above) - Derrick floor/ working platform

❑ **Engineering Crews**

1. Supervision/ Fitter - Keep-in with D.E.
2. Remaining Jugali - 2 at pump + at outfit engine
3. Engine Driver - Electrical switch board
4. Chemical Deptt. - At flow line
5. Production Crews - At well head

❑ **Drilling Engineer**

1. Shut-in well immediately
2. If the string is out of hole run back as far as possible without any depth consideration set the top joint on slip. Direct crews to install shut-in valve and close BOP.
3. If the string is already in hole set top too joint on slip and direct crews to install shut-in-valve, and close BOP.
4. Notify installation Manager / higher official.
5. Read & record shut-in tubing and casing pressures and pit gain.

❑ **Kill Procedures**

The following variables are generally considered in killing a well:

1. Present following status
2. Magnitude of the formation pressure
3. Formation fracture pressure
4. Casing & Tubing burst pressure
5. Limitations of the working string such as packer leaks, tubing holes etc.

6. Limitations of surface Equipment
7. After studying all known & unknown variable the kill procedure can be evolved under a given situation.

VII. Precautions To Be Taken After A Blowout Has Occurred

1. An area within 500m of the well shall be demarcated as danger zone.
2. An electrical installation within the danger zone shall be de- energised and an alternative DG shall be commissioned for area lighting.
3. Only approved torches or safety lamps shall be used within the danger zone.
4. No naked light or Vehicular traffic are to be allowed within danger zone.
5. A portable gas detector shall be made available to indicate the presence of inflammable gas.
6. Person engaged in well control shall be equipped with gas masks. Adequate firefighting equipment shall be mobilized at the well site at the earliest. It may be necessary to provide additional sources of water for fire fighting.
7. An emergency medical unit shall be arranged outside the danger zone to render prompt medical help as and when required. This shall be equipped with minimum life saving drugs. One ambulance or any suitable vehicle shall also be kept standby near the site.
8. Temporary accommodation like tents with canteen facility shall be erected near the site.
9. Proper Radio or Telephone communication system shall be made available near the site. A Control room at Duliajan shall be established & shall be manned' round the clock by officers of Sr. manager level.
10. Civil authorities shall be notified to warn the local inhabitants about the possible fire hazard. The danger zone shall be preferably cordoned off by Security personnel.
11. Transport facility to place additional pumps and tank ages shall also be available at site.

Contingency Plan to Prevent Blow-out

The following actions shall be taken by the Shift – in charge to bring the situation under control.

A. On experiencing Kick, following safety actions to be taken, if BOP fails to seal Well Mouth

Sl.No.	Situations	Actions
1	Alert crew to ensure escape if situation worsens	Shift I/C
2	Divert flow partially, intermittently or fully to waste pit (safe distance)	Drilling crew
3	Send SOS message to Base Office, (i) By EPABX (II) By Emergency Vehicles	Shift I/C
4	Switch off all engines/ generators	I/C Mech/ Elect
5	Remove all inflammable material away	Rig Crew (Drilling/ Mech./ Elect.)
6	Remove important Records to Safe place	Rig Crew (Drilling/ Mech./ Elect.)
7	Remove costly instruments/ equipments to safe place	Rig Crew (Drilling/ Mech./ Elect.)

B. If the Blow out is sudden and massive while initial safety action could not be performed

Sl.No.	Situations	Actions
1	Carry out rescue operation for Top man and move other Rig crew to safe distance	Shift I/C
2	Send SOS message to Base Office, (i) By EPABX (II) By Emergency Vehicles	Shift I/C
3	Reorganize to try operations like BOP, Diversion of flow etc. as listed in (A), if situation permits	Shift I/C
4	If heavy spillage occurs, try to contain in the restricted area	Shift I/C
5	Alert the inhabitants, if private residence near	Geologist/ Chemist

7.7.5.6 ESSENTIAL SERVICES

1. Water Supply

On declaration of Emergency situation, Manager (Water Supply) and his team would organize availability of Water supply for Fire fighting and drinking water requirement. He would check up the feasibility of maintaining water from central water supply station, failing which he would commission the same from available Tube wells.

2. Transport and Salvage Equipment

Manager (Transport) would check up the fleet and driver's availability or- all Rescue, Salvage, Transport operations and provide the services.

3. Telephone Communication

On declaration of Emergency situation, Incharge- Control Room would check up the feasibility of operation the telephone exchange on mains supply. He would keep ready such alternate arrangements to operate the exchange with portable DG Sets. He would ensure that emergency telephones at declared control rooms are made available readily and available wireless sets at critical operational centers are in working condition.

4. Electricity

On declaration of Emergency situation, Manager (Elect.) and his team would ensure that Power supply is cut off immediately where ever required so. He would try to maintain Power supply at critical locations like Medical relief centers, Water supply sources etc. Manager (Elect.) and Manager (Water Supply) would organise to provide electricity at essential centers, in case Mains power supply from Power station could not be made available there.

5. Civil Engineering Jobs

On declaration of crisis situation, Manager (Civil) would organise gangs for debris removal, construction of temporary camps, etc.

During the critical phase of emergency, all out efforts would be made for meeting the needs of rescue, relief and fire fighting operation. During this phase maintenance of services like water and electricity for other purposes would receive lower priority. While restoring services, high priority would be given for maintenance of drinking water supply, then electricity.

DO'S AND DON'TS
Do'S ✓ <i>Release only authorised, verified written information</i> ✓ <i>Keep accurate records and logs of all enquiries and news coverage.</i> ✓ <i>Escort the Press and government agencies to the nearest safer place at the emergency site.</i> ✓ <i>Have a designated Spokesman.</i> ✓ <i>Know what information can and cannot be released.</i>
Don't's ✓ <i>Speculate on the causes of an emergency.</i> ✓ <i>Speculate on the resumption of normal operations.</i> ✓ <i>Speculate on the outside effects of emergencies.</i> ✓ <i>Speculate on the value of losses and damages.</i> ✓ <i>Place blame of emergencies.</i> ✓ <i>Allow crowd in the affected area (Those who have no role assigned in the disaster plan should stick to their jobs).</i> ✓ <i>Spread rumours.</i>

7.7.5.7 CONCLUSION

Even though the key contact personnel chart and role clarity are spelt out, experience has shown that in critical situation like a disaster, there is invariably some sort of panic at the beginning. Each Co-ordinator shall have a manual which will help him to train the personnel under him. This can be achieved if regular mock drills are undertaken. Each and everyone will become more conscious of the type of roles they will have to play to successfully combat the crisis situation.

7.7.6 OFF-SITE DISASTER MANAGEMENT PLAN

Offsite emergency preparedness is covered in the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996. The following are the Block operator's responsibilities towards generation of the Offsite Emergency Plan:

- To provide basic information on Risk and Environmental Impact Assessment to the Local/District Authority, Police, Fire Brigade, Doctors, surrounding industries and the

public and to appraise them on the consequences and the protection/prevention measures and control plans and seek their help to manage the emergency.

- To assist the District Authorities in preparing the Off-site Emergency Plan.

An off-site emergency plan organization has essentially two parts:

- A. *Formation of the Local Crisis Group: This Group is headed by the Deputy Collector or the Magistrate of the Industrial area and is responsible for the management of any industrial emergency confined to the local area.*
- B. *Formation of the District Crisis Group: This Group is headed by the District Collector of the District and is responsible for any major Industrial emergency affecting Local and beyond any industrial area of the District.*

The composition of the Off-Site Crisis Group is covered in. Since, the actual offsite plan requires the participation of outside agencies; this report does not dwell further on the issue.

7.7.6.1 COMMUNICATION SYSTEMS NETWORK

An efficient and reliable communication system is required for the success of the emergency plan. The efficient communication system is required to alert:

- *Emergency Authorities and Services*
- *Neighbouring area and public in the vulnerable zone*

The communication system requires the following:

- *Communication between Control Room to other units in the terminal*
- *Hotlines between Control Room to Emergency Services, Meteorological Station and the mutual aid members*
- *Paging system and alarm for with the Control Room for alerting the employees*
- *P&T Telephone lines*

A communication flow chart is to be prepared and kept in the Control Room. An up-to-date Telephone Directory of key personnel concerned with the emergency should be available at all times. These matters should be documented and kept within the Disaster Management Plan manual. The Disaster Management Plan Manual is required to maintain a record of police stations, hospitals and fire brigade stations in the area to seek assistance in dealing with emergency situations. The emergency team of Block operator should liaise with these

agencies and with district officials and furnish them information on the possible hazards, extent of damage and actions to be taken by them during such emergencies.

7.7.6.2 ROLE OF EXTERNAL SERVICES

Police	The Police should assist in cordoning off the accident site; organize evacuation and removing any seriously injured people to the hospitals. They shall divert traffic as and when necessary.
Fire Brigade	The fire brigade shall organise to fight fires other than gas fires and provide assistance as required.
Hospitals and Doctors	Hospitals and doctors should treat any injuries, which may primarily be burn injuries.
Mutual Aid from Neighboring Installations	Block operator may also depend on the local facilities handling emergencies. They will have to arrange with the local administration for providing services, such as fire fighting and medical needs during incident particularly in the nearby regions. Telephone links with neighboring industries and customer facility control rooms should be established.

7.7.6.3 PUBLIC INFORMATION SYSTEM

During a crisis following an incident, the people of the area and a large number of media representatives would like to know about the situation from time to time and the response of the district authority to the crisis. It is important to give timely information to the public in order to prevent panic and rumors. The emergency public information could be carried out in three phases.

Before the Crisis

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 the vicinity

During the Crisis

Dissemination of information about the nature of the incidents, actions taken and instructions to the public about protective measures to be taken, evacuation etc. are the important steps during this phase

After the Crisis

Attention should be focused on information concerning restoration of essential services, travel restrictions, etc

7.7.6.4 WARNING SYSTEM

In an off-site management plan, one of the most important prerequisites is a good 'Warning System'. Efficient warning system will save lives, prevent injuries and reduce losses. The Emergency Co-ordinator - Onsite in consultation with Emergency Co-ordinator Offsite will decide the appropriate warning system and implement it. The warning systems are of the following types:

- ✓ Disaster Warning (Maximum Credible Loss Scenario) High pitched continuous wailing siren
- ✓ Fire/Toxic Release
- ✓ Long siren followed by short siren
- ✓ All Clear

Depending upon the nature of hazards and the area affected, other methods of warning may be used as follows:

- ✓ Out-door warning sirens
- ✓ Public address system with police
- ✓ ARP sirens
- ✓ Mass media
- ✓ Door to door visit by Civil/Defence Personnel
- ✓ Telephone contact with schools and other organisations/public institutions
- ✓ Information to be provided at common gathering places such as village canteens, shops, etc.

7.7.6.5 SERVICES SUPPORT SYSTEM

A major off-site incident may affect a number of units and the surrounding colonies. Hence in addition to the communication, warning, public information, fire fighting system, following additional service support will be required:

- ✓ Health and medical services
- ✓ Transportation services
- ✓ Security and police
- ✓ Media
- ✓ Mutual aid services

A telephone directory containing the contact numbers of all these support services should be documented and be part of the offsite disaster management plan.

