Risk Assessment Studies
for the Development of CBM Activities
in Raniganj Block, West Bengal

DRAFT REPORT

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Table of Contents

List of Annexure

List of Tables

List of Figures

1 QUANTITATIVE RISK ASSESSMENT

Quantitative Risk Assessment (QRA) involves the systematic analysis and evaluation of risks related to various phases of the CBM development and production assessment project including feasibility and concept development, design, construction, operation and decommissioning. The QRA is an integrated risk management process outlining rational evaluations of the identified risks based on their significance and recommending appropriate preventive and risk mitigation measures. The results of the QRA provides valuable inputs into the overall project planning to ensure that the project risks stay As Low As Reasonably Practicable (ALARP) levels at all times during project implementation.

QRA – INTEGRATED RISK MANAGEMENT PROCESS

QRA as a part of integrated risk management process for the proposed project consists of the following iterative steps:

- *Identification of hazards*
- *Setting Acceptance Standards for the defined risks*
- *Evaluation of likelihood and consequences and risks of possible events.*
- *Confirmation of arrangements to mitigate the events and respond to the same on occurrence.*
- *Establishment of performance standards*
- *Establishment of continuous monitoring, review and auditing of arrangements*

1.1 Objective of the QRA Study

The overall objective of this QRA with respect to the proposed project involves the identification and evaluation of major risks, prioritizing the risks identified based on their hazard consequences and formulating suitable risk reduction/mitigation measures in line with the ALARP principle. Hence in order to ensure effective management of any emergency situations (with potential individual and societal risks) that may arise during the development and production phase the following specific objectives need to be achieved.

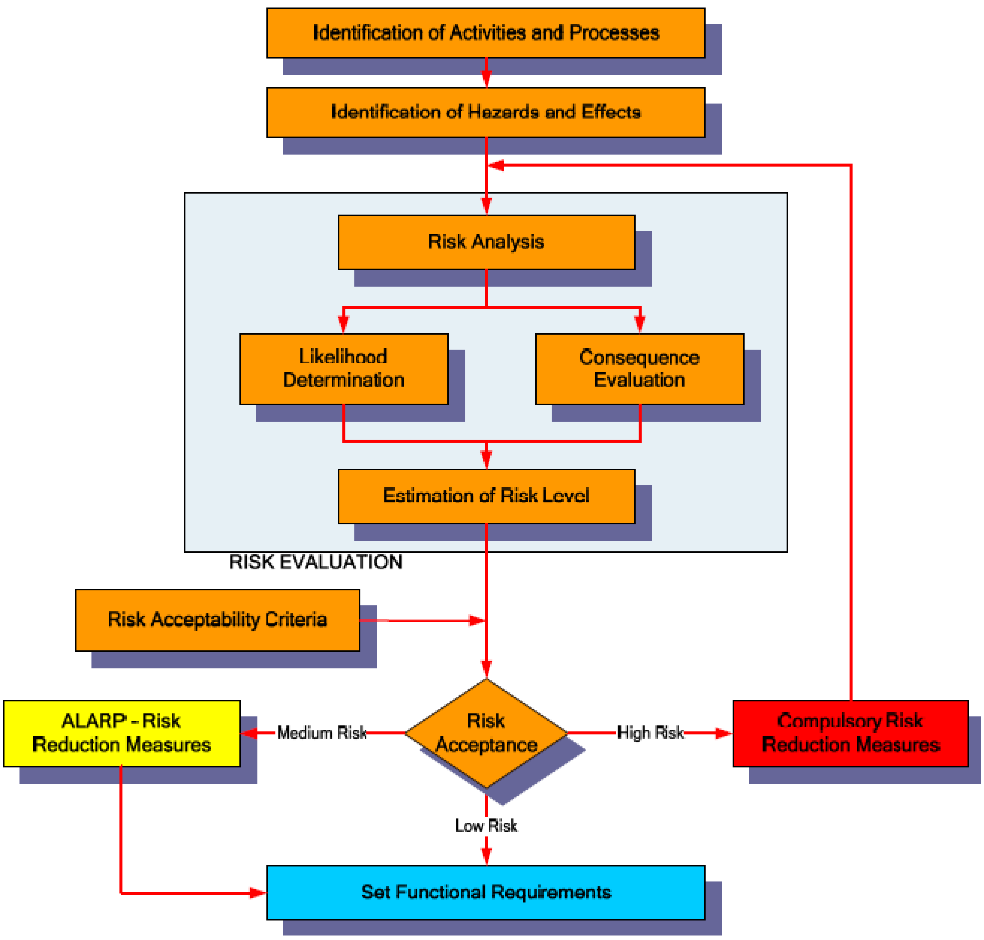
- Identify potential risk scenarios that may arise from the proposed CBM gas production cum development project particularly during transportation of CBM from production wells to GGS and subsequently to MCS through pipeline network.
- Analyze the possible likelihood and frequency of such risk scenarios by reviewing historical accident related data for the onshore oil and gas industries.
- Predict the consequences of such potential risk scenario's and if consequences are high, establish the same by through application of quantitative simulations.
- Recommend feasible preventive and risk mitigation measures as well as provide inputs for drawing up of Disaster Management Plan (DMP) for the project.

1.2 RISK ASSESSMENT METHODOLOGY

The risk assessment process is primarily based on likelihood of occurrence of the risks identified and their possible hazard consequences particularly being evaluated through hypothetical accident scenarios. With respect to the proposed project, the major risks *viz.* methane gas leaks, fire etc have been assessed and evaluated through a risk matrix generated to combine the risk severity and likelihood factor. Risk associated with the CBM development cum production activities have been determined semi- quantitatively as the product of likelihood/probability and severity/consequence by using order of magnitude data (*risk ranking = severity/consequence factor X likelihood/probability factor*). Significance of such project related risks was then established through their classification as high, medium, low, very low depending upon risk ranking.

The risk matrix is a widely accepted and standardized method of quantitative risk assessment and is preferred over purely quantitative methods, given its inherent limitations to define a risk event with certainty. The application of this tool has resulted in the prioritization of the potential risks events proposed CBM development cum production project thus providing the basis for drawing up risk mitigation measures and leading to formulation of plans for risk and emergency management. The overall approach is summarized in the **Figure 1.1**

Figure 1.1: Risk Assessment Methodology



1.2.1 Hazard Identification

Hazard identification for the purposes of this QRA involves the qualitative review of the project design and operations including relevant information provided by ONGC. Available literature related to previous safety assessment survey studies, project hazardous material handled and work procedures were reviewed for various phases of the proposed project including site preparation, drilling activities, well testing, well logging and setting up of surface facilities. Information (including historical data) related to possible hazards associated with CBM and natural gas operations were also sourced from veritable secondary sources of the upstream oil and gas industry viz. OSHA, UNEP, API, OGP, EGIG etc.

Based on the result of this exercise, potential hazards that may arise at the project locations were identified and a qualitative understanding of their probability and significance were obtained. It is to be noted here that many of these potential hazards could be triggered by natural events like earthquakes, cyclones or floods and such factors have been considered in arriving at probable frequency of occurrence of such hazards.

Taking into account the applicability of different risk aspects in context of the CBM production activities to be undertaken in the Raniganj block, three major categories of hazards that can be associated with proposed project has been dealt with in detail.

- Release of methane from CBM transportation pipeline leak/rupture leading to jet fire.
- Instantaneous release of CBM from leaks/damage to cascade cylinders during transportation
- Blow outs leading to instantaneous release of methane
- Non process fires/explosions
- Structural failure – faulty design, failure of general safety, collapse of Drilling rig mast, sabotage.

Other possible hazard scenarios like oil and chemical spills, etc. have not been considered for detailed assessment as preliminary evaluation has indicated that the overall risk that may arise out of them would be very low or insignificant. In addition, it is understood that the causative factors and mitigation measures for such events can be adequately taken care of through existing safety management procedures and practices of ONGC.

1.2.2 Frequency Analysis

The frequency analysis of the hazards identified with respect to the proposed CBM development cum production well operations was undertaken to estimate the likelihood of their occurrences during the project life cycle. Hazard frequencies in relation to the proposed project were estimated based on the analysis of historical accident frequency data and professional judgment. Based on the range of probabilities arrived for different potential hazards that may be encountered during the proposed development phase, the following frequency categories and criteria have been defined (**Table 1.1**)

Table 1-1: Frequency Categories and Criteria

Likelihood Ranking	Criteria Ranking (cases/year)	Frequency Class
5	>1.0	Frequent
4	$>10^{-1}$ to <1.0	Probable
3	$>10^{-3}$ to $<10^{-1}$	Occasional/Rare
2	$>10^{-5}$ to $<10^{-3}$	Not Likely
1	$>10^{-6}$ to $<10^{-5}$	Improbable

1.2.3 Consequence Analysis

In parallel with the frequency analysis, hazard prediction / consequence analysis exercises were undertaken to assess the likely impact of project related risks on onsite personnel, infrastructure and environment. In relation to the proposed project, the estimation of the consequences for each possible event has been based either on accident experience, consequence modeling or professional judgment, as appropriate. Overall, the consequence analysis takes into account the following aspects:

- Nature of impact on environment and community;
- Occupational health and safety;
- Asset and property damage;
- Corporate image
- Timeline for restoration of environmental and property damage
- Restoration cost for environmental and property damage

The following criteria for consequence rankings (**Table 1.2**) have been drawn up in context of the possible consequences of the risk events that may occur during the CBM development phase (Phase III)

Table 1-2: Severity Categories and Criteria

Consequence	Ranking	Criterion Definition
Catastrophic	5	Multiple fatalities/Permanent total disability to more than 50 persons Severe violations of national limits for environmental emission More than 5 years for natural recovery Net negative financial impact of >10 crores Long term impact on ecologically sensitive areas International media coverage National stakeholder concern and media coverage
Major	4	Single fatality/permanent total disability to one or more persons Major violations of national limits for environmental emissions 2-5 years for natural recovery Net negative financial impact of 5 -10 crores Significant impact on endangered and threatened floral and faunal species Loss of corporate image and reputation
Moderate	3	Short term hospitalization and rehabilitation leading to recovery Short term violations of national limits for environmental emissions 1-2 years for natural recovery

		Net negative financial impact of 1-5 crores Short term impact on protected natural habitats

Consequence	Ranking	Criterion Definition
		State wide media coverage
Minor	2	Medical treatment injuries 1 year for natural recovery Net negative financial impact of 0.5 – 1 crore Temporary and mitigable environmental impacts Local stakeholder concern and public attention
Insignificant	1	First Aid treatment with no Lost Time Incidents (LTIs) Natural recovery < 1year Net negative financial impact of <0.5 crores. No significant impact on environmental components No media coverage

1.2.4 Risk Evaluation

Based on ranking of likelihood and frequencies, each identified hazard has been evaluated based on the likelihood of occurrence and the 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

The **Table 1.3** below illustrates all possible product results for the five likelihood and consequence categories while the **Table 1.4** assigns risk significance criteria in three regions that identify the limit of risk acceptability as per the HSE management system of ONGC. 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 1-3: Risk Matrix

			Likelihood →				
			Frequent	**Probable**	**Remote**	**Not Likely**	**Improbable**
			5	**4**	**3**	**2**	**1**
Consequence →	**Catastrophic**	**5**	25	20	15	10	5
	Major	**4**	20	16	12	8	4
	Moderate	**3**	15	12	9	6	3
	Minor	**2**	10	8	6	4	2
	Insignificant	**1**	5	4	3	2	1

Table 1-4: Risk Criteria And Action Requirements

Risk Significance	Criteria Definition and Action Requirements
High (16 - 25)	**"Risk requires attention"** – Project HSE Management need to ensure that necessary mitigation are adopted to ensure that possible risk remains within acceptable limits
Medium (10 – 15)	**"Risk is tolerable"** – Project HSE Management needs to adopt necessary measures to prevent any change/modification of existing risk controls and ensure implementation of all practicable controls.
Low (5 – 9)	**"Risk is acceptable" –** Project related risks are managed by well-established controls and routine processes/procedures. Implementation of additional controls can be considered.
Very Low (1 – 4)	**"Risk is acceptable" –** All risks are managed by well-established controls and routine processes/procedures. Additional risk controls need not to be considered

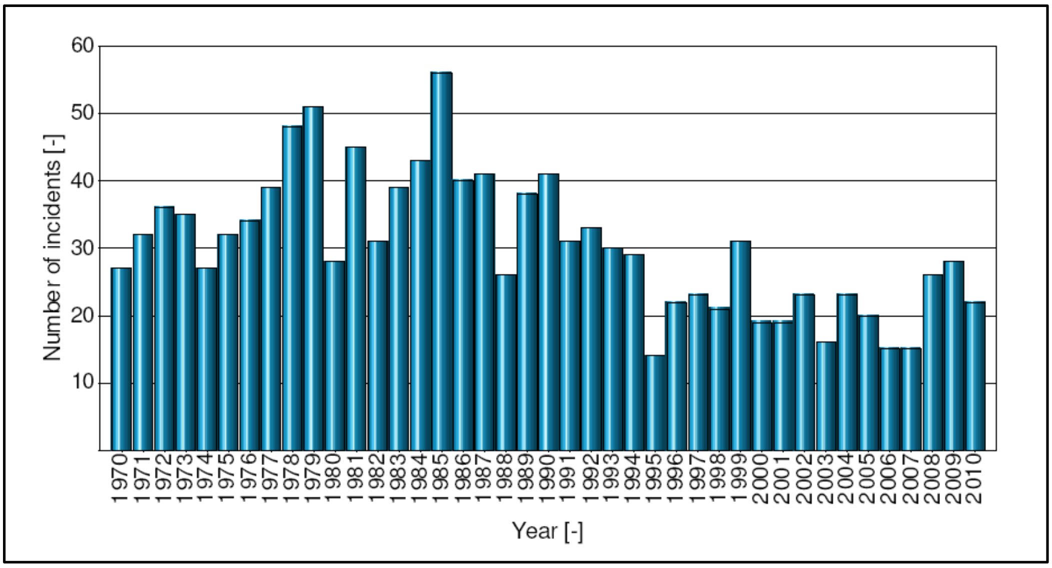
1.3 RISK ASSESSMENT OF IDENTIFIED PROJECT HAZARDS

As already discussed in the previous section, four major categories risk have identified in relation to the proposed CBM development cum production well drilling activities. A comprehensive risk assessment study has been undertaken for these risks to evaluate their significance in terms of severity of consequences and likelihood of occurrence. Considering the CBM transportation pipeline leak/rupture as the major potential risk associated with the proposed project the same has been assessed and evaluated in detail along with other process and non-process related risks and summarized in the subsequent sections below:

1.3.1 Pipeline Failure Incidents & Causes

Considering the absence/limited availability of historical accident data pertaining to CBM operations worldwide the failure frequency analysis of CBM gas transportation pipeline interconnecting production wells, GGS and MCS have been carried out based on the review of European Gas Pipeline Incident Data Group (EGIG) database. The EGIG is a cooperation of 15 major gas transmission systems in Europe with the objective of providing a broad basis for the calculation of safety performance of the pipeline systems thus providing a more realistic picture of the frequencies and probabilities of incidents. The 7th EGIG report recorded a total of 1173 nos. incidents for the period 1970-2007, with 76 nos. incidents being reported for the last three years which bring the total no of incidents to 1249 for the period (2007-2010). The number of pipeline failure incidents per year for the period 1970-2010 has been presented in the **Figure 1.2** below.

Figure 1-2: CBM Gas Pipeline Failure Incidents (1970-2010)



[Source: 8h EGIG Report]

Pipeline failure leading to release of hydrocarbons may occur under the following circumstances –

- Internal corrosion
- External corrosion – from defects in protective system, in cased crossings beneath roads and railway lines
- External interference – due to construction machinery, unauthorized excavations, missing ground markers;
- Structural failure/mechanical defects
- Ground movement resulting from natural hazards viz. seismic events, subsidence, landslides, floods etc.

External interference and construction defects are also potential cause of pipeline accidents and may also occur at valve and pump stations. Based on the aforesaid factors, accidental releases from pipelines are classified as either leaks or ruptures (*Pluss, Niederbaumer & Sagesser, 2000*). Similar failure cases have been considered for the proposed pipeline project.

[23] *GEM/TD/2 provides a framework for carrying out an assessment of the acute safety risks associated with major accident hazard pipelines (MAHPs) containing high pressure Natural Gas. It provides guidance on the selection of pipeline failure frequencies and on the modelling of failure consequences for the prediction of individual and societal risks.*

1.3.2 Pipeline Failure – Potential Hazards

Pipeline leaks or rupture may possibly result in various fire hazards depending upon whether the ignition is immediate or delayed. The initial release rate of hydrocarbon through a leak depends mainly on the pressure inside the equipment (pipeline or storage cylinders), the size of hole and phase of release i.e. gas, liquid or two-phase. Considering possible consequences associated with hydrocarbon leaks, release rate is considered to be important as it affects the size of the resulting gas cloud and hence the probability of ignition. It also determines the size of fire or smoke plume which may result. The IGEM/TD/2[23] (Institution of Gas Engineers & Managers) standard recognizes the following possible fire hazards as being applicable following a gas pipeline release that ignites:

1.3.3 Ignition of a Leak (Immediate or Delayed) to give a Jet Fire

In case of leaks from buried pipelines, the transient flow will be channelized through the voids from the overlaying soil. If the leak is sufficiently large then soil will be ejected above the pipeline. The jet will entrain air as it moves upward and will get disperse depending on the prevailing wind direction and other meteorological conditions. The concentration of gas till its Lower Flammability Limit (LFL) is hazardous, as it can catch fire on availability of ignition source. The total duration of release and its impact/consequence will depend on how quickly the release is identified and the sectionalizing valve isolates the pipeline section. If the material encounters an ignition source while it is in the flammable concentration range, a jet fire may occur. The momentum of released material from a buried pipeline generally results in vertically oriented fires. Such fires have smaller hazard ranges than horizontally orientated fires.

1.3.4 Immediate Ignition of a Rupture to give a Fireball & Crater Fire

Following a rupture, or large puncture, there will be rapid depressurization in the vicinity of the failure. For the buried pipelines as in this case, the overlying soil will be ejected with the formation of a crater of a size and shape, which influences the behavior of the released gas. At the start of the release, a highly turbulent mushroom shaped cap is formed which increases in height above the release point due to the source momentum and buoyancy, and is fed by the gas jet and entrained air from the plume which follows. In addition to entrained air the release can also result in entrainment of ejected soil into the cap and plume. Eventually, the cap will disperse due to progressive entrainment and a quasi-steady plume will remain. (Acton, Gosse & McCollum, 2002). If the large scale quasi-instantaneous flammable gas release is under pressure is ignited almost immediately a fireball will result. In order for a fireball to occur, the cloud must be ignited before it has time to disperse hence there must be an ignition source close to the release point at the time of release. The energy released by the rupture of the pipeline typically results in the formation of a crater around the rupture point. Gas enters the crater from each end of the ruptured pipeline. Once the fireball has dissipated, this gas continues to burn as a crater (or trench) fire. Crater fire generally occurs when the ignition of the gas released by rupture is delayed.

Flash Fires: The buoyancy of CBM gas and momentum of the high-pressure release tend to propel the gas away from ground level within a relatively short distance from the source. This means that it is highly unlikely that flammable concentrations of gas will be produced at ground level beyond a short distance from the source. For this reason, flash fires are not included within the QRA.

1.3.5 Pipeline Failure – Frequency Analysis

In view of the transportation of CBM generated from production wells to GGS/MCS via pipeline network an effort has also been made to understand the primary failure frequencies of gas pipeline which is the result of the number of incidents within a period divided by the corresponding total system exposure. Based on the EGIG database the evolution of the primary failure frequencies over the entire period and for the last five years has been provided in **Table 6.5** below.

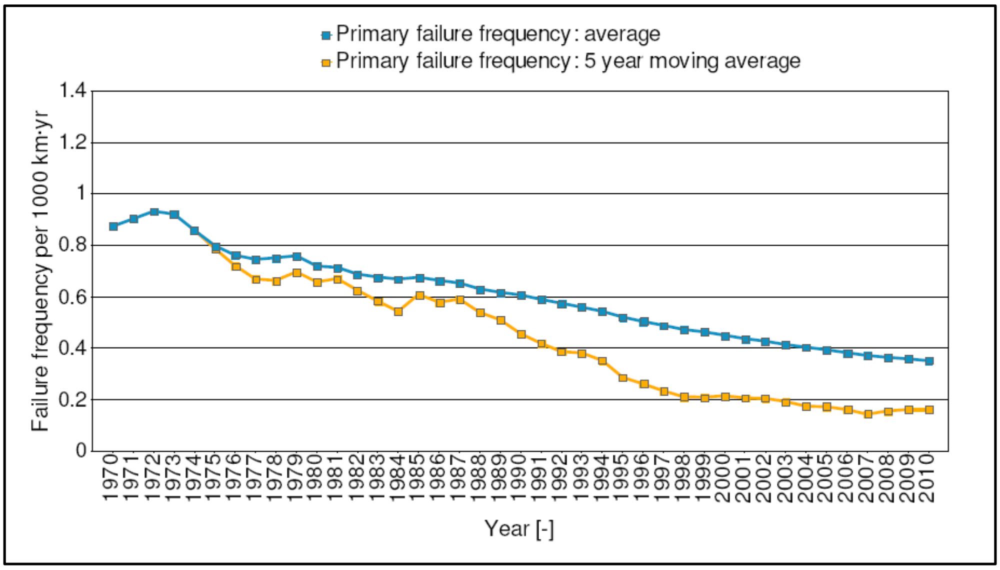
Table 1-5: Primary Gas Pipeline Failure Frequency

Period	Interval	No. of Incidents	Total System Exposure (km.yr)	Primary failure frequency (1000 km. yr)
1970-2010	41 years	1249	$3.55.10^6$	0.351
1970-2007	38 years	1173	$3.15.10^6$	0.372
1971-2010	40 years	1222	$3.52.10^6$	0.347
1981-2010	30 years	860	$3.01.10^6$	0.286
1991-2010	20 years	460	$2.25.10^6$	0.204
2001-2010	10 years	207	$1.24.10^6$	0.167
2006-2010	5 years	106	$0.65.10^6$	0.162

[Source: 8h EGIG Report]

The primary failure frequency declined from 0.87 per 1000 km.yr in 1970 to nearly 0.35 per 1000 km.yr in 2010 indicating an improvement in pipeline safety performance over the recent years. The failure frequency of the last five years (2007-10) was also computed to be 0.16 which is half the failure frequency recorded for the entire period (1970-2010). The evolution of primary failure frequencies over the entire period including the 5 year period of 2007-2010 has been presented in the **Figure 1.3** below.

Figure 1-3: Evolution Of Primary Failure Frequencies

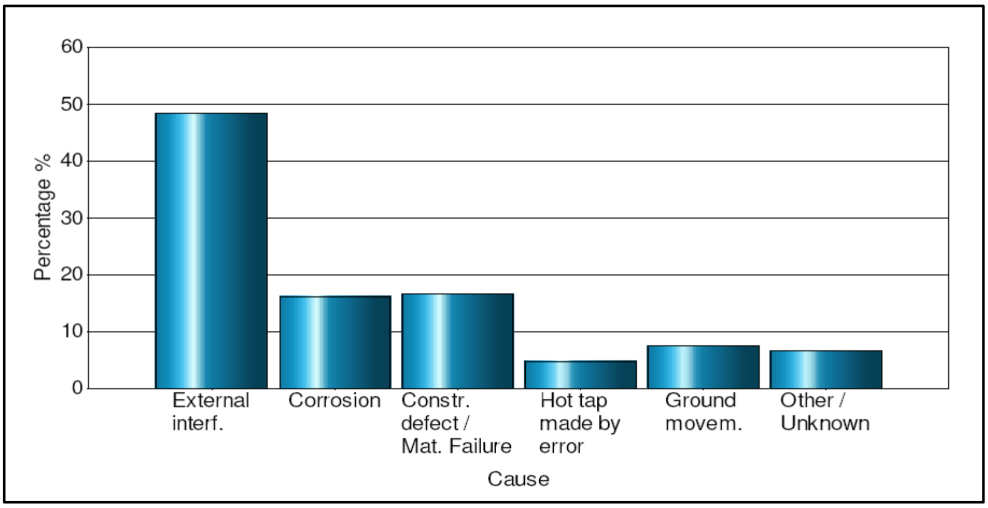


[Source: 8th EGIG Report]

The above figure depicts a steady drop of the primary failure frequencies and the failure frequencies of the 5 years moving average. The moving average primary failure frequency over five years decreased by a factor 5 (0.86 to 0.16 per 1000 km.yr). Data published by the UK Onshore Pipeline Operators Association (UKOPA) show a similar trend, with the frequency of accidental releases in the period 2002-2006 being over 25 times lower than the frequency for the period 1967-1971 (0.028 as opposed to 0.706 releases per 1000 km of pipe per year).

Pipeline Failure Frequency Analysis – Incident Causes: As discussed, gas pipeline failure incidents can be attributed to the following major causes viz. external interference, construction defects, corrosion (internal & external), ground movement and hot tap. The distribution of incidents with cause has been presented in the **Figure 1.4** below.

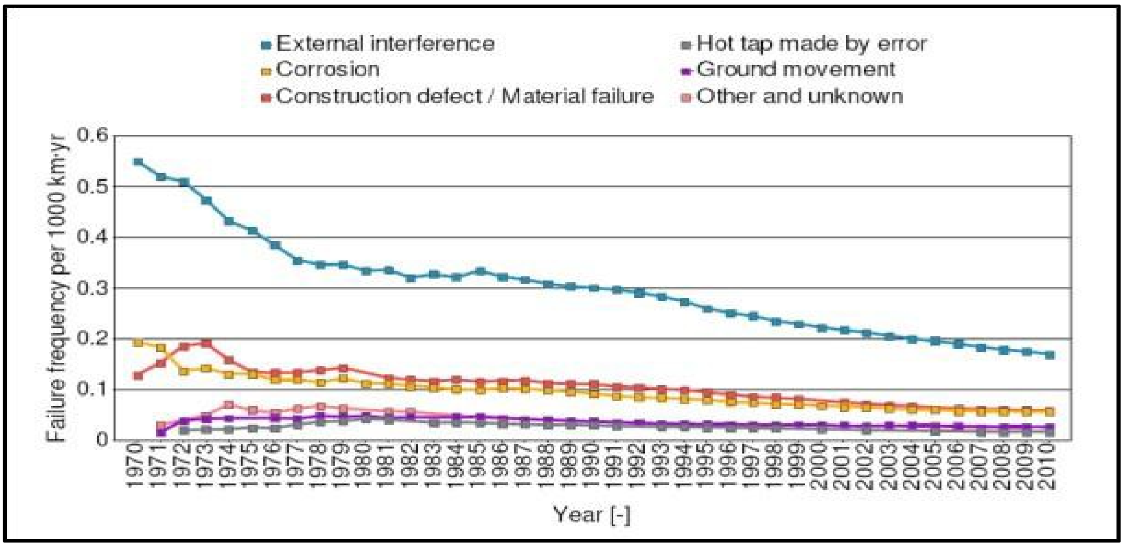
Figure 1-4: CBM Gas Pipeline Failure – Distribution Of Incident & Causes



Source: 8th EGIG Report

The interpretation of the aforesaid figure indicated external interference as the major cause of pipeline failure contributing to about 48.4% of the total failure incidents followed by construction defects (16.7%) and corrosion related problems (16.1%). Ground movement resulting from seismic disturbance, landslides, flood etc contributed to only 7.4% of pipeline failure incident causes. The primary failure frequencies per cause for the period 1970-2010 have been presented in **Figure 6.5** below.

Figure 1-5: CBM Gas Pipeline Primary Failure Frequencies Per Cause



[Source: 8th EGIG Report]

The **Figure 1.5** illustrate the reducing failure frequency over the years which has been achieved primarily due to technological developments viz. welding, inspection, condition monitoring using in-line inspection and improved procedures for damage prevention and detection. As far as the cause of external interference is concerned, its associated primary failure frequency over the period 1970-2007 decreased to 0.17 per 1000 km.yr while the 5-years moving average has leveled off at around 0.10 per 1000 km.yr since 1997. However external interference to this date remains the main cause of pipeline failure incidents, with nearly 50% of the incidents being attributed to the former over the period 2003-2007.

The pipeline failure frequency viz. leaks or rupture for the proposed project involved pipeline transportation of CBM to GGS/MCS and end users is established based on the interpretation of the database of European Pipeline Incident Data Group (EGIG) representing almost 2 million kilometer year of pipeline operations. The failure rate reported by EGIG for on-shore gas pipeline with design pressure greater than 15 bar **is 4.76 x 10^{-4} km/year**. Full Bore Rupture (FBR) represents 13% of the cases (**6.188 x 10^{-5} failure /km/yr.**) and 87% of the cases represents Leaks (**4.14 x 10^{-4} failure /km/yr**). Hence based on the EGIG historical data as discussed above the probability of failure for CBM gas interconnecting pipeline network is as follows.

Pipeline Failure Frequency Analysis

EGIG Full Bore Rupture Historical Frequency: **6.188 x 10^{-5} failure /km/yr**

EGIG Historical Frequency of Pipeline Leaks: **4.14 x 10^{-4} failure /km/yr**

The frequency of pipeline failure during transportation of CBM gas through a network of pipelines interconnecting production wells with GGS/MCS is presented in the **Table 1.6** below.

Table 1-6: CBM Transportation Pipeline Failure Frequency & Class

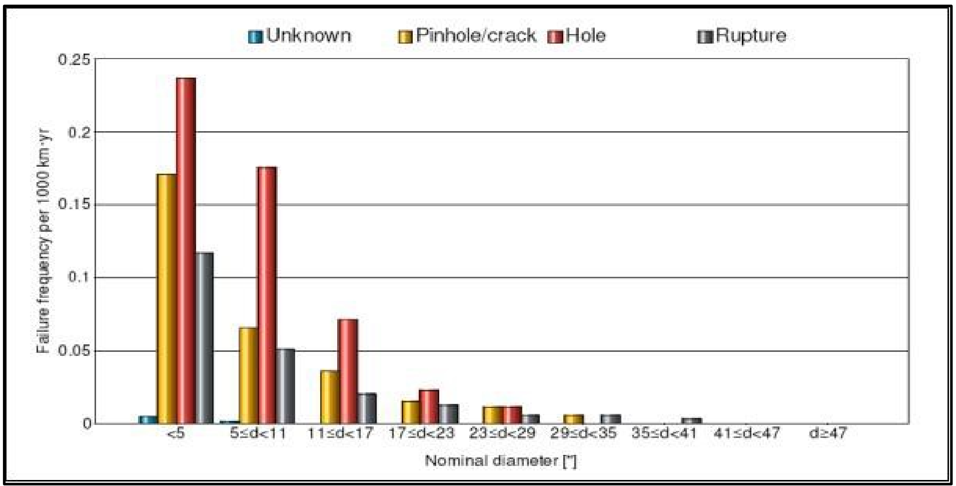
S.N.	Pipeline Failure Case	Failure Frequency (km/year)	Frequency Class
1	CBM transportation pipeline rupture	6.188 x 10^{-5}	Remote
2	CBM transportation pipeline leak	4.14 x 10^{-4}	Remote

Further considering that adequate preventive measures viz. installation and operation of SCADA system, provision of isolation/sectional valves etc are likely to be adopted by ONGC for addressing any potential pipeline related safety risks/hazards viz. jet fire etc the failure frequencies for the proposed pipeline project are likely to be lower.

Pipeline Failure Frequency Analysis – Damage Type: As discussed in the earlier section potential hazards from pipeline failure primarily results from pin-hole cracks, holes and/or ruptures caused due to external disturbances, construction defects, corrosion etc. As external disturbance has been identified as one of the major cause for pipeline incidents (EGIG database) the same has been considered in evaluating the failure frequency with respect to the nature of damage and pipeline design parameters viz. diameter class.

The pipeline failure frequency in relation with external interference, damage type and diameter class have been presented in the **Figure 1.6** below.

Figure 1-6: External Failure Frequency – Relation With Damage Type & Diameter Class



The above figure reveals that pipeline with smaller diameter are more susceptible to damage by external disturbance as compared to larger diameter pipes. Thinner wall thickness of pipelines with smaller diameter also contributes to the increased failure frequency for such pipelines. Hence based on the aforesaid discussion it can be therefore concluded that the failure frequency of the 7.8”, 9.75”, 11.7” and 17.5” dia CBM transportation pipeline interconnecting GGS and MCS will be lower compared to 4” dia pipeline to be involved in routing CBM from production wells to GGS.

Pipeline Failure – Ignition Probability

In the period 1970-2010, only 4.4% of the gas releases recorded as incidents in the EGIG database ignited. Ignition depends on the existence of random ignition sources. The EGIG database gives the opportunity to evaluate the link between ignition and leak size.The ignition probability of pipeline failure (rupture & leaks) with respect to the proposed project is derived based on the following equations as provided in the IGEM/TD/2 standard.

$P_{ign} = 0.0555 + 0.0137pd2$; for $0 \leq pd^2 \leq 57$

$\mathbf{P_{ign} = 0.81}$; **for** $\mathbf{pd^2 > 57}$

(Ignition Probability for pipeline ruptures)

$\boldsymbol{P_{ign} = 0.0555 + 0.0137(0.5pd2);}$

for $\mathbf{0 \leq 0.5pd^2 \leq 57}$

$\mathbf{P_{ign} = 0.81}$; **for** $\mathbf{0.5pd^2 > 57}$

(Ignition Probability for pipeline leaks)

Where:

P_{ign} = Probability of ignition

p = Pipeline operating press

d = Pipeline diameter (m)

The ignition probability of natural gas release from 4” & 18” pipeline leak or rupture is calculated based on the above equations utilizing the following input parameters as discussed below.

Pipeline Inlet Pressure (bar) = p= 50 kg/cm^2 or 49
bar Pipeline diameter = d = 4 inches or 0.101 m
Pipeline diameter = d = 18 inches or 0.457 m
For 4” pipeline rupture pd^2 = (49) X (0.101)^2 = 0.499
For 4” pipeline leak 0.5 pd^2 = 0.5 X (49) X (0.101)^2 = 0.249
For 18” pipeline rupture pd^2 = (49) X (0.457)^2 = 10.23
For 18” pipeline leak 0.5 pd^2 = 0.5 X (49) X (0.457)^2 = 5.11
Since **$0 \leq pd^2 \leq 57$** and **$0 \leq 0.5pd^2 \leq 57$,** the following equation has been utilized for deriving the ignition probability for pipeline failure.

P ign for 4’ pipeline rupture = 0.0555 + 0.0137pd^2 = 0.0555 + 0.0137 (0.499) = 0.062

P ign for 4” pipeline leak = 0.0555 + 0.0137(0.5pd^2) = 0.0555 + 0.0137 (0.249) = 0.058

P ign for 18’ pipeline rupture = 0.0555 + 0.0137pd^2 = 0.0555 + 0.0137 (10.23) = 0.195

P ign for 18” pipeline leak = 0.0555 + 0.0137(0.5pd^2) = 0.0555 + 0.0137 (5.11) = 0.125

Based on the aforesaid calculation the probability of jet fire occurring from accidental gas release from pipeline leak or rupture and subsequent ignition has been presented in Table **6.7** below:

Table 1-7: Ignition Probability – Cbm Transportation Pipeline Failure

S. N	Pipeline Failure Case	Project Pipeline Failure Frequency (per year)	Ignition Probability	Jet fire Probability
1	4” Gas Pipeline Rupture	6.683 x 10-4	0.06	4.009 x 10-5
2	4” Gas Pipeline Leak	4.471 x 10-3	0.05	2.235 x 10-4
3	18” Gas Pipeline Rupture	6.683 x 10-4	0.19	1.269 x 10-4
4	18” Gas Pipeline Leak	4.471 x 10-3	0.12	5.365 x 10-4

Process Leak – Frequency Analysis

The frequency of process leaks can be estimated directly from analysis of historical data obtained from E & P Forum hydrocarbon leak database (E&P forum 1992), World Offshore Accident Database (WOAD) and OREDA. Although onshore data is available for process leaks, the information is not considered representative of the actual scenario. Under such circumstances historical data available on hydrocarbon leaks in the OGP authenticated offshore accident databases have been considered for purpose of process leak frequency analysis.

Failure frequencies of process equipment as in this case where leaks have been considered from valves and flanges of the GCS facility has been presented in **Table 6.8** below.

Table 1-8: Leak Frequencies From Process Equipment

Equipment Type	Frequency (per equipment item year)
Flanges	8.8×10^{-5}
Valves	2.3×10^{-4}

Source: HSE Hydrocarbon Release Database

1.2.5 Consequence Analysis

Pipeline generally contains large inventories of oil or gas under high pressure; although accidental releases from them are remote they have the potential of catastrophic or major consequences if related risks are not adequately analyzed or controlled. The consequences of possible pipeline failure is generally predicted based on the hypothetical failure scenario considered and defining parameters such as meteorological conditions (stability class), leak hole & rupture size and orientation, pipeline pressure & temperature, physicochemical properties of chemicals released etc.

As discussed earlier**,** jet fire have been identified as the possible consequences resulting from release and is dependent on the ignition time. Taking into account the GCS facility and pipeline the hypothetical risk scenarios have been considered for failure consequence modeling with respect to proposed project. In addition to the above the following design specifications as presented in **Table 6.9** have been considered for consequence modeling

Table 1-9: Scenaios for QRA Studies

S.N	Plant Section	Initiating Event	Risk Scenario	Potential Outcome Scenario
1	Valves/Flanges of GCS facility	Leaks	Leak from 1” dia	Jet fire
2	Pipeline	Rupture	4” & 18” pipeline	Jet fire, flash fire

Table 1-10: Leak Frequencies from Pipeline and GCS

S. N.	Parameters	Values
1	Pipeline diameter (inch)	4 inch and 18 inch
2	Pipeline length (km)	10 km
4	Design pressure (bar)*	49
5	Design temperature (in °C)	40

In the present study, we have estimated the consequence of each reference scenarios (as mentioned in **Table 1.9**) in terms of fatality only. For each effect type (i.e. radiation, overpressure and toxic release), a set of threshold values were considered having 1, 5, 10, 20 and 50% fatality (**Table 1.11**). These threshold values were derived from Probit functions using the following equations:

Thermal Radiation [1]: Pr = -14.9 + 2.56 x In (Q4/3 x t)... Eq.

Overpressure [2]: Pr = 1.47 + 1.37 ln (p).. Eq.

Toxic release [3]: Pr = a +b x In (Cn x t).. Eq.

where,

Pr = Probit

Q = heat radiation (W/m2)

t = exposure time (s)

p = peak overpressure (psig)

a, b, n = constants describing the toxicity of a substance

C = concentration (mg/m3)

t = exposure time (minutes)

Table 1-11: Threshold Values For Each Effect Level

Fatality (%)	Radiation (kW/m^2)	Overpressure (psi)
50	26.50	13.10
20	20.78	7.15
10	18.25	5.20
5	16.42	3.95
1	13.42	2.40

[N. B. The values were derived using the above mentioned Probit equations]

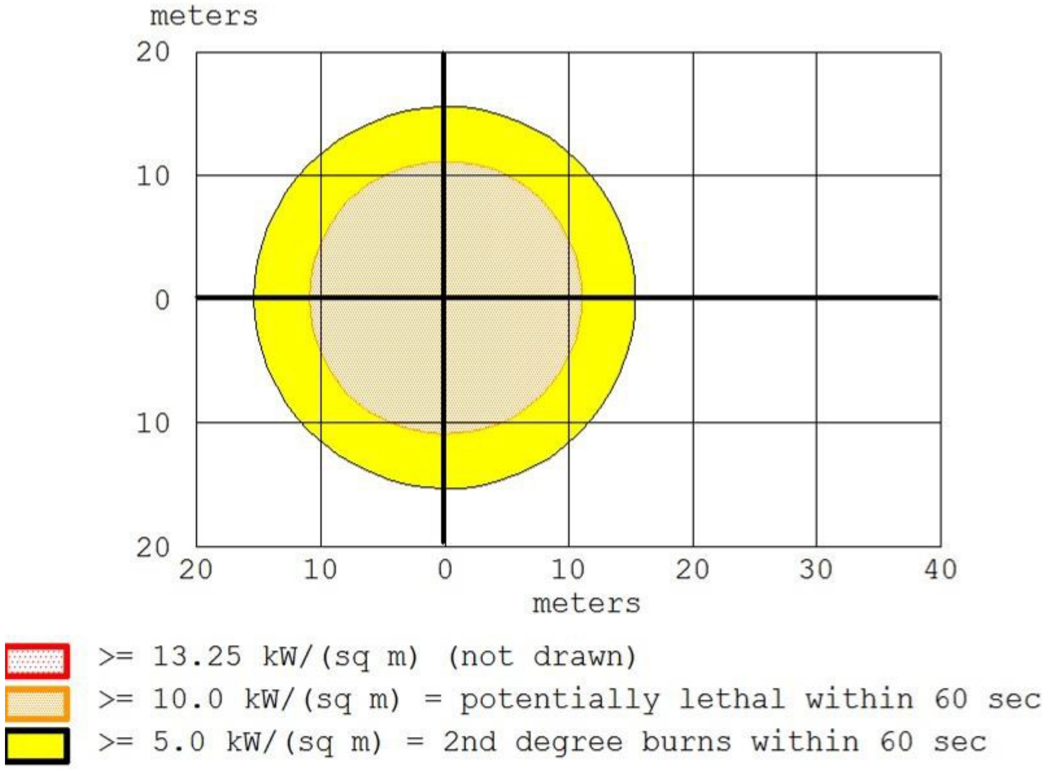
Based on these threshold values, effect distances were calculated to delineate different threat-zones for each reference scenario. The analysis made use of the ALOHA model, one of the most commonly used effect models to generate the consequence effects showing the estimated distances for each scenario considered to a specified hazard end-point. These zones are displayed on a single Threat Zone plot displayed as red, orange and yellow with red representing the worst hazard. The threat zone displayed by ALOHA represent thermal radiation levels and also indicates the effects on people who are exposed to those thermal radiation levels but are able to seek shelter within one minute.

Predominant local meteorological conditions and composition of the natural gas as provided during discussions with ONGC personnel was also considered for this study. Nearly about 98% of the CBM gas is constituted by methane with ethane representing the remaining 2%.

Case I: Release of CBM gas from valves/flanges of GCS – hole size (1"dia)

The jet fire threat zone plot for release and ignition of flammable CBM gas from GCS facility valves/flanges leak of size - diameter 1 inch is represented in **Figure 1.7** below.

Figure 1-7: Threat Zone Plot For Jet Fire - 1'' Dia Leak



THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

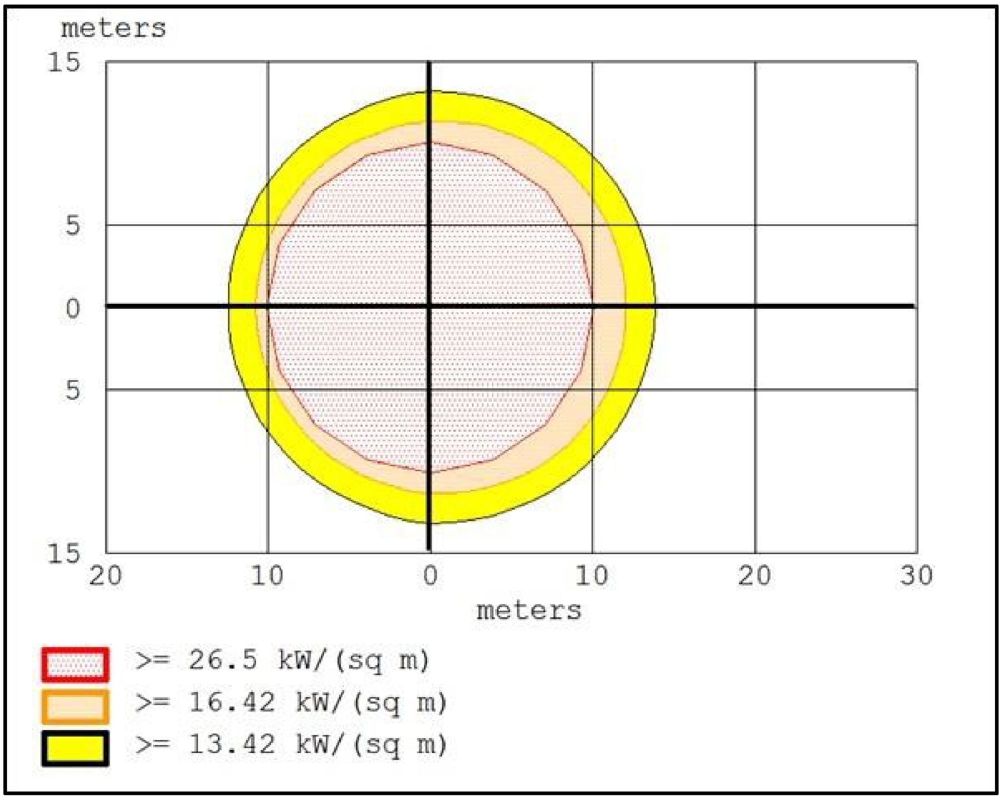
Orange: 11 meters --- (10.0 kW/ (sq m) = potentially lethal within 60 sec Yellow: 16 meters --- (5.0 kW/ (sq m) = 2nd degree burns within 60 sec

Taking into consideration established probit values that are linked to fatality caused by thermal radiation from fire, no endpoint distances have been computed below thermal radiation of 13.42 kW/sq.m.

Case II: Ignition of natural gas from complete rupture of 4" pipeline

The complete rupture of 4" pipeline will result in the release of methane gas (in gaseous phase) the ignition of which is likely to result in jet fire. The threat zone plot of jet fire resulting from pipeline rupture is derived using ALOHA and represented in **Figure 1.8**.

Figure 1-8: Threat Zone Plot For Jet Fire - 4” Pipeline Rupture



THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire resulting from full bore rupture Red : 10 meters --- (26.50 kW/ (sq m) = 50% fatality

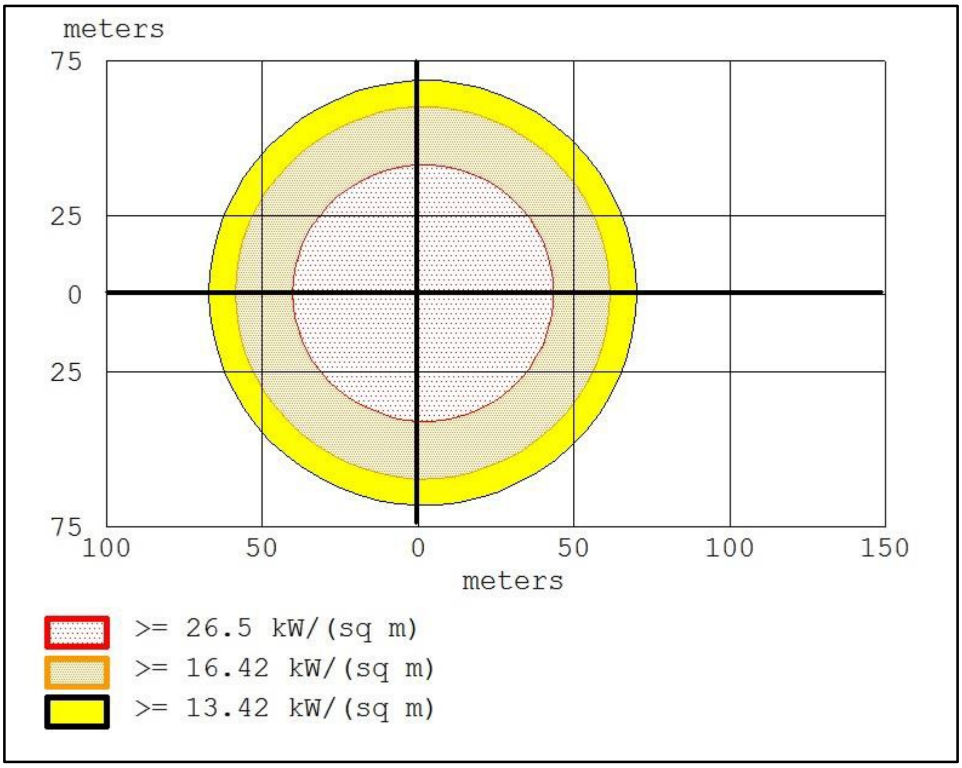
Orange: 12 meters --- (16.42 kW/ (sq m) = 10% fatality Yellow: 14 meters --- (13.42 kW/ (sq m) = 1% fatality

The worst hazard for release and ignition of natural gas from complete rupture of 4" dia pipeline will be experienced to a maximum radial distance of 10 m from the source with 50% fatality.

Case III: Ignition of natural gas from complete rupture of 18” pipeline

The complete rupture of 18” pipeline will result in the release of methane gas (in gaseous phase) the ignition of which is likely to result in jet fire. The threat zone plot of jet fire resulting from pipeline rupture is derived using ALOHA and represented in **Figure 1.9**

Figure 1-9: Threat Zone Plot For Jet Fire - 18" Pipeline Rupture



Threat Zone

Threat Modeled: Thermal radiation from jet fire resulting from full bore rupture

Red : 44 meters --- (26.50 kW/ (sq m) = 50% fatality Orange: 62 meters --- (16.42 kW/ (sq m)

= 10% fatality Yellow: 70 meters --- (13.42 kW/ (sq m) = 1% fatality

The worst hazard for release and ignition of natural gas from complete rupture of 18" dia pipeline will be experienced to a maximum radial distance of 44 m from the source with 50% fatality.

For various hypothetical scenarios considered with respect to proposed CBM development project, the threat zones calculated using ALOHA for defined thermal radiation intensities have been presented in the **Table 1.12** below.

Table 1-12: Threat Zone Distance For Hypothetical Risk Scenarios

Case No	Pipeline Failure Case	Hole Size (inch)	Distance to 26.50 kW/m^2 (m) – 50% fatality	Distance to 16.42 kW/m^2 (m) – 10% fatality	Distance to 13.42 kW/m^2 (m) – 1% fatality
I	Valves/flanges leak	1.00	<10	<10	<10
II	4" pipeline rupture	4.00	10	12	14
III	18" pipeline rupture	18.00	44	62	70

Modeling Risk of Overpressure from Vapour Cloud Explosion

A flash fire is the most likely outcome upon ignition of a dispersing vapour cloud from a natural gas release. If ignited in open (unconfined) areas, pure methane is not known to generate damaging overpressures (explode). However, if the gas is ignited in areas where there is significant degree of confinement and congestion an explosion may result.

Although an unconfined explosion is considered to be unlikely for the proposed project an effort has been made to establish the overpressure (blast force zone) that may result from delayed ignition of vapour cloud generated from any such accidental release from ruptures. For overpressure risk modeling using ALOHA a delayed ignition time of 15 minutes was considered of the vapour cloud mass. However the threat modeled revealed that Level of Concern (LOC) was never exceeded that may possibly lead to loss of life within the blast radius. This is in agreement with the earlier assessment that no damaging overpressure is likely to be generated from unconfined ignition of natural gas vapour cloud. The results have been provided in **Figure 6.10** below

Figure 1-10: VCE Modeling Results for Overpressure

```
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Time of Ignition: 15 minutes after release begins
Type of Ignition: ignited by spark or flame
Level of Congestion: congested
Model Run: Gaussian
No explosion: no part of the cloud is above the LEL at the given time
```

1.2.6 Individual Risk

Individual risk is the probability at which an individual may be expected to sustain a given level of harm from the realization of specified hazards. In simple terms it is a measure to assess the overall risk of the area concerned thus to protect each individual against hazards involving hazardous chemicals, irrespective of the size of the accident that may occur. Graphically it represents as iso-risk contour which connects all of the geographical locations around a hazardous activity with the same probability of fatality.

In order to generate different level of iso-risk curves for the area concerned, it is required to estimate the respective contribution of each reference scenario. Accordingly, individual risk of each scenario was estimated by combining the frequency of the initiating event, the conditional probability of that scenario sequence and the Probit value of the effect footprints. In particular following expression was used to estimate the Individual Risk (IR) at a given geographical location for each reference scenario:

………………………………………………………………………………………… (Eq. iv)

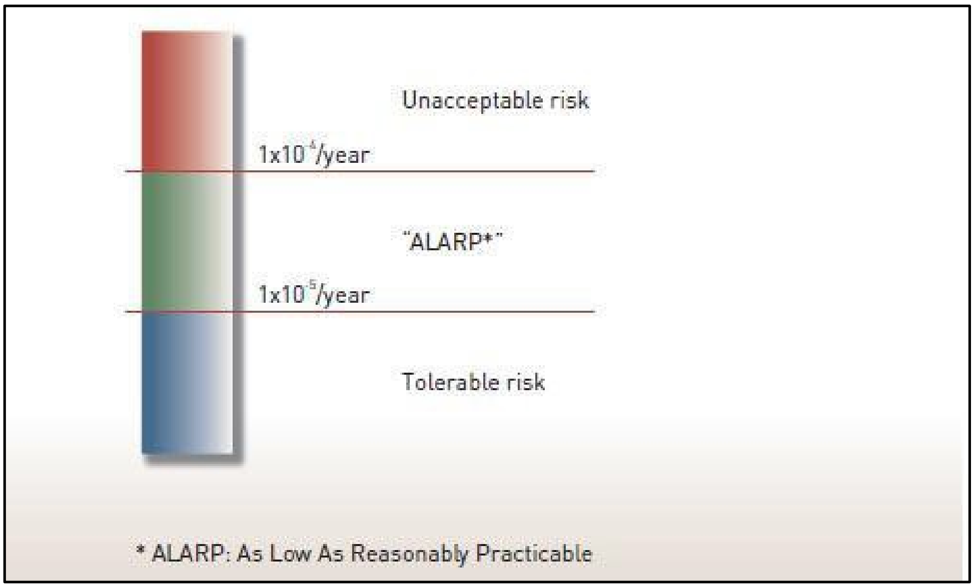
where

- f_i is the frequency of the accident scenario i (year^{-1}); calculated as multiplicative factor of the frequency of the initiating event and the probability that the sequence of events leading to the accident scenario i will occur: $f_i = f_{incident\ i} . P_{sequence\ i}$

- PF_i is the probability of fatality that the accident scenario i will result at location (i.e. Probit).

The individual risk so obtained is then compared with the Tolerance Criteria of Individual Risk as provided in the **Figure 1.11** below.

Figure 1-11: Tolerance Criteria for Individual Risks



Hence for the proposed project the individual risk has been considered only for pipeline rupture as no predicted fatality has been established for the consequence modeling undertaken for CBM gas release ignition from valves/flanges of the GCS facility. Based on the above equation the individual risk as calculated including the tolerance criteria has been presented in the **Table 1.13** below.

Table 1-13: Individual Risk – Pipeline Rupture

Accident Scenario Frequency	Fatality Probability	Individual Risk	Individual Risk Criterion
4 inch Pipeline Rupture			
4.009×10^{-5}	0.50	2×10^{-5}	ALARP
4.009×10^{-5}	0.10	4×10^{-6}	Tolerable
4.009×10^{-5}	0.01	4×10^{-7}	Tolerable
18 inch Pipeline			
1.269×10^{-4}	0.50	6.3×10^{-5}	ALARP
1.269×10^{-4}	0.10	1.2×10^{-5}	Tolerable
1.269×10^{-4}	0.01	1.2×10^{-6}	Tolerable
1.269×10^{-4}	0.50	6.3×10^{-5}	ALARP

1.4 DISASTER MANAGEMENT PLAN

1.4.1 Objective

The primary objective of the DMP is to provide a safe, timely, effective and coordinated response by the onsite Emergency Response Team (ERT), along with the other local and government agencies/departments to prevent or minimize any major emergencies that may arise from possible failures/risks viz. blow outs, oil spill, fire & explosion etc. associated with exploratory and development drilling.

The main objectives of this plan are:

- To minimize the risk for human life, environment and common property resources, by means of an effective and efficient intervention;
- Protection of the environment;
- Protection of public safety;
- To initiate the early and efficient response throughout the utilization of all available resources.

1.4.2 Purpose

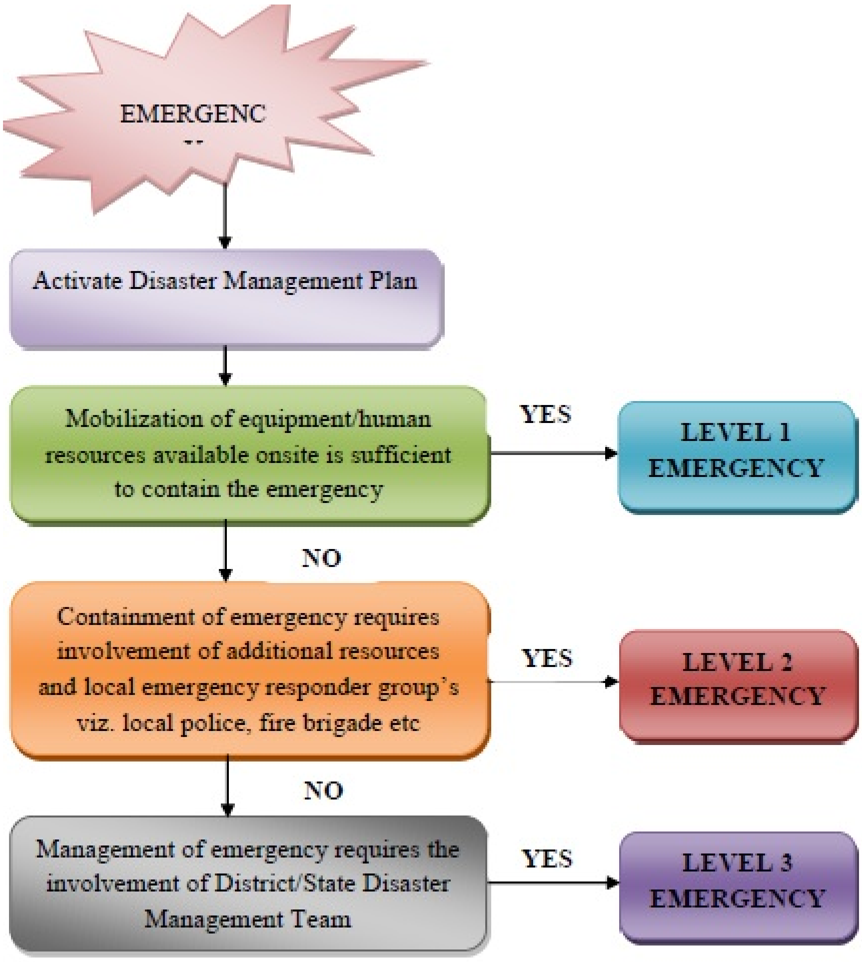
The purpose of the DMP is to effectively manage and control the emergencies occurring during project operations. This DMP ensures,

- emergency response group is effective & adequate;
- clear roles and responsibilities of key personnel & support groups;
- availability and adequacy of emergency infrastructure & resources; and
- efficient emergency communication

Emergency Classification

Due consideration is given to the severity of potential emergency situation that may arise as a result of storage tank and pipeline accident events as discussed in the Quantitative Risk Analysis (QRA) study. Not all emergency situations call for mobilization of same resources or emergency actions and therefore, the emergencies are classified into three levels depending on their severity and potential impact, so that appropriate emergency response procedures can be effectively implemented by the ONGC Emergency/Crisis Management Team. The emergency levels/tiers defined with respect to this project based on their severity have been discussed in the subsequent sections with 'decision tree' for emergency classification being depicted in **Figure 1.12**

Figure 1-12: Emergency Classification Of "decision Tree"



1.4.3 Level 1 - Emergency

An event that can be dealt with by on-site/location personnel and resources; the event does not have any effect outside the site and external agencies are unlikely to be involved. There is unlikely to be danger to life, to the environment, or to Company assets or reputation. The Disaster Management Plan and relevant procedures are activated; the Site Head is notified.

1.4.4 Level 2 - Emergency

It is an event which may be dealt by the ONGC Emergency/Crisis Management Team but requires involvement of wider Company support and external services. The initial event may be "on-site", having some effects outside the site or be "off-site", and external emergency services will be involved. There is likely to be a danger to life, the environment, or company assets or reputation. The Disaster Management Plan and relevant procedures are activated;

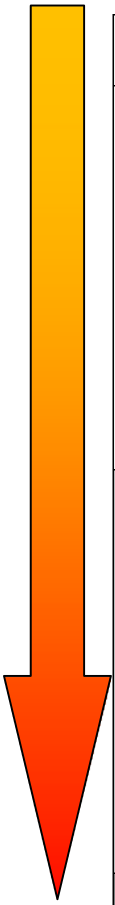
local administrative bodies and Emergency Response Groups including ONGC Corporate are notified.

1.4.5 Level 3 - Emergency

It is a major event which requires the involvement of District or State Crisis Management Group. For Company this may result from insufficient local resources and/or because the incident has broader implications such as reputation, legal prosecution, financial loss etc. Under such circumstances, the Disaster Management Plan is activated; ONGC Corporate, District/State Administrative Authorities and other Emergency Response Groups are notified.

The criterion for classification of various levels of emergencies and associated response has been presented in the **Figure 6.13** below.

FIGURE 1-13 Emergency Response Levels



Level	Type	Criteria for Classification
1Level 1	2Small	• Minor medical or injury case requiring no external support • Equipment damage without any significant impact on operation • Minor fire without any personnel injury or plant damage • Net negative financial impact of <1 crores. • Small operational spills • No potential impact on flora and fauna of identified eco-sensitive areas. • Local stakeholder concern and public attention
3Level 2	4Medium	• Fire and explosion which requires external assistance • Requires evacuation of injured personnel and locals through assistance from local emergency groups. • Loss of corporate image and reputation • Adverse impact on environmental sensitivities (if any) within a radius of 1km. • Medium sized spills • Net negative financial impact of 1 - 5crore
5Level 3	6Large	• Incident leading to multiples injuries or fatalities • Requires assistance from District/State emergency responding groups. • Adverse impact on environmental sensitivities (if any) within a radius of >1km. • Major oil spills • State/nationwide media coverage • Net negative financial loss of >5crore

1.4.6 ONGC Disaster Management Plan

ONGC has in place a Disaster Management Plan which has been developed to set up the appropriate mechanism and course of action to mitigate the impact of an Emergency event viz. blow out, fire, explosion etc. The plan provides a procedure allowing all those involved in and outside ONGC to mobilize their resources in an orderly manner and react effectively in time. The plan therefore, aims at immediate response to an Emergency event to prevent escalation to a Disaster and also the response in the event of such escalation. The plan will be updated as and when necessary, but at least once in every year by Basin HSE in consultation with Surface Team, Sub surface Team, Drilling Services and Well Services Group. Also ONGC has been accredited with ISO 9001:2008; 14001:2004 and OHSAS 18001.

The roles and responsibilities of both ONGC emergency response team to combat with any emergency situation as discussed in the earlier section are presented in the **Table 1.13** below while the details of the resources available onsite with the Crisis Management Team to control key emergency events particularly blow outs has been presented in **Annexure XX**

Table 1-14: ONGC On - Site Disaster Management Team Profile

S.N.	Response Team/Resource	Location	Facilities	Functions
1	Site Control Room	In case of Emergency at site, a Site Control Room will be set up at a safe distance near the Site.	Emergency vehicle, Communication facilities, Mobile Van, Ambulance, Lighting arrangement and Food shall be provided at the SCR in the minimum possible time.	• Assessment of situation and requirements, tor mobilization of equipment / resources etc. • To pass on the information regarding latest positions to Emergency Control Room. • To keep record of all decisions and messages received • To keep records of all materials received at site during Emergency.
2	Emergency Control Room (ECR)	The control room will function from Drilling Services (DBC) Control Room.	To 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.	• Command and control of entire operations. • Round the clock monitoring and flow of information to & from the site of emergency. • Maintenance of running record of events and action taken • Casualty list and information to next if Kin. • Preparation of Management report on the situation at every 12 hrs. interval. • Co-ordination with the key personnel's for guidance and assistance required at site. • Co-ordination with other oil companies • Co-ordination with local authorities — Police, Civil Administration, Hospital & Fire. • Sanction and procurement of the items required during emergency. • Arrangement of food, water, shelter, medicine& logistics etc., • Information to public.

S.N.	Response Team/Resource	Location	Facilities	Functions
				• Co-ordination -with regions / projects and Head — Quarter. • Co-ordination with fire brigade & fire tender facilities available with different organizations nearby.
3	On Scene Commander (OSC)	At initial stage, someone close enough to the scene of Emergency (Installation manager / DIG / senior most person) will exercise as On Scene Coordinator. He will take the charge of the situation immediately.	-	• Initial assessment at the spot and need for mobilization of sources. • Inform Emergency Control Room in case, the communication is lost due to disaster. Seek assistance from nearby rig or installation for communication. • In case of fire, commands the firefighting operations till tire service assistance reaches on the scene. • Arrange ambulance & doctor if required.
4	Chief Emergency Coordinator	The Head of the concerned Operational Group will be the Chief Emergency Coordinator and will exercise control through ECR.	-	Will keep record of messages and decisions taken to control the Emergency. He will also appraise the Basin Manager from time to time on steps taken to control the situation and status of emergency.
5	Regional Crisis Management Team (RCMT)	Regional Crisis Management Team comprises of officers having experience in handling major emergency. The RCMT is expected to be informed within 30 minutes of occurrence of incident by the Mines Manager / Emergency Control Room. The Team will immediately proceed	-	• Familiarize itself thoroughly with the manual and its implications. • To plan strategies for different Crisis situation so that all necessary inputs can be mobilized without loss of time. Frequent mock drill be carried out. • In the event of crisis, go to the scene of emergency, assess the situation and take over all fronts out and / or fire up o the point of normalizing the well.

S.N.	Response Team/Resource	Location	Facilities	Functions
		to the location and take action to bring the situation under control.		• Determine the type of assistance required for handling the emergency. • To seek guidance and assistance from coordinator group. • Updating the action plan of disaster management on the basis of their experience. • Keep them well informed of the technical development through various journals/ magazines, suggest scope of improvement in equipment and practices.
6	Support Services Group	The Support Services Group will comprise of coordinators from Central Workshop, Electrical, Civil, Logistics, E&T, Health Services and P&A, Geology and Reservoir etc. They will provide all necessary help required by emergency control room / Site Control Room / RCMT and be in constant touch with Emergency Control Room and may have to stay at the site of Emergency	-	• Support Manager • To identify location of relief camp at a safe distance from the affected area and arrangement for shelter (tent, cot, chair, blanket etc.) • To arrange food, drinking water, beverage at relief camp • Maintenance of record of casualties • Co-ordinate with local authorities. • Fire Services • Mobilize firefighting person and equipment onsite. • Information & communication manager • Ensure communication facilities. • Set up Emergency communication (Walkie-talkie, VHF etc.) at the site control room. • Electrical • Arrangement of Emergency Gen. set and flame proof lighting at the site. • Logistics • Arrangement of transport facilities, cranes, moles etc. for man and material.

S.N.	Response Team/Resource	Location	Facilities	Functions
				• Material Management • To assist in issuing of materials • Arrangement of equipment, materials, expertise etc., as per requirement of Emergency Control Room / RCMT. • Civil • Civil jobs such as construction of temporary road, control of Oil spread by sand bags or digging of pits, water pumping and storage arrangement etc. • Security • Deployment of Security personals at vulnerable locations. • Cordoning off the affected site. • Police Help • Sub surface Team (Geology & Reservoir) • To assist in Geological / Reservoir information about the well • Medical Services • Mobilize first — aid team with adequate medical facility and ambulance at Emergency site. • Corporate Communication (PRO) • Press briefing with approval of basin manager

For Level 3 emergency (refer **Figure 1.13**) apart from the mobilization of onsite Emergency Response Team as referred above ONGC also need to activate the off-site Disaster Plan to safeguard the lives and properties of nearby communities with the assistance/support from local/district authorities.

Local/District Authorities – Roles and Responsibilities

I. Deputy Commissioner/ Addl. Deputy Commissioner

- Take overall responsibility for combating the Off-site Emergency,
- Declare an area of 2 km around the site as Emergency zone.
- Direct the District Police, Fire services for warning and evacuating the public.
- Direct the team of Doctors headed by the District Medical Officer to attend the affected people.
- Direct the Revenue Officer of the District to provide safe shelter, food and other life sustaining requirements for the evacuees.
- Direct the District Transport Officer to arrange for transportation of victims and evacuation of the people trapped within the Emergency zone.

II. Superintendent of Police

- Mobilize force to the site of Emergency on receipt of instruction from DC / Addl. DC to cordon off the affected site / area and disperse the unwanted crowd for easy fire fighting operation / rescue operation.
- Post adequate nos. of Police personnel in the following places.
- In all the evacuated areas to provide security to the properties of the evacuees.
- In the entire Road junction outside the emergency zone to control traffic and priority for movement of fire tender ambulance etc.
- Warning and advising the affected population through unambiguous, reliable and rapid announcement by the SDIPRO/DIPRO. The information to be given to the public should be the nature of the incident, the degree of the incident; the steps taken to control the situation and the Emergency counter measures. The announcement shall be both in Assamese and Hindi.
- Liaison with the Medical co-coordinator for post mortem of the dead bodies, if any,
- Any other action as desired by the Dy.

Commissioner. III. District Transport Officer

On receipt of the request from Emergency Control Room, ONGC, the Transport Officer shall arrange for the dispatch of vehicle to reach the Emergency site immediately. The dispatched vehicle shall be at the disposal of ONGC until the release order is issued. He also takes up the action as directed by the Dy. Commissioner / Addl. Dy. Commissioner.

IV. District Medical & Health Officer

On receipt of information form Dy. Commissioner / Addl. Dy. Commissioner about the Emergency, the District Medical Officer shall extend the facilities available at the Hospital and make the services of the trained doctors to provide necessary medical care for Emergency medical cases. He shall ensure that the Primary Health Centers & Municipal Dispensaries are equipped with required quantities of drugs & equipment's.

V. District Fire Officer

Shall assist in Fire Fighting in case of Off-site Emergency and rescue operations in the affected area with the help of Civil defense / Home guards etc.

VI. Officer in-charge of Relief Camp

An officer in the cadre of Revenue Inspector shall be the In-charge of the Relief camps. He shall maintain a record of the evacuees under the headmen, women and children. The department concerned at the Relief Camps shall provide the following facilities.

Sanitation: This is very important at the Relief Camps. A team of Sanitary Inspector shall attend the camp round the clock. Latrine facilities shall be provided.

Water: Municipal Board shall arrange storage of Water.

Lights: Assam Electricity Beard shall arrange Electric Lights at the Camp. VII. District Veterinary & Animal Husbandry Officer

Shall depute as many persons as required (taking in to account the number of Cattle especially milking animals in the affected areas) to look after the welfare of the cattle and protect their lives by applying precautionary measures. He shall also be responsible for arranging food for the Cattle during Emergency.

VIII. District Agriculture Officer

Will prepare an action plan to protect the food grains / standing crops in the Emergency affected area and will take action accordingly.

IX. Station Director (Door-Darshan)

On receipt of the message from the Superintendent of Police, he will immediately telecast the Emergency message as given by the Police authority, if required. Similarly, he will also arrange to telecast periodic review message and completion of Emergency / all clear message.

The section below highlights the sequential action to be performed by the ONGC Emergency Response Team along with drilling personnel under various emergency situations viz. blow outs, fire and explosion etc.

❖ *Action Plan – In event of Blow Outs*

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, it BOP fails to seal Well Mouth*

1	Alert Crew to ensure escape if situation worsens Action : Shift I/C
2	Divert flow partially, intermittently or fully to waste pit (safe distance) Action : Drilling Crew
3	Send SOS message (i) By EPABX (ii) By Emergency Vehicle Action Shift I/C
4	Switch off all Engines / Generators Action: I/C Mech. / Elect.
5	Remove all inflammable material away Action: Rig Crew (Drilling / Mech. / Elect.)
6	Remove important Records to Safe place Action: Rig Crew (Drilling / Mech. / Elect.)
7	Remove costly instruments / equipments to safe place Action: Rig Crew (Drilling / Mech. / Elect.)

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

1	Carry out rescue operation for Top man and move other Rig Crew to safe distance. Action : Shift I/C
2	Send SOS message by Phone and by Emergency vehicle Action : Shift I/C
3	Reorganize to try operations like BOP, Diversion of flow etc., as listed in (A), if situation permits, Action : Shift I/C
4	If heavy spillage occurs, try to contain in the restricted area Action : Shift I/C
5	Alert the inhabitants, if private residence is near Action : Geologist / Chemist

As soon as an Emergency is declared and the site is evacuated, Site Control Room will be established near the drill site at a safe distance.

❖ ***Action Plan – Process Leak / Loss of control resulting in Fire and Explosion***

1	Shout "FIRE", "FIRE", "FIRE", "AAG", “AAG", “AAG", "JUI', "JUI', "JUI”,.... In case of fire
2	Inform Shift. In-charge/Site In-charge at first site of Fire / heavy Gas leakage / Oil spill Action: Person who notices the incident first.
3	Inform Field Fire Station, Base Fire Station and Base Control Room Action: Shift I/C. Site I/C.
4	Identify the Source of leakage, isolate and attempt to extinguish tile Fire with hand held Fire Extinguisher. Action: Shift I/C. Site I/C.
5	Nearby source of ignition should be cut off immediately (like stoppage of the cutting / welding jobs, stopping engines, switching off the Electricity etc. Action: Shift I/C. Site I/C. Elect. I/C. Mech. I/C.
6	Start Fire water pumps and pressurized Fire Header to extinguish Fire Action: Mechanics / Shift Operator
7	Inform other GGS to stop supply of Oil & Gas to the affected Installation. Action: Shift I/C. Site I/C.
8	If needed, close all wells and shut down the Installation under Emergency conditions. Action: Shift I/C. Site I/C.
9	Release over pressure wherever required. Action: Shift I/C. Site I/C.
10	Inform nearby Installation for Help. Action: Shift I/C. Site I/C.
11	If heavy spillage occurs, try to contain in the restricted area. Action: Shift I/C. Site I/C.
12	Fire crew In-charge after arriving at Site will report to the Shift in-charge /Installation In-Charge and access the situation and position the Fire tender at appropriate place from where it can be fought effectively. Action: Fire Crew I/C.
13	The quantum of spillage / Gas leakage shall be briefed by the installation I/C to Fire in-charge for Fire fighting Action: Fire Installation I/C.
14	Cooling and quenching of nearby pressure vessel / tanks to be carried out Action: Fire crew
15	All persons present at the site should assist the Fire crew in tire fighting. Action: All persons present at site
16	Continuous monitoring of Gas concentration should be done. Action: Safety Officer/Asst. Shift I/C

17	Entry at Main Gate should be regulated and Contract personals should be removed from the affected site by CISF. Action: Area Commander CISF
18	Pass the information and progress to Emergency Control Room at regular intervals. Action: Installation I/C., Field I/C.

ANNEXURE XX: RESOURCES AVAILABLE ONSITE WITH THE CRISIS MANAGEMENT TEAM