RISK ASSESSMENT REPORT FOR PROPOSED PROJECT

CHAPTER-7: ADDITIONAL STUDIES

7.1 RISK ASSESSMENT

7.1.1 General

Industrial activities, which produce, treat, store and handle hazardous substances, have a high hazard potential endangering the safety of man and environment at work place and outside. Recognizing the need to control and minimize the risks posed by such activities, the Ministry of Environment, Forests and Climate control have notified the "Manufacture Storage & Import of Hazardous Chemicals Rules" (MSIHC) in the year 1989 and subsequently modified, inserted and added different clauses in the said rule to make it more stringent. For effective implementation of the rule, Ministry of Environment, Forests and Climate Control (MoEFCC) has provided a set of guidelines. The guidelines, in addition to other aspects, set out the duties required to be performed by the occupier along with the procedure. The rule also lists out the industrial activities and chemicals, which are required to be considered as hazardous.

BSL is engaged the production of Steel from iron ore and other required raw materials. During the process of manufacture of steel and other associated materials hazardous gases are generated which are stored and used in the plant. In addition to this, some other hazardous substances, which are required as feed/fuel in the process or produced as a by-product, will also be stored/handled by BSL. The major substances handled / stored by BSL includes Coke Oven gas (primarily H_2& CH_4), Blast furnace gas (primarily CO), LD Gas (primarily CO, N_2& CO_2), Liquefied Petroleum Gas (LPG)/Propane, etc.

In view of this, BSL's existing and proposed activities are scrutinized in line of the above referred "Manufacture, storage and import of hazardous chemicals rules" and observations / findings are presented in this chapter. An elaborate and well-documented Disaster Management Plan covering all substances/gases handled by BSL for their existing plant covering all the chemicals / gases handled by BSL is already in place. The same shall be upgraded and extended to the units under the expansion programme of BSL.

The assessment has been made in a systematic manner covering the requirements of the above-mentioned rules. Accordingly subsequent sections have been divided as follows:

- Brief Process description
- Applicability of the rule
- Description of hazardous substances
- Hazard Identification
- Hazard Assessment (& hazard scenarios)
- Consequence analysis
- Brief description of the measures taken and
- On site emergency plan

Accordingly next sections are elaborated.

7.1.2 Brief Process Description

BSL is producing steel products via BF- BOF Route of steel making. Iron ore lumps, sinters and coke (made from coking coal) and fluxes such as limestone, dolomite are the major raw materials. The major steps in the manufacturing process are as follows:

- Coke making - coal carbonisation
- Sintering
- Hot metal production (blast furnace)
- Steel production (basic oxygen furnace)
- Continuous casting

The detailed process of each of the aforementioned major activities is elaborated in **Chapter-2** of this report.

The detailed analysis of the plant processes at BSL indicates that the process of Iron & Steel manufacturing via BF-BOF route requires considerable thermal energy. This thermal energy is supplied through fuel gasses generated in the plant e.g. Coke oven gas (COG), Blast Furnace gas (BFG), BOF gas as well as LPG/Propane gas. If there is any shortfall of these generated gasses then fuel gas is also supplied from outside source also.

The present proposal of BSL for expansion will create additional energy requirements, which will be catered to by in-plant COG, BFG, BOFG and/or Mixed Gas. In addition, use of LPG/Propane has also been considered for catering to the cutting requirements of SMS, Caster and auxiliary shops. In addition to these fuel gasses, a number of chemicals are being produced in the by-product plant of Coke Oven. Further Oxygen is also required as mentioned above. Therefore to run the plant, it is required to store and/or handle all these chemicals along with their distribution arrangement.

The expansion-cum modernization programme of BSL primarily envisages replacement as well as installation of new storage facilities such as replacement of existing BOF gas holder (50,000 m^3) in modernized SMS-1, new BOF Gas holder in SMS-II (80,000 m^3),and revamped existing Propane storages of 2 x 100 tonnes within the SMS complex to meet its requirements.

The major hazardous materials to be stored, transported, handled and utilized within the facility have been summarized in **Table 7.1**:

TABLE 7.1: List of Major Hazardous Substances to be Stored /Handled

Sn.	Hazardous substance handled/stored	Quantity handled/ stored	Type of vessel used for handling / storage	Nature of hazard associated
1.	Coke Oven gas[1] (major components being CH_4, H_2 and CO)	2.5 tonnes handled via in-plant piping network	In-plant Steel pipelines to new Gas Mixing Station (GMS)	Flammable gas
2.	Blast Furnace Gas[2]	86 tonnes handled via in-plant piping network	In-plant Steel pipelines to new GMS.	Flammable gas
3.	Mixed Gas[3]	81 tonnes handled via plant piping network	In-plant Steel pipelines from new GMS.	Flammable gas
4.	BOF gas[1]	102.1 T + 63.8 T = 165.9 Tonnes stored in 02 BOF Gas holders	Stored in steel Cylindrical shaped gas holder (Wiggin's type) with Dry Rubber seal and handled via In-plant Steel pipelines	Flammable gas
5.	Propane	2 x 100 T = 200 Tonnes stored in 02 bullets	Horizontally placed steel Bullet with hemispherical ends.	Flammable pressurized liquid

Note:[1]*Coke Oven Gas density as 0.499 kg/m*^{3} *calculated at 25°C, 1 atm pressure conditions considering tentative gas mixture composition*
[2]*Blast Furnace Gas density 1.145 kg/m*^{3} *as calculated at 25°C, 1 atm pressure conditions considering tentative gas mixture composition*
[3]*Mixed Gas density as 1.08 kg/m*^{3} *calculated at 25°C, 1 atm pressure conditions*
[4]*BOF Gas quantity computed considering density as 1.37 kg/Nm*^{3}

7.1.3 Applicability of the Rule

As per MSIHC Rules, 1989 with subsequent amendments, the galvanization process is classified as an "industrial activity" storing/handling hazardous substances.

To decide whether the above mentioned industrial activities/substances are likely to come within the scope of the above mentioned "Manufacture Storage and Import of Hazardous Chemicals Rules, 1989 & subsequent amendments", the threshold quantities mentioned in the rules are used for comparison, as given in **Table 7.2.**

TABLE 7.2: Threshold Quantity &Identified Hazardous Substances to be Handled as per MSIHC Rules, 1989& Subsequent Amendments

Sn	Hazardous substance handled/ stored	Maximum Quantity handled/ stored	Whether Included in The List of Hazardous & Toxic Chemicals	Type of vessel used for handling / storage	Lower Threshold Qty. (In Tonne) *[For rules 5,7 to 9 & 13 to 15]*	Upper Threshold Qty. (In Tonne) *[For rules 10 to 12]*	Remarks
1.	Coke Oven gas	**2.5tonnes** handled	**Yes**, As per Sch. 3(i)	In-plant Steel pipelines to new Gas Mixing station (GMS)	15	200	***Below the lower threshold limit.*** *Does not require additional However, consequence analysis carried out due to COG's high flammability potential*
2.	Blast Furnace Gas	**86 tonnes** handled	**Yes**, As per Sch. 3(i)	In-plant Steel pipelines to new GMS	15	200	***Exceeds lower threshold limit but below upper threshold limit.*** *Consequence analysis required to be carried out.*
3.	Mixed Gas	**81 tonnes** handled	**Yes**, As per Sch. 3(i)	In-plant Steel pipelines from new GMS	15	200	***Exceeds lower threshold limit but below upper threshold limit.*** *Consequence analysis required to be carried out.*

Sn	Hazardous substance handled/ stored	Maximum Quantity handled/ stored	Whether Included in The List of Hazardous & Toxic Chemicals	Type of vessel used for handling / storage	Lower Threshold Qty. (In Tonne) *[For rules 5,7 to 9 & 13 to 15]*	Upper Threshold Qty. (In Tonne) *[For rules 10 to 12]*	Remarks
4.	BOF gas	102.1 T + 63.8 T = **165.9 Tonnes** stored in 02 BOF Gas holders	**Yes**, As per Sch. 3(i)	Steel Cylindrical shaped gas holder (Wiggin's type) with Dry Rubber seal and handled via In-plant Steel pipelines	15	200	***Exceeds lower threshold limit but below upper threshold limit.*** *Consequence analysis required to be carried out.*
5.	Propane	2 x 100 T = **200 Tonnes** stored in 03 bullets	**Yes**, As per Sch. 3(i)	Horizontally placed steel Bullets with hemispherical ends.	15	200	***Equal to upper threshold limit.*** *Consequence analysis required to be carried out.*

After comparison of the stored / handled and threshold quantities, it can be noticed that BOF gas and propane exceed the lower threshold limits and come under the purview of MSIHC Rules, 1989 amended in 2000. Accordingly, Rule-7 i.e. notification of site requires submission of a written report containing among other information the followings:

- Identification of major accident hazards
- The conditions or events which could be significant in bringing one about
- Brief descriptions of the measures taken
- Area likely to be affected by the major accident etc.

Further, rule 17 i.e. preparation and maintenance of material safety data sheets are required for both the substances.

Owing to the hazardous nature of BOF gas, Mixed gas and propane, consequence analysis of the facility has been done, taking in consideration all hazardous substances identified at Table 7.2 above. MCAA (maximum credible accident analysis) approach ash been used to identify plausible worst case scenarios for hazard identification and risk assessment. As per Rule-17 of the MSIHC Rules-1989 amended in 2000, the material safety data sheets for identified hazardous substances are provided at **Annexure 7.1**.

7.1.4 Description of Hazardous Substances

The hazardous substances which are expected to be handled, are presented in Table 7.2 above. The Material Safety data sheets of different hazardous substances identified in the table are presented in **Annexure 7.1**. The brief nature of identified hazardous substances is described in the following paragraphs.

Coke Oven Gas: It is a flammable gas which is proposed to be used as fuel in the plant and is primarily a mixture of Hydrogen (55-56%), Methane (27.3-27.8%) and Carbon monoxide (7.3-7.6%). Coke Oven gas will be generated from existing Coke Oven batteries as well as proposed new coke oven battery, which will be transported via the gas network using pipelines, directly to the consumer units of BSL. Since, the gas is not proposed to be stored within the BSL complex, the risks associated with gas leakage and explosion are very low. A regular inspection of pipelines and maintenance operations along with installation of pressure detection systems in the pipelines will ensure no occurrence of pipeline failure. The physical & chemical properties of Coke Oven gas are given below:

PHYSICAL PROPERTIES*		
Form	:	Gas
Colour	:	Colourless
Odour	:	Characteristic phenolic with a trace of hydrogen sulphide
Density	:	0.42 kg/m³ at NTP
Molecular weight	:	~170 g/mol
Lower explosion limit (LEL)	:	4.0 %
Upper explosion limit (UEL)	:	30.0 %
Flash point	:	<60°C
Solubility in water	:	Slightly soluble in water
Toxicity	:	Acutely toxic if inhaled
Flammable nature	:	Extremely flammable
Based on tentative data sourced from Material Safety Data Sheet of Clean Coke Oven Gas		

CHEMICAL COMPOSITION* (mol %)		
Carbon Dioxide (CO_2)	:	2.6 – 2.8
Carbon Monoxide (CO)	:	7.3 - 7.6
Hydrogen (H_2)	:	55 - 56
Methane (CH_4)	:	27.3 - 27.6
Nitrogen (N_2)	:	4.4 - 4.8
Oxygen (O_2)	:	0.4
Other higher hydrocarbons (C_nH_m)	:	2.1 – 2.2
Based on typical data for Clean Coke Oven Gas		

The toxic component of the Coke Oven gas is listed below:

Sn.	Chemical Component	Max quantity	Quantity in % by wt.
1.	Carbon Monoxide (CO)	7.8 % by mole	~1.20
2.	Ammonia (NH_3)	0.05 g/Nm³	~0.012
3.	Hydrogen sulphide (H_2S)	0.85 g/Nm³	~0.20
4.	Naphthalene	0.1 g/Nm³	~0.024

The high concentration of hydrogen and methane in COG suggests that the gas can be ignited by a low ignition energy (e.g., static). Therefore, the probability of ignition of COG leaks is likely to be high relative to other flammable gases. COG is a corrosive gas due to the presence of hydrogen and sulphides. This has significant implications for the maintainability of COG systems, because COG pipework frequently develops small corrosion holes.

Blast Furnace Gas (BFG): BFG is a by-product of the iron making process and is used as a fuel gas. It is an odourless, colourless and toxic gas. Its toxicity is mainly due to the presence of carbon monoxide (CO) (typically 21-25% v/v) in the gas. In confined space, it can form an explosive mixture.

BFG is a low heating value fuel (CV=800-900 Kcal/Nm³), containing approximately 56-58% nitrogen, 17-26% carbon monoxide and 18-20% carbon dioxide. Therefore, the gas is only likely to support stable combustion at elevated temperature, or with a permanent pilot flame. BFG may be ignited by a high ignition source such as a welding torch. However, the resulting combustion is slow.

BFG is not typically considered an explosion hazard for the following reasons:

- Very high ignition energies are required to initiate BFG combustion;
- High concentration of inerts (N_2 & CO_2) in the gas; and
- Very low combustion energy (3.2 MJ/m³).

BOF Gas (BOFG): Convertor gas or BOF gas, typically has a high carbon monoxide content, low combustion speed and is very harmful. It has got a calorific value which varies in the range of 1600 to 2400 kcal/Nm^3 of the gas. It is the function of the air ratio. Lower is the air ratio higher is the calorific value, since nitrogen percentage of the gas reduces. Lower air ratio also means lower specific yield of the gas. Density of Convertor gas is 0.865 kg/m^3.

Convertor gas is highly poisonous and explosive and requires high degree of disciplined operation at the time of recovery .The gas is invisible and colourless. It cannot be detected by odor. It can readily form explosive mixtures with air, which are easily ignited by a static charge. Therefore, any leakage from flanges, valves and joints, may lead to severe explosion in the area resulting in fatal accident. Any ingress of external air or oxygen can also cause explosion in the system. So, supreme care is needed to avoid any kinds of leakage in the recovery, transportation as well as the utilization of the Convertor gas.

The physical & chemical properties of BOF gas is given below:

PHYSICAL PROPERTIES*		
Form	:	Gas
Colour	:	Colourless
Odour	:	Not distinctive
Density	:	1.37 kg/Nm^3
Toxicity	:	Acutely toxic if inhaled
Flammable nature	:	Flammable gas

CHEMICAL COMPOSITION* (mol %)		
Carbon Dioxide (CO_2)	:	16.7
Carbon Monoxide (CO)	:	54.3
Hydrogen (H_2)	:	0.7
Nitrogen (N_2)	:	27.3
Oxygen (O_2)	:	1.0
		**Based on typical data for BOF gas*

BSL's expansion-cum-expansion plan envisages a new BOF gas holder in SMS-II of 80,000 m^{3}capacity and replacement of existing BOF gas holder in modernized SMS-I of 50,000 m^3 capacity. Both of these are situated within the existing SMS complex of BSL.

Mixed gas: Mixed gas is a homogenous mixture of Coke Oven Gas, Blast furnace gas and sometimes, BOF gas. Its chemical and physical properties are similar to BF gas. The Mixed gas to be used by BSL for the proposed facility will be a mixture of BFG and COG.

A new Gas mixing station is proposed to be installed for the new Coke Oven Battery 9 of BSL, which is designed to handle a total capacity of 75,000 m^3/hr of mixed gas. Proposed new pipelines carrying Coke Oven gas as well as Blast furnace gas will be proportioned using control valves and mixed via conventional gas mixing (in-pipe mixing) method to generate Mixed gas of desired calorific value.

Propane: It is a primarily handled in liquefied form under pressurised conditions. It is a flammable hydrocarbon gas used as fuel for heating purposes as well as for cutting etc. in manufacturing processes. In liquefied form, it is a colourless and odourless liquid.

The physical properties of Propane (C_3H_8) are given below:

PHYSICAL PROPERTIES*		
Form	:	Gas, liquefied under pressure
Colour	:	Colourless
Odour	:	Odourless
Liquid density	:	0.54 kg/m^3
Molecular weight	:	44 g/mol
Lower explosion limit (LEL)	:	2.2 %
Upper explosion limit (UEL)	:	9.5 %
Flash point	:	-104°C
Solubility in water	:	Slightly soluble in water
Flammable nature	:	Highly flammable
		Based on tentative data sourced from Material Safety Data Sheet of Propane

Propane is envisaged to be stored at BSL in existing (2 x 100T) bullets with inlet, outlet and vapour balancing lines and associated pumps, compressors etc. The mounded bullet, as per design considerations mentioned in OISD-150(The Oil Industry Safety Directorate), eliminates chances of a BLEVE (Boiling Liquid Expanding Vapor Explosion) and reduces chances of fatal hazards at design stage itself. As for the pipes which form the part of inlet, outlet and vapour balancing lines, regular inspection of the pipelines and maintenance operations along with installation of pressure detection systems in the pipelines will ensure no occurrence of pipeline failure.

7.1.5 Hazard Identification

Hazards associated with the identified hazardous chemicals based on NFPA (National Fire Protection Association) ratings as well as other parameters are presented in **Table 7.3.**

Table 7.3: Type of Hazards Associated With Identified Hazardous Chemicals

Name of Chemical		Type of Hazard	*NFPA Hazard Rating*			IDLH Value	Flash point (°C)	Flammability range (for gases)	Remarks
			Health	*Flammability*	*Reactivity*				
Constituents of ***COG/ BFG/ BOFG/ Mixed Gas***	Hydrogen	1,6,9	0	4	0	-	-	LEL = 4% (<13%)	All gases transported directly through pipelines. *Release: Leak/rupture* *LD gas stored in Steel Gas holders. Release: Leak/ Rupture*
	Methane	1,6,9	2	4	0	-	-	LEL = 4.4% (<13%)	
	Carbon monoxide	1,3,9	2	4	0	1200 ppm	-	LEL = 12% (<13%)	
	Ammonia (NH3)	4,8	3	1	0	300 ppm	-	LEL = 16% UEL = 25%	
	Hydrogen sulphide (H_2S)	1,4,8	4	4	0	100 ppm	-	LEL = 4.3% UEL = 46%	
	Naphthalene	1,7,8	2	2	0	250 ppm	79°	LEL = 0.9% UEL = 5.9%	
Propane (C_3H_8)		1,3,9	2	4	0	2100 ppm	-104°	LEL = 2.2% UEL = 9.5%	Stored in mounded bullets. *Release: Leak/rupture*

Note: IDLH: Immediately Dangerous to Life or Health

Type of Hazard :

1 Flammable substance
2 Oxidising substance, reacts with reducing agents
3 Emits a toxic gas or vapour
4 Emits an irritating gas or vapour
5 Emits a narcotic gas or vapour
6 Gas or vapour not dangerous other than displacing air
7 Causes skin irritation or burns
8 Toxic substance
9 Explosive material under certain conditions

NFPA HAZARD Rating

a) HEALTH

1 - None	2 - Minor	3 - Moderate, could cause temporary incapacitation or injury	4 - Severe, short exposure may cause serious injury	5 - Extreme, short exposure may cause death

b) FLAMMABILITY				
1-None, Material does not burn	2- Minor, material must be preheated to ignite	3- Moderate, moderate heating is required for ignition and volatile vapours are released	4- Severe, material ignites at normal temperature	5- Extreme, very flammable substance that readily forms explosive mixtures
c) REACTIVITY				
1-None, stable when exposed to fire	2-Minor, unstable at high temp. or press and may react with water	3-Moderate, unstable but does not explode, may form explosive mixture with water	4-Severe, Explodes if heated or water added	5-Extreme, readily explosives under normal condition

From the above table it can be observed that Coke Oven gas, BF gas, BOF gas, mixed gas and propane are the hazardous materials of concern for the proposed project. Propane is proposed to be stored in mounded bullets, as per the design guidelines of OISD-150, which also confirms high levels of safety of mounded bullets, diminishing possibilities of BLEVE from the bullets.

The catastrophic potential of a hazardous substance depends on its flammability, toxicity and volatility. The ambient temperature vapour pressure of a substance is used as a measure of the ability to become air borne. Although COG, BFG and Mixed gas are not proposed to be stored in the plant and also, as per applicability of MSIHC Rules, 1989, there is no specific requirement for carrying out its consequence analysis, the fire hazards associated have been quantified owing to its toxic as well as high flammable nature. BOF gas and propane being highly flammable and stored in significant quantities in the plant require consequence analysis to be carried out for them.

7.1.6 Hazard Assessment

In the earlier section, type of hazard associated with different type of substances and the event of release of these substances is being identified. It has also been identified the category of hazard associated with different chemicals.

In any plan hazardous situation arises due to:

- Failure in the monitoring of crucial process parameters e.g. pressure, temperature, flow quantity etc.
- Failure in the utilities e.g. cooling water
- Failure control elements e.g. pressure, temperature level, flow controllers etc.
- Failure of components such as pumps, compressor etc.
- Failure of safety systems, safety valves / relief valves, sprinkler systems, alarm etc.
- Mechanical failure of vessels or pipe work due to excessive stress, over pressure, corrosion etc.
- Wrong operation, failing to adhere to the safety norms etc.

Such a situation is possible during the storage as well as handling of aforementioned hydrocarbon gases. It is unlikely that small leakage through pipes, gaskets, glands or any other means (user points) will create a hazardous situation unless allowed to be released for a long time as will be established in the subsequent sections. It is expected that during such small leakage preventive steps will be taken within a specified time span. Therefore a Preliminary Hazard Analysis (PHA) is carried out first for assessment of hazard. It is to note that the storage of Propane involves mounded storage bullets, which are designed to be intrinsically safe from the occurrence of a BLEVE condition. It is also to be noted that the storage of BOF gas involves vertical storage tanks called Gas holders located at separate locations nearer to the existing SMS complex of BSL, considering the nature of risks involved in storage of BOF gas. All the above gases shall be transported through steel pipelines constructed as per applicable safety standards.

Effects of the above Hazards:
The effect of accidents in these areas will be confined to the facilities only and can be controlled within the areas by the operating personnel themselves. At the extreme, it may require the resources of the whole facility to control the effects but these are not at all expected to spill over to the community. Primary Hazard Analysis is given in **Table 7.4**.

Table 7.4: Preliminary Hazard Analysis

Sn.	Project component	Incident type	Failure Scenario	Causes of failure	Proposed preventive measures
1.	**Mounded Storage bullets**	Release of pressurized gas into the atmosphere, Formation of vapour cloud, fire, explosion	Failure in inlet, outlet or vapour balancing line or associated fittings, pump or pipe-work or operator error leading to impacts including chemical or fuel contamination	□ Overfilling □ Pressure increase in bullet □ Rupture of hose □ Gasket Failure □ Leak at flanges □ Wrong line-up □ Non adherence to SOP for sampling □ Instrumentation failure □ Operator error □ External fire □ Corrosion	□ Design of storage structures / tanks to relevant standards and legislations. □ Design of pipelines (i.e. wall thickness and stress relief), well sites, Central Processing Facility and related infrastructure to relevant standards and legislation. □ Installation of pressure monitoring systems. □ Regular inspections and maintenance. □ Housekeeping activities – site would be kept clean and tidy and fire hazards removed where practicable. □ Availability of firefighting equipment. □ Maintenance of fire breaks to slow the progress of bushfires. □ Routine hazard reduction burns. □ Fire-fighting equipment located in on-site vehicles and infrastructure (wherever appropriate). □ Regular inspections and maintenance of firefighting equipment and storage areas, where required. □ Operator induction and ongoing training. □ Operational procedures. □ Material safety data sheet (MSDS) register and MSDSs kept on-site at different locations in form of signage etc. □ Hazard Signage. □ Location of explosive storage shall be such that it has minimum interaction with people and property.
		Sabotage	Malicious act/sabotage resulting in off-site impacts.	□ Inadequate protection of facilities. □ Lapse in safety procedures due to Human error.	□ Restriction of access to storage areas, including securing storage facilities. □ Provision of adequate lighting around storage facilities. □ Signage (i.e. unauthorized entry warning and information signs). □ Police would be notified as soon as possible in case of a suspected breach.
2.	**Vertical Storage tanks**	Release from Leak / rupture	Failed tank or associated fittings, pump or pipework	□ Rupture of hose □ Gasket Failure	□ Design of storage structures / tanks to relevant standards and legislations.

Sn.	Project component	Incident type	Failure Scenario	Causes of failure	Proposed preventive measures
	(gas holders)		or operator error.	▫ Leak at flanges ▫ Non adherence to SOP for sampling ▫ Instrumentation failure ▫ Operator error ▫ External fire ▫ Corrosion	▫ Regular inspections and maintenance. ▫ Operator induction and ongoing training. ▫ Operational procedures. ▫ Material safety data sheet (MSDS) register and MSDSs kept on-site at different locations in form of signage etc. ▫ Hazard Signage.
			Failed vessel due to mechanical impact or corrosion	▫ Corrosion ▫ Mechanical impact	
		Fire or Explosion	Poor maintenance, poor design, collision or human error leading to fire / explosion / fume related impacts.	Human/ Operator error in design and construction	▫ Design of storage structures / tanks to relevant standards and legislations. ▫ Appropriate storage of all chemicals, fuel and dangerous substances in accordance with relevant Hazardous Chemical Rules, 2000 with subsequent amendments and associated legislations. ▫ Housekeeping activities – site would be kept clean and tidy and fire hazards removed where practicable. ▫ Availability of firefighting equipment, such as overhead water spray system, mounted on top of gas holders. ▫ Regular inspections and maintenance of firefighting equipment and storage areas, where required. ▫ Site policies, management plans and procedures. ▫ Protection of storage facilities (e.g. bollards). ▫ Operator induction and ongoing training. ▫ Location of explosive storage should be such that it has minimum interaction with people and property.
		Sabotage	Malicious act/sabotage resulting in off-site impacts.	▫ Inadequate protection of facilities. ▫ Lapse in safety procedures due to Human error.	▫ Restriction of access to storage areas, including securing storage facilities. ▫ Provision of adequate lighting around storage facilities. ▫ Signage (i.e. unauthorized entry warning and information signs). ▫ Police would be notified as soon as possible in case of a suspected breach.
2.	**Gas Pipelines**	Release of flammable gas, Formation of vapour cloud, fire, explosion	Failure of pipeline, bursting of pipeline due to - Corrosion - Vibration - External loading - Operation error - Over pressure - Maintenance failure - Communication failure - Sabotage	▫ Pressure increase ▫ Rupture of pipe ▫ Leak in pipework ▫ Instrumentation failure ▫ Operator error ▫ External fire ▫ Corrosion	▫ Design of pipelines (i.e. wall thickness and stress relief), well sites, Central Processing Facility and related infrastructure to relevant standards and legislation. ▫ Installation of pressure monitoring systems. ▫ Conduct regular inspections, maintenance and testing of equipment. ▫ Site policies, management plans and procedures. ▫ Operator induction and ongoing training.

Sn.	Project component	Incident type	Failure Scenario	Causes of failure	Proposed preventive measures
					◻ Maintenance of fire breaks to slow the progress of bushfires. ◻ Routine hazard reduction burns. ◻ Fire-fighting equipment and spill kits located in on-site vehicles and infrastructure (where appropriate).
		Sabotage	Malicious act/sabotage resulting in off-site impacts.	◻ Inadequate protection of facilities. ◻ Lapse in safety procedures due to Human error.	◻ Restriction of access to storage areas, including securing storage facilities. ◻ Provision of adequate lighting around storage facilities. ◻ Signage (i.e. unauthorized entry warning and information signs). ◻ Police would be notified as soon as possible in case of a suspected breach.

7.1.7 Maximum Credible Accident Analysis (MCAA)

A Maximum Credible Accident (MCA) can be characterized, as an accident with a maximum damage potential, this is still believed to be probable. The selection of accident scenarios representative for a MCA-Analysis has been done on the basis of engineering judgement and expertise in the field of risk analysis studies, especially accident analysis.

In the proposed expansion programme of BSL, which is also identified as an “Industrial activity” handling hazardous substances as per MSIHC Rules, 1989 and subsequent amendments, hazardous substances may be released as a result of failures or catastrophes, causing possible damage to the surrounding area.

As mentioned above, the hazardous substances identified of posing major threats to the facility and people working at the facility are listed at **Table 7.3** above.

MCA Analysis assists in identifying the potential major accidents arising due to flammable and/or toxic storages or handling facilities and estimate the maximum consequent effects on the surrounding environment in terms of damage distances of heat, radiation, toxic release, vapor cloud explosion etc. depending upon the effective hazardous attributes and the impact of the event, in the worst possible hazard situations.

The visualization of MCA scenarios has been done considering the chemical inventory being handled at the proposed plant, various loss of containment scenarios and subsequent accident scenarios and analysis of incident history of similar nature to establish credibility of the identified accident scenarios. Based on the above, the identified credible accident scenarios having maximum damage effects (worst case) were as follows:

i. For **BOF gas Holders:**
   a. Release of BOF gas due to rupture resulting in
      - Fireball
      - Flash fire
      - Vapour Cloud explosion
      - Toxic cloud dispersion

ii. For **Gas Mixing Station/facility:**

a. Release of COG from **COG inlet pipeline** due to

- leak from hole (eq. size 100mm) of piping resulting in
  - Jet fire
  - Flash fire

Note: *No Vapour Cloud explosion and Toxic cloud dispersion effects observed due to hole releases due to very low release rates of gas quantity from the holes. Thus, they have been excluded from the analysis.*

- rupture of pipeline resulting in
  - Fireball
  - Flash fire
  - Vapour Cloud explosion
  - Toxic cloud dispersion

b. Release of BF gas from **BF gas inlet** pipeline due to rupture resulting in
  - Fireball
  - Flash fire
  - Vapour Cloud explosion
  - Toxic cloud dispersion

Note: *Due to low mass release rates of the gas, no significant hazard distances were observed due to release from holes of all sizes upto 20% of pipe dia. Thus, only full bore rupture considered for the analysis.*

c. Release of Mixed gas from **Mixed gas outlet** pipeline due to rupture resulting in
  - Fireball
  - Flash fire
  - Vapour Cloud explosion
  - Toxic cloud dispersion

Note: *Due to low mass release rates of the gas, no significant hazard distances were observed due to release from holes of all sizes upto 20% of pipe dia. Thus, only full bore rupture considered for the analysis.*

iii. For **Mounded bullet storage of Propane:**

a. Release of Propane from Bullet's Liquid Inlet, Outlet Lines and/or Vapour Balancing Line connection points resulting in
  - Jetfire
  - Flash fire
  - Vapour Cloud explosion

7.1.8 Consequence Analysis

Subsequent to the accidental release of hazardous chemicals, the consequence depends on various factors e.g. type and inventory of released hazardous materials, presence and location of an ignition source, meteorological conditions, etc. Consequence analysis for the selected accident scenarios has been carried to estimate the vulnerable zones.

7.1.8.1 Consequence Model / Software Used

DNV's PHAST (Version 6.4) software, which is a consequence and risk assessment software for calculation of physical effects (fire, explosion, atmospheric dispersion) of the escape of hazardous materials has been used to perform the consequence calculations. The software allows detailed modeling and quantitative assessment of release of pure chemicals as well as mixtures from different scenarios.

7.1.8.2 Hazardous Scenarios Modeled

Consequence analysis quantifies vulnerable zone for a conceived incident and once the vulnerable zone is identified for an incident, measures can be proposed to eliminate damage to plant and potential injury to personnel. Consequence analysis for existing BOF gas stored in gas holders, additional COG, BFG and Mixed Gas proposed to be handled via pipelines of new Gas mixing station and Propane envisaged to be stored in Mounded bullets at BSL has been carried out. The release scenarios selected and associated hazards based on MCA Analysis are listed below in **Table 7.5**.

Table 7.5: Probable Release&Accident Scenarios Identified as per MCAA

Sl. No.	Hazardous substance	Credible Release scenario	Credible identified accidents
1.	BOF gas	Complete failure of Gas holder leading to catastrophic release of BOF gas	Fireball, Flash fire, Vapour Cloud explosion, Toxic Cloud dispersion
2.	Propane	Complete failure of inlet-outlet and other lines connected to the bullets leading to release from connecting points.	Fireball, Flash fire, Vapour Cloud explosion
3.	Coke Oven Gas, BF Gas, Mixed gas	Leak from hole (100mm dia. hole) [for COG only]	Jet fire, Flash fire
		Full bore rupture of piping [for all gases]	Fireball, Flash fire, Vapour Cloud explosion, Toxic Cloud dispersion

7.1.8.3 Meteorological Conditions Considered

Minimum wind speed of 1.0 m/s and stable as well as neutral atmospheric stability conditions have been assumed to model fire effects in a worst case scenario having low chance of dilution of flammable substance concentration in the atmosphere and a higher damage effect. An average Wind speed of 3.0 m/s based on annual climatological trend of wind speeds at Bokaro as collected from IMD Atlas at Bokaro with neutral atmospheric stability conditions has been assumed to predict maximum extent of dispersion of toxic components of the identified hazardous substances during a release.

7.1.8.4 Damage Criteria Considered in the Model

In order to apprehend the damage produced by various scenarios, it is appropriate to discuss the physiological/physical effects of thermal radiation intensities due to fire accidents and overpressure effects of explosions. The thermal radiation due to pool fire or jet fires usually results in burn on the human body. Furthermore, inanimate objects like equipment, piping, cable, etc. may also be affected and also need to be evaluated for damages. The effect of overpressure due to blast effect and the effect of thermal radiation due to fire on unprotected skin, as per **Indian Standard IS 15656 : 2006** ***HAZARD IDENTIFICATION AND RISK ANALYSIS — CODE OF PRACTICE*** is presented below in **Tables 7.6(a)** and **7.6(b)**, respectively.

Table 7.6(a): Effect of Different Over-Pressures on Human Life& Property

Overpressure (bar)	Type of Damage on structure	Type of Damage on Human life
0.02	Typical window glass breakage	-
0.14	Partial collapse of buildings	Personnel knocked down
0.21	Steel framed buildings get distorted and uprooted from their foundations	Ear drum rupture (beginning of serious injury to human life)

Table 7.6(b): Relation Between Heat Radiation Intensity, Time &Effect on Man

Heat Radiation Level (Kw/m^2)	Duration (Secs)	Effect on Humans	Effect on property
4 -6	20	Sufficient to cause pain to personnel	Impairment of escape routes
12.5	5-20	Extreme pain within 20s	Provides minimum energy required for piloted ignition of wood and melting of plastic
37.5	10	Immediate fatality (100% lethality)	Sufficient to cause severe damage to process equipment

The results of consequence analysis are summarised in the succeeding **Table 7.7** below.

Table 7.7: Results of Consequence Analysis

Plant Unit	Hazardous Substance Handled/ Stored	Failure size (mm)	Hazard effects	End Point Criteria	Hazard extent(m) Atmospheric Conditions 1.5F	1.5D	3D
GAS MIXING STATION							
COG Inlet Pipeline	COG	Hole (100mm)	Jet fire *Flame length:12.27 m*	4.0 kW/m²	9	-	11
				12.5 kW/m²	-	-	-
				37.5 kW/m²	-	-	-
			Flash Fire *[½ LFL conc:23698.9 ppm]*	LFL	5	5	4
				½ LFL	8	8	7
		Rupture (FBR)	Fire Ball *[Max Fireball radius= 13.79m]*	4.0 kW/m²	115	115	115
				12.5 kW/m²	66	66	66
				37.5 kW/m²	38	38	38
			Flash Fire *[½ LFL conc: 23698.9]*	LFL	14	12	13
				½ LFL	34	31	35
			Vapour Cloud Explosion *[Distance of ignition: 10m]*	0.21 bar	36	36	37
				0.14 bar	44	43	44
				0.02 bar	142	140	143
			Toxic Dispersion *[Probability of fatality at distance of]*	0 m	0.83	0.63	0.04
				25 m	0	0	0
BFG Inlet Pipeline	BFG	Rupture (FBR)	Fire Ball *[Max Fireball radius= 52.3m]*	4.0 kW/m²	111	111	111
				12.5 kW/m²	51	51	51
				37.5 kW/m²	-	-	-
			Flash Fire *[½ LFL conc: 162338 ppm]*	LFL	65	14	23
				½ LFL	210	34	51
			Vapour Cloud Explosion *[Distance of ignition: 10m]*	0.21 bar	48	47	47
				0.14 bar	59	58	58
				0.02 bar	198	197	197
			Toxic Dispersion *[Probability of fatality at distance of]*	0 m	0.83	0.93	0.34
				25 m	0	0	0
Mixed gas Outlet Pipeline	Mix. G	Rupture (FBR)	Fire Ball *[Max Fireball radius= 38.25m]*	4.0 kW/m²	99	99	99
				12.5 kW/m²	49	49	49
				37.5 kW/m²	9	9	9
			Flash Fire *[½ LFL conc:104424 ppm]*	LFL	12	10	15
				½ LFL	43	26	51
			Vapour Cloud Explosion	0.21 bar	44	43	43

Plant Unit	Hazardous Substance Handled/ Stored	Failure size (mm)	Hazard effects	End Point Criteria	Hazard extent(m) Atmospheric Conditions 1.5F	1.5D	3D
			[Distance of ignition: 10m]	0.14 bar	54	53	53
				0.02 bar	178	177	177
			Toxic Dispersion *[Probability of fatality at distance of]*	0 m	0.87	0.93	0.31
				25 m	0	0	0
BOF GAS HOLDERS	BOF Gas	Rupture (FBR)	Fire Ball *[Max Fireball radius= 135m]*	4.0 kW/m²	410	410	410
				12.5 kW/m²	219	219	219
				37.5 kW/m²	84	84	84
			Flash Fire *[½ LFL conc: 110644 ppm]*	LFL	127	76	120
				½ LFL	262	126	192
			Vapour Cloud Explosion *[Distance of ignition: 10m]*	0.21 bar	136	136	136
				0.14 bar	173	173	173
				0.02 bar	640	640	640
			Toxic Dispersion *[Probability of fatality at distance of]*	0 m	0.52	0.90	0.37
				25 m	0	0.01	0
				50 m	0	0	0
PROPANE BULLET							
Connection point of Inlet/ outlet pipelines (80mm Ø)	Propane	Vessel hole (80mm)	Jet fire *Flame length:132 m]*	4.0 kW/m²	131	131	154
				12.5 kW/m²	-	-	45
				37.5 kW/m²	-	-	-
			Flash Fire *[½ LFL conc: 10000 ppm]*	LFL	6	6	8
				½ LFL	23	21	22
			Vapour Cloud Explosion *[Distance of ignition: 10m]*	0.21 bar	44	45	42
				0.14 bar	54	55	51
				0.02 bar	179	184	169
Connection point of Vapour Balancing lines/ other pipelines (80mm Ø)	Propane	Vessel hole (50mm)	Jet fire *Flame length: 88.25 m]*	4.0 kW/m²	81	9	98
				12.5 kW/m²	-	-	22
				37.5 kW/m²	-	-	-
			Flash Fire	LFL	*Not observed due to low mass flow release rate from hole*		
				½ LFL			
			Vapour Cloud Explosion *[Distance of ignition: 10m]*	0.21 bar	33	33	30
				0.14 bar	39	39	35
				0.02 bar	123	123	108

The above table makes evident that the majority of the hazardous consequence have highest hazard extents in the atmospheric stability class D. The worst case results for the different releases enumerated above have been observed in the atmospheric scenario similar to 3D. As observed from the table above, the worst case results are summarized in **Table 7.8**. For assessing maximum damage from most credible scenarios, results have been shown for end point criteria corresponding to maximum observed damage due to a particular hazard effect.

Table 7.8: Worst Case Hazard Extents for Identified Hazardous Facilities

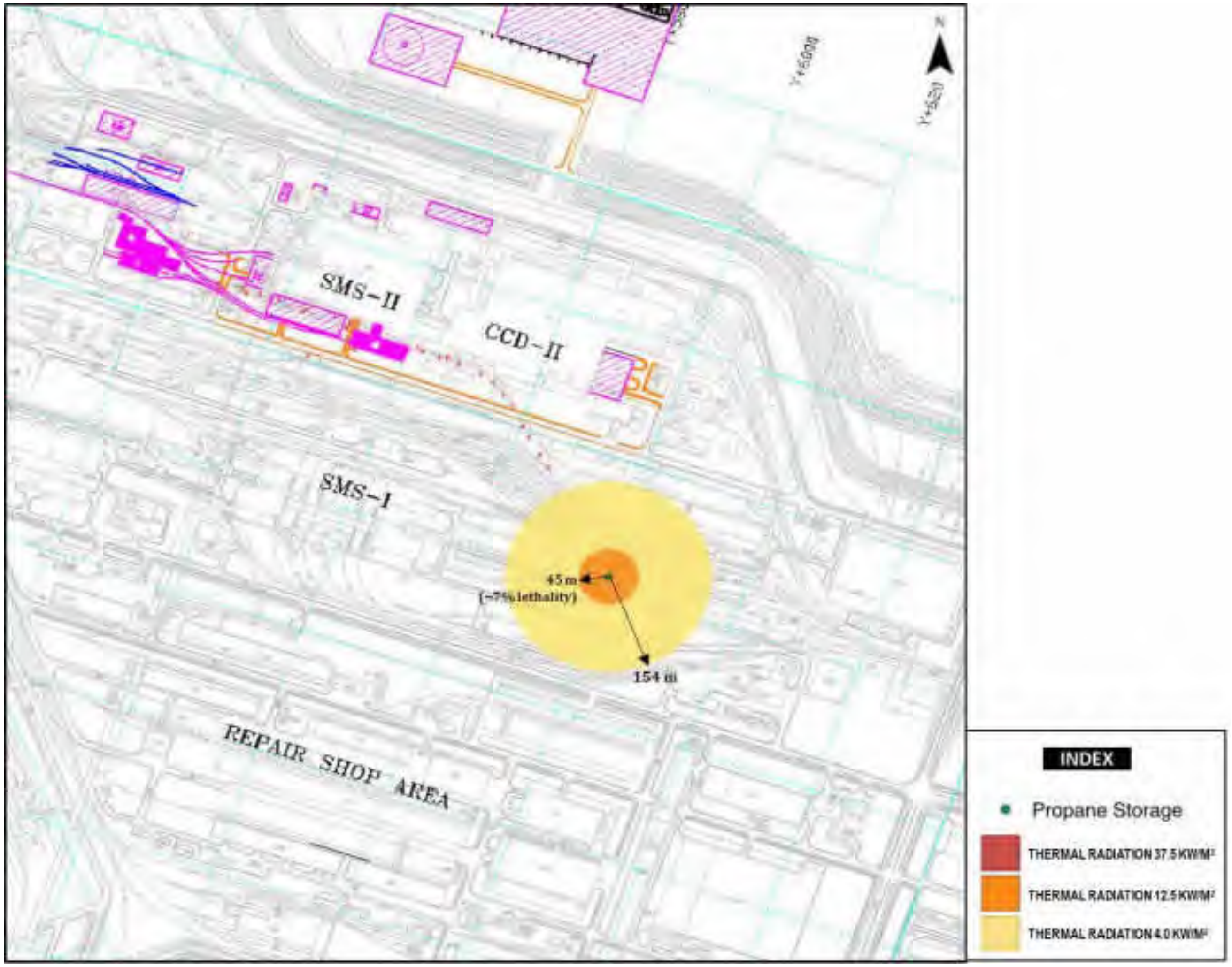
Plant Unit	Failure size	Nature of hazard	Hazard effects	Worst case Hazard extent (m)
GAS MIXING STATION	Hole	*Fire & Explosion*	Jet fire	*11m @ 4.0 kW/m²*
			Flash Fire	*8m @ LFL*
	Rupture	*Fire & Explosion*	Fireball	*38m* @37.5 kW/m²
			Flash Fire	*65m* @LFL
			Vapour Cloud Explosion	*48m* @0.21 bar(g)
		Toxic effect	Toxic effect safe distance	*≥ 25m @ no probability of fatality*
BOF GAS HOLDERS	Rupture	*Fire & Explosion*	Fireball	*84m* @37.5 kW/m²
			Flash Fire	*127m* @LFL
			Vapour Cloud Explosion	*136m* @0.21 bar(g)
		Toxic effect	Toxic effect safe distance	*≥ 50m @ no probability of fatality*
MOUNDED PROPANE BULLET	Vessel failure at pipe junctions	*Fire & Explosion*	Jetfire	*45m at 12.5 kW/m²*
			Flash Fire	*8m @ LFL*
			Vapour Cloud Explosion	*45m* @0.21 bar(g)

The worst case Hazard extents of all identified major hazardous units is shown in **Figures. 7.1(a) to 7.1(f)**.

FIG 7.1: (a) Hazard Extents For Thermal Fire Radiation Effects

GAS MIXING STATION WITH ASSOCIATED PIPEWORK

BOF GAS HOLDERS



MOUNDED PROPANE BULLET

FIG 7.1: (b) Hazard Extents For Flash Fires In Identified Hazardous Facilities

GAS MIXING STATION WITH ASSOCIATED PIPEWORK

BOF GAS HOLDERS

FIG 7.1: (c) Hazard Extents For Flash Fires In Identified Hazardous Facilities

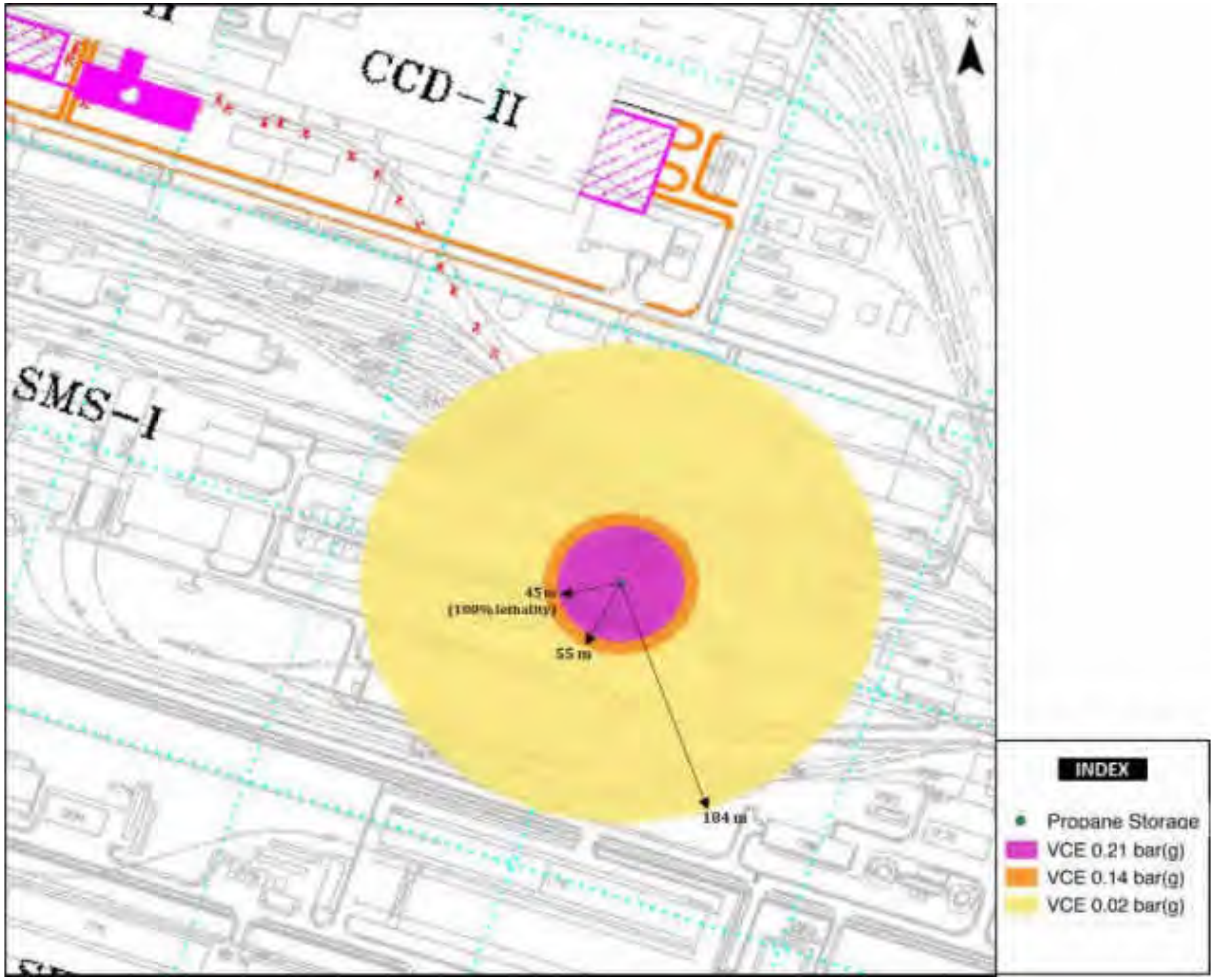
MOUNDED PROPANE BULLET

FIG 7.1: (d) Hazard Extents For Vapour Cloud Explosion Effects In Identified Hazardous Facilities

GAS MIXING STATION WITH ASSOCIATED PIPEWORK

BOF GAS HOLDERS

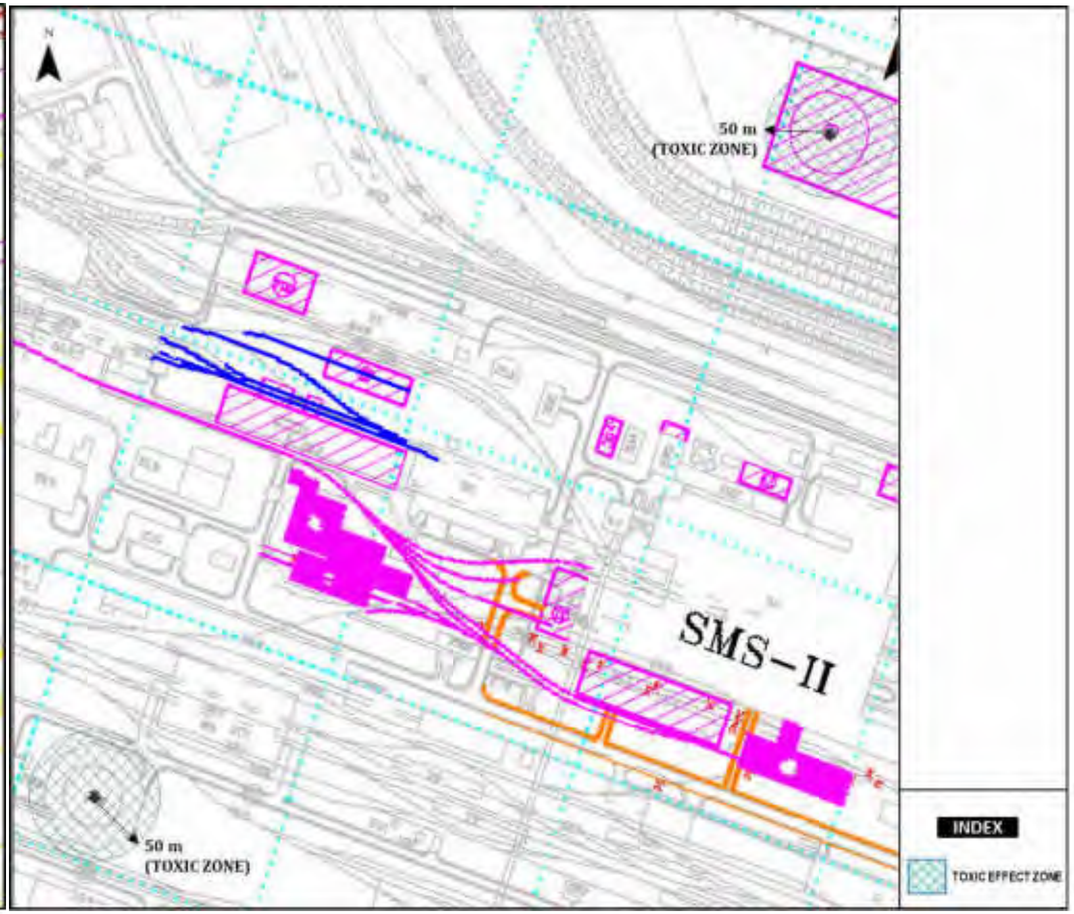
FIG 7.1: (e) Hazard Extents For Vapour Cloud Explosion Effects In Identified Hazardous Facilities



MOUNDED PROPANE BULLET

FIG 7.1: (f) Hazard Extents For Toxic Cloud Dispersion Effects In Identified Hazardous Facilities

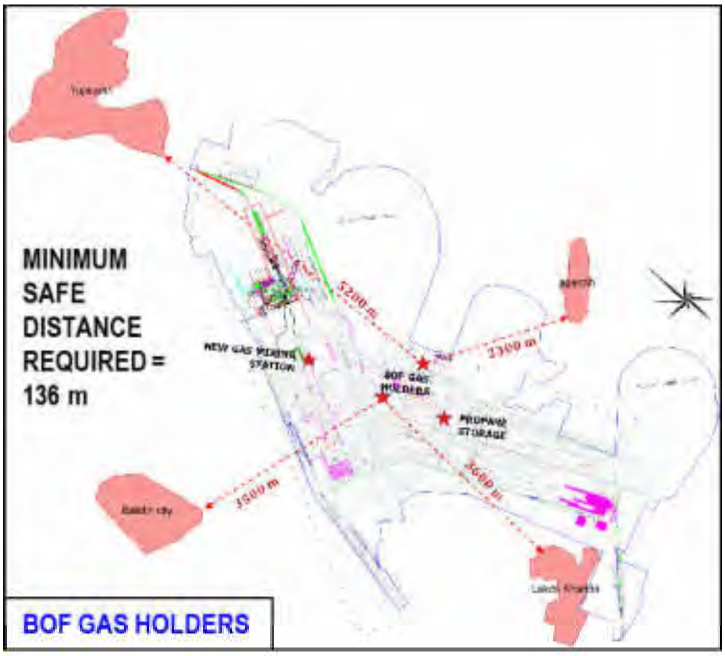
GAS MIXING STATION WITH ASSOCIATED PIPEWORK

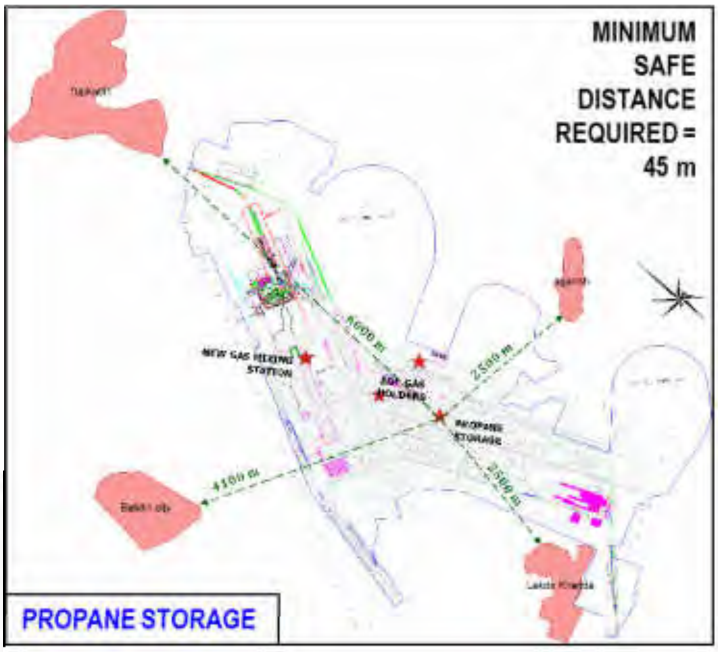


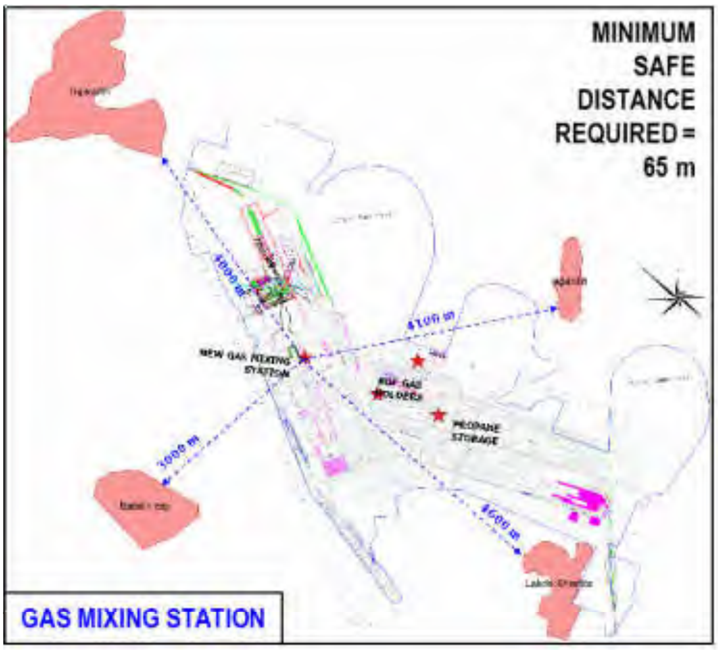
BOF GAS HOLDERS

The proximity of nearest habitations to **Identified Hazardous facilities** is shown in **Figure 7.2** below:

FIG 7.2: Safe Distances From Hazardous Installations Of BSL To Nearest Habitations







7.1.9 Conclusion on MCA Analysis

7.1.9.1 Gas Mixing Station

A maximum total of 75,000 m^3/hr of mixed gas is proposed to be handled by a new Gas mixing station envisaged at BSL's Coke Oven complex, wherein BF Gas and Coke Oven gas will be tapped from existing as well as future producing units and will be mixed in suitable proportions to produce Mixed gas of desired calorific value for use at the existing and new coke oven batteries. The results of MCA analysis indicates a maximum fire hazard distance for causing significant damage (@37.5 Kw/m^2 thermal radiation) extending up to **38 m** in the case of complete failure of the holder and catastrophic release of BOF gas, subsequently being ignited during worst meteorological conditions resulting in a fireball. The hazard extent for flash fire extends till **65 m** (@ LFL concentration). Explosion effects having significant potential for damage (@0.21 bar(g) overpressure) is observed to be upto a distance of **48m**.

The toxic effect of BFG, COG as well as Mixed gas (attributed to presence of Carbon Monoxide in the gases) will be limited to **25m** from the gas holder, beyond which there will be no probability of fatality due to toxic effect in case of a release.

Overall, a minimum safe distance of **65 m** from the Gas mixing station will ensure no damage to personnel as well as property, outside the plant premises. As observed from the overall analysis, t*he hazard extents will be contained within the plant premises and will not extend beyond plant boundary into any nearby settlement in the area.*

7.1.9.2 BOF Gas Holders

There are two (2) BOF gas holders, i.e. a replaced BOF gas holder of SMS-1 of 50,000 m^3 capacity and a new gas holder of 80,000 m^3 capacity, both located within the SMS complex of BSL's Bokaro Steel Plant. The results of MCA analysis indicates a maximum fire hazard distance for causing significant damage (@37.5 Kw/m^2 thermal radiation) extending up to **84 m** in the case of complete failure of the holder and catastrophic release of BOF gas, subsequently being ignited during worst meteorological conditions resulting in a fireball. Explosion effects having significant potential for damage (@0.21 bar(g) overpressure) is observed to be upto a distance of **136m**.

The toxic effect of BOF Gas (attributed to Carbon Monoxide in BOFG) will be limited to **50m** from the gas holder, beyond which there will be no probability of fatality due to toxic effect in case of a release.

Overall, a minimum safe distance of **136 m** from the BOF Gas holders will ensure no damage to personnel as well as property, outside the plant premises. As observed from the overall analysis, *the hazard extents will be contained within the plant premises and will not extend beyond plant boundary into any nearby settlement in the area.*

7.1.9.3 Mounded Propane Bullet

BSL has envisaged two (2) propane bullets, each of 100Tonne capacity, located within the BSL's Bokaro Steel Plant for heating and cutting purposes. The results of MCA analysis indicates a maximum fire hazard distance for causing significant damage (@12.5 Kw/m^2 thermal radiation) extending up to **45 m** in the case of complete failure of the pipeline connections on the bullets and release of propane, subsequently being ignited during worst meteorological conditions resulting in a jetfire. Explosion effects having significant potential for damage (@0.21 bar(g) overpressure) is also observed to be upto a distance of **45 m**.

Overall, a minimum safe distance of **45 m** from the Propane bullets will ensure no damage to personnel as well as property, outside the plant premises. As observed from the overall analysis, *the hazard extents will be contained within the plant premises and will not extend beyond plant boundary into any nearby settlement in the area. Also, pressure-monitoring systems shall be installed to detect leaks or cracks in the pipeline. Fire-fighting facilities will also be installed to check any fire incident that may occur.*

7.1.10 Hazardous Events with Greatest Contribution to Fatality Risk

The hazardous event scenarios likely to make the significant contribution to the risk of potential fatalities are enlisted in **Table 7.9**. The risks to people at plant site are categorized as “On-site” risks while the risks to communities outside the plant premises is categorized as “Off-site” risks.

Table 7.9: Hazardous Events Contributing to Risk and their Risk Ranking

			(A)	(B)	C = A*B
Sn.	**Hazardous event**	**Consequence of significant damage**	**Consequence severity*** *(1=least severe; 5=most severe)*	**Likelihood*** *(1=least likely; 5=most likely)*	**RISK RANK**
1.	Onsite vehicle impact on personnel	Potential for single fatalities, onsite impact only	3	3	9
2.	Entrapment/struck by Machinery	Potential for single fatalities, onsite impact only	3	2	6
3.	Fall from heights	Potential for single fatalities, onsite impact only	1	3	3
4.	Electrocution	Potential for single fatalities, onsite impact only	2	3	6
5.	Gas Mixing Station fire & explosion as well as toxic dispersion	Potential for multiple fatalities, onsite impact only	4	1	4
6.	BOF gas holder failure and fire & explosion as well as toxic dispersion	Potential for multiple fatalities, onsite impact only	5	1	5
7.	Propane Bullet's fire & explosion	Potential for multiple fatalities, onsite impact only	3	1	3

**based on Historical survey of similar facilities*

The above risk ranking indicates that although the most severe consequences will be due to rupture of BOF Gas holders followed by Gas Mixing station and Mounded propane bullets, their chances of occurrences are low due to implementation of better safety features in the installations and constant monitoring of vessel/pipework integrity for regular repair and maintenance, and hence these facilities have **low levels of risk** in the facility.

7.1.11 Summary & Conclusions of Risk Assessment

The risk assessment and analysis for BSL's steel plant for most severe hazardous events is broadly summarized below:

- The nearest habitations in the vicinity of the BSL Plant are Tupkadih village at distance >**4000m**in NW, Balidih village at distance >**3000m** in SW, LakdaKhanda village in SEat distance **>2500m**and Agardih village at distance **>2300m** in the NE, which are far away from the hazard distances observed for thermal effects *(maximum at 127m)* as well as toxic effects *(maximum at 50m)* due to failure of above identified hazardous facilities of BSL. Also, these facilities are located in the central part of the Bokaro steel plant away from each other to prevent multiple hazards, initiated due to fire in one facility and leading to a hazard in another facility, also known as domino effect. So, there will be no significant impact on the local community or damage to property / environment.

- The most severe damage effects due to the identified hazardous facilities will be limited to the plant premises and adequate safety controls as well as implementation of recommended control strategies in the design as well as operation stage will ensure effective management of the associated risks.

7.1.12 Recommended Risk Reduction and Mitigation Measures

The following opportunities shall be considered as a potential means of reducing identified risks during the detailed design phase:

- *The zones identified from consequence modelling as affected areas due to thermal radiations greater than 12.5 kW/m^2 shall be marked as "Heat Zones" and provisions for fire fighting will be made available close to these zones.*
- *It is also recommended to provide portable gas detectors within the site in order to facilitate manual gas leak monitoring and regular leakage checks. Constant monitoring of gas leak shall be ensured for immediate identification of leaks and subsequent implementation of action plan to prevent development of any hazardous situation.*
- *Further, all major units / equipment shall be provided with the following safety facilities:*
    - *Smoke / fire detection and alarm system*
    - *Water supply*
    - *Fire hydrant and nozzle installation*
    - *Foam system*
    - *Water fog and sprinkler system*
    - *Mobile fire-fighting equipment*
    - *First-aid appliances*
- *Personal Protective Equipment (PPE) shall be provided for additional protection to workers exposed to workplace hazards in conjunction with other facility controls and safety systems.*
- *Restricted access to these areas to have minimum casualties in an event of exposure.*
- *The onsite Emergency Plan will be integrated with the Bokaro district's Offsite Emergency Plan for comprehensive management of emergencies in minimum response time and maximum rescue*

results in an event of a disaster /emergency. Co-ordination with nearby industries will also be maintained for creating unified Disaster management resource pool to be utilised in case of any disaster occurrence.

- *The plant structures shall be designed for cyclone floods and seismic events to prevent structural collapse and integrity of weather (water) proofing for storage of dangerous goods.*
- *Isolate people from load carrying/mechanical handling systems, vehicle traffic and storage and stacking locations.*
- *Security of facility to prevent unauthorized access to plant, introduction of prohibited items and control of onsite traffic; and*
- *Development of emergency response management systems commensurate with site specific hazards and risks (fire, explosion, rescue and first aid).*
- *Regular safety audits shall be undertaken to ensure that hazards are clearly identified and risk-control measures are maintained within tolerable limits.*

7.1.13 On Site Emergency Plan

The on-site emergency plan relates to the laid-down and well-practiced procedure after taking care of all design based precautionary measures for risk control. This plan is aimed for tackling any emergency situation, if arises. The onsite emergency plan for the existing plant has been already prepared by BSL. The same will be extended to the proposed units also. The contents of the onsite emergency plan are briefed here under.

a) Identification & Assessment of Hazards

Three major hazards of the steel plants are:

1. Fire
2. Explosion
3. Toxic release

b) Elements of assessment:

1. Potential sources – Storage, tanker loading points, plant equipment, pipe lines.
2. Vulnerable points – Flanges, valves etc.
3. High risk points to be mapped
4. Emission rate and dispersion behaviour were estimated

In each emergency preparedness plan (EPP), the above have been identified and assessed for development of emergency plan for each unit.

c) Development of Emergency

1. Raising of alarms
2. Declaration of emergency
3. implementation of emergency procedure

d) Work Emergency Plan

Each emergency preparedness plan (EPP) has the following elements.

Elements for plan:

1. Communication and control system
2. Personnel with specified responsibilities
3. Communication of the emergency
4. Works emergency procedure

(i) <u>Communication and control system</u>

A. Emergency control centre

1. Located in position of minimum risk zone with good access to both works and outside road system.
2. Accessible for controller to reach
3. Should be linked by telephones
4. Radio provisions
5. Contain a copy of the emergency plan
6. All the appropriate equipment required to deal emergency
7. Manned by Chief controller Senior officer Messengers

B. Alarm system

1. Raising alarms
   Easily accessible points
   Receivable by all part of workers
   Audio, visual alarms
2. Declaration of emergency long period alarm

(ii) <u>Personnel with specified responsibilities</u>

Essential Functions and Nominated Personnel are as follows:

1. Chief controller
   Responsibilities:
   a. Relieve the Dy. Chief controller to perform his duty.
   b. Ensure outside emergency services have been called in
   c. Ensure key personnel called in
   d. Exercise direct operation controlled of those parts of the works outside the affected area
   e. Maintain a speculative review of possible developments
   f. Direct the shutting down of plant and evacuation of plant personnel
   g. Ensure casualties receive adequate attention
   h. Liaisoning with chief officers of various agencies
   i. Control traffic movement within the works
   j. Ensure authorized elements to news media.
2. Dy. Chief controller
   Responsibilities:
   a. Assess the scale of emergency

b. Direct all the operations to minimize loss
c. Direct rescue and fire fighting operation
d. Ensure that the affected area is searched for casualties
e. Ensure all non-essential workers, evacuated
f. Setting up proper communication points
g. Ensure other agencies, called in
h. Report significant development to chief controller

3. Other functions and personnel
    a. Plant control / shut down
    b. Leakage control
    c. Hazard reduction (removal of tanker etc.)
    d. Movement of equipment (fire fighting first aid etc.)
    e. Engineering activities (repair of plant, utilities etc.)
    f. Traffic control
    g. Evacuation
    h. Rescue
    i. First aid and causality clearance
    j. Communication inside / outside works

(iii) <u>Communication of emergency</u>

1. Raising the alarm after assessing the situation quickly
   Authorization, training of personnel

2. Declaration of emergency
   After raising alarm, work emergency procedure is activated
   Dy. Chief Controller will declare the emergency

3. Communication
   Chief controller communicates to
    - Personnel of the plant concerned
    - Personnel of other threatened plants
    - Personnel throughout the works
    - Key works personnel
    - Police
    - Fire services
    - Medical services
    - Press
    - Head office etc.

   Elements for plan:
    a. Communication and control system'
    b. Personnel with specified responsibilities

c. Communication of the emergency
d. Works emergency procedure
e. Co-operation with outside services
f. Public relation

(iv) Work emergency procedure

Action on declaration of emergency:

Personnel should be trained

After alarm is raised following procedure to be followed:

a. All members of the work force come to assembly point; key persons rush to man key areas/ positions.
b. Personnel, in-charges, return to their office & wait for instructions
c. Senior personnel go to emergency control center/ assembly point and act upon the instructions of the Dy. Chief controller.

Evacuation of personnel:

- Non-essential workers to assembly points
- Shelter at assembly point with breathing apparatus etc.
- Manned to note the name of persons
- List of contractors, visitors should be available

Co-operate planning, training and exercise:

a. Planned co-operation with other agencies: *Area of responsibilities, chain of command and system of communication defined.*
b. Training for emergency: *All personnel, contractors, visitors, outside agencies to be trained*
c. Exercise for emergencies: *Mock drill, Fire fighting exercise*

Transport Emergency

Emergency planning includes:

a. Chemical data
b. Information and labelling (placards) & TRAM-CARD with the driver
c. Incident control network
d. Emergency procedure
e. Emergency team
f. External services
g. Public relation

Emergency procedure:

a. Keep people away, inform them about the hazards of chemical
b. Inform incident control
c. Try to Contain chemical spill & Avoid ignition
d. Obtain chemical data

Communication to incident control center

a. Place and time of incident
b. Chemical involve
c. Condition of the container
d. Injuries or death
e. Area surrounding
f. Weather conditions
g. Assistance available
h. Means of maintaining contracts

Emergency team:

Team should have

a. Chemical data
b. Protective clothing
c. Breathing apparatus
d. Safety harness and lines
e. General tools and flash lights
f. Leak plugging equipment
g. Analytical equipment
h. Flood light with generator
i. First aid kit

(v) <u>Co-Operation with outside services</u>

1. *BSL has Fire Brigade* – well equipped having 14 fire tenders distributed at 4 posts inside plant with well-trained manpower (249). It caters the needs of the plant as well as Jharkhand State and helps the Government agencies.
2. BSL is having a well-equipped 910 bedded *hospital* to take care of health conditions of employees as well as outsiders. Its casualty department is open 24 hrs.
3. *District administration* - District Magistrate and District Collector, Bokaro is Chairman of "District Crisis Management Group" Bokaro steel city. The committee meets in case of any disaster in the district. He is informed whenever BSL carries a full scale Mock-drill and he participates on one or two important Mock- drills.
4. *Police department*:
   Superintendent of Police Bokaro District is informed of all the Mock-drills where evacuation and general public is involved. His services are available whenever some disaster affecting general public living in nearby areas get affected and need for mass evacuation arises.

(vi) <u>Public relation</u>

Bokaro Steel Plant is having a well-established Public Relations department who are always in constant touch with the media. Any information and in case of any disaster, Chief of Communications who is heading the P.R. Department is responsible for press release etc. and takes care of all the information flowing out to media persons in case of disaster.

Hazard Identification and Risk Assessment of existing Bokaro Steel plant:

Bokaro Steel plant has an established Hazard Identification and Risk Assessment, developed for all critical shops of the plant. The same is integrated in the unit-wise emergency plans. Engineering measures have been taken for ensuring safety in plant operation and maintenance activities. The Onsite Emergency Plan along with Hazard Identification and Risk Assessment (HIRA) addressing all possible hazards / risks is attached as **Annexure 7.2.**

The safety procedures to be adhered to while handling hazardous gases as well as liquid metal at BSL is also elaborated in various Inter Plant Standard · Steel Industry (IPSS) attached as **Annexure 7.3**.

The safety management practices at BSL is detailed in Chapter-4 of this report.

SAFETY MANEGEMENT PRACTICES AT BSL

(as elaborated in Chap.4 of EIA-EMP report)

4.7.4 Occupational Health & Safety

Anticipated impacts:

The work place is divided in terms of activities e.g. raw material handling, loading, handling of processed raw materials (e.g. calcined lime, coke, sinter), handling of hot metal and molten slag, processing of metal, handling of finished products and wastes etc. . The principal occupational risks in integrated steel plants are:

- Diseases due to dust inhalation
- Exposure to very high temperatures
- Exposure to very low temperatures (in oxygen plant)
- Exposure to toxic and / or inflammable gases
- Working in confined spaces where suffocating / toxic / inflammable gases may be present
- Fire and explosion which may also lead to generation / release of toxic gases
- Accidents during handling of liquid metal and slag
- Accidents during handling of corrosive and / or toxic liquids
- Hearing loss and other disorders due to exposure to very high noise
- Accidents involving various machinery
- Accidents involving electrical installations, including fire
- Accidents in raw material handling area
- Accidents in finished product handling area.
- Accidents involving fall from height
- Accidents involving railway rolling stock and heavy vehicles.
- Accidents during construction, repair and maintenance

The most common safety issues are given in **Table 4.16**.

Table 4.16: Most Common safety issues

Sl.No.	Nature of Hazard	Sources
1	Fire Hazard	Release/leakage of Oxygen, Hydrogen, Acetylene, CO gas, BF gas, LD gas, Mixed gas, Propane, Methane, Benzene vapours, Fuel Oil, Coal Tar Fuel and liquid metal. Fire in storages of inflammable and / or combustible chemicals and dry vegetation in vacant areas.
2	Explosion Hazard	Release/leakage of Hydrogen, Acetylene, CO gas, BF gas, LD gas, Mixed gas, propane, methane.
3	Toxic Hazard	Release of CO gas, BF gas, Mixed gas, LD Gas, Chlorine.
4	Burns	Release / leakage of steam, hot flue gases.
5	Cold Burns	Exposure to liquid oxygen, liquid nitrogen and liquid argon
6	Asphyxiation	Release of Nitrogen, Argon, Oxygen, CO gas, BF gas, LD gas, Mixed gas
7	Exposure to corrosive chemicals	Leakage spillage of acids and alkalies.
8	Fire/Explosions due to Spillage of Liquid Metal	Spillage/Transfer of liquid metal, liquid steel and hot slag
9	Heat Radiations due to coke, hot metal / molten slag Handling	Spillage of hot coke, hot sinter, liquid metal and hot slag
10	Accidents due to Material Handling	Connected with all Material Handling Equipment, railway locomotives & wagons and vehicles

Management measures:

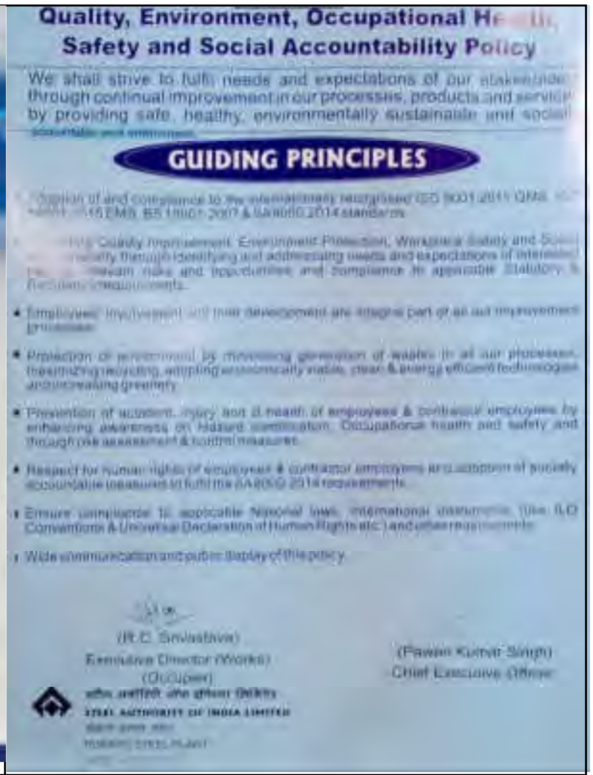
A. Safety Management & Practices in BSL

Safety is a prime concern for SAIL as well as BSL. The plant has a dedicated "Safety Engineering Department" headed by the General Manager (Safety). He is assisted by the Dy. General Manager (Safety).There are around 30 Safety officers under him to look after the safety activities in all the departments. This department regularly scrutinizes, supervises and ensures implementation of safe working practices in various departments of the company.

SAIL has dedicated safety department at the corporate level - SAIL Safety Organization (SSO), which, monitors and guides the safety Promotional, fire and Occupational Health Services activities undertaken at different steel Plants/Units/Mines/Stockyards. To accomplish the above mentioned functions, SSO formulates and prepares appropriate safety policies, procedures, systems, action plans, guidelines etc. and follows up for their implementation and thereby helps in providing accident free work environment. Consistent efforts are also being made by SSO for competence building in the area of safety management through HRD interventions covering heads of shops, line managers, safety personnel & trade union leaders. SAIL has Safety Policy which is shown below. Bokaro Steel Plant also has a dedicated Integrated policy for Quality, Environment, Occupational Health Safety and Social Accountability as shown in **Fig 4.10**.

Fig 4.10: BSL's Policy for Quality, Environment, Occupational Health Safety and Social Accountability

OVERALL SAFETY POLICY OF SAIL



INTEGRATED QUALITY, ENVIRONMENT, OCCUPATIONAL HEALTH SAFETY AND SOCIAL ACCOUNTABILITY OF SAIL-BOKARO

Safety aspects are considered in the design stage itself for all the equipment. In spite of that, during process of steel making, many hazards may be encountered. The following are some of the identified hazards:

- Heat, Dust and Noise Hazards
- Chemical Hazards
- Material Handling Hazards
- Burns due to hot metal / Hot objects
- Cold burns
- Slips & Falls
- Fall from Heights
- Gas Hazards
- Explosion Hazards
- Electrical and Fire Hazards

For managing these hazards "Occupational Health and Safety Management System" becomes key function of the top management. BSL manages the above safety and health hazards by adopting appropriate control measures to reduce / eliminate hazards for maintaining a safe and healthy environment at work place.

Several safety management practices are being adopted aiming to achieve Zero Accidents and to meet the safety requirements of the company. Important efforts in this direction include:

B. Safety Inspections:

- All the identified Contractual Agency Jobs, Shop-Floors and Equipment in various departments are inspected as per the schedule.
- The unsafe points identified or the non-conformances noticed are communicated to the concerned HOD for liquidation. Compliance of the same is monitored by the Zonal Safety Officers.
- Safety during all the major repairs and capital repairs is monitored round the clock and safety officers are deployed exclusively for this purpose.
- All the height related jobs performed by the qualified workers are closely monitored to ensure safety. Usage of certified safety appliances like safety belt and safety net are ensured while executing such jobs.

C. Safety Training:

Safety Engineering Department conducts Safety Training Programmes for all regular employees / contractual workers of BSL at various levels to inculcated safety awareness. Periodically, regular/contractual employees undergo training on several subjects of safety every year. During 2016-17, 17555 contract workers were imparted Induction training and 1888 were imparted safety training by IISM, Jamshedpur & 58 ROKOTOKO safety campaigns were carried out.

Special Training Programmes by external safety experts on various topics are being conducted on different topics such as Material Handling, Legal awareness on Safety Implementation of The Factories Act, Electrical Safety, BBSM, Road Safety, First Aid etc.

Regular Employees Training

The safety programs include General safety, Safety in Material Handling, Gas Safety, Electrical Safety, Fire Safety, Crane Safety, OH&S Management, Conveyor Belt Safety, Safety during welding, safety with rotating equipment, etc.

Special Training Programmes by external safety experts on various topics are also being conducted in co-ordination with Management Development Centre and Technical Training Institute.

Contractor Workers

- Once in a year, refresher safety training (Induction training) is imparted to all the contractors' workers and their safety passes are renewed only after such training. Training material/literature in local language is distributed to all the workers during safety training.
- Only those workers, who have undergone Job Specific and Site Specific Safety Training, are permitted to work at site only those.
- Special safety training programmes on Gas Cutting, Welding, and Conveyor Belt Safety are conducted regularly.
- Height test is conducted for workers to work at heights and safety precautions to be taken during painting and roof sheeting jobs etc. are also imparted from time to time.

D. Safety audits:

OHSMS Internal Audits are conducted once in a quarter in all major departments to improve the safety performance. Surveillance Audits are being conducted once in six months by an external certifying agency M/s. BVCI to assess the functioning of the system of safety in various departments of the plant.

Safety Audit is being conducted once in six months by the respective Zonal Safety Officers in all the major departments and the Safety Audit is conducted by a third party external experts once in a year as a part of the legal requirements.

E. Emergency Preparedness:

On site emergency mock drills are conducted to test the emergency preparedness for fire, electric shock, gas leak, rescue from heights, burn injuries in departments as well as plant level. Departmental mock drills are conducted every year. Two plant level mock drills are being conducted in a year in the presence of the Factories Dept. Officials, to know the preparedness of the rescue operations. Overall, more than 25 mock drills are conducted every year to ensure emergency preparedness of the plant personnel. Besides, a safety talk is conducted in every department at the end of every day for discussion on Safety issues, suggestions and discussion regarding safety to carry out the job assigned.

F. Safety committees:

The steel plant has an Apex Safety Committee. This Committee is convened by GM (Safety & FS) which has significant number of members as workers' representatives and the rest are representatives of the Management. The Apex Safety Committee's responsibility is to assist and guide the management in implementing Health and Safety measures effectively throughout the organisation. The Committee meets once every quarter as per Rule 62 - C of The Bihar Factories Rules, 1950. The points raised by the members are addressed on priority basis.

In addition there are Departmental Safety Committees, headed by a Departmental Safety Officer in the plant to discuss on Safety issues pertaining to their respective departments. Departmental Safety Committee meetings are held once every month.

G. Equipment Safety:

Equipment safety was properly addressed and was given due attention during its design stage itself. Safety devices like inter-locks, limit switches, battery backup system, emergency push buttons, safety valves, route relay inter locking for rail traffic, pull cords, earth fault protections, flame proof electrical fittings etc. are provided in the plant and their functioning is tested periodically and necessary corrective actions are taken.

H. Fire Safety:

In BSL has a dedicated Fire Department manned by three (3) officers and 90 (ninety) trained fire fighters. The Head of the Fire Department reports to the General Manager (safety & Fire Services).

There are three fire stations (Central Fire Station, Coke Oven Fire Station & SMS Fire Station). There are four Fire Turnouts (fire fighting teams), each comprising of six trained fire-fighters. Two Fire-turnouts are stationed at the Central Fire Station and one each at the Coke Oven Fire Station and the SMS Fire Station. It has eight water tenders in working condition, two foam tenders, one Dry Chemical Powder (DCP) tender (cap.2 t of dry chemical powder), one Crash Fire Tender and one Emergency Tender. The fire department has about 30 closed circuit breathing apparatus sets. For fighting electrical fires, the Fire Department has Dry Chemical Powder type fire extinguishers and two nos. Ultra High Pressure Mist Systems. About 8500 portable fire extinguishers are provided throughout the plant and are inspected at regular intervals.

Extensive network of fire hydrant points (>2000 nos.), landing valves and Fire Fighting Pump Houses are in place. Fire Detection and Alarm (FDA) systems are installed in all major production departments and fire sensitive areas to inform the Fire Wing in the event of any fire mishap and request necessary assistance. There is a Central Fire Control Room at the Central Fire Station and two sub fire control stations – one each at the other two fire stations.

On receiving fire alarm, the nearest fire station responds immediately. If necessary, help of the other fire stations may be sought. Though there is no written agreement, help may also be sought from Jharkhand Fire Services and the Fire Departments of DVC's Chandrapura Thermal Power Station, ONGC – Parbatpur, IOCL, HPCL, M/s Electro Steel Castings' steel plant. The arrangement is reciprocal.

3-4 Mock drills are conducted by the Safety Department every month, in which the Fire Department is a participant. The Fire Department also conducts response time training exercises for its personnel.

I. Protocols:

Protocols have been prepared for all critical jobs like, jobs in confined spaces, jobs near gassy areas, underground drains, etc. where prior permission from other departments is required to undertake any work. The role/responsibility of each dept./officer is defined and indicated on these permits till safe completion of the job.

Special drives are conducted for monitoring the implementation of Permit-To-Work and Shut-Down systems and usage of PPEs etc.

J. Gas Safety

- Gas Safety is given top most priority at BSL.
- Periodic Inspections are carried out in the Gas equipment and pipe lines.
- Regular monitoring of gas leakages in the gas prone areas.
- Gas detectors are provided at vulnerable areas (e.g. In confined spaces in coke oven batteries, CO gas detectors linked to alarm systems have been installed).
- On-line CO gas analyzers installed at gas prone control rooms.
- U - Seals are provided in gas lines for better isolation.

K. Road Safety:

Road safety indeed is a matter of concern for BSL. Company has been continuously creating awareness on safety among the employees and contract workers. To prevent road accidents, various initiatives are taken like Awareness Campaigns, Road safety week celebrations, Special Road Safety training programs, Speed barriers, Speed Breakers, Signals Lights, Speed Limit Boards etc.

L. Personnel Protective Equipment (PPE):

The PPE provided in the plant are

a) Protective helmets
b) Safety boots.
c) Dust masks, canisters etc. for respiratory protection
d) Ear plugs , ear muffs etc. for noise protection
e) Goggles, spectacles for protection of eyes.
f) Safety belts, Safety harnesses for protection against falls.
g) Canvas gloves, Leather gloves, PVC gloves, Rubber gloves etc. for Hand protection
h) Aprons for Body protection.
i) Heat resistant Coat-Kevlar aluminium suit.
j) Molten metal resistant jackets and trousers
k) Molten metal resistant gloves-Kevlar gloves;
l) Face shields or vented goggles;

Appropriate safety PPEs such as Safety Helmet, Safety Shoes, Goggles, Hand gloves, Aprons, Safety belts, Nose Masks, Ear Muffs etc. are provided to all employees as per the requirement at work place. The usage and importance of these appliances are being communicated through workshops and classroom training. Safety personnel carry out regular inspections to enforce the use of appropriate PPE.

The Safety Engineering Department is responsible for the purchase and issue of all PPE. PPE are distributed to both company employees and contractors' employees. If any PPEs are damaged before their scheduled replacement, fresh equipment is issued.

M. Accident Investigation:

All the incidents/accidents of the plant and near miss cases are discussed in all Departmental Safety Committee meetings and remedial measures are implemented wherever such situation exists. As a pro-active measure, all major accidents happening in other steel plants are discussed and remedial measures are implemented wherever similar situation exists in our plant.

- Root cause analysis is carried out to prevent the recurrence.
- All Near Miss Incidents & Reportable Accidents- Jointly analysed by central and shop floor Officers
- All Road Accidents - By a team of Safety, Personnel and Concerned dept.

- Fatal & Fire Accidents - By a Standing Committee
- Recommendations are ensured for compliance.

The Departmental safety committee (DSC) meetings are carried out every month in all the zones while Apex Safety Committee meetings are carried out quarterly in all the shops.

Procedure for Investigation of accidents and incidents:

The investigation of accidents and incidents for finding out causes of accidents/incidents and implementing remedial measures for different shops at BSL is carried out jointly by Safety Engg. Department, BSL along with different Line managers in various shops. The details of the activities and responsibility is indicated below:

SN	ACTIVITY	RESPONSIBILITY
1	Collection of information of accidents from OHS and co-workers of injured	Shift safety inspectors
2	Logging information in shift log book and filling the format "daily accident report"	Shift safety inspectors
3	Collecting IOW form from OHS.	Shift safety inspectors
4	Sending IOW forms with daily accident report to SED office next morning	Shift safety inspectors
5	If the accident is serious in nature inform HOD and concerned In-charges of SED immediately	Shift safety inspectors
6	IOW forms and daily accident reports is sent to statistical cell/SED	Shift safety inspectors
7	Grid I/c notes down the details from the IOW/daily accident report	Grid I/c
8	Grid I/c/representative visits the site of accident/incident	Grid I/c & DSO
9	Observes the site condition - Equipment - Procedures - Housekeeping	Grid I/c & DSO
10	Interrogates -Injured person -Eye witness - Co-workers -Supervisor -Shift I/c	Grid I/c & DSO
11	Grid I/c/representative discusses the matter with senior officials and other concerned	Grid I/c & DSO
12	Gathers fact about - Violation of SOP - Violation of legal requirement - Failure/ defects of equipment - Unsafe condition - Unsafe practices	Grid I/c & DSO
13	Fixes the responsibility	Grid I/c & DSO
14	Suggest /recommend remedial measures	Grid I/c & DSO
15	Fills up the accident investigation report form	Grid I/c & DSO/Engg I/c
16	Documentation of records	SED & DSO
17	Monitors implementation status of the recommendation	Grid I/c(SED)

N. Budget for safety.

The annual budget for procurement of PPE, conducting safety trainings, safety audits and safety promotional activities is around Rs.3 Crores.

4.7.5 Occupational Health Services at BSL

BSL has a full-fledged Occupational Health Services Centre (OHC) inside the plant premises, with round the clock doctor facility. Medical check-ups are carried out for all the workers at regular intervals. Facilities for carrying out lung function test, sputum test, X-ray etc. are available. First aid boxes are provided at strategic locations at shop floor.

The unit is manned by qualified OHS specialists, toxicologist and trained paramedical staff. The In-Charge is an M.B.B.S doctor with M.D. degree and is an AFIH (Associate Fellow of Industrial Health), which is a statutory requirement as per Indian Factories Act.

The OHS Centre is a part of Bokaro Steel Plant's main hospital - Bokaro General Hospital (BGH) located in the plant's township. BGH is a910 bedded hospital BGH is a full-fledged, multi-disciplinary Hospital whose emergency Medicare services are available to the OHS Centre round the clock including various facilities such as OPD facility, pipeline oxygen supply system, Critical care ambulances, Computerised audiometry, lung function test & ECG, well equipped library, air conditioned training hall etc.

First-aid stations are located in the plant, functioning round the clock with qualified doctors, paramedical staff and ambulances. After first aid at the site of the accident, the injured worker may be evacuated to the OHS Centre at the plant for further treatment. If necessary, the injured worker may be transferred to Bokaro General Hospital. BGH may refer the case to specialist hospitals in Kolkata, Ranchi or even Delhi and other places.

All employees undergo a Pre-employment Medical Examination followed by a Periodical Medical Examination (PME). The periodicity of the PME as per the workers' deployment is given in **Table 4.17**.

Table 4.17: Periodicity of the PME

Departments	Planned periodicity
All workers in Benzol plant section of CO&CCP	Once in 3 months
CO&CCP, BF, SMS, SP, TPP, RMHP, CRMP, Foundry unit of engineering shops, RED, and EMD, departments of Works division	Once in 3 months
All other departments of works division	Once in 3 months
All departments of non-works division	Once in 6 months
All canteen contract workers	Once a year

Periodical health check-up covers lung function test, audiometry, vision test, pathological test and bio-chemical test is being done. Various health awareness and training programme are being organized.

A preliminary interaction with OHC members of BSL indicates that the probable occupational health issues in plant employees can be Pneumoconiosis, NIHL, Dermatitis due to Benzene primarily, Melonosis (due to heat) and Silicosis. However, so far there is no Occupational disease detected as per OHC BSL.

The OHS Centre performs Annual Check-up of all BSL personnel with a daily maximum target of check-up of 60 persons a day. Various new initiatives are taken by the OHS also such as mass check-ups through setting up of in-plant Health check-up camps for every department on every Wednesday along with coverage by physician, ophthalmologist, health counselling to risk groups, heath awareness programme, conducting Yoga classes etc. Occupational Health Services Performance for the years 2011-2018 are given in **Table 4.18**.

Table 4.18: Occupational Health Services Performances (2011-2018)

Sn.	Activity	Number of check-up						
		2011-12	2012-13	2013-14	2014 -15	2015 -16	2016 -17	2017 -18
1.	Periodical health check up	8765	8949	9035	7085	7335	7812	8392
2.	Audiometry	-do-	-do-	-do-	-do-	-do-	-do-	-do-
3.	Vision Test	-do-	-do-	-do-	-do-	-do-	-do-	-do-
4.	Lung Function test	-do-	-do-	-do-	-do-	-do-	-do-	-do-
5.	Chest X-Ray (as required)	-do-	-do-	-do-	-do-	-do-	-do-	-do-
6.	FBS	-do-	-do-	-do-	-do-	-do-	-do-	-do-
7.	Urea	-do-	-do-	-do-	-do-	-do-	-do-	-do-
8.	Uric acid	-do-	-do-	-do-	-do-	-do-	-do-	-do-
9.	Creatinine	-do-	-do-	-do-	-do-	-do-	-do-	-do-
10.	Cholesterol	-do-	-do-	-do-	-do-	-do-	-do-	-do-
11.	ECG (>45 yrs of age)	-do-	-do-	-do-	-do-	-do-	-do-	-do-
12.	PMT, MSD (as required)	-do-	-do-	-do-	-do-	-do-	-do-	-do-
13.	Yoga Classes	-do-	-do-	-do-	-do-	-do-	-do-	-do-

Health records of employees are stored safely for periodic retrieval and analysis. A specific coding system has been developed and followed for efficient and systematic placement. The historical employee health data is also stored in soft form and is linked to online system.

ANNEXURES

(Uploaded separatley as part of Annexures)

Annexure-7.1 *Material Safety Data Sheets*
Annexure-7.2 *Onsite emergency plan and HIRA*
Annexure-7.3 *Safety procedures for hazardous gas handling*