RISK ASSESSMENT

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 have notified the "Manufacture Storage & Import of Hazardous Chemicals Rules" in the year 1989. For effective implementation of the rule, Ministry of Environment & Forests 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.

During the process of manufacture of steel and other associated materials hazardous gases are generated which are used in the plant. In addition to this, some other hazardous chemicals, which are required in the manufacture of steel or produced as a bye product also, being stored and handled.

The major chemicals to be handled / stored by the plant includes coke oven gas (COG), Blast furnace gas (BF gas), Basic Oxygen Furnace gas (BOF gas), different acids etc. In view of this, present and proposed activities are being scrutinized in line of the above referred "Manufacture, storage and import of hazardous chemicals rules" and observations / findings are presented in this chapter. Further the unit is already having a well documented Disaster Management Plan for their existing plant covering all the chemicals / gasses handled by them.

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:

- Process description
- Applicability of the rule
- Description of hazardous chemicals
- Hazard identification
- Hazard assessment
- Consequence analysis
- Brief description of the measures taken and

- On site emergency plan

Process Description

DAPCL in the proposed expansion is following the BF- BOF Route of steel making. Iron ore lumps, sinters and, coke (made from cooking coal) and fluxes such as limestone, dolomite are the major raw materials. The main steps in manufacturing process are as follows:

From the process description it can be noticed that the process of manufacture requires considerable thermal energy. This thermal energy is supplied through fuel gasses generated in the plant e.g. Coke oven gas, Blast Furnace gas, DRI Gas and BOF gas. After the proposed expansion generation of fuel gasses will meet the requirement of expanded capacity. Further Oxygen is also required in the process.

Applicability of the Rule

From the above description of the process, it is observed that the chemicals handled and involved are:

(i) Blast furnace gas (ii) Coke Oven gas (iii) DRI Gas (iv) Low Sulphur high stock (LSHS) oil (v) Light diesel oil

To decide whether the above mentioned industrial activities are likely to come within the scope of the above mentioned " Manufacture Storage and Import of Hazardous Chemicals Rules", pertaining to occupiers guide to the hazardous chemical regulation -1989 and the threshold quantities mentioned in the rules are used as given in **Table**

Table: Threshold Quantity & the Quantity Stored and Handled

S. No.	Chemical Stored Handled	Qty.stored / Handled (in Tonne) and Storage / Handling Conditions	Whether Included in the List of Hazardous & Toxic Chemicals	Lower Threshold Qty. (in Tons)	Upper Threshold Qty. (in Tons)	Remarks
1	Blast Furnace Gas (Major constituents Carbon Monoxide)	(Handled. No storage)	Yes	15	200	No storage. Shall be used in RH Fce.
2	Coke Oven Gas (Major Constituents	58300 Tons / year	Yes	15	200	No storage. Shall be

	Hydrogen & Methane)	(Handled. No storage)				used in CPP
3	BOF Gas (Major constituents Carbon Monoxide)	(Handled. No storage)	Yes	15	200	No storage. Bleed-off
4	DRI Kiln Gas	47473 Tons / year (Handled. No storage)				No storage. Shall be used in CPP

It can be seen that there is no storage for any of the chemical and quantity of chemical handled at any point of time is within the lower threshold quantities. Accordingly, rule nos. 7,8,9,13,14, and 15 of the notification will not be applicable. Accordingly, only rule 17 i.e. preparation and maintenance of material safety data sheets for these chemicals are required. Rule -7 i.e. notification of site requires submission of a written report containing among other information the followings:

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

Description of Hazardous Chemicals

The chemicals, which are expected to be handled after capacity expansion, are presented in **Table .** After capacity expansion major hazardous chemical constituent of the BF Gas, BOF Gas, DRI Gas and CO Gas will be Carbon Monoxide. The Material Safety data sheets of the Carbon Monoxide are presented below:

Table : DATA SHEET

Carbon monoxide	**CAS : 630-08-0**
CO	**RTECS : FG3500000**
Synonyms & Trade Names	**DOT ID & Guide :1016 119**
Carbon oxide, Flue gas, Monoxide	**9202 168 (cryogenic liquid)**
Exposure	***NIOSH REL****: TWA 35 ppm (40 mg/m3) C 200 ppm (229 mg/m3)*
Limits	**OSHA PEL†: TWA 50 ppm (55 mg/m3)**
IDLH	***Conversion***
1200 ppm See: 630080	1 ppm = 1.15 mg/m3

Physical	Colorless, odorless gas. [Note: Shipped as a non-liquefied or

Description	liquefied compressed gas.		
MW: 28.0	BP: -313°F	MLT: -337°F	Sol: 2%
VP: >35 atm	IP: 14.01 eV	RGasD: 0.97	
Fl.P: NA (Gas)	UEL: 74%	LEL: 12.5%	
Flammable Gas			

Incompatibilities & Reactivities	Strong oxidizers, bromine trifluoride, chlorine trifluoride, lithium
Measurement Methods	NIOSH 6604; OSHA ID209, ID210 See: NMAM or OSHA Methods
Personal Protection & Sanitation (See protection) Skin: Frostbite Eyes: Frostbite Wash skin: No recommendation Remove: When wet (flammable) Change: No recommendation Provide: Frostbite wash	***First Aid*** (See procedures) Eye: Frostbite Skin: Frostbite Breathing: Respiratory support

Hazard Identification

The following two methods for hazard identification have been employed in the study:

- Identification of major hazardous units based on manufacture, storage and import of hazardous chemicals rules, 1989 of Government of India (GOI rules,1989); and
- Identification of hazardous units and segments of plants and storage units based on relative ranking technique, viz. fire-explosion and toxicity index (FE&TI).

Classification of Major Hazardous Units

Hazardous substances may be classified into three main classes namely flammable substances, unstable substances and toxic substances. The ratings for a large number of chemicals based on flammability, reactivity and toxicity have been given in NFPA Codes 49 and 345 M. The major hazardous materials to be stored, transported, handled and utilized within the facility have been summarized in the **Table-7**. The fuel storage details and properties are given in **Table**.

Table Category Wise Schedule of Storage Tanks

Materials	Hazardous
Blast furnace gas (carbon monoxide)	UN 1016. Dangerous Goods Class 3 ± Flammable Gas
Coke oven gas (hydrogen)	UN 2034. Dangerous Goods Class 3 ± Flammable Gas

Coke oven gas (methane)	UN 1971. Dangerous Goods Class 3 ± Flammable Gas
BOF gas (carbon monoxide)	UN 1016. Dangerous Goods Class 3 ± Flammable Gas
LDO	UN 1203. Dangerous Goods Class 3 ± Flammable Liquid

Table Hazardous Materials Stored, Transported and Handled

A	Material	No. of Tanks	Capacity (Storage Condition)
1	Blast furnace gas (carbon monoxide)	2	50,000 m^3 gaseous, ambient temperature and pressure
2	Coke oven gas (hydrogen & methane)	2	50,000 m^3 gaseous, ambient temperature and pressure
3	BOF gas (carbon monoxide)	2	50,000 m^3 gaseous, ambient temperature and pressure
6	LDO	2	250 m^3

Table Properties of Fuels used in the Plant

Chemical	Codes/Label	TLV	FBP	MP	FP	UFL	LFL
			°c			%	
Blast furnace gas (carbon monoxide)	Flammable	50 ppm	-191.45	-205	-	74	12.5
Coke oven gas (hydrogen)	Flammable	-	-252.8	-259.2	-	74	4
Coke oven gas (methane)	Flammable	1000 ppm	-161.5	-	-187.8	15	5
BOF gas (carbon monoxide)	Flammable	50 ppm	-191.45	-205	-	74	12.5
LDO	Flammable	-	371	-	54.4	6	0.7

TLV : Threshold Limit Value
MP : Melting Point
UEL : Upper Explosive Limit
FBP : Final Boiling Point
FP : Flash Point
LEL : Lower Explosive Limit

Physio-Chemical Properties of Hazardous Chemicals Stored/Used

The physio-chemical properties of BF/CO gas (toxic component is carbon monoxide) are given below:

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 toxic properties are due to the presence of carbon monoxide (CO) (typically 21-25% v/v) in the gas. In confined space, it can form explosive mixture.

BFG is a very low heating value fuel (CV=800-900 Kcal/nm^3), containing inerts of approximately 58% nitrogen and 17% carbon monoxide. 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 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 in the gas and
- Very low combustion energy (3.2 MJ/m^3).

Coke Oven Gas (COG)

G is toxic and flammable gas and has a very strong odour. Its toxic properties are due to the presence of CO (typically 9% v/v) in the gas. COG has a specific gravity of 0.43 and therefore, is a very buoyant gas, which tends to disperse rapidly when released to the atmosphere.

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 (H_2S=2500 mg/Nm^3). This has significant implications for the maintainability of COG systems, because COG pipework frequently develops small corrosion holes.

Carbon Monoxide

CO is colourless, odourless gas, which is also flammable (limits 12% to 74%). It has an auto-ignition temperature of 160ÛC. It is a flammable gas with serious fire hazard.

The health effects of CO are largely the result of the formation of carboxyhemoglobin (COHb) which impairs the oxygen carrying capacity of the blood. Resumption of the normal oxygen supply process takes place once the blood. Resumption of the normal oxygen supply process takes place once an individual is removed from the contaminated atmosphere. However, any damage due to the prolonged loss of oxygen supply to the brain may not be reversible. The TLV, STEL and IDLH values for CO is 50 ppm, 400 ppm and 1200 ppm respectively.

Hazard Assessment

Methodology

An assessment of the conceptual design is conducted for the purpose of identifying and examining hazards related to feed stock materials, major process components, utility and support systems, environmental factors, proposed operations, facilities, and safeguards.

Preliminary Hazard Analysis (PHA)

A preliminary hazard analysis is carried out initially to identify the major hazards associated with storages and the processes of the plant. This is followed by consequence analysis to quantify these hazards. Finally, the vulnerable zones are plotted for which risk reducing measures are deduced and implemented.

Fire Explosion and Toxicity Index (FE&TI) Approach

Fire, explosion and toxicity indexing (FE & TI) is a rapid ranking method for identifying the degree of hazard. The application of FE & TI would help to make a quick assessment of the nature and quantification of the hazard in these areas. However, this does not provide precise information.

Disaster Management Plan

Disasters

A disaster is a catastrophic situation in which suddenly, people are plunged into helplessness and suffering, as a result, need protection, clothing, shelter, medical and social care and other necessities of life.

Disasters can be divided into two main groups. In the first, disasters resulting from natural phenomena like earthquakes, volcanic eruptions, storm surges, cyclones, tropical storms, floods, avalanches, landslides, forest fires etc. The second group includes disastrous events occasioned by man, or man's impact upon the environment. Examples are armed conflict, industrial accidents, radiation accidents, factory fires, explosions and escape of toxic gases or chemical substances, river pollution, mining or other structural collapses, air, sea, rail and road transport accidents and can reach catastrophic dimensions in terms of human loss.

There can be no set criteria for assessing the gravity of a disaster in the abstract since this depends to a large extent on the physical, economic and social environment in which it occurs. What would be considered a major disaster in a developing country, ill equipped to cope with the problems involved, may not mean more than a temporary emergency elsewhere. However, all disaster bring in their wake similar consequences that call for immediate action, whether at the local, national or international level, for the rescue and relief of the victims. This includes the search for the dead and injured and removal of debris and social care, the provision of temporary shelter to the homeless food, clothing and medical supplies, and the rapid re-establishment of essential services.

Objectives of Disaster Management Plan (DMP)

The disaster management plan is aimed to ensure safety of life, protection of environment, protection of installation, restoration of production and salvage operations in this same order of priorities. For effective implementation of the disaster management plan, it will be widely circulated and personnel training given through rehearsals/drills.

The disaster management plan would reflect the probable, consequential severalties of the undesired event due to deteriorating conditions or through Knock on effects. Further, the management should be able to demonstrate that their assessment of the consequences uses good supporting evidence and is based on currently available and reliable information, incident data from internal and external sources and if necessary the reports of outside agencies.

To tackle the consequences of a major emergency inside the factory or immediate vicinity of the factory, a disaster management plan has to be formulated and this planned emergency document is called [3]Disaster Management Plan.

The objective of the industrial disaster management plan is to make use of the combined resources of the plant and the outside services to achieve the following:

- Effect the rescue and medical treatment of casualties;
- Safeguard other people;
- Minimize damage to property and the environment;
- Initially contain and ultimately bring the incident under control;
- Identify any dead;
- Provide for needs of relatives;
- Provide authoritative information to the news media;
- Secure the safe rehabilitation of affected area; and
- Preserve relevant records and equipment for the subsequent inquiry into the cause and circumstances of the emergency.

In effect, it is to optimize operational efficiency to rescue, rehabilitation and render medical help and to restore normalcy.

Occupational Health and Safety

Large industries, in general, and chemical plants in particular where multifarious activities are involved during construction, erection, testing, commissioning, operation & maintenance, the men, materials and machines are the basic inputs. Along with the boons, the industrialization generally bring several problems like occupational health and safety.

Following are the additional occupational and safety measures to implement in the proposed DAPCL project.

Occupational Health

Occupational health needs attention both during construction & erection and operation & maintenance phases. However, the problem varies both in magnitude and variety in the above phases.

Construction & Erection

The occupational health problems envisaged at this stage can mainly be due to constructional accident and noise.

To overcome these hazards, in addition to arrangements to reduce it within TLV's personal protective devices should also be supplied to workers.

Operation and Maintenance

The problem of occupational health, in the operation and maintenance phase is due to respirable dust and noise. With suitable engineering controls the exposures can be reduced to less than TLV limits and proper personnel protective devices should be given to employees.

The working personnel should be given the following appropriate personnel protective devices.

- Industrial safety helmet;
- Crash helmets;
- Face shield with replacement acrylic vision;
- Zero power plain goggles with cut type filters on both ends;
- Zero power goggles with cut type filters on both sides and blue colour glasses;
- Chemical goggles;
- Welders equipment for eye & face protection;
- Cylindrical type earplug;
- Ear muffs;
- Dust masks;
- Canister gas mask;
- Self contained breathing apparatus;
- Leather apron;
- Aluminized fiber glass fix proximity suit with hood and gloves;
- Boiler suit;

- Safety belt/lime man's safety belt;
- Leather hand gloves;
- Asbestos hand gloves;
- Acid/alkali proof rubberized hand gloves;
- Canvas cum leather hand gloves with leather palm;
- Lead hand glove;
- Electrically tested electrical resistance hand gloves;
- Industrial safety shoes with steel toe;
- Rubber boots (alkali resistant); and
- Electrical safety shoes without steel toe and gum boots.

Full fledged hospital facilities should be made available round the clock for attending emergency arising out of accidents, if any. All working personnel should be medically examined at least once in every year and at the end of his term of employment. This is in addition to the pre-employment medical examination.

Safety Plan

Safety of both men and materials during construction and operation phases is of concern. The preparedness of an industry for the occurrence of possible disasters is known as emergency plan. The disaster in the plant is possible due to leakage of hazardous chemicals, collapse of structures and fire/explosion etc.

Keeping in view the safety requirement during construction, operation and maintenance phases, steel plant has formulated safety policy with the following regulations:

- To allocate sufficient resources to maintain safe and healthy conditions of work;
- To take steps to ensure that all known safety factors are taken into account in the design, construction, operation and maintenance of plants, machinery and equipment;
- To ensure that adequate safety instruction are given to all employees;
- To provide wherever necessary protective equipment, safety appliances and clothing, and to ensure their proper use;
- To inform employees about materials equipment or processes used in their work which are known to be potentially hazardous to health or safety;

- To keep all operations and methods of work under regular review for making necessary changes from the point of view of safety in the light of experience and upto date knowledge;
- To provide appropriate facilities for fist aid and prompt treatment of injuries and illness at work;
- To provide appropriate instruction, training, retraining and supervision to employees in health and safety, first aid and to ensure that adequate publicity is given to these matters;
- To ensure proper implementation of fire prevention methods and an appropriate fire fighting service together with training facilities for personnel involved in this service;
- To organize collection, analysis and presentation of data on accident, sickness and incident involving personnel injury or injury to health with a view to taking corrective, remedial and preventive action;
- To promote through the established machinery, joint consultation in health and safety matters to ensure effective participation by all employees;
- To publish/notify regulations, instruction and notices in the common language of employees;
- To prepare separate safety rules for each types of occupation/processes involved in a project; and
- To ensure regular safety inspection by a competent person at suitable intervals of all buildings, equipment, work places and operations.

Safety Training

A full fledged training center will be set up. Safety training will be provided by the safety officer with the assistance of faculty members called from corporate center, professional safety institutions and universities. In addition to regular employees, limited contractor labors are also provided safety training.

To create safety awareness safety films will be shown to workers and leaflets etc. will be distributed.

Some precautions and remedial measures proposed to be adopted to prevent fires are:

Compartmentation of cable galleries, use of proper sealing techniques of cable passages and crevices in all directions would help in localizing and identifying the area of occurrence of fire as well as ensure effective automatic and manual fire fighting operations;

- Spread of fire in horizontal direction would be checked by providing fire stops for cable shafts;

- Reliable and dependable type of fire detection system with proper zoning and interlocks for alarms are effective protection methods for conveyor galleries;
- House keeping of high standard helps in eliminating the causes of fire and regular fire watching system strengthens fire prevention and fire fighting; and
- Proper fire watching by all concerned would be ensured.