



TECHNICAL EIA GUIDANCE MANUAL FOR METALLURGICAL INDUSTRY

Prepared for
The Ministry of Environment and Forests
Government of India



by
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TABLE OF CONTENTS

1. INTRODUCTION TO THE TECHNICAL EIA GUIDANCE MANUALS PROJECT	1-1
1.1 Purpose.....	1-2
1.2 Project Implementation.....	1-4
1.3 Additional Information	1-4
2. CONCEPTUAL FACETS OF EIA.....	2-1
2.1 Environment in EIA Context	2-1
2.2 Pollution Control Strategies.....	2-2
2.3 Tools for Preventive Environmental Management	2-2
2.3.1 Tools for assessment and analysis	2-3
2.3.2 Tools for action.....	2-5
2.3.3 Tools for communication.....	2-10
2.4 Objectives of EIA	2-10
2.5 Types of EIA.....	2-11
2.6 Project Cycle.....	2-13
2.7 Environmental Impacts	2-14
2.7.1 Direct impacts	2-14
2.7.2 Indirect impacts.....	2-15
2.7.3 Cumulative impacts	2-15
2.7.4 Induced impact.....	2-15
2.8 Significance of Impacts.....	2-16
2.8.1 Criteria/methodology to determine the significance of the identified impacts	2-17
3. ABOUT METALLURGICAL INDUSTRY INCLUDING PROCESS AND POLLUTION CONTROL TECHNOLOGIES.....	3-1
3.1 Introduction to the Industry	3-1
3.1.1 Types of metals	3-3
3.2 Metal Industry in India.....	3-8
3.2.1 Current Status	3-8
3.3 Scientific Aspects of Industrial Process.....	3-16
3.3.1 Process technology for ferrous metal industries	3-18
3.3.2 Process technology for non-ferrous metals.....	3-32
3.3.3 Secondary metallurgical industries	3-41
3.3.4 Re-rolling Mills.....	3-50
3.3.5 Iron and steel foundries.....	3-51
3.4 Industrial Processes in the Context of Environmental Pollution	3-53
3.4.1 Iron & steel industry (Ferrous metal industry).....	3-53
3.4.2 Non-ferrous industry	3-65
3.5 Qualitative and Quantitative Analysis	3-73
3.5.1 Waste characteristics of iron and steel manufacturing industry (Ferrous metal)....	3-73
3.5.2 Waste characteristics of Non-ferrous industry.....	3-80

Table of Contents

3.5.3	Emissions, effluents and solid wastes from secondary metallurgical industries	3-89
3.5.4	Exposure pathways	3-93
3.6	Technological Aspects	3-94
3.6.1	Clean technologies	3-94
3.6.2	Pollution control technologies	3-114
3.6.3	Pollution prevention and control.....	3-120
3.6.4	Pollution reduction targets.....	3-120
3.6.5	Occupational Health and Safety of ferrous metal industry	3-121
3.6.6	Occupational health and safety for non-ferrous metal industry	3-126
3.7	Summary of Applicable National Regulations	3-128
3.7.1	General description of major statutes	3-128
3.7.2	General standards for discharge of environmental pollutants.....	3-128
3.7.3	Industry-specific requirements.....	3-128
4.	OPERATIONAL ASPECTS OF EIA.....	4-1
4.1	Coverage of Metallurgical Industries under the Purview of Notification.....	4-1
4.2	Screening	4-5
4.2.1	Applicable conditions for Category B projects.....	4-5
4.2.2	Criteria for classification of Category B1 and B2 projects	4-6
4.2.3	Application for prior environmental clearance	4-6
4.2.4	Siting guidelines	4-6
4.3	Scoping for EIA Studies	4-7
4.3.1	Pre-feasibility report	4-9
4.3.2	Guidance for providing information in Form 1	4-10
4.3.3	Identification of appropriate valued environmental components.....	4-10
4.3.4	Methods for identification of impacts.....	4-11
4.3.5	Testing the significance of impacts.....	4-16
4.3.6	Terms of reference for EIA studies.....	4-16
4.4	Environmental Impact Assessment.....	4-23
4.4.1	EIA team	4-23
4.4.2	Baseline quality of the environment	4-24
4.4.3	Impact prediction tools	4-27
4.4.4	Significance of the impacts.....	4-27
4.5	Social Impact Assessment.....	4-28
4.6	Risk Assessment	4-30
4.6.1	Disaster management plan	4-36
4.7	Mitigation Measures	4-39
4.7.1	Important considerations for mitigation methods	4-40
4.7.2	Hierarchy of elements of mitigation plan	4-41
4.7.3	Typical mitigation measures	4-42
4.8	Environmental Management Plan.....	4-45
4.9	Reporting	4-46
4.10	Public Consultation.....	4-48
4.11	Appraisal	4-51
4.12	Decision Making.....	4-53
4.13	Post-clearance Monitoring Protocol.....	4-54

5. STAKEHOLDERS' ROLES AND RESPONSIBILITIES	5-1
5.1 SEIAA.....	5-3
5.2 EAC and SEAC	5-6

LIST OF TABLES

Table 3-1: Material Inputs in Secondary Ferrous Metallurgical Processes	3-2
Table 3-2: Material Inputs in Secondary Non-Ferrous Metallurgical Processes	3-2
Table 3-3: Production and Export of Hematite in India.....	3-9
Table 3-4: Classification of Indian Steel Sector by JPC	3-10
Table 3-5: Crude Steel Production in India in the 10 th and 11 th Plan.....	3-10
Table 3-6: Production of Crude Steel ('000 tonnes).....	3-11
Table 3-7: Production for Sale, Import, Export and Consumption of Steel (MT)	3-13
Table 3-8: Technology Facility at Various Processing Levels	3-18
Table 3-9: Resource required for a typical Indian Steel plant is as follows.....	3-27
Table 3-10: Raw Material Consumption per Tonne of Charge Chrome Product	3-29
Table 3-11: Raw Material Consumption per Tonne of High Carbon Ferro-chrome Product	3-29
Table 3-12: Raw Material Consumption per Tonne of High Carbon Ferro-chrome Product	3-30
Table 3-13: Raw Material Consumption per Tonne of Aluminum Product	3-35
Table 3-14: Raw Material Consumption per Tonne of Aluminum Metal Product	3-35
Table 3-15: Comparison between Coal Based and Gas Based Products	3-45
Table 3-16: Amount of Harmful Substance from Blast Furnace Plant.....	3-74
Table 3-17: Generation of Combustion Products from fuels	3-76
Table 3-18: Continuous Cold Mill with BACT Controls.....	3-77
Table 3-19: Emission from Continuous Casting Shop.....	3-78
Table 3-20: Air Emission Levels for Integrated Steel Plants ^C	3-78
Table 3-21: Exposure Pathways.....	3-93
Table 3-22: Existing Management System v/s Requirements for Steel Industry	3-114

Table of Contents

Table 3-23: Existing Management System v/s Requirements for Aluminum Industry	3-115
Table 3-24: Required Management System for Other Non-Ferrous Industry	3-116
Table 3-25: Effluent Discharge Standards	3-129
Table 3-26: Stack Emission Standards.....	3-129
Table 3-27: Characteristics of wastewater before treatment in Zinc extraction	3-131
Table 3-28: Standards for effluent in Zinc extraction.....	3-131
Table 3-29: Standards for Effluent in Copper Smelting	3-132
Table 3-30: Integrated Iron & Steel Plant: Emission Standards	3-132
Table 3-31: Coke Oven and Refractory Material Plant: Emission Standards.....	3-132
Table 3-32: Integrated Iron & Steel Plant: Waste-water Discharge Standards.....	3-133
Table 3-34: International Reference Norms for Consumption of Water and Energy for non-ferrous industry	3-134
Table 3-35: International Carbon Foot Prints for Non-ferrous Sector.....	3-135
Table 3-36: Activity-specific Direct Emissions from Lead and Copper Production	3-136
Table 4-1: Advantages and Disadvantages of Impact Identification Methods	4-11
Table 4-2: Matrix of Impacts	4-13
Table 4-3: List of Important Physical Environment Components and Indicators of EBM.....	4-25
Table 4-4: Choice of Models for Impact Predictions: Risk Assessment.....	4-32
Table 4-5: Typical Mitigation Measures.....	4-43
Table 4-6: Structure of EIA Report.....	4-47
Table 5-1: Roles and Responsibilities of Stakeholders Involved in Prior Environmental Clearance ..	5-1
Table 5-2: Organization-specific Functions.....	5-2
Table 5-3: SEIAA: Eligibility Criteria for Chairperson/ Members/ Secretary	5-5
Table 5-4: EAC/SEAC: Eligibility Criteria for Chairperson / Members / Secretary	5-8

LIST OF FIGURES

Figure 2-1: Inclusive Components of Sustainable Development.....	2-1
Figure 2-2: Types of Impacts.....	2-14
Figure 2-3: Cumulative Impact.....	2-15
Figure 3-1: Process Flow Diagram.....	3-17
Figure 3-2: A Sinter Plant with State-of-the-Art Cooler Heat Recovery System.....	3-19
Figure 3-3: Blast Furnace.....	3-21
Figure 3-4: A Basic Oxygen Furnace.....	3-24
Figure 3-5: A Continuous Caster.....	3-26
Figure 3-6: Rolling and Finishing.....	3-26
Figure 3-7: Bayer Process to Produce Alumina.....	3-33
Figure 3-8: Zinc Production Process.....	3-40
Figure 3-9: Process Flow Diagram of Coal Based Sponge Iron Plant.....	3-43
Figure 3-10: General Arrangement of Coal Based Customized / Indigenous Technology.....	3-44
Figure 3-11: Flow Diagram of Midrex Process.....	3-45
Figure 3-12: Electric Arc Furnace.....	3-52
Figure 3-13: Flowchart Linking Pollutants and Principal Processes.....	3-53
Figure 3-14: Resources and Waste Generation for Production of 1 tonne Crude Steel.....	3-75
Figure 3-15: Typical Use of Iron & Steel Slag in Japan.....	3-79
Figure 3-16: The Pittsburgh Reduction Company's First Cell Room.....	3-82
Figure 3-17: Electrolytic Cell for 300 kA Prebaked Carbon Anode Technology in the Cell Room.....	3-83
Figure 3-18: Soderberg Electrolytic Cell Line - Kaiser Chalmette Plant.....	3-84
Figure 3-19: Carbonization of slag.....	3-111
Figure 4-1: Prior Environmental Clearance Process for Activities Falling Under Category A.....	4-3
Figure 4-2: Prior Environmental Clearance Process for Activities Falling Under Category B.....	4-4
Figure 4-3: Approach for EIA Study.....	4-23

Table of Contents

Figure 4-4: Risk Assessment – Conceptual Framework4-32

Figure 4-5: Comprehensive Risk Assessment - At a Glance4-33

Figure 4-6: Elements of Mitigation.....4-41

LIST OF ANNEXURES

Annexure I

A Compilation of Legal Instruments

Annexure II

General Standards for Discharge of Environmental Pollutants as per CPCB

Annexure III

Form 1 (Application Form for Obtaining EIA Clearance)

Annexure IV

Critically Polluted Industrial Areas and Clusters / Potential Impact Zone

Annexure V

Pre-feasibility Report: Points for Possible Coverage

Annexure VI

Types of Monitoring and Network Design Considerations

Annexure VII

Guidance for Assessment of Baseline Components and Attributes

Annexure VIII

Sources of Secondary Data

Annexure IX

Impact Prediction Tools

Annexure X

Form through which the State Government/Administration of the Union Territories Submit Nominations for SEIAA and SEAC for the Consideration and Notification by the Central Government.

Annexure XI

Composition of EAC/SEAC

Annexure XII

Best Practices & Latest Technologies available and reference

ACRONYMS

AAQ	Ambient Air Quality
ABC	After Burner Chamber
APCD	Air Pollution Control Devices
B/C	Benefits Cost Ratio
BACT	Best Available Control Technology
BAT	Best Available Technology
BHEL	Bharat Heavy Electricals Ltd.
BIS	Bureau of Indian Standards
BLT	Bell Less Top
BOD	Biochemical Oxygen Demand
BOF	Basic Oxygen Furnace
BOQ	Bill of Quantities
BOT	Build Operate Transfer
BOOT	Build Own Operate Transfer
CCA	Conventional Cost Accounting
CDQ	Coke Dry Quenching
CEA	Central Electricity Authority
CER	Corporate Environmental Reports
CEAA	Canadian Environmental Assessment Agency
CFE	Consent for Establishment
CGAR	Compounded Annual Growth Rate
CO	Carbon Monoxide
COG	Coke Oven Gas
CPCB	Central Pollution Control Board
CPWD	Central Public Works Department
CREP	Corporate Responsibility for Environmental Protection
CRZ	Coastal Regulatory Zone
DfE	Design for Environment
DMP	Disaster Management Plan
DRI	Direct Reduced Iron
DSC	Dust Settling Chamber
EAC	Expert Appraisal Committee
EAF	Electric Arc Furnace
ECI	Environmental Condition Indicators
EcE	Economic-cum-Environmental
EIA	Environmental Impact Assessment

EIS	Environmental Information System
EMA	Environmental Management Accounting
EMF	Electric and Magnetic Field
EMP	Environmental Management Plan
EMS	Environmental Management System
EOS	Emission Optimized Sintering
EPI	Environmental Performance indicators
EPR	Extended Producers Responsibilities
EPZ	Export Processing Zones
ES	Environmental Statements
ESPs	Electrostatic Precipitators
FBC	Fluidized Bed Combustion Boiler
FCA	Full Cost Assessment
FDI	Foreign Direct Investment
FSA	Fuel Supply Agreement
FTA	Free Trade Agreement
GCP	Gas Cleaning Plant
GCT	Gas Conditioning Tower
GHGs	Green House Gases
HAZID	Harzard identification Study
HAZOP	Hazard and Operability Studies
HBI	Hot Briquetted Iron
HCL	Hindustan Copper Ltd.
HMT	Hindustan Machine Tools Ltd.
HTL	High Tide Level
IF	Induction Furnace
IISCO	Indian Iron & Steel Company
IL&FS	Infrastructure Leasing and Financial Services
IR	Infrared
IVI	Importance Value Index
ISO	International Standard Organization
JPC	Joint Plant Commission
KIOCL	Kudremukh Iron Ore Company Ltd.
LCA	Life Cycle Assessment
LD	Linz-Donawitz
LDAR	Leak Detection and Repair
LTL	Low Tide Level
MBF	Mini Blast Furnace

MCA	Maximum Credible Accident
MoEF	Ministry of Environment & Forests
NAQM	National Air Quality Monitoring
NGO	Non-Government Organizations
NMDC	National Mineral Development Corporation
O&M	Operation and Maintenance
OECD	Organization for Economic Co-operation and Development
OMC	Orissa Mining Corporation
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyls
PCDDs	Polychlorinated Dibenzodioxins
PCDFs	Polychlorinated Dibenzofurans
PCI	Pulverized Coal Injection
PICs	Products of Incomplete Combustion
PM	Particulate Matter
PPA	Participatory Poverty Assessment
PPE	Personal Protection Equipment
PRA	Participatory Rural Appraisal
PSA	Pressure Swing Adsorption
PWDs	Public Works Departments
QA/QC	Quality Assurance/Quality Control
QRA	Quantitative Risk Assessment
RHF	Rotary Hearth Furnace
RINL	Rashtriya Ispat Nigam Ltd.
RLE	Roast Leach Electrowin
RM	Red Mud
SAIL	Steel Authority of India Ltd.
SEA	Strategic Environmental Assessment
SEAC	State Level Expert Appraisal Committee
SEIAA	State Level Environment Impact Assessment Authority
SEZ	Special Economic Zone
SIA	Social Impact Assessment
SIIL	Sterlite Industries (India) Ltd.
SME	Small and Medium Scale Enterprises
SMS	Steel Melting Shop
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
SSIs	Small Scale Industries

Table of Contents

TA	Technology Assessment
TCA	Total Cost Assessment
TEQM	Total Environmental Quality Movement
TGM	Technical EIA Guidance Manual
TISCO	Tata Iron and Steel Company
ToR	Terms of Reference
TRT	Top Pressure Recovery Turbine
UT	Union Territory
UT	Ultrasonic Testing
UTEIAA	Union Territory Level Environment Impact Assessment Authority
UTPCC	Union Territory Pollution Control Committee
VD	Vacuum Degassing
VISL	Visvesvaraya Iron & Steel Ltd.
VOC	Volatile Organic Compound
VSDs	Variable Speed Drives
WHRB	Waste Heat Recovery Boilers

Mahesh Babu
Chief Executive Officer

Acknowledgement

The Notification issued on the prior environmental clearance process by the Ministry of Environment and Forests (MoEF) on September 14, 2006 delegated substantial powers to the State Level Environment Impact Assessment Authorities (SEIAA) to grant environmental clearance for certain categories of developmental activities/projects. It was felt that proper guidance to the stakeholders would enhance appreciation of environmental impacts of proposed projects and possible mitigation measures. Further, such a guidance would also help ensure that decision making authorities across different States and Union Territories could adopt similar considerations and norms with due weightage for site-specific considerations.

We feel privileged to be part of the interventions being spearheaded by Sh. Jairam Ramesh, Hon'ble Minister, MoEF, Government of India, to mainstream environmental considerations in the decision making process. IL&FS Ecosmart as part of this important initiative, prepared Technical EIA Guidance Manuals for 27 identified development activities. In view of the diversity of 27 developmental activities entrusted to IL&FS Ecosmart Ltd., in consultation with the MoEF, an expert Peer and Core Committee was constituted to review and finalize each of the draft Manuals. The Manuals prepared by IL&FS were technically reviewed and up-dated by the respective sector-specific expert resource persons.

The Manuals designed by the Expert Committee have benefitted from the advise and feedback received from MoEF. The Manuals are designed to provide readers with an in-depth understanding of the environmental clearance mechanism, developmental activity specific environmental impacts with possible mitigation measures, environmentally compliant manufacturing/ production processes and pollution control technologies, etc.

IL&FS Ecosmart hopes that these Manuals are a step forward to realize the MoEF's desired objective of enhancing functional efficiency and effectiveness in the environmental clearance process. We hope the stakeholders will find the Manuals useful.

We take this opportunity to convey our appreciation to the MoEF team under the leadership of Mr. J.M. Mauskar, Additional Secretary, for the technical inputs, guidance and support extended throughout the project period for successful completion of the project. The technical guidance and support extended by the Expert Peer and Core Committee under the Chairmanship of Dr. V. Rajagopalan, former Chairman, Central Pollution Control Board and inputs of the sector-specific resource persons are gratefully acknowledged.


(Mahesh Babu)

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FOREWORD

The Ministry of Environment & Forests (MOEF) introduced the Environmental Impact Assessment (EIA) Notification 2006 on 14th September 2006, which not only reengineered the entire environment clearance (EC) process specified under the EIA Notification 1994, but also introduced a number of new developmental sectors which would require prior environmental clearance. The EIA Notification 2006 has notified a list of 39 developmental sectors which have been further categorised as A or B based on their capacity and likely environmental impacts. Category B projects have been further categorised as B1 and B2. The EIA Notification 2006 has further introduced a system of screening, scoping and appraisal and for the setting up of Environment Impact Assessment Authority (EIAA) at the Central level and State Level Environment Impact Assessment Authorities (SEIAAs) to grant environmental clearances at the Central and State level respectively. The Ministry of Environment & Forests is the Environment Impact Assessment Authority at the Central level and 25 State Level Environment Impact Assessment Authorities (SEIAAS) have been set up in the various States/UTs. The EIA Notification 2006 also stipulates the constitution of a multi-disciplinary Expert Appraisal Committee (EAC) at the Centre and State level Expert Appraisal Committees (SEACs) at State/UT Level for appraisal of Category A or B projects respectively and to recommend grant/rejection of environmental clearance to each project/activities falling under the various sectors to the EIAA/SEIAAs respectively.

Although the process of obtaining environmental clearance consisting of Screening, Scoping and Appraisal and for undertaking public consultation including the process of conduct of Public Hearing has been elaborated under the EIA Notification 2006, the Notification itself provides for bringing out guidelines from time to time on the EIA Notification 2006 and the EC process with a view to bringing clarity on the EC process for expediting environmental clearance. This need was further reinforced after the constitution of SEIAAs and SEACs in various States, who were assigned the task for the first time and with a need for addressing the concerns of standardization of the quality of appraisal and in reducing inconsistencies between SEACs/SEIAAs in granting ECs for similar projects in different States.

The Technical Guidance Manual of “**Metallurgical Industry**” sector describes types of process and pollution control technologies, operational aspects of EIA with model TOR of that Sector, technological options with cleaner production and waste minimization techniques,

monitoring of environmental quality, post clearance monitoring protocol, related regulations, and procedure of obtaining EC if linked to other clearances for e.g., CRZ, etc.

Metallurgical industries cause great devastation of both terrestrial and aquatic environment on a local and regional scale. The major effects are due to pollution of air, soil, river water, and groundwater with heavy metals. The metallurgical industry has responded in a variety of ways. The steel industry has stopped the use of open hearth furnaces and switched over to cleaner technology. The aluminum industry has switched over from Soderberg to pre-baked electrodes in electrolytic cells. The copper industry has abandoned the reverberatory furnace to a flash smelting technology and introduction of tall stacks has helped dispose of SO₂ emissions. India's industrial competitiveness and environmental future depends on Industries such as Metallurgical Industry adopting energy and resource efficient technologies. Recycling and reuse of materials is critical.

To keep pace with changing technologies and needs of sustainable development, the manual would require regular updating in the future. The manual will be available on the MoEF website and we would appreciate receiving responses from stakeholders for further improvements.

I congratulate the entire team of IL&FS Ecosmart Ltd., experts from the sector who were involved in the preparation of the Manuals, Chairman and members of the Core and Peer Committees of various sectors and various Resource Persons whose inputs were indeed valuable in the preparation and finalization of the Manuals.


(Jairam Ramesh)

1.

INTRODUCTION TO THE TECHNICAL EIA GUIDANCE MANUALS PROJECT

Environmental Impact Assessment (EIA) is a process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made. These studies integrate the environmental concerns of developmental activities into the process of decision-making.

EIA has emerged as one of the successful policy innovations of the 20th Century in the process of ensuring sustained development. Today, EIA is formalized as a regulatory tool in more than 100 countries for effective integration of environmental concerns in the economic development process. The EIA process in India was made mandatory and was also given a legislative status through a Notification issued by the Ministry of Environment and Forests (MoEF) in January 1994. The Notification, however, covered only a few selected industrial developmental activities. While there are subsequent amendments, the Notification issued on September 14, 2006 supersedes all the earlier Notifications, and has brought out structural changes in the clearance mechanism.

The basic tenets of this EIA Notification could be summarized into the following:

- Pollution potential as the basis for prior environmental clearance instead of investment criteria; and
- Decentralization of clearing powers to the State/Union Territory (UT) level Authorities for certain developmental activities to make the prior environmental clearance process quicker, transparent and effective.

Devolution of the power to grant clearances at the state level for certain category of the developmental activities/projects is a step forward to fulfill the basic tenets of the re-engineering *i.e.*, quicker, transparent and effective process but many issues impede/hinder its functional efficiency. These issues could be in technical and operational as listed below:

Technical issues

- Ensuring level playing ground to avoid arbitrariness in the decision-making process
- Classification of projects which do not require public hearing and detailed EIA (Category B2)
- Variations in drawing Terms of Reference (ToR) for EIA studies for a given developmental activity across the States/UTs
- Varying developmental-activity-specific expertise requirement for conducting EIA studies and their appraisal
- Availability of adequate sectoral experts and variations in competency levels
- Inadequate data verification, cross checking tools and supporting institutional framework

- Meeting time targets without compromising with the quality of assessments/ reviews
- Varying knowledge and skill levels of regulators, consultants and experts
- Newly added developmental activities for prior environmental clearance, *etc.*

Operational issues

- State level /UT level EIA Authorities (SEIAA/UTEIAA) are formulated for the first time and many are functioning
- Varying roles and responsibilities of involved organizations
- Varying supporting institutional strengths across the States/UTs
- Varying manpower availability, *etc.*

1.1 Purpose

The purpose of developing the sector-specific technical EIA guidance manuals (TGM) is to provide clear and concise information on EIA to all the stakeholders *i.e.*, the project proponent, the consultant, the reviewer, and the public. The TGMs are organized to cover following:

Chapter 1 (Introduction): This chapter provides a brief introduction on the EIA, basic tenets of EIA Notification, technical & operational issues in the process of clearance, purpose of the TGMs, project implementation process and additional information.

Chapter 2 (Conceptual facets of an EIA): Provides an overall understanding to the conceptual aspects of control of pollution and EIA for the developmental projects. This basic understanding would set the readers at same level of understanding for proper interpretations and boundaries for identifying the environmental interactions of the developmental projects and their significance for taking mitigative measures. This chapter covers the discussion on environment in EIA context *i.e.*, sustainable development, pollution control strategies, preventive environmental management tools, Objectives of EIA, types and basic principles of EIA, project cycle for metallurgical industry, understanding on type of environmental impacts and the criteria for the significance analysis.

Chapter 3 (Metallurgical Industry): The purpose of this chapter is to provide the reader precise information on all the relevant aspects of the industry, which is essential to realize the likely interaction of such developmental activities on the receiving environment. Besides, this Chapter gives a holistic understanding on the sources of pollution and the opportunities of the source control.

The specific coverage which provides precise information on the industry include (i) Introduction to the industry and types of metals, (ii) metal industry in India, (iii) Scientific aspects - Process technology for ferrous metal industries, Process technology for non-ferrous metals, Secondary metallurgical industries, Re-rolling Mills, Iron and steel foundries, (iv) industrial processes in the context of environmental pollution, (v) qualitative and quantitative analysis of rejects from this industry, (vi) technological aspects - cleaner and pollution control technologies, and (vii) the summary of applicable national regulation for this developmental activity.

Chapter 4 (Operational aspects): The purpose of this chapter is to facilitate the stakeholders to extend clear guidance on coverage of legislative requirements, sequence

of procedures for obtaining the EIA clearance and each step-wise provisions and considerations.

The coverage of the Chapter include provisions in the EIA Notification regarding metallurgical industry, screening (criteria for categorization of B1 and B2, siting guidelines, *etc.*), scoping (pre-feasibility report, guidance for filling form 1, identification of valued environmental components, identification of impacts, *etc.*), arriving at terms of reference for EIA studies, impact assessment studies (EIA team, assessment of baseline quality of environment, impact prediction tools, significance of impacts), social impact assessment, risk assessment considerations, typical mitigation measures, designing considerations for environmental management plan, structure of EIA report for incorporation of study findings, process of public consultation, project appraisal, decision making process and post-clearance monitoring protocol.

Chapter 5 (Roles and responsibilities of various organizations involved in the process of prior environmental clearance): The purpose of this Chapter is to brief the stakeholders on the institutional mechanism and roles & responsibilities of the stakeholders involved in the process of prior environmental clearance. The Coverage of the Chapter include (i) roles and responsibilities of the stakeholders, (ii) organization specific functions, (iii) constitution, composition and decision making process of SEIAA and (iv) EAC & SEAC and (v) other conditions which may be considered.

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue. Text within each section was researched from many sources, and was condensed from more detailed sources pertaining to specific topics.

The contents of the document are designed with a view to facilitate addressing of relevant technical and operational issues as mentioned in the earlier section. Besides, the TGM facilitates various stakeholders involved in the EIA clearance process *i.e.*

- Project proponents will be fully aware of the procedures, common ToR for EIA studies, timelines, monitoring needs, *etc.*, in order to plan the projects/studies appropriately.
- Consultants across India will gain similar understanding about a given sector, and also the procedure for EIA studies, so that the quality of the EIA reports gets improved and streamlined.
- Reviewers across the States/UTs will have the same understanding about an industrial sector and would able to draw a benchmark in establishing the significant impacts for the purpose of prescribing the ToR for EIA studies and also in the process of review and appraisal.
- Public who are concerned about new or expansion projects, use this manual to get a basic idea about the manufacturing/production details, rejects/wastes from the operations, choice of cleaner/control technologies, regulatory requirements, likely environmental and social concerns, mitigation measures, *etc.*, in order to seek clarifications appropriately in the process of public consultation. The procedural clarity in the document will further strengthen them to understand the stages involved in clearance and roles and responsibilities of various organizations.
- In addition, these manuals would substantially ease the pressure on reviewers at the scoping stage and would bring in functional efficiency at the central and state levels.

1.2 Project Implementation

The Ministry of Environment & Forests (MoEF), Government of India took up the task of developing sector-specific technical EIA guidance manuals for all the developmental activities listed in the re-engineered EIA Notification. The Infrastructure Leasing and Financial Services Ecosmart Limited (IL&FS Ecosmart), has been entrusted with the task of developing these manuals for 27 industrial and related sectors. Metallurgical industry (ferrous & non-ferrous) is one of these sectors, for which this manual is prepared.

The ability to design comprehensive EIA studies for specific industries depends on the knowledge of several interrelated topics. Therefore, it requires expert inputs from multiple dimensions *i.e.*, administrative, project management, technical, scientific, social, economic, risk *etc.*, in order to comprehensively analyze the issues of concern and to draw logical interpretations. Thus, Ecosmart has designed a well-composed implementation framework to factor inputs of the experts and stakeholders in the process of finalization of these manuals.

The process of manual preparation involved collection & collation of the secondary available information, technical review by sectoral resource persons and critical review & finalization by a competent Expert Committee composed of core and sectoral peer members.

The MoEF appreciates the efforts of Ecosmart, Expert Core and Peer Committee, resource persons and all those who have directly and indirectly contributed to this Manual.

1.3 Additional Information

This TGM is brought out by the MoEF to provide clarity to all the stakeholders involved in the 'Prior Environmental Clearance' process. As such, the contents and clarifications given in this document do not withstand in case of a conflict with the statutory provisions of the Notifications and Executive Orders issued by the MoEF from time-to-time.

TGMs are not regulatory documents. Instead, these are the tools designed to assist in successful completion of an EIA.

For the purpose of this project, the key elements considered under TGMs are: conceptual aspects of EIA; developmental activity-specific information; operational aspects; and roles and responsibilities of involved stakeholders.

This manual is prepared considering the Notification issued on 14th September, 2006 and its latest amendment as on 1st December 2009. For recent updates, if any, please refer the website of the MoEF, Government of India *i.e.*, <http://moef.nic.in/index.php>.

2.

CONCEPTUAL FACETS OF EIA

It is an imperative requirement to understand the basic concepts concerned to the pollution control and the environmental impact assessment in an overall objective of the sustainable development. This Chapter highlights the pollution control strategies and their tools besides the objectives, types & principles of EIA, type of impacts their significance analysis, in order to provide consistent understanding to the reader before assessing the development of activity-specific environmental concerns in Chapter 3 and identification & prediction of significant impacts in order to design mitigation measures as detailed in Chapter 4.

2.1 Environment in EIA Context

“Environment” in EIA context mainly focuses, but is not limited to physical, chemical, biological, geological, social, economical, and aesthetic dimensions along with their complex interactions, which affect individuals, communities and ultimately determines their forms, character, relationship, and survival. In EIA context, ‘effect’ and ‘impact’ can often be used interchangeably. However, ‘impact’ is considered as a value judgment of the significance of an effect.

Sustainable development is built on three basic premises *i.e.*, economic growth, ecological balance and social progress. Economic growth achieved in a way that does not consider the environmental concerns, will not be sustainable in the long run. Therefore, sustainable development needs careful integration of environmental, economic, and social needs in order to achieve both an increased standard of living in short term, and a net gain or equilibrium among human, natural, and economic resources to support future generations in the long term.

“It is necessary to understand the links between environment and development in order to make choices for development that will be economically efficient, socially equitable and responsible, as well as environmentally sound.”

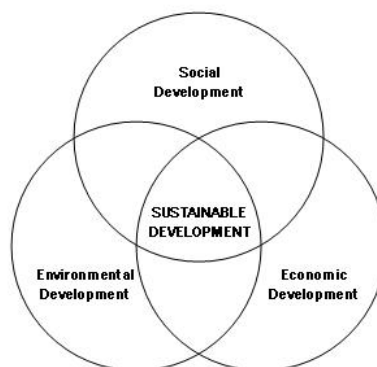


Figure 2-1: Inclusive Components of Sustainable Development

2.2 Pollution Control Strategies

Pollution control strategies can be broadly categorized into preventive and reactive. The reactive strategy refers to the steps that may be applied once the wastes are generated or contamination of receiving environment takes place. The control technology or a combination of technologies to minimize the impact due to the process rejects/wastes varies with quantity and characteristics, desired control efficiency and economics.

Many combinations of techniques could be adopted for treatment of a specific waste or the contaminated receiving environment, but are often judged based on techno-economic feasibility. Therefore, the best alternative is to take all possible steps to avoid pollution itself. This preventive approach refers to a hierarchy that involves i) prevention & reduction; ii) recycling and re-use; iii) treatment; and iv) disposal, respectively.

Therefore, there is a need to shift the emphasis from the reactive to preventive strategy *i.e.*, to promote preventive environmental management. Preventive environmental management tools may be grouped into management based tools, process based tools and product based tools, which are given below:

Management Based Tools	Process Based Tools	Product Based Tools
Environmental Management System (EMS)	Environmental Technology Assessment	Industrial Ecology
Environmental Performance Evaluation	Toxic Use Reduction	Extended Producers Responsibility
Environmental Audits	Best Operating Practices	Eco-labeling
Environmental Reporting and Communication	Environmentally Best Practice	Design for Environment
Total Cost Accounting	Best Available Technology (BAT)	Life Cycle Assessment (LCA)
Law and Policy	Waste Minimization	
Trade and Environment	Pollution Prevention	
Environmental Economics	Cleaner Production	
	4-R Concept	
	Cleaner Technology	
	Eco-efficiency	

2.3 Tools for Preventive Environmental Management

The tools for preventive environmental management can be broadly classified into following three groups.

- Tools for assessment and analysis - risk assessment, life cycle assessment, total cost assessment, environmental audit / statement, environmental benchmarking, environmental indicators
- Tools for action - environmental policy, market based economic instruments, innovative funding mechanism, EMS and ISO certification, total environmental quality movement, eco-labeling, cleaner production, eco-efficiency, industrial ecosystem or metabolism, voluntary agreements
- Tools for communication - state of environment, corporate environmental reporting

Specific tools under each group are discussed precisely in next sections.

2.3.1 Tools for assessment and analysis

2.3.1.1 Risk assessment

Risk is associated with the frequency of failure and consequence effect. Predicting such situations and evaluation of risk is essential to take appropriate preventive measures. The major concern of the assessment is to identify the activities falling in a matrix of high & low frequencies at which the failures occur and the degree of its impact. The high frequency, low impact activities can be managed by regular maintenance *i.e.*, LDAR (Leak detection and repair) programmes. Whereas, the low frequency, high impact activities (accidents) are of major concern in terms of risk assessment. As the frequency is low, often the required precautions are not realized or maintained. However, the risk assessment identifies the areas of major concerns, which require additional preventive measures; likely consequence distances considering domino effects, which will give the possible casualties and ecological loss in case of accidents. These magnitudes demand the attention for preventive and disaster management plans (DMP). Thus is an essential tool to ensure safety of operations.

2.3.1.2 Life cycle assessment

A broader approach followed to deal with environmental impacts during manufacturing is called life cycle assessment (LCA). This approach recognizes that environmental concerns are associated with every step of the processing w.r.t. manufacturing of the products and also examines environmental impacts of the product at all stages of project life cycle. LCA includes product design, development, manufacturing, packaging, distribution, usage and disposal. LCA is concerned with reducing environmental impacts at all stages and considering the total picture rather than just one stage of the production process.

Industries/firms may apply this concept to minimize costs incurred on the environmental conservation throughout the project life cycle.

2.3.1.3 Total cost assessment

Total cost assessment (TCA) is an enhanced financial analysis tool that is used to assess the profitability of alternative courses of action, *e.g.*, raw material substitution to reduce the costs of managing the wastes generated by process; an energy retrofit to reduce the costs of energy consumption. This is particularly relevant for pollution prevention options. These options because of their nature often produce financial savings that are overlooked in conventional financial analysis, either because they are misallocated, uncertain, hard to quantify, or occur more than three to five years after the initial investment. TCA involves all of relevant costs and savings associated with an option so that it can compete for scarce capital resources fairly, on a level playing field. The assessments are often beneficial in respect of the following:

- Identification of costly resource inefficiencies
- Financial analysis of environmental activities/projects such as investment in cleaner technologies
- Prioritization of environmental activities/projects
- Evaluation of product mix and product pricing
- Benchmarking against the performance of other processes or against the competitors

A comparison of cost assessments is given below:

- Conventional cost accounting (CCA): Direct and indirect financial costs+ Recognized contingent costs
- Total cost assessment (TCA): A broader range of direct, indirect, contingent and less quantifiable costs
- Full cost assessment (FCA): TCA + External social costs borne by society

2.3.1.4 Environmental audit/statement

Key objectives of an environmental audit include compliance verification, problem identification, environmental impact measurement, environmental performance measurement, conforming effectiveness of EMS, providing a database for corrective actions and future actions, developing company's environmental strategy, communication and formulating environmental policy.

The MoEF, Government of India (GoI) has issued Notification on 'Environmental Statements' (ES) in April, 1992 and further amended in April 1993. As per the Notification, the industries are required to submit environmental statements to the respective State Pollution Control Board (SPCB). ES is a proactive tool for self-examination of the industry to reduce/minimize pollution by adopting process modifications, recycling and reusing of the resources. The regular submission of ES will indicate the systematic improvement in environmental pollution control being achieved by the industry. In other way, specific points in ES may be used as environmental performance indicators for relative comparison, implementation and to promote better practices.

2.3.1.5 Environmental benchmarking

Environmental performance and operational indicators could be used to navigate, manage and communicate significant aspects and give enough evidence of good environmental house keeping. Besides the existing prescribed standards, an insight to identify the performance indicators and prescribing schedule for systematic improvement in performance of these indicators will yield better results.

Relative indicators may be identified for different industrial sectors and be integrated in companies and organizations to monitor and manage different environmental aspects of the company, to benchmark and compare two or more companies from same sector. These could cover water consumption, wastewater generation, energy consumption, solid/hazardous waste generation, chemical consumption *etc.*, per tonne of final product. Once these benchmarks are developed, the industries which are below the may be guided and enforced to reach them while those which are better than the benchmark may be encouraged further by giving incentives *etc.*

2.3.1.6 Environmental indicators

Indicators can be classified into environmental performance indicators (EPI) and environmental condition indicators (ECI). The EPIs can be further divided into two categories *i.e.*, operational performance indicators and management performance indicators.

The operational performance indicators are related to the process and other operational activities of the organization. These would typically address the issue of raw material consumption, energy consumption, water consumption in the organization, the quantities

of wastewater generated, other solid wastes &, emissions generated from the organization, *etc.*

Management performance indicators are related to management efforts to influence environmental performance of organizational operations.

The environmental condition indicators provide information about the environment. These indicators provide information about the local, regional, national or global condition of the environment. This information helps an organization to understand the environmental impacts of its activities and thus helps in taking decisions to improve the environmental performance.

2.3.2 Tools for action

2.3.2.1 Environmental policy

An environmental policy is a statement of an organization's overall aim and principles of action w.r.t the environment, including compliance with all relevant regulatory requirements. It is a key tool in communicating environmental priorities of the organizations to all its employees. To ensure an organization's commitment towards a formulated environmental policy, it is essential for the top management to be involved in the process of formulating the policy and setting priorities. Therefore, the first step is to get the commitment from the higher levels of management. The organization should then conduct an initial environmental review and draft an environmental policy. This draft should be discussed and approved by the board of directors. The approved environmental policy statement should then be communicated internally among all its employees and should also be made available to the public.

The Ministry of Environment & Forests, Government of India published the National Environment Policy, thus the individual firms while making their environmental policies may like to refer the national environment policy for synchronization.

2.3.2.2 Market-based economic instruments

Market based instruments are regulations that encourage behavior through market signals rather than through explicit directives regarding pollution control levels. These policy instruments such as tradable permits, pollution charge, *etc.*, are often described as harnessing market forces. Market based instruments can be categorized into the following four major categories, which are discussed below:

- **Pollution charge:** Charge system will assess a fee or tax on the amount of pollution a firm or source generates. It is worthwhile for the firm to reduce emissions to the point, where its marginal abatement cost is equal to the tax rate. Thus firms control pollution to different degrees *i.e.* High cost controllers – less; low-cost controllers – more. The charge system encourages the industries to reduce the pollutants further. The collected charges can form a fund for restoration of the environment. Another form of pollution charge is a deposit refund system, where, consumers pay a surcharge when purchasing a potentially polluting product, and receive a refund on return of the product after useful life span at appropriate centers. The concept of extended producers' responsibility brought in to avoid accumulation of dangerous products in the environment.

- **Tradable permits:** Under this system, firms that achieve the emission levels below their allotted level may sell the surplus permits. Similarly, the firms, which are required to spend more to attain the required degree of treatment/allotted levels, can purchase permits from others at lower costs and may be benefited.
- **Market barrier reductions:** Three known market barrier reduction types are as follows:
 - Market creation: Measures that facilitate the voluntary exchange of water rights and thus promote more efficient allocation of scarce water supplies
 - Liability concerns: Encourage firms to consider potential environmental damages of their decisions
 - Information programmes: Eco-labeling and energy- efficiency product labeling requirements
- **Government subsidy reduction:** Subsidies are the mirror images of taxes and, in theory, can provide incentive to address environmental problems. However, it has been reported that the subsidies encourage economically inefficient and environmentally unsound practices, and often leads to market distortions due to differences in the area. However, these are important to sustain the expansion of production, in the national interests. In such cases, the subsidy may be comparable to the net social benefit.

2.3.2.3 Innovative funding mechanism

There are many forums under which the fund is made available for the issues which are of global/regional concern (GEF, OECD, Deutch green fund, *etc.*) *i.e.*, climate change, Basal Convention and further fund sources are being explored for the Persistent Organic Pollutants Convention. Besides the global funding mechanism, there needs to be localized alternative mechanisms for boosting the investment in environmental pollution control. For example, in India the Government has established mechanism to fund the common effluent treatment plants, which are specifically serving the small and medium scale enterprises *i.e.*, 25% share by the State Government, matching grants from the Central Government and surety for 25% soft loan. It means that the industries need to invest only 25% initially, thus encouraging voluntary compliance.

There are some more options, if the pollution tax/charge is imposed on the residual pollution being caused by the industries, municipalities *etc.*, fund will automatically be generated, which in turn, can be utilized for funding the environmental improvement programmes. The emerging concept of build-operate-transfer (BOT) is an encouraging development, where there is a possibility to generate revenue by application of advanced technologies. There are many opportunities which can be explored. However, what is required is the paradigm shift and focused efforts.

2.3.2.4 EMS and ISO certification

EMS is that part of the overall management system, which includes the organizational structure, responsibilities, practices, procedures, process and resources for determining and implementing the forms of overall aims, principles of action w.r.t the environment. It encompasses the totality of organizational, administrative and policy provisions to be taken by a firm to control its environmental influences. Common elements of an EMS are the identification of the environmental impacts and legal obligations, the development of

a plan for management & improvement, the assignment of the responsibilities and monitoring of the performance.

2.3.2.5 Total environmental quality movement

Quality is regarded as:

- A product attribute that had to be set at an acceptable level and balanced against the cost
- Something delivered by technical systems engineered by experts rather than the organization as a whole
- Assured primarily through the findings and correction of mistakes at the end of the production process

One expression of the total environment quality movement (TEQM) is a system of control called Kaizen. The principles of Kaizen are:

- Goal must be continuous improvement of quality instead of acceptable quality
- Responsibility of the quality shall be shared by all members of an organization
- Efforts should be focused on improving the whole process and design of products
- With some modifications, TEQM approach can be applied in improvement of corporate environmental performance in both process and product areas.

2.3.2.6 Eco-labeling

Eco-labeling is the practice of supplying information on the environmental characteristics of a product or service to the general public. These labeling schemes can be grouped into three types:

- Type I: Multiple criteria base; third party (Govt. or non-commercial private organizations) programme claims overall environmental preferability
- Type II: Specific attribute of a product; often issued by a company/industrial association
- Type III: Agreed set of indices; provides quantified information; self declaration

Among the above, Type I are more reliable because they are established by a third party and considers the environmental impacts of a product from cradle to grave. However, the labeling program will only be effective if linked with complementary program of consumer education and up on restriction of umbrella claims by the producers.

2.3.2.7 Cleaner production

Cleaner production is one of the tools, which has lot of bearing on environmental pollution control. It is also seen that the approach is changing with time *i.e.*, dumping-to-control-to-recycle-to-prevention. Promotion of cleaner production principles involves an insight into the production processes not only to get desired yield but also to optimize on raw material consumption *i.e.*, resource conservation and implications of the waste treatment and disposal.

2.3.2.8 4-R concept

The concept endorses utilization of wastes as by-product to the extent possible *i.e.*, recycle, recover, reuse and recharge. Recycling refers to using wastes/by-products in the process again as a raw material to maximize production. Recovery refers to engineering means such as solvent extraction, distillation, precipitation, *etc.*, to separate the useful constituents of wastes, so that these recovered materials can be used. Re-use refers to the utilization of waste from one process as a raw material to other. Recharging is an option in which the natural systems are used for renovation of waste for further use.

2.3.2.9 Eco-efficiency

The World Business Council on Sustainable Development (WBCSD) defines eco-efficiency as “the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle, to a level at least in line with earth’s carrying capacity”. The business implements the eco-efficiency on four levels *i.e.* optimized processes, recycling of wastes, eco-innovation and new services. Fussler (1995) defined six dimensions of eco efficiency, which are given below to understand/examine the system.

- Mass: There is an opportunity to significantly reduce mass burdens (raw materials, fuels, utilities consumed during the life cycle)
- Reduce energy use: The opportunity is to redesign the product or its use to provide significant energy savings
- Reduce environmental toxins: This is a concern to the environmental quality and human health. The opportunity here is to significantly control the dispersion of toxic elements.
- Recycle when practical: Designing for recyclability is important
- Working with mother nature: Materials are borrowed and returned to the nature without negatively affecting the balance of the ecosystem.
- Make it last longer: It relates to useful life and functions of products. Increasing the functionality of products also increases their eco-efficiency.

The competitiveness among the companies and long-term survival will continue and the successful implementation of eco-efficiency will contribute to their success. There is a need to shift towards responsible consumerism equal to the efficiency gains made by corporations – doing more with less.

2.3.2.10 Industrial ecosystem or metabolism

Eco-industrial development is a new paradigm for achieving excellence in business and environmental performance. It opens up innovative new avenues for managing business and conducting economic development by creating linkages among local 'resources', including businesses, non-profit groups, governments, unions, educational institutions, and communities. They can creatively foster dynamic and responsible growth. Antiquated business strategies based on isolated enterprises are no longer responsive enough to market, environmental and community requirements.

Sustainable eco-industrial development looks systematically at development, business and environment attempting to stretch the boundaries of current practice on one level. It is as directly practical as making the right connections between the wastes and resources needed for production and at the other level, it is a whole new way of thinking about doing business and interacting with communities. At a most basic level, each organization seeks higher performance within itself. However, most eco-industrial activity is moving to a new level by increasing the inter connections between the companies.

Strategic partnership networked manufacturing and performed supplier arrangements are all the examples of ways used by the businesses to ensure growth, contain costs and to reach out for new opportunities.

For most businesses, the two essentials for success are the responsive markets and access to cost-effective, quality resources for production or delivering services. In absence of these two factors, virtually, every other incentive becomes a minor consideration.

Transportation issues are important at two levels, the ability to get goods to market in an expeditious way is essential to success in this day of just in time inventories. The use of least impact transportation with due consideration of speed and cost supports business success and addresses the concerned in community.

Eco-industrial development works because it consciously mixes a range of targeted strategies shaped to the contours of the local community. Most importantly, it works because the communities want nothing less than the best possible in or near their neighborhood. For companies, it provides a path towards significantly higher operating results and positive market presence. For our environment, it provides great hope that the waste will be transformed into valued product and that the stewardship will be a joint pledge of both businesses and communities.

2.3.2.11 Voluntary agreements

Voluntary environmental agreements among the industries, government, public representatives, NGOs and other concerned towards attaining certain future demands of the environment are reported to be successful. Such agreements may be used as a tool where Government would like to make the standards stringent in future (phase-wise-stringent). These may be used when conditions are temporary and require timely replacements. Also, these may be used as supplementary/ complimentary in implementation of the regulation. The agreements may include:

- Target objectives (emission limit values/standards)
- Performance objectives (operating procedures)
- R&D activities – Government and industry may have agreement to establish better control technologies.
- Monitoring & reporting of the agreement conditions by other agents (NGOs, public participants, civil authority, *etc.*)

In India, the MoEF has organized such programme, popularly known as the corporate responsibility for environment protection (CREP) considering identified 17 categories of high pollution potential industrial sectors. Publication in this regard is available with Central Pollution Control Board (CPCB).

2.3.3 Tools for communication

2.3.3.1 State of environment

The Government of India has brought out the state of environment report for entire country and similar reports are available for many of the states. These reports are published at regular intervals to record trends and to identify the required interventions at various levels. These reports consider the internationally accepted DPSIR framework for the presentation of the information. DPSIR refers to

- D – Driving forces – causes of concern *i.e.* industries, transportation *etc.*
- P – Pressures – pollutants emanating from driving forces *i.e.* emission
- S – State – quality of environment *i.e.* air, water & soil quality
- I – Impact – impact on health, ecosystem, materials, biodiversity, economic damage *etc.*
- R – Responses – action for cleaner production, policies (including standards/guidelines), targets *etc.*

Environment reports including the above elements give a comprehensive picture of specific target area in order to take appropriate measures for improvement. Such reports capture the concerns, which could be considered in EIAs.

2.3.3.2 Corporate environmental reporting

Corporate environmental reports (CERs) are only one form of environmental reporting defined as publicly available, stand alone reports, issued voluntarily by the industries on their environmental activities. CER is just a means of environmental improvement and greater accountability, not an end in itself.

Three categories of environmental disclosure are:

- Involuntary Disclosure: Without its permission and against its will (env. Campaign, press *etc.*)
- Mandatory Disclosure: As required by law
- Voluntary Disclosure: The disclosure of information on a voluntary basis

2.4 Objectives of EIA

Objectives of EIA include the following:

- To ensure environmental considerations are explicitly addressed and incorporated into the development decision-making process;
- To anticipate and avoid, minimize or offset the adverse significant biophysical, social and other relevant effects of development proposals;
- To protect the productivity and capacity of natural systems as well as the ecological processes which maintain their functions; and
- To promote development that is sustainable and optimizes resource use and management opportunities.

2.5 Types of EIA

Environmental assessments could be classified into four types *i.e.* strategic environmental assessment, regional EIA, sectoral EIA and project level EIA. These are precisely discussed below:

Strategic environmental assessment

Strategic Environmental Assessment (SEA) refers to systematic analysis of the environmental effects of development policies, plans, programmes and other proposed strategic actions. SEA represents a proactive approach to integrate environmental considerations into the higher levels of decision-making – beyond the project level, when major alternatives are still open. Example of strategic EIA is the study done in India under the World Bank guidance on power sector reform and restructuring programmes named Environmental Issues of Power Sector Reform – India (EIPS-India), where various alternatives of reform and restructuring were weighed against their environmental impacts and a decision making model was developed. A GHG Overlay Technique was then used and all the alternatives were also studied against their GHG emission potentials. The model was then disseminated to various states and a national synthesis was also done. Stress given was to arrive at an optimal decision rather than the best decision.

Regional EIA

EIA in the context of regional planning integrates environmental concerns into development planning for a geographic region, normally at the sub-country level. Such an approach is referred to as the economic-cum-environmental (EcE) development planning. This approach facilitates adequate integration of economic development with management of renewable natural resources within the carrying capacity limitation to achieve sustainable development. It fulfils the need for macro-level environmental integration, which the project-oriented EIA is unable to address effectively. Regional EIA addresses the environmental impacts of regional development plans and thus, the context for project-level EIA of the subsequent projects, within the region. In addition, if environmental effects are considered at regional level, then cumulative environmental effects of all the projects within the region can be accounted. Example of a Regional EIA is the environmental impact study of Kalinga Nagar Industrial Complex at Orissa where a large number of steel and captive/ utility power plants were planned to be developed in phased manner within a limited area by studying its carrying and assimilative capacity *i.e.* threshold for absorbing deterioration and a certain capacity for self-regeneration.

Sectoral EIA

Instead of project-level-EIA, an EIA should take place in the context of regional and sectoral level planning. Once sectoral level development plans have the integrated sectoral environmental concerns addressed, the scope of project-level EIA will be quite minimal. Sectoral EIA helps in addressing specific environmental problems that may be encountered in planning and implementing sectoral development projects.

Project level EIA

Project level EIA refers to the developmental activity in isolation and the impacts that it exerts on the receiving environment. Thus, it may not effectively integrate the cumulative effects of the development in a region.

From the above discussion, it is clear that EIA shall be integrated at all the levels *i.e.* strategic, regional, sectoral and the project level. Whereas, the strategic EIA is a structural change in the way the things are evaluated for decision-making, the regional EIA refers to substantial information processing and drawing complex inferences. The project-level EIA is relatively simple and reaches to meaningful conclusions. Therefore in India, project-level EIA studies are take place on a large-scale and are being considered with limited studies on Strategic and Regional EIAs. However, in the re-engineered Notification, provisions have been incorporated for giving a single clearance for the entire industrial estate for *e.g.*, leather parks, pharma cities, *etc.*, which is a step towards the regional approach.

As we progress and the resource planning concepts emerge in our decision-making process, the integration of overall regional issues will become part of the impact assessment studies.

Basic EIA Principles

By integrating the environmental impacts of the development activities and their mitigation early in the project planning cycle, the benefits of EIA could be realized in all stages of a project, from exploration and planning, through construction, operations, decommissioning, and beyond site closure.

A properly-conducted-EIA also lessens conflicts by promoting community participation, informing decision makers, and also helps in laying the base for environmentally sound projects. An EIA should meet at least three core values:

- Integrity: The EIA process should be fair, objective, unbiased and balanced
- Utility: The EIA process should provide balanced, credible information for decision-making
- Sustainability: The EIA process should result in environmental safeguards

Ideally an EIA process should be:

- Purposive - should inform decision makers and result in appropriate levels of environmental protection and community well-being.
- Rigorous - should apply 'best practicable' science, employing methodologies and techniques appropriate to address the problems being investigated.
- Practical - should result in providing information and acceptable and implementable solutions for problems faced by proponents.
- Relevant - should provide sufficient, reliable and usable information for development planning and decision making.
- Cost-effective - should impose minimum cost burdens in terms of time and finance on proponents and participants consistent with meeting accepted requirements and objectives of EIA.
- Efficient - should achieve the objectives of EIA within the limits of available information, time, resources and methodology.
- Focused- should concentrate on significant environmental effects and key issues; *i.e.*, the matters that need to be taken into account in making decisions.

- Adaptive - should be adjusted to the realities, issues and circumstances of the proposals under review without compromising the integrity of the process, and be iterative, incorporating lessons learned throughout the project life cycle.
- Participative - should provide appropriate opportunities to inform and involve the interested and affected publics, and their inputs and concerns should be addressed explicitly in the documentation and decision making.
- Inter-disciplinary - should ensure that appropriate techniques and experts in relevant bio-physical and socio-economic disciplines are employed, including use of traditional knowledge as relevant.
- Credible - should be carried out with professionalism, rigor, fairness, objectivity, impartiality and balance, and be subject to independent checks and verification.
- Integrated - should address the interrelationships of social, economic and biophysical aspects.
- Transparent - should have clear, easily understood requirements for EIA content; ensure public access to information; identify the factors that are to be taken into account in decision making; and acknowledge limitations and difficulties.
- Systematic - should result in full consideration of all relevant information on the affected environment, of proposed alternatives and their impacts, and of the measures necessary to monitor and investigate residual effects.

2.6 Project Cycle

The generic project cycle including that of the metallurgical industries (ferrous & non-ferrous) has six main stages:

1. Project concept
2. Pre-feasibility
3. Feasibility
4. Design and engineering
5. Implementation
6. Monitoring and evaluation

It is important to consider the environmental factors on an equal basis with technical and economic factors throughout the project planning, assessment and implementation phases. Environmental considerations should be introduced at the earliest in the project cycle and must be an integral part of the project pre-feasibility and feasibility stage. If the EIA environmental considerations are given due respect in the site selection process by the project proponent, the subsequent stages of the environmental clearance process would get simplified and would also facilitate easy compliance to the mitigation measures throughout the project life cycle.

A project's feasibility study should include a detailed assessment of significant impacts, and the EIA include a detailed prediction and quantification of impacts and delineation of Environmental Management Plan (EMP). Findings of the EIA study should preferably be incorporated in the project design stage so that the project is studied, the site alternatives are required and necessary changes, if required, are incorporated in the project sight at the design stage. This practice will also help the management in assessing the negative impacts and in designing cost-effective remedial measures. In general, EIA enhances the project quality and improves the project planning process.

2.7 Environmental Impacts

Environmental impacts resulting from proposed actions can be grouped into following categories:

- Beneficial or detrimental
- Naturally reversible or irreversible
- Repairable via management practices or irreparable
- Short term or long term
- Temporary or continuous
- Occurring during construction phase or operational phase
- Local, regional, national or global
- Accidental or planned (recognized before hand)
- Direct (primary) or Indirect (secondary)
- Cumulative or single

The category of impact as stated above, and its significance will facilitate the Expert Appraisal Committee (EAC)/State level EAC (SEAC) to take a look at the ToR for EIA studies, as well as in decision making process about the developmental activity.

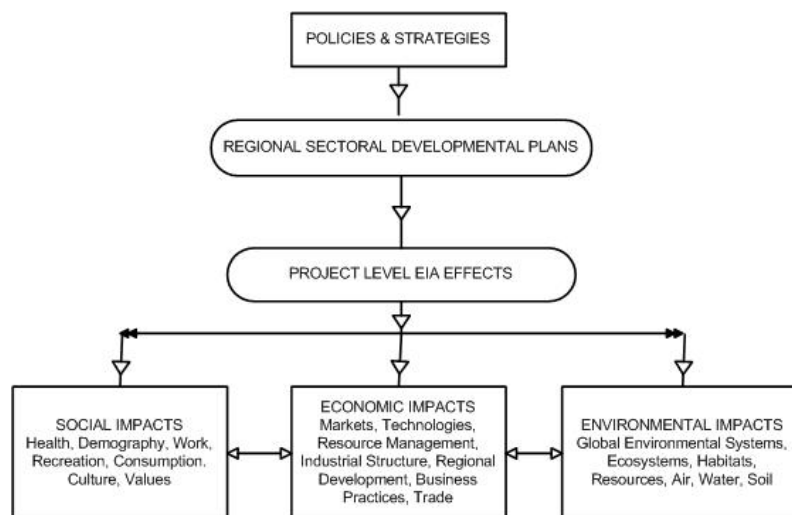


Figure 2-2: Types of Impacts

The nature of impacts could fall within three broad classifications *i.e.*, direct, indirect and cumulative, based on the characteristics of impacts. The assessment of direct, indirect and cumulative impacts should not be considered in isolation or considered as separate stages in the EIA. Ideally, the assessment of such impacts should form an integral part of all stages of the EIA. The TGM does not recommend a single method to assess the types of impacts, but suggests a practical framework/approach that can be adapted and combined to suit a particular project and the nature of impacts.

2.7.1 Direct impacts

Direct impacts occur through direct interaction of an activity with an environmental, social, or economic component. For example, a discharge of Metallurgical industries or an effluent from the Phenolic Effluent Treatment Plant (ETP), normally a BOD plant into a river may lead to a decline in water quality in terms of high biochemical oxygen demand (BOD) or dissolved oxygen (DO) or rise of water toxins.

2.7.2 Indirect impacts

Indirect impacts on the environment are those which are not a direct result of the project, often produced away from or as a result of a complex impact pathway. The indirect impacts are also known as secondary or even tertiary level impacts. For example, ambient air SO₂ rise due to stack emissions may deposit on land as SO₄ and cause acidic soils. Another example of indirect impact is the decline in water quality due to rise in concentration of metals and heavy metals of water bodies receiving wastewater discharge from the nearby industry. This, in turn, may lead to a secondary indirect impact on aquatic life in that water body and may further cause reduction in fish population as well as leads to biomagnification. Reduction in fishing harvests, affecting the incomes of fishermen is a third level impact. Such impacts are characterized as socio-economic (third level) impacts. The indirect impacts may also include growth-inducing impacts and other effects related to induced changes to the pattern of land use or additional road network, population density or growth rate. In the process, air, water and other natural systems including the ecosystem may also be affected.

2.7.3 Cumulative impacts

Cumulative impact consists of an impact that is created as a result of the combination of the project evaluated in the EIA together with other projects in the same vicinity, causing related impacts. These impacts occur when the incremental impact of the project is combined with the cumulative effects of other past, present and reasonably foreseeable future projects. Figure 2-3 depicts the same. Respective EAC may exercise their discretion on a case-by-case basis for considering the cumulative impacts.

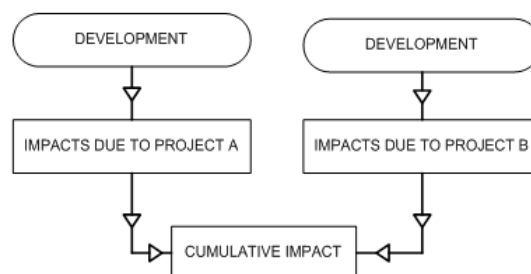


Figure 2-3: Cumulative Impact

2.7.4 Induced impact

The cumulative impacts can be due to induced actions of projects and activities that may occur if the action under assessment is implemented such as growth-inducing impacts and other effects related to induced changes to the pattern of future land use or additional road network, population density or growth rate (e.g., excess growth may be induced in the zone of influence around a metallurgical project, and in the process causing additional effects on air, water and other natural ecosystems). Induced actions may not be officially announced or be part of any official plan. Increase in workforce and nearby communities contributes to this effect.

They usually have no direct relationship with the action under assessment, and represent the growth-inducing potential of an action. New roads leading from those constructed for a project, increased recreational activities (e.g, hunting, fishing), and construction of new service facilities are examples of induced actions.

However, the cumulative impacts due to induced development or third level or even secondary indirect impacts are difficult to be quantified. Because of higher levels of uncertainties, these impacts cannot normally be assessed over a long time horizon. An EIA practitioner usually can only guess as to what such induced impacts may be and the possible extent of their implications on the environmental factors. Respective EAC may exercise their discretion on a case-by-case basis for considering the induced impacts by specifying it very early at ToR stage.

2.8 Significance of Impacts

This TGM establishes the significance of impacts first and proceeds to delineate the associated mitigation measures. So the significance here reflects the “worst-case scenario” before mitigation is applied, and therefore provides an understanding of what may happen if mitigation fails or is not as effective as predicted. For establishing significance of different impacts, understanding the responses and interaction of the environmental system is essential. Hence, the impact interactions and pathways are to be understood and established first. Such an understanding will help in the assessment process to quantify the impact as accurately as possible. Complex interactions, particularly in case of certain indirect or cumulative impacts, may give rise to non-linear responses which are often difficult to understand and therefore their significance is difficult to assess. It is hence understood that indirect or cumulative impacts are more complex than the direct impacts. Currently, the impact assessments are limited to direct impacts. In case mitigation measures are delineated before determining significance of the effect, the significance represents the residual effects.

However, the ultimate objective of an EIA is to achieve sustainable development. The development process shall invariably cause some residual impacts even after implementing an EMP effectively. Environmentalists today are faced with a vital, not-easy-to-answer question—“What is the tolerable level of environmental impact within the sustainable development framework”? As such, it has been recognized that every ecosystem has a threshold for absorbing deterioration and a certain capacity for self-regeneration. These thresholds based on concept of carrying capacity are as follows:

- Waste emissions from a project should be within the assimilative capacity of the local environment to absorb without unacceptable degradation of its future waste absorptive capacity or other important services.
- Harvest rates of renewable resource inputs should be within the regenerative capacity of the natural system that generates them; depletion rates of non-renewable inputs should be equal to the rate at which renewable substitutes are developed by human invention and investment.

The aim of this model is to curb over-consumption and unacceptable environmental degradation. But because of limitation in available scientific basis, this definition provides only general guidelines for determining the sustainable use of inputs and outputs. To establish the level of significance for each identified impact, a three-stage analysis may be referred:

- First, an impact is qualified as being either negative or positive.
- Second, the nature of impacts such as direct, indirect, or cumulative is determined using the impact network
- Third, a scale is used to determine the severity of the effect; for example, an impact is of low, medium, or high significance.

It is not sufficient to simply state the significance of the effect. This determination must be justified, coherent and documented, notably by a determination methodology, which must be described in the methodology section of the report. There are many recognized methodologies to determine the significance of effects.

2.8.1 Criteria/methodology to determine the significance of the identified impacts

The criteria can be determined by answering some questions regarding the factors affecting the significance. This will help the EIA stake-holders, the practitioner in particular, to determine the significance of the identified impacts eventually. Typical examples of such factors include the following:

- Exceeding threshold Limit: Significance may increase if a threshold is exceeded. *e.g.*, emissions of particulate matter exceed the permissible threshold.
- Effectiveness of mitigation: Significance may increase as the effectiveness of mitigation measures decreases. *e.g.*, control technologies, which may not assure consistent compliance to the requirements.
- Size of study area: Significance may increase as the zone of effects increases.
- Incremental contribution of effects from action under review: Significance may increase as the relative contribution of an action increases.
- Relative contribution of effects of other actions: Significance may decrease as the significance of nearby larger actions increase.
- Relative rarity of species: Significance may increase as species becomes increasingly rare or threatened.
- Significance of local effects: Significance may increase as the significance of local effects is high.
- Magnitude of change relative to natural background variability: Significance may decrease if effects are within natural assimilative capacity or variability.
- Creation of induced actions: Significance may increase as induced activities also highly significant
- Degree of existing disturbance: Significance may increase if the surrounding environment is pristine

For determining significance of impacts, it is important to remember that secondary and higher order effects can also occur as a result of a primary interaction between a project activity and the local environment. Wherever a primary effect is identified, the practitioner should always think if secondary or tertiary effects on other aspects of the environment could also arise.

The EIA should also consider the effects that could arise from the project due to induced developments, which take place as a consequence of the project. Example: Population density and associated infrastructure and jobs for people attracted to the area by the project. It also requires consideration of cumulative effects that could arise from a combination of the effects due to other projects with those of other existing or planned developments in the surrounding area. So the necessity to formulate a qualitative checklist is suggested to test significance, in general.

3.

ABOUT METALLURGICAL INDUSTRY INCLUDING PROCESS AND POLLUTION CONTROL TECHNOLOGIES

3.1 Introduction to the Industry

Metals can be broadly classified into two categories, 'ferrous' and 'non-ferrous' metals based on characteristics and quality of metal. The metallurgical processes of ferrous and non-ferrous metals can be broadly divided into primary and secondary based on the raw materials and the method of processing.

Though the periodic table gives a comprehensive classification of metals, it is unable to show their relative economic value. Therefore, a commercial classification has come into being.

Commercial classification groups the metals into ferrous and non-ferrous. In the first category it places iron which is used in a great variety of alloys with carbon known as iron and steel. In some metallurgical text books, non-ferrous metals are divided into heavy, such as copper, nickel, lead, zinc and tin; and light among which aluminum is a commercially important metal. Specific gravities of heavy non-ferrous metals range between 7 and 11 (in round figures) while in light metals is below 4. In addition to the specific gravity, there are many other commercial classifications like noble (or precious) (gold and silver among others); minor (As, Sb, Bi, Cd, Hg, Co); refractory (W, Mo, Ta, Nb, Ti, Zr, V); scattered (Ge, In, Ga, Tl, Hf, Re); radioactive (Ra, Ac, Th, Pa, U and elements 93 to 102); rare earth (Y, La, Sc among others) and ferroalloys (Cr, Mn).

Primary metallurgical process: Primary metallurgy is the science of extraction of metals from ores and minerals. If there are more than one ways of extracting a metal from its ore or mineral, then the process which gives a purer form of metal will belong to the category of primary metallurgy while the others fall into the secondary metallurgy category. *e.g.* in case of iron making, the blast furnace process is a primary metallurgical process, whereas other processes of iron making *i.e.*, sponge iron or HBI making will belong to the category of secondary metallurgy. In India, the commercially most acceptable primary metallurgical processes in metal extraction from its ore include:

- Aluminum production
- Lead smelting
- Copper smelting
- Zinc smelting
- Steel production

Secondary metallurgical process: Secondary metallurgical processes are the production processes that start with the output of the ore reduction process, scrap, salvage and ingots as input to the industry and its products are semi-finished products and finished products. It includes the melting, giving the aimed shape to the final output, through forming, pouring liquid metal and alloys to the mold cavity and forging. The processes and input materials used for the production of metals like sponge iron, foundries, re-rolling mills,

Metallurgical Industry

mini-blast furnace (MBF) based steel plants, electric arc furnace (EAF) and induction furnaces, aluminum, lead, copper, zinc, and ferroalloys are given in table below:

Table 3-1: Material Inputs in Secondary Ferrous Metallurgical Processes

Process	Material Inputs
Iron making	
Coal and Gas based Sponge Iron Plants	Iron ore, coal
Mini Blast Furnace	Iron ore, coke, limestone
Furnaces	
Induction and electric arc furnace	Steel scrap, liquid steel, direct reduced iron, or /and pellets briquettes, metal scrap and pig iron, coke or carbonizes, ferroalloys, limestone, gas fuel, bentonite and binding materials.
Oil and coal fired Preheating furnace	
Cupola and crucible furnace	
Re-rolling, drawing, extrusion and forging	
Rolling	billets or slabs, bars, blooms, lubricating oils, greases
Drawing	
Extrusion	
Forging	
Conventional casting in foundries	
Molding	Green sand, dry sand, clay, core sand, raw material, scrap, gaseous and solid fluxes (CO ₂ , He, N ₂ , Ar, cl, AlCl, ZnCl, AlF)
Casting	

Table 3-2: Material Inputs in Secondary Non-Ferrous Metallurgical Processes

Process	Material Inputs
Copper	New scrap produced in the fabrication of finished products or old scrap from automobiles and domestic appliances. Other materials with copper value include slags, drosses, foundry ashes and sweepings from smelters.
Lead	Battery scrap
Zinc	New clippings, skimmings and ashes, die-cast skimmings, galvanizer's dross, flue dust and chemical residue as sources of zinc. Most of the new scrap processed is zinc- and copper-based alloys from galvanizing and die-casting pots. Included in old scrap are zinc engraver's plates, die castings, and rod and die scrap.
Aluminum	New and old scrap, sweated pig, and some primary aluminum. New scrap consists of clippings, forging, and other solids purchased from the aircraft industry, fabricators, automobile, and other manufacturing plants. Borings and turnings are byproduct of the machining of castings, rods and forging. Drosses, skimmings, and slags are obtained from primary reduction plants,

Process	Material Inputs
	secondary smelting plants and foundries. Old scrap includes automobile parts, household items, and airplane parts.

3.1.1 Types of metals

A) Ferrous metals

Ferrous metals are those metals which contain iron. They may have small amounts of other metals or other elements added, to give the required properties. All ferrous metals are magnetic and give little resistance to corrosion. Most commonly used ferrous metals are mild steel, high speed steel, stainless steel, high tensile steel and cast iron, high carbon steel and medium carbon steel.

Mild steel

It is the most commonly used ferrous metal. Its major properties are toughness, high tensile strength and ductility. It contains 0.15 to 0.30% of carbon. Because of low carbon content, it can not be hardened and tempered. It must be case hardened. It is normally used in manufacturing of girders, plates, nuts and bolts and other general purposes.

Cast iron

Cast iron is another example of commonly used ferrous metal. It is hard, brittle, strong, cheap, and self-lubricating ferrous metal. It is remelted pig iron with small amounts of scrap steel. It can be classified as white cast iron, grey cast iron, and malleable cast iron. It is normally used in the manufacturing of heavy crushing machinery. Car cylinder blocks, vices, machine tool parts, brake drums, machine handle and gear wheels, plumbing fittings *etc.* It is an important ferrous metal in automotive pressing.

High tensile steel

It is very strong and very tough ferrous metal and is exclusively used in manufacturing of gears, shafts, engine parts, *etc.* This is one of the most frequently used ferrous metals in industries because of its strength, hardness and toughness.

Stainless steel

It is another very important ferrous metal. It comprises 18% chromium, and 8% nickel. Its special characteristic is its strong resistance to corrosion. Its common uses are kitchen draining boards, pipes, cutlery and aircraft.

High speed steel

High speed steel is also a ferrous metal. It contains medium carbon, tungsten, chromium and vanadium. It can be hardened, tempered and can be brittle. Its special characteristic is that it retains hardness at high temperatures.

High carbon steel

High carbon steel is a ferrous metal which contains of 0.70% to 1.40% carbon. It is the hardest of the carbon steels, but is less ductile, tough and malleable. It is used in making of Chisels, hammers, drills, files, lathe tools, taps and dies.

Medium carbon steels

As the name says, this ferrous metal contains less Carbon contents, *i.e.*, 0.30% to 0.70%. It is stronger and harder than mild steels, less ductile, tough and malleable. It is used in making metal ropes, wire, garden tools, springs *etc.*

B) Non-ferrous metals

Non-ferrous metals and their alloys do not contain iron as a principle. The term non-ferrous is used to indicate metals other than iron and alloys that do not contain an appreciable amount of iron ingredient, although they may contain small percentages. Aluminum, beryllium, and titanium are used in structural applications. Nickel and lead have widespread applications as copper does, which is often chosen for its high thermal and electrical conductivity. Cadmium, tin, and zinc are often used as coatings, electrical applications, and for bearing surfaces. Cobalt and manganese are common alloying elements in steels.

Copper

Copper is famous for its distinctive reddish brown color. Copper is an ancient metal; ornaments and coins were fashioned from it throughout the history of mankind. Ancient copper was mined from copper itself, but currently almost all copper is extracted from copper sulphides. Copper is notorious for its green tarnish, which is caused by weathering. If kept away from water and moisture, it will not tarnish.

Aluminum

Aluminum is the most abundant metal in the Earth's crust, and the third most abundant element therein, after oxygen and silicon. It makes up about 8% by weight of the Earth's solid surface. Aluminum is too reactive chemically, to occur in nature as the free metal. Instead, it is found combined in over 270 different minerals. The chief source of aluminum is bauxite ore. Aluminum is remarkable for its ability to resist corrosion (due to the phenomenon of passivation) and its low density. Structural components made from aluminum and its alloys are vital to the aerospace industry and very important in other areas of transportation and building. Its reactive nature makes it useful as a catalyst or additive in chemical mixtures, including being used in ammonium nitrate explosives to enhance blast power.

Zinc

Zinc has the third highest usage of nonferrous metal, behind aluminum and copper. It has a relatively low melting point and is used in the production of a number of alloys such as brass. It can be easily applied to the surface of other metals such as steel (galvanising) and when it is used as a metal coating, zinc corrodes preferentially as a sacrificial coating. Zinc is also used in the pharmaceutical, nutrient, construction, battery and chemical industries.

Lead

Lead is a soft, malleable poor metal, also considered to be one of the heavy metals. Lead has a bluish-white color when freshly cut, but tarnishes to a dull grayish color when exposed to air. It has a shiny chrome-silver luster when melted into a liquid. Lead is used in building construction, lead-acid batteries, bullets and shot, weights, and is part of solder, pewter, fusible alloys and radiation shields. Lead has the highest atomic number of all stable elements, although the next element, bismuth, has a half-life so long (longer than the estimated age of the universe) it can be considered stable. Like mercury, another heavy metal, lead is a potent neurotoxin that accumulates in soft tissues and bone over time.

Cadmium

It is associated with zinc in minerals at a ratio of 1: 200 Cd to Zn. It is physically similar to zinc but is more dense softer and can be polished. Unlike zinc it is also resistant to alkalis. Cadmium is also a good absorber of neutrons and is therefore often used in nuclear reactors.

Nickel

Nickel is a silver white metal with typical metallic properties. The great importance of nickel lies in its ability, when alloyed with other elements, to increase a metal's strength, toughness and corrosion resistance over a wide temperature range. Most primary nickel is used in alloys; the most important of which is stainless steel. Other uses include electroplating, foundries, catalysts, batteries, coinage, and other miscellaneous applications. Nickel is found in transportation products, electronic equipment, chemicals, construction materials, petroleum products, aerospace equipment, durable consumer goods, paints and ceramics.

Cobalt

Cobalt is a silvery white metal with typical metallic properties. Pure metallic cobalt has few applications, but its use as an alloying element for heat or wear resistant applications and as a source of chemicals makes it a strategically important metal. Cobalt is used in alloys including super alloys for aircraft engines, magnetic alloys for powerful permanent magnets, hard metal alloys for cutting tool materials, cemented carbides, wear- or corrosion resistant alloys, and electro-deposited alloys to provide wear and corrosion resistant metal coatings. Its use in rechargeable batteries has been a fast growing application over the last few years

Mercury

Mercury is the only metal that is in liquid form at room temperature and has the lowest fusion and boiling points of all metals. It also has a high electrical conductivity and these features are used in a variety of applications such as electrical switchgear and battery production. Mercury forms alloys easily with a number of other metals and these are known as amalgams, which are extensively used in dentistry. The major use of mercury is as a flowing cathode in the Chlor-alkali process. This process exploits mercury's high conductivity and the formation of an amalgam with sodium. Mercury is characterised by the toxicity of the metal and its vapour and the extreme toxicity of some of its compounds.

C) Precious metals

Precious metals include well-known metals such as gold and silver as well as the six platinum group metals – platinum, palladium, rhodium, iridium, ruthenium and osmium. They are termed precious metals because of their rarity and corrosion resistance, even though the actual mineral resources of such metals are very limited. The recycling of precious metals from scrap and industrial residues has always been an important raw material source for the industry. Consumption of gold is mainly for jewellery, while smaller amounts of it are used in electronics, other industrial and decorative applications. The principal users of silver are the photographic and jewellery industries.

D) Refractory metals

Due to its capacity to withstand heat, these materials are known as refractory metals. Refractory metals are chromium, manganese, tungsten, vanadium, molybdenum, titanium, tantalum, niobium, rhenium, zirconium and hafnium. Refractory metals and hard metal powders are used for a wide range of industrial applications. Chromium metal is important in steel alloying and as a metal coating in the galvanic industry. Among a variety of other uses like steel alloying, manganese is the key component of certain widely used aluminum alloys and is used in oxide form in dry cell batteries. The largest use of tungsten is as cemented carbides, which are also called hard metals.

E) Alkali and alkaline earth metals

Alkali metals are characterised by their low melting point and density. They have a silvery-white colour and are softer than other metals. Alkali metals have only one single, highly mobile electron in the outermost shell. Due to this fact alkali metals are highly reactive especially with oxygen or water where they also can react violently by producing gaseous hydrogen and heat. Alkaline-earth metals resemble alkali metals in several ways but they react less vigorously with water.

Carbon and graphite

Carbon is the fourth most abundant element in the universe by mass after hydrogen, helium, and oxygen. It is present in all known life forms, and in the human body carbon is the second most abundant element by mass (about 18.5%) after oxygen. This abundance, together with the unique diversity of organic compounds and their unusual polymer-forming ability at the temperatures commonly encountered on Earth, make this element the chemical basis of all known life.

There are three principal types of natural graphite, each occurring in different types of ore deposit: (1) Crystalline flake graphite (or flake graphite for short) occurs as isolated, flat, plate-like particles with hexagonal edges if unbroken and when broken the edges can be irregular or angular; (2) Amorphous graphite occurs as fine particles and is the result of thermal metamorphism of coal, the last stage of coalification, and is sometimes called meta-anthracite. Very fine flake graphite is sometimes called amorphous in the trade; (3) Lump graphite (also called vein graphite) occurs in fissure veins or fractures and appears as massive platy intergrowths of fibrous or acicular crystalline aggregates, and is probably hydrothermal in origin. The name "graphite fiber" is also sometimes used to refer to carbon fibre or carbon fibre reinforced plastic.

F) Ferro alloys

Ferro alloys are master alloys containing some iron and one or more non-ferrous metals as alloying elements. Ferroalloys enable alloying elements such as chromium, silicon, manganese, vanadium, molybdenum *etc.* to be safely and economically introduced into metallurgical processes, thus giving certain desirable properties to the alloyed metal, for instance to increase the corrosion resistance, hardness or wear resistance. Their importance grew with progress of steel metallurgy, which implied more diversified alloying elements, in better controlled quantities, in pure steel.

Ferro alloys are ferrochrome, ferrosilicon and silicon alloys, ferromanganese and manganese alloys, ferronickel, ferrovanadium, ferromolybdenum, ferrotungsten, ferrotitanium, ferroboron, ferroniobium.

G) Heavy metals

A heavy metal is a member of elements that exhibit metallic properties, which would mainly include the transition metals, some metalloids, lanthanides, and actinides. As per some definitions, metal of high specific gravity, especially a metal having a specific gravity of 5.0 or greater are the heavy metals. These may include As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn, Sn and Tl.

H) Toxic metals

Toxic metals are metals that form poisonous soluble compounds and have no biological role, *i.e.* are not essential minerals, or are in the wrong form. Often heavy metals are thought as synonymous, but lighter metals also have toxicity, as exemplified by beryllium, and not all heavy metals are particularly toxic and some are even essential (such as iron). The definition may also include trace elements when considered in abnormally high, toxic doses, the major difference being, no beneficial dose for a toxic metal with no biological role.

Toxicity is a function of solubility. Insoluble compounds as well as the metallic forms often exhibit negligible toxicity. In some cases, organometallic forms, such as dimethyl mercury and tetraethyl lead, can be extremely toxic. In other cases, organometallic derivatives are less toxic such as cobaltocenium cation. Decontamination for toxic metals is different from organic toxins because toxic metals are elements which cannot be destroyed. Toxic metals may be made insoluble or collected, possibly by the aid of chelating agents. Toxic metals can bioaccumulate in the body and in the food chain. The exceptions are barium and aluminum. Therefore, a common characteristic of toxic metals is the chronic nature of their toxicity. The toxic metals include following five:

- Lead
- Cadmium
- Arsenic
- Mercury
- Chromium

Substances associated with industrial processes which are suspect to be heavy or toxic metals need careful examination at Central or State level depending upon whether they are primary or secondary metallurgical processes and their production capacity.

3.2 Metal Industry in India

Metal industries are the indispensable part of an economy; they form the backbone of industrial development of any country. In India, the industrial development began with the setting up of Tata Iron and Steel Company (TISCO) at Jamshedpur in 1907. It started its production in 1912. Then came up Burnpur and Bhadravati Steel Plants in 1919 and 1923 respectively. It was, however, only after the Independence that the steel industry has been able to find its feet. Barring the Jamshedpur plant of the Tatas, all are in public sector and looked after by the Steel Authority of India Ltd. (SAIL). Bhilai and Bokaro plants were set up with the Soviet collaboration. Durgapur and Rourkela came up with British and German technology know-how respectively. Iron and steel industry is by nature a heavy industry. Proximity to raw materials and access to efficient transportation network are crucial to this industry. The Chhotanagpur plateau bordering West Bengal, Bihar, Orissa and Madhya Pradesh, therefore has been the natural core of this industry. Besides, iron and steel industry, heavy engineering and machine tools industries are the main dealers of metals. These industries have witnessed phenomenal growth and produce a whole range of capital goods and consumer durables. The capital goods required for textile industry, fertilizer plants, power projects, cements, steel and petro-chemical plants, mining, construction and agricultural machineries such as equipment for irrigation projects, diesel engines, pumps and tractors, transport vehicles, *etc.* are being produced indigenously.

The Heavy Engineering Corporation Ltd., set up at Ranchi in 1958 fabricates huge machines required for the iron and steel industry. Locomotives are manufactured by three units, viz. Locomotive Works, Chittaranjan (West Bengal), Diesel Locomotive Works and Varanasi (Uttar Pradesh). The Hindustan Machine Tools Ltd. (HMT) is a major manufacturer of a wide range of machines and tools. It has its units in Bangalore, Pinjore (Haryana), Kalamassery (Kerala), and Hyderabad. The Bharat Heavy Electricals Ltd. (BHEL) is a public sector undertaking which produces power generation equipments. Its manufacturing plants are located at Bhopal, Tiruchirapalli, Hyderabad, Haridwar, Ranipet, Bangalore and Jagdishpur (Uttar Pradesh). The Hindustan Aeronautics Ltd., Bangalore has acquired capability of manufacturing aircrafts of different types. It has its manufacturing units at Bangalore, Kanpur, Nasik, Koraput, Hyderabad, and Lucknow. Vishakhapatnam, Mumbai, Calcutta and Kochi are the major center of ship-building industry. Many of the above units which brought stability to nation's industrial revolution are now going through the stage of disinvestment.

3.2.1 Current Status

3.2.1.1 Ore miners

Iron ore occurs in the form of hematite, magnetite, goethite, and siderite. However, the production of iron is mostly by extensive use of hematite and magnetites as principle oxide ores. The majority of the steel production is from hematite in India. Total reserve of hematite is 14,630,388,000 T. As high-grade ore reserves of hematite are depleting, the deterioration in raw ore quality calls for rigorous beneficiation techniques so as to:

- Ensure sustainable development of mines
- Meet the stringent quality required by end users

The production capacity of hematite is given in the table below:

Table 3-3: Production and Export of Hematite in India

Year	Production (MT)	Export (MT)
2004-05	146	
2005-06	169	
2006-07	181	
2007-08	210	95

(Source: Discussions with OMC)

Ore miners include companies, which are engaged in mining iron ore for the use of integrated producers. Key players include National Mineral Development Corporation (NMDC), Kudremukh Iron Ore Company Ltd. (KIOCL), Essel Mining & Industries Ltd, Orissa Mining Corporation (OMC) and Sesa Goa (Sesa). Apart from these, some of the integrated steel companies like Steel Authority of India and TISCO have their own captive mines. The production of iron ore in India has grown from 80.5 million tonnes (MT) in 2001 to 120.6 MT in 2003-04, at a compounded annual growth rate of around 14.4 % and then to 210 MT by 2007-08.

3.2.1.2 Ferrous metals

Steel

India's steel industry is significant, even by global standards. With an installed capacity of 60 MT in 2007-08, India is the fifth largest steel producer in the world. The industry has a well established presence across all sectors – ore miners, integrated producers and other producers.

Steel production in India

Steel production in India got a momentum with the announcement of Industrial Policy Resolution of 1956 when three steel plants were set up in the public sector - erstwhile Hindustan Steel Limited (now Steel Authority of India Limited-SAIL) in the late 1950s and the fourth in early 1970. These plants along with Indian Iron & Steel Company (IISCO) (now a part of SAIL), Visvesvaraya Iron & Steel (VISL) and TISCO (now Tata Steel) were the only integrated steel producers till the eighties. Vizag Steel Plant, Rashtriya Ispat Nigam Limited (RINL) came into production in early 1990s.

The 1970s saw the emergence of secondary sector – small-scale steel producers in the private sector who opted for production of pig iron and sponge iron in the form of Direct Reduced Iron (DRI) and set up DRI-based electric arc furnace/induction furnace routes to meet primary local demands. This led to the commissioning of large numbers of re-rolling mills. It was only with the announcement of new industrial policy in 1991-92 and the deregulation of the steel sector, that the private sector emerged in a big way to set up new generation steel plants.

Secondary producers consist of suppliers of processed inputs for steel making, the primary steel makers, and the independent re-rollers. The producers primarily include stand alone producers and the re-rollers. As per Joint Plant Commission (JPC) of Ministry of Steel, during 2007-08, out of a total crude steel production of 53,904,000 T, secondary producers produced 31,800,000 T. India accounts for almost 13% of the

world's total DRI production. The present DRI production capacity is approximately 12 MTPA. There are 118 large and small sponge iron plants operating in India, among them only 3 are natural gas based processes and balance 115 are coal based processes. Several small sponge iron plants are under planning/commissioning stage.

Joint Plant Commission (JPC) with the approval of the Ministry of Steel, have devised the following classification of the Indian iron and steel industry: (The list is under continuous updating as new plants come up.)

Table 3-4: Classification of Indian Steel Sector by JPC

Category	Includes
Main Producers	SAIL plants
	Vizag Steel/RINL
	Tata Steel
Secondary Producers	
Capacity 0.5 MT/ year or above - Majors	Essar Steel
	Ispat Industries
	JSW Steel
	Jindal Steel and Power Limited
	Jindal Stainless Limited
Capacity less than 0.5 MTPA - Other Secondary Producers	Other Electric Arc Furnaces (EAFs)
	All Induction Furnaces (IFs)
	All processors

With an installed capacity of about 60 MTPA in 2007-08, India ranks the world's 5th largest producer of crude steel. India has the potential of becoming the world's 2nd largest crude steel producer by 2015. The National Steel Policy 2005, envisaged a production of 110 MTPA in the country by 2020 at the time of its formulation while the 11th plan projected a 77 MTPA of domestic finished steel production by 2012. The Table below indicates compounded annual growth rate (CAGR) and crude steel production capacity in India in the start of 10th plan, end of 10th plan and start of 11th plan.

Table 3-5: Crude Steel Production in India in the 10th and 11th Plan

Crude Steel (MTPA)	2002-03 Start of 10th Plan	2006-07 End of 10 th Plan	Compund Annual Growth Rate (CAGR)	2007-08* Start of 11 th Plan
Production	34.71	50.82	9.7%	53.90
Capacity	40.41	56.84	8.1%	59
Capacity utilization	86%	89%	-	91%

Source: JPC, * provisional

Table 3-6: Production of Crude Steel ('000 tonnes)

Plants	Production of Crude Steel (in '000 tonnes) 2007-08 (provisional)
(A) Main Producers	
Bhilai Steel Plant	5055
Durgapur Steel Plant	1914
Rourkela Steel Plant	2093
Bokaro Steel Plant	4127
Alloy Steel Plant	157
Visvesvaraya Iron & Steel	158
Indian Iron & Steel	458
Tata Steel	5013
RINL	3129
Sub Total (A):	22104
(B): Secondary Producers	
EAF Units (including COREX-BOF/MBF-BOF)	14800
IF Units	17000
Sub Total (B)	31800
Total (A) + (B)	53904

Source: JPC Bulletin on Iron & Steel, June 2008, Volume VIII, Issue 6

3.2.1.3 Non-ferrous metals

The non-ferrous metals industry in India is growing strongly aided by the privatisation process started in early 2000. By 2020, it is expected that the industry, comprising of aluminum, copper, lead and zinc sectors, will be completely privatised, and India will grow to become a global player in the non-ferrous metals industry.

Aluminum

India has nearly 10% of the world's bauxite reserves and a growing aluminum sector that leverages this. Demand in the domestic market is expected to grow by 8-10 % in 2005-06. By 2020, India is expected to have an installed aluminum capacity of 1.7 to 2 million tonnes per annum (MTPA). The primary market for aluminum in India is the power sector, which consumes about 35% of the domestic production. This is in contrast to the global market, where the bulk of aluminum is consumed by the construction and packaging sectors. The ongoing reforms in the power sector and focus on improving power infrastructure, is expected to further boost the aluminum sector in India.

Copper

Copper has a number of applications across several sectors such as telecom, power, construction, transportation, handicrafts, engineering, and consumer durables. The Indian industry has an installed capacity – about 477,500 tonnes per annum (TPA) in 2003-04 - that is greater than the domestic market – about 290,000 tonnes - leading to a surplus situation. This is an advantage that can be leveraged for boosting exports, especially since the Asian region has a deficit of around 2.6 MT. Nearly 40% of copper production in India is currently exported.

Currently, the industry has three major players - Sterlite, Hindalco and Hindustan Copper Ltd. (HCL), which together account for nearly 80% of the total copper production in the country. Other players include around 1000 small-scale industries (SSIs), which are primarily involved in converting scrap into ingots. While HCL is the only primary producer, which mines and refines copper, Hindalco and Sterlite are secondary producers, who process indigenous and/or imported copper concentrate to produce end products like copper bars, rods and wires. The performance of the copper industry is highly dependent on the performance of and demand for products like power and telecommunication cables, transformers, generators, radiators and other ancillary components. Hence, its growth is closely linked to the country's economic and industrial growth. India has been growing at a steady and sustained compounded average growth rate of 5.6 % for the past 20 years. This is expected to improve further to a level of around 8 % in the future. The outlook for the copper industry in India is therefore positive.

Zinc

With privatisation of the largest zinc producer, Hindustan Zinc Ltd, sold to the Sterlite group in April 2002, the Indian zinc industry is completely under the private sector and is in the midst of expansion. At present, the smelting capacity for primary zinc in India is 2,60,000 TPA, as against a domestic demand of about 3,50,000 TPA. Over the next 5 to 6 years, the demand is expected to grow at about 12-15 % annually, as against a global average of 5 %. Domestic production capacity, however, is also expected to increase to attain self-sufficiency by 2010. The main consumer for zinc in the domestic market is the steel industry – over 70 % of zinc is used for galvanising. Other sources of demand for zinc include die-casting, guard rails for highways and imported-substituted zinc alloys. The steel industry has bright prospects with demand drivers being the construction industry and exports. With continued infrastructure development such as roads, irrigation, construction, oil & gas, ports, *etc*, there is a rising demand for steel, thus providing significant opportunities for zinc in India.

3.2.1.4 Exports – potential for growth

In the steel sector, as can be observed from Table 3-7, both production for sale (9.5%) and consumption (10%) of steel have recorded robust growth rates during the plan period, though the former is slightly lower than the latter, in terms of CAGR performance. The difference in respective rates of growth got accentuated in 2007-08, leading to a rise in imports and pushing up prices as well. Exports have registered lower growth than imports, in view of the pressure of domestic demand, which caused channeling of material to meet domestic requirements prior to exporting. Imports have recorded the highest growth rates amongst all, due partly to a discrepancy in supply-demand growth rates and in part to a lack of local availability of specific grades/sizes.

Table 3-7: Production for Sale, Import, Export and Consumption of Steel (MT)

Total Finished Steel	10 th Plan		11 th Plan	
	Start Year 2002-03	End Year 2006-07	Growth CAGR	Start Year 2007-08*
Production for sale	37.16	52.53	9.5%	55.26
Imports	1.66	4.93	29%	6.92
Export	4.52	5.24	14%	5.05
Consumption	30.68	46.78	10%	51.49

Source: JPC, * Provisional

Historically, India is a net exporter of steel - the total exports of steel from India were around US\$ 2.6 billion against imports worth around US\$ 1.8 billion in 2004. Exports increased further to 3.45 MT during the 11 months ending Feb 2005. India's exports mainly consists of carbon steel, which accounts for 95 % of total steel exports, the balance being pig iron. The main consuming market for steel exported from India is China, which accounted for 24% of the total steel exports in 2004. The other key markets include USA (8 %), UAE and Thailand (5 % each). The major steel import destinations for India include Russia, Germany, Japan, UK and Korea.

In case of non-ferrous metals, India is a net exporter of copper and net importer of zinc. Forty % of copper production in India is exported. Given the surplus in production of various metals in India and deficit in other markets, there is ample opportunity for growth in exports for the Indian Metals industry.

Foreign Direct Investments (FDI)

In India, 100% FDI has been approved in metallurgical industries since 1991. During the period 1991-2004, the industry received 407 approvals for FDI worth US\$ 4.27 billions. Actual inflow of FDI has been US\$ 0.31 billion. The metallurgical sector accounts for 5.31 % of total FDI approved in India.

Competitive advantages

India's competitiveness in metal industry can be analysed by using the framework given below. The key advantages can be categorised under:

- Growing market demand
- Favorable factor conditions for production
- Presence of related and supporting industries
- Government support for helping companies improve performance and stimulating industry environment

Growing market demand

Metals constitute a key input to other manufacturing sectors like engineering, electrical and electronics, automobile and automobile components, packaging and infrastructure. The performance of the metal sector is hence a reflection of the overall economy. There are several positive indicators for growth in the metals industry, such as capacity creation and growth in sectors like infrastructure, power, mining, oil & gas, refinery, automotive and consumer durables. For example:

- India's overall economic growth is expected to sustain an annual projected growth of about 8 %. The manufacturing sector, that currently constitutes about 17% of GDP, is expected to grow faster and contribute significantly to the overall economic growth. This will have a positive effect on the demand for metals.
- The industrial sector has been registering healthy growth -overall industrial growth (measured in terms of the Index of Industrial Production) was at a rate of 7.9% during the April– September 2004-05 compared with 6.2 % during the same period last year.
- Major infrastructure projects such as the World Bank-funded Golden Quadrilateral Project, and the North-South and East- West corridors linking major cities across the country have also fuelled the industry's growth, which in turn, has positively impacted the metals industry. The user industries are also getting increasingly demanding and sophisticated. This drives firms in the metals industry to constantly improve their competitiveness through innovative products of higher quality, thereby improving their global competitiveness.

Favorable conditions for production

India has rich reserves of minerals like bauxite, iron ore, copper, zinc *etc.* India has large resources of high-grade bauxite deposits - 3037 million tones. India ranked fifth in the world bauxite reserves next to Australia, Guinea, Brazil and Jamaica. Bauxite reserves in India account for 7.5% of the world's total world deposits. Total reserve of hematite is 14,630,388,000 T. Indian steel has earned a niche of its own in the global market. Apart from being the fifth largest producer of steel in the world, ahead of South Korea and Germany, India is also the largest producer of sponge iron in the world – a status it has maintained over the last few years. This in fact has been due predominantly to the phenomenal growth in the coal based route of sponge iron production in the country, which has led to a significant jump in domestic production, from 7.86 MT in 2002-03 to a provisionally estimated 19.2 MT in 2007-08. India also has a growing workforce that is English-speaking and highly skilled. India's well developed designing and machining capabilities makes it second only to Germany in these areas. These strengths provide competitive advantage to India in the engineering and manufacturing fields, which in turn positively, impact the metals sector.

Conditions are also favourable for the sector's growth, from the point of view of capital investments. Indian players in the sector have been investing in capacity building to fuel growth. Sterlite Industries (India) Ltd. (SIIL) is expanding its Tuticorin complex for an estimated total cost of US\$ 81.4 million, while Hindalco is planning a brown field expansion in its Copper business to double its capacity from 250,000 TPA to 500,000 TPA. Total production capacity expansion planning by steel sector has been 76.5 MT by 2012 subject to firm land acquisition. Ample availability and potential growth in key factors of production provide the right stimulus for India's metal sector to grow and become globally competitive. Presence of related and supporting industries, apart from the favourable demand and factor conditions, the Indian metals industry is well supported

by India's mining industry and educational and research institutions. India is endowed with significant mineral resources and has a well-developed mining sector to leverage these resources. Indigenous mining capability supports the metals sector by making available raw materials at lower costs and reducing dependence on imports. India also has several educational institutions, for advanced studies in the areas of metallurgy and materials science, R&D Organisations, Consultants, Heavy Machine Builders, and Construction Firms and experienced operating experts for the metallurgical industry. These not only provide a steady stream of qualified persons to the metals industry, but also promote fundamental research and innovation.

Government regulations and support

The Government of India has revised its foreign direct investment policy to attract foreign investments in the metal sector. Government initiatives to boost the end-user segments (like telecom, power, construction, transportation, engineering, consumer durables, *etc.*) also have a significant positive impact on the demand. Some of the policies aimed at boosting investment and growth in the metals sector are:

- Foreign equity holding is allowed up to 100% on the automatic route for all non-fuel, non-atomic minerals except diamond and precious stones for which the limit for automatic approval is 74 % foreign equity.
- Thirteen minerals like iron ore, manganese ore, chrome ore, sulphur, gold, diamond, copper, lead, zinc, molybdenum, tungsten, nickel and platinum group of minerals, which were reserved exclusively for public sector have been thrown open for exploitation by private sector.
- Duty reduced to 10 % on inputs to the steel industry such as electrodes, graphite and refractory catalysts.
- Import duty on stainless steel & alloy steel reduced from 15 - 10 %.
- Customs duty on primary and secondary metals reduced to 10 % from 15.
- Customs duty on coking coal reduced to 5 % from 10. This will increase the profitability of the steel sector
- Entered into a Free Trade Agreement (FTA) with Sri Lanka, which has resulted in a large influx of copper and copper products at zero import duty from Sri Lanka.
- Government has come up with India's National Steel Policy 2005, which envisages production level of steel to touch 110 MT by the end of 2020. These government policy initiatives reflect the importance perceived by government of the metals sector. Liberalised overall policy regime, with specific incentives, provides a very conducive environment for investments and exports in the sector.

Future outlook

The outlook for the metal sector in India is bright. Sustained growth is expected across all key segments, aided by several factors, such as growing domestic demand, investment in capacity addition, increasing supply deficit in other countries and favourable government regulations.

Government's initiatives such as power and infrastructure development, reduction in import duties and facilitation of FDI, along with overall economic growth, will provide a boost for the Indian metal industry.

Per capita steel consumption in Indian urban areas is about 41.5 kg whereas the same in rural areas is very meager. With economy projected to grow at 8 % in the coming years, there is expected to be a surge in per capita steel consumption. Presently, this is much less as compared to the data of a few other countries as follows:

Singapore	:	1200 kg
South Korea and Taiwan	:	860-900 kg
Germany	:	540 kg
USA	:	410 kg
Malaysia	:	350 kg
Thailand	:	160 kg
China	:	250 kg
Vietnam	:	50 kg
World average	:	145 kg

It is, however, observed that since 2005, demand of steel in western countries have started falling whereas the same in India and China have started increasing.

Growth in the steel sector will have an immediate positive rub-off on the zinc sector, as 70 % of zinc production is used for galvanising.

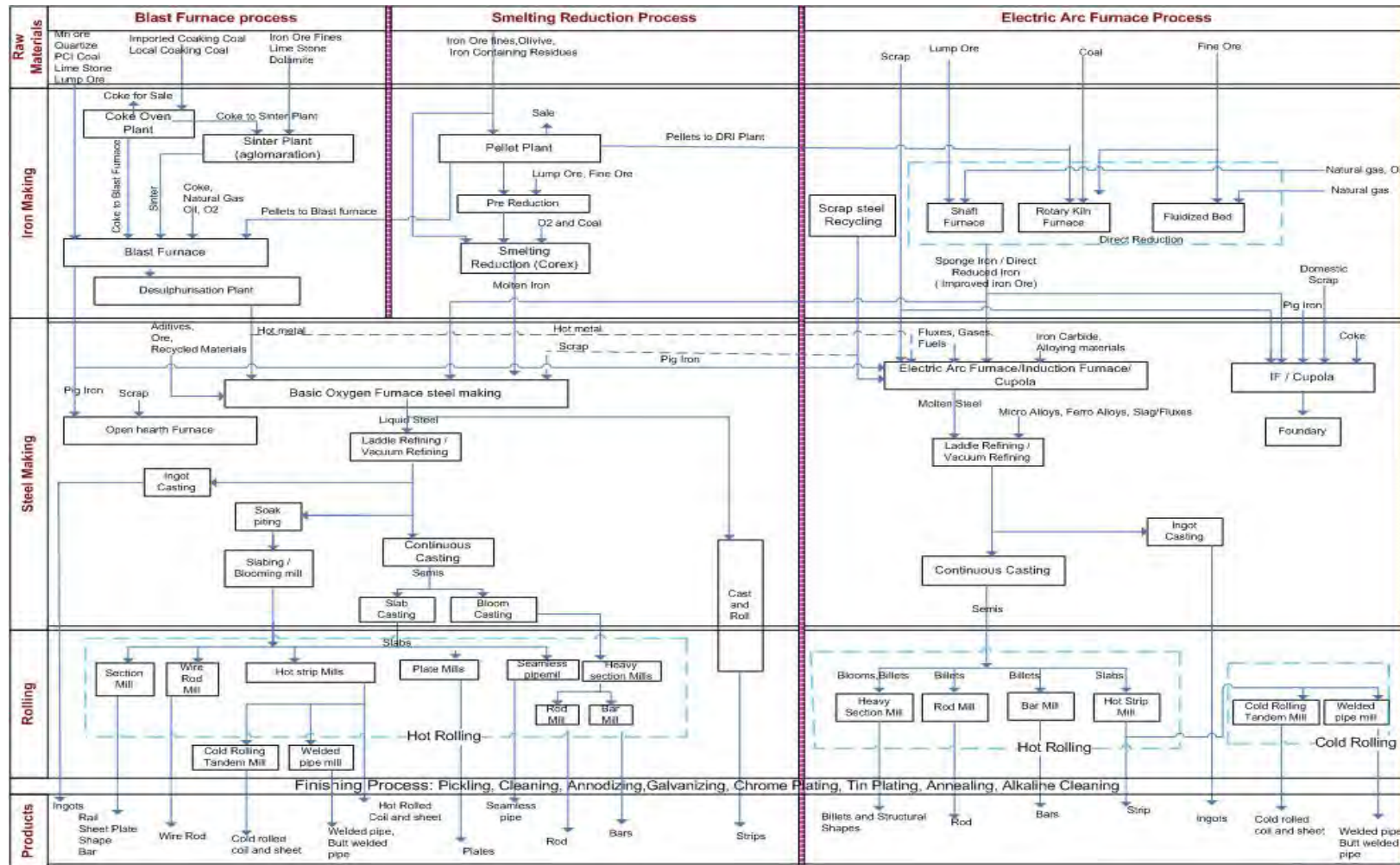
Current shortages in worldwide copper supplies are expected to continue following production cuts by leading producers in Mexico and Chile. This would further shore up demand for Indian copper. For aluminum, exports would be a major demand source.

The positive outlook in the Indian metals sector has attracted multinationals like BHP Billiton and Rio Tinto to enter India for prospecting. At the same time, successful Indian players are looking at acquiring mining rights abroad, for example, the AV Birla group has acquired mining rights in two copper mines in Australia. Tata Steel by acquiring Corus and Mittal Steel by many foreign firms have become leading steel players in the world. The metal sector in India is clearly an attractive sector for investment and offers significant growth potential both in the domestic as well as exports markets.

The journey of the impressive growth of the Indian metal sector is not free from rough weathers. Economic slow downs – though temporary, fluctuations in the global market, crude prices, problems of land acquisitions, pressure from environmentalists, increasing domestic demand of high quality metals will continuously need policy reviews and revisions of the priorities.

3.3 Scientific Aspects of Industrial Process

The current technological scenario suggests that the new technologies for iron production have still not reached sufficient levels to eliminate blast furnace route of iron making. Thus coke ovens and sinter plants will continue to exist and the challenge of producing better quality coke and sinter for higher sophisticated blast furnaces exist by increased utilization of inferior quality of coal, raw materials and optimizing cost of production of steel. The Coke Ovens have been dealt with separately in the TGM for Coke Oven Plants. The process flow sheet of steel making by most accepted BF-BOF-Continuous Casting route is shown in Figure 3-1.



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Figure 3-1: Process Flow Diagram

3.3.1 Process technology for ferrous metal industries

The technological facilities required at each processing step to achieve good quantity rolled products are described briefly in the following sections. The technology facilities most commonly followed in the processes is given in Table 3-8.

Table 3-8: Technology Facility at Various Processing Levels

S. No.	Processing Step	Technological Facility
1	Coke making	Recovery coke oven
2	Iron ore beneficiation plant	Beneficiation
3	Pelletization	Pellet plant
4	Sintering	Sinter plant
5	Iron making	Blast furnace/Sponge iron plant
6	Steel making	Basic oxygen furnace
7	Secondary refining	Ladle furnace
		RH degassing
8	Continuous casting	Slab caster

The following paragraphs will briefly describe units and their technological processes:

An ungraded ore would severely handicap the operation of the blast furnace. The fines would clog the space between the lumps, thereby preventing the free flow of gases. A large proportion of fines is usually carried off as flue dust. Besides, fines account for a large proportion of ore in India. All these call for the use of agglomeration, mainly by pelletisation and sintering.

An advantage of agglomerated burden in the blast furnace is well established and almost all the high capacity blast furnaces world wide are using agglomerated burden for most efficient furnace operation. The major advantages for use of sinter in blast furnace are as follows:

- Control of physical, chemical and high temperature properties of burden materials
- Avoid use of raw flux charging directly in the blast furnace
- Increase in productivity of the furnace
- Decrease in coke/fuel rate
- Longer life of furnace
- Production of desired grade of hot metal, *etc*

Pellet plant

Pellet plant, an alternative to sinter plant, will utilize iron ore fines to produce BF grade pellets to be used in blast furnace. The process involves drying of the ores (from 8-10% to less than 1% moisture), grinding to 45 micron size, feed preparation by adding binders and moisture, green pelletization and induration (heat hardening).

Sinter plant

The sinter plant will be equipped with the following major facilities:

- Base blending for input materials
- Flux and fuel crushing facilities
- Lime dozing facility
- Mixing and nodulising unit
- Sintering machine equipped with sinter strand, ignition furnace, wind boxes, suction fan, dust cleaning unit, *etc.*
- Sinter coolers; and
- Sinter screening and transportation facilities

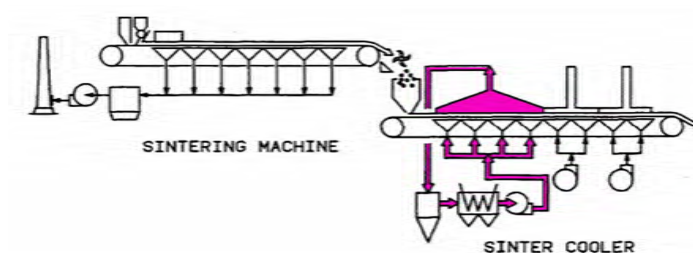


Figure 3-2: A Sinter Plant with State-of-the-Art Cooler Heat Recovery System

Capacity of the sinter plant will be estimated based on use of about 70-80% sinter in the burden of blast furnaces. Prior to sintering, the fine ore and flue dust are thoroughly mixed with 4 to 6 % of fuel (coke breeze) and 25 to 30% of iron bearing materials, such as mill scale and the mixture is slightly moistened. The charge is fed onto the grate of a sintering machine so that the material forms a bed of 250 to 350 mm deep. A burner fired with gas or liquid fuel heats the top layer of the bed to 750 – 850°C. The grate is placed over chambers in which an exhaust fan builds up vacuum. As a result, air is sucked through the bed of charge from the top to the bottom. The combustion initiated in the top relatively thin layer propagates downwards, towards the grate and the products of combustion are removed through the openings in the grate.

The combustion rises the temperature inside the charge to 1300-1600°C, depending on the amount of fuel burnt and the rate of air flow through the charge. Melting takes place according to chemical reactions and on solidifying, the molten silicates bind the charge particles together into a strong sinter. The sinter bed then passes through a cooling bed where air is sucked from top on the moving grate or rotary cooler and the sinter gets cooled. The cooled sinter is screened, over size sent to blast furnace and the under size is sent back as sintering charge.

The hot exhausts have sufficient sensible heat value and can be used to generate low pressure steam through a waste heat boiler and ultimately generate electricity.

Feed charging on the sintering machine has received much attention to improve sintering quality. Intensive mixing of raw materials and formation of micro balls will largely minimize requirement of base blending yard and drastically reduce the space requirements and consequently the cost related to base blending yard for sinter plant. The advantages are as follows:

- No pre blending required
- Completely homogenous sinter raw mix.
- High productivity of sinter plant even with ultra fine grain size of materials

- Low solid fuel consumption

Another technology developed by JIEC, Japan, is improvement in segregated charging of sintering materials. The charge, which is normally fed by a roll feeder is additionally fed onto a drum chute in order to decrease the falling height. Then the mix is fed through a segregated slit wire mesh onto the pallets. Thus the segregation of the raw mix becomes appropriate as the bed uniformly consist of larger particles at the bottom and finer particles at the top. By this, the permeability increases and the quality of sintered ores in the upper layer are improved, resulting in the overall yield improvement. Further, the return ores are reduced. Accordingly, the coke consumption is reduced and the energy saving effect is achieved. This helps in better sintering, and specific coke consumption reduces by 2.8 kg/t-sinter. Also, coal addition rate reduces by 0.54%.

Iron making

Early iron reduction furnaces using charcoal as a fuel and reducing agent had no real shafts, consisting merely of holes or hearths in the ground supplied with air by some primitive means such as foot-bellows. As a result, the temperatures created were insufficient to melt the reduced iron, which was produced in a pasty condition. However, due to the low temperature reached, only a comparatively small amount of impurities was introduced into the metal and fairly pure wrought iron was obtained.

Shafts were introduced about the fourteenth and fifteenth century in efforts to increase capacities. The impure pig iron produced is made into steel in a separate furnace.

Metallurgical coke of good strength is the usual fuel and reducing agent in the modern blast furnaces. Iron ores are commonly siliceous in gangue and usually, therefore, limestone (or sometimes dolomite), which should be as pure as possible, is used as flux; the ash from the coke is to be fluxed as well. In recent years, there has been a steady increase in the addition of sinter in the charge. Up to 100% sinter can be added in place of ore.

A blast furnace is a tall cylindrical structure consisting of essentially a foundation, furnace bottom, hearth, bosh, stack and top (see Figure 3-3). The furnace bottom is supported on a heavy foundation. Molten metal and slag are accumulated in the hearth and tuyers to blow hot air from bottom are located at the hearth. The bosh is the hottest part and forms the zone of fusion. The stack or shaft extends from the bosh to top. The top is the place from where the charge is fed onto the stack through a charging apparatus near which top gases are withdrawn. Some 500 mm above the bottom of the hearth there is a tap hole called the iron notch, for tapping off molten pig iron from the furnace. Just below the tuyers, 1400 to 1900 mm above the hearth bottom, are slag notches through which slag is flushed. Hot air for the blast is supplied by the hot blast main from the hot blast stoves. The stove is heated by combusting a part of cleaned blast furnace gas which contains in average 39-40% CO + CO₂, 8-12% CO₂, 0.2-0.4% CH₄, 2.5-3% H₂ and 57-58% N₂ which heats checker bricks in the stove dome. The blast furnace gas has a calorific value of about 805 kCal/Nm³. The air to be blasted is heated by passing through the hot checker bricks of the stove to about 1000 °C. Balance blast furnace gas is used as a fuel in the plant.

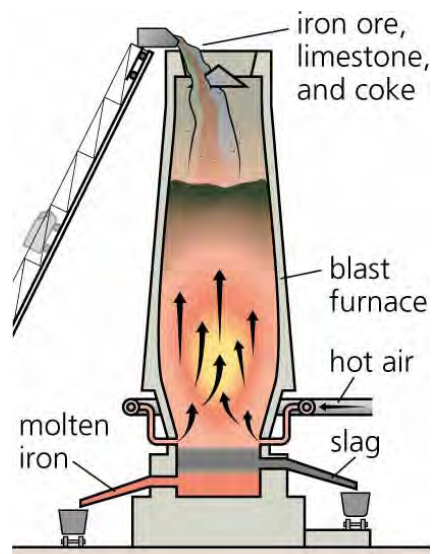


Figure 3-3: Blast Furnace

Some of the features affecting large blast furnaces are:

- Higher blast pressure
- Lower ratio of raceway length to hearth diameter leading to lesser heat penetration towards the centre of the dead man
- Greater probability of distortion
- Instability of cohesive zone

Due to these reasons, attempts should be made reduce the softening-melting gap, larger coke size in the hearth and lower slag volume with higher fluidity. To attain the above, agglomerate %age in the burden composition should be 70 to 80. To attain higher coke size in hearth, choice of coal blend is to be optimized to obtain better coke quality viz. higher CSR > 65%, reasonable CRI – 25%, lower ash, alkali and sulphur content. It has been observed that alumina ore is the detrimental factor in the Indian iron ore lumps and needs beneficiation of iron ore and iron ore fines. The burden quality can be improved by focusing on the following issues:

- Higher sinter strength
- Lower alumina content
- Higher sinter proportion
- Use of superior iron ore
- Introduction of pellet and use of Direct Reduced Iron (DRI)

State-of-the-art blast furnace equipped with the following major facilities can be envisaged for the plant.

- Stock house with automatic conveyor charging facilities
- Bell less top charging equipment
- High top pressure operation (2.5 kg/cm² top pressure) and matching gas-cleaning plant
- Stoves for generation of high hot blast temperature (1250°C blast temperature)
- Coal dust injection facilities (150-200 kg/T hm)
- Oxygen enrichment of blast
- Cast house slag granulation plant; and
- Level- III automation and control system, *etc.*

The coke quality can be improved by concentrating on following factors:

- Lower ash content
- Higher CSR and CRI.

The presence of alkali degrades feed materials including coke, promotes wall buildup, deteriorates furnace operation, thereby decreases production and increases coke consumption. Washing of coal and blending of about 50% good quality imported coal, use of better quality limestone have been found to reduce alkali load.

3.3.1.1 Steel making

Steel is made from pig iron by fire-refining treatments of an oxidising nature. In each case, a slag is produced and two types of processes are distinguished, namely, acid and basic, depending on whether the slag is predominantly siliceous (acid) or high in lime (basic). Hence the furnace lining in contact with slag is made of siliceous materials or, basic material (such as dolomite or magnesite) according to the nature of the slag. By the Bessemer process, pig iron is converted into steel in a vessel which is known as a Converter.

Acid bessemer process

By this process, the carbon, silicon and manganese of molten iron can only be eliminated by blowing a current of air through the metal, converting it into steel. The charge for the converter, which must be molten, is brought in hot metal ladle cars. The blast is introduced through the tuyers in the bottom for 10 to 18 minutes. The molten steel is poured into a ladle car, and the slag into a slag pit. Three clearly distinctive stages may be noted in the conversion of normal pig iron into steel.

(i) The first stage commences as soon as the blast is put on. The oxygen of the blast oxidises the iron to ferrous oxide. As a slag, the ferrous oxide mixes with the metal. Having a greater affinity for oxygen, the silicon and manganese rob the iron of its oxygen and forms separate oxides into the slag. This lasts for 2 to 3 minutes and can be called the slag formation stage.

(ii) The second stage commences after the oxidation of iron, silicon and manganese, when the metal bath has reached a temperature of 1600 to 1625°C, and the dissolved carbon is oxidised by the ferrous oxide of the slag. The gas evolved during this stage is reach in CO which burns at the nose of the converter.

(iii) The third stage begins when the flame drops – a sign that the carbon has been practically removed from the charge. Instead, the oxidation of the remaining silicon and manganese and then some iron is stepped up.

Basic bessemer process

In basic Bessemer practice the vessel is the same as that used for acid working except for the lining of dolomite. The charge for the basic Bessemer process consists of molten pig iron, scrap, lime and iron ore. The blow can again be divided into three stages.

(i) During the first stage the iron, silicon and manganese are oxidised. The slag consists of oxides of iron, silicon and manganese.

(ii) During the second stage the carbon is oxidised and the slag changes its composition, as it picks up more lime.

(iii) During the third stage, the phosphorous is vigorously oxidised by the ferrous oxide content of the slag. By the moment the third stage begins, the lime has been fully dissolved in the slag and the P_2O_5 unites with such lime to form stable phosphate, which in turn is absorbed by the slag.

Open hearth process

The may be regarded as a special form of reverberatory. The charge is contained in a relatively shallow hearth, and heating is by means of a gas, oil, tar or combination of flame burning across the top, alternatively from each end, employing the regenerative principle for preheating the air and lower grade gases when used. In the acid process the working hearth is made of silica sand sintered into place; the basic hearth is made of mixtures of calcined magnesite or dolomite and the basic slag. The use of oxygen in the open hearth furnace offers a means of increasing the production rate.

The open hearth furnaces usually had considerable large capacities than converters earlier, but the time of operation is much longer, from about 6 to 20 hours.

The basic process is more important. The hearth, after the previous charge has been tapped, is fettled or repaired with raw or burnt dolomite. Limestone is charged first, followed by ore, steel scrap and then any solid pig iron or old ingot moulds. When the temperature has reached at least about 12000 C, and the charge is beginning to melt, the molten pig iron is poured in from a ladle via chute. As the heating continues, considerable amount of carbon monoxide are evolved from the oxidation of the carbon, causing foaming of the slag, which may run off from the slag notch.

Open hearth furnaces may be broadly classified into fixed or tilting. The later are advantageous in the conversion of high phosphorous pig iron. The furnace can be tilted more than once to flush out slag. On the tapping side, steel is run off on a ladle car and cast from the ladle car to ingot moulds. Depending on the quality of steel needed, the open hearth furnace working can be adjusted based on metallurgical principles.

In India, open hearth furnaces are being slowly phased out with basic oxygen furnaces.

Oxygen steelmaking

Steel makers are interested in a process which could combine the high quality product of the open hearth with the greater production rate of the Bessemer converters. As a result, a variety of oxygen steel making processes has appeared. The revolution in the oxygen steelmaking was brought by the Linz-Donawitz (LD) process. The conversion of pig iron takes place in a vessel lined with dolomite or magnesite on a tar binder such as in the Basic Bessemer Process. As such, LD converters are also known as Basic Oxygen Furnaces (BOFs). A blast of almost pure oxygen is blown vertically from top by a water cooled lance. Tip of the lance is within about 1200 mm of the surface of the bath.

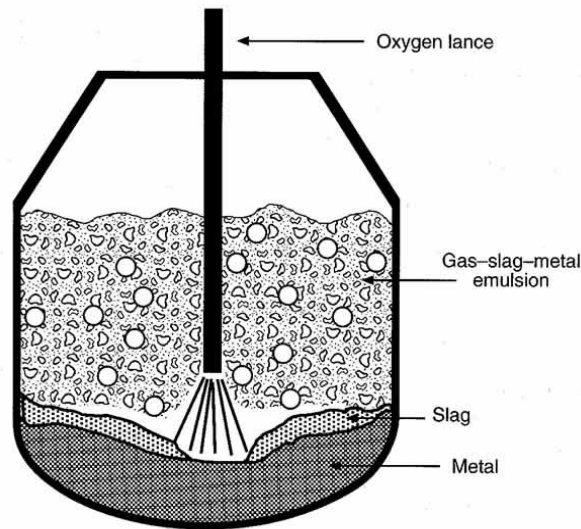


Figure 3-4: A Basic Oxygen Furnace

Phosphorous removal and carbon oxidation proceed practically simultaneously. For this reason, when the blow is stopped at the desired carbon content, the phosphorous concentration is sufficiently low (0.015%). Sulphur removal is very efficient, and its content in LD steels is often lower than in open hearth grades. Nitrogen concentration in LD steels is likewise lower than in open hearth grades for the reason that the metal is prevented from absorbing nitrogen by the intensive evolution of carbon monoxide and the oxygen blast delivered onto the surface of the metal. The LD process runs hot. The charge, in addition to molten pig iron, includes some scrap and iron ore. Lime is added during the blow. Blowing time is 18 to 20 minutes. The oxygen consumption is above what is theoretically necessary for the oxidation of impurities. The use of commercially pure oxygen supplies ample heat and pig iron of practically any analysis can be worked. Scrap consumption varies from iron to iron and may some times reach 30%.

The flexibility of LD process is amazing. The blow can be stopped at any desired carbon content, especially when the pig iron use is low or medium phosphorous quality. The converted steel may be of widely varying grades, both plain carbon and alloy, such as rail steel, ball-bearing (C-Cr) steel, shafting (Cr-Mo) steel, spring (Si-Mn) steel, *etc.* these advantages have own LD process general recognition. Almost all the steel plants in India depend on BF-BOF/COREX-BOF route for steel plant capacity expansion. In the older designs, the CO rich BOF gas was used to be burnt at the mouth of the converter by providing a gap between the suction hood and the converter top, through which air can enter the hood and combust the gas. In case the BOF is not provided with suppressed combustion system, the gas is burnt at the throat (temperature reaching about 1800 degree C) and then cooled in the flue duct by cooling water and ultimately produce steam. The cooled gas is cleaned in electrostatic precipitator (at 200 degree C) and discharged by a chimney.

The modern BOFs are provided with suppressed combustion by closely fitting the hood over the converter mouth without allowing entry of air for combustion at converter mouth. Exhaust gas generated (by suppressed combustion) during a BOF refining process is high temperature gas containing mainly CO. A large volume of gas with much dust is generated intermittently. Energy of BOF gas is recovered after dedusting, generally in wet venture scrubber and stored in a gas holder for utilization as fuel.

The recovered gas has CO content more than 60% and heating value of about 2000 kcal/Nm³. It can be used as a fuel for boilers, re-heating furnaces of rolling mills and power generation plants. It has negligible sulphur content. The temperature of gas at mouth of hood is about 1450°C and cools down to 1000°C in radiation section before entry to dust catcher. Recently, the sealed type OG method has been developed and is getting widely used, where the section between the furnace throat and the skirt is sealed during refining in order to reduce the recovery loss of BOF gas. The ingot production is done in the following ways:

Casting into moulds

Steel is cast into ingot moulds on the pouring side or the casting floor of a steel making plant. Up on solidification, ingots are either rolled or forged to shape. Casting into foundry moulds is usually employed in the foundries engineering works.

After it has been tapped from a furnace, the metal is held in the ladle for 5 to 10 minutes in order to (i) equalise the composition of the steel; (ii) to allow non metallic particles produced by de-oxidation or spalls from the lining to float; and (iii) to allow the occluded gases to escape in a ladle furnace and by vacuum degassing.

Ladle furnace (LF)

After steel is created in a BOF or EAF, it may be refined before being cast into a solid form. This process is called “ladle refining”, “secondary refining” or “secondary metallurgy”, and is performed in a separate ladle/furnace after being poured from the BOF or EAF. Steel refining helps steelmakers meet steel specifications demanded by their customers. Refining processes include: chemical sampling; adjustments for carbon, sulphur, phosphor and alloys; vacuum degassing to remove dissolved gases; heating/cooling to specific temperatures; and inert gas injection to “stir” the molten steel. With a view to achieve improved homogeneity and productivity of the primary unit and serving as a buffer between the primary unit and the caster, ladle furnace is the ideal secondary refining unit.

Vacuum degassing (VD)

In order to produce value-added products subject to market requirements, VD/VOD/RH are essential as secondary refining units. The processes assure liquid steel of high purity, low level of inclusions and good homogeneity with respect to temperature and chemistry. The vacuum which is 5 to 0.1 mm Hg, efficiently degasses the metal (some 60% of the occluded hydrogen is removed) and decreases the total amount and size of non-metallic inclusions. This appreciably improves the mechanical properties of the steel, especially ductility. These processes thus help attainment of very low levels of gases and inclusions and provide controlled alloying and mixing to produce a great variety of alloys. These processes also allow improvement in plant productivity (through sharing of refining load) and yield, in addition to ensuring good quality.

Continuous casting

All modern steel plants in India are provided with continuous casting facilities avoiding the mould casting and heavy section mills like blooming or slabbing mills. The waste of energy by cooling the ingots and then re-heating it before rolling is avoided as the liquid steel is directly cast into blooms, billets or other shapes in the steel melting shop itself.

From the casting ladle, steel is emptied into a tundish from which the steel flows in a continuous strand into the desired shape. From the mould, a pair of withdrawal rolls pulls the strand at a prescribed rate, while keeping it straight. Casting is cooled by spraying with water. Past the rolls, the solidified strand is cut by an automatic oxy-acetylene or oxy-gas cutter into billets or blooms for further shaping and treating. This is shown in Figure 3-5.

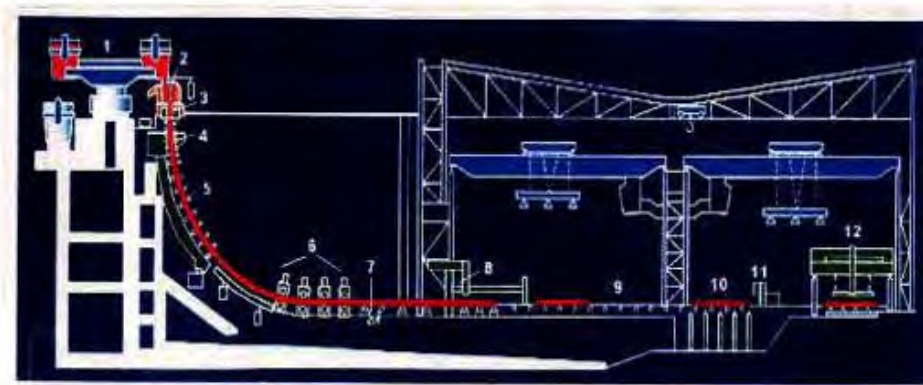


Figure 3-5: A Continuous Caster

The modern slab caster is equipped with the state-of-the-art facilities like electromagnetic stirring, mould oscillation, shrouding of liquid metal with inert gas, online width control, etc.

Rolling and finishing

Rolling and finishing are the processes of transforming semi-finished shapes into finished steel products, flat or non flat, which are used by downstream customers directly or to make further goods. Figure 3-6 summarizes the basic rolling and finishing processes.

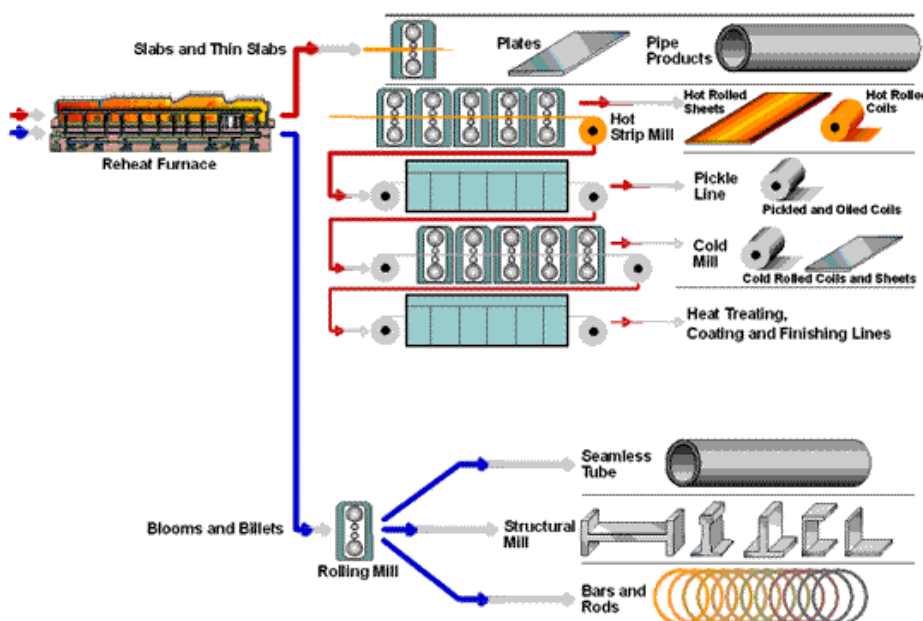


Figure 3-6: Rolling and Finishing

Finishing processes can impart important product characteristics that include: final shape, surface finish, strength, hardness and flexibility, and corrosion resistance. Current finishing technology research focuses on improving product quality, reducing production costs and reducing pollution. Rolling and forming semi-finished steel (slabs, blooms or billets) is the mechanical shaping of steel to achieve desired shape and mechanical properties. Operations can include hot rolling, cold rolling, forming or forging. In hot rolling of steel to strip, for example, steel slabs are heated to over 1,000°C and passed between multiple sets of rollers. The high pressure reduces the thickness of the steel slab while increasing its width and length. After hot rolling, the steel may be cold-rolled at ambient temperatures to further reduce thickness, increase strength (through cold working), and improve surface finish. In forming, bars, rods, tubes, beams and rails are produced by passing heated steel through specially shaped rollers to produce the desired final shape. In forging, cast steel is compressed with hammers or die-presses to the desired shape, with a resultant increase in its strength and toughness.

Table 3-9: Resource required for a typical Indian Steel plant is as follows

Name of the product	Raw materials	*Consumption of raw material per tonne of product
Hot Metal	Coal	1.0346
	Iron Lump	0.49
	Iron ore fines	1.077
	Lime stone	0.053
	Dolomite	0.195
	Manganese ore	0.00297

Source: Rourkela steel plant

3.3.1.2 Ferroalloys processing

Alloy Steel plants are considered as a Primary Producer by JPC. Ferroalloys are mainly used as master alloys in the iron and steel industry, because it is the most economic way to introduce an alloying element in the steel melt. Besides this, special ferroalloys are also needed for the production of aluminum alloys and as starting material in specific chemical reactions. As an additive in the steel production ferroalloys improve the properties especially the tensile strength, wear and corrosion resistance. The effect of improved properties of steel by using ferroalloys as an alloying element depend more or less on the following influences

- A change in the chemical composition of the steel;
- The removal or the tying up of harmful impurities such as oxygen, nitrogen, sulphur or hydrogen;
- A change in the nature of the solidification, for example, upon inoculation.

Depending on the raw material that is used (primary or secondary raw material), the production of ferroalloys can be carried out as a primary or secondary process. The principal chemistry of both processes can be shown as follows.

A. Primary processes

Oxidic metal ore + iron ore/scrap + reductant \longrightarrow ferroalloy + reductant oxide + slag

B. Secondary processes

Metal scrap + iron scrap \longrightarrow ferroalloy

Primary ferro alloys are principally produced either by the carbothermic or metallothermic reduction of oxide ores or concentrates. The most important process is the carbo-thermic reduction in which carbon in the form of coke (metallurgical coke), coal or charcoal is normally used as a reducing agent. When a blast furnace is used coke is also needed as an energy source. The metallo-thermic reduction is mainly carried out with either silicon or aluminum as the reducing agent. The following chemical equations show the basic principles of the carbo and metallo-thermic production routes.

Carbo-thermic reduction

Metal-oxide + Carbon \longrightarrow Metal + Carbon-monoxide

Silico-thermic reduction

Metal-oxide + Silicon \longrightarrow Metal + Silicon-oxide

Alumino-thermic reduction

Metal-oxide + Aluminum \longrightarrow Metal + Aluminum-oxide

C. Applied processes and techniques

Depending on the production rate, ferro alloys can be divided into two main categories, bulk alloys and special alloys. Bulk ferro alloys (ferrochrome, ferrosilicon, ferromanganese, silicomanganese and ferronickel) account for about 90% of the total production of ferroalloys. Compared to bulk ferroalloys, the production rate of special ferroalloys is rather small. Special ferroalloys (ferrovanadium, ferromolybdenum, ferrotungsten, ferrotitanium, ferroboration, and ferroniobium) are mostly used in the iron, steel and cast-iron industry. Besides this some special ferroalloys are increasingly used also in other industry sectors *e.g.* aluminum and chemical industries.

(i) Ferrochrome

Ferrochrome, along with nickel (ferronickel) is the major alloying element in the production of stainless steel. Stainless steel is used in a variety of areas from cutlery to aircraft engine turbine blades. The chromium content of ferrochrome normally varies from 45 to 75% together with various amounts of iron, carbon and other alloying elements. The use of ferrochrome depends widely on the carbon content. Ferrochrome can therefore be classified as follows:

- High-carbon ferrochrome (HC FeCr) with 4 – 10% C (“ferrochrome carbure”)
- Medium-carbon ferrochrome (MC FeCr) with 0.5 – 4% C (“ferrochrome affine”)

- Low-carbon ferrochrome (LC FeCr) with 0.01 – 0.5% C (“ferrochrome suraffine”)

Table 3-10: Raw Material Consumption per Tonne of Charge Chrome Product

Name of the Product	Raw Material	*Raw Material Consumption per Tonne of Product
Charge Chrome/ High Carbon Ferro Chrome	Chrome ore	2.681
	Coke	0.572
	Carbon Paste	0.016
	Quartzite	0.318
	Lime stone	0.001
	Bauxite	0.014
	Lime	0.075
	Molasses	0.151
	Magnesite	0.009

Table 3-11: Raw Material Consumption per Tonne of High Carbon Ferro-chrome Product

Name of the Product	Raw Material	Raw Material Consumption per Tonne of Product	
*High Carbon ferro Chrome	Chrome ore friable	1.875	
	Chrome ore lump	0.625	
	LAM coke	0.6	
	Anthracite Coal	0.102	
	Quartz	0.160	
	Bauxite	0.030	
	Hydrated lime	0.135	
	Molasses	0.170	
	Electrode carbon paste	0.012	
Silico and ferro manganese		SiMn	FeMn
	Mn ore (35-37)	0.335	-
	Mn ore(38-40)	0.335	0.323
	MOIL LGHS	1.030	-
	MOIL Mn ore Blend -46	0.165	1.134
	Mn ore 40-42	-	0.323
	MOIL Mn ore Ist Gr-48	-	0.716

Name of the Product	Raw Material	Raw Material Consumption per Tonne of Product	
	Steam coal	1.320	-
	Anthracite coal	-	0.525
	Quartz	0.023	-
	Dolomite	0.237	0.204
	Electrode carbon paste	0.022	0.016

Source: Typical Ferro Alloys Unit

Table 3-12: Raw Material Consumption per Tonne of High Carbon Ferro-chrome Product

Name of the Product	Raw Material	*Raw Material Consumption per Tonne of Product
High Carbon Ferro Chrome	Chrome ore	1.205
	Chrome briquette	1.395
	Coke+Coal	0.502
	Quartzite	0.066
	magnesite	0.010
	Pyrexonite	0.172
	Electrode paste	0.020

Source: Typical Ferro chrome unit Ferrosilicon and silicon alloys

Ferrosilicon, silicon metal and silico-calcium (SiCa) are used as additives in different industrial activities. As an alloying element, ferrosilicon increases the strength of steel and is therefore used to melt steel that is needed to produce for instance wire-cords for tyres or ball-bearings. High purity FeSi is used to produce high permeability steel for electric transformers. Silicon metal is important as alloying element in aluminum and for the production of chemicals and electronic equipment. The major user for silico-calcium is also the steel industry. The above mentioned metals can be classified by their silicon-content as follows.

- Ferrosilicon, silicon content less than 96%
- Si-metal, silicon content above 96%
- Silico-calcium, silicon content about 60 – 65% and calcium content of 30 – 35%
- Ferromanganese and manganese alloys

Ferromanganese is another bulk ferro alloy of great importance mainly in the steel and stainless steel industry. Initially employed as a deoxidising and de-sulphurising agent, today ferromanganese is mostly used to improve the hardness and wear resistance of steel. Ferromanganese and other important manganese alloys can basically be classified as:

- High-carbon ferromanganese (HC FeMn) with max 7.5% C
- Medium-carbon ferromanganese (MC FeMn) with max 1.5% C
- Low-carbon ferromanganese (LC FeMn) with max 0.5% C
- Silicomanganese (SiMn) with max 2.0% C

- Low-carbon silico-manganese (LC SiMn) with max 0.05% C

(ii) Ferronickel

Raw materials

Ferronickel (FeNi) as well as ferrochrome is the major alloying agent in the production of stainless steel. Laterite ore is the main raw material. Laterite ore is characterized by relatively low nickel content (1.2 – 3%) and high moisture content (up to 45%) together with chemically bound water in the form of hydroxide. Besides laterite ore, coke or coal is the second raw material that is needed in the ferronickel production. Coke or coal is used as a reducing agent because the ferronickel production takes place by a carbo-thermic process. FeNi can also be produced from secondary raw materials, such as spent catalysts and sludge from the galvanizing industry.

Production of ferronickel from primary raw material

The production of ferronickel from primary raw material is carried out exclusively by the rotary kiln-electric furnace process. As mentioned before the raw material carries a significant amount of water, therefore the first step of the process is a drying operation. Drying normally takes place in a directly fired rotary dryer where the moisture content can be reduced from about 45 to 15%. Further drying below 15% should be avoided in order to keep the dust generation in the subsequent calcining and smelting process as low as possible. The next process step is homogenization where the different ores are mixed with coal and pelletised dust, which is recycled from the main process. The dry feed mix is then fed to a rotary kiln. The rotary kiln is used to de-hydrate the ore by calcination and to pre-reduce the nickel and iron oxide. The process takes place at about 900 – 1000 °C. The calcining and pre-reducing process results in a furnace feed which contains about 40% of the nickel as a metal and the iron content in form of iron (II)-oxides. The hot pre-reduced calcine can be introduced directly to the smelting furnace or by insulated containers. The containers may be used for two reasons, first to conserve the heat and second to add coke or coal required for complete reduction before they are discharged into the electric furnace, where or melting and final reduction occurs. Ferronickel smelting today only takes place in electric arc furnaces. In the electric furnace the reductive smelting operation occurs by the combined action of carbon electrodes and added solid carbonaceous reductant.

The slag melting temperature in the ferronickel smelting process is strongly dependent on the FeO-content. The operation mode of the furnace therefore changes if the slag melting temperature is above or below the melting temperature of the metal. If the melting temperature of the slag is higher than the melting point of the metal the furnace can easily be operated with a covered bath. In this case the electrode tips are not immersed in the slag and the final reduction of the nickel and iron oxides takes mostly place in the hot charge which covers the slag layer. If the melting temperature of the slag is below the melting temperature of the metal the furnace is more difficult to operate. In order to reach the melting temperature of the metal the electrodes should penetrate deep in to the slag layer. The highest bath temperature will then be around the electrode tips where smelting takes place in the slag metals interface. These operating conditions result in a high generation rate of CO-gases, which requires an open bath surface around the electrodes. To reduce a high content of nickel oxides commonly the burden contains an excess proportion of carbon. These also increase the amount of iron that will be reduced and the final carbon content of the crude ferronickel. To reduce the iron and carbon content a

further refining step is necessary. To avoid further refining several process improvements had been made. For instance in the “Ugine Ferronickel Process” no reductant is added. The electric furnace produces a molten ore, which is reduced to ferronickel by using ferrosilicon in a further ladle furnace. In the “Falcondo Ferronickel Process” a shaft furnace is used instead of a rotary kiln. In the shaft furnace a briquetted ore is reduced with a reducing gas (low sulphur naphta). The subsequent electric furnace is then only used to melt the metal and to separate it from the slag.

Ferronickel produced by the conventional process needs further refining. Besides the reduction of iron and carbon the impurities like sulphur, silicon and phosphorus should be removed. For ferronickel refining a variety of equipment is available *e.g* shaking reaction ladle, induction furnace, electric arc furnace and oxygen blown converters. The purified ferronickel is cast into ingots or granulated under water. The dust containing off-gas from the rotary kiln, the electric arc smelting furnace and the refining step is treated by an appropriate abatement system. The dust content can be pelletised and recycled to the raw material blending station.

Production of ferronickel from secondary raw material

FeNi can also be produced from nickel containing residues used as secondary raw material. These residues, mostly spent catalysts from the grease production, are burned in a rotary kiln in order to concentrate the Ni-content as Ni-oxide in the flue dust. The flue dust containing of gas is cleaned in a membrane bag filter, where the collected dust is used as the raw material for the smelting process. The production of FeNi then takes place in a submerged electric arc furnace. The molten alloy is tapped, granulated in water and packed in drums or big-bags for supply.

3.3.2 Process technology for non-ferrous metals

3.3.2.1 Primary aluminum

Bayer Process

In 1888, Karl Josef Bayer developed and patented a process, which has become the cornerstone of the aluminum production industry worldwide. The Bayer process, as it has become known, is used for refining bauxite to smelting grade alumina (aluminum oxide), the precursor to aluminum. Typically, depending upon the quality of the ore, between 1.9 and 3.6 tonnes of bauxite is required to produce 1 tonne of alumina.

The Bayer process is a cyclic one and is often called Bayer cycle. It involves four steps: digestion, clarification, precipitation, and calcination.

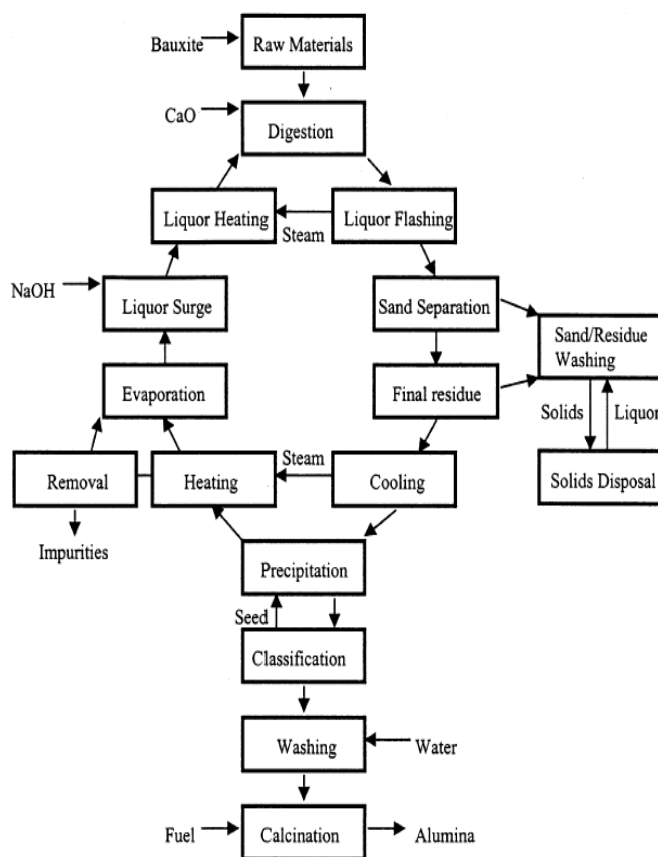
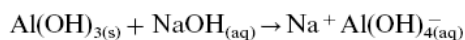


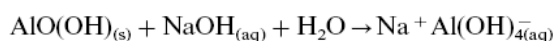
Figure 3-7: Bayer Process to Produce Alumina

Digestion

In the first step, bauxite is ground, slurried with a solution of caustic soda (sodium hydroxide), and pumped into large pressure tanks called digesters, where the ore is subjected to steam heat and pressure. The specific conditions depend on the quality of bauxite used (*i.e.* the type of aluminum (oxy) hydroxides present). The sodium hydroxide reacts with the aluminous minerals of bauxite to form a saturated solution of sodium aluminate; insoluble impurities, called red mud (RM), remain in suspension and are separated in the clarification step. The following reactions describe this step:



and,



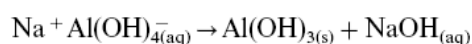
Clarification

Following digestion, the mixture is passed through a series of pressure-reducing tanks (called blow-off tanks), where the solution is flashed to atmospheric pressure. The next step in the process is to separate the insoluble red mud from the sodium aluminate solution. Coarse material (*e.g.* beach sand) is removed in crude cyclones called sand traps. Finer residue is settled in raking thickeners with the addition of synthetic flocculants, and solids in the thickener overflow are removed by cloth filters. These residues are then washed, combined, and discarded. The clarified solution is further

cooled in heat exchangers, enhancing the degree of super saturation of the dissolved alumina, and pumped into tall, silo like precipitators.

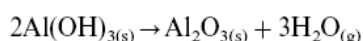
Precipitation

Sizable amounts of aluminum hydroxide crystals are added to the solution in the precipitators as seeding to hasten crystal separation. The seed crystals attract other crystals and form agglomerates; these are classified into larger product-sized material and finer material that is recycled as seed. The product-sized agglomerates of aluminum hydroxide crystals are filtered and washed to remove entrained caustic or solution. The following reaction takes place:



Calcination

The agglomerates of aluminum hydroxide are calcined in rotary kilns or stationary fluidized-bed flash calciners at temperatures in excess of 960°C (1,750°F). Free water and water that is chemically combined are driven off, leaving commercially pure alumina. The following reaction describes this step:



As can be seen in the flowsheet (Fig. 3-7), lime (CaO) is also introduced in the Bayer process. According to a review on this issue by B.I. Whittington 1996, it can enhance the extraction of alumina (improving the dissolution of boehmite and diaspore or the conversion of aluminogothite), control liquor impurities (desilication, causticisation or phosphorous control), assist with the removal of impurities from the pregnant liquor (liquor "polishing") and minimise soda losses in the red mud (formation of alternate desilication products or calcium titanates).

Alumina produced by the Bayer process is quite pure, containing only a few hundredths of 1 % of iron and silicon. The major impurity, residual soda, is present at levels of 0.2 to 0.6 %. In addition to being the primary raw material for producing metallic aluminum, alumina itself is an important chemical. It is used widely in the chemical, refractories, ceramic, and petroleum industries.

Refining four tonnes of bauxite yields about two tonnes of alumina. A typical alumina plant, using the Bayer process, can produce 4,000 tonnes of alumina per day. The cost of alumina can vary widely, depending on the plant size and efficiency, on labour costs and overhead, and on the cost of bauxite.

Aluminum oxide cannot be reduced to metallic aluminum by carbon smelting because the metal will again react with the carbon to form aluminum carbide, Al_4C_3 . Nor can aluminum be obtained by the electrolytic decomposition of an aqueous solution of its salts, for only hydrogen will evolve at the cathode. This is the reason why metallic aluminum at the present time is produced commercially by the electrolysis of alumina in a liquid bath of cryolite. Aluminum up to 99.6% purity is normally prepared by direct electrolysis, and up to 99.85% purity by using very pure oxides and electrodes. By subsequent electrolytic refining, using a fused salt electrolyte, purity of at least 99.99% may be attained.

The principle of electrolytic refining of aluminum is to use a three layer molten bath. On the bottom is the crude aluminum alloyed with copper (to about 33%) to increase its density, and with some silicon to reduce the melting point; on top of this is a layer of fused salt electrolyte of lower density; the third layer is the pure refined aluminum. Electrical connections are made to the two metal layers to make them in effect anode and cathode respectively. On electrolysis, aluminum dissolves at the anode and is deposited at the cathode; the impurities or alloying elements in the anode alloy, being more noble, do not dissolve.

The first successful application of the technique was by Hoops; he used a fused salt mixture of barium, aluminum and sodium fluorides containing dissolved alumina, an operating temperature of 950-1000°C being necessary. Hoops employed a steel cell with a carbon bottom connected to the positive side of the electric supply; electrical contact was made with the cathode metal by means of several carbon electrodes. The cell walls were water jacketed and were lined with a layer of electrolyte which solidified. There are certain difficulties in working, but according to Bray the process is still used.

Table 3-13: Raw Material Consumption per Tonne of Aluminum Product

Name of the Product	Raw Materials	*Consumption of Raw Material Per Unit of Output Per Tonne of Product
Aluminum	Alumina	1933
	C.P Coke	381
	C.T Pitch	99
	Aluminum Fluoride	23.33
	H.F.O	77.10
	Power	13700 KWH/T

Source: NALCO

Table 3-14: Raw Material Consumption per Tonne of Aluminum Metal Product

Name of the Product	Raw Materials	*Consumption of Raw Material Per Tonne of Product
Aluminum metal (ingot and con. Cast coil)	Alumina	2.035
	Cryolite	0.0220
	Aluminum fluoride	0.015
	Calcium fluoride	0.0004
Carbon paste	Calcined pet coke	0.386
	pitch	0.168

Source: HINDALCO

3.3.2.2 Primary lead production process

Mining the ore

The first step in retrieving lead-bearing ore is to mine it underground. Workers using heavy machinery drill the rock from deep tunnels with heavy machinery or blast it with dynamite, leaving the ore in pieces. Then they shovel the ore onto loaders and trucks, and haul it to a shaft. The shaft at a large mine may be a mile or more from the drill or blast site. The miners dump the ore down the shaft, and from there it is hoisted to the surface.

Concentrating the ore

After the ore is removed from the mine, it is treated at a concentrating mill. Concentrating removes the waste rock from the lead. To begin, the ore must be crushed into very small pieces. The ore is ground at the mill, leaving it in particles with diameters of 0.1 millimeter or less. This means the individual granules are finer than table salt. The texture is something like granulated sugar.

Flotation

The principal lead ore, galena, is properly known as lead sulphide, and sulphur makes up a substantial portion of the mineral. The flotation process collects the sulphur-bearing portions of the ore, which also contains the valuable metal. First, the finely crushed ore is diluted with water and then poured into a tank called a flotation cell. The ground ore and water mixture is called slurry. One % pine oil or a similar chemical is then added to the slurry in the tank. The tank then agitates, shaking the mixture violently. The pine oil attracts the sulphide particles. Then air is bubbled through the mixture. This causes the sulphide particles to form an oily froth at the top of the tank. The waste rock, which is called gangue, sinks to the bottom. The flotation process is controlled by means of X-ray analyzers. A flotation monitor in the control room can check the metal content of the slurry using the X-ray analysis. Then, with the aid of a computer, the monitor may adjust the proportion of the chemical additive to optimize recovery of the metal. Other chemicals are also added to the flotation cell to help concentrate the minerals. Alum and lime aggregate the metal, or make the particles larger. Xanthate is also added to the slurry, in order to help the metal particles float to the surface. At the end of the flotation process, the lead has been separated from the rock, and other minerals too, such as zinc and copper, have been separated out.

Filtering

After the ore is concentrated in the flotation cells, it flows to a filter, which removes up to 90% of the water. The concentrate at this point contains from 40-80% lead, with large amounts of other impurities, mostly sulphur and zinc. It is ready at this stage to be shipped to the smelter. The gangue, or rock that was not mineral-bearing, must be pumped out of the flotation tank. It may be dumped into a pond resembling a natural lake, and when the pond eventually fills, the land can be replanted.

Roasting the ore

The lead concentrate fresh from the filter needs to be further refined to remove the sulphur. After the concentrate is unloaded at what is called the sinter plant, it is mixed with other lead-bearing materials and with sand and limestone. Then the mixture is

spread on a moving grate. Air which has been heated to 2,550°F (1,400°C) blows through the grate. Coke is added as fuel, and the sulphur in the ore concentrate combusts to sulphur dioxide gas. This sulphur dioxide is an important byproduct of the lead refining process. It is captured at a separate acid plant and converted to sulphuric acid, which has many uses. After the ore has been roasted in this way, it fuses into a brittle material called sinter. The sinter is mostly lead oxide, but it can also contain oxides of zinc, iron, and silicon, some lime, and sulphur. As the sinter passes off the moving grate, it is broken into lumps. The lumps are then loaded into the blast furnace.

Blasting

The sinter falls into the top of the blast furnace, along with coke fuel. A blast of air comes through the lower part of the furnace, combusting the coke. The burning coke generates a temperature of about 2,200°F (1,200°C) and produces carbon monoxide. The carbon monoxide reacts with the lead and other metal oxides, producing molten lead, nonmetallic waste slag, and carbon dioxide. Then the molten metal is drawn off into drossing kettles or molds.

Refining

The molten lead as it comes from the blast furnace is from 95-99% pure. It is called at this point base bullion. It must be further refined to remove impurities, because commercial lead must be from 99-99.999% pure. To refine the bullion, it is kept in the drossing kettle at a temperature just above its melting point, about 626°F (330°C). At this temperature, any copper left in the bullion rises to the top of the kettle and forms a scum or dross which can be skimmed off. Gold and silver can be removed from the bullion by adding to it a small quantity of zinc. The gold and silver dissolves more easily in zinc than in lead, and when the bullion is cooled slightly, zinc dross rises to the top, bringing the other metals with it.

Casting

When the lead has been sufficiently refined, it is cooled and cast into blocks which may weigh as much as a ton. This is the finished product. Lead alloys may also be produced at the smelter plant. In this case metals are added to the molten lead in precise proportions to produce a lead material for specific industrial uses. For example, the lead commonly used in car batteries, and also for pipe, sheet, cable sheathing, and ammunition, is alloyed with antimony because this increases the metal's strength.

3.3.2.3 Primary copper production process

From its original home buried underground in a mine to its use in a finished product such as wire or pipe, copper passes through a number of stages. When it is recycled it can pass through some over and over again. Below is quick description of the path.

Mining and crushing

The beginning for all copper is to mine sulphide and oxide ores through digging or blasting and then crushing it to walnut-sized pieces.

Grinding

Crushed ore is ball or rod-milled in large, rotating, cylindrical machines until it becomes a powder usually containing less than 1% copper. Sulphide ores are moved to a concentrating stage, while oxide ores are routed to leaching tanks.

Concentrating

Minerals are concentrated into slurry that is about 15% copper. Waste slag is removed. Water is recycled. Tailings (left-over earth) containing copper oxide are routed to leaching tanks or are returned to the surrounding terrain. Once copper has been concentrated, it can be turned into pure copper cathode in two different ways: Leaching & electrowinning or smelting and electrolytic refining.

Leaching

Oxide ore and tailings are leached by a weak acid solution, producing a weak copper sulphate solution.

Electrowinning (SX/EW)

The copper-laden solution is treated and transferred to an electrolytic process tank. When electrically charged, pure copper ions migrate directly from the solution to starter cathodes made from pure copper foil. Precious metals can be extracted from the solution.

Smelting

Several stages of melting and purifying the copper content result, successively, in matte, blister and, finally, 99% pure copper. Recycled copper begins its journey to finding another use by being resmelted.

Electrolytic refining

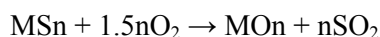
Anodes cast from the nearly pure copper are immersed in an acid bath. Pure copper ions migrate electrolytically from the anodes to "starter sheets" made from pure copper foil where they deposit and build up into a 300-pound cathode. Gold, silver and platinum may be recovered from the used bath.

3.3.2.4 Zinc smelting

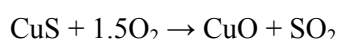
Zinc smelting is the process of converting zinc concentrates (ores that contain zinc) into pure zinc. The most common zinc concentrate processed is zinc sulphide, which is obtained by concentrating sphalerite using the froth flotation method. Secondary (recycled) zinc material, such as zinc oxide, is also processed with the zinc sulphide. Approximately 30% of all zinc produced is from recycled sources.

There are two methods of smelting zinc: the pyrometallurgical process and the electrolysis process. Both methods are still used. Both of these processes shares the same first step is roasting.

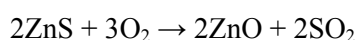
Roasting is a metallurgical process involving gas-solids reactions at elevated temperatures. A common example is the process in which sulphide ores are converted to oxides, prior to smelting. Roasting differs from calcination, which merely involves decomposition at elevated temperatures. A typical sulphide roasting chemical reaction takes the following form:



For example:



and



The gaseous product of sulphide roasting, sulphur dioxide (SO₂) is often used to produce sulphuric acid.

Multiple-hearth roaster

In a multiple-hearth roaster, the concentrate drops through a series of 9 or more hearths stacked inside a brick-lined cylindrical column. As the feed concentrate drops through the furnace, it is first dried by the hot gases passing through the hearths and then oxidized to produce calcine. The reactions are slow and can be sustained only by the addition of fuel. Multiple hearth roasters are unpressurized and operate at about 690°C (1,274 °F). Operating time depends upon the composition of concentrate and the amount of the sulphur removal required. Multiple hearth roasters have the capability of producing a high-purity calcine.

Suspension roaster

In a suspension roaster, the concentrates are blown into a combustion chamber very similar to that of a pulverized coal furnace. The roaster consists of a refractory-lined cylindrical steel shell, with a large combustion space at the top and 2 to 4 hearths in the lower portion, similar to those of a multiple hearth furnace. Additional grinding, beyond that required for a multiple hearth furnace, is normally required to ensure that heat transfer to the material is sufficiently rapid for the desulphurization and oxidation reactions to occur in the furnace chamber. Suspension roasters are unpressurized and operate at about 980°C (1,800°F).

Fluidized-bed roaster

In a fluidized-bed roaster, finely ground sulphide concentrates are suspended and oxidized in a feedstock bed supported on an air column. As in the suspension roaster, the reaction rates for desulphurization are more rapid than in the older multiple-hearth processes. Fluidized-bed roasters operate under a pressure slightly lower than atmospheric and at temperatures averaging 1,000°C (1,830°F). In the fluidized-bed process, no additional fuel is required after ignition has been achieved. The major advantages of this roaster are greater throughput capacities, greater sulphur removal capabilities, and lower maintenance.

Electrolysis process

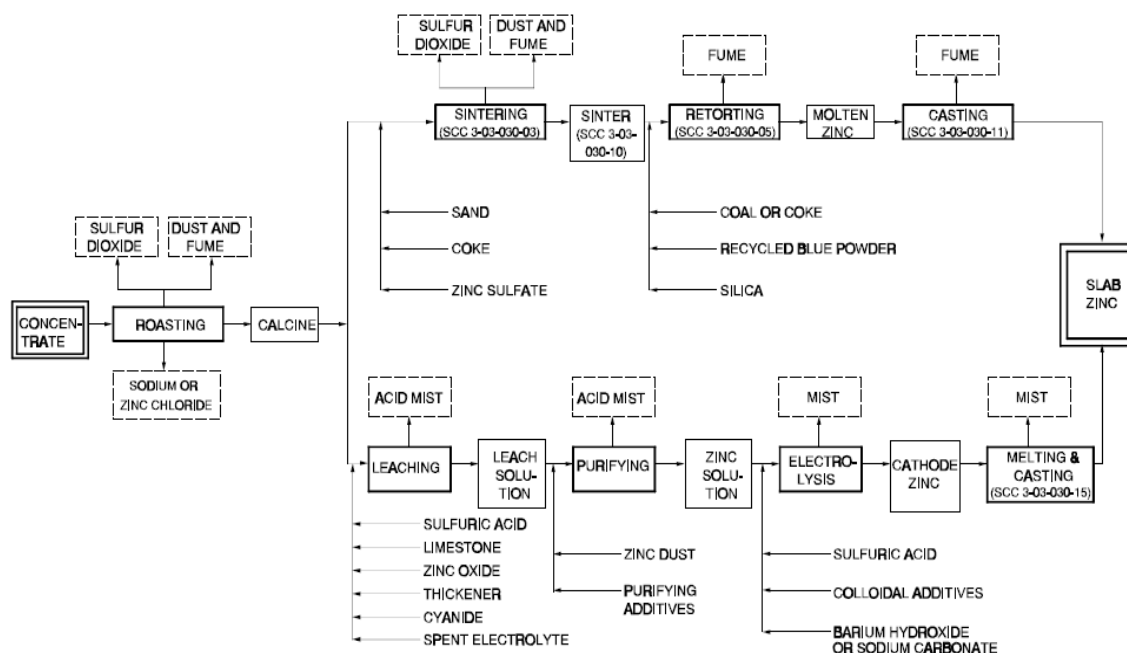


Figure 3-8: Zinc Production Process

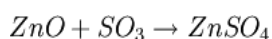
The electrolysis process, also known as the hydro-metallurgical process, Roast-Leach-Electrowin (RLE) process, or electrolytic process, is more widely used than the pyro-metallurgical processes. The electrolysis process consists of 4 steps:

- leaching
- purification
- electrolysis and
- Melting and casting

The top path is the pyro-metallurgical process of smelting zinc and the bottom path is the electrolytic process

Leaching

The basic leaching chemical formula that drives this process is:



This is achieved in practice though a process called double leaching. The calcine is first leached in a neutral or slightly acidic solution (of sulphuric acid) in order to leach the zinc out of the zinc oxide. The remaining calcine is then leached in strong sulphuric acid to leach the rest of the zinc out of the zinc oxide and zinc ferrite. The result of this process is a solid and a liquid; the liquid contains the zinc and is often called leach product; the solid is called leach residue and contains precious metals (usually lead and silver) which are sold as a by-product. There is also iron in the leach product from the strong acid leach, which is removed in an intermediate step, in the form of goethite, jarosite, and haematite. There is still cadmium, copper, arsenic, antimony, cobalt, germanium, nickel, and thallium in the leach product. Therefore it needs to be purified.

Purification

The purification process utilizes the cementation process to further purify the zinc. It uses zinc dust and steam to remove copper, cadmium, cobalt, and nickel, which would interfere with the electrolysis process. After purification, concentrations of these impurities are limited to less than 0.05 milligram per liter (4×10^{-7} pounds per gallon). Purification is usually conducted in large agitated tanks. The process takes place at temperatures ranging from 40 to 85°C (104 to 185°F), and pressures ranging from atmospheric to 240 kilopascals (2.4 atm). The by-products are sold for further refining. The zinc sulphate solution must be very pure for electrowinning to be at all efficient. Impurities can change the decomposition voltage enough to where the electrolysis cell produces largely hydrogen gas rather than zinc metal.

Electrolysis

Zinc is extracted from the purified zinc sulphate solution by electro winning, which is a specialized form of electrolysis. The process works by passing an electric current through the solution in a series of cells. This causes the zinc to deposits on the cathodes (aluminum sheets) and oxygen to form at the anodes. Sulphuric acid is also formed in the process and reused in the leaching process. Every 24 to 48 hours, each cell is shut down, the zinc-coated cathodes are removed and rinsed, and the zinc is mechanically stripped from the aluminum plates.

Electrolytic zinc smelters contain as many as several hundred cells. A portion of the electrical energy is converted into heat, which increases the temperature of the electrolyte. Electrolytic cells operate at temperature ranges from 30 to 35°C (86 to 95°F) and at atmospheric pressure. A portion of the electrolyte is continuously circulated through the cooling towers both to cool and concentrate the electrolyte through evaporation of water. The cooled and concentrated electrolyte is then recycled to the cells. This process accounts for approximately 1/3 of all the energy usage when smelting zinc.

There are two common processes for electrowinning the metal: the low current density process, and the Tainton high current density process. The former uses a 10% sulphuric acid solution as the electrolyte, with current density of 270–325 amperes per square meter. The latter uses 22–28% sulphuric acid solution as the electrolyte with a current density of about 1,000 amperes per square meter. The latter gives better purity and has higher production capacity per volume of electrolyte, but has the disadvantage of running hotter and being more corrosive to the vessel in which it is done. In either of the electrolytic processes, each metric *tonne* of zinc production expends about 3,900 kWh (14 GJ) of electric power.

3.3.3 Secondary metallurgical industries

The term secondary resources encompasses a whole range of materials and can be categorized depending on their physical state (solid/ liquid/gas) or originating process (pyro/hydro/electro metallurgical operations) or originating industries including many belonging to non-metallurgical sectors like automobiles, petrochemicals, fertilizers and energy. Processing of such secondary resources is a broad subject drawing attention of technologists and researchers.

As far as various secondary resources are concerned, the largest input possibly comes from metal extraction and fabrication industries generating huge quantities of metal alloy

scraps. The metals and alloys are then put into use by whole range of industries starting from construction, transport, communication, information, petrochemical, fertilizer and nuclear to name a few, who in turn generate obsolete metal scrap after the metal bearing products have out lived their useful lives.

Since metal scraps are already in liberated form, at worst contaminated with metallic and or interstitial impurities or unwanted non-metallic materials, its recycle after proper cleaning and sorting leads to considerable energy savings. According to experts aluminum could be recycled as many times as possible and during recycle and each re-use would lead to 95% savings in energy.

In the case of copper, against a primary production of 0.3 MT in our country, almost 0.1 MT of secondary copper is produced through processing of scraps generated by Electricity Boards, Railways, Defense sectors and those sourced through imports. In contrast to aluminum and copper, recovery of zinc metal from zinc scrap is minimal as it is predominantly used on steel for protection purpose called galvanizing. In fact large amount of zinc is lost every year as fumes during reprocessing of galvanized scrap. Most of the zinc is recycled as chemicals like zinc oxide and zinc sulphate or pure zinc dust by processing of various secondary resources like iron-zinc intermetallic compound, oxide ash, and dross rejected by galvanizing bath.

Between two major categories of batteries namely wet and dry cell the former are lead-acid variety primarily used for automotive products. A typical lead acid battery weighing 16.4 kg contains 10 kg of lead with more than 50% as sulphate and oxide paste, remaining as antimonial lead containing 3 to 11% Sb. In fact 75% of total demand of lead in the world is due to this particular use in the manufacture of lead acid batteries. When such batteries are discarded it can be processed to recover the lead value. In fact in our country there are many producers in the unorganized sector with 6 producers of secondary lead in the organized sector with a capacity of 45,000 tonne per annum indicating a recycle rate of 40%.

Industrial process of secondary steel are discussed in subsequent sections

3.3.3.1 Sponge iron manufacturing

The reduction of iron ore can be achieved by using either carbon bearing material, such as non-coking coal or a suitable reducing gas in the form of reformed natural gas. The processes employing coal are known as solid-reductant or coal-based processes while those employing reducing gases are known as gas-based processes. Sponge Iron produced by gas-based process is normally hot briquette and hence it is also known as Hot Briquetted Iron (HBI).

(i) Coal-based

This process utilizes non-coking coal as reducing agent along with lumpy rich grade iron ore. The reduction is carried out in an inclined horizontal rotary kiln, which rotates at a predetermined speed. DRI gases flow counter-current to the kiln feed. The temperature at the product discharge end in a rotary kiln is about 950-1050°C compared to 750-900°C towards the feed end. The counter-current flow of hot DRI gases enables it to remove the moisture content from feed. The hot DRI gases contains huge amount of fine dust comprising oxides and unburnt carbon and toxic carbon monoxide. The raw material feed side of rotary DRI Kiln has a natural structure below the After Burner Chamber (ABC)

that acts as Dust Settling Chamber (DSC). About 15-20% coarse dust settles in DSC by means of gravity. In ABC, the CO content of gases is converted to CO₂. This conversion process is exothermic and the temperature of gases rises to 1000-1050°C.

A temperature profile ranging from 800-1050°C is maintained along the length of the kiln at different zones and as the material flows down due to gravity the ore is reduced. The hot reduced sponge iron along with semi-burnt coal, discharged from kiln is cooled in water-cooled cylindrical rotary cooler to a temperature of 100–200 degree centigrade. The discharge from cooler consisting of sponge iron, char other contaminations are passed on through magnetic separators so that sponge iron can be separated from other impurities. The process flow diagram is shown as Figure 3-9.

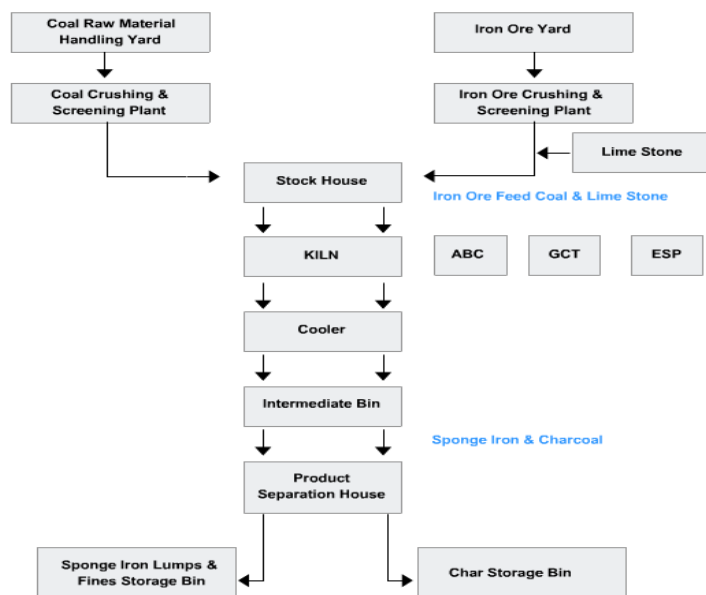
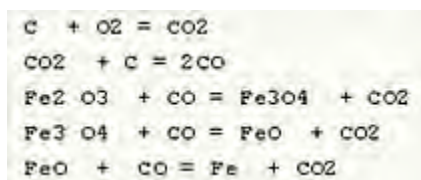


Figure 3-9: Process Flow Diagram of Coal Based Sponge Iron Plant

Later the sponge iron is screened into two size fractions *i.e.* -3 mm & +3 mm +3 mm fraction directly goes for usage, -3 mm fraction can be either used directly where ever it is possible or is to be briquetted by using molasses and hydrated lime as binders.

The basic reactions in this process are as follows:



General arrangement of indigenous coal based sponge iron process is given in Figure 3-10.

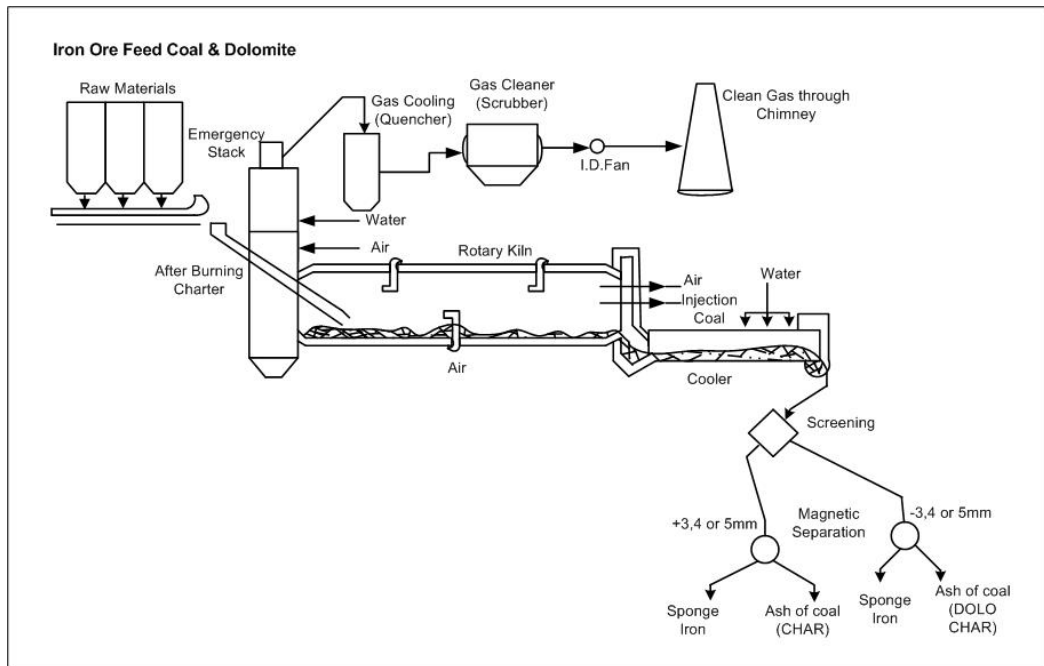


Figure 3-10: General Arrangement of Coal Based Customized / Indigenous Technology

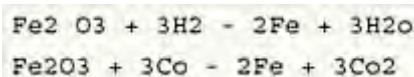
Raw material requirements

As in case of any process, here also quality of raw materials plays a vital role in obtaining the rated capacity and product quality. The iron ore shall have resistance for physical & thermal decrepitation and good reducibility and the coal should be of reactive nature along with the characteristics of high fusion temperature and less amount of ash.

(ii) Gas-based process

This process utilizes natural gas the reducing agent. Natural gas is reformed to enrich with H₂ and CO mixture and this enriched and reformed gas mixture is preheated in gas-based process. A vertical retort is used for the reduction of iron ore as against a rotary kiln in coal based sponge iron process. When the gases are traveling upwards, the charge moves downward by gravity. Gas-based sponge iron is not subjected for magnetic separation, as no contamination with non-magnetic is possible. Either it can be cooled indirectly or briquetted in hot condition to get hot briquetted iron (HBI).

The basic reactions are as follows:



There are only two well established processes

1. Midrex
2. Hyl

In gas-based process more preferable feed is pellets but lump ore is also used for with proper size distribution to have required permeability. Flow diagram of a Midrex Process is shown as Figure 3-11.

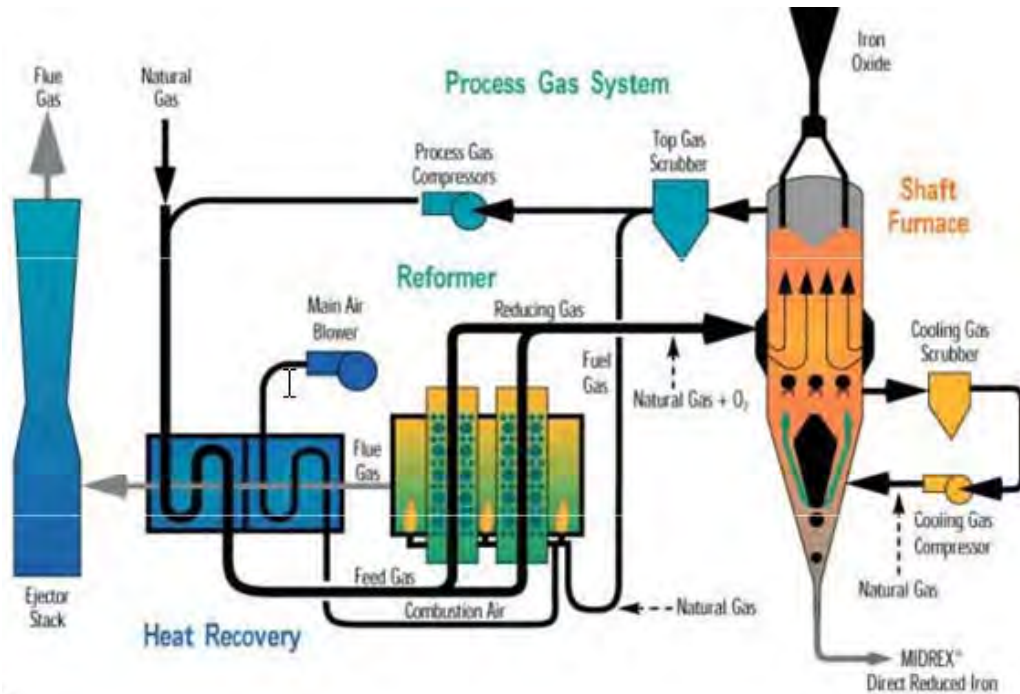


Figure 3-11: Flow Diagram of Midrex Process

Table 3-15: Comparison between Coal Based and Gas Based Products

No.	Parameters	Gas Based	Coal Based
1	Metallization	85 - 93 %	88 - 92 %
2	Carbon	1.2 - 2.5 %	0.2 - 0.25 %
3	Size of the product	Mostly uniform as pellets are commonly used	Wide variation as lump ore is used (3-20) mm
4	Recitation	Prone for re-oxidation unless briquetted	Relatively more stable
5	Melting in EAF	Higher carbon content is advantageous for reducing residual iron oxide in S.I	Low carbon content. Extra carbon required for reducing residual iron oxide.
6	L.D Converter	Carbon content will be high.	Carbon in the liquid metal is reduced because of FeO content in S.I.
7	Bulk density MT/m ³	1.5-1.9	1.6-2.0
8	Non - magnetic (Char)	Nil	0.3 to 0.5 %
9	% of usage of change mix in EAF	Max 30%.	Up to 80 % in continuous charging

No.	Parameters	Gas Based	Coal Based
10	Yield	1-2 % will be more when compare with coal based sponge iron.	1-2 % will be less when compared with gas based sponge iron.

Usage of waste heat recovery boilers

DRI kilns of sizes 50 TPD to 500 TPD are common in India. However, there are plants even as small as 25 TPD, which are now getting phased-out.

The DRI plants installed in early eighties and nineties uses quenching through wet scrubber to treat the dust bearing flue gases. In this system, huge amount of sludge is generated, which is disposed in ash ponds. The latest trend in DRI plants is to use electrostatic precipitator for dust trapping. In this system, the flue gas, at about 900°C - 950°C, is taken to a gas conditioning tower (GCT), where quenching water is added to cool the gas to about 150°C. The cooled gas then travels to the Electrostatic Precipitator (ESP). Dust is trapped in the ESP and the flue gas is let out using chimney.

Off late, some large DRI plants have installed Waste Heat Recovery Boiler (WHRB) after the ABC, to utilize the waste heat content of the flue gas. The WHRB generates steam at high pressure and uses it to run turbines for power generation.

Sponge iron plants of capacity more than 100 TPD kilns may use WHRB for generation of power. Installation of WHRB may qualify the industry for availing CDM benefits.

Utilization of char for a centralized power generation unit

For coal based sponge iron plants, disposal of char is a problem and mostly receives adverse public reaction as this is dumped in an unscientific way by many small producers. Char should be mixed with coal or coal washery rejects and used as fuel for generation of power. It is a techno-economically viable option for plants having capacity of 200 TPD and above. Also the smaller capacity individual Sponge Iron Plants (Capacity up to 100 TPD) and operating in clusters can collectively install common unit for power generation. The Sponge Iron Plant is free to explore other options / possibilities to use char for generation of power. Char can be sold to local entrepreneurs for making coal briquettes. It can also be mixed with coal fines, converted to briquettes and can be used in brick kilns. The industry can explore other reuse / recycling techniques for Char.

Unauthorised disposal of char in agricultural fields/other areas may not be permitted and logbook for daily record, of Char production and usage be maintained.

3.3.3.2 Secondary aluminum

In the secondary production of aluminum, scrap is usually melted in gas-or oil-fired reverberatory furnaces of 14000 to over 45000 kg capacities. The furnaces have one or two charging wells separated from the main bath by a refractory wall that permits only molten metal into the main bath. The principal processing of aluminum-base scrap involves the removal of magnesium by treating the molten bath with chlorine or with various fluxes such as aluminum chloride, aluminum fluoride, or mixtures of sodium and potassium chlorides and fluorides. To facilitate handling, a significant proportion of the

old aluminum scrap, and in some cases new scrap, is simply melted to form sweated pig that must be processed further to make specification-grade ingot.

Another method of secondary aluminum recovery uses aluminum drosses as the charge instead of scrap. Traditionally, the term dross was defined as a thick liquid or solid phase that forms at the surface of molten aluminum, and is a by-product of melting operations. It is formed with or without fluxing and the free aluminum content of this by-product can vary considerably. Most people in the industry have generally referred to dross as being lower in aluminum content, while the material with higher aluminum content is referred to as "skim," or "rich" or "white dross." If a salt flux is used in the melting process, the by-product is usually called a "black dross" or "salt cake." Drosses containing about 30 % metallics are usually crushed and screened to bring the metallic content up to about 60 to 70 %. They are then melted in a rotary furnace, where the molten aluminum metal collects on the bottom of the furnace and is tapped off. Salt slag containing less than 30 % metallics may be leached with water to separate the metallics. In addition to this classic dross-recycling process, a new dross treatment process using a water-cooled plasma gas arc heater (plasma torch) installed in a specially-designed rotary furnace was patented recently. The new process eliminates the use of salt flux in the conventional dross treatment process, and reports recovery efficiencies of 85 to 95 %.

3.3.3.3 Secondary lead production

The secondary production of lead begins with the recovery of old scrap from worn-out, damaged, or obsolete products and new scrap that is made of product wastes and smelter-refinery drosses, residues, and slags. The chief source of old scrap is lead-acid batteries, though cable coverings, pipe, sheet, and terne bearing metals also serve as a source of scrap. Solder, a tin-based alloy, may also be recovered from the processing of circuit boards for use as lead charge.

While some secondary lead is recovered directly for specialty products like babbitt metal, solder, re-melt, and copper-base alloys, about 97 % of secondary lead is recovered at secondary lead smelters and refineries as either soft (unalloyed) or antimonial lead, most of which is recycled directly back into the manufacture of new batteries. Unlike copper and zinc, where scrap processing varies tremendously by scrap type and ultimate use, the dominance of lead battery scrap allows for a more standard secondary recovery process. Prior to smelting, batteries must be broken by one of several techniques, and classified into their constituent products. The modern battery breaking process classifies the lead into metallics, oxides and sulphate fragments, and organics into separate casing and plate separator fractions. Cleaned polypropylene case fragments are recycled back into battery cases or other products. The dilute sulphuric acid is either neutralized for disposal, or recycled into the local acid market. One of three main smelting processes is then used to reduce the lead fractions to produce lead bullion

The majority of domestic battery scrap is processed in blast furnaces or rotary reverberatory furnaces. Used to produce a semi soft lead, a reverberatory furnace is more suitable for processing fine particles and may be operated in conjunction with a blast furnace. The reverberatory furnace is a rectangular shell lined with refractory brick, and is fired directly with oil or gas to a temperature of 1260°C. The material is heated by direct contact with combustion gases. The average furnace can process about 50 tonnes per day. About 47 % of the charge is recovered as lead product and is periodically tapped into mold or holding pots. Forty six percent of the charge is removed as slag and later processed in blast furnaces. The remaining seven % of the furnace charge escapes as dust or fume. Short (batch) or long (continuous) rotary furnaces may be used. Slag from

reverberatory furnaces is processed through the blast furnace for recovery of alloying elements.

Blast furnaces produce hard lead from charges containing siliceous slag from previous runs (about 4.5 % of the charge), scrap iron (about 4.5 %), limestone (about 3 %), and coke (about 5.5 %). The remaining 82.5 % of the charge comprise oxides, pot furnace refining drosses, and reverberatory slag. The proportions of rerun slags, limestone, and coke, vary to as high as 8%, 10%, and 8% of the charge respectively. Processing capacity of the blast furnace ranges from 20 to 80 tonnes per day. Similar to iron cupolas, the blast furnace is a vertical steel cylinder lined with refractory brick. Combustion air at 350 to 530 mm WC is introduced through tuyeres (pipes) at the bottom of the furnace. Some of the coke combusts to melt the charge, while the remainder reduces lead oxides to elemental lead.

As the lead charge melts, limestone and iron float to the top of the molten bath and form a flux that retards oxidation of the product lead. The molten lead flows from the furnace into a holding pot at a nearly continuous rate. The product lead constitutes roughly 70 % of the charge. From the holding pot, the lead is usually cast into large ingots, called pigs or sows. About 18 % of the charge is recovered as slag, with about 60 % of this being matte. Roughly five % of the charge is retained for reuse, and the remaining seven % of the charge escapes as dust or fume.

Refining/casting is the use of kettle type furnaces for re-melting, alloying, refining, and oxidizing processes. Materials charged for re-melting are usually lead alloy ingots that require no further processing before casting. Alloying furnaces simply melt and mix ingots of lead and alloy materials. Antimony, tin, arsenic, copper, and nickel are the most common alloying materials. Refining furnaces, as in primary lead production, are used either to remove copper and antimony to produce soft lead, or to remove arsenic, copper, and nickel for hard lead production. Newer secondary recovery plants use lead paste desulphurization to reduce sulphur dioxide emissions and waste sludge generation during smelting.

The storage battery scrap is the chief source of secondary lead production in India. More than 40% of the total lead consumption goes to the manufacture of batteries and around 80% of this re-enters the market as secondary lead. This secondary lead containing antimony is used in the battery manufacture.

The smelting of battery scrap in an unscientific way has been practiced for a long time in India as a small scale industry mostly located in residential areas creating considerable pollution due to sulphur and lead emission. The recovery of lead is not very good due to slag matte losses and sulphur fumes. Cost effective scientific technologies are needed to be provided to these small scale operators.

Lead can be recovered from waste battery scrap by electrolysis method as well. Ponomarev and Znev obtained compact lead of 99.5% purity from waste powder consisting of lead and zinc by electrolysis. The solution from lead electrolysis was used for zinc extraction.

3.3.3.4 Secondary copper process

The primary processes involved in secondary copper recovery are scrap metal pretreatment and smelting. Pretreatment includes cleaning and concentration to prepare the material for the smelting furnace. Pretreatment of the feed material can be

accomplished using several different procedures, either separately or in combination. Feed scrap is concentrated by manual and mechanical methods such as sorting, stripping, shredding, and magnetic separation. Feed scrap is sometimes briquetted in a hydraulic press. Pyrometallurgical pretreatment may include sweating, burning of insulation (especially from scrap wire), and drying (burning off oil and volatiles) in rotary kilns. Hydrometallurgical methods include flotation and leaching with chemical recovery.

After pretreatment the scrap is ready for smelting. Though the type and quality of the feed material determines the processes the smelter will use, the general fire-refining process is essentially the same as for the primary copper smelting industry.

3.3.3.5 Secondary zinc production

The secondary zinc industry processes scrap metals for the recovery of zinc in the form of zinc slabs, zinc oxide, or zinc dust. Zinc recovery involves three general operations; pretreatment, melting, and refining. Secondary recovery begins with the separation of zinc-containing metals from other materials, usually by magnetics, sink-float, or hand sorting. In situations where nonferrous metals have been mixed in shredder scrap, zinc can be separated from higher-melting metals such as copper and aluminum, by selective melting in a sweating furnace. A sweating furnace (rotary, reverberatory, or muffle furnace) slowly heats the scrap containing zinc and other metals to approximately 420°C. This temperature is sufficient to melt zinc but is still below the melting point of the remaining metals.

Molten zinc collects at the bottom of the sweat furnace and is subsequently recovered. The remaining scrap is cooled and removed to be sold to other secondary processors. In the case of zinc-galvanized steel, the zinc will be recovered largely in furnace dust after the scrap is charged into a steel making furnace and melted. Almost all of the zinc in electric arc furnace (EAF) dust is first recovered in an upgraded, impure zinc oxide product and is then shipped to primary pyrometallurgical zinc smelter for refinement to metal.

Clean new scrap, mainly brass and rolled zinc clippings and reject die-castings, generally require only re-melting before reuse. During melting, the zinc-containing material is heated in kettle, crucible, and reverberatory, and electric induction furnaces. Flux is used to trap impurities from the molten zinc. Facilitated by agitation, flux and impurities float to the surface of the melt as dross, and is skimmed from the surface. The remaining molten zinc may be poured into molds or transferred to the refining operation in a molten state. Drosses, fragmentized die-castings, and mixed high-grade scrap are typically re-melted, followed by zinc distillation with recovery as metal, dust, or oxide. Sometimes, high-purity drosses are simply melted and reacted with various fluxes to release the metallic content; often the recovered metal can be used directly as a galvanizing brightener or master alloy. Zinc alloys are produced from pretreated scrap during sweating and melting processes. The alloys may contain small amounts of copper, aluminum, magnesium, iron, lead, cadmium, and tin. Alloys containing 0.65 to 1.25 % copper are significantly stronger than unalloyed zinc.

Medium and low-grade skims, oxidic dust, ash, and residues generally undergo an intermediate reduction-distillation pyrometallurgical step to upgrade the zinc product before further treatment; or, they are leached with acid, alkaline, or ammoniacal solutions to extract zinc. For leaching, the zinc containing material is crushed and washed with water, separating contaminants from zinc-containing material. The contaminated aqueous stream is treated with sodium carbonate to convert zinc chloride into sodium chloride and

insoluble zinc hydroxide. The sodium chloride is separated from the insoluble residues by filtration and settling. The precipitate zinc hydroxide is dried and calcined (dehydrated into a powder at high temperature) to convert it into crude zinc oxide. The zinc oxide product is usually refined to zinc at primary zinc smelters. The washed zinc-containing metal portion becomes the raw material for the melting process.

Distillation retorts and furnaces are used either to reclaim zinc from alloys or to refine crude zinc. Bottle retort furnaces consist of a pear-shaped ceramic retort (a long-necked vessel used for distillation). Bottle retorts are filled with zinc alloys and heated until most of the zinc is vaporized, sometimes as long as 24 hours. Distillation involves vaporization of zinc at temperatures from 980 to 1250 °C, and condensation as zinc dust or liquid zinc. Zinc dust is produced by vaporization and rapid cooling, and liquid zinc results when the vaporous product is condensed slowly at moderate temperatures.

A muffle furnace is a continuously charged retort furnace which can operate for several days at a time. Molten zinc is charged through a feed well that also acts as an airlock. Muffle furnaces generally have a much greater vaporization capacity than bottle retort furnaces.

For the most part, the zinc materials recovered from secondary materials such as slab zinc, alloys, dusts, and compounds are comparable in quality to primary products. Zinc in brass is the principal form of secondary recovery, although secondary slab zinc has risen substantially over the last few years because it has been the principal zinc product of EAF dust recycling. Impure zinc oxide products and zinc-bearing slag are sometimes used as trace element additives in fertilizers and animal feeds

3.3.4 Re-rolling Mills

After de-control and de-regulation in steel sector, a rapid growth in industry (reheating furnace and steel re-rolling units) especially in the private sector is playing a vital role to meet growing demand of steel in the country. The technology of re-rolling is the same as rolling mills except that infusion of latest rolling technologies has not been possible due to fund and resource constraints. The other difference is that the reheating furnaces are fired by polluting fuels like coal or oil and create pollution in work place and environment. The raw materials to these reheating furnaces have been coal or fuel oil, steel ingots from electric arc furnace or induction furnaces, either captive to the plant or from outside, and plates/ sheets from ship breaking yards. The units are aware of inadequate design of furnace and heating equipment, untrained workers' handling of raw materials, usage of fuel and heating equipment, higher quantity of burning losses and increased fuel consumption. The high cost of production in the present competitive regime has compelled the entrepreneurs to use energy saving measures which are indirectly linked with the design and type of furnaces. A diagnostic study revealed that the average oil consumption in re-rolling mills generally range from 45 to 60 l/T of MS round section at Mandi Govindgarh, the biggest steel re-rolling complex of the country, in comparison to international standard of 25 to 30 l/T. Similarly, coal fired reheating furnaces consume 150 to 250 kg coal/T rolled product, which is higher than international levels. Another issue is to reheat painted sheets from Ship Breaking Yards containing toxic paints and coatings, which will release toxic substances during heating and in case of PCB coatings, dioxins and furans due to low heating temperatures. If the sheets are cleaned at the facility, the hazardous wastes will be generated, which need to be handled as per regulations. Effluents will also be released from re-rolling mills from roll cooling and scrap handling.

3.3.5 Iron and steel foundries

In iron foundries harmful substances are evolved in cupola furnaces, the places where the cast iron is poured into moulds, and where the mould and cores are dried. In steel foundries, harmful substances are mainly evolved in the electric furnaces for melting the steel, during preparation of the moulds, when extracting the casting from the moulds and cleaning them.

3.3.5.1 Cupola furnace

Cupola furnace is used to manufacture iron casting in Indian foundries. Most of the foundries in India are classified as small to medium scale industry, producing varieties of items ranging from simple man hole covers to sophisticated railway spare parts. Hard coke is used as a fuel. Foundries in India are concentrated in areas such as Howrah, Agra, Batala, Coimbatore, Kolhapur, Bhavnagar *etc.* One important but easily identifiable problem in Indian foundries is the technological obsolescence. In many cases, layout, equipment, process and man power are totally inadequate to cater for the increasingly stringent quality and cost competitiveness demanded by the customers of foundry products. Many of the foundries are too small to employ professional managers for proper quality, personnel and financial management. Apart from this, the Indian foundries are perpetually plagued by poor quality input materials such as pig iron, coke, lime stone, sand *etc.* and the acute shortage of funds both for equipment purchase and working capital due to the reluctance of financial institutions to extend a helping hand to foundries of small and tiny scale.

Presently, by-product coke produced by coke oven batteries is not available for the foundries. Foundry men are forced to use beehive coke. Beehive coke is inferior compared to BP coke. It has more ash, more volatiles, more sulphur and less shatter resistance than BP coke. As it is, BP coke in India has an ash content of around 30% while beehive coke may contain up to 40% ash. This high ash content is sometimes reduced by beehive producers by mixing lower ash but higher sulphur content coal. As a result, a beehive coke with lower ash content will have a sulphur content of more than 1% which will increase the SO₂ emission from the melting unit. An integrated approach, combining energy efficiency with pollution control will be able to address the problem by reducing energy consumption of the cupola, which will consume less coke and release less pollutant.

Cupola furnace is a simple vertical cylinder made of steel and lined with refractory bricks. Initially, a bed of coke is laid in the cupola up to a height of about 2 to 3m above the base and ignited. Raw materials like iron scrap, pig iron, coke and limestone are charged through the opening at the top of the cupola and the hot metal and slag are drawn from the bottom. Air for proper combustion is supplied through the tuyers provided at the base. Average size and melting rate of a typical cupola is as follows:

- Cupola height (m) : 9
- Cupola diameter(m) : 1.22
- Melting rate (t/h) : 4 - 5
- Average working hour : 6 - 8

Foundry activity is a substantial contributor to the environmental pollution through solid (particulates) and gaseous emissions arising from sand preparation and handling, moulding and core making, melting and pouring, fettling and cleaning *etc.*

3.3.5.2 Electric induction furnace

Electric Induction Furnaces are employed for both non-ferrous and steel making. The basis of this method of melting is to surround the metal in a crucible by a coil through which an alternating electric current passes. The current induced in the metal causes heating and melting and also creates a useful stirring action. Two salient types may be distinguished:

The low frequency furnace which incorporate an iron core and operate on normal supply; the best known is the Ajax-Wyatt, applied principally to non-ferrous metal, specially brass;

The high frequency coreless furnace, which has particular application with special steels, supplementing the coke fired crucible furnace for this purpose, although having non-ferrous application as well.

Induction furnaces can be employed for vacuum melting.

3.3.5.3 Electric arc furnace

Electric arc furnace (EAF) steelmaking uses heat supplied from electricity that arc from graphite electrodes to the metal bath to melt the solid iron feed materials. Although electricity provides most of the energy for EAF steelmaking, supplemental heating from oxy-fuel and oxygen injection is used.

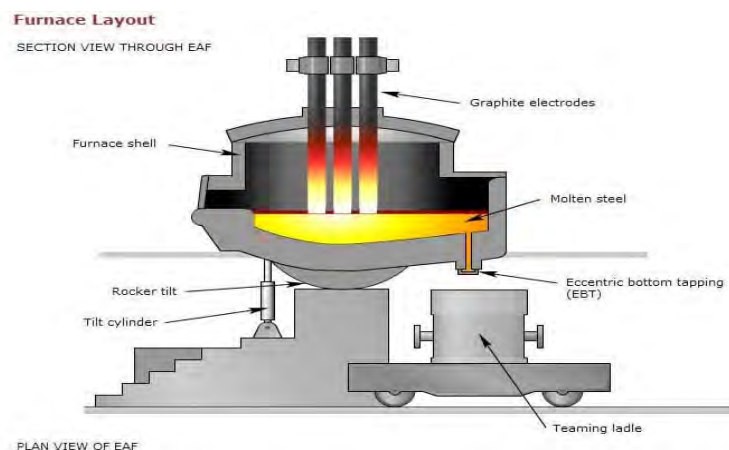


Figure 3-12: Electric Arc Furnace

The major advantage of EAF steelmaking is that it does not require molten iron supply. By eliminating the need for blast furnaces and associated plant processes like coke oven batteries, EAF technology has facilitated the proliferation of mini-mills, which can operate economically at a smaller scale than larger integrated steelmaking. EAF steelmaking can use a wide range of scrap types, as well as direct reduced iron (DRI) and molten iron (up to 30%). This recycling saves virgin raw materials and the energy required for converting them.

The EAF operates as a batch melting process, producing heats of molten steel with tap-to-tap times for modern furnaces of less than 60 minutes. EAF steelmaking represents about 25% of steel production in the APP countries. APP countries produce 46% of all EAF steel produced globally. Current ongoing EAF steelmaking research includes

reducing electricity requirement per tonne of steel, modifying equipment and practices to minimize consumption of the graphite electrodes, and improving the quality and range of steel produced from low quality scrap.

3.4 Industrial Processes in the Context of Environmental Pollution

3.4.1 Iron & steel industry (Ferrous metal industry)

Iron and steel industry which comprises preparation of raw materials, agglomeration of fines in sinter plant, feeding of burden to blast furnace, manufacturing of coke in coke ovens, conversion of pig iron to steel, making and shaping of steel, granulation of slag, recovery of chemicals in by-product plant *etc.* All the above mentioned processes add to air, water, solid waste and noise pollution. Flow chart of linking pollutants and principle processes is shown in Figure 3-13.

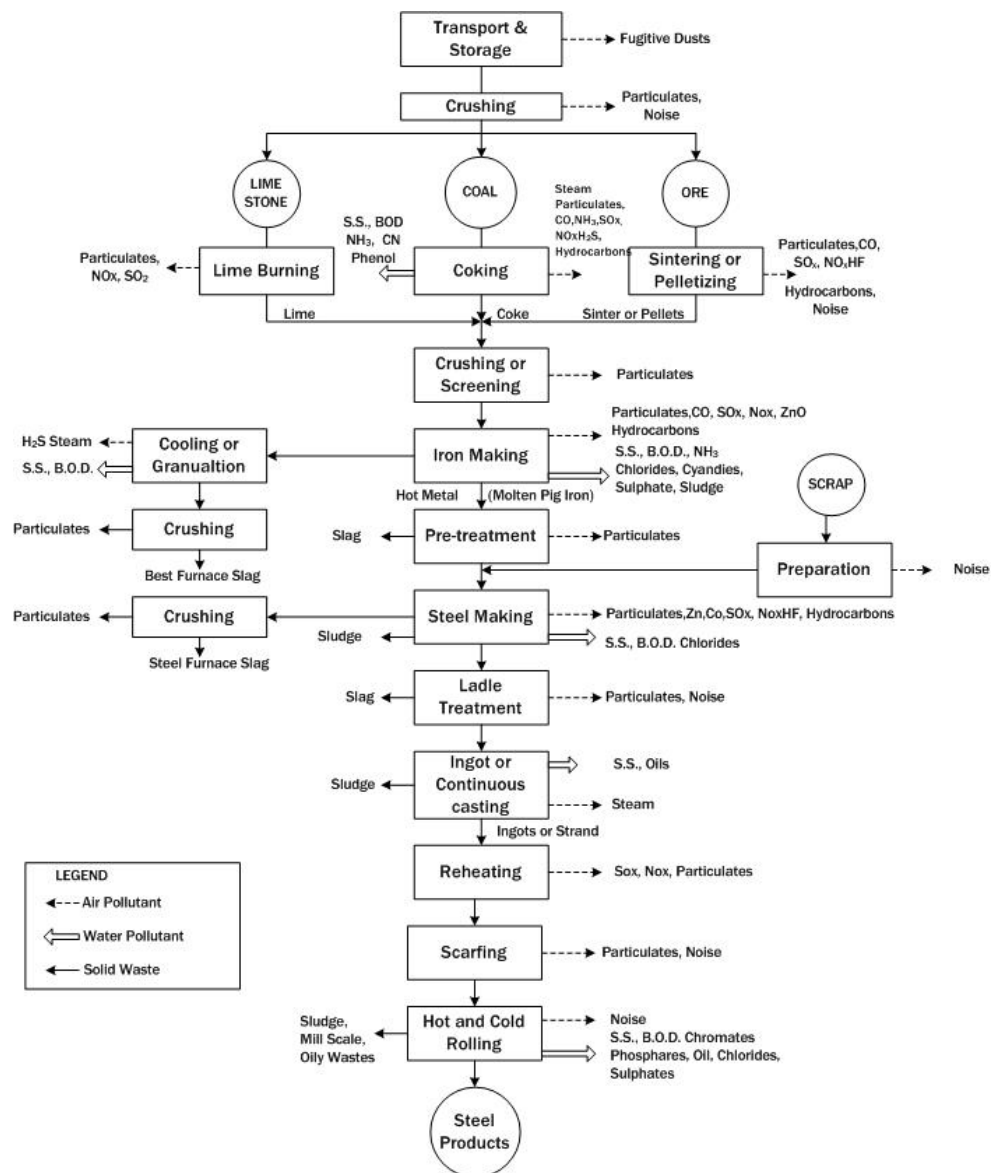


Figure 3-13: Flowchart Linking Pollutants and Principal Processes

3.4.1.1 Air emissions

In addition to the process related air emissions discussed below, air emissions may be generated from captive power plants fueled with coal, by-product gas (*e.g.* coke oven gas [COG], blast furnaces gas, and basic oxygen furnace [BOF] gas).

Particulate matter

Particulate matter (PM) may be generated in each of the process steps, and may contain varying concentrations of mineral oxides, metals (*e.g.* arsenic, cadmium, mercury, lead, nickel, chromium, zinc, manganese), and metal oxides. Sources include melting and refining activities (BF, BOF, EAF) and heating furnaces (depending of type of fuels used); mechanical actions (*e.g.* scarfing and grinding); and handling of materials (*e.g.* raw materials, additive, recycled and waste materials, and by-products). Additional sources of particulate matter (PM) emissions include coal storage, conveying, charging, coking, pushing, and quenching.

Thermal Processes: Particulate matter emissions may arise from thermal processes including coke making, sintering, pelletizing, and direct reduction. Coke oven plants are another significant source of dust emissions. Continuous particulate matter emissions may result from the under-firing process through the combustion stack. Intermittent and fugitive emissions may arise from a large number of sources including oven and leveling doors, valves, and charging holes. Other emissions may arise from pushing, quenching and screening (discontinuous emissions) and from coke oven gas (COG) treatment.

Recommended measures to prevent and control particulate matter emissions from coke oven plants include:

- Installation of collection hoods for coke oven batteries;
- Maintenance and cleaning of all fugitive emissions sources associated with the coke oven (*e.g.* oven chamber, oven doors, leveling doors, valves and charging holes, and frame seals ascension pipes) are essential for clean and safe operation;
- Good operational management to achieve steady state operation to, for example, avoid green push;
- Adoption of “smokeless” charging measures;
- Adoption of coke dry quenching (CDQ) system;
- Adoption of non recovery-coke battery;
- Reduction of the coke charge in the blast furnace, including use of pulverized coal injection.

For details in coke oven plants, a separate TGM on coke oven may be referred.

Sinter plants may generate the most significant quantity of particulate matter emissions in integrated steel plants. Emissions in the sinter plant arise primarily from materials-handling operations, which result in airborne particulate matter and from the combustion reaction on the strand.

Recommended measures to prevent and control particulate matter emissions from the sinter plant include:

- Implement partial or total recirculation of waste gas in the sinter plant, according to sinter quality and productivity;
- Use of electrostatic precipitator (ESP) pulse systems, ESP plus fabric filter, or adoption of pre-dedusting (ESP or cyclones) in addition to high pressure wet scrubbing system for waste gas de-dusting. The presence of fine dust, which consists mainly of alkali and lead chlorides, may limit the efficiency of ESPs.

The pelletization of iron ore (an alternative to sintering) may generate dust and particulate matter emissions from grinding of raw material; from the firing zone of the induration strand; and from screening and handling activities.

Recommended measures to prevent and control particulate matter emissions from pelletization are similar to those for sinter operations, as above.

Melting activities: Particulate matter emissions generated by the blast furnace plant include emissions from the cast house (primarily iron oxide particulates and graphite) and the cleaning of BF gas leaving the top of the furnace. Measures to prevent and control particulate matter emissions from the blast furnace include use of dedusting systems, typically including scrubbers and electrostatic precipitators (ESP), before reuse of the off-gas

Particulate matter emissions from the basic oxygen furnace (BOF) arise from hot metal pre-treatment (including hot metal transfer, desulphurization and deslagging processes); charging operations; oxygen blowing to reduce carbon level and oxidation of impurities; and tapping operations.

Recommended measures to prevent and control particulate matter emissions from the BOF include:

- Use of primary controls for the flue gas of the BOF, including venturi scrubbers with complete combustion techniques; with suppressed combustion systems, BOF gas is cleaned and stored to be used as a fuel.
- Installation of secondary controls to capture off-gas escaping from the BOF process;
- Electric arc furnaces (EAFs) generate particulate matter during melting; oxygen injection and decarbonizing phases (primary off gas emissions); and charging / tapping (secondary off-gas emissions) and is discussed in a separate TGM.
- In the casting area (ingots and continuous casting), particulate matter and metals arise from the transfer of molten steel to the mold and from the cutting to length of the product by oxy-fuel torches during continuous casting. Exhausts should be fitted to filters and other relevant abatement equipment, especially in the casting and rolling, and finishing shops, where relevant.
- Baghouse filters and ESP have higher particulate collection efficiency, whereas wet scrubbers also allow capturing water soluble compounds (e.g sulphur dioxide [SO₂] and chlorides) but need additional effluent treatment facilities.
- Bag filters are typically installed to control melting shop emissions. They are often preceded by cyclones, which are installed to act as spark separators.
- Mechanical Actions: Scarfing and grinding activities may generate particulate matter emissions. Exhausts should be fitted to filters chosen based on the specified activity.

- **Raw Material Handling:** To reduce fugitive emissions of particulate matter during handling of materials, the following prevention and control techniques are recommended:
- Use indoor or covered stockpiles or, when open-air stockpiles are unavoidable, use water spray system (not sea water, see ‘Chlorides’ section below), dust suppressants, windbreaks, and other stockpile management techniques;
- Design a simple, linear layout for material handling operations to reduce the need for multiple transfer points;
- Maximize use of enclosed silos to store bulk powder;
- Enclose conveyer transfer points with dust-controls;
- Clean return belts in the conveyor belt systems to remove loose dust;
- Implement routine plant maintenance and good housekeeping to keep small leaks and spills to a minimum;
- Implement correct loading and unloading practices.

Fugitive emissions of coal dust are a significant concern.

Recommendations to prevent and control fugitive coal dust emissions during coal transfer, storage, and preparation include the following:

- Minimize the height of coal drop to the stockpile;
- Use of water spray systems and polymer coatings to reduce the formation of fugitive dust from coal storage (*e.g* on stockpiles);
- Use of bag filter or other particulate control equipment for coal dust emissions from crushing / sizing activities;
- Installation of centrifugal (cyclone) collectors followed by high efficiency venturi aqueous scrubbers on thermal dryers;
- Installation of centrifugal (cyclone) collectors followed by fabric filtration for pneumatic coal cleaning equipment and activities;
- Use of enclosed conveyors combined with extraction and filtration equipment to prevent the emission of dust at conveyor transfer points;
- Rationalizing transport systems to minimize the generation and transport of dust on site.

Nitrogen oxides

Nitrogen oxides (NO_x) emissions are caused by high furnace temperature and the oxidation of nitrogen. NO_x emissions are associated with sinter operations; pelletization plant operations; fuel combustion for coke oven firing, including the combustion of recycled coke oven gas; cowper and hot stoves in the BF process; the use of process gases or high air combustion temperature in the re-heating and annealing furnace; and from mixed acid pickling, among other sources.

Specific recommended techniques for the prevention and control of NO_x emissions in steel operations include:

- Application of waste gas recirculation

- Use of oven batteries with multi-stage air supply systems
- Adoption of suppressed combustion in BOF

Sulphur dioxides

Sulphur dioxide (SO₂) emissions are mainly associated with combustion of sulphur compounds in the sinter feed, primarily introduced through the coke breeze. SO₂ emissions may also result during the induration process in pelletization, and from coke oven firing. The SO₂ emission level in waste gases from reheating and annealing furnaces depends on the sulphur in the available fuel.

Other specific recommended techniques for the prevention and control of SO₂ include the following

- Selection of raw feedstocks with low sulphur content
- Minimizing the sulphur content of the fuel
- Addition of absorbents such as hydrated lime [Ca(OH)₂], calcium oxide (CaO), or fly ashes with high CaO content injected into the exhaust gas outlet before filtration
- Installation of gas wet scrubbing systems in dedicated collecting and dedusting system
- Use of a wet-scrubber injection of a slurry mix containing calcium carbonate (CaCO₃), CaO, or Ca(OH)₂
- Use of a dry scrubber, if necessary

Carbon monoxide

Sources of carbon monoxide (CO) include waste gases from the sinter strand, coke oven, BOF, BF and EAF. CO is generated from the oxidation of coke in smelting and reduction processes, and from the oxidation of the graphite electrodes and the carbon from the metal bath during melting and refining phases in EAFs.

Recommended pollution prevention and control techniques to reduce CO emissions include the following:

- Full capture of off gases from coke oven, BF and BOF
- Recycling gases containing CO
- Use of foamy slag practices in EAF process

Chlorides and fluorides

Chlorides and fluorides are present in the ore and tend to form hydrofluoric acid (HF), hydrochloric acid (HCl), and alkali chlorides during the sintering and pelletization processes. HF and HCl may arise from off gas in the EAF process, depending on the quality of the scrap charged. Hydrogen chloride emissions arise from pickling lines (HCl type), and necessitate use of HCl recovery systems. Recommended pollution prevention and control techniques include:

- Use of dry dedusting or wet scrubbing techniques, which are also typically installed to control particulate matter and sulphur oxide emissions respectively
- Control the input of chlorine via raw materials through the materials selection process

- Avoid spraying with sea water
- If it is necessary to exclude chlorine from the system, the chlorine-rich fine fraction of filter dust should not be recycled to the sinter feed (although it is generally favorable to recycle all iron-bearing process residues)

VOCs and organic HAPs

VOCs and polynuclear aromatic hydrocarbons (PAH) may be emitted from various stages in steel manufacturing including from off gas in the sintering and pelletization processes due to oil entering the sinter or pelletization feed (mainly through the addition of mill scale); from coke ovens, quenching, and the by-product plant; and from the EAF, especially when coal is added as a ‘nest’ to the scrap basket. PAH also may be present in the EAF scrap input, but may also be formed during EAF operation. Hydrocarbons and misted oil emissions may also arise from the cold rolling mill (tandem mill) operations.

Recommended pollution prevention and control techniques for VOC emissions include the following process integrated measures:

- Pre-treat mill scales through such practices as pressure washing to reduce oil content;
- Optimize operation practices, particularly combustion and temperature controls;
- Minimize oil input via dust and mill scale through use of “good housekeeping” techniques in the rolling mill;
- Use of advanced emission collection and demisting systems (*e.g.* precoated bag filters);
- Recirculation of off-gas;
- Treat the captured off-gas through post combustion, chemical scrubbing, or biofiltration.

Dioxins and furans

Sinter plants are a significant potential source of polychlorinated dibenzodioxin and dibenzofuran (dioxins and furans or PCDD/F) emissions. PCDD/F may be produced if chloride ions, chlorinated compounds, organic carbon, catalysts, oxygen, and certain temperature levels exist simultaneously in the metallurgical process. In addition, high oil content in mill scale may give rise to higher emissions of PCDD/F. Another potential PCDD/F emissions source is off-gas in the EAF. The potential presence of polychlorinated biphenyls (PCB), PVC, and other organics in the scrap input (shredded scrap mainly obtained from old equipment) may be a source of concern, due to its high potential for PCDD/F formation.

Recommended techniques to prevent and control PCDD/F emissions include the following:

- Recirculation of waste gases may reduce pollutant emissions and reduces the amount of gas requiring end-of-pipe treatment;
- Fine feed material (*e.g.* dust) should be agglomerated;
- In sintering plants: minimizing chloride input in the bed; use of additions such as burnt lime; and control of mill scale oil content (<1 %);
- Exclude the chlorine-rich fine fraction of filter dust from recycling in the sinter feed;

- Use of clean scrap for melting;
- Use of post combustion of the EAF off gas to achieve temperatures above 1200°C, and maximizing residence time at this temperature. The process is completed with a rapid quenching to minimize time in the dioxin reformation temperature range;
- Use of oxygen injection to ensure complete combustion;
- Injection of additive powders (*e.g* activated carbons) into the gas stream to adsorb dioxins before the dust removal by filtration (with subsequent treatment as a hazardous waste);
- Installation of fabric filters with catalytic oxidation systems.
- Exhaust gas treatment through denitrification, desulphurization, and activated coke packed bed absorption
- Exhaust gas treatment through low-temperature plasma

Dioxins and furans from Sinter plant and monitoring

The sinter plant plays a central role in an integrated iron and steel work for recycling of wastes from production residues, which would have to be disposed otherwise. Sinter plants are, therefore, known as the dust bin of steel plants. Slags from steel production, filter dusts of diverse flue gas cleaning systems (including those applied to the sinter plant itself) and various iron-containing materials from residue treatment are recycled in the sinter plant. When sinter is charged in the blast furnace, its productivity increases. Proportion of sinter in the charge is now an index of productivity for blast furnaces.

Recycling may lead to an enrichment of relevant compounds, particularly heavy metals. Some residue materials like roll mill scale may be contaminated with organic compounds (oils) that could act as precursors for PAH and Polychlorinated Dibenzodioxin/difurans (PCDD/F) formation.

In a Sinter Plant, iron ore and additives are mixed in a mixing drum. Before they enter the sinter band this is protected by a layer of material that has already been sintered. On the sinter machine air is sucked through the mixture by several suction hoods which are connected to an electrostatic precipitator. This waste gas constitutes the main flue gas flow which could be more than 1 million m³/h. Further waste gas is collected from the feeding process at the front and from the sieving process at the end of the sinter band (so-called "room-dedusting").

Flue gas concentrations of PCDD/F measured at European sinter plants usually ranged from below 1 to more than 10 ng I-TEQ/m³, however, an extreme concentration of 43 ng I-TEQ/m³ was found at one plant leading to an estimate freight of 250g I-TEQ/year generated by this particular sintering machine. When the high potential for dioxin emissions became public in Germany a special working group was founded by the operators of sintering plants. With subsidy from the Federal Agency for Environment (UBA) additional measurements were conducted at facilities of iron and steel industry. Besides a confirmation of the typical emission data these experiments also revealed that the PCDD/F homologue profile is determined by the lower chlorinated furans; dioxin emissions therefore are most probably due to de-novo-synthesis during the sintering process.

In Japan, Sintering exhaust gas containing SO_x, NO_x, dust and dioxins are processed, absorbed, decomposed and/or collected as non-toxic by-products to increase the quantity of steam recovery, and improve total fuel savings. Treatment methods to achieve these

include: (1) Denitrification Equipment, (2) Desulphurization Equipment, and (3) Activated Coke Packed Bed Absorption.

Energy/Environment/Cost/Other Benefits:

- SO_x is absorbed and recovered as useful by-product
- NO_x is decomposed to nitrogen, water and oxygen by ammonia
- Dust is collected in activated coke
- Dioxins are collected or absorbed in activated coke and decomposed at 400°C with no oxygen
- Activated coke absorption removes dioxins to <0.1 ng-TEQ/m³N, dust to <10 mg/m³N, and SO_x to <65 % absorbing ratio.

Also, as reported by Korea, active radicals of low temperature plasma remove SO_x, NO_x, and HCl simultaneously with significant efficiency. Commercial scale plant installed at an incinerator in Kwang works, has shown a substantial reduction of Sox (>70%), NO_x (>95%) and HCl (>99%) respectively. Dioxin also decreased (<0.2 ng-TEQ/N m³) with the addition of Lignite in the process. Its reliability as well as the stability has been proved through the operation more than 5 years.

Metals

Heavy metals may be present in off gas fumes from thermal processes. The amount of metal emissions depends on the particular process type and on the composition of raw materials (iron ore and scrap). Particulates from the sinter plant, BF, BOF, and EAF may contain zinc (which has the highest emission factor in EAFs, particularly if galvanized steel scrap is used); cadmium; lead; nickel; mercury; manganese; and chromium. Metal particulate emissions should be controlled with high efficiency dust abatement techniques applied to particulate emissions control as discussed above. Gaseous metal emissions are typically controlled through the cooling of gases followed by bag filters.

Greenhouse gases (GHGs)

Steel manufacturing facilities are energy intensive and may emit significant amounts of carbon dioxide (CO₂). GHG emissions from integrated steel mills are mainly generated from the combustion of fossil fuels such as coal for energy (heat), ore reduction, electrical energy production, and the use of lime as feedstock. The average value of carbon dioxide intensity in the sector is estimated at 0.4 t C/T of crude steel.

Recommended carbon dioxide (CO₂) emission prevention and control techniques include the following:

- Minimize energy consumption and increase energy efficiency through primary measures, including, but not limited to:
 - Adequate surface insulation to limit heat dispersion
 - Control of the air / fuel ratio to reduce gas flow
 - Implementation of heat recovery systems
- Use of waste gas through a heat exchanger to recover gas thermal energy, and as a combustion gas to produce hot water and air, and / or steam and power

- Implement good practice for combustion, such as oxygen enrichment or preheating of blast air and automatic control of combustion parameters;
- Preheat clean scrap
- Reduce fuel consumption in heating and thermal treatment by using recovery gas and / or adopting good combustion control
- Select fuel with a lower ratio of carbon content to calorific value, such as natural gas (CH₄). CO₂ emissions from the combustion of CH₄ account for approximately 60 % of the emissions from coal or pet-coke
- Recover energy wherever possible, utilize all process gases (*e.g.* coke gas, blast furnace gas, basic oxygen furnace gas), and install a top gas pressure recovery turbine (TRT) in the blast furnace and coke dry cooling in coke oven
- Optimize intermediate storage logistics to allow for a maximum rate of hot charging, direct charging or direct rolling, thereby reducing reheating needs
- Use near-net-shape casting and thin slab casting processes, where feasible

3.4.1.2 Solid wastes and by-products

Most waste residue from the integrated iron and steel sector is recycled to obtain added value from various types of byproducts, slag, scales and dust. Waste materials may include slag from BF; fine dust and sludge from BF gas cleaning; fine dust from BOF gas cleaning; some BOF slag; high alkali chlorides and heavy metal chlorides from the last field of electrostatic precipitators; and treatment of the off-gas from sinter strands.

Tar and other organic compounds (*e.g.* BTX) recovered from COG in the coke oven gas treatment plant should be managed so as to avoid leaks or accidental releases, according to the Hazardous Waste (Management and Handling) Rules and Manufacture, Storage and Import of Hazardous Chemicals Rules of Government of India, and recycled into the coke making process or sold for use in other industrial activities.

Slag

Slag residues may be sold as by-products (*e.g.* slag from BF for cement production if granulated or from BOF for use in civil engineering, road construction, and as railway ballast after processing). Slag is a by-product of iron and steelmaking, not a waste. Slag pulverization is a process during which water is sprayed when the slag temperature is at 600-800°C. The water spray produces hot steam, which reacts with free calcium oxide and magnesium oxide. Consequently, the slag is pulverized due to the volume expansion, thus making the iron and steel separate naturally from the slag. Slag is also used outside of steel making, *e.g.* in water/bottom muck purification materials to reduce phosphate concentration in red tides and as marine block to help grow seaweed. Some amount of BOF slag can also be reused in BF. EAFs produce a significant amount of slag. Where reuse of EAF slag is not financially or technically feasible, it should be disposed of, along with the dust from the treatment of off-gas, in a landfill designed with consideration of slag and dust characteristics. Local geological conditions also should be considered when locating slag heaps.

Metallic waste

Metallic waste and by-products from rolling and finishing operations (*e.g.* scarfing scale / swarf, dusts from scarfing, rolling mill scale, water treatment and mill scale sludge,

grinding sludge, and oil / greases) should be reused in the process. Some by-products (*e.g.* oily mill scale and grinding sludge from water treatment plants), should be conditioned before internal recycling, such as reduction of oil content and depending on process requirements. Metals from filter dust, slag, and waste metals should be recovered and recycled to sinter feed.

Acids

Pickling acid regeneration sludge can be recycled in steel plants (EAF and blast furnace) or processed for the production of iron oxides. The iron oxide from hydrochloride acid regeneration can be used in several industries as production of ferromagnetic materials, iron powder, or construction material, pigments, glass and ceramics).

Sludge

Sludge from wastewater treatment may contain heavy metals (*e.g.* chromium, lead, zinc, and nickel) and oil and grease. Part of the sludge from wastewater treatment may be internally recycled or else deposited in special landfills. Sludge reuse may require a pre-treatment stage, which typically consists of pressing, drying, and granulation.

3.4.1.3 Wastewater

Effluent streams normally present in the sector include cooling water, stormwater, rinse water, and several different process effluent streams. Cooling water is normally recycled within the process. Rinse water may contain suspended solids, dust, lubricating oil, and other pollutants depending on the process.

Recommended measures to prevent effluent generation from cooling and rinsing water activities include the following:

- Prepare a plant wide water recycling plan to maximize efficiency of water use. More than 95 % recycling of water is normally achievable;
- Dry techniques for removal of dust from plant equipment and premises should be used where possible, and rinse water should be collected and treated before discharge or reuse;
- Collect spillages and leakages (*e.g.* using safety pits and drainage systems).

Industrial process wastewater

Process effluent sources include the coke oven plant, the rolling process, and the pickling plant.

Coke Oven Plant: Please also refer TGM on Coke Oven. Effluent streams generated in the coke oven plant include water from the tar / water separator (consisting of water vapor formed during the coking process and condensate water used in coolers and for cleaning the COG); water from wet oxidative desulphurization system; and water from the closed cooling system. Effluent from the tar/water separator contains high concentrations of ammonia. This effluent should be treated with an ammonia stripper, and the resulting stream contains various organic (such as phenols) and inorganic compounds (such as residual ammonia and cyanides). A phenol-specific biological treatment (BOD plant) should be employed at the coke plant.

Batch emissions to water can in some cases be generated by wet coke quenching operations. Excess quenching water should be collected and used for the next quenching operation. Effluent from the wet oxidative desulphurization processes may contain suspended solids (including heavy metals), PAHs, sulphur compounds, and fluorides / chlorides, depending on the adopted dedusting systems. This effluent stream may have a detrimental effect on the biological wastewater treatment plant. Indirect gas cooling water is recirculated and will not influence the wastewater quantity. In the case of direct gas cooling, the cooling water should be considered as washing liquor and eventually drained via the still.

Compliance to effluent standards for cyanides and phenols:

The overall efficiency of biological treatment of coke oven wastewater, even after employing well acclimatized microorganisms, is far from satisfactory due to its resistance to biodegradability and inhibition. As all steel plants have a BOD plant for phenolic effluents, it will be advantageous if these can be made more efficient without totally changing the technology.

SAIL, R&D, (RDCIS), Ranchi, has observed that it is essential to increase biodegradability of the effluents by breaking the refractory chemicals prior to biological process in order to achieve high level of overall efficiency. Advanced Oxidation Processes (AOPs) have the potential to enhance biodegradability of toxic constituents and can be a viable pre-treatment and /or post treatment technology for treatment of coke oven wastewater. AOPs are of special interest for wastewater treatment due to their efficiency in minimizing a great variety of pollutants, including recalcitrant compounds, through the oxidation by generated hydroxyl radicals. AOPs are suited for destroying dissolved organic contaminants such as halogenated hydrocarbons, aromatic compounds (BTX), pentachlorophenols, detergents, pesticides, *etc.* AOPs can also be used to oxidize inorganic contaminants such as cyanides, sulphides, and nitrites.

A partial list of AOP techniques include:

- homogeneous ultraviolet irradiation
- using semiconductor catalysts
- X-ray or gamma ray radiolysis
- ultrasonic irradiation
- electro hydraulic cavitations

Of all these, photochemical and electrochemical techniques were chosen for experiment. The experiment done by RDCIS focused on key parameters like COD, cyanide, ammonia, TSS, turbidity, colour *etc.*

RDCIS recommended the following;

- Electrolytic coagulation coupled with electro-oxidation was found to be having potential application in the steel plant wastewater treatment system. Arrangements can be introduced just before mixing units.
- It was observed that significant amount of floc was generated during electrolysis, which was found to float. This may lead to easier removal of constituents.
- The process needs to be optimized on a plant scale by controlling reaction chamber materials (iron, aluminum, titanium, graphite, *etc.*), amperage, voltage, flow rate, and the pH of water. The technology can handle mixed waste streams (oil, metals, and bacteria).

Rolling Process: Effluent from scale removal contains suspended solids and emulsified oil, in addition to coarse scale. Treatment of effluent includes a sedimentation basin in which solids, mainly iron oxides, are allowed to settle at the bottom of the basin and the oil pollutants on the surface are removed by means of skimmers and discharged to collecting basins. Cooling water from rolling processes should be collected and treated prior to reuse.

Pickling plants: Pickling plants generate three streams of process effluent, including rinse water, spent pickle baths, and other wastewaters (*e.g.* water from fume absorbers of the pickling tank exhaust system and flushing water from plant cleaning). The largest volume of wastewater derives from rinsing, whereas the most significant contamination load comes from the continuous or batch exchange of pickle baths.

Recommended techniques to prevent effluent from pickling plants include the following:

- Install acid recovery and recycling unit;
- Reduce effluent volume and minimize contaminant loading of the waste streams through optimization of the pickling process;
- Apply counter flow cascading and, in some cases, recycling of acid-pickling rinse water discharges to the acid regeneration plant.

Process wastewater treatment

Techniques for treating industrial process wastewater in this sector include source segregation and pretreatment of wastewater streams for (i) reduction in ammonia using air stripping, (ii) reduction in toxic organics, such as phenols using biological treatment and (iii) reduction in heavy metals using chemical precipitation, coagulation and flocculation, *etc.* Typical wastewater treatment steps include oil water separators or dissolved air floatation for separation of oils and floatable solids; filtration for separation of filterable solids; flow and load equalization; sedimentation for suspended solids reduction using clarifiers; dewatering and disposal of residuals in designated hazardous waste landfills. Additional engineering controls may be required for (i) advanced metals removal using membrane filtration or other physical/chemical treatment technologies, (ii) removal of recalcitrant organics using activated carbon or advanced chemical oxidation, and (iv) reduction in effluent toxicity using appropriate technology (such as reverse osmosis, ion exchange, activated carbon, *etc.*). Wastewater treatment methods typically include coagulation / flocculation / precipitation using lime or sodium hydroxide; pH correction / neutralization; sedimentation / filtration / flotation and oil separation; and activated carbons

Other wastewater streams & water consumption

Contaminated streams should be routed to the treatment system for industrial process wastewater. Contaminated stormwater may result from coal, coke and other material storage areas. Soil surrounding outdoor coal storage areas may be impacted by highly acidic leachate containing PAHs and heavy metals. Industry-specific recommendations include:

- Store scrap and other materials, (*e.g.* coke and coal) under cover and / or in banded area to limit contamination of stormwater and collect drainage

- Pave process areas, segregate contaminated and non-contaminated stormwater, and implement spill control plans. Route stormwater from process areas into the wastewater treatment unit
- Design leachate collection system and location of coal storage facilities to prevent impacts to soil and water resources. Coal stockpile areas should be paved to segregate potentially contaminated stormwater for pretreatment and treatment in the wastewater treatment unit.

Noise

Integrated steel manufacturing facilities generate noise from various sources including scrap and product handling; waste or by-product gas fans; process cooling and draft fans; rotating equipment in general; dedusting systems; furnace charging; EAF melting processes; fuel burners; cutting activities; wire rod pay-off units; and transport and ventilation systems.

Recommended techniques to reduce, prevent, and control noise includes the following:

- Enclose the process buildings and/or insulate structures
- Cover and enclose scrap and plate/slab storage and handling areas
- Enclose fans, insulate ventilation pipes, and use dampers
- Adopt foaming slag practice in EAFs
- Limitation of scrap handling and transport during nights, where required
- Noise abatement measures should achieve the ambient noise levels as per Environment (Protection) Act, 1986

3.4.2 Non-ferrous industry

All non-ferrous industrial processes for aluminum, copper, lead, zinc *etc.* follow material handling, pyroprocessing, leach processing, pyro-refining, melting and casting *etc.* and pass through similar conditions of release to environment except pollutants and its severity. As such they have been bundled here for description by mentioning the process whenever felt necessary.

Significant environment aspects:

- Air emissions
- Wastewater
- Hazardous materials
- Residues and waste
- Noise

3.4.2.1 Air emissions

Particulate matter

Like any industry where material handling is involved, emissions of particulate matter (which may contain metals) may result from fugitive and point sources, including receiving, conditioning, handling, transport (*e.g.*, conveyors, vehicular traffic), and storage (*e.g.*, outdoor piles) of ores, concentrates, and secondary raw materials; from hot gases during pyroprocessing (*e.g.*, sintering, smelting, roasting, and converting); during

leach processing (e.g., dry material handling, filtering, storage of leach residues); during pyro-refining (e.g., furnace processing and transfer of the hot materials); during collection and transport of contents of abatement systems (e.g., baghouse filters); and during melting and casting (e.g molten metal and dross handling). Fugitive emissions can be greater than those that are collected and abated; therefore, control of fugitive emissions is particularly important. Measures to prevent and control particulate matter emissions include the following:

- Characterize all feed materials with regard to risk reduction potential
- Store dust- forming materials in enclosed buildings or containers and transfer using pneumatic or enclosed conveyor systems. Cover all transport vehicles
- Reduce the quantity of materials transported, and transport distances, through efficient plant layout and design
- Reduce off-gas volumes where possible (e.g by employing oxygen-smelting processes)
- Design for continuous operation where possible, and ensure environmental control systems are adequate to optimize smooth, consistent operation
- Use sealed furnaces and reactors with reduced pressure, or retrofit existing furnaces with maximum sealing (e.g. use of a “fourth hole” in the roof of an electric arc furnace to extract the process gases as efficiently as possible)
- Enclose, contain, or use hoods to collect emissions from process vessels, feed and discharge points, and conveyor systems
- Use systems that maintain the sealing or hood deployment during transfer of materials, such as through electrode additions of material; additions via tuyeres or lances; and the use of robust rotary valves on feed systems
- Use damper controls that change the extraction points automatically during different stages of the process in order to target the extraction effort to the fume source and thereby minimize energy consumption. Extraction of fumes at the roof ventilator should generally only be used as an additional mitigation if needed (like roof mounted canopy hoods over EAFs to collect charging and tapping fugitive emissions which the fourth hole cannot achieve) and not as an alternative to fourth hole, because of the high energy use and reduced collection efficiency
- Control particulate matter emissions using electrostatic precipitators, bagfilters, scrubbers, or cyclones that are appropriate for the exhaust stream characteristics (e.g., considering temperature, size fraction of particulate matter)
- Maintain the collector hood, ducts, and filter system to ensure that collection or extraction rates remain at the designed level
- Cover all transport vehicles and enclose storage and process equipment
- Employ a watering program (dust suppression system) to minimize airborne particulate matter emissions from on-site roadways, storage piles, and other sources where hoods cannot be provided
- Diligent housekeeping and providing vehicle wash facilities to prevent the migration of materials within the facility and offsite.

Metals

In addition to the primary base metals, feed materials may contain trace amounts of other metals (*e.g.*, aluminum, arsenic, antimony, bismuth, cadmium, chromium, copper, germanium, gold, indium, lead, mercury, nickel, selenium, silver, thallium, tin and zinc). Emissions of metals in various forms and compounds, which may be mobilized as contaminants in particulate matter, mists, fumes or in liquids, may be generated throughout all of the production stages including pyro-processing (*e.g.*, large volumes of hot gas are generated containing particulate matter and metal fumes during sintering, smelting, roasting, and converting); pyrorefining (*e.g.*, fine particulate matter and metal fume are generated during the furnace processing and transfer of the hot materials); electro-refining (*e.g.*, acid mist emissions from electrolyte solutions); and melting and casting (*e.g.*, metal fume emissions from molten metal and dross handling, and baghouse particles). The degree to which these metals may impact the environment depends on their form, toxicity and concentration. Emissions of metals are controlled through the application of measures to control particulate matter.

Mercury: A special note is made for metal emissions that are generated from smelting and refining processes that have the potential to release mercury. While most exhaust streams that contain metals are effectively controlled using the same abatement controls as particulate matter, mercury remains as a vapor at ambient temperatures and pass through some control equipment. It is important to significantly cool the inlet gas to the particulate matter control system to ensure efficient capture of mercury or to use an activated charcoal media to adsorb mercury.

Sulphur dioxide

Sulphur dioxide (SO₂) is produced from the combustion of fossil fuels and when metal sulphide concentrates are roasted, sintered, smelted, converted or refined. The concentration of SO₂ in off-gas streams is an important characteristic for managing SO₂ emissions. If the concentrations are within the range of 5–7% in raw gas stream, SO₂ can be processed into sulphuric acid. Lower concentrations in gas streams require the use of raw materials containing lower amounts of sulphur, or some form of scrubbing to fix sulphur and minimize SO₂ emissions to the atmosphere and achieve appropriate ambient air concentrations. Oxygen smelting processes reduce the volume of off-gases and increase the concentration of SO₂, which result in greater conversion efficiency and reduced contaminant emissions with lower volume. Measures to prevent and control sulphur dioxide emissions include the following:

- Process (fix) the sulphur for safe storage and/or use as a product (*e.g.*, sulphuric acid, liquid sulphur dioxide, fertilizer, and elemental sulphur);
- Consider technology choices to reduce gas volumes and increase SO₂ concentration
- Implement process control systems to ensure consistent operation
- Install gas scrubbing processes that remove SO₂ from low concentration streams
- Enclose process equipment and vessels to prevent fugitive emissions
- Use pre-treatment (*e.g.*, flotation) to remove unwanted sulphide and reduce sulphur in feeds
- Use low-sulphur fuels (*e.g.*, natural gas instead of heavy fuel oil or coke) and raw materials (*e.g.*, lower sulphur raw materials)

Nitrogen oxides

NO_x emissions are primarily related to the combustion of fuels (*e.g.*, coal in smelting and natural gas in pyro-refining). NO_x may be formed from nitrogen components that are present in the fuel or the concentrates, or as thermal NO_x. In aluminum production, NO_x is also produced during electrolysis due to the presence of nitrogen at anode.

- Minimize NO_x generation by using low NO_x gas burners and staged combustion air in pyro-refining furnaces and other combustion facilities.
- Treat roasting gases to remove NO_x (*e.g.*, using oxidizing scrubber) if high levels of NO_x are present to enhance the quality and usability of sulphuric acid produced from off-gasses containing SO₂;
- Use of oxy fuel burners can result in reduced NO_x formation. When using oxygen enrichment, consider introducing oxygen downstream of the burner if the higher temperatures caused by using pure oxygen at the burner result in additional NO_x formation.

Dioxins and furans

Polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs) may be generated during the production of metals (*e.g.*, pyro-processing), particularly with respect to production from secondary raw materials or in processes that require chlorination. Impurities in the scrap material may result in PCDD/F formation during incomplete combustion or de-novo synthesis. Measures to prevent and control dioxins and furans include the following:

- Cull metal scrap to eliminate or minimize the presence of organic materials (*e.g.*, plastics and wood) prior to any combustion and / or heating involving metal scrap;
- Implement procedures for the operation and maintenance of combustion equipment to ensure efficient combustion at the designed temperatures and residence times to ensure destruction of dioxins, and avoid reformation as gases cool;

Consider use of activated carbon in a fixed bed or moving bed reactor or by injection into the gas stream, and subsequent removal as filter dust.

Volatile organic compounds

Volatile Organic Compounds (VOCs) are produced by poor combustion and during operations such as degreasing of components, solvent extraction processes, and from the venting of tanks used to store solvents and fuel. VOCs can also be released during smelting and refining of secondary metals if the feed includes organic materials. Recommended measures to prevent, minimize, and control releases of VOCs include:

- Use water-based solvents where possible, or use the least toxic solvent suitable for the application
- Contain emissions (*e.g.*, by use of sealed equipment or hoods)
- Use mixer / settlers that minimize contact with air to minimize evaporation of VOCs
- Control VOC emissions using afterburners, scrubbers, biofilters or bioreactors, activated carbon traps, or chiller / condenser systems, depending on, for example, the composition of the gas stream

- Use back venting of displaced gases to the delivery vehicle when filling solvent or fuel tanks, and use of automatic resealing of delivery connections to prevent spillage

Acid mist and arsine

Electro winning and other processes such as pressure leaching and production of sulphuric acid may produce acid mist containing soluble metals. Acid mists can also be generated during of breaking lead-acid batteries. Arsine gas may be produced when certain trace metals and acid are mixed (*e.g.*, during the leaching process). Acid mist is produced by the reactions in the electro winning cells, as well as by any aeration or aggressive mixing and / or chemical reactions in subsidiary processes and / or at open drop points handling liquid flows. Measures to prevent and control acid mist and arsine emissions include the following:

- Monitor process control parameters to reduce and / or eliminate upset conditions
- Install hoods on tanks, maintaining an adequate foam layer on the surface of the electrolyte solution, and treatment of the exhaust gases and mists using control equipment (*e.g.*, scrubbers)
- Use stack and candle filters to control acid mist emissions at sulphuric acid plants
- Collect and treat acid mist (*e.g.*, using wet scrubbers or mist filters) generated in the milling stages of battery breaking

Carbon monoxide

Some pyrometallurgical processes (*i.e.* the carbo-thermic production of ferroalloys in closed submerged electric arc furnaces) produce a carbon monoxide rich off-gas as a byproduct. The amount of CO varies largely depending on the metal and production process. Measures to control and minimize CO emissions include collecting and cleaning the CO rich gas (*e.g.*, using a cascade wet scrubber), and use or sale of the gas as fuel. CO may also be produced by incomplete combustion and from smelting and refining of secondary feedstocks containing organic material. Control of CO from these sources is similar to control of VOCs, described above.

Carbon dioxide

Carbon dioxide (CO₂) is produced in significant quantities during smelting and refining operations. Main sources include smelting of concentrates, direct combustion of fossil fuels for power & heat generation, and indirect emissions resulting from fossil fuels used to generate electrical energy for facility operations (*e.g.*, for electrolysis in aluminum smelting). Further indirect contributions to greenhouse gases in this sector are associated with the use of chemical reagents that release a significant quantity of greenhouse gases during offsite manufacturing. Opportunities to reduce greenhouse gas generation are closely linked to measures to increase energy efficiency and reduce energy consumption, both of which are addressed in the 'Energy Consumption and Efficiency' section below.

Perfluorocarbons (Aluminum only)

Two perfluorocarbons (PFCs) - tetra-fluoromethane (CF₄) and hexa fluoroethane (C₂F₆), are formed during the anode effects (temporary imbalance of raw material feed-in rate and the aluminum production rate) stage of aluminum manufacturing and, once formed, they cannot be removed from the gas stream with existing technology. Anode effects occur when the alumina content of the electrolyte falls below 1 - 2 % which results in the

formation of a gas film on the electrode. The formation of the film on the anode results in stoppage of metal production and increases cell voltage from the 4 – 5 volt range to 8 - 50 volts. The generation of PFCs is dependent upon the frequency and duration of the anode effects.

Measures to control perfluorocarbons (and reduce overall GHG emissions) include the following:

- Increased use of recycled aluminum (use of recycled aluminum requires significantly less energy than is required for primary production)
- better electrical conversion efficiency
- Reduce anode effects that produce PFS
 - Control anode effects by adjustment of cell voltage and alumina additions
 - Use of semi-continuous point feeding of the alumina combined with process control
 - Change the reduction technology to minimize use of fossil carbon.

Energy consumption and efficiency

Smelting and refining facilities require large amounts of energy, notably the fuel energy used for drying, heating, smelting, fuming, melting and transportation, and the electrical energy used in electrolysis and for powering utilities / equipment. The following recommendations are specific to this sector:

- Assess alternative smelting and processing technologies that optimize energy use (*e.g.*, flash smelting requires about half the energy of conventional blast furnace smelting, and use of recycled aluminum typically requires significantly less energy than needed for primary production);
- Employ heat and energy recovery techniques to maximize energy utility (*e.g.*, waste heat boilers, heat exchangers, steam-driven drives), for example from gases generated by pyrometallurgical processes. Heat recovery techniques will vary between facilities but may include use of oxygen rich air to reduce energy consumption; use of waste heat boilers to capture hot gases generated by smelting or roasting; and use of heat generated by smelting and refining processes to melt secondary material.

Fluorides (aluminum only)

The main source of gaseous fluorides is the pots during electrolysis. The majority of the gaseous fluorides produced are in the form of hydrogen fluoride, which results from the reaction of aluminum fluoride and cryolite with hydrogen. Control of fluoride emissions can be achieved through fume capture. Captured fumes (typically greater than 98 % of total fumes) can be cleaned using alumina injection in the off gas for the absorption of the fluoride, followed by use of bag filters (the dust is returned to the pots) or wet scrubbers (typically greater than 99.5 to 99.9 % efficient).

Tar and polycyclic aromatic hydrocarbons (aluminum only)

Tar and PAHs may be released (mainly from the anode baking plants). Measures to prevent and control these emissions include the following:

- Improve combustion efficiency
- Switch to another type of anode

- Removal of tar and PAHs utilizing alumina scrubbers and fabric filters
- Use of dry anode paste and maintenance of anode tops at cold temperatures to reduce PAH emissions

Anode preparation (aluminum only)

The electrolysis of alumina into aluminum results in the consumption of the anode, during which the released oxygen will burn away the carbon. These anodes are normally prepared onsite in an anode baking facility where the carbon containing materials (including petroleum pitch) are attached to a metal core and baked to increase the strength. The baking will release volatile hydrocarbons and also other contaminants such as sulphur from the raw materials. If feasible, the heating value from VOC emissions could be used by combusting these substances within the baking furnace. The off-gas from the baking house should be treated by scrubbing or by absorption followed by filtering in plants integrated with a primary aluminum smelter, where hydrocarbons are returned to the production process; alternatively afterburners and wet ESPs can be used depending on the site and scale of production.

3.4.2.2 Wastewater

Industrial process wastewater

The main sources of wastewater in the smelting and refining sector include process water from hydro-metallurgical processes (*e.g.*, roasting gas cleaning, leaching, purification, and electrolysis); wet off-gas cleaning; slag granulation; cooling water; and surface runoff /stormwater. Wastewaters typically contain soluble and non-soluble metal compounds, oil and organic material. Direct contact cooling water (*e.g.*, for some casting operations) may contain elevated levels of metals and suspended solids, and should be routed through a process wastewater treatment system.

Process wastewater treatment

Techniques for treating industrial process wastewater in this sector include source segregation and pretreatment of wastewater streams for reduction in heavy metals using chemical precipitation, coagulation and flocculation, *etc.* Typical wastewater treatment steps include oil water separators or dissolved air floatation for separation of oils and floatable solids; filtration for separation of filterable solids; flow and load equalization; sedimentation for suspended solids reduction using clarifiers; dewatering and disposal of residuals in designated hazardous waste landfills. Additional engineering controls may be required for (i) advanced metals removal using membrane filtration, electrolysis or other physical/chemical treatment technologies, (ii) removal of recalcitrant organics using activated carbon or advanced chemical oxidation, and (iii) reduction in effluent toxicity using appropriate technology (such as reverse osmosis, ion exchange, activated carbon, *etc.*).

Other wastewater streams & water consumption

Non-contact cooling water systems in smelting and refining sector may be a direct once-through design, or a recirculation route involving the use of evaporative cooling towers. Water from a once through system is typically discharged to surface waters after appropriate consideration/reduction of temperature effects on the receiving water body. Stormwater may become contaminated through contact with material stockpiles and

surface deposition of airborne contaminants. Contaminated streams should be routed to the treatment system for industrial process wastewater.

3.4.2.3 Hazardous materials

The smelting and refining sector utilizes a number of acids, alkalis, and chemical reagents (in leaching and precipitation of metals, and for pollution control systems); and process gases (*e.g.*, oxygen, carbon dioxide, argon, nitrogen, chlorine, hydrogen, among others). Guidance on the safe storage, transport, and use of hazardous materials is addressed in the Manufacture, Import and Storage of Hazardous Chemicals Rules, Government of India

3.4.2.4 Residues and waste

Sources of hazardous and non-hazardous residues and waste in the smelting and refining sector include slag, drosses, mattes, and skimmings from pyrometallurgical processes; spent linings and refractories from furnaces; waste from abatement systems (*e.g.*, flue gas dust, sludge, and spent filter material); sludge from wastewater treatment (*e.g.*, from wet scrubber systems and process water treatment, which may contain gypsum [CaSO₄] and metal hydroxides and sulphides); and sludge from leaching, purification, and electrolysis activities. Opportunities to recycle the by-products and waste from smelting and refining activities back to the process (*e.g.*, drosses, mattes, and skimmings, pot and furnace linings, cleanouts) should be maximized. Large quantities of slag produced at the smelting stage may be processed (*e.g.*, fuming to recover residual metals) to produce an inert granular material that can be sold for industrial use, such as cement manufacturing and insulation products. Waste from abatement systems, and sludge from leaching and wastewater treatment may be recycled into pyro-processing stages depending on the level of process integration available at the facility. Anode and tank bottom sludge may be recycled for residual metals recovery. Guidance for management and safe disposal of hazardous industrial waste is addressed in the Hazardous Waste (Management and Handling) Rules, Government of India. Generation and management of selected wastes specific to the non-ferrous metals smelting and refining sector are described below.

Spent cathodes (aluminum only)

Spent cathodes, also known as spent potlinings, are the major source of waste in primary aluminum manufacturing. A spent cathode consists of a carbon portion which was formerly the cathode from the electrolysis cell, and the refractory material which consists of various types of insulating material. The spent potlinings contain soluble fluoride and cyanide, and can produce an alkaline leachate if the material is rendered wet. Spent potlinings should be treated and reused (*e.g.*, in pyrometallurgical furnaces, in cryolite production, in the cement industry, or as a fuel source) where possible, or disposed of according to the Hazardous Waste (Management and Handling) Rules, Government of India.

Red mud (aluminum only)

Red mud is generated from the extraction of aluminum from bauxite and is an alkaline substance which requires controlled storage, typically in sealed (lined) ponds, to minimize potential for contamination of surface and ground water. Excess water from the mud is returned to the process.

The main environmental problems in alumina production are the disposal of the bauxite residue, saturated with caustic soda ("red mud"), and emissions of gases and particles from boilers, calcinations furnaces and bauxite dryers.

Red mud from bauxite refining are precipitated from a caustic suspension of sodium aluminate in a slurry and routed to large on-site surface impoundments known as red mud pond. The mud settles to bottom and the water is removed, treated, and either discharged or reused. The muds dry to a solid with a very fine particle size, sometimes less than 1 micron. Red muds contain significant amounts of iron (20-50%), aluminum (20-30%), silicon (10-20%), calcium (10-30%), and sodium. Red muds may also contain trace amounts of elements such as barium, boron, cadmium, chromium, cobalt, gallium, vanadium, scandium and lead as well as radionuclides. The types and concentration depend on type of ores and the operating condition in the digesters.

Red muds can not be considered as hazardous wastes. Several processes have been developed to recover iron from red mud residues, and the potential exists to use mud in the iron and steel production. Alumina and titanium recovery is also technically feasible. Recovery of metals other than iron is, however, not cost effective.

Other than recovery of iron, other methods of potential utilization of red mud is in making construction blocks, bricks, Portland cement, in light weight aggregate to make concrete, in plastic and resin as filler, pigments, and application in making ceramic products. Research has also been conducted on the potential use of red muds as a reagent in various proposed waste treatment processes.

3.4.2.5 Noise

Smelting and refining operations are inherently noisy due to the large amount of mechanical equipment, transport vehicles, physical activities, and energy usage, notably furnaces and steam. The significant sources are transport and handling of raw materials and products; the production processes involving pyro-metallurgy, grinding and milling operations; the use of pumps and fans; the venting of steam and the existence of unattended alarm systems.

3.5 Qualitative and Quantitative Analysis

3.5.1 Waste characteristics of iron and steel manufacturing industry (Ferrous metal)

3.5.1.1 Sintering/pelletising

Sintering operations can emit significant dust levels of about 20 kilograms per tonne (kg/T) of steel as average (24-26 kg/T of agglomerate without cooling facilities and with cooling facilities 18-20 kg/T agglomerate from sintering strand and 25-31 kg/T of agglomerate from cooling strand with 80% particle of size less than 100 μ m in diameter); the concentration of CO in sintering gases should be taken to be 8-15 g/m³ or 30-50 kg/T of agglomerate; of SO₂, 0.8 – 9 g/m³ or 3-25 kg/T of agglomerate depending on the sulphur content of charge; some levels of dioxins and furans which is presently under study by CPCB. Pelletizing operations can emit dust levels of about 13-15 kg/T of pellet or 4-5g/m³; and approximately 6 kg of SO₂, 14 kg of CO and 0.8 kg of NO/T agglomerate.

3.5.1.2 Iron making

During the manufacture of iron in the blast furnace, some hydrogen cyanide, HCN, and cyanogen gas, C₂N₂, are formed as a result of the reaction of nitrogen in the blast with coke. Blast furnace gas contains 200–2000 mg/m³ of these cyano compounds which are highly toxic. In the dust collecting system, the gases are scrubbed with water and some of this water finds its way in waste disposal. Before discharging this water, cyanide compounds dissolved in it must be destroyed. Blast furnace slag contains CaS which originates mainly from the sulphur in the coke. It emits H₂S during quenching and stock piling. H₂S has the smell of foul eggs and is highly poisonous.

The amount of dust emitted with blast furnace gases is on the average 10 kg/T of cast iron; 24-30 % CO; and 4% of sulphur content of the materials charged is emitted as H₂S.

The amount of non-process dust and gases are as follows:

Table 3-16: Amount of Harmful Substance from Blast Furnace Plant

Location	Amount of harmful substances (g/T of cast iron)			
	Dust	CO	SO ₂	H ₂ S
Stock yard and high lines	50	Nil	Nil	Nil
Underneath overhead beans	Up to 1200	Nil	Nil	Nil
Casting yard	400-700	700-1150	110-170	Nil
Stove building	- Nil	11-44	Nil	Nil
Casting machine	40	60	Nil	Nil
Slag processing	20	8	20	50
Inter cone space (leakages)	4000	200	Nil	0.5-3

3.5.1.3 Steelmaking

Open hearth process

During the manufacture of steel by the open hearth process, fluorspar, CaF₂ was used as a flux. The presence of water in the combustion gases in the furnace results in its decomposition to form HF gas, which finds its way in the stack. Hydrogen fluoride concentration in the stack gas was about 3000 ppm. About 100 000 t of hydrogen fluoride were emitted annually from this source. Fluorosis in cattle or damage to vegetation has occurred in the vicinity of iron and steel plants. This was one of the reasons why this process has been abandoned in the 1970s.

Oxygen steelmaking

During the manufacture of steel by oxygen top blowing (LD Process) thick brown fumes of iron oxide are formed. Because of their extremely fine particle size they were difficult to remove from the stack gases and thus they cause nuisance to the inhabitants of the neighborhood. Bottom oxygen blowing process is now competing with the LD Process because of this, among other reasons.

BOF

The amount of gases that escape from a converter is directly related to the content of carbon in the pig iron and the amount of ore and lime added. The amount of converter gases evolved per tonne of iron varies from 70 to 90 m³. The content of CO in the gases varies from 85 to 95 %. The temperature of the gases at the mouth of the converter is 1550 to 1650 °C. The amount of dust varies from 13 to 25 kg/T steel for heats cooled with ore and from 12 to 32 kg/T steel for heats cooled with scrap and ore. The average concentration of dust is from 150 to 350 g/m³ but it may increase to 1500 g/m³ for short time when the fluxes are added. Sulphur passes in the converter gas as SO₂. Up to 14% of the sulphur contained in the charge is carried away by the converter gases but only 1% or less of this sulphur passes into gaseous phase, the remainder into the dust. Practically, no oxide of nitrogen is formed in the converter.

Raw materials/resources required and wastes generated for the production of tonne of crude steel from a well managed steel plant is given in Figure 3-14.

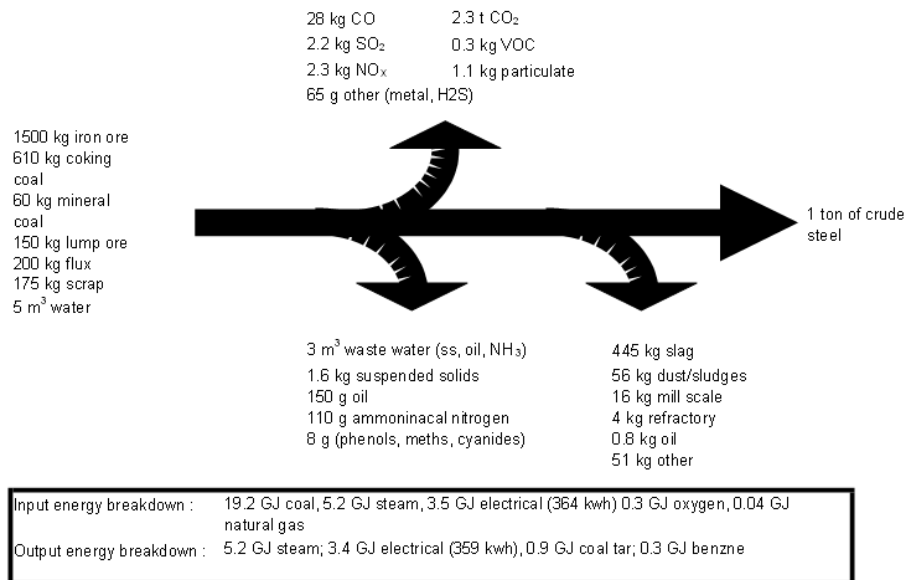


Figure 3-14: Resources and Waste Generation for Production of 1 tonne Crude Steel

3.5.1.4 Ferroalloys

The amount of process gases evolved in ferroalloy furnaces depends on the kind of ferroalloy being produced, the composition of the charge, and the rate at which the process is carried out. In smelting processes, 140 to 900 m³ of gas is evolved per tonne of ferroalloys; in refining processes, 50,000 to 70,000 m³ of gas/ t of alloys; in the aluminothermic process, 1100 m³/T of alloys when producing metallic chromium; 42,000 m³ when producing carbon free ferrochromium (in the melting period) and 600 m³/T (in reducing period). The actual amount should be determined from material balance.

The process gases in smelting furnace mostly consist of CO from 70 to 90%. Other harmful substances are SO₂, H₂S, PH₃, AsH₃, HCN, CN₂ etc. but no reliable data is presently available.

3.5.1.5 Hot & cold rolling mills

Heating furnace

The main source of emission is the reheating furnace, annealing furnaces and soaking pits and the main pollutant is SO₂ and NO_x. They are used to reheat the different metals to prepare it for the hot rolling processes or annealing of cold rolled products for surface treatment. These furnaces are utilized to heat the metal to a proper temperature (1100-1250°C, before hot formation. Inputs to heating furnaces are slabs, blooms, bars, billets and rounds.

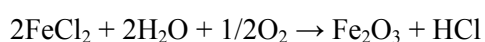
In both hot and cold rolling, one can expect nitrogen oxides (NO_x) emissions resulting from combustion in reheat furnaces, in annealing furnaces, or from boilers. The primary means of controlling NO_x emissions is through combustion modification or selective catalytic reduction. Nitrogen oxides formed from combustion of air constituents are referred to as thermal NO_x. In both hot and cold forming, one can expect nitrogen oxides (NO_x) emissions resulting from combustion in reheat furnaces, in annealing furnaces, or from boilers. The general technique to control thermal NO_x is to suppress combustion temperature to below 140°C. Above this temperature, NO_x formation is exponential, while below this temperature, it is linear at a very limited rate. NO_x concentration is approximately 100 to 150 mg/m³ of flue gas evolved. SO₂ depends on the concentration of sulphur in the fuel being used and can be calculated from the following table:

Table 3-17: Generation of Combustion Products from fuels

Kind of fuel	Maximum Content of Sulphur in Fuel, % v/v	Heat Value Assumed (kJ/m ³)	Amount of SO ₂ (g/m ³)
Natural gas	Nil	35,800	Nil
Blast furnace gas	Nil	3720	Nil
Coke Oven Gas (COG)	0.4	20,700	11.4
Mixture of BFG and COG	0.04 to 0.34	5000 to 14,700	1.2 to 9.7
Fuel oil, Low sulphur/ High sulphur	0.5-2.9/ 5% v/v	39,000	10-58 g/kg

Pickling

Before surface treatment, steel must be pickled, i. e., treated in an acid solution to remove the thin oxide film. Sulphuric acid was universally used for this purpose because it was the cheapest acid. The waste acid, now containing ferrous sulphate, was thrown away. With increased regulations, the waste acid was neutralized by lime at the same time precipitating the iron before disposal. It became a costly operation. The problem was solved in the 1960s by switching over to hydrochloric acid instead of sulphuric, although it was more expensive. The reason was that ferrous chloride could be economically converted to Fe₂O₃, which is suitable as pigment, and HCl for recycle by oxyhydrolysis:



Rolling, extrusion, drawing and forging

During the state-of-the-art of forming, the metal is introduced onto the line and passes through the major processing steps. Uncontrolled emission estimates, calculated controlled emissions, the types of air pollution control utilized, and the techniques expected control efficiencies are summarized in Table (3-18). Continuous Cold Mill with current best available control technology (BACT) Controls.

Table 3-18: Continuous Cold Mill with BACT Controls

Purpose	Emission Type	Expected Uncontrolled Emissions, mg/nm ³	Control Technology	Calculated Controlled Emissions mg/m ³	% Control
Flattens steel	Particulate matter	1000	Fabric filter	10	99
Connects coil	Particulate matter	300	Fabric filter	3.6	99
Remove oxidation	Particulate matter	1000	Fabric filter	10	99
Cleans surfaces	HCl vapor	3250	Counter current packed tower scrapper with missed eliminator	6.5	99
Reduces thickness of strip	Roll coolant spray (water & oil)	100	Baffle plate collision mist eliminator	20	80
Removes oil from strip	Alkali mist	100	Horizontal air washer	5	95
Removes light Oxide	HCl vapor	140	Gas washing tower	1.7	99
Tempers/restores/flattens	Negligible	-	Non	-	-
Applies protective oil coat	Oil aerosols	13	mist eliminator	1.3	90

Source: Egyptian Pollution Abatement Project (EPAP)

Continuous Casting

Ladle emissions are negligible. The molten steel is sometimes driven a cover of inert material such as rice hulls to provide thermal insulation. In addition, many modern casting facilities employ refractory-lined lids. The molten steel stream from the ladle bottom generates almost no emissions, particularly when a ceramic submersion tube surrounds it. Some emissions are seen to emerge from the molds. The emissions are caused by mold powders and mold lubricating oils. These emissions are mostly a white-blue haze generated by evaporated oil condense or mold powder combustion products.

The emissions are greater if the molten steel stream is nitrogen shrouded because nitrogen prevents the burn-off of combustibles. The caster cut-off torches may also generate minor emissions because a traveling torch with an oxidizing flame cuts the red-hot steel section that emerges from the casting machine. Other emissions are generated during the maintenance of tun dishes and casting ladles. These are mostly dust and iron oxide fumes from dumping and oxygen lancing skulls.

The amount of harmful substances emitted to atmosphere is as follows:

Table 3-19: Emission from Continuous Casting Shop

Zone	Composition (g/T steel)			
	CO	CH ₄	NO	Dust
Pouring area	0.6	360	-	-
Gas cutting zone	120	-	90	240

The table below indicates the international benchmark emissions from steel plants.

Table 3-20: Air Emission Levels for Integrated Steel Plants^C

Pollutant	Units	Guideline Value
Particulate Matter	mg/Nm ³	20-50 ^a
Oil Mist	mg/Nm ³	15
NOX	mg/Nm ³	500 750 (coke oven)
SO ₂	mg/Nm ³	500
VOC	mg/Nm ³	20
PCDD/F	ng TEQ/ Nm ³	0.1
Carbon Monoxide (CO)	mg/Nm ³	100 (EAF) 300 (coke oven)
Chromium	mg/Nm ³	4
Cadmium (Cd)	mg/Nm ³	0.2
Lead (Pb)	mg/Nm ³	2
Nickel (Ni)	mg/Nm ³	2
Hydrogen Chloride (HCl)	mg/Nm ³	10
Fluoride	mg/Nm ³	5
Hydrogen Fluoride (HF)	mg/Nm ³	10
H ₂ S	mg/Nm ³	5
Ammonia	mg/Nm ³	30

Pollutant	Units	Guideline Value
Benzo(a)pyrene	mg/Nm ³	0.1
Tar fume ^b	mg/Nm ³	5

Notes:

a Lower value where toxic metals are present

b Tar fume measured as organic matter extractable by solvent from total matter collected by membrane filter

c Reference conditions for limits. For combustion gases: dry, temperature 273K (0°C), pressure 101.3 kPa (1 atmosphere), oxygen content 3% dry for liquid and gaseous fuels, 6% dry for solid fuels. For non-combustion gases: no correction for water vapor or oxygen content, temperature 273K (0°C), pressure 101.3 kPa (1 atmosphere)

3.5.1.6 Liquid and solid wastes from steel production

In the conventional process without recirculation, wastewaters, including those from cooling operations, are generated at an average rate of 80 cubic meters per tonne (m³/T) of steel manufactured. Major pollutants present in untreated wastewaters generated from pig iron manufacture include total organic carbon (typically 100-200 milligrams per liter, mg/l); total suspended solids (7,000 mg/l, 137 kg/T); dissolved solids; cyanide (15 mg/l); fluoride (1,000 mg/l); chemical oxygen demand, or COD (500 mg/l); and zinc (35 mg/l). Major pollutants in wastewaters generated from steel manufacturing using the BOF include total suspended solids (up to 4,000 mg/l, 1030 kg/T), lead (8 mg/l), chromium (5 g/l), cadmium (0.4 mg/l), zinc (14 mg/l), fluoride (20 mg/l), and oil and grease. Mill scale may amount to 33 kg/T. The process generates effluents with high temperatures. Process solid waste from the conventional process, including furnace slag and collected dust, is generated at an average rate ranging from 300 kg/T of steel manufactured to 500 kg/T, of which 30 kg may be considered hazardous depending on the concentration of heavy metals present. Approximately, 65% of BOF slag from steel manufacturing can be recycled in various industries such as building materials and, in some cases, mineral wool. An example of slag utilization in Japan is as follows. As can be seen, about 95% of slag is re-cycled in other industries and about 5% is reused in the plant. India needs to follow such a model.

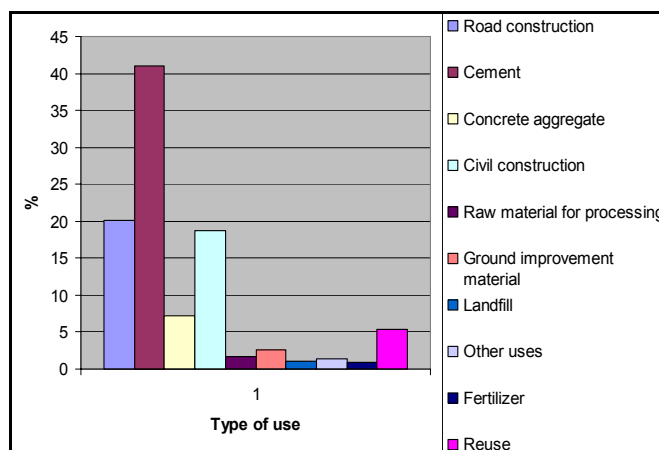


Figure 3-15: Typical Use of Iron & Steel Slag in Japan

3.5.2 Waste characteristics of Non-ferrous industry

3.5.2.1 Smelting and refining

Nickel production

Pyrometallurgical processes for processing sulphides ores are generally dry, and effluents are of minor importance, although wet electrostatic precipitators (ESPs) are often used for gas treatment, and the resulting wastewater could have high metal concentrations. Process bleed streams may contain antimony, arsenic, or mercury. Large quantities of water are used for slag granulation, but most of this water should be recycled. The smelter contributes a slag that is a dense silicate. Sludges that require disposal will result when neutralized process effluents produce a precipitate.

Sulphur dioxide (SO₂) is a major air pollutant emitted in the roasting, smelting, and converting of sulphide ores. (Nickel sulphide concentrates contain 6-20% nickel and up to 30% sulphur.) SO₂ releases can be as high as 4 tonnes of sulphur dioxide per tonne of nickel produced, before controls. Reverberate furnaces and electric furnaces produce SO₂ concentrations of 0.5-2.0%, while flash furnaces produce SO₂ concentrations of over 10%-a distinct advantage for the conversion of the sulphur dioxide to sulphuric acid. Particulate emission loads for various process steps include 2.0-5.0 kg/T for the multiple hearth roaster; 0.5-2.0 kg/T for the fluid bed roaster; 0.2-1.0 kg/T for the electric furnace; 1.0-2.0 kg/T for the Pierce-Smith converter; and 0.4 kg/T for the dryer upstream of the flash furnace. Ammonia and hydrogen sulphide are pollutants associated with the ammonia leach process; hydrogen sulphide emissions are associated with acid leaching processes. Highly toxic nickel carbonyl is a contaminant of concern in the carbonyl refining process. Various processes of gases contain fine dust particles and volatilized impurities. Fugitive emissions occur at furnace openings, launders, casting molds, and ladles that carry molten product. The transport and handling of ores and concentrates produce windborne dust.

Lead and zinc production

The principal air pollutants emitted from the processes are particulate matter and SO₂. Fugitive emissions occur at furnace openings and from launders, casting molds, and ladles carrying molten materials, which release sulphur dioxide and volatile substances into the working environment. Additional fugitive particulate emissions occur from materials handling and transport of ores and concentrates. Some vapors are produced in hydrometallurgy and in various refining processes. The principal constituents of the particulate matter are lead/zinc and iron oxides, but oxides of metals such as arsenic, antimony, cadmium, copper, and mercury are also present, along with metallic sulphates. Dust from raw materials handling contains metals, mainly in sulphidic form, although chlorides, fluorides, and metals in other chemical forms may be present. Off-gases contain fine dust particles and volatile impurities such as arsenic, fluorine, and mercury. Air emissions for processes with few controls may be of the order of 30 kg/T of lead or zinc produced. The presence of metals in vapor form is dependent on temperature. Leaching processes will generate acid vapors, while refining processes result in products of incomplete combustion (PICs).

Emissions of arsine, chlorine, and hydrogen chloride vapors and acid mists are associated with electro refining. Wastewaters are generated by wet air scrubbers and cooling water. Scrubber effluents may contain lead/zinc, arsenic, and other metals. In the electrolytic

refining process, by-products such as gold and silver are collected as slimes and are subsequently recovered. Sources of wastewater include spent electrolytic baths, slimes recovery, spent acid from hydro metallurgy processes, cooling water, air scrubbers, wash downs, and storm water, pollutants include and suspended solids, metals, and oil and grease. The larger proportion of the solid waste is discarded slag from the smelter. Discard slag may contain 0.5-0.7% lead/zinc and is frequently used as fill or for sandblasting. Slag with higher lead/ zinc content say, 15% zinc can be sent for metals recovery. Leaching processes produce residues, while effluent treatment results in sludge that require appropriate disposal. The smelting process typically produces less than 3 tonnes of solid waste per tonne of lead/zinc produced.

The disposal of Lead/Zinc bearing wastes requires scientific procedures to avoid contamination, following the Hazardous Waste Management Rules.

Copper production

The principal air pollutants emitted from the processes are sulphur dioxide and particulate matter. The amount of sulphur dioxide released depends on the characteristics of the ore-complex ores may contain lead, zinc, nickel, and other metals and on whether facilities are in place for capturing and converting the sulphur dioxide. SO₂ emissions may range from less than 4 kilo grams per tonne (kg/T) of copper to 2,000 kg/T of copper. Particulate emissions can range from 0.1 kg/T of copper to as high as 20 kg/T of copper. Fugitive emissions occur at furnace openings and from launders, casting molds, and ladles carrying molten materials. Additional fugitive particulate emissions occur from materials handling and transport of ores and concentrates. Some vapors, such as arsine, are produced in hydrometallurgy and various refining processes. Dioxins can be formed from plastic and other organic material when scrap is melted. The principal constituents of the particulate matter are copper and iron oxides. Other copper and iron compounds, as well as sulphides, sulphates, oxides, chlorides, and fluorides of arsenic, antimony, cadmium, lead, mercury, and zinc, may also be present. Mercury can also be present in metallic form. At higher temperatures, mercury and arsenic could be present in vapor form.

Leaching processes will generate acid vapors, while fire refining processes result in copper and SO₂ emissions. Emissions of arsine, hydrogen vapors, and acid mists are associated with electro refining. Wastewater from primary copper production contains dissolved and suspended solids that may include concentrations of copper, lead, cadmium, zinc, arsenic, and mercury and residues from mold release agents (lime or aluminum oxides). Fluoride may also be present, and the effluent may have a low pH. Normally there is no liquid effluent from the smelter other than cooling water; wastewaters do originate in scrubbers (if used), wet electrostatic precipitators, cooling of copper cathodes, and so on. In the electrolytic refining process, by-products such as gold and silver are collected as slimes that are subsequently recovered. Sources of wastewater include spent electrolytic baths, slimes recovery, spent acid from hydro metallurgy processes, cooling water, air scrubbers, wash downs, storm water, and sludge from wastewater treatment processes that require reuse/recovery or appropriate disposal. The main portion of the solid waste is discarded slag from the smelter. Discard slag may contain 0.5-0.7% copper and is frequently used as construction material or for sandblasting. Leaching processes produce residues, while effluent treatment results in sludge, which can be sent for metals recovery. The smelting process typically produces less than 3 tonnes of solid waste per tonne of copper produced.

Aluminum manufacturing

At the bauxite production facilities, dust is emitted to the atmosphere from dryers and materials-handling equipment, through vehicular movement, and from blasting. Although the dust is not hazardous, it can be a nuisance if containment systems are not in place, especially on the dryers and handling equipment. Other air emissions could include nitrogen oxides (NO_x), sulphur dioxide (SO₂), and other products of combustion from the bauxite dryers. Ore washing and beneficiation may yield process wastewaters containing suspended solids. Runoff from precipitation may also contain suspended solids. At the alumina plant, air emissions can include bauxite dust from handling and processing; limestone dust from limestone handling, burnt lime dust from conveyors and bins, alumina dust from materials handling, red mud dust and sodium salts from red mud stacks (impoundments), caustic aerosols from cooling towers, and products of combustion such as sulphur dioxide and nitrogen oxides from boilers, calciners, mobile equipment, and kilns. The calciners may also emit alumina dust and the kilns, burnt lime dust.

Although alumina plants do not normally discharge effluents, heavy rainfalls can result in surface runoff that exceeds what the plant can use in the process. The excess may require treatment. The main solid waste from the alumina plant is red mud (as much as 2 tonnes of mud per tonne of alumina produced), which contains oxides of alumina, silicon, iron, titanium, sodium, calcium, and other elements. The pH is 10-12. Disposal is to an impoundment. Hazardous wastes from the alumina plant include spent sulphuric acid from descaling in tanks and pipes. Salt cake may be produced from liquor purification if this is practiced. In the aluminum smelter, air emissions include alumina dust from handling facilities; coke dust from coke handling; gaseous and particulate

Comparison of technologies for Aluminium making

The Hall-Heroult process for aluminum production:

Hall and several associates started the Pittsburgh Reduction Company in 1888 in Pittsburgh. They had two electrolytic cells in series, operating at about 1750 amperes and 16 volts across the two cells, producing 50 lb/day (~23 kg/day). The cell line was powered by two steam-powered dynamos in parallel, rated at 1000 amperes and 25 volts each. The plant was enlarged to 475 lb/day (~215 kg/day) in 1890 and in 1891 a new plant was built at New Kensington, near Pittsburgh (Figure 3-16).

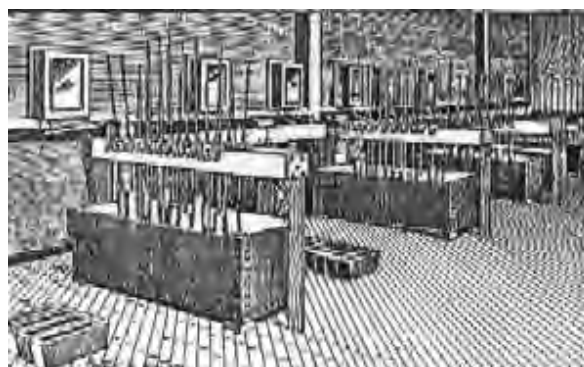


Figure 3-16: The Pittsburgh Reduction Company's First Cell Room

The new plant produced 1000 pounds per day (lb/day) (~453 kg/day) in 1893 and 2000 lb/day (~906 kg/day) in 1894. In 1907, the company changed its name to Aluminum Company of America, now known as Alcoa. Plants were built at Niagara Falls and other

places where inexpensive water power was available. In 1901, a plant was built in Canada, which later became part of Aluminum Company of Canada, Alcan. Meanwhile, the Heroult process was commercialized in France and Switzerland. Other plants were built in England, Germany, Italy, and Norway early in the 20th century where water power was available.

Hall's first electrolytic cells, or "pots," were of cast iron, 24 inches (~61 cm) long, 16 inches (~41 cm) wide and 20 inches (~51 cm) deep, with a 3-inch (~8-cm) baked carbon lining. Six to ten carbon anodes, 3 inches (~8 cm) in diameter and 15 inches (~38 cm) long when new, were suspended in the electrolyte (bath) from a copper busbar above. The pots held 300 to 400 lbs (~136 to ~181 kg) of cryolite bath in which alumina was dissolved. The pots were arranged so that they could be heated from below by a gas flame, but it was found that they were self sustaining by the electrical heat generated. It is interesting that present-day cells are qualitatively of the same design, although considerably larger and under more precise quality control. The overall cell reaction is:



Aluminum reduction cells today are of two types: those with prebaked anodes and those with baked-in-place anodes (Soderberg). Both types of anodes are made of baked petroleum coke and coal-tar or petroleum pitch. Prebaked anodes are baked in brick-lined pits and the hydrocarbon off gases can be captured and burned. Soderberg anodes are baked by the heat generated in the cells, and the off gas are more difficult to collect. Modern cell rooms with prebaked and with Soderberg anodes are shown in Figures 3-17 and Figure 3-18.



Figure 3-17: Electrolytic Cell for 300 kA Prebaked Carbon Anode Technology in the Cell Room



Figure 3-18: Soderberg Electrolytic Cell Line - Kaiser Chalmette Plant

The components of a prebaked anode cell are described as follows. A carbon lining contains the bath and a pool of molten aluminum on the bottom. Carbon anodes suspended from an anode bus conduct current into the cell. Anode rods carry the current from the anode bus through steel stubs cast with iron into holes in the tops of the anodes. Current is conducted out of the cell through steel collector bars to the cathode bus and on to the next cell. The aluminum metal pad is the cathode where aluminum is deposited from the bath. Oxygen from the alumina dissolved in the bath combines with the bottom surface of the carbon anode to form carbon dioxide. The anodes are consumed in the process and replacements are added at individual locations on a regular schedule. The anode butts are sent back to the anode plant to be ground and mixed into new anode paste to be pressed and baked. Aluminum is siphoned out of the cells on a daily basis into vacuum crucibles and sent to the cast house. The carbon lining is contained in a steel shell with a thermal insulation of alumina or insulating brick.

In operation, cryolite freezes on the sidewalls of the cells forming a "ledge" which protects the sideling from severe attack by aluminum and molten cryolite. Cryolite also freezes over the top of the bath and forms a "crust" to support a top layer of alumina thermal insulation. Alumina is fed to the bath through holes punched in the crust. The carbon dioxide exits through holes in the crust and is collected under the hoods. The carbon dioxide and air leaking in is now ducted to dry scrubbers which remove fluorides from the gas stream. Fresh alumina contacting the gases removes the hydrogen fluoride and evaporated fluoride particulate. This alumina, fed to the cells, returns fluoride to the cells. The hydrogen fluoride comes from residual hydrocarbons in the anodes and traces water in the alumina and air humidity reacting with the fluoride bath.

Control of alumina concentration in the cells is accomplished by a slight underfeeding. When the alumina reaches a critical level the cell goes on anode effect, caused by a limiting rate of diffusion of alumina to the anode surfaces. The cell voltage then rises and some fluorocarbons are generated. A light bulb connected across the cell lights up with increased cell voltage as a signal for the operators to feed the cell with alumina and kill the anode effect. Cells now run a day or longer between anode effects. The ratio of

sodium fluoride to aluminum fluoride in the cryolite bath changes over time and corrective additions are added based on laboratory analyses.

Since inception of the process, cells in new plants have increased with time. This increase is driven by a need to reduce labor costs and to increase energy efficiency. On the average, cell size has doubled about every 18 years in the 20th century. As a result of increasing cell size and better process control, energy consumption has improved with time as shown in Figure 6. Energy efficiency is approaching about 50% based on the heat of reaction for the cell reaction. Significant further improvements in energy efficiency may be hard to achieve with the existing cell design. As cells have become larger, electromagnetic effects caused by interaction of the current through the cell with the magnetic field of the bus work have resulted in swirling of the metal pad and vertical distortions in the metal-bath interface. This effect has limited the minimum anode-cathode distance (ACD) to about 4.5 cm because of spurious short circuits by metal contacting the anodes. Since a major voltage drop in the cell is caused by bath resistance, this effect limits energy efficiency.

The industry has largely solved the fluoride emission problem with dry scrubbing but economical disposal of used carbon cell linings remains a problem. The linings contain highly alkaline bath, aluminum carbide, cyanides, and other materials. A small part is ground and added to cement kilns as a source of fluoride, but most of it still end-up in landfills. Two improvements to the Hall-Heroult process have been under development for many decades but have not reached commercial application yet: wetted cathodes, and non-consumable anodes. Titanium diboride is a material with good electrical conductivity, is wetted by aluminum and is highly-resistant to corrosion by aluminum and bath if kept cathodic. By coating a slightly-sloping carbon cell bottom with titanium diboride and providing a sump to collect aluminum, the electromagnetic problem is eliminated and a smaller ACD (anode-cathode distance) can be used, with lower bath voltage loss. Many materials have been tested as non-consumable anodes, such as hematite (an oxide of iron), tin oxide and a cermet of nickel ferrite and copper. The cell reaction would then be:

alumina = aluminum + oxygen

Energetically this reaction requires a one-volt increase in the cell, but this is partially offset by a lower anode over voltage. The saving would be in eliminating the manufacture and changing carbon anodes. The production of greenhouse gases, carbon dioxide and fluorocarbons in the cells, would be eliminated. By combining titanium diboride cathodes and non-consumable anodes as vertical electrodes the anode-cathode spacing could be further decreased and cell voltage could be less than for the conventional Hall-Heroult cells.

Alternative processes

In the past half century there have been a number of attempts at alternatives to the Hall-Heroult process. Several alternatives have been developed almost to industrial scale, and then abandoned because of technical problems and lack of overall economic advantage over the Hall-Heroult process. In the 1960's Alcan developed a carbothermic subhalide (aluminum monochloride) process. Bauxite or low-grade ores were reduced with carbon and the resulting impure aluminum was purified with an aluminum sub-chloride process. It turned out that the energy costs were higher than for the Hall-Heroult process and severe corrosion problems were encountered. The Toth Company in the same period did a carbothermal chlorination of clay and reduced the aluminum chloride produced with

manganese. The manganese chloride formed was converted to manganese oxide and chlorine with air. The chlorine was recycled and the manganese oxide carbothermally reduced to manganese and recycled. A manganese-aluminum alloy formed that was uneconomical to separate. Alcoa had a large-scale development program in the 1970s for an aluminum chloride (aluminum trichloride) process. Alumina was carbothermally chlorinated to aluminum chloride, which was electrolytically decomposed to aluminum and chlorine in bipolar cells with graphite electrodes. It was said that the cells worked well but there were technical problems with the plant to produce aluminum chloride. Thus the Hall-Heroult process remains to be displaced.

Table 3-21 indicates international benchmark values for air emissions from non-ferrous industry. Emission values of dust given are for specific metals. For total dust emission, Environment (Protection) Act may be referred.

Table 3-21: Air Emissions for Nickel, Copper, Lead, Zinc, and Aluminum Smelting & Refining*

Pollutant	Emission Source (By Metal Type / Smelting Process)	Units	Guideline Value
SO ₂	<ul style="list-style-type: none"> ▪ Copper: Primary smelting and converting ▪ Lead and Zinc: Primary smelting, roasting and sintering ▪ Nickel: Roasting and smelting of sulphide concentrates and intermediates 		>99.1% conversion efficiency (for ~ 1 – 4 % SO ₂ off gas) >99.7 % conversion efficiency (for >5 % SO ₂ off gas)
	<ul style="list-style-type: none"> ▪ Copper: Secondary smelting and converting, primary and secondary fire refining, electric slag cleaning and melting ▪ Aluminum: Holding and de-gassing of molten metal from primary and secondary aluminum ▪ Lead and Zinc: Materials pre-treatment, secondary smelting, thermal refining, melting, slag fuming, and Waelz kiln operation 	mg/Nm ³	<50 – 200 _{1,2,3}
NO _x	<ul style="list-style-type: none"> ▪ Copper: Secondary smelting and converting, primary and secondary fire refining, electric slag cleaning and melting ▪ Aluminum: Holding and de-gassing of molten metal from primary and secondary aluminum, materials pre-treatment, and from melting and smelting of secondary aluminum ▪ Lead and Zinc: Melting of clean material, alloying, and zinc dust production; From materials pre-treatment, secondary smelting, thermal refining, melting, slag fuming, and Waelz kiln operation ▪ Nickel: Leaching, chemical extraction and refining, electro-winning and solvent 	mg/Nm ³	100 – 300 _{4,5,6}

Metallurgical Industry

Pollutant	Emission Source (By Metal Type / Smelting Process)	Units	Guideline Value
	extraction; From materials pre-treatment incineration or after-burning, roasting, smelting thermal refining, and melting.		
Acid Mists / Gases	<ul style="list-style-type: none"> ▪ Copper: Hydrometallurgical and electro-winning processes ▪ Lead and Zinc: Chemical refining, electro-winning, and solvent extraction ▪ Nickel: Leaching, chemical extraction and refining, electro-winning and solvent extraction 	mg/Nm ³	50 _{1,7}
VOC / solvents (as C)	<ul style="list-style-type: none"> ▪ Copper: Hydrometallurgical and electro-winning processes ▪ Lead and Zinc: Chemical refining, electro-winning, and solvent extraction ▪ Nickel: Leaching, chemical extraction and refining, electro-winning and solvent extraction 	mg/Nm ³	5 – 15 ₉
Dust _{2.5}	<ul style="list-style-type: none"> ▪ Copper: Secondary smelting and converting, primary and secondary fire refining, electric slag cleaning and melting, secondary fume collection systems, and drying. ▪ Aluminum: Primary aluminum electrolysis, from holding and de-gassing of molten metal from primary and secondary aluminum, materials pre-treatment, and from melting and smelting of secondary aluminum ▪ Lead and Zinc: Melting of clean material, alloying, and zinc dust production; From materials pre-treatment, secondary smelting, thermal refining, melting, slag fuming, and Waelz kiln operation ▪ Nickel: Materials pre-treatment incineration or after-burning, roasting, smelting thermal refining, and melting. 	mg/Nm ³	1 – 5 _{3,}
TOC (as C)	<ul style="list-style-type: none"> ▪ Copper: Secondary smelting and converting, primary and secondary fire refining, electric slag cleaning and melting ▪ Aluminum: Materials pre-treatment, and from melting and smelting of secondary aluminum ▪ Lead and Zinc: Melting of clean material, alloying, and zinc dust production; From materials pre-treatment, secondary smelting, thermal refining, melting, slag fuming, and Waelz kiln operation ▪ Nickel: Materials pre-treatment incineration or after-burning, roasting, smelting thermal refining, and melting. 	mg/Nm ³	5 – 50 _{12,13}

Metallurgical Industry

Pollutant	Emission Source (By Metal Type / Smelting Process)	Units	Guideline Value
Dioxins	<ul style="list-style-type: none"> ▪ Copper: Secondary smelting and converting, primary and secondary fire refining, electric slag cleaning and melting, secondary fume collection systems, and drying. ▪ Aluminum: Materials pre-treatment, and from melting and smelting of secondary aluminum ▪ Lead and Zinc: Melting of clean material, alloying, and zinc dust production; From materials pre-treatment, secondary smelting, thermal refining, melting, slag fuming, and Waelz kiln operation ▪ Nickel: Materials pre-treatment incineration or after-burning, roasting, smelting thermal refining, and melting. 	ngTEQ/m ³	0.1 – 0.5 _{3,10,1}
Ammonia	<ul style="list-style-type: none"> ▪ Nickel: Leaching, chemical extraction and refining, electro-winning and solvent extraction 	mg/Nm ³	5 ₁₇
Chlorine		mg/Nm ³	0.5 _{2,18}
CO and carbonyls		mg/Nm ³	5 ₁₉
Arsine	<ul style="list-style-type: none"> ▪ Lead and Zinc: Chemical refining, electro-winning, and solvent extraction 	mg/Nm ³	0.5 ₆
Mercury	<ul style="list-style-type: none"> ▪ All types of metals / smelting processes 	mg/Nm ³	0.02
Hydrogen Chloride	<ul style="list-style-type: none"> ▪ Aluminum: Holding and de-gassing of molten metal from primary & secondary aluminum, materials pre-treatment, melting and smelting of secondary aluminum ▪ aluminum 	mg/Nm ³	5 ₁
Hydrogen Fluoride	<ul style="list-style-type: none"> ▪ Aluminum: Primary aluminum electrolysis, materials pre-treatment, and from melting and smelting of secondary aluminum ▪ Aluminum: Primary aluminum electrolysis 	mg/Nm ³	0.5 _{10,20}
Total Fluoride		mg/Nm ³	0.8 _{10,22}
Polyfluorinated hydrocarbons		0.1 (anode effects / cell / day)	
<ol style="list-style-type: none"> 1. Alkali scrubber (semi -dry and fabric filter, wet scrubber or double alkali using lime, magnesium hydroxide, sodium hydroxide). 2. Combinations of sodium or alumina/aluminum sulphate in combination with lime. 3. For copper smelting, an SO₂ emission concentration of 500 mg/m³ can be achieved through use of a fabric filter with lime injection. 4. Low NO_x burner 5. Oxy-fuel burner 6. Oxidizing scrubber 7. De-mister 8. Excluding Aluminum smelting 9. Containment, condenser, carbon and bio -filter 			

Pollutant	Emission Source (By Metal Type / Smelting Process)	Units	Guideline Value
<p>10. Fabric filter</p> <p>11. Temperature control</p> <p>12. Afterburner</p> <p>13. Optimized combustion</p> <p>14. Afterburner followed by quenching</p> <p>15. Adsorption by activated carbon</p> <p>16. Oxidation catalyst</p> <p>17. Acidic scrubber</p> <p>18. Collection and re -use</p> <p>19. Process control and sealed reactor</p> <p>20. Alumina scrubber</p> <p>21. Excluding Aluminum smelting</p> <p>22. Emissions of metals are dependent on the composition of the dust produced by the processes. The composition varies and is influenced by the process source of dust and by the raw materials that are being processed.</p> <p>Source: Based in part on EU BREF in the Non-Ferrous Metals Industries (2001) *Associated emissions to air are given as daily averages based on continuous monitoring and standard conditions of 273 K, 101.3 kPa, measured oxygen content and dry gas without dilution of the gases with air. In cases where continuous monitoring is not practicable the value should be the average over the sampling period. If thermal cleaning and pyrolysis systems (e.g., swarf drying and decoating) are used to destroy combustion products (e.g., VOCs and dioxins) oxygen content 6 % dry.</p>			

3.5.3 Emissions, effluents and solid wastes from secondary metallurgical industries

3.5.3.1 Sponge iron plants

Air emissions

The coal based sponge iron plants are considered to be highly polluting. Most of the small size plants in India do not use any pollution control equipment. The old rotary kiln DRI plants have used Gas Cleaning Plant (GCP) based on Venturi Scrubbers (wet cleaning) for the treatment of DRI gases. This system generates dust bearing sludge that needs separate handling and disposal. However, this system can take care of particulate matter as well as gaseous pollutants. Some plants have Gas Conditioning Tower (GCT) to cool the gases before taking to dry pollution control equipment. In some of the bigger size plants, the heat content of hot gases is utilized to generate steam through Waste Heat Recovery Boilers (WHRB). The steam is used to operate small size turbines to produce electricity. The exhaust gases coming out of WHRB, having temperature around 150-175°C is taken to Electrostatic Precipitators (ESP).

Rotary kiln DRI plants have emergency stack/safety cap above the ABC of feed end column. The safety cap is required to maintain the positive pressure inside the kiln and

avoid chances of CO related explosion. This is not to be used to by-pass pollution control equipment but is occasionally done by entrepreneurs who do not care for environment. SPM concentration before cleaning is about 25 g/m^3 . The SPM concentration after cleaning is found to be in the range of very low (47 mg/m^3) to high (727 mg/m^3); SO_2 from 51 to 92 mg/m^3 and NO_x from 45 to 11 mg/m^3 .

Fugitive dust generation

The sources of fugitive dust generation in rotary kin based DRI plants are the Raw Material Handling Yard (unloading, stacking, reclaiming operations) and Product discharge system (cooler discharge conveyors, transfer points, junction house, screens, magnetic separators, storage silos, truck loading and packing operations). The dust at RMH yard is controlled by using water sprinklers in bigger sized plants. Covered Product House further reduces the wind blown dust. Skirt boards and covered conveyor belts also generates less fugitive dust. Typical work zone concentration values varied between 9000 to $47000 \text{ } \mu\text{g/m}^3$ – indicating very high values; SO_2 between 17 to $47 \mu\text{g/m}^3$; and NO_x between 22 to $68 \mu\text{g/m}^3$.

Water pollution

In the coal based sponge iron plants, water is used mainly in three areas namely cooler, ABC and wet scrubber (in case dry type equipment are not in operation). The water requirement in rotary kiln DRI plant is mainly for cooling the discharge feed from $950\text{-}1050^\circ\text{C}$ to below 100°C . Water is continuously sprinkled over the rotary cooler shell and is allowed to fall on a settling tank located below the rotary cooler/ near the cooler. Make-up water is added in the tank to cool the hot water and compensate evaporation loss. The water from settling tank is re-circulated for sprinkling over the rotary cooler. The water requirement varies from 5-6 kl/ h/ 100 TPD DRI. In ABC water is sprayed through the nozzles in the form of fine spray. This controls the temperature of the gasses. The quantity of water required is 2 kl/h/100 TPD DRI. Normally, no wastewater is discharged from the plants.

Some of the big plants are using water for fugitive dust suppression in RMH yard, haul roads and other places. The water requirement varies from 1-1.5 kl/h/100 TPD DRI. Some of the plants are having wet scrubber as pollution control system for kiln off gas (instead of ESP). Here after ABC the gas is passed through scrubber/venturi scrubber wherein the gas is scrubbed with plain water. The water with finer particles is collected and taken to thickener. The water from thickener is recirculated to scrubber unit. Underflow of thickener is cleaned periodically for small plants and for big plants it is taken to sludge settling ponds. Plants coming up now are mostly with ESP system. The water requirement varies from 3-3.5 kl/h/100 TPD DRI. The domestic water consumption is for cooling, washing and sanitary purpose. About 50-100 kl/ person/ day water is used for domestic purpose. About 5-10% water is generated as sanitary wastewater. The sanitary wastewater is disposed into soak pits / septic tanks.

Solid waste generation and disposal

Char, flue dust, GCP sludge and kiln accretions are the solid wastes generated from DRI plants. Char comprises unburnt carbon, oxides and gangue and is segregated from the product during magnetic separation. The material deposited on the inner surface of kiln, comprising metallic oxides is called accretion. Flue dust is generated from air pollution

control systems like DSC, ESP and Bag Filter. Sludge is generated from the GCP, if the plant is based on wet scrubber for dust treatment.

Char contains moderate calorific value (1500-1600 kcal/kg) because of the presence of fixed carbon content. Char do not have volatile matter and cannot be independently used as fuel. It is washed to free the impurities, mixed with coal fines, pulverized and then used as fuel in Fluidized Bed Combustion Boilers (FBC). In India very few plants are using char to produce electricity. Most of the plants (up to 100 TPD) dump it in low-lying area creating pollution problems. Some of the plants sell it to local entrepreneurs for making coal briquettes. It can also be mixed with coal fines, converted to briquette and used in brick kiln.

The kiln accretions are dislodged from the shell at periodic intervals because it hampers the feed movement and heat transfer inside kiln. It also reduces the surface area of kiln. The dislodged accretions are heavy solid lumps and are being used as landfill. However this material can be used as sub-base material for road construction. The flue dust and sludge collected from air pollution control equipment are non-hazardous, non-toxic oxides that are mainly dumped in near by areas. These can be used for brick making and land filling

3.5.3.2 Mini steel plants

Mini steel plants having mini blast furnace and BOF produce the same types of pollutants that are produced by such units of primary producers.

3.5.3.3 Re-rolling mills

Major pollutants present in the air emissions include particulates (1,000 milligrams per normal cubic meter, mg/Nm³), nitrogen oxides from cutting, scarfing, and pickling operations, and acid fumes (3,000 mg/Nm³) from pickling operations. Both nitrogen oxides and acid fumes vary with steel quality. Mini mills generate up to 80 cubic meters of wastewater per tonne (m³/T) of steel product. Untreated wastewaters contain high levels of total suspended solids (up to 3,000 milligrams per liter, mg/l), copper (up to 170 mg/l), lead 10 mg/l), total chromium (3,500 mg/l), hexavalent chromium (200 mg/l), nickel (4,600 mg/l), and oil and grease (130 mg/l). Chrome and nickel concentrations result mainly from pickling operations. The characteristics of the wastewater depend on the type of steel, the forming and finishing operations, and the quality of scrap used as feed to the process. Solid wastes, excluding EAF dust and wastewater treatment sludge, are generated at a rate of 20 kg/T of steel product. Sludge and scale from acid pickling, especially in stainless steel manufacturing, contain heavy metals such as chromium (up to 700 mg/kg), lead (up to 700 mg/kg), and nickel (400 mg/kg). These levels may be even higher for some stainless steels.

3.5.3.4 Secondary aluminum processing

Secondary aluminum processing also results in air emissions, wastewaters, and solid wastes. Atmospheric emissions from reverberatory (chlorine) smelting/refining represent a significant fraction of the total particulate and gaseous effluents generated in the secondary aluminium industry. Typical furnace exhaust gases contain combustion products, chlorine, hydrogen chloride and metal chlorides of zinc, magnesium, and aluminium, aluminium oxide and various metals and metal compounds, depending on the quality of scrap charges. Emissions from reverberatory (fluorine) smelting/refining are

similar to those from reverberatory (chlorine) smelting/refining. The use of AlF_3 rather than chlorine in the demagging step reduces demagging emissions. Fluorides are emitted as gaseous fluorides or as dusts. Baghouse /scrubbers are usually used for fluoride emission control.

Solid wastes are also generated during secondary scrap aluminium smelting. The slag generated during smelting contains chlorides resulting from the use of fluxes and magnesium. Waste waters are also generated during secondary aluminium processing when water is added to the smelting slag to aid in the separation of metallics. The waste waters are also likely to be contaminated with salt from the various fluxes used.

3.5.3.5 Secondary copper processing

Secondary copper processing produces the same types of wastes as primary pyrometallurgical copper processing. One type of secondary processing pollutant that differs from primary processing is the air emissions. Air pollutants are generated during the drying of chips and borings to remove excess oils and cuttings fluids and causes discharges of large amounts of dense smoke containing soot and unburned hydrocarbons. These emissions can be controlled by baghouses and/or direct-flame afterburners.

3.5.3.6 Secondary lead processing

Secondary lead processing, results in the generation of air emissions and solid-phase wastes. As with primary lead processing, reverberatory and blast furnaces used in smelting account for the vast majority of the total lead emissions. Other emissions from secondary smelting include oxides of sulphur and nitrogen, antimony, arsenic, copper, and tin. Smelting emissions are generally controlled with a settling and cooling chamber, followed by a baghouse. Other air emissions are generated during battery breaking. Emissions from battery breaking are mainly sulphuric acid and dusts containing dirt, battery case material, and lead compounds. Emissions from crushing are also mainly dusts.

The solid wastes generated by secondary processing are emission control dust and slag. Slag is generated from smelting, and the emission control dust, when captured and disposed of, is considered to be hazardous waste.

3.5.3.7 Secondary zinc processing

Secondary zinc processing generates air emissions and solid wastes. Air pollution control can be an area of concern when pyrometallurgical processes are employed in the secondary recovery of zinc. When the recovery process used is simply an iron pot re-melt operation to produce zinc metal, fumes will not be normally generated. If slab zinc is needed and a rotary furnace is used, any air emissions are captured directly from the venting system (a rotating furnace sweats, or melts, the zinc separating it from drosses with different melting points, which allows it to be poured off separately). Air emissions become more of a concern when more complicated processes are used to produce zinc powder. Retort and muffle furnaces used to produce zinc powder heat the zinc and other charges to such a high temperature that the zinc vaporizes and is captured in the pollution control equipment. It is this zinc oxide dust that is the process' marketable product. Hoods are employed around the furnace openings used to add additional charge. The fumes collected from the hoods are not normally of high quality and will be used for products like fertilizer and animal feed. Zinc fumes are negligible at low furnace temperatures.

Substantial emissions may arise from incomplete combustion of carbonaceous material in the zinc scrap. These contaminants are usually controlled by afterburners, and particulate emissions are most commonly recovered by fabric filters. Emissions from refining operations are mainly metallic fumes. Distillation/oxidations operations emit their entire zinc oxide product in the exhaust dust. Zinc oxide is usually recovered in fabric filters.

The secondary zinc recovery process generates slag that contains metals such as copper, aluminum, iron, and lead. Therefore if secondary processing slag exhibits a characteristic (e.g., toxicity for lead), it would need to be managed as a hazardous waste.

3.5.4 Exposure pathways

Exposure pathway is the path due to which exposure of the receptor takes place. The “Exposure” has been defined as contact with a chemical or physical agent. It is the process by which an organism acquires a dose. The estimation of exposure of a target organism requires an exposure scenario that answers to four questions:

- given the output of fate models, which media (ecosystem components) are significantly contaminated?
- to which contaminated media are the target organisms exposed?
- how are they exposed (pathways and rates of exposure)? and
- Given an initial exposure, will the organism modify its behavior to modify exposure pathways or rates (attraction or avoidance)?

Table 3-21 identifies some of the major exposure pathways.

Table 3-21: Exposure Pathways

Media	Pathways	Comment
Air-Gases and Aerosols	Respiration	Assuming accurate fate model estimates, exposure is relatively predictable based on assumption of homogenous distribution in air
Water – Soluble Chemicals	Respiration	Assuming accurate fate model estimates, exposure is relatively predictable based on assumption of homogenous distribution in water
Sediment (Solids and pore water)	Benthic animals absorb chemicals, respire pore water or food or food from the water column. Plants rooted in the sediment may take up material from sediments, surface water and air	Processes are very complicated and usually simplifying assumptions are required
Soil (solids, pore water and pore air)	Organisms in soils may absorb material from soil, pore water, pore air, ingest soil, soil – associated food.	Processes are very complicated and usually simplifying assumptions are required.
Ingested Food and Water	Consumption by fish and wildlife	Assume the test animal consumption rates in laboratory for a given availability of food or water are the same as those occurring naturally in the environment.
Multimedia	More than one of the above pathways	It is often possible to assume one pathway is

		dominant. In some cases, it will be necessary to estimate the combined dosage.
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For Environmental Risk Management there are three major risk factors and exposure Pathway is one of three factors. To determine whether risk management actions are warranted, the following assessment approach should be applied to establish whether the three risk factors of ‘Contaminants’, ‘Receptors’, and ‘Exposure Pathways’ co-exist, or are likely to co-exist, at the project site after the operational phase of the proposed development.

- Contaminant(s): Presence of pollutants and/or any hazardous materials, waste, or oil in any environmental media at potentially hazardous concentrations
- Receptor(s): Actual or likely contact of humans, wildlife, plants, and other living organisms with the contaminants of concern
- Exposure pathway(s): A combination of the route of migration of the contaminant from its point of release (*e.g.*, leaching into potable groundwater) and exposure routes

Metallurgical industries emissions or rejects (gaseous, solid & hazardous as well as liquid effluents) can cause damage to human health, aquatic and terrestrial ecology as well as material due to various exposure routes (pathways). For example, adverse effects of metallurgical industries on human health can derive from the direct impact of noxious gases on the organism and/or their indirect impact via the food chain and changes in the environment. Especially in connection with high levels of fine particulates, noxious gases like SO₂ and NO_x can lead to respiratory diseases. SO₂ and NO_x can have health-impairing effects even at concentrations below those of standard of 120 µg/m³. The duration of exposure is decisive. Injurious heavy metals (*e.g.*, lead, mercury and cadmium) can enter the food chain and, hence, the human organism by way of drinking water and vegetable and animal products. Climatic changes such as warming and acidification of surface waters, Forest depletion can occur due to acid rain and/or the greenhouse effect of CO₂ and other trace gases can have long-term detrimental effects on human health. Similarly important are the effects of climatic changes on agriculture and forestry (and thus on people's standard of living), *e.g.*, large-scale shifts of cultivation to other regions and/or deterioration of crop yields due to climate change impacts. Hence, the construction and operation of metallurgical industries can have both socioeconomic and socio-cultural consequences; appropriate preparatory studies, gender-specific and otherwise, are therefore required, and the state of medical services within the project area must be clarified in advance. Beside, noise pollution generated from operational equipment is an important source of Occupational exposure, has direct effects on humans and animals. The main sources of noise in metallurgical industries are the mouth of the smokestack, belt conveyors, fans, motors/engines, transformers, flues, piping and turbines.

3.6 Technological Aspects

3.6.1 Clean technologies

In the middle of the 1960s environmental groups started pressing for cleaner environment. The metallurgical industry responded in a variety of ways. The steel industry closed open hearth furnaces and switched over to other cleaner technology. The aluminium industry switched over from Soderberg to pre-baked electrodes in the electrolytic cells. The copper industry abandoned the reverberatory furnace to a flash smelting technology. Tall stacks were constructed to dispose of SO₂, but the zinc industry eliminated SO₂ emissions

completely by using pressure leaching technology which may well be applied to other nonferrous industries.

Beside government legislation against pollution, residents in many communities now protest against the erection of industrial plants in their regions. The construction of tall stacks has been a new development in the past decades. The problem of dust has been generally solved by adding efficient scrubbers and electrostatic precipitators. This not only improved the local environment but also allowed the recovery of valuable particulates. In most cases the value of these particulates offsets the capital investment in the dust recovery system. The metallurgist is now trying to cope with the environmental problems by adding new equipment in existing plants that would abate pollution, by improving equipment design, and in some cases is forced to develop new processes that are less polluting than the conventional ones. Closely related to these attempts is the need to conserve the national resources through recycling of scrap metal, valorization of mineral waste, and recovery of metals that would otherwise be lost in process streams

3.6.1.1 Clean technologies in iron and steel

Considerable advancement in the field of clean technologies has taken place in the iron & steel sector. The following clean technologies are possible in the iron & steel sector:

1) Sintering

Sinter plant heat recovery

Description: Heat recovery at the sinter plant is a means for improving the efficiency of sinter making. The recovered heat can be used to preheat the combustion air for the burners and to generate high pressure steam, which can be run through electricity turbines. Various systems exist for new sinter plants (*e.g.* Lurgi Emission Optimized Sintering (EOS) process) and existing plants can be retrofit.

Energy/environment/cost/other benefits:

- Retrofitted system at Hoogovens in the Netherlands:
- Fuel savings in steam and coke of 0.55 GJ/T sinter, with increased electricity use of 1.5 kWh/T sinter
- NO_x, SO_x and particulate emissions reduced
- Capital costs of approximately \$3/T sinter
- Wakayama sintering plant trial operation in Japan:
 - 110-130 kg/T of sinter recovered in steam
 - 3-4% reduction in coke
 - 3-10% reduction in SO_x
 - 3-8% reduction in NO_x
 - About 30% reduction in dust
 - Increased productivity, yield, and cold strength
- Taiyuan Steel in Japan:
 - Recovered exhaust heat equaled 15 t/h (or 12,000 KL/year crude oil)
 - SO₂ reduced

2) Dust emissions control

Description: Production increase leads to increased dust generation, thereby increasing particulate emissions. These emissions - off/waste gas – are dust-laden, containing a wide

variety of organic and heavy metal hazardous air pollutants (HAPs). Total HAPs released from individual sinter manufacturing operations may exceed ten tonnes per year. By sending waste gas to Electrostatic Precipitators (ESPs) through negatively charged pipes, the particulate matter (PM) in the waste stream becomes negatively charge. Routing the stream past positively charged plates will then attract and collect the negatively charged PM, thereby producing clean waste gas and increasing the quantity of steam recovery. Course dusts are removed in dry dust catchers and recycled.

Energy/environment/cost/other benefits:

- Can achieve over 98% efficiency, reducing dust load in off-gas of a typical plant from 3,000 mg/m³ to about 50 mg/m³
- ESP removal of fine dust may reduce PM emission levels at sinter plants to about 50 – 150 mg/m³ depending on actual specific dust resistivity and/or sinter basicity
- ESPs can be installed at new and existing plants
- ESPs cause increased energy consumption of about 0.002 to 0.003 GJ/T sinter
- Kashima Steel Works in Japan installed ESP

3) Exhaust gas treatment through denitrification, desulphurization, and activated coke packed bed absorption

Description: Sintering exhaust gas contains SO_x, NO_x, dust and dioxins. These contaminants are processed, absorbed, decomposed and/or collected as non-toxic by-products to increase the quantity of steam recovery, and improve total fuel savings. Treatment methods to achieve these include:

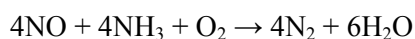
- (1) Denitrification Equipment
- (2) Desulphurization Equipment
- (3) Activated Coke Packed Bed Absorption

Energy/environment/cost/other benefits

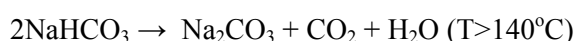
- SO_x is absorbed and recovered as useful by-product
- NO_x is decomposed to nitrogen, water and oxygen by ammonia
- Dust is collected in activated coke
- Dioxins are collected or absorbed in activated coke and decomposed at 400oC with no oxygen
- Activated coke absorption removes dioxins to <0.1 ng-TEQ/m³N, dust to <10 mg/m³N, and SO_x to <65 % absorbing ratio.

4) Exhaust Gas Treatment through Selective Catalytic Reduction

Description: SO_x and dioxins contained in the sinter flue gas are removed in this process by adding sodium bicarbonate and Lignite. NO_x is removed by the selective catalytic reduction reaction at around 200~450oC:



For SO_x removal the reactions are:





Lignite Injection produces dioxin < 0.2 ng-TEQ/Nm³.

Energy/environment/cost/other benefits

- High SO_x and NO_x removal efficiency

5) Exhaust Gas Treatment through Low-Temperature Plasma

Description: Active radicals of low-temperature plasma remove SO_x, NO_x and HCl simultaneously. Dioxin also decreased with the addition of Lignite to the process. Reliability and stability have been proven (over five years of operation). Core technology includes full-scale magnetic pulse compressor, stabilizing pulse width and rising time, proper reactor capacity design, and energy saving technology through additives.

Energy/environment/cost/other benefits

- Low cost with high pollutants removal efficiency
- Compact - less space required than other technologies
- A commercial scale plant installed at an incinerator in Kwang Works showed a substantial reduction of Sox (>70%), NO_x (>95%) and HCl (>99%)
- Dioxin also decreased to less than 0.2 ng-TEQ/Nm³

6) Improvements in Feeding Equipment

Description: An additional screen is installed on the conventional sloping chute, which promotes a more desirable distribution of granulated ore on the palette.

Energy/environment/cost/other benefits

- The screen with a sloping chute places coarser granulated ore in the lower part of the palette and finer ore on the upper part, which achieves high permeability

7) Segregation of raw materials on pellets

Description: Segregation and granulation reinforcement of raw materials on sintering pellets improve permeability and decrease return rate to sintering pellets, thus increasing productivity and saving energy.

Energy/environment/cost/other benefits:

- Effective in improving permeability and decrease return rate to sintering pellets
- Increases productivity and saves energy

8) Multi-slit burner in ignition furnace

Description: Multi-slit burners produce one wide, large stable flame, which eliminates “no flame” areas and supplies minimum heat input for ignition, therefore saving energy.

Energy/environment/cost/other benefits

- Total heat input for ignition was reduced by approximately 30% in Wakayama Steel Works of Sumitomo Metals in Japan

9) Equipment to reinforce granulation

Description: A high-speed mixer and a drum mixer are added to the conventional systems for producing granulated ore.

Energy/environment/cost/other benefits

- Reinforced granulation at Wakayama Steel works found:
 - Productivity increased from 34.7 to 38.3 t/day m²
 - Water content increased from 7.0 to 7.3%
 - Granulation rate increased by 45%
 - Permeability increased by 10%
 - Flame front speed increased by 10%
 - Return fine rate decreased less than 1%

10) Biomass for iron and steel making

Description: Biomass utilization practices for iron and steelmaking are being developed to replace coke breeze in the sintering process. Charcoal has been found to be an effective fuel and reductant as high rank coals for the bath smelting of iron ores and wood char has been shown to be a suitable replacement for coke breeze in the sintering process, resulting in process improvements and reduction of acid as levels in process emissions.

Energy/environment/cost/other benefits

- Substantial reductions in CO₂ emissions
- Reductions in acid gas emissions
- Improved carburization rates and increased product quality
- Reduced demand for fluxing agents
- Lower slag volume and levels of process wastes
- Higher productivity through use of more reactive carbon

11) Coke ovens

Coke dry quenching

Description: Coke dry quenching is an alternative to the traditional wet quenching of the coke. It reduces dust emissions, improves the working climate, and recovers the sensible heat of the coke. Hot coke from the coke oven is cooled in specially designed refractory lined steel cooling chambers by counter-currently circulating an inert gas media in a closed circuit consisting of a cooling chamber, a dust collecting bunker, a waste heat boiler, dust cyclones, a mill fan, a blowing device (to introduce the cold air from the bottom) and circulating ducts. Dry coke quenching is typically implemented as an environmental control technology. Various systems are used in Brazil, Finland, Germany, Japan, India and Taiwan, but all essentially recover the heat in a vessel where the coke is quenched with an inert gas (nitrogen). The heat is used to produce steam, which may be used on-site or to generate electricity.

Dry Coke Quenching - CDM Benefits

As described in the TGM, sensible heat of hot coke is lost in wet quenching as steam. In dry quenching, this can be used to produce steam in waste heat recovery boilers and then can be used to produce electricity. Such energy conservation projects are permitted to be taken as CDM projects, where Certified Emission Reduction (CERs) will be issued by UNFCCC to encourage such voluntary energy conservation efforts. CERs can be traded in the international market at the prevailing market rate of carbon (carbon trading). Each CER is issued for saving 1 t of CO₂ emission, directly or indirectly. For CDQ projects, the CO₂ reduction is indirect, as it will replace power needs from grid and therefore burning of coal and consequently emission of CO₂ at the grid connected power plants, which is a predominant fuel in Indian power sector. The project activity contributes significantly to the sustainable development in the following ways:

- Reclaim the sensible heat of red coke, improve the quality of coke, reduce the air pollution caused by the traditional wet quenching, increase the energy utilization efficiency, reduce the energy loss and protect environment
- Prevent the dust pollution caused by the general wet quenching technology
- Reduce the rely on fossil fuel
- Reduce the pollution emission caused by burning fossil fuel
- Reduce the greenhouse gas emission caused by burning the fossil fuel
- Reduce the demand from the power grid, thus mitigate the electricity shortage
- Provide working opportunity for local residents and increase their income

Energy/environment/cost/other benefits

- Energy recovered is approximately 400-500 kg steam/T, equivalent to 800-1200 MJ/T coke. Others estimate energy conservation through steam generation (0.48T/T coke) for Electricity generation.
- New plant costs are estimated to be \$50/T coke, based on the construction costs of a recently built plant in Germany; retrofit capital costs depend strongly on the lay-out of the coke plant and can be very high, up to \$70 to \$90/GJ saved
- Decreased dust, CO₂ and SO_x emissions
- Increased water efficiency
- Better quality coke produced, improved strength of coke by 4%

Pollution problems from the by-product recovery type coke ovens

- The gaseous emissions from the coke ovens during the coking process are drawn off and are subjected to various operations for separating ammonia, coke oven gas, tar, phenol, light oil (benzene, toluene, and xylene), and pyridine. After separation, these gases become a potential energy source for other areas of the steel plant. However, if the coke oven gas is not desulphurized, the combustion process will emit SO₂.
- The cleaned coke oven gases are taken to a by-product plant for extraction of by-products. The major solid wastes and by products generated are tar, ammonia products, sulphur, light oil, ammonia still sludge and sludge from the biological treatment plant.
- Waste water generated in the by-product plant is mostly treated by biological processes.

- In case of by-product recovery type coke ovens, USEPA developed a model treatment process which mixes benzol plant waste waters, naphthalene crystallizer blow down, and final cooler blow down and are treated with waste pickle liquor. This effluent is combined with other by-product plant wastewaters and treated with lime in ammonia still to remove both free and fixed ammonia. The ammonia recovered from the still is injected into the coke oven gas stream. The pH of the effluent is lowered by addition of acid and treated in a two stage biological reactor with sludge recycle.

Waste minimization and pollution prevention opportunities in by-products plant:

- Usage of caustic soda rather than lime in the ammonia still; though more costly, it minimizes sludge formation, reduces down time due to scaling problems, and may solve disposal problems.
- Indirect cooling of the coke oven gas to eliminate any contact of the process water with pollutants in the coke oven gas with the exception of flushing liquor.
- Elimination of the recovery of naphthalene and the naphthalene sump.
- The use of an indirect type system for light oil recovery eliminates process wastewater streams since no water comes into contact with the gas, the wash oil, the light oil or the final cooler.
- All pumping stations, oil storage tanks and oil transfer points should be located on impervious, dyked pads with the pad effluent directed to the waste ammonia liquor steam for treatment in order to prevent contamination of ground water.
- Wet oxidation sulphur removal processes for coke oven gas has created highly contaminated waste water streams. Alternative processes like Zimpro Modified Wet Air Oxidation Process, the Dofasco Fixed Salts Recovery Process, or the Nippon Steel HIROHAX process exists.
- Tar by products should be recycled in-plant after processing (*e.g.*, for use as a fuel) or sold as a by-product.
- Sludge generated by the biological treatment system can be recycled to the coke oven.
- Tar decanter sludge can be circulated through a solvent grinding pump and then sprayed onto the coal prior to charging into oven.

12) Coal moisture control

Description: Coal moisture control uses the waste heat from the coke oven gas to dry the coal used for coke making. The moisture content of coal varies, but it is generally around 8-9% for good coking coal. Drying further reduces the coal moisture content to a constant 3-5%, which in turn reduces fuel consumption in the coke oven. The coal can be dried using the heat content of the coke oven gas or other waste heat sources.

Energy/environment/cost/other benefits:

- Fuel savings of approximately 0.3 GJ/T 8, 9
- Coal moisture control costs for a plant in Japan were \$21.9/T of steel
- Coke quality improvement (about 1.7%)
- Coke production increase (about 10%)
- Shorter cooking times
- Decrease in water pollution (ammonia reduction)

13) High pressure ammonia liquor aspiration system

Description: The High Pressure Ammonia Liquor Aspiration System (HPALA) is effective for controlling charging emissions in coke oven batteries. In this system, the ammoniacal liquor, which is a byproduct in the coke oven, is pressurized to about 35-40 bar and injected through special nozzles provided in the gooseneck at the time of charging. This creates sufficient suction inside the oven, thereby retaining pollutants from being released into the atmosphere. The system consists of high-pressure multistage booster pumps, sturdy pipe-work, specially designed spray nozzles, suitable valves and control instruments.

Energy/environment/cost/other benefits

- Emissions control
- High reliability and simplicity of operation
- Low operational and maintenance costs
- Appreciable saving in quantity of process steam required and increased raw gas yield/byproducts generation, due to elimination of gases vented into the atmosphere

14) Modern leak-proof door

Description: Coke oven leaking doors can be a major source of pollution. With the advent of recovery type ovens, the design of oven doors has gone through a process of evolution, beginning from luted doors to the present generation self-regulating zero-leak doors. The important features of the leak-proof door include: (1) a thin stainless steel diaphragm with a knife edge as a sealing frame built in between the door body and the brick retainer, (2) spring loaded regulation on the knife edge for self-sealing, (3) provision for air cooling of the door body, and (4) large size gas canals for easier circulation of gas inside oven.

Energy/environment/cost/other benefits

- Minimization of door leakage
- Regulation free operation
- Longer life due to less warping of the air cooled door body
- Reduced maintenance frequency
- Conventional doors can be replaced by leak-proof doors without altering battery/door frame design

15) Land-based pushing emission control system

Description: The smoke and fumes produced during the pushing of red hot coke contains a huge amount of coke dust (estimated at 11% of the total pollution in the coke oven). Land based pushing emission control systems mitigate this pollution. It consists of three parts: (1) a large gas suction hood fixed on the coke guide car and moving with the coke guide, sending fumes to the coke side dust collecting duct; (2) the dust collection duct; and (3) the final equipment for smoke purification on the ground (ground piping, accumulator cooler, pulse bag dust collector, silencer, ventilation unit, stack, etc). The large amount of paroxysmal high-temperature smoke produced during coke discharging is collected under the hot float fan into the large gas suction hood installed in the coke guide car, and enters the dust collection duct through the other equipment. The air is dissipated into the atmosphere after purification by the pulse dust collector and after being cooled by the accumulator cooler. The total de-dusting system is controlled by PLC.

Energy/environment/cost/other benefits

- Elimination of pushing emission up to the large extent

16) Iron making**Blast Furnace Iron making****Top pressure recovery turbine**

Description: Top pressure recovery turbine (TRT) is a power generation system, which converts the physical energy of high-pressure blast furnace top gas into electricity by using an expansion turbine. Although the pressure difference is low, the large gas volumes make the recovery economically feasible. The key technology of TRT is to secure the stable and high-efficiency operation of the expansion turbine in dusty blast gas conditions, without harming the blast furnace operation.

Energy/environment/cost/other benefits

- Generates electric power of approximately 40-60 kWh/T pig iron
- Japanese Integrated Steel Works:
 - Generates more than 8% of electricity consumed in Japanese ironworks (about 3.33 TWh)
- Excellent operational reliability, abrasion resistant
- Suitable for larger furnaces and higher temperature gases compared to Bag filter systems
- Wet TRT System (US):
 - Typical investments of about \$20/T power recovery of 30 kWh/T hot metal
 - No combustion of BF gas
- Dry TRT System, e.g., Venturi Scrubber- Electrostatic Space Clear Super (VS-ECS):
 - Lower water consumption compared with wet type
 - Raises turbine inlet temperature, increasing power

17) Pulverized coal injection (PCI) system

Description: PCI replaces part of the coke used to fuel the chemical reaction, reducing coke production, thus saving energy. The increased fuel injection requires energy from oxygen injection, coal, and electricity and equipment to grind coal. The coal replaces the coke, but coke is still used as a support material in the blast furnace. The maximum injection depends on the geometry of the BF and impact on the iron quality (e.g., sulphur).

Energy/environment/cost/other benefits

- Reduces emissions of coke ovens
- Increased costs of oxygen injection and maintenance of BF and coal grinding equipment offset by lower maintenance costs of existing coke batteries and/or reduced coke purchase costs, yielding a net decrease in operating and maintenance costs, estimated to be \$15/T, but a cost savings of up to \$33/T are possible, resulting in a net reduction of 4.6% of costs of hot metal production

- Decreased frequency of BF relining
- Improved cost competitiveness with cost reduction of hot metal
- Investment of coal grinding equipment estimated at \$50-55/T coal injected
- High reliability and easy operation
- Increased productivity
- Uniform transfer of pulverized coal
- No moving parts in injection equipment
- Even distribution to Tuyeres

18) Blast Furnace Heat Recuperation

Description: Recuperation systems, *e.g.*, Hot Blast Stove, BFG Preheating System, *etc.*, are used to heat the combustion air of the blast furnace. The exit temperature of the flue gases, approximately 250°C, can be recovered to preheat the combustion air of the stoves.

Energy/environment/cost/other benefits

- Hot blast stove
 - Fuel savings vary between 80-85 MJ/T hot metal
 - Costs are high and depend strongly on the size of the BF, estimated at \$18-20/(GJ saved), equivalent to \$1.4/T hot metal
 - Efficient hot blast stove can run without natural gas
- BFG Preheating System at POSCO in Korea:
 - Anti-corrosion technology with high surface temperatures
 - Economic recovery for low to medium temperature grade heat
 - 102 kcal/kWh reduction in fuel input; thermal efficiency increase of 3.3%
 - Energy savings of 3-5% for boiler, with payback period of within 1.5 years
 - Proven reliability and stability for more than 10 years of operation

19) Improve blast furnace charge distribution

Description: Charging systems of old blast furnaces and new blast furnaces are being retrofitted or equipped with the Paul Wurth Bell Less Top (BLT) charging systems. Input materials like coke and sinter are screened before charging. Proper distribution of input materials improves the coking rate and increases production.

Energy/environment/cost/other benefits

- Increased fuel efficiency
- Reduced emissions
- Increased productivity
- Improved coking rate

20) Blast furnace gas and cast house dedusting

Description: When blast furnace gas leaves the top of the furnace it contains dust particles. Dust particles are removed either with a conventional wet type dedusting system or a dry type dedusting system. Both systems consist of a gravity dust catcher to remove dry large particulate from the BFG stream. The wet fine particulate is then removed in wet type dedusting with a two stage Venturi or Bisholff scrubber, whilst dry type

dedusting does not require water scrubbing and instead employs an electro-precipitator or a bag filter to clean the BFG.

Energy/environment/cost/other benefits

- Dust catcher removes about 60% of particulate from BFG
- Wet Type Dedusting:
 - Produces gas containing less than 0.05 grams/m³ of particulate
 - Pressure and noise control devices not necessary
- Dry Type Dedusting:
 - 30% increase in power generated with dry-type TRT system compared to wet type dedusting
 - 7-9 Nm³/T HM reduction in recirculated water consumption, of which 0.2m³ is fresh water
 - Eliminates generation of polluted water and slurry
 - Improved gas cleanness with dust content of <5mg/Nm³
 - 50% less occupied land area than wet type dedusting
 - Minimized investment cost and accelerates project construction, as only accounts for 70% in investment compared to wet type dedusting

21) Cast house dust suppression

Description: The primary source of blast furnace particulate emissions occurs during casting. Molten iron and slag emit smoke and heat while traveling from the taphole to ladle, or the slag granulator to pit. The cast house dust suppression system is designed to contain emissions. “Dirty” air is drawn through the baghouse, which contains separate collection chambers each with a suction fan, and is then exhausted into the atmosphere. The system has multiple collection hoods: overhead hoods above each taphole and skimmer, and below-floor hoods above each tilting spout.

Energy/environment/cost/other benefits

- Individual baghouse collection chambers can be shut down without affecting operation

22) Direct iron making

Smelting Reduction Processes

Description: Smelting reduction processes, including Aumelt Ausiron®, HIsmelt®, CCF, DIOS and COREX, involve the pre-reduction of iron ore by gases coming from a hot bath. The pre-reduced iron is then melted in the bath, and the excess gas produced is used for power generation, production of direct reduced iron (an alternative iron input for scrap), or as fuel gas. In this way, smelting reduction eliminates the need for coke and sintering, and future processes will also eliminate ore preparation.

Energy/environment/cost/other benefits:

- Low capital and operating costs:
 - 5-35% below production cost of conventional route
 - Direct use of iron ore fines/steel plant dusts and thermal coals
 - No coke ovens, sinter plants, blending yards

- Single furnace with direct waste energy recovery
- Low environmental impact:
 - No coke-oven or sinter plant emissions, and reduced CO₂, SO₂ and NO_x, no production of dioxins, furans, tars or phenols
 - Recycling of steel plant dusts and slag, making effective uses of coal energy
- High quality iron product, with impurities reported to the slag not the metal
- Greater flexibility in the range of raw materials accepted, including steel plant wastes and high phosphorous ores

23) Direct reduction processes

Description: Direct reduced iron (DRI) is produced through the reduction of iron ore pellets below the melting point of the iron. This is achieved with either natural gas (MIDREX® process) or coal-based (FASTMET® process) reducing agents. The DRI produced is mainly used as a high quality iron input in electric arc furnace (EAF) plants.

Energy/environment/cost/other benefits

- Pre-treatment of raw material not necessary
- Eliminates coke oven
- Low capital and operating costs
- FASTMET® Process:
 - Faster speed and lower temperatures for reduction reaction
 - Fuel usage can be reduced; not necessary to recover and reuse exhaust gases as secondary combustion of close to 100% is achieved in the rotary hearth furnace
 - Low heat loss, as reduced iron is fed to the melting furnace for hot metal production without cooling
 - Low emissions – 0.3-1.5 kg/THM NO_x, 2.4 kg/THM SO_x, and 0.3 kg/THM PM10 (-particulate matter less than 10.0 microns in diameter)
 - Energy consumption is 12.3 GJ/T-hot metal less than mini blast furnace; CO₂ is reduced by 1241 kg/T hot metal

24) Corex process

The chief source of metallic iron today, globally, is through Blast furnace, as the technology is most established, energy efficient, and versatile both technologically and economically. However, due to metallurgical coal to produce BF grade coke, and setting up of coke ovens which pollutes the environment with its NO_x and SO_x emissions, and rigid quality BF has become highly capital intensive. The economic, environmental and cost pressures led to the development of Smelting-Reduction processes like COREX, ROMELT, HISMELT, DIOS, AUSMELT *etc.* COREX is the only Smelting-Reduction process so far commercialized and in India has been adopted by Jindal Vidyanagar Steel Limited.

COREX consists of two reactors, the reduction shaft to produce DRI and the melter-gasifier to produce hot metal. The reduction shaft is placed above the melter-gasifier and reduced iron bearing material descends by gravity. The hot DRI at around 600-800°C along with partially calcined limestone and dolomite are continuously fed into the melter-gasifier through DRI down pipes. The hot metal and slag are collected in the hearth. The stable and highly successful operation of four COREX plants (POSCO, Korea, JVSL, India, SALDANHA, South Africa) confirms that COREX process is a proven and viable alternative to conventional blast furnace technology.

Thus in COREX, liquid hot metal is produced from DRI, whereas in Sponge Iron plants solid DRI in the form of sponge iron is produced.

25) Steel making

Electrochemical dezincing – dezincing of steel scrap improves recycling

Description: This electrochemical dezincing process provides an environmentally friendly economic method of removing zinc from steel scrap to reuse both the steel and zinc. With the use of zinc-coated scrap increasing, steelmakers are feeling the effect of increased contaminant loads on their operations. The greatest concerns are the cost of treatment before disposal of waste dusts and the water associated with remelting zinc-coated scrap. This technology separates steel scrap into dezincing steel scrap and metallic zinc in two basic steps:

- dissolving the zinc coating from scrap in a hot, caustic solution, and
- recovering the zinc from the solution electrolytically. Through a galvanic process, the zinc is removed from the steel and is in solution as sodium zincate ions rather than zinc dust. The steel is then rinsed with water and ready for reuse. Impurities are removed from the zinc solution, and then a voltage is applied in order to grow metallic zinc via an oxidation-reduction reaction. All waste streams in this process are reused.

Energy/environment/cost/other benefits

- The removal of zinc from steel scrap increases the recycleability of the underlying steel, decreases steelmaking dust, and decreases zinc in waste-water streams.
- Reduction of steelmaking dust to air and wastewater streams
- Removing zinc prior to processing of scrap saves time and money in disposal of waste dusts and water; without the zinc, this high quality scrap does not require extra handling, blending or sorting for remelting in steelmaking furnaces
- Improves the quality of steel scrap
- Produces 99.8% pure zinc for resale

26) BOF steelmaking

Increase thermal efficiency by using BOF exhaust gas as fuel

Description: BOF gas and sensible heat recovery (suppressed combustion) is the single most energy-saving process improvement in this process step, making the BOF process a net energy producer. By reducing the amount of air entering over the converter, the CO is not converted to CO₂. The sensible heat of the off-gas is first recovered in a waste heat boiler, generating high-pressure steam. The gas is cleaned and recovered.

Energy/environment/cost/other benefits

- Energy savings vary between 535 and 916 MJ/T steel, depends on the way in which the steam is recovered; with increased power of 2 kWh/T the total primary energy savings is 136%
- CO₂ reduction of 12.55 kg C per tonne crude steel
- \$20 per tonne crude steel investment costs and increased operations and maintenance costs

- Significant reduction of CO and PM emissions, as well as dust which can be recycled in the sinter or steel plant

27) Use enclosures for BOF

Description: BOF enclosures operate by covering mixer shop filling, mixer pouring, de-slagging station, converter charging, converter tapping and bulk material handling system on BOF top platform. On the charging top side, a dog house enclosure captures secondary fumes generated during charging. Rectangular high pick-up velocity suction hoods above charging side are connected to duct lines below the operating platform. Suction hoods capture dust during tapping operations above the receiving ladle. Deflector plates guide fumes towards suction hoods. Below the operating platform is a header duct that connects to a centralized fume extraction system of electrostatic precipitators, fans and a stack. Capacity varies between 1,000,000 m³/h to 2,600,000 m³/h, depending on heat capacity and operating sequence. Space can sometimes be a limited factor for this technology.

Energy/environment/cost/other benefits

- Better working conditions in terms of temperature and dust control
- Visibility of steel making operation and safety improves
- Accumulation of dust over building roofs can be avoided
- Collected dust can be recycled in steel plant

28) Control and automatization of converter operation

Description: As converters have become larger, operational control and automatic operation have been promoted with various advantages, which are discussed below. Along with the advancement of processing computers and peripheral measuring technology, blowing control for converters has shifted from a static control system to a dynamic or fully automatic operational control system. Indirect measurement of the exhausted gas method is employed in Europe and the United States, whereas direct measurement by the sublance method – direct measurement of the temperature of molten steel simultaneously during blowing – is employed in Japan. Sublance is used for bath leveling, slag leveling, measurement of oxygen concentration and slag sampling.

Energy/environment/cost/other benefits

- Increase productivity and product quality
- Decreased labor
- Improved working environment

29) OG-boiler system (non-combustion)/dry-type cyclone dust catcher

Description: Since steel refining is conducted in a short period of time, about 35 minutes per charge, the dust concentration is very high. In non-combustion-type converters with a gas recovery function, the dust concentration is 70-80g/m³N at the inlet of the first dedusting device. Non-combustion-type converters, without combusting CO gas, manage the volume of intake air from the throat, and control the concentration to below the explosion limit, thereby recovering CO as fuel. Exhaust gas treatment consists of an exhaust gas cooling system and a cleaning system. Non-combustion-type systems can be largely divided into the OG-type and the IC (IRSIDCAFL) type. The OG-type system basically has no space between the throat and the hood skirt, and controls pressure at the closed throat. The IC-type system has a gap of several hundred millimeters between the

throat and the hood skirt (which has a slightly larger diameter than that of the throat), and controls pressure at the throat opening. The non-combustion type system keeps gas temperature low and shuts out combustion air; therefore, the cooling device and dedusting device installed in the system are smaller than those installed in the combustion-type system. Since the system handles gas that mainly consists of CO, attention is paid to sealing for the flux and coolant input hole and the lance hole, and leak control at the periphery of devices, as well as purge at the gas retention part.

As the volume of converters increases, exhaust gas treatment equipment becomes larger.

Large converters adopt the non-combustion-type system for various reasons, such as the relatively small size of the system as a whole, ease of maintenance, and stable dedusting efficiency. The OG-type system is frequently used because of its operational stability.

The OG-type cooling system makes it possible not only to recover the sensible heat of exhaust gas as steam, but also to increase the IDF efficiency by lowering the temperature of the exhaust gas by use of a cooling device.

Energy/environment/cost/other benefits

- OG-boiler system recovers 65% of the sensible heat of the total exhaust gas, about 70 kg/T
- Increases the IDF efficiency by lowering the temperature of the exhaust gas, achieving high-speed oxygen feeding

30) Casting - Castrip® technology

Description: The Castrip® process has been developed to allow the direct casting of thin strip from liquid steel, in gauges currently ranging from 0.8mm to 2.0 mm.

Energy/environment/cost/other benefits

- Potential energy savings of 80 to 90% over conventional slab casting and hot rolling methods
- More tolerant of high residual elements without loss of quality, enabling greater flexibility in ferrous feed sourcing
- Higher scrap recycling rates potential and less dependence on pig iron and HBI

31) Reducing fresh water use

Description: To reduce steel works dependence on fresh water, the following efforts have been made at Port Kembla Steelworks, Australia:

- Municipal waste-water reclamation – The treatment of sewerage water using microfiltration and reverse osmosis technology for re-use as industrial water, up to 20 ML/day
- Internal waste-water recycling schemes – Cooling tower blowdown water from the hot strip mill and slab casters does not go to the drain, but is treated and reused for dust collection in steelmaking
- Stormwater containment initiatives – 13ML synthetic lined water recovery basin in coke ovens area collects rainwater, coal stockpile run-off water, and spent water from coke quenching for re-use at gas processing and coke quenching

Energy/environment/cost/other benefits

- Using recycled sewerage water has reduced fresh dam water use on site by 20ML/day
- Hot strip mill and slab caster blowdown water saves steelmaking 0.5ML/day
- Recycling reduces fresh dam water use from 2.3kL/slab tonne to 1.0kL/slab tonne

32) Rotary hearth furnace dust recycling system

Description: Dust recycling in the rotary hearth furnace (RHF) was applied at Nippon Steel's Kimitsu Works in 2000. The dust and sludge, along with iron oxide and carbon, are agglomerated into shaped articles and the iron oxide is reduced at high temperatures. Zinc and other impurities in the dust and sludge are expelled and exhausted into off-gas.

Energy/environment/cost/other benefits

- DRI pellets made from the dust and sludge have 70% metallization and are strong enough to be recycled to the blast furnaces
- Waste reduction and decreased disposal costs
- Extended landfill life
- Recovery of unused resources (recycling iron, nickel, zinc, carbon, *etc.*)
- Increase in productivity: 1kg of DRI charged per tonne of BF smelt pig iron
- Decrease in fuel ratio to BF to 0.2kg/T-pig
- Decrease in coke ratio by charging DRI to BF

33) Activated carbon absorption

Description: Use of activated carbon to remove high pollutant concentrations has been proven successful in many cases. In coke making, activated carbon absorption system is used not only to eliminate the yellow brown color typical of coke wastewater (which may cause complaints from stakeholders) but also to reduce the COD of the secondary wastewater treatment plant.

Energy/environment/cost/other benefits

- Eliminate the yellow brown color of coke wastewater
- Significant reduction of COD of the secondary wastewater treatment plant to below 5 mg/l
- Heavy metals removal

34) Variable speed drives for flue gas control, pumps and fans

Description: Variable speed drives (VSDs) better match speed to load requirements for motor operations. VSD systems are offered by many suppliers and are available worldwide.

Energy/environment/cost/other benefits

- Based on experience in the UK:
 - Electricity savings of 42% are possible through the use of VSDs on pumps and fans
 - Payback of 3.4 years, assuming an electricity price of 3pence/kWh, under U.S. 1994 conditions
 - Costs of \$1.3/T product

35) Regenerative Burner

Description: A regenerative burner is a heat recovery system that recovers the waste heat of the furnace exhaust gas to heat-up the combustion air of the furnace. The regenerative burner uses heat reservoirs and dual heat-recovering generators at each burner to channel heat more efficiently. During combustion, one side of a burner combusts fuel while the other accumulates the exhaust heat into the heat-recovering generator. Then the burners switch so that the one accumulating heat combusts the fuel and the other now accumulates exhaust heat.

Energy/environment/cost/other benefits

- 20-50% of energy reduction possible, depending on types of furnace and condition of fuel
- Up to 50% NO_x reduction possible with high temperature combustion
- Excellent operational reliability, with introduction of regenerative burner systems in over 540 furnaces in various Japanese industries

36) Technology for Effective Use of Slag

- Description: Slag is a by-product of iron and steelmaking, not a waste. The fresh SMS slag absorbs moisture and expands. Thus its use for Road making and as rail ballast gets restricted unless it is matured. Slag which is already dumped outside and exposed to rain loses this characteristic and is useful if broken from large uneven lumps to required sizes by installing crushers at old dump sites. This is being practiced and SMS dump sites have started declining. However, the process needs to be made scientifically acceptable including the measures for control of leaching from the dumps.
- SMS slag is also partly used in blast furnaces as input/charging material.
- Fresh SMS slag, which is at 600-800°C can be directly pulverized in automatic pulverizers by spraying water on it. The water spray produces steam, which reacts with free calcium oxide and magnesium oxide. Consequently, the slag is pulverized due to the volume expansion, thus separating steel from slag, and steel falls through a chute. Pulverized slag is sucked through a slag separator by an exhaust fan and collected for use as road materials, construction and rail ballast.

Slag is also used for applications beyond steel making, *e.g.*, in water/bottom muck purification materials to reduce phosphate concentration in red tides and as marine block to help grow seaweed. Slag can be employed for various applications i.e.

- Converting slag as a purification catalyst can help restore ecosystems in water areas.
- In concrete and as a low-quality aggregate
- For land improvement
- In Japan, through an emerging technology, techniques for formation of carbonates of steel slag are under development. Carbonates of steel slag are formed when slag solidifies by absorbing CO₂ in a carbonation reactor. Then can be used as marine blocks, which help grow sea weeds. The process of carbonization of slag is shown in Figure.

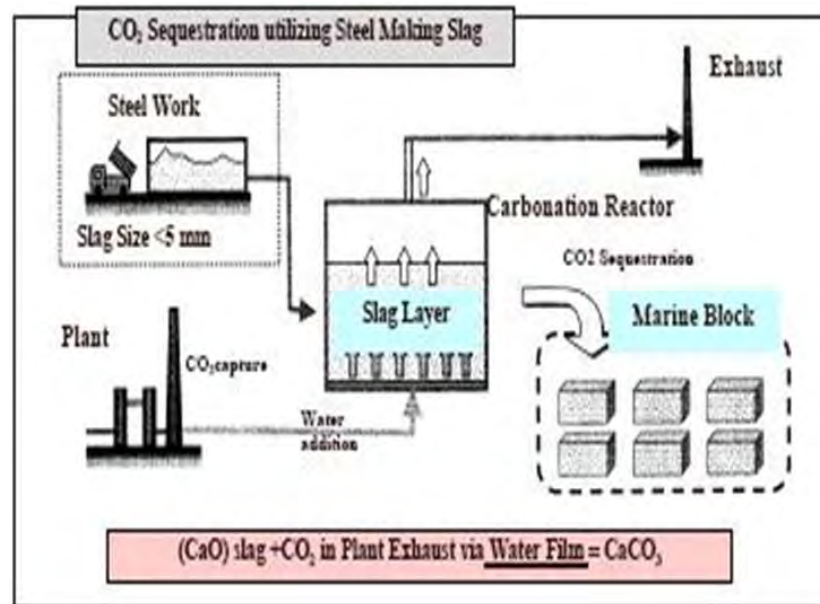


Figure 3-19: Carbonization of slag

Energy/environment/cost/other benefits

- Around 3.8 million t/year of scrap steel is recovered from slag produced
- Revenue generated is equivalent to 3.8 billion Yuan/year, based on 1,000 Yuan (\$130 2006 US)/T scrap steel
- Substitute for cement in building industry, thereby minimizing CO₂ emissions generated by cement production
- Land area occupied by piled slag minimized by slag reutilization
- Application of slag in Japan (marine block and water/bottom much purification materials)
 - Reduce phosphate concentration that causes red tide
 - Fix hydrogen sulphide (cause of blue tide)
 - Grow seaweed to restore lost shallows in seaweed beds
- Slag usage in marine applications is a new field with huge potential for shoreline improvement and restoration of lost shallows and seaweed beds
- Using BF slag in cement manufacturing helps to reduce energy use by eliminating granulation and heating [340 kg-CO₂/T slag]

Other applications include concrete aggregate, railroad ballast, agricultural use, sewage trickling filters, and construction.

37) Hydrogen production

Description: Coke oven gas (COG), a byproduct gas of the iron-making process, contains around 55% hydrogen. It is easy to produce hydrogen with high purity from COG by a very simple process called pressure swing adsorption (PSA). Significant efforts to recover sensible heat of COG as hydrogen enrichment are under way. Developing proper catalysts is the key to success.

Energy/environment/cost/other benefits:

- Hydrogen is expected to be an important energy carrier for fuel cells

- Because of its ease of production, its abundance, and its distribution, COG is one of the major candidates for a hydrogen source in the future

38) Carbonation of steel slag

Description: Carbonates of steel slag are formed when slag solidifies by absorbing CO₂. This sequesters the CO₂ in the slag, which can then be used in marine applications.

Energy/environment/cost/other benefits

- Steel slag carbonates can be used to make “marine blocks” which can improve the coastal environment by helping to grow seaweed [which improves sea surroundings]
- Marine blocks are also used for coral nursery beds, which may help to revive dead coral areas

3.6.1.2 Clean technologies in non-ferrous sector

Pollution prevention through clean technologies, whether through source material reduction/reuse, or waste recycling, is practiced in various sectors of the nonferrous metals industry. Pollution prevention techniques and processes currently used by the nonferrous metals industry can be grouped into the following general categories:

- Process equipment modification
- Raw materials substitution or elimination
- Solvent recycling
- Precious metals recovery

It is interesting to note that while the stated rationale for the use of many of these techniques or processes is applicable environmental regulations; their use is both fairly universal and profitable.

Process equipment modification is used to reduce the amount of waste generated. Many copper, lead, and zinc refiners have modified their production processes by installing sulphur fixation equipment. This equipment not only captures the sulphur before it enters the atmosphere, but also processes it so that a marketable sulphuric acid is produced. Another example is the use of pre-baked anodes in primary aluminum refining. When a pre-baked anode is used, the electrolytic cell, or pot, can be closed, thereby increasing the efficiency of the collection of fluoride emissions. In addition, new carbon liners have been developed which significantly increase the life of the aluminum reduction cell. This has resulted in large reductions in the amount of spent pot liner material generated by the aluminum industry.

Raw material substitution or elimination is the replacement of raw materials with other materials that produce less waste, or a non-toxic waste. Material substitution is inherent in the secondary nonferrous metals industry primarily by substituting scrap metal, slag, and baghouse dust for ore feedstock. All of these materials, whether in the form of aluminum beverage cans, copper scrap, or lead-acid batteries, are commonly added to other feedstock or charges (usually slag containing residual metals) to produce marketable grades of metal. Primary nonferrous metals refining also uses previously refined metals as feedstock, especially zinc-containing electric arc furnace dust (a by-product of the iron and steel industry).

Precious metals recovery is the modification of a refining process to allow the capture of marketable precious metals such as gold and silver. Like sulphur fixation, precious

metals recovery is a common waste minimization practice. During primary copper smelting, appreciable amounts of silver and gold present in copper ore will be concentrated into the anode copper and can be recovered as a by-product in the electro-refining process (as the copper anode is electrochemically dissolved and the copper attaches itself to the cathode, silver and gold drop out and are captured in the slime at the bottom of the tank). In the lead refining process the copper often present in lead ore is removed during the initial lead bullion smelting process as a constituent of dross. Silver and gold are removed from the lead bullion later in the process by adding certain fluxes which cause them to form an impure alloy. The alloy is then refined electrolytically and separated into gold and silver. Precious metals recovery also takes place during zinc refining to separate out copper, a frequent impurity in zinc ore. Copper is removed from the zinc ore during the zinc purification process (after zinc undergoes leaching, zinc dust is added which forces many of the deleterious elements to drop out; copper is recovered in a cake form and sent for refining).

Important pollution prevention case studies

Various pollution prevention case histories have been documented for nonferrous metals refining industries. In particular, the actions of the AMPCO Metal Manufacturing Company, Inc. typify industry efforts to simultaneously lessen the impact of the industrial process on the environment, reduce energy consumption, and lower production costs.

(i) AMPCO Metal Manufacturing Company, Inc., in Ohio is participating in the development of pollution prevention technologies. The project, sponsored by the U.S. DOE and EPA, consists of researching and developing the use of electric induction to replace fossil fuel combustion currently used to heat tundishes. Tundishes are used to contain the heated reservoir of molten alloy in the bar stock casting process. The fossil fuel combustion processes currently used requires huge amounts of energy and produces tremendous amounts of waste gases, including combustion bases and lead and nickel emissions. According to new OSHA regulations, lead emissions from foundries must be reduced by 80 % by 1998.

Heating the tundish by electric induction instead of fossil fuel combustion will substantially improve the current process, saving energy and reducing pollution. Energy efficiency will jump to an estimated 98 %, saving 28.9 billion Btu/yr/unit. Industry-wide energy savings in 2010 are estimated to be 206 billion Btu/yr, assuming a 70 % adoption at U.S. foundries.

In addition to the energy savings, the new process also has substantial environmental benefits. Along with the elimination of lead and nickel gases, carbon dioxide, carbon monoxide, and nitrogen oxide emissions from combustion will decrease. The consumption of refractory (a heat-resisting ceramic material) will decline by 80 %, resulting in a similar reduction of refractory waste disposal. In all, prevention of various forms of pollution is estimated to be 147 million lb (66.7 million kg)/yr by 2010.

(ii) In an experiment at NML, Jamshedpur, the whole mass of battery scrap was washed with water with a view to remove the sulphuric acid and then with a concentrated solution of soda ash at the ambient temperature in order to remove the sulphur. The temperature of the smelting zone was around 1250 to 13000 C and lead was trapped periodically. To control pollution, the pilot plant was provided with a suction point at the top of the furnace and a hood to capture tapping emissions and connected to a exhaust fan through a 1st stage dust catcher and a bag filter. This was to capture lead dust. In another

experiment, a Flue Gas Desulphurization plant was provided with activated carbon for adsorbing lead and lime scrubber to catch SO₂. Lead recovery of 86.5% was obtained.

Economically, the elimination of lead and nickel emissions will result in an improved product because exposure of the metal to combustion gases in the current process results in porosity and entrainment of hydrogen gas in the metal. Overall, AMPCO estimates an annual savings in operations and maintenance expenses of \$1.2 million with the use of this technology. Assuming the same 70 % industry adoption, economic savings by 2010 could reach \$5.8 million. Without the new electric induction heating process, the capital costs required for compliance could be \$3 million.

3.6.2 Pollution control technologies

The following tables indicate existing management system v/s clean technology requirements for aluminum industry and steel industry.

Table 3-22: Existing Management System v/s Requirements for Steel Industry

Technologies/Current Practices	Requirements
<p>Coke Oven</p> <p>In coke ovens the volatile materials released during cooking flows from the oven to the by-product plants where ammonia, benzol, xylene, toluene, tar, pitch and tar acids are recovered. The operations are associated with fugitive and stack emissions. The PAH compounds released during coking operation as fugitive emissions are carcinogenic in nature. The technologies available to control the pollution are</p> <ul style="list-style-type: none"> ▪ HPLA system ▪ Hydraulic door and door frame cleaner ▪ Doors with double knife edge and rope sealing ▪ Water sealed AP caps ▪ Screw feeder 	<ul style="list-style-type: none"> ▪ Land based pushing and charging emission control with dust extraction system ▪ Automation for process operations ▪ Self sealing air cooled doors ▪ Possibility of coke dry quenching needs to be tried out ▪ Effluent treatment plant to treat cyanide, phenol, ammonia, COD <i>etc.</i> ▪ Hazardous waste (tar sludge and ETP sludge) handling and disposal following Hazardous Waste Handling, Rules; or, tar sludge / ETP sludge charging along with the coal fines in the coke ovens
<p>Sintering Plant</p> <ul style="list-style-type: none"> ▪ ESP / bag filter / wet scrubber for process emissions ▪ ESP / bag filter / wet scrubber for work zone environment 	<ul style="list-style-type: none"> ▪ ESP / bag filters with higher efficiency of removal for process emissions. ▪ System for removal of SO₂, NO_x, dioxins and furans.
<p>Thermal Power Plant</p> <ul style="list-style-type: none"> ▪ ESP for the emissions 	<ul style="list-style-type: none"> ▪ Proper management and utilization of fly ash
<p>Steel Melting Shop</p> <ul style="list-style-type: none"> ▪ Suppressed combustion system ▪ ESP/ bag filter wet scrubber for the process emissions ▪ Effluent treatment comprising settling unit and re-circulation system for the treated effluent 	<ul style="list-style-type: none"> ▪ Proper operation and maintenance of air emission control and effluent treatment systems. ▪ Secondary ventilation systems to control charging and tapping fugitive emissions. ▪ Collection of BOF gas for use as fuel. BOF slag processing for better acceptance

Technologies/Current Practices	Requirements
Blast Furnace <ul style="list-style-type: none"> ESP / bag filter / wet scrubber for controlling cast house air emissions 	<ul style="list-style-type: none"> Proper operation and maintenance of ESP / bag filter / wet scrubber for air emissions Cast house BF slag granulation Utilization Coal dust injection High top pressure BF with TRT
Lime / dolomite plant <ul style="list-style-type: none"> ESP bag filter / multiclones for process and work zone dust emissions 	<ul style="list-style-type: none"> Effective operation and maintenance of ESP / bag filter / multiclones for process and work zone dust emissions High efficiency kilns
Mills <ul style="list-style-type: none"> Oil & Grease traps and settling tanks for waste water treatment 	<ul style="list-style-type: none"> API separators and settling tanks for wastewater treatment Use regenerative burners Hot charging of slab
Raw material handling units <ul style="list-style-type: none"> Enclosures and water sprinkling system 	<ul style="list-style-type: none"> Improvements in the systems for controlling fugitive emissions. Processing of dust and sludge for reuse

Source: CPCB/APPD Handbook on Steel

The methods or technologies or equipments used to control and treatment of other metallurgical industries are as shown in table below.

Table 3-23: Existing Management System v/s Requirements for Aluminum Industry

Existing Management System	Requirements
Red Mud : a) Wet disposal : In this method, washed red mud slurry containing 10 – 30% solids is pumped to the pond.	Dry disposal in secured land fill, as dry disposal requires much less space(1/3 to 1/5 of Wet disposal) and less seepage is expected.
b) Dry disposal : In this method, the red mud disposed contains 30 – 50% moisture and also known as thickened tailing disposal	
Spent Pot Lining : a) Fluoride recovery followed by use as fuel. b) Disposal in secured landfill to avoid leakage of fluoride and cyanide.	a) Fluoride recovery followed by reuse for carbon portion (Impact of such reuses need to be investigated). b) Disposal in secured landfill for refractory portion.
Fluoride emission : a) Dry scrubbing (using alumina): By this most of the fluoride is recycled into the system. b) Wet scrubbing. This causes water pollution. The treatment of water pollutants results in generation of solid waste (calcium fluoride).	Dry scrubbing, as this helps in recycling fluoride and also there is no water pollution.

Source: CPCB

Table 3-24: Required Management System for Other Non-Ferrous Industry

Nickel	
Flash smelting	Control of sulphur dioxide emissions
Impervious clothing	To protect workers against contact of liquid nickel carbonyl.
Encapsulation of furnaces and conveyors	To prevent emissions of particulate matter.
Cyclones followed by wet scrubbers, ESPs, or bag filters	To control discharge of particulate matter
Fabric filters	To reduction of gas temperature
Mini Steel	
Improving feed quality	Reduces the pollutants
Fabric filters	Dry dust collection
Cyclones, baghouses, and electrostatic precipitators (ESPs). Scrubbers	Dust emission control
Lead and zinc	
Oxidizing scrubber	Reduces NO _x
Adsorption by activated carbon	Reduces dust and acid mist
Alkali scrubber (semi -dry and fabric filter, wet scrubber or double alkali using lime, magnesium hydroxide, sodium hydroxide).	Reduces SO ₂
Fabric filter	Reduces dust
Copper	
Fabric filter with lime injection	Reduces SO ₂
Fabric filter	Reduces dust
Adsorption by activated carbon	Reduces dioxin
Scrubber	Reduces acid mist

Table 3-26: Comparison of New Technologies for Pollution Control

S.No.	Standard Technology	Alternative Technology
1	<p>Coke Making:</p> <p>Coke Oven batteries from small to large sizes (up to 7.5m battery). Coking coal charged from top. Alternate batteries fired with coke oven gas or mixed gas. Coking time: 17.5 hrs.</p>	<p>Super Coke Oven For Productivity and Environmental Enhancement towards the 21st Century (SCOPE21), established through a ten year national program in Japan, replaces existing coke ovens with a new process that expands upon the previous choices for coal sources, while increasing productivity, decreasing environmental pollution, and increasing energy efficiency compared to the conventional coke making process.</p> <p>SCOPE21 has three sub-processes: (1) rapid</p>

S.No.	Standard Technology	Alternative Technology
		<p>preheating of the coal charge, (2) rapid carbonization, and (3) further heating of coke carbonized up to medium temperatures. The aim of dividing the whole process into three is to make full use of the function of each process in order to maximize the total process efficiency.</p> <p>Energy/Environment/Cost/Other Benefits:</p> <ul style="list-style-type: none"> • Improved coke strength; Drum Index increased by 2.5 (DI150) over conventional coking • Reduced coking time from 17.5 hours to 7.4 hours • Increased potential use of poor coking coal from 20 to 50% • Productivity increased 2.4 times • NO_x content reduced by 30% • No smoke and no dust • Energy consumption reduced by 21% <p>• Reduction in production cost by 18% and construction cost by 16%</p> <p>Coke dry quenching is an alternative to the traditional wet quenching of the coke. It reduces dust emissions, improves the working climate, and recovers the sensible heat of the coke. Hot coke from the coke oven is cooled in specially designed refractory lined steel cooling chambers by counter-currently circulating an inert gas media in a closed circuit consisting of a cooling chamber, dust collecting bunker, a waste heat boiler, dust cyclones, a mill fan, a blowing device (to introduce the cold air from the bottom) and circulating ducts. Dry coke quenching is typically implemented as an environmental control technology. Various systems are used in Brazil, Finland, Germany, Japan and Taiwan, but all essentially recover the heat in a vessel where the coke is quenched with an inert gas (nitrogen). The heat is used to produce steam, which may be used on-site or to generate electricity.</p>
	<p>Coke Quenching:</p> <p>Wet in old plants; red hot coke cooled with water in Quenching Tower; effluents cleaned and reused; emission of carcinogenic pollutants possible if phenolic water used for quenching.</p>	<p>Energy/Environment/Cost/Other Benefits:</p> <ul style="list-style-type: none"> • Energy recovered is approximately 400-500 kg steam/T, equivalent to 800-1200 MJ/T coke. <p>Others estimate energy conservation through steam generation (0.48T/T coke). Electricity generation.</p>

S.No.	Standard Technology	Alternative Technology
		<ul style="list-style-type: none"> • New plant costs are estimated to be \$50/T coke, based on the construction costs of a recently built plant in Germany; retrofit capital costs depend strongly on the lay-out of the coke plant and can be very high, up to \$70 to \$90/GJ saved • Decreased dust, CO₂ and SO_x emissions • Increased water efficiency • Better quality coke produced, improved strength of coke by 4%
2	<p>Iron Making:</p> <p>Blast furnace charged from top with ore, sinter, coke and additives; molten hot metal and slag taken out from bottom; BF gas from top extracted and cleaned and used as a fuel; proven technology; sizes vary from mini BF (250^{m3}) to large BF (5000^{M3}); high top pressure BFs with TRT for steam generation possible.</p>	<p>Smelting reduction processes, including Ausmelt Ausiron®, HIs melt®, CCF, DIOS and COREX, involve the pre-reduction of iron ore by gases coming from a hot bath. The pre-reduced iron is then melted in the bath, and the excess gas produced is used for power generation, production of direct reduced iron (an alternative iron input for scrap), or as fuel gas. In this way, smelting reduction eliminates the need for coke and sintering, and future processes will also eliminate ore preparation.</p> <p>Energy/Environment/Cost/Other Benefits:</p> <ul style="list-style-type: none"> • Low capital and operating costs: <ul style="list-style-type: none"> – 5-35% below production cost of conventional route – Direct use of iron ore fines/steel plant dusts and non coking coals – No coke ovens, sinter plants, blending yards – Single furnace with direct waste energy recovery • Low environmental impact: <ul style="list-style-type: none"> – No coke-oven or sinter plant emissions, and reduced CO₂, SO₂ and NO_x, no production of dioxins, furans, tars or phenols – Recycling of steel plant dusts and slag, making effective uses of coal energy • High quality iron product, with impurities reported to the slag not the metal • Greater flexibility in the range of raw materials accepted, including steel plant wastes and high phosphorous ores <p>Direct reduced iron (DRI) is produced through the reduction of iron ore pellets below the melting point of the iron. This is</p>

S.No.	Standard Technology	Alternative Technology
	<p>Sponge Iron (Direct Reduced Iron): Rotary kilns 50 to 500 tpd; non coking coal as fuel; hot waste gases cleaned in scrubbers/water spray cooled and cleaned in ESPs; small kilns are without waste heat recovery; char normally dumped and used as low CV fuel cakes; can be used for AFBC/CFBC for steam/power generation; Pre-treatment of raw material not necessary; Eliminates coke oven; Low capital and operating costs; India world's largest coal based sponge iron producer. From amongst various solid based processes, only a few have attained commercial significance Most of the processes such as SL/RN, KRUPP-CODIR, DRC, TDR, SIIL, JINDAL, OSIL, Popuri utilize rotary kiln for reduction whereas Kinglor Metor process utilizes an externally heated vertical retort. In India, the standard DRI processes are modified in a minor way and thereafter referred to as customized / indigenous technology. Only trivial changes in terms of the feed ratio, length and the diameter of the kiln are made in the name of customized technology. These customized technologies are dominating the coal based sponge iron process in India. Jindal, TDR, Sponge Iron India Limited (SIIL), Orissa Sponge Iron Limited (OSIL), Popurri Engineering, etc have customized and adopted and market such technology. Except OSIL none of the customized processes are patented.</p>	<p>achieved with either natural gas (MIDREX® process) or coal-based (FASTMET® process) reducing agents. Rotary hearth furnace is used in this process. The DRI produced is mainly used as a high quality iron input in electric arc furnace (EAF) plants.</p> <p>Energy/Environment/Cost/Other Benefits:</p> <ul style="list-style-type: none"> ▪ Pre-treatment of raw material not necessary ▪ Eliminates coke oven ▪ Low capital and operating costs ▪ FASTMET® Process: <ul style="list-style-type: none"> – Faster speed and lower temperatures for reduction reaction – Fuel usage can be reduced; not necessary to recover and reuse exhaust gases as secondary combustion of close to 100% is achieved in the rotary hearth furnace – Low heat loss, as reduced iron is fed to the melting furnace for hot metal production without cooling – Low emissions – 0.3-1.5 kg/THM NO_x, 2.4 kg/THM SO_x, and 0.3 kg/THM PM10 (- particulate matter less than 10.0 microns in diameter) – Energy consumption is 12.3 GJ/T-hot metal less than mini blast furnace; CO₂ is reduced by 1241 kg/T hot metal

3.6.3 Pollution prevention and control

The most effective pollution prevention option is to choose a process that entails lower energy usage and lower emissions. Modern flash-smelting processes save energy, compared with the conventional sintering and blast furnace process. Process gas streams containing over 5% sulphur dioxide are usually used to manufacture sulphuric acid. The smelting furnace will generate gas streams with SO₂ concentrations ranging from 0.5% to 10%, depending on the method used. It is important, therefore, to select a process that uses oxygen-enriched air or pure oxygen. The aim is to save energy and raise the SO₂ content of the process gas stream by reducing the total volume of the stream, thus permitting efficient fixation of sulphur dioxide. Processes should be operated to maximize the concentration of the sulphur dioxide. An added benefit is the reduction (or elimination) of nitrogen oxides (NO_x).

- Use doghouse enclosures where appropriate; use hoods to collect fugitive emissions.
- Mix strong acidic gases with weak ones to facilitate production of sulphuric acid from sulphur oxides, thereby avoiding the release of weak acidic gases.
- Maximize the recovery of sulphur by operating the furnaces to increase the SO₂ content of the flue gas and by providing efficient sulphur conversion. Use a double-contact, double-absorption process.
- Desulphurize paste with caustic soda or soda ash to reduce SO₂ emissions.
- Use energy-efficient measures such as waste heat recovery from process gases to reduce fuel usage and associated emissions.
- Recover acid, plastics, and other materials when handling battery scrap in secondary lead production.
- Recycle condensates, rainwater, and excess process water for washing, for dust control, for gas scrubbing, and for other process applications where water quality is not of particular concern.
- Give preference to natural gas over heavy fuel oil for use as fuel and to coke with lower sulphur content.
- Use low-NO_x burners.
- Use suspension or fluidized bed roasters, where appropriate, to achieve high SO₂ concentrations when roasting zinc sulphides.
- Recover and reuse iron-bearing residues from zinc production for use in the steel or construction industries.
- Give preference to fabric filters over wet scrubbers or wet electrostatic precipitators (ESPs) for dust control.

Good housekeeping practices minimize losses and prevent fugitive emissions. Losses and emissions are minimized by enclosed buildings, covered conveyors and transfer points, and dust collection equipment. Yards should be paved and runoff water routed to settling ponds.

3.6.4 Pollution reduction targets

Implementation of cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following production-related targets can be achieved by measures such as those described above. The figures relate to

the production processes before the addition of pollution control measures. All efforts should be made to voluntarily reduce dust emission level to 50 mg/m³ and less and control SO₂ and NO_x emissions as given in this TGM. This should be followed by reducing dioxin and furan emissions to the TGM levels.

BF and SMS slag reuse and recycling should be given priority to reach 100% level by adopting international best practices.

Dust and sludge processing by applying international technology must be adopted.

Entire plant waste water and sanitary waste water must be treated and reused in the plant.

The target pollutant load for lead and zinc smelting operations for particulate matter is 0.5 kg/T of concentrated ore processed. ESPs are used to recover dust. Pollutant load factors for lead in air emissions are 0.08 kg/T from roasting, 0.08 kg/ t from smelting, and 0.13 kg/T from refining.

A double-contact, double-absorption plant should emit no more than 2 kg of sulphur dioxide per tonne of sulphuric acid produced, based on a conversion efficiency of 99.7%. Sulphur dioxide should be recovered to produce sulphuric acid, thus yielding a marketable product and reducing SO₂ emissions. Fugitive emissions are controlled by using enclosed conveyors.

Treatment technologies

ESPs and baghouses are used for product recovery and for the control of particulate emissions. Dust that is captured but not recycled will need to be disposed of in a secure landfill or in another acceptable manner.

Arsenic trioxide or pentoxide is in vapor form because of the high gas temperatures and must be condensed by gas cooling so that it can be removed in fabric filters.

Collection and treatment of vent gases by alkali scrubbing may be required when sulphur dioxide is not being recovered in an acid plant.

Effluent treatment of process bleed streams, filter backwash waters, boiler blow down, and other streams is required to reduce suspended and dissolved solids and heavy metals and to adjust pH. Residues that result from treatment are recycled to other industries such as the construction industry, sent to settling ponds (provided that groundwater and surface water contamination is not a concern), or disposed of in a secure landfill.

Slag should be either landfilled or granulated and sold for use in building materials.

3.6.5 Occupational Health and Safety of ferrous metal industry

Occupational health and safety issues during the construction, operation, maintenance, and decommissioning of integrated steel manufacturing facilities are common to those of large industrial facilities. The following occupational health and safety issues are specific to steel manufacturing activities:

- Physical hazards
- Heat and hot liquids
- Radiation

- Respiratory hazards
- Chemical hazards
- Electrical hazards
- Noise
- Entrapment hazards
- Fire and explosions

Physical hazards

Industry specific physical hazards are discussed below. Potential physical hazards in integrated steel plant operations are related to handling of large and heavy raw materials and product (*e.g.* blast furnace and EAF charging, storage and movement of billets and thick slabs, movement of large ladles containing liquid iron and steel); heavy mechanical transport (*e.g.* trains, trucks and forklifts); grinding and cutting activities (*e.g.* contact with scrap material ejected by machine-tools); rolling processes (*e.g.* collision and crushing high speed rolled materials and processes); and work at heights (*e.g.* platforms, ladders, and stairs). Heavy Loads / Grinding & Cutting / Rolling Lifting and moving heavy loads at elevated heights using hydraulic platforms and cranes presents a significant occupational safety hazard in steel plants. Recommended measures to prevent and control potential worker injury include the following;

- Clear signage in all transport corridors and working areas;
- Appropriate design and layout of facilities to avoid crossover of different activities and flow of processes;
- Implementation of specific load handling and lifting procedures, including:
 - Description of load to be lifted (dimensions, weight, position of center of gravity), specifications of the lifting crane to be used (maximum lifted load, dimensions).
 - Train staff in the handling of lifting equipments and driving mechanical transport devices
- The area of operation of fixed handling equipment (*e.g.* cranes, elevated platforms) should not cross above worker and pre-assembly areas;
- Material and product handling should remain within restricted zones under supervision;
- Regular maintenance and repair of lifting, electrical, and transport equipment should be conducted.
- Prevention and control of injuries related to grinding and cutting activities, and use of scrap, include the following:
 - Locate machine-tools at a safe distance from other work areas and from walkways;
 - Conduct regular inspection and repair of machine-tools, in particular protective shields and safety devices / equipment
 - Train staff to properly use machines-tools, and to use appropriate personal protection equipment (PPE).

Prevention and control of hazards associated with rolling processes and activities include the following:

- Provide grids around stands and shields where rolled material could accidentally come off rolling guides;

- Provide rails along transfer plate with interlocked gates that open only when machine is not in use.

Heat and hot liquid

High temperatures and direct infrared (IR) radiation are common hazards in integrated steel plants. High temperatures can cause fatigue and dehydration. Direct IR radiation also poses a risk to sight. Potential contact with hot metal or hot water may occur from the cooling spray zone of continuous casting, from splashes of melted metal, and from contact with hot surfaces. Recommended measures for prevention and control of exposure to heat and hot liquids / materials include the following:

- Shield surfaces where close contact with hot equipment or splashing from hot materials is expected (*e.g.* in coke oven plants, blast furnaces, BOF, EAF, continuous casting and heating oven in rolling plants, and ladles);
- Implement safety buffer zones to separate areas where hot materials and items (*e.g.* billets, thick slabs, or ladles) are handled or temporarily stored. Rail guards around those areas should be provided, with interlocked gates to control access to areas during operations;
- Use appropriate PPE (*e.g.* insulated gloves and shoes, goggles to protect against IR and ultraviolet radiation, and clothing to protect against heat radiation and liquid steel splashes);
- Install spot cooling ventilation systems to control extreme temperatures work zones;
- Implement work rotations providing regular work breaks, access to a cool rest area, and drinking water/ anti-dehydration drinks.

Radiation

Gamma ray testing of steel plant equipment and products during operation is typically required to determine the steel composition and integrity. The following techniques may be used as per AERB guidelines to limit the worker exposure risk:

- Gamma ray testing should be carried out in a controlled, restricted area using a shielded collimator. No other activities should be undertaken in the testing area;
- All incoming scrap should be tested for radioactivity prior to use as feedstock material;
- If the testing area is near the plant boundary, ultrasonic testing (UT) should be considered as an alternative to gamma ray techniques; Regular maintenance and repair should be conducted on testing equipment, including protective shields.

Respiratory hazards

Insulation materials

Asbestos and other mineral fibers have been widely used in older plants and may pose a risk from inhalation of cancer causing substances. Recommended management practices include:

- A plant-wide survey and a management plan for asbestos containing insulation materials should be completed by certified professionals;

- Damaged or friable material should be repaired or removed while other materials may be monitored and managed in-situ. Any handling of insulation materials deemed to contain asbestos or any other hazardous material should only be performed by properly trained and certified contractors and personnel following BIS accepted procedures for their repair or removal;
- Use of asbestos must be avoided in new installations or upgrades;
- An LDPE sheet should be placed under the item to be insulated (*e.g.* tube or vessel) and under the stock of insulation material to be layered, to prevent surface contamination with fibers.

Dust and Gases

Dust generated in integrated steel mills includes iron and metallic dusts, which are mainly present in BF, BOF, EAF, continuous casting buildings, pelletization and sinter plants; and mineral dusts which are mainly present in raw material storage, BF, and the coke oven plant. In the former case, workers may be exposed to iron oxide and silica dust that can be contaminated with heavy metals such as chromium (Cr), nickel (Ni), lead (Pb), and manganese (Mn), zinc (Zn), and mercury (Hg). The most significant is the dust present in the melting and casting processes (*e.g.* BF, BOF, continuous casting), where the dust, which is generated by high temperature operations, is finer and more easily inhaled than in the rolling processes. In raw material storage, blast furnace and coke oven plant, workers are exposed to mineral dust, which may contain heavy metals. In addition, BF tapping results in graphite release. In the melting and casting processes where high temperature operations are conducted, workers may be exposed to gas inhalation hazards, which may contain heavy metals. In the BF, BOF and coke oven plant, workers may be exposed to gas inhalation hazards of carbon monoxide. Further inhalation hazards in the coke oven plant include sulphur oxides and Volatile Organic Compounds (VOC). In the COG refinery plant, the presence of ammonia, aromatic hydrocarbons, naphthalene and polycyclic aromatic hydrocarbons (PAH) may present other inhalation hazards. Recommendations to prevent exposure to gas and dust include the following:

- Sources of dust and gases should be separated and enclosed;
- Design natural ventilation system in hot shops to maximize air circulation.
- Exhaust ventilation should be installed at the significant point sources of dust and gas emissions, particularly the BF topping area, the BOF or the EAF;
- Provide a sealed cabin with filtered air conditioning if an operator is needed in a contaminated area;
- Provide separated eating facilities that allow for washing before eating;
- Provide facilities that allow work clothes to be separated from personal clothes, and for washing / showering after work; Implement a policy for periodic health checks. Respiratory hazard control technologies should be used when exposure cannot be avoided with other means, such as operations for refilling the coke oven; manual operations such as grinding or use of non-enclosed machine-tools; and during specific maintenance and repair operations. Recommendations for respiratory protection include the following:
 - Use of filter respirators when exposed to heavy dust (*e.g.* fettling works);
 - For light, metallic dust and gases, fresh-air supplied respirators should be used. Alternatively, a complete facial gas mask (or an “overpressure” helmet) may be used, equipped with electrical ventilation as per BIS guidelines;

- For carbon monoxide (CO) exposure, detection equipment should be installed to alert control rooms and local personnel. In case of emergency intervention in areas with high levels of CO, workers should be provided with portable CO detectors, and fresh-air supplied respirators.

Chemical hazards

In addition to inhalation hazards addressed above, workers in integrated steel plants may be exposed to contact and ingestion hazards from chemical substances, particularly in the coke oven and COG refinery plant, where naphthalene, heavy oil compounds, and aromatic hydrocarbons are present. Recommended measures to prevent contact or ingestion of chemical substances are provided in the Factories Act.

Electrical hazards

Workers may be exposed to electrical hazards due to the presence of heavy-duty electrical equipment throughout integrated steel plants. Recommendations to prevent and control exposure to electrical hazards are provided in the Factories Act.

Noise

Raw and product material handling (*e.g.* ore, waste metals, plates, and bars), as well as the production processes themselves (*e.g.* blast furnace, BOF, EAF, continuous casting, rolling, *etc.*) may generate excessive noise levels. Recommended measures to prevent and control noise emissions are discussed in the Factories Act / Environment (Protection) Act, Government of India.

Entrapment

Risk of entrapment may occur in storage areas and in particular during maintenance operation (*e.g.* inside large mineral hopper). Measures to prevent burials include the following:

- Ensure proper containment wall for mineral heaps;
- Ensure distance between heaps and transit way;
- Develop and adopt specific safety procedures for working inside hoppers (*e.g.* verification systems / procedures to stop refilling belt and to close refilling hole);
- Train staff to make stable heaps and to follow procedures.

Explosion and fire hazards

Handling of liquid metal may result in explosions causing melt runout, and burns, especially if humidity is trapped in enclosed spaces. Other hazards include fires caused by melted metal, and the presence of liquid fuel and other flammable chemicals. Recommended techniques to prevent and control explosion and fire hazards include the following:

- Ensure complete dryness of materials prior to contact with liquid iron and steel;
- Design facility layout to ensure adequate separation of flammable gas, oxygen pipelines, and combustible materials and liquids from hot areas and sources of ignition (*e.g.* electrical panels);

- Protect flammable gas, oxygen pipelines and combustible materials during ‘hot work’ maintenance activities; Design electrical equipment to prevent risk of fire in each plant area (*e.g.* voltage / ampere design and degree of cable insulation; protection of cables against hot liquid exposure; use of cable types that minimize fire propagation);
- Provide Disaster Management Plan (DMP) Guidance on emergency preparedness and response. Coal is susceptible to spontaneous combustion due to heating during natural oxidation of new coal surfaces. Coal dust is combustible and represents an explosion hazard in coal handling facilities associated with integrated steel mills. Recommended techniques to prevent and control explosion risks due to coal dust storage include the following:
 - Coal storage times should be minimized;
 - Coal piles should not be located above heat sources such as steam lines or manholes;
 - Covered coal storage structures should be made of noncombustible materials;
 - Storage structures should be designed to minimize the surface areas on which coal dust can settle, and dust removal systems should be provided;

Ignition sources should be kept to an absolute minimum, providing appropriate equipment grounding to minimize static electricity hazards. All machinery and electrical equipment inside the storage area or structure should be approved for use in hazardous locations and provided with spark-proof motors

3.6.6 Occupational health and safety for non-ferrous metal industry

Occupational health and safety issues should be considered as part of a comprehensive hazard or risk assessment, including, for example, a hazard identification study [HAZID], hazard and operability study [HAZOP], or other risk assessment studies. The results should be used for health and safety management planning, in the design of the facility and safe working systems, and in the preparation and communication of safe working procedures. Occupational health and safety issues for consideration in smelting and refining operations include:

- Chemical exposure
- Physical hazards
- Noise
- Radiation
- Confined space entry

Chemical exposure

The smelting and refining sector utilizes a number of hazardous materials including acids, alkalis, and chemical reagents (*e.g.*, in leaching and precipitation of metals, and for pollution control systems); and process gases (*e.g.*, oxygen, carbon dioxide, argon, nitrogen, chlorine, hydrogen, among others). Workers may be exposed to hazardous materials in organic and inorganic dusts, vapors, gases, mists and fumes released as part of operations and / or human activities in all stages of production and maintenance. Inorganic hazardous materials typically include soluble and insoluble base metals (*e.g.* nickel, copper, and trace contaminants such as arsenic, antimony, thallium, mercury, and cadmium, among others). Trace contaminants and their metals depend on the nature of the ore being processed and the specific process being used. Exposure to acid mists may occur during leaching and / or electro-refining. Exposure to organic materials may include dioxins and furans, residual organic solvents used as reagents, and polycyclic

aromatics associated with pitch fume and dust (in carbon electrode plants and aluminum reduction cell processes). Exposure to gases may include sulphur dioxide, ammonia, carbon monoxide, oxygen, arsine, chlorine, and fluoride, among others. Some gases may be metallic in nature such as cobalt, iron, and nickel carbonyls. The following specific measures are recommended to prevent, minimize, and control potential chemical exposures:

- Enclose and isolate potential sources of air emissions to the work zone to the extent practical;
- Provide continuous work zone monitoring in areas where sudden and unexpected hazards may occur (*e.g.* where arsine or hydrogen cyanide releases might be possible);
- Monitor worker exposure using personal occupational hygiene sampling devices;
- Provide training and encourage good personal hygiene, and prohibit smoking and eating at the worksite;
- Automate processes and material handling to the extent practical and provide enclosures for operators;
- Provide local exhaust ventilation to limit exposure to, for example, sulphur dioxide, carbon monoxide, and sulphuric acid mists.

Physical hazards

Physical hazards, including exposure to heat from furnaces and molten metal and ergonomic stress, may result in bodily injury related to equipment operation, burns, and explosions associated with work involving hot metals (*e.g.* during pyroprocessing activities), acids, caustics, solvents, leach solutions, and solutions used in electro-refining. The following specific measures are recommended to prevent, minimize, and control potential heat illnesses:

- Use water screens or air curtains in front of furnaces
- Provide spot cooling where necessary
- Install enclosed air-conditioned booths for operators
- Provide heat-protective clothing and air-cooled suits
- Allow sufficient time for acclimatization to hot environments, provide work breaks in cool areas, and provide an adequate supply of anti dehydration drinks for frequent drinking

Noise

Smelting and refining personnel may be potentially exposed to high levels of noise from heavy equipment operation and furnaces. As most of these noise sources cannot be prevented, control measures should include the use of personal hearing protection by exposed personnel and implementation of work rotation programs to reduce cumulative exposure.

Radiation

Occupational exposure to radiation may occur as a result of radioactive sources in certain process equipment (*e.g.* load cells and particulate monitors) and laboratory equipment.

Recommendations on the management of radiation exposure are provided in the AERB Guidelines.

Confined spaces

A smelting and refining facility has equipment and situations that require entry into confined spaces. Facilities should develop and implement confined space entry procedures as described in the Factories Act.

Electric and magnetic fields

Electric and magnetic fields (EMF) are invisible lines of force emitted by and surrounding any electrical device. Electric fields are produced by voltage and increase in strength as the voltage increases. Magnetic fields result from the flow of electric current and increase in strength as the current increases. Electric fields are shielded by materials that conduct electricity and other materials, such as trees and building materials. Magnetic fields pass through most materials and are difficult to shield. Both electric and magnetic fields decrease rapidly with distance. The power supplied to electrolytic reduction cells is direct current, and the electromagnetic fields generated in the pot rooms are mainly of the static or standing field type. Such fields, in contrast to low frequency electromagnetic fields, are even less readily shown to exert consistent or reproducible biological effects. The flux levels of the magnetic fields measured cell rooms are commonly found to be within threshold limit values for static magnetic, sub-radio frequency and static electric fields. Exposure to ultra-low frequency electromagnetic fields may occur in reduction plants, especially adjacent to rectifier rooms. The flux levels found in the pot rooms are minimal and below present standards. EMF exposure may also be associated with electric arc furnaces and other electrical equipment

3.7 Summary of Applicable National Regulations

3.7.1 General description of major statutes

A comprehensive list of all the laws, rules, regulations, decrees and other legal instruments applicable to Metallurgical industry is attached as **Annexure I**.

3.7.2 General standards for discharge of environmental pollutants

General standards for discharge of environmental pollutants as per CPCB are given in **Annexure II**.

3.7.3 Industry-specific requirements

Integrated iron & steel industry

Environmental standards

In order to regulate the discharge of effluent and emission from metal industries, the following standards are notified under Environment (Protection) Act, 1986. Corresponding standards are annexed as **Appendix III**.

- Effluent and emission standards
- Stack height/ limit

Effluent discharge

Water Consumption for production of one tonne of finished steel is 16 m³ (it has been mentioned as 5 and 7 m³/T for non-flat and flat steel production respectively in CREP) and its Effluent discharge standards are:

Table 3-25: Effluent Discharge Standards

Name of the Plants	Standards
Sinter Plant, Blast Furnace, Steel Melting Shop and Rolling Mills	pH - 6-9
	SS - 100
	Oil & Grease -10
CO-BP Plant	pH- 6-8
	SS - 100
	Oil & Grease -10
	Phenol - 1.0
	Cyanide - 0.2
	BOD (5 days at 20°C) - 30
	COD - 250
	Ammonical Nitrogen- 50
	Note : All in mg/l except pH

Source: CPCB

Stack Emission Standards

Table 3-26: Stack Emission Standards

Plants	Particulate Matter Emission (mg/Nm ³)
Sintering Plant	150
Steel Melting Shop	150 (during normal operation) 400 (during oxygen lancing)
Refractory Material Plant/ Dolomite Plant	150

Environmental Issues Pertaining to Steel Melting Shops and Adoption of the following clean technology/techniques

- Particulate matter emission control from hot metal pre-treatment (including hot metal transfer processes, desulphurisation and deslagging) by means of effective utilization of fabric filters or ESPs.

- BOF gas recovery and primary dedusting, applying:
 - Suppressed Combustion
 - Scrubbing and
 - Dry Electrostatic Precipitation
- Clean BOF gas shall be used subsequently as a gaseous fuel in the steel plant. In some cases, it may not be economical or with regard to desired quantity of energy requirement, it will not be feasible to recover BOF gas. In such cases BOF gas shall be combusted for steam generation.
- Collected dusts and / or sludge shall be recycled as much as possible taking into consideration the heavy metal content of dust / sludge.
- Secondary dedusting facilitating through:
 - Efficient evacuation during charging and tapping with subsequent cleaning by means of fabric filters or ESPs or any other equally effective method.
 - Efficient evacuation during hot metal handling (ladling and reladling operation) deslagging of hot metal and secondary metallurgy, with subsequent cleaning by means of fabric filters or any other equally effective method.
- Recycling of scrubbing water as much as possible after coagulation and sedimentation of suspended solids.
- Centralized vacuum cleaner, for cleaning dust depositions in the upper floors of converter where bulk material handling operations take place.
- Minimize waste generation and implement efficient waste management.
- Proper monitoring of stack emission and fugitive emission during charging time.
- Processing of SMS slag for 100% reuse by high pressure water spray on hot slag or any other suitable facility.

Environmental Issues Pertaining to Blast Furnace and Adoption of the following clean technology/techniques

- Direct injection of reducing agents
- Energy recovery of top BF gas
- Use of Tar-free runner linings

Blast Furnace gas cleaning with efficient dedusting:

- Coarse particulate matter (flue dust) shall be reused.
- Fine particulate matter shall be removed by means of
 - Scrubber
 - Wet ESP
 - An equally effective method, So that, residual particulate matter concentration in the cleaned BF gas shall be less than 10 mg/Nm³ is achieved
- Cast House dedusting (tap holes, runners, skimmers, ladle charging points)
- Emissions should be minimized by covering the above mentioned areas and extraction and treatment by means of fabric filters or ESPs
- Suppression of fugitive emissions using nitrogen gas or any other inert gas depending upon the design of the cast house
- Treatment of waste water generated from BF gas scrubbing using:
 - Hydro cyclones for sludge with subsequent reuse of coarse fraction when grain size distribution allows reasonable separation

- Slag treatment
 - Preferably by means of granulation where market conditions favour.
 - Condensation of fumes or equally effective method shall be used, if odour reduction is required.

In principle the techniques listed above are applicable to both new and existing installations, if the prerequisites are met.

Standard for air pollutants in zinc extraction processes

- SO₂ - 4 kg/1000 kg H₂SO₄ production
- SPM - 150 mg/m³

Table 3-27: Characteristics of wastewater before treatment in Zinc extraction

Parameter	Value
pH	2 to 3
TSS (mg/l)	400 to 600
TDS (mg/l)	5000 to 6000
SO ₄ (mg/l)	3800 to 4000
Lead (mg/l as lead)	1.2
Zinc (mg/l as zinc)	300 to 350
Copper (mg/l as copper)	15 to 16
Cadmium (mg/l as Cadmium)	30 to 31
Fluoride (mg/l as Fluoride)	6 to 7

Source: CPCB

Table 3-28: Standards for effluent in Zinc extraction

Parameter	Value
pH	5.5-9.0
TSS (mg/l)	30
TDS (mg/l)	2000
SO ₄ (mg/l)	30
Lead (mg/l as lead)	0.1
Zinc (mg/l as zinc)	5.0
Copper (mg/l as copper)	3.0
Cadmium (mg/l as Cadmium)	1.0
Fluoride (mg/l as Fluoride)	2.0

Source: CPCB

Standard for air pollutants in copper smelters

- SO₂ - 4 kg/1000 kg H₂SO₄ production
- SPM - 150 mg/m³

Table 3-29: Standards for Effluent in Copper Smelting

Parameter	Value
pH	5.5-9.0
TSS (mg/l)	100
TDS (mg/l)	2000
SO ₄ (mg/l)	30
Lead (mg/l as lead)	0.1
Zinc (mg/l as zinc)	5.0
Copper (mg/l as copper)	3.0
Cadmium (mg/l as Cadmium)	1.0
Fluoride (mg/l as Fluoride)	2.0

Source: CPCB

Table 3-30: Integrated Iron & Steel Plant: Emission Standards

Pollutant	Source	Emission Limit
Particulate Matter	A. Sintering lant	150mg/Nm ³
	B. Steel making	
	During normal operation	150mg/Nm ³
	During oxygen lancing	400mg/Nm ³
	Rolling Mill	150mg/Nm ³
Carbon Monoxide	Coke-oven	3kg/tone of coke produced

Source: EPA Notification [S.O. 64(E). dt 18th Jan, 1988]

Table 3-31: Coke Oven and Refractory Material Plant: Emission Standards

Source	Parameter	Emission (mg/Nm ³)
Coke Oven	Particulate Matter	50
Refractory material plant	Particulate Matter	150

Table 3-32: Integrated Iron & Steel Plant: Waste-water Discharge Standards

	Parameter	Concentration in mg/l Except pH (not to exceed)
Cokeoven by product plant	pH	6.0 to 8.5
	Suspended solids	100
	Phenol	1.0
	Cyanide	0.2
	BOD, 3 days at 27 0C	30
	COD	250
	Ammonical Nitrogen	50
	Oil & grease	10
Other plants such as sintering platn, blast furnace, steel melting furnace	pH	6.0 to 9.0
	Suspended solids	100
	Oil & grease	10
Source: EPA Notification [G.S.R. 913(E). dt 20th Oct, 1989]		

Proposed Fugitive Emission Control:

At the international level there are different standards for fugitive emissions. In China, standards are for dolomite dust, coal dust and lime stone dust in work zone. However, Germany has single standard for all types of dusts. Parameters prescribed are Respirable Dust and Total Dust in China and Germany. (China: total dust TWA= 8 mg/ m³ & respirable dust= 4 mg/ m³; Germany: total dust TWA= 10 mg/ m³ & respirable dust = 5 mg/m³). Indian standards for work place air quality (as per Factory's Act) suggest for measurement of silica and crystalline quartz to calculate total dust and respirable dust. Considering the national and international standards, limits for fugitive emissions in Indian sinter plants are proposed for the following parameters:

Respirable Dust

Total Dust

A sinter plant consists of various units such as raw material proportioning section, mixing and nodulising section, sinter strand, sinter cooler and screening section. Fugitive emissions are generated in all these processes and spread all around. These emissions travel from the point of generation to the entire floor area of a particular shop. A distance of about 5 m has been recommended for measurement of fugitive emissions. The measurements shall be of 8 hour time average.

Limits for fugitive emissions were decided considering the national and international standards and data available and measured at various existing sinter plants. Also technological limitations imposed by international technology know how supplier such as OTO-KUMPU (Erstwhile LURGI), Siemens VAI *etc.* has been considered. The proposed standards are as under:

	Respirable dust	Total dust
New Plants	3 mg/m ³	6 mg/m ³
Existing Plants	4 mg/m ³	8 mg/m ³

Following locations are proposed for fugitive emission monitoring:

- 1 Raw feed proportioning building
- 2 PMD/ SMD/ MND feed area
- 3 Sinter machine discharge end
- 4 Hot sinter breaker area
- 5 Sinter cooler zone
- 6 Sinter crusher & screening area.

Table 3-33: International Reference Norms for Consumption of Water and Energy for non-ferrous industry

Facility	Energy used (GJ/T)a
Copper--production from concentrate	14 – 20
Copper—electro-refining	1.1 – 1.4
Alumina production	8 – 13.5
Aluminum--primary production (electrolysis, including anode production)	53 - 61
Lead—shaft furnace, primary	6.8 – 10.3b
Lead—shaft furnace, secondary	4.4 – 5.5b
Lead—rotary furnace, secondary, with CX system and Na2SO4 production	4.0 – 4.7b
Lead—QSL	2.3 – 3.5b
Lead—Kivcet	4.9b
Lead—top blown rotary converter	4.0 – 4.4b
Zinc—electrolysis	15
Zinc—imperial smelting furnace & New Jersey distillation	44b
Zinc—Waelz kiln	26b,c
Zinc—slag fuming	7.7b,d
Nickel—matte from sulphide ores containing 4-15% Ni	25-65b
Nickel--refining Facility	17 - 20

Facility	Energy used (GJ/T) ^a
Facility	Water Use (kg/T)
Alumina production	1000 – 6000
Aluminum--primary production (electrolysis, including anode production)	200 - 12000
Sources: EU BREF in the Non-Ferrous Metals Industries	
Notes:	
<ul style="list-style-type: none"> ▪ Gigajoules (10⁹ Joules) per metric ton ▪ Calculated based on quantities of coke, coal, natural gas, and electric power used and typical heat values of the petroleum fuels. ▪ Per tonne of Waelz oxide leached ▪ Per tonne of slag 	

Carbon footprint

Carbon footprint for various Indian sectors is as follows:

- Power- 51%
- Transport - 16%
- Industrial sector:
- Steel - 10%
- Cement - 4%
- Chemicals- 3%
- Others - 16%

Table 3-34: International Carbon Foot Prints for Non-ferrous Sector

Activity	Range of direct emissions (T CO ₂ /T product)
Zinc Production	
RLE zinc production, roasting step	0.000 - 0.0351
RLE zinc production, hydrometallurgical leaching & Electrolysis	0.002 - 0.030
RLE zinc production, pyrometallurgical leaching & Electrolysis	1.0 - 1.8
ISF zinc production, furnace	4.3 - 5.0
Foundry/Casting of zinc	0.005 - 0.0502
1 In some installations the whole or part of the feedstock passes through the roaster, in others it is directly introduced to the neutral leaching step.	
2 Gas or electricity can be used as melting energy.	

Table 3-35: Activity-specific Direct Emissions from Lead and Copper Production

Activity	Range of Direct Emissions (t CO ₂ /T of product)
Lead Production	
Primary lead production	0.7 – 1.5
Secondary lead production	0.4 – 1.5
Copper production	
Primary cathodes	0.20 – 3.85
Secondary cathodes	0.05 – 0.65
Wire rod production ¹	0.05 – 0.30
Shape production	0.05 – 0.30
Anode production ²	0.15 – 1.20
<p>1 Data is from a limited number of installations (ECI members only). It has to be checked how many installations are missing</p> <p>2 Only contains anodes transferred to another installation. The emissions of anodes that are used within the same installation to produce cathodes are included in the cathode's direct emissions</p>	

Lead batteries

The Batteries (Management and Handling) Rules, 2001

Responsibilities of manufacturer, importer, assembler and re- conditioner: It shall be the responsibility of a manufacturer, importer, assembler and re-conditioner to

- Ensure that the used batteries are collected back as per the Schedule against new batteries sold excluding those sold to original equipment manufacturer and bulk consumer(s);
- Ensure that used batteries collected back are of similar type and specifications as that of the new batteries sold;
- File a half-yearly return of their sales and buy-back to the State Board in Form-I latest by 30 June and 30 December of every year;
- Set up collection centres either individually or jointly at various places for collection of used batteries from consumers or dealers;
- Ensure that used batteries collected are sent only to the registered recyclers;
- Ensure that necessary arrangements are made with dealers for safe transportation from collection centres to the premises of registered recyclers;
- Ensure that no damage to the environment occurs during transportation;
- Create public awareness through advertisements, publications, posters or by other means with regard to the following:
 - Hazards of lead;

- Responsibility of consumers to return their used batteries only to the dealers or deliver at designated collection centres; and
- Addresses of dealers and designated collection centres.
- Use the international recycling sign on the Batteries;
- Buy recycled lead only from registered recyclers; and
- Bring to the notice of the State Board or the Ministry of Environment and Forests any violation by the dealers.

Dumping and disposal / utilization of fly ash

In a bid to prevent the dumping and disposal of fly ash discharged from coal/lignite based integrated steel and power plants, the MoEF has specified the following measures to regulate the use of fly ash. The Notification No. S.O.763 (E), dated the 14th September, 1999 and subsequent amendments are annexed as Appendix III.

At the time of clearance of integrated steel and power plants projects generating fly ash, it is ensured that provisions are made for proper utilization and disposal of fly ash. Stipulations are made for 20% utilization and disposal of fly ash within one year of commissioning of the plants, with progressive 10% utilization increases for the next 7 years, reaching 100% utilization within 9 years. The project authorities are also asked to keep provision for dry ash collection system and a maximum of 100 – 350 acres land is permitted to acquire for ash disposal depending upon each case.

Recycling of fly ash by prohibiting the manufacture of clay bricks, tiles or blocks without mixing 25% of the ash with soil on weight-to-weight basis within a radius of 100 km of power plant, has been made mandatory. Integrated power and steel plants are also required to maintain monthly records of ash made available to each brick kiln. To ensure unhindered loading and transport of ash, there is a provision of constituting a Dispute Settlement Committee in each coal based integrated steel and power plant.

Use of beneficiated / blended coal

Govt. of India has promulgated a Gazette Notification (GSR 560(E) & 378(E), dated September 19, 1997 and June 30, 1998 respectively) on use of beneficiated/blended coal containing ash not more than 34 % w.e.f. June 2001 in the following power plants:

- Integrated steel and power plants located beyond 1000 km from pit head;
- Integrated steel and power plants located in critically polluted areas, urban areas and in ecologically sensitive areas.

The integrated steel and power plants using FBC (CFBC, PFBC & AFBC) and IGCC combustion technologies are exempted to use beneficiated coal irrespective of their locations.

3.7.3.1 CREP guidelines

Following are the Charter on Corporate Responsibility for Environmental Protection (CREP) action points which needs to be implemented.(needs editing)

Coke oven plants

- To meet the parameters PLD (% leaking doors), PLL (% leaking lids), PLO (% leaking off take), of the notified standards under EPA within three years. Industry will submit time bound action plan and PERT Chart along with the Bank Guarantee for the implementation of the same.
- To rebuild at least 40% of the coke oven batteries in next 10 years

Steel melting shop

Fugitive emissions to reduce 30% and 100% by certain time (including installation of secondary de-dusting facilities)

- Direct inject of reducing agents in Blast furnace
- Solid Waste / Hazardous Waste Management
- Utilization of Steel Melting Shop (SMS)/Blast Furnace Slag as per the schedule
- Water Conservation / Water Pollution
- Installation of Continuous stack monitoring system & its calibration in major stacks and setting up of the online ambient air quality monitoring stations
- To operate the existing pollution control equipment efficiently and to keep proper record of run hours, failure time and efficiency with immediate effect. Compliance report in this regard be submitted to CPCB / SPCB every three months.
- To implement the recommendations of Life Cycle Assessment (LCA) study sponsored by MoEF

The industry should initiate the steps to adopt the following clean technologies/measures to improve the performance of industry towards production, energy and environment:

- Energy recovery of top blast furnace gas.
- Use of Tar-free runner linings.
- De-dusting of Cast House at tap holes, runners, skimmers ladle and charging points.
- Suppression of fugitive emissions using nitrogen gas or other inert gas.
- To study the possibility of slag and fly ash transportation back to the abandoned mines, to fill up the cavities through empty railway wagons while they return back to the mines and its implementation.
- Processing of the waste containing flux & ferrous wastes through waste recycling plant.
- To implement rainwater harvesting.
- Reduction of Green House Gases by:
 - Reduction in power consumption
 - Use of by-products gases for power generation
 - Promotion of Energy Optimization Technology including energy audit
 - To set targets for Resource Conservation such as Raw material, energy and water consumption to match International Standards.
- Upgrade in the monitoring and analysis facilities for air and water pollutants. Also to impart elaborate training to the manpower so that realistic data is obtained in the environmental monitoring laboratories.

- To Improve overall house keeping.
- CREP For coal based integrated steel and power plants
- Implementation of environmental standards (both emission and effluent) in non-compliant steel and power plants
- Tightening of emission norms for new integrated steel and power plants/expansion projects
- Development of SO₂ and NO_x emission standards for coal-based steel and power plants
- Re-circulation of ash pond effluent by all integrated steel and power plants except the power plants located in coastal area and using sea water for ash disposal
- Installation/activation of opacity meters with recording facility in all the units of integrated steel and power plants in the country with proper calibration system
- Development of guidelines/standards for toxic metals including mercury, arsenic and fluoride emissions
- Review of stack height requirement and guidelines for integrated steel and power plants
- Implementation of notification for use of beneficiated coal steel plants should sign fuel supply agreement (FSA) to meet the requirement as per the matrix prepared by CEA for compliance of the notification. Options/mechanism for setting up of coal washeries:
 - Coal India will set up its own washery
 - State Electricity Board to set up its own washery
 - Coal India to ask private entrepreneurs to set up washeries for CIL and taking washing charges
 - State Electricity Board to select a private entrepreneur to set up a washery near pit-head Installation of coal beneficiation plant
- All the Integrated steel plants shall indicate their requirement for ash disposal in abandoned mines and Coal India Ltd./ Min. of Coal shall provide list abandoned coalmines
- Integrated steel plants to provide dry fly ash to the users outside the plant premises and uninterrupted access at the ash pond
- Integrated steel plants to provide dry fly ash free of cost to the users as per the notification
- The amendments made by the Central Public Works Department (CPWD) in its respective schedules/ specifications for building construction, to be adhered by the State Public Works Departments (PWDs)/construction and development agencies, *etc.*
- Draft amendments in the notification on use of up to 5% fly ash in OPC for improvement in the performance of the OPC, issued by the Bureau of Indian Standards (BIS) to be finalized and circulated to all concerned
- Fly ash mission to prepare guidelines on prioritization of sector-wise areas for utilization of fly ash particularly in regard to value added products
- New integrated steel and powers to be considered for environmental clearance need to adopt dry ash disposal/medium (42-45%) ash concentration slurry disposal systems.

- New integrated steel plants shall also promote adoption of clean coal and clean power generation technologies

Sponge Iron Plants: Inventorisation of sponge iron plants to be completed by SPCBs /CPCB and units will be asked to install proper air pollution control equipment to control primary and secondary emissions.

Dumping and disposal / utilization of fly ash

The Govt. of India has proposed to issue a new notification, in suppression of the existing notification number S.O. 763(E) dated 14th September 1999, regarding use of fly ash in construction activities, responsibilities of integrated steel Plants and specifications for use of ash-based products/responsibility of other agencies.

4. OPERATIONAL ASPECTS OF EIA

Prior environmental clearance process has been revised in the Notification issued on 14th September, 2006, into following four major stages *i.e.*, screening, scoping, public consultation and appraisal. Each stage has certain procedures to be followed. This section deals with all the procedural and technical guidance, for conducting objective-oriented EIA studies, their review and decision-making. Besides, the Notification also classifies projects into Category A, which requires prior environmental clearance from MoEF and Category B from SEIAA/UTEIAA.

Consistency with other requirements

- Clearance from other regulatory bodies is not a prerequisite for obtaining the prior environmental clearance and all such clearances will be treated as parallel statutory requirements.
- Consent for Establishment (CFE) and Prior Environmental Clearance are two different legal requirements, a project proponent should acquire. Therefore, these two activities can be initiated and proceeded with simultaneously.
- If a project falls within the purview of CRZ and EIA Notifications, then the project proponent is required to take separate clearances from the concerned Authorities.
- Rehabilitation and Resettlement (R&R) issues need not be dealt under the EIA Notification as other statutory bodies deal with these issues. However, socio-economic studies may be considered while taking environmental decisions.

4.1 Coverage of Metallurgical Industries under the Purview of Notification

All the new metallurgical industries including expansion and modernization require prior environmental clearance. Based on pollution potential, these projects are classified into Category A and Category B *i.e.*

- Category A:
 - all primary metallurgical industrial projects,
 - sponge iron manufacturing ≥ 200 TPD,
 - secondary metallurgical processing industry and all toxic & heavy metal producing units $\geq 20,000$ tonnes /annum
- Category B:
 - Sponge iron manufacturing <200 TPD
 - Secondary metallurgical processing industry involved in
 - All toxic and heavy metal producing units $<20,000$ tonnes /annum
 - All other non-toxic secondary metallurgical processing industries > 5000 tonnes per annum

Note: For induction furnace, arc furnace and cupola furnace may please refer separate TGM.

Besides there is general condition for sponge iron manufacturing and secondary metallurgical processing industry, when it applies, a Category B project will be treated as Category A project. These conditions are discussed in subsequent sections.

Notes:

(i) Toxic metals include lead, mercury, cadmium, chromium, arsenic and heavy metals include the metals which have specific gravity more than 5, for the purpose of this Notification.

(ii) Under Secondary metallurgical processing industry, all toxic and heavy metal producing units may be assumed to be those where substances associated with industrial processes are suspect to be toxic or heavy metals.

The sequence of steps in the process of prior environmental clearance for Category A projects and Category B projects are shown in Figure 4.1 and Figure 4.2 respectively. Specific duration mentioned in the figures is maximum times that can be taken for processing clearance by EAC/SEAC, at various stages. The time for preparation of draft/summary/final EIA and time for environmental monitoring is in addition to the duration mentioned for procedural (clearance) requirements. Each stage in the process of prior environmental clearance for the metallurgical industries is discussed in subsequent sections.

In case of expansion or modernization of the developmental activity:

- Any developmental activity, which has an EIA clearance (existing plant), when undergoes expansion or modernization (change in process or technology) with increase in production capacity or any change in product mix beyond the list of products cleared in the issued prior environmental clearance, is required to submit new application for EIA clearance.
- Any developmental activity, which is listed in Schedule of the EIA Notification and due to expansion of its total capacity, if falls under the purview of either Category B or Category A, then such developmental activity requires clearance from respective Authorities.

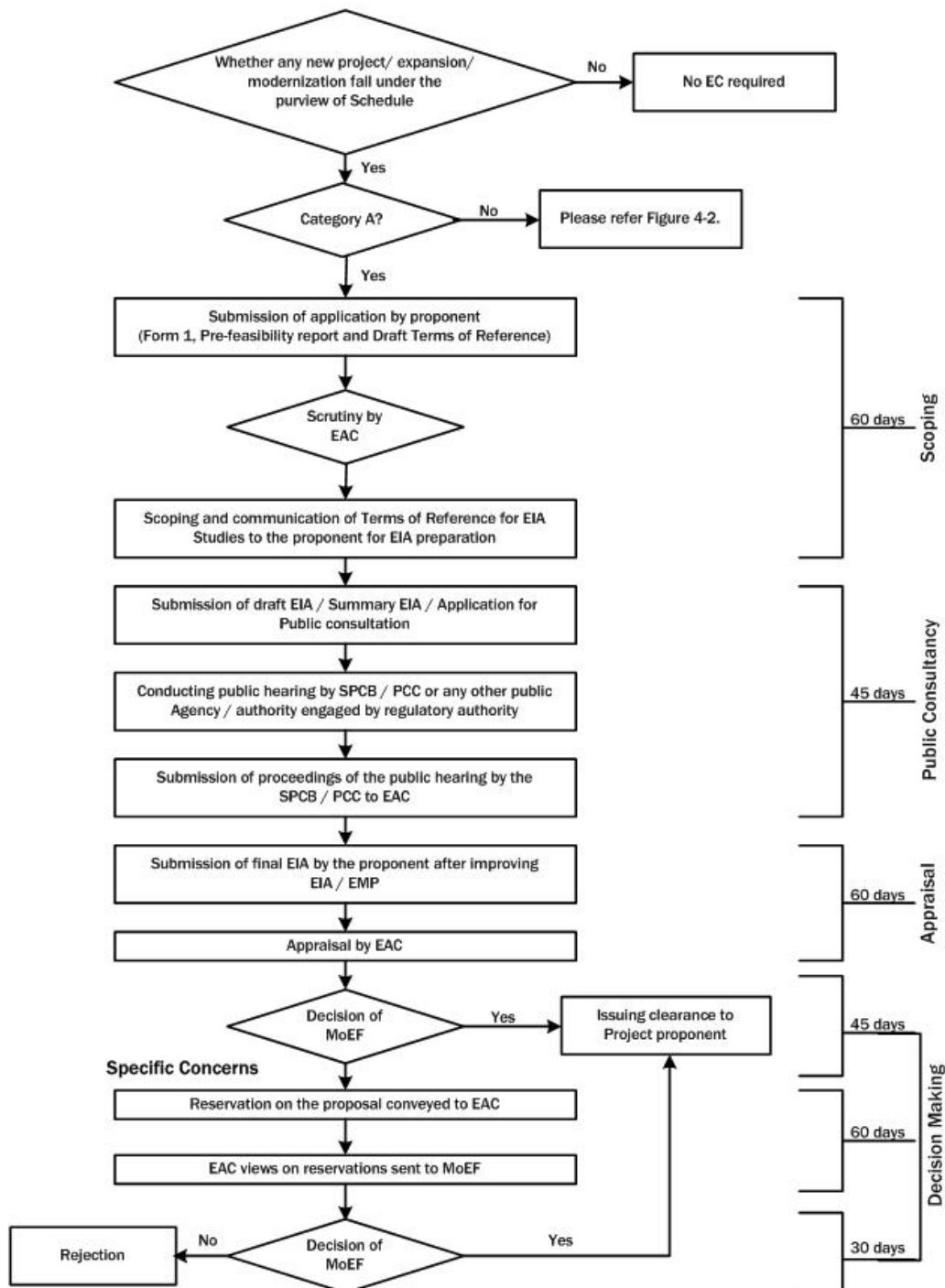


Figure 4-1: Prior Environmental Clearance Process for Activities Falling Under Category A

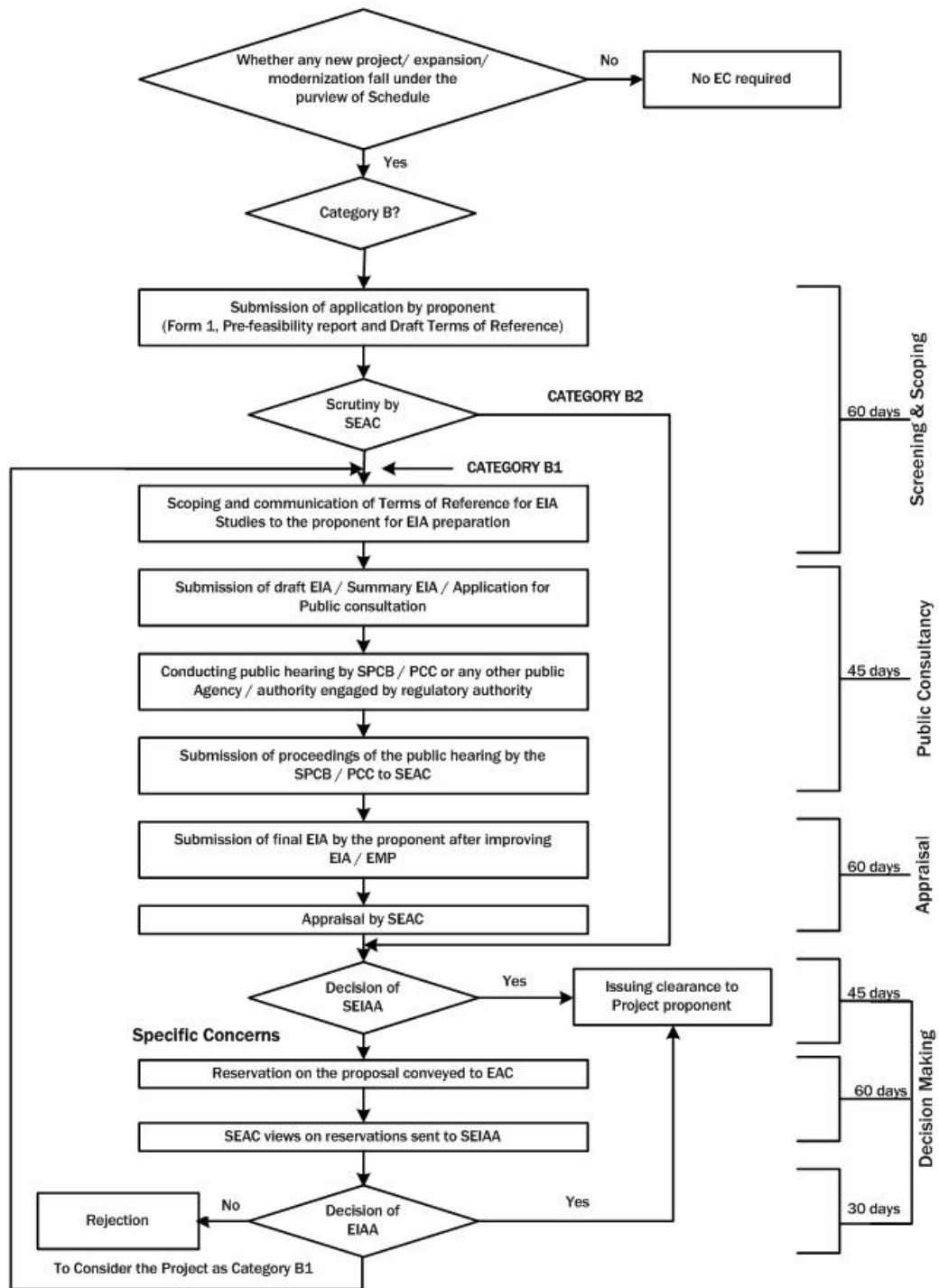


Figure 4-2: Prior Environmental Clearance Process for Activities Falling Under Category B

4.2 Screening

Screening of the project shall be performed at the initial stage of the project development so that proponents are aware of their obligations before deciding on the budget, project design and execution plan.

This stage is applicable only for Category ‘B’ developmental activity *i.e.*, if general conditions are applicable for a Category B project, then it will be treated as Category A project. Besides, screening also refers to the classification of Category B projects into either Category B1 or Category B2. Category B1 projects require to follow all stages applicable for a Category A project, but is processed at the SEIAA/UTEIAA. Category B2 projects on the other hand, require neither EIA nor public consultation.

As per the Notification, classification of Category B projects falls under the purview of the SEAC. This manual provides certain guidelines to the stakeholders for classification of Category B1 and Category B2.

4.2.1 Applicable conditions for Category B projects

General condition

- Any metallurgical industry (ferrous and non ferrous) that has a production capacity <200 TPD for sponge iron manufacturing and secondary metallurgical processing industry with <20,000 TPA for all toxic and heavy metal producing units and >5000 TPA for all other non-toxic secondary metallurgical processing industries (usually falling under Category B) will be treated as Category A, if located in whole, or in part within 10 km from the boundary of:
 - Protected areas notified under the Wild Life (Protection) Act, 1972,
 - Critically polluted areas as notified by the CPCB from time to time
 - Eco-sensitive areas as notified under Section 3 of the E(P) Act, 1986, such as Mahabaleshwar Panchgani, Matheran, Panchmarhi, Dahanu, Doon valley
 - Inter-State boundaries and international boundaries – provided that the requirement regarding distance of 10 km of the inter-state boundaries can be reduced or completely done away with, by an agreement between the respective States/UTs sharing the common boundary in case the activity does not fall within 10 km of the areas mentioned above.
- Inter-State boundaries and international boundaries. Provided that the requirement regarding distance of 10 km of the inter-state boundaries can be reduced or completely done away with by an agreement between the respective States/UTs sharing the common boundary.
- The SEIAA shall base its decision on the recommendations of a State/UT level EAC for the purpose of environmental clearance
- In absence of a duly constituted SEIAA or SEAC, a Category B project shall be appraised at the Central level *i.e.* at the MoEF.
- The EAC at the State/UT level shall screen the projects or activities in Category B. SEAC shall meet at least once every month.
- If any Category B metallurgical project/activity, after proposed expansion of capacity/production or fuel change, falls under the purview of Category A in terms of production capacity, then clearance is required from the Central Government.

4.2.2 Criteria for classification of Category B1 and B2 projects

The classification of Category B projects or activities into B1 or B2 (except the project or activities listed in item 8(b) in the Schedule to the EIA Notification, 2006) will be determined based on whether or not the project or activity requires further environmental studies for preparation of an EIA for its appraisal prior to the grant of environmental clearance. The necessity of this will be decided, depending upon the nature and location specificity of the project, by SEAC after scrutiny of the applications seeking Environmental Clearance for Category B projects or activities.

The projects requiring an EIA report shall be included in Category B1 and remaining projects will fall under Category B2 and will not require an EIA report and public consultation.

4.2.3 Application for prior environmental clearance

- The project proponent, after identifying the site and carrying out a pre-feasibility study, is required to apply for the prior environmental clearance using Form 1 given in **Annexure III**. The proponent has to submit the filled in Form 1 along with the pre-feasibility report and draft ToR for EIA studies to the concerned Authority *i.e.* MoEF, Government of India for Category A projects and the SEIAA in case of Category B projects. Please refer subsequent sections for the information on how to fill the Form 1, contents of pre-feasibility report and draft ToR for Metallurgy.
- Prior environmental clearance is required before starting any construction work, or preparation of land is started on the identified site / project or activity by the project management, except for securing the land.
- If the application is made for a specific developmental activity, which has an inherent area development component as a part of its project proposal and the same project also attracts the construction and area development provisions under 8a and 8b of the Schedule, then the project will be seen as a developmental activity other than 8a and 8b of the Schedule.

4.2.4 Siting guidelines

These are the guidelines, stake holders may consider while siting the developmental projects, to minimize the associated possible environmental impacts. In some situations adhering to these guidelines is difficult and unwarranted. Therefore these guidelines may be kept in the background, as far as possible, while taking the decisions.

Areas preferably be avoided

While siting industries, care should be taken to minimize the adverse impact of the industries on immediate neighborhood as well as distant places. Some of the natural life sustaining systems and some specific landuses are sensitive to industrial impacts because of the nature and extent of fragility. With a view to protect such sites, the industries may maintain the following distances, as far as possible, from the specific areas listed:

- Ecologically and/or otherwise sensitive areas: Preferably 5 km; depending on the geo-climatic conditions the requisite distance may be decided appropriately by the agency.
- Coastal Areas: Preferably ½ km away from high tide line (HTL).

- Flood Plain of the Riverine System: Preferably ½ km away from flood plain or modified flood plain affected by dam in the upstream or flood control systems.
- Transport/Communication System: Preferably ½ km away from highway and railway line.
- Major Settlements (3,00,000 population): Distance from major settlements is difficult to maintain because of urban sprawl. At the time of siting of the industry, if the notified limit of any major settlement is found to be within 50 km from the project boundary, the spatial direction of growth of the settlement for at least a decade must be assessed. Subsequently, the industry may be sited at least 25 km from the projected growth boundary of the settlement.
- Critically polluted areas are identified by MoEF from time-to-time. Current list of critically polluted areas is given in **Annexure IV**.

NOTE:

Ecological and/or otherwise sensitive areas include (i) Religious and Historic Places; (ii) Archaeological Monuments (e.g. identified zone around Taj Mahal); (iii) Scenic Areas; (iv) Hill Resorts; (v) Beach Resorts; (vi) Health Resorts; (vii) Coastal Areas rich in Corals, Mangroves, Breeding Grounds of Specific Species; (viii) Estuaries rich in Mangroves, Breeding grounds of Specific Species; (ix) Gulf Areas; (x) Biosphere Reserves; (xi) National Parks and Sanctuaries; (xii) Natural lakes, Swamps; (xiii) Seismic Zones; (xiv) Tribal Settlements; (xv) Areas of Scientific and Geological Interest; (xvi) Defence Installations, specially those of security importance and sensitive to pollution; (xvii) Border Areas (International) and (xviii) Air Ports.

Pre-requisite: State and Central Governments are required to identify such areas on a priority basis.

General siting factors

In any particular selected site, the following factors must also be recognized.

- No forest land shall be converted into non-forest activity for the sustenance of the industry (Ref: Forest Conversation Act, 1980).
- No prime agricultural land shall be converted into industrial site.
- Land acquired shall be sufficiently large to provide space for appropriate green cover including green belt, around the battery limit of the industry.
- Layout of the industry that may come up in the area must conform to the landscape of the area, without affecting the scenic features of that place.
- Associated township of the industry may be created at a space having physiographic barrier between the industry and the township.
- The distance from the boundary of reserve forest, if any, shall be as per SPCB guidelines, if specifically mentioned.

4.3 Scoping for EIA Studies

Scoping exercise is taken up soon after the project contours are defined. The primary purpose of scoping is to identify the concerns and issues which may affect the project decisions. Besides, scoping defines the requirements and boundaries of an EIA study.

Scoping refers to the process by which EAC, in case of Category ‘A’ projects or activities, and SEAC in case of Category ‘B1’ projects, including applications for expansion and/or modernization of existing projects, determine ToR for EIA studies

addressing all relevant environmental concerns for preparation of an EIA Report for a particular project.

- Project proponent shall submit application to concerned authority. The application (Form 1 as given in **Annexure III**) shall be attached with pre-feasibility report and proposed ToR for EIA Studies. The proposed sequence to arrive at the draft ToR is discussed below:
 - Pre-feasibility report summarizes project details and also the likely environmental concerns based on secondary information, which will be availed for filling the Form 1.
 - From the pre-feasibility report and Form 1, valued environmental components (VECs) may be identified for a given project (receiving environment/social components, which are likely to get affected due to the project operations/activities).
 - Once the project details from pre-feasibility report & Form 1; and VECs are identified, a matrix establishing interactions which can lead to effects/impacts could be developed (Qualitative analysis).
 - For each identified possible effect in the matrix, significance analysis could be conducted to identify the impacts, which need to be studied further (quantitative analysis) in subsequent EIA studies. All such points find a mention in the draft ToR to be proposed by the project proponent. The draft ToR shall include applicable baseline parameters (Annexure VII) and impact prediction tools (Annexure IX) proposed to be applied.
 - The information to be provided in pre-feasibility report, guidelines for filling Form 1 and guidelines for developing draft ToR is summarized in subsequent sections.
 - Authority consults the respective EAC/SEAC to reply to the proponent. The EAC/SEAC concerned, reviews the application form, pre-feasibility report and proposed draft ToR by the proponent and makes necessary additions/deletions to make it a comprehensive ToR that suits the statutory requirements for conducting the EIA studies.
- The concerned EAC/SEAC may formulate a sub-committee for a site visit, if considered necessary. The sub-committee will act up on receiving a written approval from chairperson of the concerned EAC/SEAC. Project proponent will facilitate such site visits of the sub-committees.
- EAC/SEAC shall provide an opportunity to the project proponent for presentation and discussions on the proposed project and related issues as well as the proposed ToR for EIA studies. If the State Government desires to present its views on any specific project in the scoping stage, it can depute an officer for the same at the scoping stage to EAC, as an invitee but not as a member of EAC. The Govt. of India may invite the SEIAA representatives, in case of projects falling in problem areas. However, non-appearance of the project proponent before EAC/SEAC at any stage will not be a ground for rejection of the application for the prior environmental clearance.
- If a new or expansion project is proposed problem area as identified by the CPCB, then the Ministry may invite representative SEIAA to the EAC to present their views, if any at the stage of scoping.
- The final set of ToR for EIA Studies shall be conveyed to the proponent by the EAC/SEAC within sixty days of the receipt of Form 1 and pre-feasibility report. If the

finalized ToR for EIA studies is not conveyed to the proponent within sixty days of the receipt of Form 1, the ToR suggested by the proponent shall be deemed as final and will be approved for EIA studies.

- Final ToR for EIA Studies shall be displayed on website of the MoEF/SEIAA.
- Applications for prior environmental clearance may be rejected by the concerned Authority based on the recommendations by the concerned EAC/SEAC at the scoping stage itself. In case of such rejection, the decision together with reasons for the same, shall be communicated to the proponent in writing within sixty days of the receipt of the application.
- The final EIA report and other relevant documents submitted by the proponent shall be scrutinized by the concerned Authority strictly with reference to the approved ToR for EIA studies.

4.3.1 Pre-feasibility report

The pre-feasibility report should include, but not limited to highlight the proposed project information, keeping in view the environmental sensitivities of the selected site, raw material, technology options and its availability. Information required in pre-feasibility report varies from case to case even in the same sector depending upon the local environmental setting within which the plant is located/proposed. However, the environmental information to be furnished in the pre-feasibility report may include:

I. Executive summary

II. Project details: Description of the project including in particular;

- a description of the main characteristics of production processes, for instance, nature and quantity of the materials used,
- an estimate, by type and quantity, of expected residues and emissions (water, air and soil pollution, noise, vibration, light, heat, radiation, *etc.*) resulting from the operation of the proposed project.
- a description of the physical characteristics of the whole project and the land-use requirements during the construction and operational phases

III. Selection of site based on least possible impacts

- An outline of the main alternatives studied by the developer and an indication of the main reasons for this choice, taking into account, the environmental effects.

IV. Anticipated impacts based on project operations on receiving environment

- A description of environment as aspects likely to be significantly affected by the proposed project, including, in particular, population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, landscape and the inter-relationship between the above factors.
- A description of the likely significant effects of the proposed project on the environment resulting from:
 - existence of project,
 - use of natural resources,

- emission of pollutants, creation of nuisances and elimination of waste, and description by the developer of the forecasting methods used to assess the effects on environment.

V. Proposed broad mitigation measures which could effectively be internalized as project components to have environmental and social acceptance of the proposed site

- A description of the key measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment

VI. An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the project proponent in compiling the required information

Details of the above listed points which may be covered in pre-feasibility report are listed in **Annexure VI**.

4.3.2 Guidance for providing information in Form 1

The information given in specifically designed pre-feasibility report for this developmental activity may also be availed for filling Form 1.

Form 1 is designed to help users identify the likely significant environmental effects of proposed projects right at the scoping stage. There are two stages for providing information under two columns:

- First - identifying the relevant project activities from the list given in column 2 of Form 1. Start with the checklist of questions set out below and complete Column 3 by answering:
 - Yes - if the activity is likely to occur during implementation of the project;
 - No - if it is not expected to occur;
 - May be - if it is uncertain at this stage whether it will occur or not.
- Second - For each activity for which the answer in Column 3 is “Yes” the next step is to refer to the fourth column which quantifies the volume of activity which could be judged as significant impact on the local environmental characteristics, and identify the areas that could be affected by that activity during construction/operation/decommissioning of the project. Form 1 requires information within 15 km around the project, whereas actual study area for EIA will be as prescribed by respective EAC/SEAC. Project proponent will need information about the surrounding VECs in order to complete this Form 1.

4.3.3 Identification of appropriate valued environmental components

VECs are components of natural resources and human world that are considered valuable and are likely to be affected by the project activities. Value may be attributed for economic, social, environmental, aesthetic or ethical reasons. VECs represent the investigative focal point for further EIA process. The indirect and/or cumulative effects can be concerned with indirect, additive or even synergistic effects due to other projects or activities or even induced developments on the same environmental components as would be considered direct effects. But such impacts tend to involve larger scale VECs such as within entire region, river basins or watersheds; and, broad social and economic VECs such as quality of life and the provincial economy. Once VECs are identified, then appropriate indicators are selected for impact assessments on the respective VECs.

4.3.4 Methods for identification of impacts

There are various factors which influence the approach adopted for the assessment of direct, indirect, cumulative impacts, *etc.* for a particular project. The method should be practical and suitable for the project given the data, time and financial resources available. However, the method adopted should be able to provide a meaningful conclusion from which it would be possible to develop, where necessary, mitigation measures and monitoring. Key points to consider when choosing the method(s) include:

- Nature of the impact(s)
- Availability and quality of data
- Availability of resources (time, finance and staff)

The method chosen should not be complex, but should aim at presenting the results in a way that can be easily understood by the developer, decision maker and the public. A comparative analysis of major impact identification methods is given in Table 4-1.

Table 4-1: Advantages and Disadvantages of Impact Identification Methods

	Description	Advantages	Disadvantages
Checklists	<ul style="list-style-type: none"> ▪ Annotate the environmental features that need to be addressed when identifying the impacts of activities in the project 	<ul style="list-style-type: none"> ▪ Simple to understand and use ▪ Good for site selection and priority setting ▪ Simple ranking and weighting 	<ul style="list-style-type: none"> ▪ Do not distinguish between direct and indirect impacts ▪ Do not link action and impact ▪ The process of incorporating values can be controversial
Matrices	<ul style="list-style-type: none"> ▪ Identify the interaction between project activities (along one axis) and environmental characteristics (along other axis) using a grid like table ▪ Entries are made in the cells which highlights impact severity in the form of symbols or numbers or descriptive comments 	<ul style="list-style-type: none"> ▪ Link action to impact ▪ Good method for displaying EIA results 	<ul style="list-style-type: none"> ▪ Difficult to distinguish direct and indirect impacts ▪ Significant potential for double-counting of impacts
Networks	<ul style="list-style-type: none"> ▪ Illustrate cause effect relationship of project activities and environmental characteristics ▪ Useful in identifying secondary impacts ▪ Useful for establishing impact hypothesis and other structured science based approaches to EIA 	<ul style="list-style-type: none"> ▪ Links action to impact ▪ Useful in simplified form for checking for second order impacts ▪ Handles direct and indirect impacts 	<ul style="list-style-type: none"> ▪ Can become very complex if used beyond simplified version
Overlays	<ul style="list-style-type: none"> ▪ Map the impacts spatially and display them pictorially ▪ Useful for comparing site and planning alternatives for routing linear developments ▪ Can address cumulative effects ▪ Information incentive 	<ul style="list-style-type: none"> ▪ Easy to understand ▪ Good to display method ▪ Good siting tool 	<ul style="list-style-type: none"> ▪ Addresses only direct impacts ▪ Does not address impact duration or probability
GIS	<ul style="list-style-type: none"> ▪ Maps the impacts spatially and display them pictorially ▪ Useful for comparing site and 	<ul style="list-style-type: none"> ▪ Easy to understand ▪ Good to display method 	<ul style="list-style-type: none"> ▪ Do not address impact duration or probability

Operational Aspects of EIA

	Description	Advantages	Disadvantages
	planning alternatives for routing linear developments <ul style="list-style-type: none"> ▪ Can address cumulative effects ▪ Information incentive 	<ul style="list-style-type: none"> ▪ Good siting tool ▪ Excellent for impact identification and analysis 	<ul style="list-style-type: none"> ▪ Heavy reliance on knowledge and data ▪ Often complex and expensive
Expert System	<ul style="list-style-type: none"> ▪ Assists diagnosis, problem solving and decision making ▪ collects inputs from user by answering systematically developed questions to identify impacts and determine their mitigability and significance ▪ Information intensive, high investment methods of analysis 	<ul style="list-style-type: none"> ▪ Excellent for impact identification and analysis ▪ Good for experimenting 	<ul style="list-style-type: none"> ▪ Heavy reliance on knowledge and data ▪ Often complex and expensive

The project team made an attempt to construct an impact matrix considering major project activities (generic operations) and stage-specific likely impacts which is given in Table 4-2.

While the impact matrix is project-specific, Table 4-2 may facilitate the stakeholders in identifying a set of components and phase-specific project activities for determination of likely impacts. Location-specific concerns may vary from case to case; therefore, the components, even without likely impacts, are also retained in the matrix for the location-specific reference.

Table 4-2: Matrix of Impacts

			PHASE I			PHASE II										PHASE III							
			Pre Construction			Construction/Erection										Operation and Maintenance							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
ENVIRONMENT	Component	Project Activiti Paramet er/	Detailed Topographic Survey	Land Acquirement	Site Clearing Burning of wastes, refuse and cleared vegetation	Site Preparation / Change in Topography	Civil works such as earth moving and building of structures including temporary structures	Heavy Equipment operations	Disposal of construction wastes	Generation of sewage	Influx of construction workers	Deforestation	Transportation of material	Erection of equipment	Raw material use and handling	Emission from metallurgical processes	Effluent from metallurgical processes	Solid wastes from metallurgical processes	Water extraction for metallurgical processes	Employment generation	Energy use and demand		
Physical	Soil	Erosion Risks				*							*										
		Contamination					*										*						
		Soil Quality			*		*												*				
	Resources	Fuels/ Electricity												*		*							*
		Raw materials						*								*							*
		Land especially undeveloped or agricultural land								*													
	Water	Interpretation or Alteration of River Beds					*																
		Alteration of Hydraulic Regime											*								*		
		Alteration of surface run-off and interflow			*		*	*												*			
		Alteration of aquifers					*	*												*			
		Water quality					*			*							*	*					

Operational Aspects of EIA

			PHASE I			PHASE II										PHASE III								
			Pre Construction			Construction/Erection										Operation and Maintenance								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
Air	Temperature																	*						
	Air quality					*		*	*						*		*	*					*	
	Noise							*	*						*	*	*							
	Climate					*								*			*	*					*	
Biological	Terrestrial Flora	Effect on grass & flowers			*		*			*			*				*							
		Effect on trees & shrubs			*		*							*				*						
		Effect on farmland			*		*				*								*					
		Endangered species			*		*								*									
	Aquatic Biota	Habitat removal			*		*												*					
		Contamination of habitats			*		*					*								*				
		Reduction of aquatic biota			*		*													*				
	Terrestrial Fauna	Fragmentation of terrestrial habitats			*		*							*										
		Disturbance of habitats by noise or vibration			*		*																	
		Reduction of Biodiversity			*		*								*									
Social	Economy	Creation of new economic activities		*								*			*	*		*		*		*		
		Commercial value of properties											*					*				*		
		Conflict due to negotiation and/ compensation payments			*																			
		Generation of temporary and permanent jobs											*		*	*	*						*	
		Effect on crops				*			*			*							*					
		Reduction of farmland productivity			*														*	*				
		Income for the state and private sector																*					*	

Operational Aspects of EIA

			PHASE I			PHASE II										PHASE III							
			Pre Construction			Construction/Erection										Operation and Maintenance							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
		Electricity tariffs																				*	
	Education	Training in new technologies	*																				
		Training in new skills to workers	*									*			*								
	Public Order	Political Conflicts		*																	*		
		Unrest, Demonstrations & Social conflicts			*							*									*		
	Infrastructure and Services	Conflicts with projects of urban, commercial or Industrial development	*					*															
	Security and Safety	Increase in Crime								*											*		
		Accidents								*					*	*	*						
	Health					*															*		
	Cultural	Land use			*		*													*			
		Recreation																	*				
		Aesthetics and human interest									*			*						*			
		Cultural status																				*	

NOTE:

- Above table represents a model for likely impacts, which will have to be arrived case-to-case basis considering VECs and significance analysis (Ref Section 2.9).
- Project activities are shown as indicative. However, in Form 1 (application for EIA Clearance), for any question for which answer is 'Yes', then the corresponding activity shall reflect in project activities. Similarly 'parameters'/'factors' will also be changed within a component in order to reflect the target species of prime concern in the receiving local environment.

4.3.5 Testing the significance of impacts

The following set of conditions may be used as the checklist for testing the significance of the impacts and also to provide information in Column IV of Form 1.

- Will there be a large change in environmental conditions?
- Will new features be out-of-scale with the existing environment?
- Will the effect be unusual in the area or particularly complex?
- Will the effect extend over a large area?
- Will there be any potential for trans-frontier impact?
- Will many people be affected?
- Will many receptors of other types (fauna and flora, businesses, facilities) be affected?
- Will valuable or scarce features or resources be affected?
- Is there a risk that environmental standards will be breached?
- Is there a risk that protected sites, areas, and features will be affected?
- Is there a high probability of the effect occurring?
- Will the effect continue for a long time?
- Will the effect be permanent rather than temporary?
- Will the impact be continuous rather than intermittent?
- If it is intermittent will it be frequent rather than rare?
- Will the impact be irreversible?
- Will it be difficult to avoid, or reduce or repair or compensate for the effect?

For each “Yes” answer in column 3, the nature of effects and reasons for it should be recorded in the column 4. The questions are designed so that a “Yes” answer in column 3, will generally point towards the need for analyzing for the significance and requirement for conducting impact assessment for the effect.

4.3.6 Terms of reference for EIA studies

In case, a coke oven plant comes in same metallurgical industry, please refer separate TGM developed for coke oven plants. Similarly, for induction/arc/cupola furnace TGM developed for induction/arc/cupola furnace may be referred. For an integrated metallurgical industry, a fusion of all the ToRs (metallurgy, coke oven and induction/arc/cupola furnace, Power plants, Cement plants based on proposed combination) may be considered.

ToR for EIA studies in respect of metallurgical industry (ferrous and non-ferrous) may include, but not limited to the following:

- 1) Executive summary of the project – giving a prima facie idea of the objectives of the proposal, use of resources, justification, *etc.* In addition, it should provide a compilation of EIA report including EMP and post-project monitoring plan in brief.

Project description

- 2) Justification for selecting the proposed unit size.
- 3) Land requirement for the project including its break up for various purposes, its availability and optimization.
- 4) Details of proposed layout clearly demarcating various units of the plant.

- 5) Complete process flow diagram describing each unit, its processes and operations, along with material and energy inputs & outputs (material and energy balance).
- 6) Iron and steel
 - Details of Iron and steel making plant describing details on design and manufacturing process for all the units.
 - Details on blast furnace/ open hearth furnace/ basic oxygen furnace/ladle refining, casting and rolling plants *etc.*
 - Details on installation/activation of opacity meters with recording with proper calibration system
 - Details on toxic metals including mercury, arsenic and fluoride emissions
 - Details on stack height requirement for integrated steel
- 7) Details on ash disposal and management -Non ferrous metal
 - Complete process flow diagram describing production of lead/zinc/copper/ aluminium, *etc.*
 - Raw materials substitution or elimination
 - Details on smelting, thermal refining, melting, slag fuming, and Waelz kiln operation
 - Details on Holding and de-gassing of molten metal from primary and secondary aluminum, materials pre-treatment, and from melting and smelting of secondary aluminum
 - Details on solvent recycling, and
 - Details on precious metals recovery
- 8) Details of proposed source-specific pollution control schemes and equipments to meet the national standards.
- 9) Details on requirement of raw materials, its source and storage at the plant. Also, an agreement for the supply of the iron ore for the proposed plant.
- 10) Details on requirement of energy and water requirement along with its source and authorization from the concerned department.
- 11) Details on water balance including quantity of effluent generated, recycled & reused. Efforts to minimize effluent discharge and to maintain quality of receiving water body.
- 12) Details of effluent treatment plant, inlet and treated water quality with specific efficiency of each treatment unit in reduction in respect of all concerned/regulated environmental parameters.
- 13) Details of the proposed methods of water conservation, recharging.
- 14) Water drawl approval from concerned authorities like CGWB, irrigation department,
- 15) Details on use of high calorific hazardous wastes in kiln and commitment regarding use of hazardous waste.
- 16) Details on composition, generation and utilization of waste/fuel gases from coke oven plant and their utilization.
- 17) Action plan for solid/hazardous waste generation, storage, utilization and disposal particularly char and fly ash.

- 18) Details on toxic metal content in the waste material and its composition and end use (particularly of slag).
- 19) Details regarding infrastructure facilities such as sanitation, fuel, restroom, *etc.*, to be provided to the workers during construction as well as to the casual workers including truck drivers during operation phase.
- 20) In case of expansion of existing industries, remediation measures adopted to restore the environmental quality if the groundwater, soil, crop, air, *etc.*, are affected and a detailed compliance to the prior environmental clearance/consent conditions.
- 21) Any litigation pending against the project and /or any direction /order passed by any Court of Law against the project, if so, details thereof.

Description of the environment

- 22) The study area shall be up to a distance of 10 km from the boundary of the proposed project site.
- 23) Location of the project site, and nearest habitats with distances from the site to be demarcated on a toposheet (1: 50000 scale).
- 24) Landuse of study area should include data about the residential/ institutional/nearest village/ township/ locality/ housing society, industries, *etc.*, based on the satellite imagery.
- 25) Demography details of all the villages falling within the study area
- 26) Topography of the area clearly indicating the presence of pits deeper than one meter, if any. If these pits require to be filled in, details of filling material to be used, quantity required, its source, mode of transport, *etc.*
- 27) The baseline data to be collected from the study area w.r.t. different components of environment viz. air, noise, water, land, and biology and socio-economic (please refer Section 4.4.2 for guidance for assessment of baseline components and identify attributes of concern). Actual monitoring of baseline environmental components shall be strictly according to the parameters prescribed in the ToR after considering the proposed coverage of parameters by the proponent in draft ToR and shall commence after finalization of ToR by the competent Authority.
- 28) Geological features and Geo-hydrological status of the study area.
- 29) Surface water quality of nearby water sources and other surface drains.
- 30) The location map drawn on Survey of India topo sheets with satellite imageries as regards its interference with natural drainage paths.
- 31) Details on ground water quality near solid waste dump zone.
- 32) Details on water quality for parameters pH, temperature, COD, Biochemical oxygen demand (27°C, 3 days), TDS*, Suspended solids*, Phenolic compounds (As C₆H₅OH)*, Cyanides (As CN)*, Oil & grease*, Ammonical nitrogen (As N)*, chlorides*, sulphides*, *etc.* (* - As applicable)
- 33) Relevant ambient air quality parameters for monitoring include following:
 - Iron & Steel: SO₂, NO_x, PM10, PM 2.5, O₃, Pb, CO, NH₃, C₆H₆, BaP.
 - Aluminum: SO₂, NO_x, PM10, PM 2.5, O₃, Pb, CO, NH₃, fluoride
 - Lead & Zinc: SO₂, NO_x, PM10, PM 2.5, O₃, Pb, CO, NH₃, As, Ni.
 - Copper: SO₂, NO_x, PM10, PM 2.5, O₃, Pb, CO, As, Ni, Acid mist
 - Coke ovens: SO₂, NO_x, PM10, PM 2.5, O₃, Pb, CO, C₆H₆, BaP.

- Sponge Iron: SO₂, NO_x, PM₁₀, PM 2.5, O₃, Pb, CO.
 - Secondary non-ferrous: SO₂, NO_x, PM₁₀, PM 2.5, O₃, Pb, CO, As, Ni, Acid mist.
- 34) Details on existing ambient air quality and expected, stack and fugitive emissions may be monitored for SPM*, PM₁₀*, PM_{2.5}*, SO₂*, NO_x*, HC*, CO*, acid mist*, VOC* and Benzopyrenes* (at ground level and at battery top), *etc.* and evaluation of the adequacy of the proposed pollution control devices to meet gaseous emissions and Dust fall data with heavy metal analysis. (* - as applicable)
- 35) The air quality contours may be plotted on a location map showing the location of project site, habitation nearby, sensitive receptors, if any and wind roses.
- 36) Proposed pollution control devices for the controlling the releasing of SPM to 50 mg/m³
- 37) One season site-specific data excluding monsoon season.
- 38) Site-specific micro-meteorological data including mixing height.
- 39) Noise levels at sensitive/commercial receptor.
- 40) Proposed baseline monitoring network for the consideration and approval of the Competent Authority.
- 41) Ecological status (terrestrial and aquatic) of the study area such as habitat type and quality, species, diversity, rarity, fragmentation, ecological linkage, age, abundance, *etc.*
- 42) If any incompatible land use attributes fall within the study area, proponent shall describe the sensitivity (distance, area and significance) and propose the additional points based on significance for review and acceptance by the EAC/SEAC. Incompatible land use attributes include:
- Public water supply areas from rivers/surface water bodies, from ground water
 - Scenic areas/tourism areas/hill resorts
 - Religious places, pilgrim centers that attract over 10 lakh pilgrims a year
 - Protected tribal settlements (notified tribal areas where industrial activity is not permitted)
 - Monuments of national significance, World Heritage Sites
 - Cyclone, Tsunami prone areas (based on last 25 years);
 - Airport areas
 - Any other feature as specified by the State or local government and other features as locally applicable, including prime agricultural lands, pastures, migratory corridors, *etc.*
- 43) If ecologically sensitive attributes fall within the study area, proponent shall describe the sensitivity (distance, area and significance) and propose the additional points based on significance for review and acceptance by the EAC/ SEAC. Ecological sensitive attributes include:
- National parks
 - Wild life sanctuaries Game reserve
 - Tiger reserve/elephant reserve/turtle nesting ground
 - Mangrove area
 - Wetlands
 - Reserved and protected forests
 - Any other closed/protected area under the Wild Life (Protection) Act, 1972,
 - Any other eco-sensitive areas

- 44) If the location falls in Valley, specific issues connected to the natural resources management shall be studied and presented.
- 45) If the location falls in CRZ area: A CRZ map duly authenticated by one of the authorized agencies demarcating LTL, HTL, CRZ area, location of the project and associate facilities w.r.t. CRZ, coastal features such as mangroves, if any.
 - Provide the CRZ map in 1:10000 scale in general cases and in 1:5000 scale for specific observations.
 - Proposed site for disposal of dredged material and environmental quality at the point of disposal/impact areas.
 - Fisheries study should be done w.r.t. Benthos and Marine organic material and coastal fisheries.

Anticipated environmental impacts and mitigation measures

- 46) Anticipated generic environmental impacts due to this project are indicated in Table 4-2, which may be evaluated for significance and based on corresponding likely impacts VECs may be identified. Baseline studies may be conducted for all the concerned VECs and likely impacts will have to be assessed for their magnitude in order to identify mitigation measures (please refer Chapter 4 of the manual for guidance).
- 47) Tools as given in Section 4.4.3 of the Manual shall be used for the assessment of environmental impacts and same may be submitted in draft ToR for consideration and approval by EAC/SEAC.
- 48) Air pollution control system to be installed should be elaborated upon to control SPM emissions within 50 mg/Nm³ and leakages from coke oven as per the Notified standards.
- 49) Sulphur removal from CO gas containing H₂S as per the notified standards.
- 50) Proposed odour control measures
- 51) Dry quenching of coke/modified wet quenching of coke as per the notified standards.
- 52) Pushing side emission control as per the notified standards.
- 53) Impact of the transport of the raw materials and end products on the surrounding environment including agricultural land.
- 54) Unit-wise air pollution control measures proposed for the control of gaseous emissions from all the sources should be incorporated.
- 55) Impact of the project on the AAQ of the area. Details of the model used and the input data used for modeling should also be provided. The air quality contours may be plotted on a location map showing the location of project site, habitation nearby, sensitive receptors, if any. The wind roses should also be shown on this map.
- 56) Determination of atmospheric inversion level at the project site and assessment of ground level concentration of pollutants from the stack/fugitive emission based on site-specific meteorological features. Air quality modeling for specific pollutants needs to be done.
- 57) Proper and full utilization of coke oven gases in BOF/BF/Coke oven gas plant and no discharge of gases into the air should be included.
- 58) Note on treatment of wastewater from different plants, recycle and reuse for different purposes.

- 59) Efforts made to minimize use of groundwater and impact on the groundwater, if any due the proposed project.
- 60) Impact of noise and measures taken for its control.
- 61) Char handling and management
- 62) Hazard identification taking resources to hazardous indices, inventory analysis, natural hazardous probability, *etc.*, Consequent analysis of failure and accidents resulting in release of hazardous substances.
- 63) Impact of toxic metal content in the waste material and its mitigating measures
- 64) Impact of stormwater and mitigating measures.
- 65) Surface as well as roof top rainwater harvesting and groundwater recharge should be included.
- 66) Action plan for the greenbelt development – species, width of plantations, planning schedule *etc.* in accordance to CPCB published guidelines.
- 67) Action plan for solid/hazardous waste generation, storage, utilization and disposal particularly tar and sludge from by product plant, dust from APCS *etc.*
- 68) Assessment report of the impact of transport of raw material and finished product on the transport system.
- 69) Proposed measures for occupational safety and health of the workers. Indian Factories Act must be referred for values of work zone concentration and other provisions.
- 70) For identifying the mitigation measures, please refer Chapter III for source control and treatment. Besides typical mitigation measures which may also be considered are discussed in Table 4-5.

Analysis of alternative resources and technologies

- 71) Comparison of alternate sites considered and the reasons for selecting the proposed site. Conformity of the site with the prescribed guidelines in terms of CRZ, river, highways, railways, *etc.*
- 72) Details of clean technologies as elaborated in Chapter 3 or any other improved technologies.

Environmental monitoring program

- 73) Monitoring of pollution control at source
- 74) Monitoring of pollutants at receiving environment for all the appropriate notified parameters – air quality, groundwater, surface water, *etc.*, during operational phase of the project.
- 75) Specific programme to monitor occupational safety and health protection of workers.
- 76) Appropriate monitoring network has to be designed and proposed, to assess the possible residual impacts.
- 77) Monitoring of carbon foot print
- 78) Details of in-house monitoring capabilities and the recognized agencies if proposed for conducting monitoring.

Additional studies

- 79) Impact of the project on local infrastructure of the area such as road network and whether any additional infrastructure would need to be constructed and the agency responsible for the same with timeframe.
- 80) Details on risk assessment and damage control during different phases of the project and proposed safeguard measures.
- 81) Details on socio-economic development activities such as commercial property values, generation of jobs, education, social conflicts, cultural status, accidents, *etc.*
- 82) Proposed plan to handle the socio-economic influence on the local community. The plan should include quantitative dimension as far as possible.
- 83) Details on compensation package for the people affected by the project, considering the socio-economic status of the area, homestead oustees, land oustees, and landless labourers.
- 84) Points identified in the public hearing and commitment of the project proponent to the same. Detailed action plan addressing the issues raised, and the details of necessary allocation of funds.
- 85) Details on plan for corporate social responsibility including the villages, population spread, SC/ST/backward communities, upgradation of existing schools, establishing new schools with facilities (such as laboratories, toilets, *etc.*), link roads, community halls, primary health facilities, health camps, *etc.*

Environmental management plan

- 86) Administrative and technical organizational structure to ensure proposed post-project monitoring programme for approved mitigation measures.
- 87) EMP devised to mitigate the adverse impacts of the project should be provided along with item-wise cost of its implementation (Capital and recurring costs).
- 88) Mitigation measures and EMP for construction work camps and slums formed during construction and operation including other induced developments
- 89) Allocation of resources and responsibilities for plan implementation.
- 90) Details of the emergency preparedness plan and on-site and off-site disaster management plan.

NOTE:

Above points shall be adequately addressed in the EIA report at corresponding chapters, in addition to the contents given in the reporting structure (Table: 4-6).

4.4 Environmental Impact Assessment

The generic approach for accomplishing EIA studies is shown in Figure 4.3. Each stage is discussed in detail, in subsequent sections.

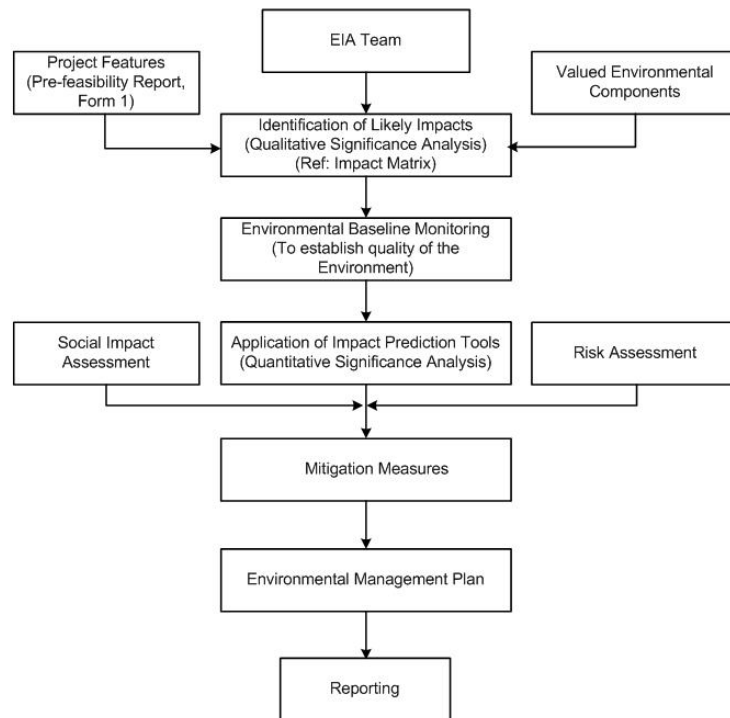


Figure 4-3: Approach for EIA Study

4.4.1 EIA team

The success of a multi-functional activity like an EIA primarily depends on constitution of a right team at the right time (preferable at the initial stages of an EIA) in order to assess the significant impacts (direct, indirect as well as cumulative impacts).

The professional Team identified for a specific EIA study should comprise of qualified and experienced professionals from various disciplines in order to address the critical aspects identified for the specific project. Based on the nature and the environmental setting, following professionals may be identified for EIA studies:

- Environmental management specialist/ environmental regulator
- Environmental landuse planner
- Metallurgical engineer
- Air and noise quality expert
- Occupational health specialist
- Geology/geo-hydrology specialist
- Ecologist
- Transportation specialist
- Safety and health specialist
- Mineral exploration and beneficiation specialist
- Social scientist, *etc.*

4.4.2 Baseline quality of the environment

EIA Notification 2006 specifies that an EIA Report should contain a description of the existing environment that would be or might be affected directly or indirectly by the proposed project. Environmental Baseline Monitoring (EBM) is a very important stage of EIA. On one hand, EBM plays a very vital role in EIA and on the other hand it provides feedback about the actual environmental impacts of a project. EBM, during the operational phase, helps in judging the success of mitigation measures in protecting the environment. Mitigation measures, intern are used to ensure compliance with environmental standards, and to facilitate the needed project design or operational changes.

Description of the existing environment should include natural, cultural, socio-economic systems and their interrelationships. The intention is not to describe all baseline conditions, but to focus the collection and description of baseline data on those VECs that are important and are likely to be affected by the proposed industrial activity.

4.4.2.1 Objective of EBM in the EIA context

The term ‘baseline’ refers to conditions existing before development. EBM studies are carried out to:

- identify environmental conditions which might influence project design decisions (*e.g.*, site layout, structural or operational characteristics);
- identify sensitive issues or areas requiring mitigation or compensation;
- provide input data to analytical models used for predicting effects;
- provide baseline data against which the results of future monitoring programs can be compared.

At this stage of EIA process, EBM is primarily discussed in the context of first purpose wherein feedback from EBM programs may be used to:

- determine available assimilative capacity of different environmental components within designated impact zone and whether more or less stringent mitigation measures are needed; and
- improve predictive capability of EIAs.

There are many institutional, scientific, quality control, and fiscal issues that must be addressed in implementation of an environmental monitoring program. Careful consideration of these issues in the design and planning stages will help avoid many of the pitfalls associated with environmental monitoring programs. Such major issues are as under:

4.4.2.2 Environmental monitoring network design

Monitoring refers to the collection of data through a series of repetitive measurements of environmental parameters (or, more generally, to a process of systematic observation). The environmental quality monitoring programme design will depend on the monitoring objectives specified for the selected area of interest. Types of monitoring and network design considerations are discussed in **Annexure VI**.

4.4.2.3 Baseline data generation

List of important physical environmental components and indicators of EBM are given in Table 4-3.

Table 4-3: List of Important Physical Environment Components and Indicators of EBM

Environmental Component	Environmental Indicators
Climatic variables	<ul style="list-style-type: none"> ▪ Rainfall patterns – mean, mode, seasonality ▪ Temperature patterns ▪ Extreme events ▪ Climate change projections ▪ Prevailing wind - direction, speed, anomalies ▪ Relative humidity ▪ Stability conditions and mixing height <i>etc.</i>
Geology	<ul style="list-style-type: none"> ▪ Underlying rock type, texture ▪ Surgical material ▪ Geologic structures (faults, shear zones, <i>etc.</i>) ▪ Geologic resources (minerals, <i>etc.</i>) <i>etc.</i>
Topography	<ul style="list-style-type: none"> ▪ Slope form ▪ Landform and terrain analysis ▪ Specific landform types <i>etc.</i>
Soil	<ul style="list-style-type: none"> ▪ Type and characteristics ▪ Porosity and permeability ▪ Sub-soil permeability ▪ Run-off rate ▪ Infiltration capacity ▪ Effective depth (inches/centimeters) ▪ Inherent fertility ▪ Suitability for method of sewage disposal <i>etc.</i>
Drainage	<ul style="list-style-type: none"> ▪ Surface hydrology ▪ Natural drainage pattern and network ▪ Rainfall runoff relationships ▪ Hydrogeology ▪ Groundwater characteristics – springs, <i>etc.</i>
Water	<ul style="list-style-type: none"> ▪ Raw water availability ▪ Water quality ▪ Surface water (rivers, lakes, ponds, gullies) – quality, water depths, flooding areas, <i>etc.</i> ▪ Ground water – water table, local aquifer storage capacity, specific yeild, specific retention, water level depths and fluctuations, <i>etc.</i> ▪ Coastal ▪ Floodplains ▪ Wastewater discharges ▪ Thermal discharges ▪ Waste discharges <i>etc.</i>
Air	<ul style="list-style-type: none"> ▪ Ambient ▪ Work zone ▪ Airshed importance ▪ Odour levels

Environmental Component	Environmental Indicators
Noise	<ul style="list-style-type: none"> ▪ Identifying sources of noise ▪ Noise due to traffic/transportation of vehicles ▪ Noise due to heavy equipment operations ▪ Duration and variations in noise over time <i>etc.</i>
Biological	<ul style="list-style-type: none"> ▪ Species composition of flora and fauna ▪ Flora – type, density, exploitation, <i>etc.</i> ▪ Fauna – distribution, abundance, rarity, migratory, species diversity, habitat requirements, habitat resilience, economic significance, commercial value, <i>etc.</i> ▪ Fisheries – migratory species, species with commercial/recreational value <i>etc.</i>
Landuse	<ul style="list-style-type: none"> ▪ Landuse pattern, <i>etc.</i>

Guidance for assessment of baseline components and attributes describing sampling network, sampling frequency, method of measurement is given in **Annexure VII**.

Infrastructure requirements for EBM

In addition to devising a monitoring network design and monitoring plan/program, it is also necessary to ensure adequate resources in terms of staffing, skills, equipment, training, budget, *etc.*, for its implementation. Besides assigning institutional responsibility, reporting requirements, QA/QC plans and its enforcement capability are essential. A monitoring program that does not have an infrastructural support and QA/QC component will have little chance of success.

Defining data statistics/analyses requirements

The data analyses to be conducted are dictated by the objectives of environmental monitoring program. The statistical methods used to analyze data should be described in detail prior to data collection. This is important because repetitive observations are recorded in time and space. Besides, the statistical methods could also be chosen so that uncertainty or error estimates in the data can be quantified. For *e.g.*, statistical methods useful in an environmental monitoring program include: 1) frequency distribution analysis; 2) analysis of variance; 3) analysis of covariance; 4) cluster analysis; 5) multiple regression analysis; 6) time series analysis; 7) the application of statistical models.

Use of secondary data

The EBM program for EIA can, at best, address temporal and/or spatial variations limited to a certain extent because of cost implications and time limitations. Therefore analysis of all available information or data is essential to establish the regional profiles. So all the relevant secondary data available for different environmental components should be collated and analyzed.

To facilitate stakeholders, IL&FS Ecosmart Ltd., has made an attempt to compile the list of information required for EIA studies and sources of secondary data, which are given in **Annexure VIIIA** and **Annexure VIIIB**.

4.4.3 Impact prediction tools

The scientific and technical credibility of an EIA relies on the ability of EIA practitioners to estimate the nature, extent, and magnitude of change in environmental components that may result from project activities. Information about predicted changes is needed for assigning impact significance, prescribing mitigation measures, and designing & developing EMPs and post-project monitoring programs. The more accurate the predictions are, the more confident the EIA practitioner will be in prescribing specific measures to eliminate or minimize the adverse impacts of development project.

Choice of models/methods for impact predictions in respect of air, noise, water, land, biological and socio-economic environment are precisely tabulated in **Annexure IX**.

4.4.4 Significance of the impacts

Evaluating the significance of environmental effects is perhaps the most critical component of impact analysis.. The interpretation of significance bears directly on the subsequent EIA process and also during Environmental Clearance on project approvals and condition setting. At an early stage, it also enters into screening and scoping decisions on what level of assessment is required and which impacts and issues will be addressed.

Impact significance is also a key to choosing among alternatives. In total, the attribution of significance continues throughout the EIA process, from scoping to EIS review, in a gradually narrowing “cone of resolution” in which, one stage sets up the next. But at this stage it is the most important as better understanding and quantification of impact significance is required.

One common approach is based on determination of the significance of predicted changes in the baseline environmental characteristics and compares these w.r.t regulatory standards, objective criteria and similar ‘thresholds’ as eco-sensitivity, cultural /religious values. Often, these are outlined in guidance. A better test proposed by the CEAA (1995) is to determine if ‘residual’ environmental effects are adverse, significant, and likely (given under). But at this stage, the practice of formally evaluating significance of residual impacts, *i.e.*, after predicting the nature and magnitude of impacts based on before-versus-after-project comparisons, and identifying measures to mitigate these effects is not being followed in a systematic way.

i. Step 1: Are the environmental effects adverse?

Criteria for determining if effects are “adverse” include:

- effects on biota health
- effects on rare or endangered species
- reductions in species diversity
- habitat loss
- transformation of natural landscapes
- effects on human health
- effects on current use of lands and resources for traditional purposes by aboriginal persons; and
- foreclosure of future resource use or production

ii. Step 2: Are the adverse environmental effects significant?

Criteria for determining ‘significance’ are to judge that the impacts:

- are extensive over space or time
- are intensive in concentration or proportion to assimilative capacity
- exceed environmental standards or thresholds
- do not comply with environmental policies, landuse plans, sustainability strategy
- adversely and seriously affect ecologically sensitive areas
- adversely and seriously affect heritage resources, other landuses, community lifestyle and/or indigenous peoples traditions and values

iii. Step 3: Are the significant adverse environmental effects likely?

Criteria for determining ‘likelihood’ include:

- probability of occurrence, and
- scientific uncertainty

4.5 Social Impact Assessment

Social Impact Assessment (SIA) is an instrument used to analyze social issues and solicit stakeholder views for the design of projects. SIA helps in making the project responsive to social development concerns, including options that enhance benefits for poor and vulnerable people while mitigating risk and adverse impacts. It analyzes distributional impacts of intended project benefits on different stakeholder groups, and identifies differences in assets and capabilities to access the project benefits.

The scope and depth of SIA should be determined by the complexity and importance of issues studied, taking into account the skills and resources available. SIA should include studies related to involuntary resettlement, compulsory land acquisition, impact of imported workforces, job losses among local people, damage to sites of cultural, historic or scientific interest, impact on minority or vulnerable groups, child or bonded labour, use of armed security guards. However, SIA may primarily include the following:

Description of the socio-economic, cultural and institutional profile

Conduct a rapid review of available sources of information to describe the socio-economic, cultural and institutional interface in which the project operates.

Socio-economic and cultural profile: Describe the most significant social, economic and cultural features that differentiate social groups in the project area. Describe different interests in the project, and their levels of influence. In particular, explain any specific effects, the project may have on the poor and underprivileged. Identify any known conflicts among groups that may affect project implementation.

Institutional profile: Describe the institutional environment; consider both the presence and function of public, private and civil society institutions relevant to the operation. Are there important constraints within existing institutions *e.g.* disconnect between institutional responsibilities and the interests and behaviors of personnel within those institutions? Or are there opportunities to utilize the potential of existing institutions, *e.g.* private or civil society institutions, to strengthen implementation capacity.

Legislative and regulatory considerations

To review laws and regulations governing the project's implementation and the access of poor and excluded groups to goods, services and opportunities provided by the project. In addition, review the enabling environment for public participation and development planning. SIA should build on strong aspects of the legal and regulatory systems to facilitate program implementation and identify weak aspects while recommending alternative arrangements.

Key social issues

SIA provides baseline information for designing social development strategy. The analysis should determine the key social and Institutional issues which affect the project objectives; identify the key stakeholder groups in this context and determine how relationships between stakeholder groups will affect or be affected by the project; and identify expected social development outcomes and actions proposed to achieve those outcomes.

Data collection and methodology

Describe the design and methodology for social analysis. In this regard:

- Build on existing data;
- Clarify the units of analysis for social assessment: intra-household, household level, as well as communities/settlements and other relevant social aggregations on which data is available or will be collected for analysis;
- Choose appropriate data collection and analytical tools and methods, employing mixed methods wherever possible; mixed methods include a mix of quantitative and qualitative methods.

Strategy to achieve social development outcomes

Identify the likely social development outcomes of the project and propose a social development strategy, including recommendations for institutional arrangements to achieve them, based on the findings of the social assessment. The social development strategy could include measures that:

- strengthen social inclusion by ensuring inclusion of both poor and excluded groups as well as then intended beneficiaries in the benefit stream, offer access to opportunities created by the project
- empower stakeholders through their participation in design and implementation of the project, their access to information, and their increased voice and accountability (*i.e.* a participation framework); and
- enhance security by minimizing and managing likely social risks and increasing the resilience of intended beneficiaries and affected persons to socioeconomic shocks

Implications for analysis of alternatives

Review proposed approaches for the project, and compare them in terms of their relative impacts and social development outcomes. Consider what implications the findings of social assessment might have on those approaches. Should some new components be added to the approach, or other components be reconsidered or modified?

If SIA and consultation processes indicate that alternative approaches may have better development outcomes, such alternatives should be described and considered, along with the likely budgetary and administrative effects these changes might have.

Recommendations for project design and implementation arrangements

Provide guidance to project management and other stakeholders on how to integrate social development issues into project design and implementation arrangements. As much as possible, suggest specific action plans or implementation mechanisms to address relevant social issues and potential impacts. These can be developed as integrated or separate action plans, for example, as Resettlement Action Plans, Indigenous Peoples Development Plans, Community Development Plans, *etc.*

Developing a monitoring plan

Through SIA process, a framework for monitoring and evaluation should be developed. To the extent possible, this should be done in consultation with key stakeholders, especially beneficiaries and affected people.

The framework shall identify expected social development indicators, establish benchmarks, and design systems and mechanisms for measuring progress and results related to social development objectives. The framework shall identify organizational responsibilities in terms of monitoring, supervision, and evaluation procedures. Wherever possible, participatory monitoring mechanisms shall be incorporated. The framework should establish:

- a set of monitoring indicators to track the progress achieved. The benchmarks and indicators should be limited in number, and should combine both quantitative and qualitative types of data. The indicators for outputs to be achieved by the social development strategy; indicators to monitor the process of stakeholder participation, implementation and institutional reform;
- indicators to monitor social risk and social development outcomes; and indicators to monitor impacts of the project's social development strategy. It is important to suggest mechanisms through which lessons learnt from monitoring and stakeholder feedback can result in changes to improve operation of the project. Indicators should be of such nature that results and impacts can be disaggregated by gender and other relevant social groups;
- Define transparent evaluation procedures. Depending on context, these may include a combination of methods, such as participant observation, key informant interviews, focus group discussions, census and socio-economic surveys, gender analysis, Participatory Rural Appraisal (PRA), Participatory Poverty Assessment (PPA) methodologies, and other tools. Such procedures should be tailored to the special conditions of the project and to the different groups living in the project area; Estimate resource and budget requirements for monitoring and evaluation activities, and a description of other inputs (such as institutional strengthening and capacity building) needs to be carried out.

4.6 Risk Assessment

Industrial accidents results in great personal and financial loss. Managing these accidental risks in today's environment is the concern of every industry including

metallurgical plants, because either real or perceived incidents can quickly jeopardize the financial viability of a business. Many facilities involve various manufacturing processes that have the potential for accidents which may be catastrophic to the plant, work force, environment, or public.

The main objective of risk assessment study is to propose a comprehensive but simple approach to carry out risk analysis and conducting feasibility studies for industries, planning and management of industrial prototype hazard analysis study in Indian context.

Risk analysis and risk assessment should provide details on Quantitative Risk Assessment (QRA) techniques used world-over to determine risk posed to people who work inside or live near hazardous facilities, and to aid in preparing effective emergency response plans by delineating a Disaster Management Plan (DMP) to handle on-site and off-site emergencies. Hence, QRA is an invaluable method for making informed risk-based process safety and environmental impact planning decisions, as well as being fundamental to any decisions while siting a facility. QRA whether, site-specific or risk-specific for any plant is complex and needs extensive study that involves process understanding, hazard identification, consequence modeling, probability data, vulnerability models/data, local weather and terrain conditions and local population data. QRA may be carried out to serve the following objectives.

- Identification of safety areas
- Identification of hazard sources
- Generation of accidental release scenarios for escape of hazardous materials from the facility
- Identification of vulnerable units with recourse to hazard indices
- Estimation of damage distances for the accidental release scenarios with recourse to Maximum Credible Accident (MCA) analysis
- Hazard and Operability studies (HAZOP) in order to identify potential failure cases of significant consequences
- Estimation of probability of occurrences of hazardous event through fault tree analysis and computation of reliability of various control paths
- Assessment of risk on basis of above evaluation against the risk acceptability criteria relevant to the situation
- Suggest risk mitigation measures based on engineering judgement, reliability and risk analysis approaches
- Delineation / upgradation of DMP
- Safety Reports: with external safety report/ occupational safety report,

The risk assessment report may cover the following in terms of extent of damage with resource to MCA analysis and delineation of risk mitigations measures with an approach to DMP.

- Hazard identification – identification of hazardous activities, hazardous materials, past accident records, *etc.*
- Hazard quantification – consequence analysis to assess the impacts
- Risk presentation
- Risk mitigation measures
- Disaster management plans

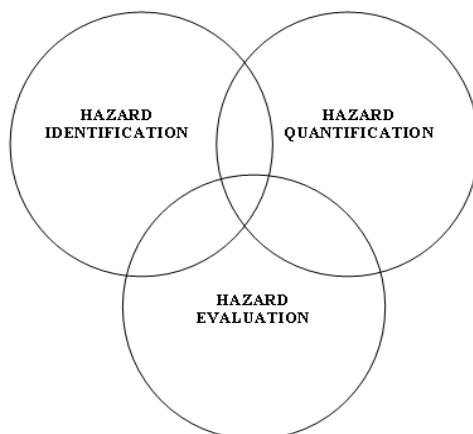


Figure 4-4: Risk Assessment – Conceptual Framework

Methods of risk prediction should cover all the design intentions and operating parameters to quantify risk in terms of probability of occurrence of hazardous events and magnitude of its consequence. Table 4-4 shows the predictive models for risk assessment.

Table 4-4: Choice of Models for Impact Predictions: Risk Assessment

Name	Application	Remarks
EFFECT WHAZAN	<ul style="list-style-type: none"> ▪ Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence ▪ Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence 	<ul style="list-style-type: none"> ▪ Heat load, press wave & toxic release exposure neutral gas dispersion
DEGADIS	<ul style="list-style-type: none"> ▪ Consequence Analysis for Visualization of accidental chemical release scenarios & its consequence 	<ul style="list-style-type: none"> ▪ Dense gas dispersion
HAZOP and Fault Tree Assessment	<ul style="list-style-type: none"> ▪ For estimating top event probability 	<ul style="list-style-type: none"> ▪ Failure frequency data is required
Pathways reliability and protective system hazard analysis	<ul style="list-style-type: none"> ▪ For estimating reliability of equipments and protective systems 	<ul style="list-style-type: none"> ▪ Markov models
Vulnerability Exposure models	<ul style="list-style-type: none"> ▪ Estimation of population exposure 	<ul style="list-style-type: none"> ▪ Uses probit equation for population exposure
F-X and F-N curves	<ul style="list-style-type: none"> ▪ Individual / Societal risks 	<ul style="list-style-type: none"> ▪ Graphical Representation

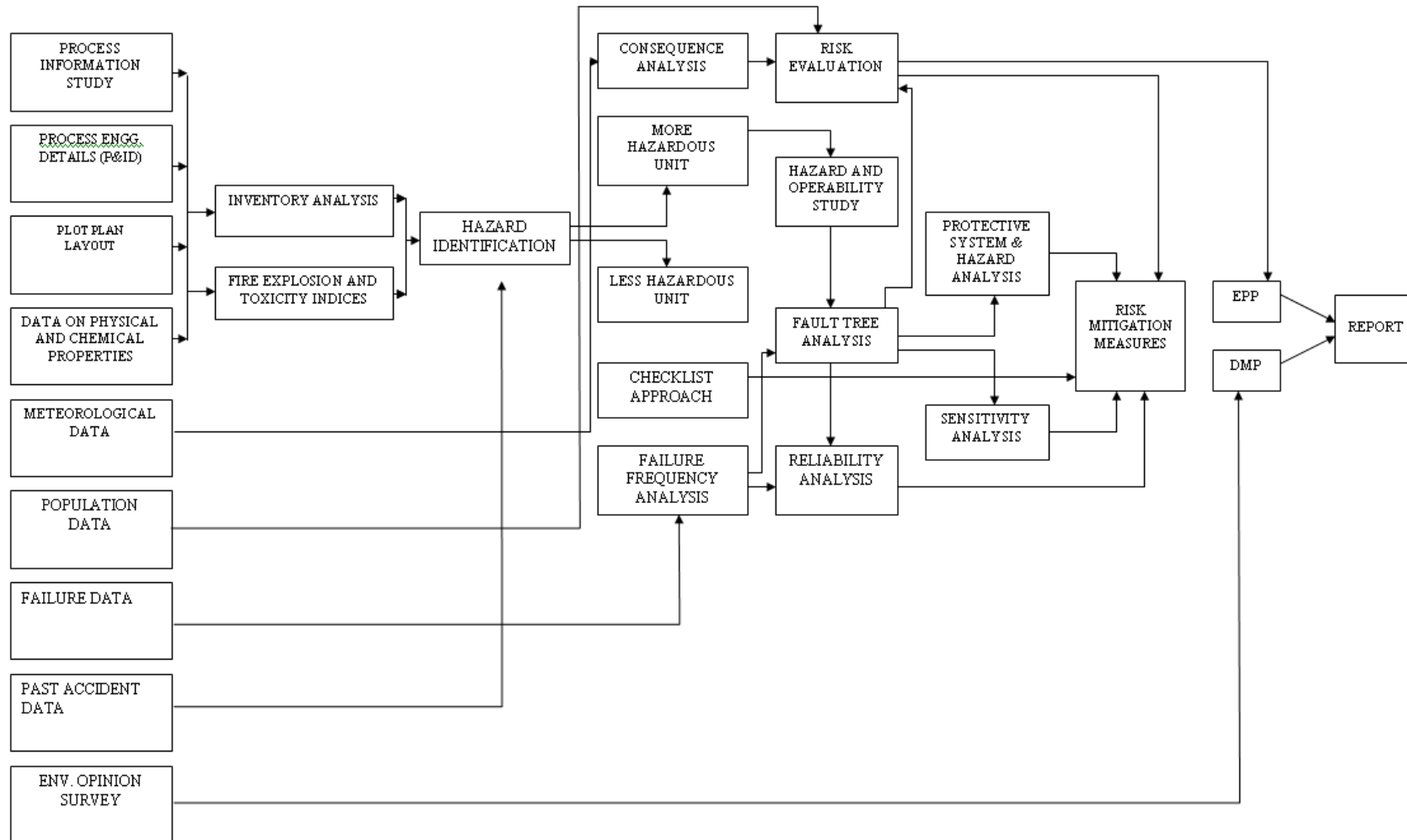


Figure 4-5: Comprehensive Risk Assessment - At a Glance

A. Storage & Handling of hazardous materials

Both hazardous and non-hazardous materials generated within the project facility shall be temporarily accommodated in appropriate units placed within the project facility built/made in line with the safety, health and environmental standards.

The size of these temporary units would depend on the quantity and type of hazardous waste materials like asbestos, PCB, oils, fuels, *etc.*, with appropriate storage capacities placed in the project facility in compliance with the Hazardous Waste Management and Handling Rules. In case of radioactive wastes, storage and handling should be based on Rules for Management of Radioactive Waste under AERB. Also, if gas cylinders must be stored in the facility, rules applicable for gas cylinders under the Explosives Act shall be followed. Later, these materials must be disposed off at a centralized disposal facility with utmost care following safety norms. Each unit in the facility should have fire hydrant system to handle fire hazards.

B. Hazard identification

Hazard is the characteristic of any system or process which has the potential for accident. Identification of hazards, in presence of any hazardous waste generating units within the project facility is of primary significance in the analysis, quantification and cost-effective control of accidents involving chemicals and process.

Hence, all components of a system/unit need to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

Typical methods for hazard identification employed are:

- Identification of major hazardous units based on Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 of Government of India (as amended in 2000)
- Identification of hazardous units and segments of plants and storage units based on relative ranking technique, *viz.* Fire-Explosion and Toxicity Index (FE&TI).

Hazardous substances may be classified into three main categories namely flammable, unstable and toxic substances. Flammable substances require interaction with air for their hazard to be realized. Under certain circumstances, vapours arising from flammable substances when mixed with air may become explosive, especially in confined spaces. However, if present in sufficient quantity, such clouds may explode in open air also. Unstable substances are liquids or solids, which may decompose with such violence giving rise to blast waves. Besides, toxic substances are dangerous and cause substantial damage to life when released into the atmosphere. The ratings for a large number of chemicals based on flammability, reactivity and toxicity are provided in NFPA Codes 49 and 345 M.

C. Hazard assessment and evaluation

A preliminary hazard analysis shall be carried out to identify major hazards associated with storages in the facility. 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.

Frequent causes of accidents

- Fire and explosion: explosives, flammable material
- Being struck by falling objects
- Caught in/or compressed
- Snapping of cables, ropes, chains, slings
- Handling heavy objects
- Electricity (electrocution)
- Poor illumination
- Falls from height inside industrial units or on the ground
- Struck by moving objects
- Slipping on wet surfaces
- Sharp objects
- Oxygen deficiency in confined spaces
- Lack of personal protective equipment (PPE), housekeeping practices, safety signs,
- Hackles, hooks, chains
- Cranes, winches, hoisting and hauling equipment;

Hazardous substances and wastes

- Heavy and toxic metals (lead, mercury, cadmium, copper, zinc, *etc.*)
- Organometallic substances (tributyltin, *etc.*)
- Lack of hazard communication (storage, labelling, material safety data sheets)
- Batteries, fire-fighting liquids
- PCBs and PVC (combustion products)
- Welding fumes
- Volatile organic compounds (solvents)
- Inhalation in confined and enclosed spaces
- Physical hazards
- Noise
- Extreme temperatures
- Vibration
- Radiation (UV, radioactive materials)

Physical hazards

- Noise
- Extreme temperatures
- Vibration
- Radiation (UV, radioactive materials)

Mechanical Hazards

- Trucks and transport vehicles
- Scaffolding, fixed and portable ladders
- Impact by tools, sharp-edged tools
- Power-driven hand tools, saws, grinders and abrasive cutting wheels
- Failure of machinery and equipment
- Poor maintenance of machinery and equipment
- Lack of safety guards in machines
- Structural failure

Biological hazards

- Toxic marine organisms (If the project facility is located in Coastal Regions)
- Risk of communicable diseases transmitted by pests, vermin, rodents, insects and other animals that may infest the project facility.
- Animal bites
- Vectors of infectious diseases (TB, malaria, dengue fever, hepatitis, respiratory infections, others)

Ergonomic and psychosocial hazards

- Repetitive strain injuries, awkward postures, repetitive and monotonous work, excessive workload
- Long working hours, shift work, night work, temporary employment
- Mental stress, human relations (aggressive behaviour, alcohol and drug abuse, violence)
- Poverty, low wages, minimum age, lack of education and social environment

General concerns

- Lack of safety and health training
- Poor work organization
- Inadequate housing and sanitation
- Inadequate accident prevention and inspection
- Inadequate emergency, first-aid and rescue facilities
- Lack of medical facilities and social protection

4.6.1 Disaster management plan

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

The DMP 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 DMP, it should be widely circulated and a personnel training is to be provided through rehearsals/drills.

To tackle the consequences of a major emergency inside the plant or immediate vicinity of the plant, a DMP has to be formulated and this planned emergency document is called DMP.

The objective of the DMP is to make use of the combined resources of the plant and the outside services to achieve the following:

- Effective 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 the needs of relatives
- Provide authoritative information to the news media
- Secure the safe rehabilitation of affected area

- 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.

The DMP should include emergency preparedness plan, emergency response team, emergency communication, emergency responsibilities, emergency facilities, and emergency actions

4.6.1.1 Emergency preparedness plan

Incidents, accidents and contingency preparedness should be accounted during construction and operation process. This shall be a part of EMS. Emergency Preparedness Plan (EPP) should be prepared following the National Environmental Emergency Plan and OSHA guidelines. According to these guidelines, an environmental emergency plan would essentially provide the following information:

- Assignment of duties and responsibilities among the authorities, participating agencies, response team, their coordinators and/or those responsible for the pollution incident
- Relationship with other emergency plans
- A reporting system that ensures rapid notification in the event of a pollution incident
- The establishment of a focal point for coordination and directions connected to the implementation of the plan
- Response operations should always cover these four phases:
 - Discovery and alarm
 - Evaluation, notification and plan invocation
 - Containment and counter measures
 - Cleanup and disposal
- Identification of expertise and response resources available for assistance for the implementation of plan
- Directions on the necessary emergency provisions applicable to the handling, treatment or disposal of certain pollutants
- Link to the local community for assistance, if necessary
- Support measures, such as procedures for providing public information, carrying out surveillance, issuing post-incident reports, review and updating of the plan, and periodic exercising of the plan.

4.6.1.2 Emergency response

Various units within the project facility are always subjected to accidents and incidents of many a kind. Therefore, a survey of potential incidents and accidents is to be carried out. Based on this, a plan for response to incidents, injuries and emergencies should be prepared. Response to emergencies should ensure that:

- The exposure of workers should be limited as much as possible during the operation
- Contaminated areas should be cleaned and, if necessary disinfected
- Limited impact on the environment at the extent possible.

Written procedures for different types of emergencies should be prepared and the entire workforce should be trained in emergency response. All relevant emergency response equipment should also be readily available.

With regard to dangerous spills, associated cleanup and firefighting operations should be carried out by specially allocated and trained personnel.

4.6.1.3 Response team

It is important to setup an Emergency Organization. A senior executive who has control over the affairs of the plant would be heading the Emergency Organization. He would be designated as Site Controller. Manager (Safety) would be designated as the Incident Controller. In case of stores, utilities, open areas, which are not under control of the Production Heads, Senior Executive responsible for maintenance of utilities would be designated as Incident Controller. All the Incident Controllers would be reporting to the Site Controller.

Each Incident Controller organizes a team responsible for controlling the incidence with the personnel under his control. Shift in charge would be the reporting officer, who would bring the incidence to the notice of the Incidence Controller and Site Controller.

Emergency Coordinators would be appointed who would undertake the responsibilities like firefighting, rescue, rehabilitation, transport and provide essential & support services. For this purposes, Security In charge, Personnel Department, Essential services personnel would be engaged. All these personnel would be designated as key personnel.

In each shift, electrical supervisor, electrical fitters, pump house in charge, and other maintenance staff would be drafted for emergency operations. In the event of power or communication system failure, some of staff members in the office/facility would be drafted and their services would be utilized as messengers for quick passing of communications. All these personnel would be declared as essential personnel.

Response to injuries

Based on a survey of possible injuries, a procedure for response to injuries or exposure to hazardous substances should be established. All staff should have minimum training to such response and the procedure ought to include the following:

- Immediate first aid, such as eye splashing, cleansing of wounds and skin, and bandaging
- Immediate reporting to a responsible designated person
- If possible, retention of the item and details of its source for identification of possible hazards
- Rapid additional medical care from medical personnel
- Medical surveillance
- Recording of the incident
- Investigation, determination and implementation of remedial action

It is vital that incident reporting should be straightforward so that reporting is actually carried out.

4.6.1.4 Emergency communication

Whoever notices an emergency situation such as fire, growth of fire, leakage *etc.* would inform his immediate superior and Emergency Control Center. The person on duty in the Emergency Control Center, would appraise the Site Controller. Site Controller verifies the situation from the Incident Controller of that area or the Shift In charge and takes a decision about an impending On-site Emergency. This would be communicated to all the Incident Controllers, Emergency Coordinators. Simultaneously, the emergency warning system would be activated on the instructions of the Site Controller.

4.6.1.5 Emergency responsibilities

The responsibilities of the key personnel should be defined for the following:

- Site controller
- Incident controller
- Emergency coordinator - rescue, fire fighting
- Emergency coordinator-medical, mutual aid, rehabilitation, transport and communication
- Emergency coordinator - essential services
- Employers responsibility

Emergency facilities

- Emergency Control Center – with access to important personnel, telephone, fax, telex facility, safe contained breathing apparatus, hand tools, emergency shut down procedures, duties and contact details of key personnel and government agencies, emergency equipments, *etc.*
- Assembly Point – with minimum facilities for safety and rescue
- Emergency Power Supply – connected with diesel generator, flame proof emergency lamps, *etc.*
- Fire Fighting Facilities – first aid fire fighting equipments, fire alarms, *etc.*
- Location of wind Stock – located at appropriate location to indicate the direction of wind for emergency escape
- Emergency Medical Facilities – Stretchers, gas masks, general first aid, emergency control room, breathing apparatus, other emergency medical equipment, ambulance

Emergency actions

- Emergency warning
- Evacuation of personnel
- All clear signal
- Public information and warning
- Coordination with local authorities
- Mutual aid
- Mock drills

4.7 Mitigation Measures

The purpose of mitigation is to identify measures that safeguard the environment and the community affected by the proposal. Mitigation is both a creative and practical phase of the EIA process. It seeks best ways and means of avoiding, minimizing and remedying

impacts. Mitigation measures must be translated into action in right way and at the right time, if they are to be successful. This process is referred to as impact management and takes place during project implementation. A written plan should be prepared for this purpose, and should include a schedule of agreed actions. Opportunities for impact mitigation will occur throughout the project cycle.

4.7.1 Important considerations for mitigation methods

The responsibility of project proponents to ‘internalize’ the full environmental costs of development proposals is now widely accepted under “Polluter Pay” principle. In addition, many proponents have found that good design and impact management can result in significant savings applying the principles of cleaner production to improve their environmental performance.

- The predicted adverse environmental as well as social impacts for which mitigation measures are required, should be identified and briefly summarized along with cross referencing them to the significance, prediction components of the EIA report or other documentation.
- Each mitigation measure should be briefly described w.r.t the impact of significances to which it relates and the conditions under which it is required (for example, continuously or in the event of contingencies). These should also be cross-referenced to the project design and operating procedures which elaborate on the technical aspects of implementing the various measures.
- Cost and responsibilities for mitigation and monitoring should be clearly defined, including arrangements for coordination between various authorities responsible for mitigation.
- The proponent can use the EMP to develop environmental performance standards and requirements for the project site as well as supply chain. An EMP can be implemented through EMS for the operational phase of the project.

Prior to selecting mitigation plans it is appropriate to study the mitigation alternatives for cost-effectiveness, technical and socio-political feasibility. Such mitigation measures could include:

- avoiding sensitive areas such as eco-sensitive area, *e.g.*, fish spawning areas, dense mangrove areas or areas known to contain rare or endangered species
- Lining of dumps / regular monitoring of ground water for leaching needs.
- adjusting work schedules to minimize disturbance
- engineered structures such as berms and noise attenuation barriers
- pollution control devices such as scrubbers, bag filters and electrostatic precipitators; dust suppression systems, BOD plants, *etc.*,
- changes in fuel feed, manufacturing, process, technology use, or waste management practices, *etc.*,

4.7.2 Hierarchy of elements of mitigation plan

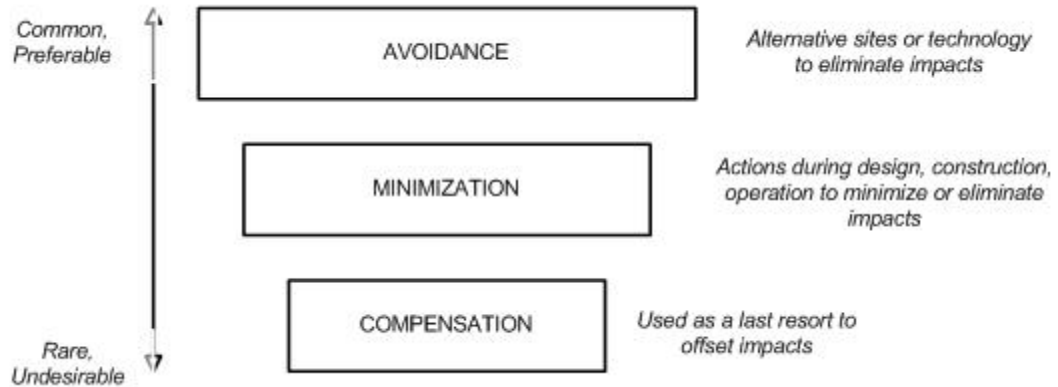


Figure 4-6: Elements of Mitigation

Good EIA practice requires a relevant technical understanding of issues and measures that work in circumstances: The priority of selection of mitigation measures should be in the order:

Step One: Impact avoidance

This step is most effective when applied at an early stage of project planning. It can be achieved by:

- not undertaking certain projects or elements that could result in adverse impacts
- avoiding areas that are environmentally sensitive; and
- putting in place the preventative measures to stop adverse impacts from occurring, for example, release of water from a reservoir to maintain a fisheries regime.

Step Two: Impact minimization

This step is usually taken during impact identification and prediction to limit or reduce the degree, extent, magnitude, or duration of adverse impacts. It can be achieved by:

- scaling down or relocating the proposal
- redesigning elements of the project and
- taking supplementary measures to manage the impacts

Step Three: Impact compensation

This step is usually applied to remedy unavoidable residual adverse impacts. It can be achieved by:

- rehabilitation of the affected site or environment, for example, by habitat enhancement and restocking fish;
- restoration of the affected site or environment to its previous state or better, as typically required for mine sites, forestry roads and seismic lines; and
- replacement of the same resource values at another location For example, by wetland engineering to provide an equivalent area to that lost to drainage or infill.

Important compensation elements

Resettlement Plans: Special considerations apply to mitigation of proposals that displace or disrupt people. Certain types of projects, such as reservoirs and irrigation schemes and public works, are known to cause involuntary resettlement. This is a contentious issue because it involves far more than re-housing people; in addition, income sources and access to common property resources are likely to be lost. Almost certainly, a resettlement plan will be required to ensure that no one is worse off than before, which may not be possible for indigenous people whose culture and lifestyle is tied to a locality. This plan must include the means for those displaced to reconstruct their economies and communities and should include an EIA of the receiving areas. Particular attention should be given to indigenous, minority and vulnerable groups who are at higher risk from resettlement.

In-kind compensation

When significant or net residual loss or damage to the environment is likely, in kind compensation is appropriate. As noted earlier, environmental rehabilitation, restoration or replacement have become standard practices for many proponents. Now, increasing emphasis is given to a broader range of compensation measures to offset impacts and assure the sustainability of development proposals. These include impact compensation 'trading', such as offsetting CO₂ emissions by planting forests to sequester carbon.

4.7.3 Typical mitigation measures

Choice of location for the developmental activity plays an important role in preventing adverse impacts on the surrounding environment. Detailed guidelines on siting of industries are provided in Section 4.2. However, if the developmental activity still produces any adverse impacts, mitigation measures should be taken.

Previous subsections of the Section 4.7 could be precisely summarized into following:

- Impacts from a developmental project could have many dimensions. As most of the direct impacts are caused by the releases from developmental projects, often impact control at source is the best opportunity to either eliminate or mitigate the impacts, in case these are cost-effective. In other words, the best way to mitigate the impacts is to prevent them from occurring. Choice of raw materials/technologies/processes which produce least impact would be one of the options to achieve it.
- After exploring cost-effective feasible alternatives to control impacts at source, various interventions to minimize the adverse impacts may be considered. These interventions, primarily aim at reducing the residual impacts on the valued environmental components of the receiving environment to the acceptable concentrations.
- The degree of control at source and external interventions differs from situation-to-situation and are largely governed by techno-economic feasibility. While the regulatory bodies stress for further source control (due to high reliability), the project proponents bargain for other interventions which may be relatively cost-effective than further control at source (in any case project authority is required to meet the industry-specific standards by adopting the best practicable technologies. However, if the location demands further control at source, then the proponents are required to adopt further advanced control technologies *i.e.* towards best available control

Operational Aspects of EIA

technologies). After having discussions with the project proponent, EAC/SEAC reaches to an agreed level of source control + other interventions (together called as mitigation measures in the given context) that achieve the targeted protection levels for the valued environmental components in the receiving environment. These levels will become the principle clearance conditions.

- Chapter 3 of this TGM offers elaborate information on cleaner technologies, waste minimization opportunities, and control technologies for various kinds of polluting parameters that emanate from this developmental activity. This information may be used to draw appropriate source control measures.

The choice of interventions for mitigation of impacts may also be numerous and depend on various factors. Mitigation measures based on location-specific suitability and some other factors are discussed in sub-sections 4.7.1 and 4.7.2. A few typical measures which may also be explored for mitigation of impacts are listed in Table 4-5.

Table 4-5: Typical Mitigation Measures

Impacts	Typical Mitigation Measures
Soil erosion	<ul style="list-style-type: none"> ▪ Windscreens, maintenance, and installation of ground cover ▪ Installation of drainage ditches ▪ Runoff and retention ponds ▪ Minimize disturbances and scarification of the surface ▪ Usage of appropriate monitoring and control facilities for construction equipments deployed ▪ Methods to reuse earth material generated during excavation, <i>etc.</i>
Resources - fuel/ construction material, <i>etc.</i>	<ul style="list-style-type: none"> ▪ Optimization of resource use ▪ Availing resources with leaset impacts ▪ Availing the resoruces which could be replenished by natural systems, <i>etc.</i>
Deforestation	<ul style="list-style-type: none"> ▪ Plant or create similar areas ▪ Initiate a tree planning program in other areas ▪ Donate land to conservationist groups, <i>etc.</i>
Water pollution	<ul style="list-style-type: none"> ▪ Conjunctive use of ground/surface water, to prevent flooding/water logging/depletion of water resources. Included are land use pattern, land filling, lagoon/reservoir/garland canal construction, and rainwater harvesting and pumping rate. ▪ Minimise flow variation from the mean flow ▪ Storing of oil wastes in lagoons should be minimised in order to avoid possible contamination of the ground water system. ▪ All effluents containing acid/alkali/organic/toxic wastes should be treated by appropriate methods ▪ Monitoring of ground waters ▪ Use of biodegradable or otherwise readily treatable additives ▪ Neutralization and sedimentation of wastewaters where applicable ▪ Dewatering of sludges and appropriate disposal of solids ▪ In case of oil waste, oil separation before treatment and discharge into the environment ▪ By controlling discharge of sanitary sewage and industrial waste into the environment ▪ By avoiding the activities that increases erosion or that contributes nutrients to water (thus stimulating alga growth) ▪ For wastes containing high TDS, treatment methods include removal of liquid and disposal of residue by controlled landfilling

Operational Aspects of EIA

Impacts	Typical Mitigation Measures
	<p>to avoid any possible leaching of the fills</p> <ul style="list-style-type: none"> ▪ All surface runoffs around mines or quarries should be collected treated and disposed. ▪ Treated wastewater (such as sewage, industrial wastes, or stored surface runoffs) can be used as cooling water makeup. ▪ Develop spill prevention plans in case of chemical discharges and spills ▪ Develop traps and containment system and chemically treat discharges on site, <i>etc.</i>
Air Pollution	<ul style="list-style-type: none"> ▪ Attenuation of pollution/protection of receptor through green belts/green cover ▪ Use of particulate removal devices such as cyclones, settling chambers, scrubbers, electrostatic precipitators, bag houses, <i>etc.</i> ▪ Use of gas removal devices using absorption (liquid as a media), adsorption (molecular sieve), and catalytic converters ▪ Use of protected, controlled equipments such as oxygen masks, <i>etc.</i> ▪ Control of stationary source emission (including evaporation, incineration, absorption, condensation, and material substitution) ▪ Dilution of odour (dilution can change the nature as well as strength of an odour), odour counteraction or neutralise (certain pairs of odours in appropriate concentrations may neutralise each other), odour masking or blanketing (certain weaker malodours may be suppressed by a considerably stronger good odour). ▪ Regular monitoring of air polluting concentrations, <i>etc.</i>
Dust pollution	<ul style="list-style-type: none"> ▪ Wetting of roadways to reduce traffic dust and reentrained particles ▪ Installation of windscreens to breakup the wind flow ▪ Burning of refuse on days when meteorological conditions provide for good mixing and dispersion ▪ Providing dust collection equipment at all possible points ▪ Maintaining dust levels within permissible limits ▪ Provision for masks when dust level exceeds, <i>etc.</i>
Noise pollution	<ul style="list-style-type: none"> ▪ Use of heavy duty muffler systems on heavy equipment ▪ Limiting certain activities ▪ By using damping, absorption, dissipation, and deflection methods ▪ By using common techniques such as constructing sound enclosures, applying mufflers, mounting noise sources on isolators, and/or using materials with damping properties ▪ Performance specifications for noise represent a way to insure the procured item is controlled ▪ Use of ear protective devices. ▪ In case of steady noise levels above 85-dB (A), initiation of hearing conservation measures, <i>etc.</i>
Biological	<ul style="list-style-type: none"> ▪ Installation of systems to discourage nesting or perching of birds in dangerous environments ▪ Increased employee awareness to sensitive areas, <i>etc.</i>
Marine	<ul style="list-style-type: none"> ▪ Water quality monitoring program ▪ Limit construction activities to day time to provide recuperation time at night and reduce turbidity ▪ Prevention of spillage of diesel, oil, lubes, <i>etc.</i> ▪ Usage of appropriate system to barges/workboats for collection of liquid/solid waste generated onboard ▪ Avoid discharge of construction/dredging waste (lose silt) into sea. It may be disposed at the identified disposal point.

Operational Aspects of EIA

Impacts	Typical Mitigation Measures
	<ul style="list-style-type: none"> ▪ Ensure usage of suitable/proper equipment for dredging in order to minimize the turbidity and suspensions at the dredging site. ▪ Checking with the complinace conditions before discharging wastes into the sea water ▪ Have a post-dredging monitoring programme in place ▪ Take up periodic maintenance dredging including inspection of sub-sea conditions, <i>etc.</i>
Social	<ul style="list-style-type: none"> ▪ Health and safety measures for workers ▪ Development of traffic plan that minimizes road use by workers ▪ Upgradation of roads and intersections ▪ Provide sufficient counselling and time to the affected population for relocation ▪ Discuss and finalize alternate arrangements and associated infrastructure in places of religious importance ▪ Exploration of alternative approach routes in consultation with local community and other stakeholders ▪ Provision of alternate jobs in unskilled and skilled categories, <i>etc.</i>
Occupational health and safety	<ul style="list-style-type: none"> ▪ Provision of worker camps with proper sanitation and medical facilities, as well as making the worker camps self-sufficient with resources like water supply, power supply, etc ▪ Arrangement of periodic health check-ups for early detection and control of communicable diseases. ▪ Arrangement to dispose off the wastes at approved disposal sites. ▪ Provide preventive measures for potential fire hazards with requisite fire detection, fire-fighting facilities and adequate water storage
Construction	<ul style="list-style-type: none"> ▪ Have a Transport Management Plan in place in order to prevent/minimize the disturbance on surrounding habitats ▪ Initiate traffic density studies
Solid/hazardous waste	<ul style="list-style-type: none"> ▪ Proper handling of excavated soil ▪ Proper plan to collect and dispose off the solid waste generated onsite. ▪ Identify an authorized waste handler for segregation of construction and hazardous waste and its removal on a regular basis to minimize odour, pest and litter impacts ▪ Prohibit burying of refuse onsite.

4.8 Environmental Management Plan

A typical EMP shall be composed of the following:

1. summary of potential impacts of the proposal
2. description of recommended mitigation measures
3. description of monitoring programme to ensure compliance with relevant standards and residual impacts
4. allocation of resources and responsibilities for plan implementation
5. implementation schedule and reporting procedures
6. contingency plan when impacts are greater than expected

Summary of impacts: The predicted adverse environmental and social impacts for which mitigation measures are identified in earlier sections to be briefly summarized with cross referencing to the corresponding sections in EIA report.

Description of mitigation measures: Each mitigation measure should be briefly described w.r.t the impact to which it relates and the conditions under which it is required. These should be accompanied by/ referenced to, project design and operating procedures which elaborate on the technical aspects of implementing various measures.

Description of monitoring programme to ensure compliance with relevant standards and residual impacts: Environmental monitoring refers to compliance monitoring and residual impact monitoring. Compliance monitoring refers to meeting the industry-specific statutory compliance requirements (Ref. Applicable National regulations as detailed in Chapter 3).

Residual impact monitoring refers to monitoring of identified sensitive locations with adequate number of samples and frequency. The monitoring programme should clearly indicate the linkages between impacts identified in the EIA report, measurement indicators, detection limits (where appropriate), and definition of thresholds that will signal the need for corrective actions.

Allocation of resources and responsibilities for plan implementation: These should be specified for both the initial investment and recurring expenses for implementing all measures contained in the EMP, integrated into the total project costs, and factored into loan negotiation.

The EMP should contain commitments that are binding on the proponent in different phases of project implementation *i.e.*, pre-construction or site clearance, construction, operation, decommissioning.

Responsibilities for mitigation and monitoring should be clearly defined, including arrangements for co-ordination between various actors responsible for mitigation. Details should be provided w.r.t deployment of staff (detailed organogram), monitoring network design, parameters to be monitored, analysis methods, associated equipments, *etc.*

Implementation schedule and reporting procedures: The timing, frequency and duration of mitigation measure should be specified in an implementation schedule, showing links with overall project implementation. Procedures to provide information on progress and results of mitigation and monitoring measures should also be clearly specified.

Contingency Plan when the impacts are greater than expected: There shall be a contingency plan for attending the situations where the residual impacts are higher than expected. It is an imperative requirement for all project authorities to plan additional programmes to deal with the situation, with the intimation to the concerned local regulatory bodies.

4.9 Reporting

Structure of the EIA report for Metallurgical industry is given in the Table 4-6. Each task prescribed in ToR shall be incorporated appropriately in the contents in addition to the described in the table.

Table 4-6: Structure of EIA Report

S.No	EIA Structure	Contents
1.	Introduction	<ul style="list-style-type: none"> ▪ Purpose of the report ▪ Identification of project & project proponent ▪ Brief description of nature, size, location of the project and its importance to the country, region ▪ Scope of the study – details of regulatory scoping carried out (As per Terms of Reference)
2.	Project Description	<p>Condensed description of those aspects of the project (based on project feasibility study), likely to cause environmental effects. Details should be provided to give clear picture of the following:</p> <ul style="list-style-type: none"> ▪ Type of project ▪ Need for the project ▪ Location (maps showing general location, specific location, project boundary & project site layout) ▪ Size or magnitude of operation (incl. Associated activities required by / for the project) ▪ Proposed schedule for approval and implementation ▪ Technology and process description ▪ Project description including drawings showing project layout, components of project <i>etc.</i> Schematic representations of feasibility drawings which give information important for EIA ▪ Description of mitigation measures incorporated into the project to meet environmental standards, environmental operating conditions, or other EIA requirements (as required by the scope) ▪ Assessment of New & untested technology for the risk of technological failure
3.	Description of the Environment	<ul style="list-style-type: none"> ▪ Study area, period, components & methodology ▪ Establishment of baseline for VECs, as identified in the scope ▪ Base maps of all environmental components
4.	Anticipated Environmental Impacts & Mitigation Measures	<ul style="list-style-type: none"> ▪ Details of investigated environmental impacts due to project location, possible accidents, project design, project construction, regular operations, final decommissioning or rehabilitation of a completed project ▪ Measures for minimizing and / or offsetting adverse impacts identified ▪ Irreversible and irretrievable commitments of environmental components ▪ Assessment of significance of impacts (Criteria for determining significance, assigning significance) ▪ Mitigation measures
5.	Analysis of Alternatives (Technology & Site)	<ul style="list-style-type: none"> ▪ In case, the scoping exercise results in need for alternatives: ▪ Description of each alternative ▪ Summary of adverse impacts of each alternative ▪ Mitigation measures proposed for each alternative and selection of alternative
6.	Environmental Monitoring Program	<ul style="list-style-type: none"> ▪ Technical aspects of monitoring the effectiveness of mitigation measures (incl. measurement methodologies, frequency, location, data analysis, reporting schedules, emergency procedures, detailed budget & procurement schedules)
7.	Additional Studies	<ul style="list-style-type: none"> ▪ Public consultation ▪ Risk assessment ▪ Social impact assessment, R&R action plans

Operational Aspects of EIA

S.No	EIA Structure	Contents
8.	Project Benefits	<ul style="list-style-type: none"> ▪ Improvements in physical infrastructure ▪ Improvements in social infrastructure ▪ Employment potential –skilled; semi-skilled and unskilled ▪ Other tangible benefits
9.	Environmental Cost Benefit Analysis	<ul style="list-style-type: none"> ▪ If recommended at the Scoping stage
10.	EMP	<ul style="list-style-type: none"> ▪ Description of administrative aspects that ensure proper implementation of the mitigative measures and their effectiveness monitored, after approval of the EIA
11.	Summary & Conclusion (This will constitute the summary of the EIA Report)	<ul style="list-style-type: none"> ▪ Overall justification for implementation of the project ▪ Explanation of how, adverse effects have been mitigated
12.	Disclosure of Consultants engaged	<ul style="list-style-type: none"> ▪ Names of the Consultants engaged with their brief resume and nature of Consultancy rendered

4.10 Public Consultation

Public consultation refers to the process by which the concerns of local affected people and others who have plausible stake in the environmental impacts of the project or activity are ascertained.

- Public consultation is not a decision taking process, but is a process to collect views of the people having plausible stake. If the SPCB/Public agency conducting public hearing is not convinced with the plausible stake, then such expressed views need not be considered.
- Public consultation involves two components, one is public hearing, and other one is inviting written responses/objections through Internet/by post, *etc.*, by placing the summary of EIA report on the web site.
- All Category A and Category B1 projects require public hearing except the following:
 - Once environmental clearance is granted to an industrial estate/SEZ/EPZ *etc.*, for a given composition (type and capacity) of industries, then individual units will not require public hearing
 - Expansion of roads and highways, which do not involve any further acquisition of land.
 - Maintenance dredging provided the dredged material shall be disposed within port limits
 - All building/ construction projects/ area development projects/townships
 - All Category B2 projects
 - All projects concerning national defense and security or involving other strategic considerations as determined by the Central Government
- Public hearing shall be carried out at the site or in its close proximity, district-wise, for ascertaining concerns of local affected people.
- Project proponent shall make a request through a simple letter to the Member–Secretary of the SPCB or UTPCC to arrange public hearing.
- Project proponent shall enclose with the letter of request, at least 10 hard copies and 10 soft copies of the draft EIA report including the summary EIA report in English

Operational Aspects of EIA

and in the official language of the State/local language prepared as per the approved scope of work, to the concerned Authority.

- Simultaneously, project proponent shall arrange to send, one hard copy and one soft copy, of the above draft EIA report along with the summary EIA report to the following Authorities within whose jurisdiction the project will be located:
 - District magistrate/District Collector/Deputy Commissioner (s)
 - Zilla parishad and municipal corporation or panchayat union
 - District industries office
 - Urban local bodies (ULBs)/PRIs concerned/development authorities
 - Concerned regional office of the MoEF/SPCB
- Above mentioned Authorities except Regional office of MoEF shall arrange to widely publicize the draft EIA report within their respective jurisdictions requesting the interested persons to send their comments to the concerned regulatory authorities. They shall also make draft EIA report for inspection electronically or otherwise to the public during normal office hours till the public hearing is over.
- Concerned regulatory Authority (MoEF/SEIAA/UTEIA) shall display the summary of EIA report on its website and also make full draft EIA report available for reference at a notified place during normal office hours at their head office.
- SPCB or UTPCC concerned shall also make similar arrangements for giving publicity about the project within the State/UT and make available the summary of draft EIA report for inspection in select offices, public libraries or any other suitable location, *etc.* They shall also additionally make available a copy of the draft EIA report to the five authorities/offices as mentioned above.
- The Member-Secretary of the concerned SPCB or UTPCC shall finalize the date, time and exact venue for the conduct of public hearing within seven days of the date of the receipt of the draft EIA report from the project proponent and advertise the same in one major National Daily and one Regional vernacular Daily/Official State language.
- A minimum notice period of 30 (thirty) days shall be provided to the public for furnishing their responses.
- No postponement of the date, time, venue of the public hearing shall be undertaken, unless some untoward emergency situation occurs. Only in case of emergencies and up on the recommendation of the concerned District Magistrate/District Collector/Deputy Commissioner, the postponement shall be notified to the public through the same National and Regional vernacular dailies and also prominently displayed at all the identified offices by the concerned SPCB or UTPCC
- In the above exceptional circumstances fresh date, time and venue for the public consultation shall be decided by the Member–Secretary of the concerned SPCB or UTPCC only in consultation with the District Magistrate/District collector/Deputy commissioner and notified afresh as per the procedure.
- The District Magistrate/District Collector/Deputy Commissioner or his or her representative not below the rank of an Additional District Magistrate assisted by a representative of SPCB or UTPCC, shall supervise and preside over the entire public hearing process.
- The SPCB or UTPCC shall arrange to video film the entire proceedings. A copy of the videotape or a CD shall be enclosed with the public hearing proceedings while forwarding it to the Regulatory Authority concerned.

Operational Aspects of EIA

- The attendance of all those who are present at the venue shall be noted and annexed with the final proceedings
- There shall be no quorum required for attendance for starting the proceedings
- Persons present at the venue shall be granted the opportunity to seek information or clarifications on the project from the proponent. The summary of the public hearing proceedings accurately reflecting all the views and concerns expressed shall be recorded by the representative of the SPCB or UTPCC and read over to the audience at the end of the proceedings explaining the contents in the local/vernacular language and the agreed minutes shall be signed by the District Magistrate/District Collector/Deputy Commissioner or his or her representative on the same day and forwarded to the SPCB/UTPCC concerned.
- A statement of the issues raised by the public and the comments of the proponent shall also be prepared in the local language or the official State language, as the case may be and in English and annexed to the proceedings.
- The proceedings of the public hearing shall be conspicuously displayed at the office of the Panchayats within whose jurisdiction the project is located, office of the concerned Zilla Parishad, District Magistrate/District Collector/Deputy Commissioner, and the SPCB or UTPCC. The SPCB or UTPCC shall also display the proceedings on its website for general information. Comments, if any, on the proceedings, may be sent directly to the concerned regulatory authorities and the proponent concerned.
- The public hearing shall be completed within a period of forty five days from date of receipt of the request letter from the proponent. Therefore the SPCB or UTPCC concerned shall send public hearing proceedings to the concerned regulatory authority within 8(eight) days of the completion of public hearing. Simultaneously, a copy will also be provided to the project proponent. The proponent may also directly forward a copy of the approved public hearing proceedings to the regulatory authority concerned along with the final EIA report or supplementary report to the draft EIA report prepared after the public hearing and public consultations incorporating the concerns expressed in the public hearing along with action plan and financial allocation, item-wise, to address those concerns.
- Up on receipt of the same, the Authority will place executive summary of the report on website to invite responses from other concerned persons having a plausible stake in the environmental aspects of the project or activity.
- If SPCB/UTPCC is unable to conduct public hearing in the prescribed time, the Central Government in case of Category A projects and State Government or UT administration in case of Category B projects at the request of SEIAA may engage any other agency or Authority for conducting the public hearing process within a further period of 45 days. The respective governments shall pay appropriate fee to the public agency for conducting public hearing.
- A public agency means a non-profit making institution/ body such as technical/academic institutions, government bodies not subordinate to the concerned Authority.
- If SPCB/Public Agency authorized for conducting public hearing informs the Authority, stating that it is not possible to conduct the public hearing in a manner, which will enable the views of the concerned local persons to be freely expressed, then Authority may consider such report to take a decision that in such particular case, public consultation may not have the component of public hearing.

Operational Aspects of EIA

- Often restricting the public hearing to the specific district may not serve the entire purpose, therefore, NGOs who are local and registered under the Societies Act in the adjacent districts may also be allowed to participate in public hearing, if they so desire.
- Confidential information including non-disclosable or legally privileged information involving intellectual property right, source specified in the application shall not be placed on the website.
- The Authority shall make available, on a written request from any concerned person, the draft EIA report for inspection at a notified place during normal office hours till the date of the public hearing.
- While mandatory requirements will have to be adhered to, utmost attention shall be given to the issues raised in the public hearing for determining the modifications needed in the project proposal and the EMP to address such issues.
- Final EIA report after making needed amendments, as aforesaid, shall be submitted by the proponent to the concerned Authority for prior environmental clearance. Alternatively, a supplementary report to draft EIA and EMP addressing all concerns expressed during the public consultation may be submitted.

4.11 Appraisal

Appraisal means the detailed scrutiny by the EAC or SEAC of the application and the other documents like the final EIA report, outcome of the public consultation including public hearing proceedings submitted by the proponent for grant of environmental clearance.

- The appraisal shall be made by EAC to the Central Government or SEAC to SEIAA.
- Project proponent either personally or through consultant can make a presentation to EAC/SEAC for the purpose of appraising the features of the project proposal and also to clarify the issues raised by the members of the EAC/SEAC.
- On completion of these proceedings, concerned EAC/SEAC shall make categorical recommendations to the respective Authority, either for grant of prior environmental clearance on stipulated terms & conditions, if any, or rejection of the application with reasons.
- In case EAC/SEAC needs to visit the site or obtain further information before being able to make categorical recommendations, EAC/SEAC may inform the project proponent accordingly. In such an event, it should be ensured that the process of environmental clearance is not unduly delayed to go beyond the prescribed timeframe.
- Up on the scrutiny of the final report, if EAC/SEAC opines that ToR for EIA studies finalized at the scoping stage are covered by the proponent, then the project proponent may be asked to provide such information. If such information is declined by the project proponent or is unlikely to be provided early enough so as to complete the environmental appraisal within prescribed time of 60 days, the EAC/SEAC may recommend for rejection of the proposal with the same reason.
- Appraisal shall be strictly in terms of ToR for EIA studies finalized at the scoping stage and the concerns expressed during public consultation.
- This process of appraisal shall be completed within 60 days from receipt of the updated EIA report and EMP reports, after completing public consultation.

- The EIA report will be typically examined for following:
 - Project site description supported by topographic maps & photographs – detailed description of topography, landuse and activities at the proposed project site and its surroundings (buffer zone) supported by photographic evidence.
 - Clarity in description of drainage pattern, location of eco-sensitive areas, vegetation characteristics, wildlife status - highlighting significant environmental attributes such as feeding, breeding and nesting grounds of wildlife species, migratory corridor, wetland, erosion and neighboring issues.
 - Description of the project site – how well the interfaces between the project related activities and the environment have been identified for the entire project cycle *i.e.* construction, operation and decommissioning at the end of the project life.
 - How complete and authentic are the baseline data pertaining to flora and fauna and socio economic aspects?
 - Citing of proper references, with regard to the source(s) of baseline data as well as the name of the investigators/ investigating agency responsible for collecting the primary data.
 - How consistent are the various values of environmental parameters with respect to each other?
 - Is a reasonable assessment of the environmental and social impact made for the identified environmental issues including project affected people?
 - To what extent the proposed environmental plan will mitigate the environmental impact and at what estimated cost, shown separately for construction, operation and closure stages and also separately in terms of capital and recurring expenses along with details of agencies that will be responsible for the implementation of environmental plan/ conservation plan.
 - How well the concerns expressed/highlighted during Public hearing have been addressed and incorporated in the EMP giving item wise financial provisions and commitments (in quantified terms)?
 - How far the proposed environmental monitoring plan will effectively evaluate the performance EMP's? Are details for environmental monitoring plan provided in the same manner as the EMP?
 - Identification of hazard and quantification of risk assessment and whether appropriate mitigation plan has been included in the EMP?
 - Does the proposal include a well formulated, time- bound green belt development plan for mitigating environmental problems such as fugitive emissions of dust, gaseous pollutants, noise, odour, *etc.*?
 - Does EIA make a serious attempt to guide the project proponent for minimizing the requirement of natural resources including land, water energy and other non renewable resources?
 - How well has the EIA statement been organized and presented so that the issues, their impact and environmental management strategies emerge clearly from it and how well organized was the power point presentation made before the expert committee?

- Is the information presented in EIA adequately and appropriately supported by maps, imageries and photographs highlighting site features and environmental attributes?

4.12 Decision Making

The Chairperson reads the sense of the Committee and finalizes the draft minutes of the meeting, which are circulated by the Secretary to all the expert members invited to the meeting. Based on the response from the members, the minutes are finalized and signed by the Chairperson. This process for finalization of the minutes should be so organized that the time prescribed for various stages is not exceeded.

Approval / Rejection / Reconsideration

- The Authority shall consider the recommendations of concerned appraisal Committee and convey its decision within 45 days of the receipt of recommendations.
- If the Authority disagrees with the recommendations of the Appraisal Committee, then reasons shall be communicated to concerned Appraisal Committee and proponent within 45 days from the receipt of the recommendations. The Appraisal Committee concerned shall consider the observations of the Authority and furnish its views on the observations within further period of 60 days. The Authority shall take a decision within the next 30 days based on the views of appraisal Committee.
- If the decision of the Authority is not conveyed within the time, then the proponent may proceed as if the environmental clearance sought has been granted or denied by the regulatory authority in terms of the final recommendation of the concerned appraisal Committee. For this purpose, the decision of the Appraisal Committee will be a public document, once the period specified above for taking the decision by the Authority is over.
- In case of the Category B projects, application shall be received by the Member Secretary of the SEIAA and clearance shall also be issued by the same SEIAA.
- Deliberate concealment and/or submission of false or misleading information or data which is material to screening or scoping or appraisal or decision on the application shall make the application liable for rejection, and cancellation of prior environmental clearance granted on that basis. Rejection of an application or cancellation of a prior environmental clearance already granted, on such ground, shall be decided by the regulatory authority, after giving a personal hearing to the applicant, and following the principles of natural justice.

If approved

- The concerned MoEF/SEIAA will issue an environmental clearance for the project.
- The project proponent should make sure that the award of environmental clearance is properly publicized in at least two local newspapers of the district or state where the proposed project is located. For instance, the executive summary of the environmental clearance may be published in the newspaper along with the information about the location (website/office where it is displayed for public) where the detailed Environmental Clearance is made available. The MoEF and SEIAA/UTEIAA, as the case may be, shall also place the environmental clearance in the public domain on Government Portal. Further copies of the environmental clearance shall be endorsed to the Heads of local bodies, Panchayats and Municipal bodies in addition to the relevant offices of the Government.

- The environmental clearance will be valid from the start date to actual commencement of the production of the developmental activity.
- Usual validity period will be 5 years from the date of issuing environmental clearance, unless specified by EAC/SEAC.
- A prior environmental clearance issued to a project proponent can be transferred to another legal person entitled to undertake the project, upon application by the transferor to the concerned Authority or submission of no-objection of the transferor by the transferee to the concerned Authority for the concurrence. In this case, EAC/SEAC concurrence is not required, but approval from the concerned authority is required to avail the same project configurations, validity period transferred to the new legally entitled person to undertake the project.

4.13 Post-clearance Monitoring Protocol

The MoEF, Government of India will monitor and take appropriate action under the EP Act, 1986.

- In respect of Category A projects, it shall be mandatory for the project proponent to make public the environmental clearance granted for their project along with the environmental conditions and safeguards at their cost by advertising it at least in two local newspapers of the district or State where the project is located and in addition, this shall also be displayed in the project proponent's website permanently.
- In respect of Category B projects, irrespective of its clearance by MoEF/SEIAA, the project proponent shall prominently advertise in the newspapers indicating that the project has been accorded environment clearance and the details of MoEF website where it is displayed.
- The MoEF and the SEIAAs/UTEIAAs, as the case may be, shall also place the environmental clearance in the public domain on Government Portal.
- Copies of the environmental clearance shall be submitted by the project proponents to the Heads of the local bodies, Panchayats and Municipal bodies in addition to the relevant offices of the Government who in turn have to display the same for 30 days from the date of receipt.

The project proponent must submit half-yearly compliance reports in respect of the stipulated prior environmental clearance terms and conditions in hard and soft copies to the regulatory authority concerned, on 1st June and 1st December of each calendar year.

All such compliance reports submitted by the project management shall be public documents. Copies of the same shall be given to any person on application to the concerned regulatory authority. The latest such compliance report shall also be displayed on the website of the concerned regulatory authority.

The SPCB shall incorporate EIA clearance conditions into consent conditions in respect of Category A and Category B projects and in parallel monitor and enforce the same.

5.

STAKEHOLDERS' ROLES AND RESPONSIBILITIES

Prior environmental clearance process involves many stakeholders *i.e.*, Central Government, State Government, SEIAA, EAC at the National Level, SEAC, Public Agency, SPCB, the project proponent, and the public.

- Roles and responsibilities of the organizations involved in different stages of prior environmental clearance are listed in Table 5-1.
- Organization-specific functions are listed in Table 5-2.

In this Chapter, constitution, composition, functions, *etc.*, of the Authorities and the Committees are discussed in detail.

Table 5-1: Roles and Responsibilities of Stakeholders Involved in Prior Environmental Clearance

Stage	MoEF/ SEIAA	EAC/ SEAC	Project Proponent	EIA Consultant	SPCB/ Public Agency	Public and Interest Group
Screening	Receives application and takes advice of EAC/ SEAC	Advises the MoEF/ SEIAA	Submits application (Form 1) and provides necessary information	Advises and assists the proponent by providing technical information		
Scoping	Approves the ToR, communicates the same to the project proponent and places the same in the website	Reviews the ToR, visits the proposed site, if required, and recommends the ToR to the MoEF/ SEIAA	Submits the draft ToR to SEIAA and facilitates the visit of the EAC/SEAC members to the project site	Prepares ToR		
EIA Report & Public Hearing	Reviews and forwards copies of the EIA report to SPCB /public agency for conducting public hearing Places the summary of EIA report in the		Submits detailed EIA report as per the finalized ToR Facilitates the public hearing by arranging presentation on the project, EIA and EMP – takes note of objections and updates the EMP	Prepares the EIA report Presents and appraises the likely impacts and pollution control measures proposed in the public hearing	Reviews EIA report and conducts public hearing in the manner prescribed Submits proceedings and views of SPCB, to the Authority and the	Participates in public hearings and offers comments and observations. Comments can be sent directly to SEIAA through Internet in response to the summary

Stakeholders' Roles and Responsibilities

Stage	MoEF/SEIAA	EAC/SEAC	Project Proponent	EIA Consultant	SPCB/ Public Agency	Public and Interest Group
	website Conveys objections to the project proponent for update, if any		accordingly		project proponent as well	placed in the website
Appraisal and Clearance	Receives updated EIA Takes advice of EAC/SEAC, approves EIA and attaches the terms and conditions	Critically examines the reports, presentation of the proponent and appraises MoEF/SEIAA (recommendations are forwarded to MoEF/SEIAA)	Submits updated EIA, EMP reports to MoEF/SEIAA. Presents the overall EIA and EMP including public concerns to EAC/SEAC	Provides technical advise to the project proponent and if necessary presents the proposed measures for mitigation of likely impacts (terms and conditions of clearance)		
Post-clearance Monitoring			Implements environmental protection measures prescribed and submits periodic monitoring results	Conducts periodic monitoring	Incorporates the clearance conditions into appropriate consent conditions and ensures implementation	

Table 5-2: Organization-specific Functions

Organization	Functions
Central Government	<ul style="list-style-type: none"> ▪ Constitutes the EAC ▪ Considering recommendations of the State Government, constitutes the SEIAA & SEAC ▪ Receives application from the project proponent in case of Category A projects or Category B projects attracting general condition ▪ Communicates the ToR finalized by the EAC to the project proponent. ▪ Receives EIA report from the project proponent and soft copy of summary of the report for placing in the website ▪ Summary of EIA report will be placed in website. Forwards the received responses to the project proponent ▪ Engages other public agency for conducting public hearings in cases where the SPCB does not respond within time ▪ Receives updated EIA report from project proponent incorporating the considerations from the proceedings of public hearing and responses received through other media

Stakeholders' Roles and Responsibilities

Organization	Functions
	<ul style="list-style-type: none"> Forwards updated EIA report to the EAC for appraisal Either accepts the recommendations of EAC or asks for reconsideration of specific issues for review by the EAC. Takes the final decision – acceptance/ rejection – of the project proposal and communicates the same to the project proponent
State Government	<ul style="list-style-type: none"> Identifies experts as per the composition specified in the Notification and subsequent guidelines to recommend to the Central Government. Extends funding support to fulfill the functions of SEIAA/SEAC Engages other public agency for conducting public hearings in cases where the SPCB does not respond within time State Governments will suitably pay the public agency for conducting such activity
EAC	<ul style="list-style-type: none"> Reviews Form 1 and its attachments Visits site(s), if necessary Finalizes ToR and recommends to the Central Government, which in turn communicates the finalized ToR to the project proponent, if not exempted by the Notification Reviews EIA report, proceedings and appraises their views to the Central government If the Central Government has any specific views, then the EAC reviews again for appraisal
SEIAA	<ul style="list-style-type: none"> Receives application from the project proponent Considers SEAC's views for finalization of ToR Communicates the finalized ToR to the project proponent Receives EIA report from project proponent Uploads the summary of EIA report in the website in cases of Category B projects Forwards the responses received to the project proponent Receives updated EIA report from project proponent incorporating the considerations from the proceedings of public hearing and responses received through other media Forwards updated EIA report to SEAC for appraisal Either accepts the recommendations of SEAC or asks for reconsideration of specific issues for review by SEAC. Takes the final decision and communicates the same to the project proponent
SEAC	<ul style="list-style-type: none"> Reviews Form 1 If necessary visits, site(s) for finalizing the ToR Reviews updated EIA - EMP report and Appraises the SEIAA
SPCB	<ul style="list-style-type: none"> Receives request from project proponent and conducts public hearing in the manner prescribed. Conveys proceedings to concerned authority and project proponent
Public Agency	<ul style="list-style-type: none"> Receives request from the respective Governments to conduct public hearing Conducts public hearing in the manner prescribed. Conveys proceedings to the concerned Authority/EAC /Project proponent

5.1 SEIAA

- SEIAA is constituted by the MoEF to take final decision regarding the acceptance/rejection of prior environmental clearance to the project proposal for all Category 'B' projects.
- The state government may decide whether to house them at the Department of Environment or at any other Board for effective operational support.
- State Governments can decide whether the positions are permanent or part-time. The Central Government (MoEF) continues to follow the model of paying fee (TA/DA,

Stakeholders' Roles and Responsibilities

accommodation, sitting fee) to the Chairperson and the members of EAC. As such, the State Government is to fund SEIAA & SEAC and decide the appropriate institutional support for them.

A. Constitution

- SEIAA is constituted by the Central Government comprising of three members including a Chairperson and Member–Secretary to be nominated by the State Government or UT Administration concerned.
- The Central Government will notify as and when the nominations (in order) are received from the State Governments, within 30 days from the date of receipt.
- The Chairperson and the non-official member shall have a fixed term of three years, from the date of Notification by the Central Government constituting the Authority.
- The form used by the State Governments to submit nominations for Notification by the Central Government is provided in **Annexure X**.

B. Composition

- Chairperson shall be an expert in the EIA process
- Member–Secretary shall be a serving officer of the concerned State Government/ UT Administration familiar with the environmental laws.
- Member–Secretary may be of a level equivalent to the Director, Dept. of Environment or above – a full time member.
- All the members including the Chairperson shall be the experts as per the criteria set in the Notification.
- The Government servants can only serve as the Member–Secretary to SEIAA and the Secretary to SEAC. All other members including Chairperson of the SEIAA and SEAC shall not be comprised of serving Government Officers; industry representatives; and activists.
- Serving faculty (academicians) is eligible for the membership in the Authority and/or the Committees, if they fulfill the criteria given in Appendix VI to the Notification.
- This is to clarify that the serving Government officers shall not be nominated as professional/expert member of SEIAA/SEAC/EAC.
- Professionals/Experts in the SEIAA and SEAC shall be different.
- Summary regarding the eligibility criteria for Chairperson and Members of the SEIAA is given in Table 5-3.

C. Decision-making process

- The decision of the Authority shall be arrived through consensus.
- If there is no consensus, the Authority may either ask SEAC for reconsideration or may reject the approval.
- All decisions of the SEIAA shall be taken in a meeting and shall ordinarily be unanimous, provided that, in case a decision is taken by majority, the details of views, for and against it, shall be clearly recorded in the minutes and a copy thereof sent to MoEF.

Stakeholders' Roles and Responsibilities

Table 5-3: SEIAA: Eligibility Criteria for Chairperson/ Members/ Secretary

S. No.	Attribute	Requirement			
		Members	Member Secretary	Chairperson	
1	Professional qualification as per the Notification	Compulsory	Compulsory	Compulsory	
2	Experience (Fulfilling any one of a, b, c)	a	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI
		b	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI
		c	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with environmental issues, problems and their management	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with environmental issues, problems and their management	-----
3	Test of independence (conflict of interest) and minimum grade of the Secretary of the Authority	<p>Shall not be a serving government officer</p> <p>Shall not be a person engaged in industry and their associations</p> <p>Shall not be a person associated with environmental activism</p>	Only serving officer from the State Government (DoE) familiar with environmental laws not below the level of Director	<p>Shall not be a serving government officer</p> <p>Shall not be a person engaged in industry and their associations</p> <p>Shall not be a person associated with environmental activism</p>	
4	Age	Below 67 years at the time of Notification of the Authority	As per State Government Service Rules	Below 72 Years at the time of the Notification of the Authority	
5	Other memberships in Central/State Appraisal Committees	Shall not be a member in any SEIAA/EAC/SEAC	Shall not be a member in any SEIAA/EAC/SEAC	Shall not be a member in any SEIAA/EAC/SEAC	
6	Tenure of earlier appointment	Only one term before this in continuity is	Not applicable	Only one term before this in continuity is	

Stakeholders' Roles and Responsibilities

S. No.	Attribute	Requirement		
		Members	Member Secretary	Chairperson
	(continuous)	permitted		permitted
7	Eminent environmental expertise with understanding on environmental aspects and impacts	Desirable	Desirable	Compulsory
8	Expertise in the environmental clearance process	Desirable	Desirable	Compulsory

Note:

1. A member after continuous membership in two terms (6 years) shall not be considered for further continuation. His/her nomination may be considered after a gap of one term (three years), if other criteria meet.
2. Chairperson/Member once notified may not be removed prior to the tenure of three years without cause and proper enquiry.

5.2 EAC and SEAC

EAC and SEAC are independent Committees to review each developmental activity and offer its recommendations for consideration of the Central Government and SEIAA respectively.

A. Constitution

- EAC and SEAC shall be constituted by the Central Government comprising a maximum of 15 members including a Chairperson and Secretary. In case of SEAC, the State Government or UT Administration is required to nominate the professionals/experts for consideration and Notification by the Central Government.
- The Central Government will notify as and when the nominations (in order) are received from the State Governments, within 30 days from the date of receipt.
- The Chairperson and the non-official member shall have a fixed term of three years, from the date of Notification by the Central Government.
- The Chairperson shall be an eminent environmental expert with understanding on environmental aspects and environmental impacts. The Secretary of the SEAC shall be a State Government officer, not below the level of a Director/Chief Engineer.
- The members of the SEAC need not be from the same State/UT.
- In case the State Governments/UTs so desire, the MoEF can form regional EAC to serve the concerned States/UTs.
- State Governments may decide to their convenience to house SEAC at the Department of Environment or at SPCB or at any other department, to extend support to the SEAC activities.

B. Composition

- Composition of EAC/SEAC as per the Notification is given in **Annexure XI**.

Stakeholders' Roles and Responsibilities

- Secretary to EAC/SEAC may invite a maximum of two professionals/experts with the prior approval of the Chairperson, if desired, for taking the advisory inputs for appraisal. In such case, the invited experts will not take part in the decision making process.
- The Secretary of each EAC shall be an officer of the level equivalent to or above the level of Director, MoEF, GoI.

C. Decision making

The EAC and SEAC shall function on the principle of collective responsibility. The Chairperson shall endeavour to reach a consensus in each case, and if consensus cannot be reached, the view of the majority shall prevail.

D. Operational issues

- Secretary may deal with all correspondence, formulate agenda and prepare agenda notes. Chairperson and other members may act only for the meetings.
- Chairperson of EAC/SEAC shall be one among the expert members having considerable professional experience with proven credentials.
- EAC/SEAC shall meet at least once every month or more frequently, if so needed, to review project proposals and to offer recommendations for the consideration of the Authority.
- EAC/SEAC members may inspect the site at various stages *i.e.* during screening, scoping and appraisal, as per the need felt and decided by the Chairperson of the Committee.
- The respective Governments through the Secretary of the Committee may pay/reimburse the participation expenses, honorarium *etc.*, to the Chairperson and members.

i. Tenure of EAC/SEIAA/SEAC

The tenure of Authority/Committee(s) shall be for a fixed period of three years. At the end of the three years period, the Authority and the committees need to be re-constituted. However, staggered appointment dates may be adopted to maintain continuity of members at a given point of time.

ii. Qualifying criteria for nomination of a member to EAC/SEIAA/SEAC

While recommending nominations and while notifying the members of the Authority and Expert Committees, it shall be ensured that all the members meet the following three criteria:

- Professional qualification
- Relevant experience/Experience interfacing with environmental management
- Absence of conflict of interest

These are elaborated subsequently.

a) Professional qualification

The person should have at least (i) 5 years of formal University training in the concerned discipline leading to a MA/MSc Degree, or (ii) in case of Engineering/Technology/

Stakeholders' Roles and Responsibilities

Architecture disciplines, 4 years formal training in a professional training course together with prescribed practical training in the field leading to a B.Tech/B.E./B.Arch. Degree, or (iii) Other professional degree (e.g. Law) involving a total of 5 years of formal University training and prescribed practical training, or (iv) Prescribed apprenticeship/articleship and pass examinations conducted by the concerned professional association (e.g. MBA/IAS/IFS). In selecting the individual professionals, experience gained by them in their respective fields will be taken note of.

b) Relevant experience

Experience shall be related to professional qualification acquired by the person and be related to one or more of the expertise mentioned for the expert members. Such experience should be a minimum of 15 years.

When the experience mentioned in the foregoing sub-paragraph interfaces with environmental issues, problems and their management, the requirement for the length of the experience can be reduced to a minimum of 10 years.

c) Absence of conflict of interest

For the deliberations of the EAC/SEAC to be independent and unbiased, all possibilities of potential conflict of interests have to be eliminated. Therefore, serving government officers; persons engaged in industry and their associations; persons associated with the formulation of development projects requiring environmental clearance, and persons associated with environmental activism shall not be considered for membership of SEIAA/ SEAC/ EAC.

iii. Age

Below 70 years for the members and below 72 years for the Chairperson of the SEIAA/SEAC/EAC. The applicability of the age is at the time of the Notification of the SEIAA/SEAC/EAC by the Central Government.

Summary regarding the eligibility criteria for Chairperson and Members of the EAC/SEAC is given in Table 5-4.

Table 5-4: EAC/SEAC: Eligibility Criteria for Chairperson / Members / Secretary

S. No.	Attribute	Requirement		
		Expert members	Secretary	Chairperson
1	Professional qualification as per the Notification	Compulsory	Compulsory	Compulsory
2	Experience (Fulfilling any one of a, b, c)	a Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification + 15 years of experience in one of the expertise area mentioned in the Appendix VI

Stakeholders' Roles and Responsibilities

S. No.	Attribute	Requirement			
		Expert members	Secretary	Chairperson	
		b	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI	Professional Qualification +PhD+10 years of experience in one of the expertise area mentioned in the Appendix VI
		c	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with environmental issues, problems and their management	Professional Qualification +10 years of experience in one of the expertise area mentioned in the Appendix VI + 5 years interface with environmental issues, problems and their management	-----
3	Test of independence (conflict of interest) and minimum grade of the Secretary of the Committees	Shall not be a serving government officer Shall not be a person engaged in industry and their associations Shall not be a person associated with environmental activism	In case of EAC, not less than a Director from the MoEF, Government of India In case of SEAC, not below the level of Director/Chief Engineer from the State Government (DoE)	Shall not be a serving government officer Shall not be a person engaged in industry and their associations Shall not be a person associated with environmental activism	
4	Age	Below 67 years at the time of Notification of the Committee	As per state Government Service Rules	Below 72 Years at the time of the Notification of the Committee	
5	Membership in Central/State Expert Appraisal committees	Only one other than this nomination is permitted	Shall not be a member in other SEIAA/EAC/SEAC	Shall not be a member in any other SEIAA/EAC/SEAC	
6	Tenure of earlier appointment (continuous)	Only one term before this in continuity is permitted	Not applicable	Only one term before this in continuity is permitted	
7	Eminent environmental expertise with understanding on environmental aspects and impacts	Desirable	Not applicable	Compulsory	

Notes:

1. A member after continuous membership in two terms (six years) shall not be considered for further continuation. His/her nomination may be reconsidered after a gap of one term (three years), if other criteria meet.

2. Chairperson/Member once notified may not be removed prior to the tenure of 3 years with out cause and proper enquiry. A member after continuous membership in two terms (6 years) shall not be considered for further continuation. The same profile may be considered for nomination after a gap of three years, i.e., one term, if other criteria are meeting.

E. Other conditions that may be considered

- An expert member of one State/UT, can have at the most another State/UT Committee membership, but in no case more than two Committees at a given point of time.
- An expert member of a Committee shall not have membership continuously in the same committee for more than two terms, *i.e.*, six years. They can be nominated after a gap of three years, *i.e.*, one term. When a member of Committee has been associated with any development project, which comes for environmental clearance, he/she may not participate in the deliberations and the decisions in respect to that particular project.
- At least four members shall be present in each meeting to fulfill the quorum
- If a member does not consecutively attend six meetings, without prior intimation to the Committee his/her membership may be terminated by the Notifying Authority. Prior information for absence due to academic pursuits, career development and national/state-endorsed programmes may be considered as genuine grounds for retention of membership.

ANNEXURE I
A Compilation of Legal Instruments

Sl. No.	Legal Instrument (Type, Reference, Year)	Responsible Ministries or Bodies	Chemical Use Categories/ Pollutants	Objective of Legislation	Relevant Articles/Provisions
1	Air (Prevention and Control of Pollution) Act, 1981 amended 1987	Central Pollution Control Board and State Pollution Control Boards	Air pollutants from chemical industries	The prevention, control and abatement of air pollution	Section 2: Definitions Section 21: Consent from State Boards Section 22: Not to allow emissions exceeding prescribed limits Section 24: Power of Entry and Inspection Section 25: Power to Obtain Information Section 26: Power to Take Samples Section 37-43: Penalties and Procedures
2	Air (Prevention and Control of Pollution) (Union Territories) Rules, 1983	Central Pollution Control Board and State Pollution Control Boards	Air pollutants from chemical industries	The prevention, control and abatement of air pollution	Rule 2: Definitions Rule 9: Consent Applications
3	Water (Prevention and Control of Pollution) Act, 1974 amended 1988	Central Pollution Control Board and State Pollution Control Boards	Water Pollutants from water polluting industries	The prevention and control of water pollution and also maintaining or restoring the wholesomeness of water	Section 2: Definitions Section 20: Power to Obtain Information Section 21: Power to Take Samples Section 23: Power of Entry and Inspection Section 24: Prohibition on Disposal Section 25: Restriction on New Outlet and New Discharge Section 26: Provision regarding existing discharge of sewage or trade effluent Section 27: Refusal or withdrawal of consent by state boards Section 41-49: Penalties and Procedures
4	Water (Prevention and Control of Pollution) Rules, 1975	Central Pollution Control Board and State Pollution Control Boards	Water Pollutants from water polluting industries	The prevention and control of water pollution and also maintaining or restoring the wholesomeness of water	Rule 2: Definitions Rule 30: Power to take samples Rule 32: Consent Applications
5	The Environment (Protection) Act, 1986,	Ministry of Environment and Forests, Central	All types of environmental pollutants	Protection and Improvement of the Environment	Section 2: Definitions Section 7: Not to allow emission or discharge of

	amended 1991	Pollution Control Board and State Pollution Control Boards			environmental pollutants in excess of prescribed standards Section 8: Handling of Hazardous Substances Section 10: Power of Entry and Inspection Section 11: Power to take samples Section 15-19: Penalties and Procedures
6	Environmental (Protection) Rules, 1986 (Amendments in 1999, 2001, 2002, 2002, 2002, 2003, 2004)	Ministry of Environment and Forests, Central Pollution Control Board and State Pollution Control Boards	All types of Environmental Pollutants	Protection and Improvement of the Environment	Rule 2: Definitions Rule 3: Standards for emission or discharge of environmental pollutants Rule 5: Prohibition and restriction on the location of industries and the carrying on process and operations in different areas Rule 13: Prohibition and restriction on the handling of hazardous substances in different areas Rule 14: Submission of environmental statement
7	Hazardous Waste (Management and Handling) Rules, 1989 amended 2000 and 2003	MoEF, CPCB, SPCB, DGFT, Port Authority and Customs Authority	Hazardous Wastes generated from industries using hazardous chemicals	Management & Handling of hazardous wastes in line with the Basel convention	Rule 2: Application Rule 3: Definitions Rule 4: Responsibility of the occupier and operator of a facility for handling of wastes Rule 4A: Duties of the occupier and operator of a facility Rule 4B: Duties of the authority Rule 5: Grant of authorization for handling hazardous wastes Rule 6: Power to suspend or cancel authorization Rule 7: Packaging, labeling and transport of hazardous wastes Rule 8: Disposal sites Rule 9: Record and returns Rule 10: Accident reporting and follow up Rule 11: Import and export of hazardous waste for dumping and disposal Rule 12: Import and export of hazardous waste for recycling and reuse

					<p>Rule 13: Import of hazardous wastes Rule 14: Export of hazardous waste Rule 15: Illegal traffic Rule 16: Liability of the occupier, transporter and operator of a facility Rule 19: Procedure for registration and renewal of registration of recyclers and re-refiners Rule 20: Responsibility of waste generator</p>
8	<p>Manufacture Storage and Import of Hazardous Chemicals Rules, 1989 amended 2000</p>	<p>Ministry of Environment & Forests, Chief Controller of Imports and Exports, CPCB, SPCB, Chief Inspector of Factories, Chief Inspector of Dock Safety, Chief Inspector of Mines, AERB, Chief Controller of Explosives, District Collector or District Emergency Authority, CEES under DRDO</p>	<p>Hazardous Chemicals - Toxic, Explosive, Flammable, Reactive</p>	<p>Regulate the manufacture, storage and import of Hazardous Chemicals</p>	<p>Rule 2: Definitions Rule 4: responsibility of the Occupier Rule 5: Notification of Major Accidents Rule 7-8: Approval and notification of site and updating Rule 10-11: Safety Reports and Safety Audit reports and updating Rule 13: Preparation of Onsite Emergency Plan Rule 14: Preparation of Offsite Emergency Plan Rule 15: Information to persons likely to get affected Rule 16: Proprietary Information Rule 17: Material Safety Data Sheets Rule 18: Import of Hazardous Chemicals</p>
9	<p>Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996</p>	<p>CCG, SCG, DCG, LCG and MAH Units</p>	<p>Hazardous Chemicals - Toxic, Explosive, Flammable, Reactive</p>	<p>Emergency Planning Preparedness and Response to chemical accidents</p>	<p>Rule 2: Definitions Rule 5: Functions of CCG Rule 7: Functions of SCG Rule 9: Functions of DCG Rule 10: Functions of LCG</p>
10	<p>Ozone Depleting Substances (Regulation and Control) Rules, 2000</p>	<p>Ministry of Environment & Forests</p>	<p>Ozone depleting substances</p>	<p>Regulate the production, import, use, sale, purchase and phase-out of the ODS</p>	<p>Rule 2: Definitions Rule 3: Regulation of production and consumption of ozone depleting substances Rule 4: Prohibition on export to or import from countries not specified in Schedule VI Rule 5: Ozone depleting substances are to be exported to or imported from countries specified in Schedule VI under a license Rule 6: Regulation of the sale of ozone depleting substances Rule 7: Regulation on the purchase of ozone</p>

					<p>depleting substances</p> <p>Rule 8: Regulation on the use of ozone depleting substance</p> <p>Rule 9: Prohibition on new investments with ozone depleting substances</p> <p>Rule 10: Regulation of import, export and sale of products made with or containing ozone depleting substances</p> <p>Rule 11: Regulation on reclamation and destruction of ozone depleting substances</p> <p>Rule 12: Regulation on manufacture, import and export of compressors</p> <p>Rule 13: Procedure for registration, cancellation of registration and appeal against such orders</p> <p>Rule 14: Monitoring and reporting requirements</p>
11	EIA Notification, 2006	MoEF, SPCB	For all the identified developmental activities in the notification	Requirement of environmental clearance before establishment of or modernization / expansion of identified developmental projects.	Requirements and procedure for seeking environmental clearance of projects
12	Batteries (Management and Handling) Rules, 2001.	SPCB, CPCB and MoEF	Lead Acid Batteries	To control the hazardous waste generation (lead waste) from used lead acid batteries	<p>Rule 2: Application</p> <p>Rule 3: Definitions</p> <p>Rule 4: Responsibilities of manufacturer, importer, assembler and re-conditioner</p> <p>Rule 5: Registration of Importers</p> <p>Rule 7: Responsibilities of dealer</p> <p>Rule 8: Responsibilities of recycler</p> <p>Rule 9: Procedure for registration / renewal of registration of recyclers</p> <p>Rule 10: Responsibilities of consumer or bulk consumer</p> <p>Rule 11: Responsibilities of auctioneer</p> <p>Rule 14: Computerization of Records and Returns</p>
13	Public Liability Insurance Act, 1991 amended 1992	Ministry of Environment & Forests, District Collector	Hazardous Substances	To provide immediate relief to persons affected by accident involving hazardous substances	<p>Section 2: Definitions</p> <p>Section 3: Liability to give relief in certain cases on principle of no fault</p> <p>Section 4: Duty of owner to take out insurance policy</p>

					Section 7A: Establishment of Environmental Relief Fund Section 14-18: Penalties and Offences
14	Public Liability Insurance Rules, 1991 amended 1993	Ministry of Environment & Forests, District Collector	Hazardous Substances	To provide immediate relief to persons affected by accident involving hazardous substances and also for Establishing an Environmental Relief fund	Rule 2: Definitions Rule 6: Establishment of administration of fund Rule 10: Extent of liability Rule 11: Contribution of the owner to environmental relief fund
15	Factories Act, 1948	Ministry of Labour, DGFASLI and Directorate of Industrial Safety and Health/Factories Inspectorate	Chemicals as specified in the Table	Control of workplace environment, and providing for good health and safety of workers	Section 2: Interpretation Section 6: Approval, licensing and registration of factories Section 7A: General duties of the occupier Section 7B: General duties of manufacturers etc., as regards articles and substances for use in factories Section 12: Disposal of wastes and effluents Section 14: Dust and fume Section 36: Precautions against dangerous fumes, gases, etc. Section 37: Explosion or inflammable dust, gas, etc. Chapter IVA: Provisions relating to Hazardous processes Section 87: Dangerous operations Section 87A: Power to prohibit employment on account of serious hazard Section 88: Notice of certain accident Section 88A: Notice of certain dangerous occurrences Chapter X: Penalties and procedures
16	The Explosives Act, 1884	Ministry of Commerce and Industry (Department of Explosives)	Explosive substances as defined under the Act	To regulate the manufacture, possession, use, sale, transport, export and import of explosives with a view to prevent accidents	Section 4: Definition Section 6: Power for Central government to prohibit the manufacture, possession or importation of especially dangerous explosives Section 6B: Grant of Licenses

17	The Explosive Rules, 1983	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, railway administration	Explosive substances as defined under the Act	To regulate the manufacture, possession, use, sale, transport, export and import of explosives with a view to prevent accidents	Rule 2: Definition Chapter II: General Provisions Chapter III: Import and Export Chapter IV: Transport Chapter V: Manufacture of explosives Chapter VI: Possession sale and use Chapter VII: Licenses
18	The Gas Cylinder Rules, 2004	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, DGCA, DC, DM, Police (sub inspector to commissioner)	Gases (Toxic, non toxic and non flammable, non toxic and flammable, Dissolved Acetylene Gas, Non toxic and flammable liquefiable gas other than LPG, LPG	Regulate the import, storage, handling and transportation of gas cylinders with a view to prevent accidents	Rule 2: Definition Chapter II: General Provisions Chapter III: Importation of Cylinder Chapter IV: Transport of Cylinder Chapter VII: Filling and Possession
19	The Static and Mobile Pressure Vessels (Unfired) Rules, 1981	Ministry of Commerce and Industry and Chief Controller of Explosives, port conservator, customs collector, DGCA, DC, DM, Police (sub inspector to commissioner)	Gases (Toxic, non toxic and non flammable, non toxic and flammable, Dissolved Acetylene Gas, Non toxic and flammable liquefiable gas other than LPG, LPG	Regulate the import, manufacture, design, installation, transportation, handling, use and testing of mobile and static pressure vessels (unfired) with a view to prevent accidents	Rule 2: Definition Chapter III: Storage Chapter IV: Transport Chapter V: Licenses
20	The Motor Vehicle Act, 1988	Ministry of Shipping, Road Transport and Highways	Hazardous and Dangerous Goods	To consolidate and amend the law relating to motor vehicles	Section 2: Definition Chapter II: Licensing of drivers of motor vehicle Chapter VII: Construction equipment and maintenance of motor vehicles
21	The Central Motor Vehicle Rules, 1989	Ministry of Shipping, Road Transport and Highways	Hazardous and Dangerous Goods	To consolidate and amend the law relating to motor vehicles including to regulate the transportation of dangerous goods with a view to prevent loss of life or damage to the environment	Rule 2: Definition Rule 9: Educational qualification for driver's of goods carriages carrying dangerous or hazardous goods Rule 129: Transportation of goods of dangerous or hazardous nature to human life Rule 129A: Spark arrestors Rule 130: Manner of display of class labels

					<p>Rule 131: Responsibility of the consignor for safe transport of dangerous or hazardous goods</p> <p>Rule 132: Responsibility of the transporter or owner of goods carriage</p> <p>Rule 133: Responsibility of the driver</p> <p>Rule 134: Emergency Information Panel</p> <p>Rule 135: Driver to be instructed</p> <p>Rule 136: Driver to report to the police station about accident</p> <p>Rule 137: Class labels</p>
22	The Mines Act 1952	Ministry of Coal and Mines	Use of toxic and inflammable gases, dust or mixtures	Safety of the mine workers	<p>Section 2: Definitions</p> <p>Chapter IV: Mining operations and management of mines</p> <p>Chapter V: Provisions as to health and safety</p> <p>Chapter IX: Penalties and procedure</p>

ANNEXURE II
General Standards for Discharge of Environmental Pollutants as per
CPCB

Table: Water Quality Standards

S. No.	Parameter	Standards			
		Inland Surface Water	Public Sewer	Land for Irrigation	Marine Coastal Areas
1.	2.	3.			
		(a)	(b)	(c)	(d)
1.	Colour and odour	See Note-1	—	See Note-1	See Note-1
2.	Suspended Solids, mg/l, Max	100	600	200	(a) For process waste water-100 (b) For cooling water effluent-10 per cent above total suspended matter of influent cooling water.
3.	Particle size of suspended solids	Shall pass 850 micron IS Sieve	—	—	(a) Floatable solids, Max 3 mm (b) Settleable solids Max 850 microns.
4.	Dissolved solids (inorganic), mg/a, mac	2100	2100	2100	—
5.	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
6.	Temperature °C, Max	Shall not exceed 40 in any section of the stream within 15 meters down stream from the effluent outlet	45 at the point of discharge	—	45 at the point of discharge
7.	Oil and grease, mg/l, max	10	20	10	20
8.	Total residual chlorine, mg/l, Max.	1.0	—	—	1.0
9.	Ammonical nitrogen (as N), mg/l, Max.	50	50	—	50
10.	Total Kjeldahl nitrogen (as N), mg/l, Max.	100	—	—	100
11.	Free Ammonia (as NH ₃), mg/l, Max.	5.0	—	—	5.0
12.	Biochemical Oxygen Demand (5 days at 20°C) Max.	30	350	100	100
13.	Chemical Oxygen Demand, mg/l, Max.	250	—	—	250
14.	Arsenic (as As), mg/l, Max.	0.2	0.2	0.2	0.2
15.	Mercury (as Hg), mg/l, Max.	0.01	0.01	—	0.01
16.	Lead (as Pb), mg/l, Max.	0.1	1.0	—	1.0
17.	Cadmium (as Cd), mg/l, Max.	2.0	1.0	—	2.0

18.	Hexavalent chromium (as Cr+6) mg/l, Max.	0.1	2.0	—	1.0
19.	Total chromium as (Cr), mg/l, Max.	2.0	2.0	—	2.0
20.	Copper (as Cu), mg/l, Max.	3.0	3.0	—	3.0
21.	Zinc (as Zn), mg/l, Max.	5.0	15	—	15
22.	Selenium (as Se), mg/l, Max.	0.05	0.05	—	0.05
23.	Nickel (as Ni), mg/l, Max.	3.0	3.0	—	5.0
24.	Boron (as B), mg/l, Max.	2.0	2.0	2.0	—
25.	Percent Sodium, Max.	—	60	60	—
26.	Residual sodium carbonate, mg/l, Max.	—	—	5.0	—
27.	Cyanide (as CN), mg/l, Max.	0.2	2.0	0.2	0.2
28.	Chloride (as Cl), mg/l, Max.	1000	1000	600	(a)
29.	Fluoride (as F), mg/l, Max.	2.0	15	—	15
30.	Dissolved Phosphates (as P), mg/l, Max.	5.0	—	—	—
31.	Sulphate (as SO ₄), mg/l, Max.	1000	1000	1000	—
32.	Sulphide (as S), mg/l, Max.	2.0	—	—	5.0
33.	Pesticides	Absent	Absent	Absent	Absent
34.	Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max.	1.0	5.0	—	5.0
35.	Radioactive materials				
	(a) Alpha emitters MC/ml, Max.	10 ⁻⁷	10 ⁻⁷	10 ⁻⁸	10 ⁻⁷
	(b) Beta emitters uc/ml, Max.	10 ⁻⁶	10 ⁻⁶	10 ⁻⁷	10 ⁻⁶

Note :-

1. All efforts should be made to remove colour and unpleasant odour as far as practicable.
2. The standards mentioned in this notification shall apply to all the effluents discharged such as industrial mining and mineral processing activities municipal sewage etc.

Table: Noise Standards

Ambient air quality standards in respect of noise

Area Code	Category of Area	Limits in dB (A) Leq	
		Day Time	Night Time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence zone	50	40

Note :

1. Day time is reckoned in between 6.00 AM and 9.00 PM
2. Night time is reckoned in between 9.00 PM and 6.00 AM
3. Silence zone is defined as areas upto 100 meters around such premises as hospitals, educational institutions and courts. The Silence zones are to be declared by the Competent Authority.
4. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.
5. Mixed categories of areas should be declared as one of the four above mentioned categories by the Competent Authority and the corresponding standards shall apply.

Standards/Guidelines for Control of Noise Pollution from Stationary Diesel Generator (DG) Sets

(A) Noise Standards for DG Sets (15-500 KVA)

The total sound power level, L_w , of a DG set should be less than, $94+10 \log_{10} (KVA)$, dB (A), at the manufacturing stage, where, KVA is the nominal power rating of a DG set.

This level should fall by 5 dB (A) every five years, till 2007, i.e. in 2002 and then in 2007.

(B) Mandatory acoustic enclosure/acoustic treatment of room for stationary DG sets (5 KVA and above)

Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the room acoustically.

The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB(A) Insertion Loss or for meeting the ambient noise standards, whichever is on the higher side (if the actual ambient noise is on the higher side, it may not be possible to check the performance of the acoustic enclosure/acoustic treatment. Under such circumstances the performance may be checked for noise reduction upto actual ambient noise level, preferably, in the night time). The measurement for Insertion Loss may be done at different points at 0.5m from the acoustic enclosure/room, and then averaged.

The DG set should also be provide with proper exhaust muffler with Insertion Loss of minimum 25 dB(A).

(C) Guidelines for the manufacturers/users of DG sets (5 KVA and above)

1. The manufacturer should offer to the user a standard acoustic enclosure of 25 dB(A) Insertion Loss and also a suitable exhaust muffler with Insertion Loss of 25 dB(A).

2. The user should make efforts to bring down the noise levels due to the DG set, outside his premises, within the ambient noise requirements by proper siting and control measures.
3. The manufacturer should furnish noise power levels of the unlicensed DG sets as per standards prescribed under (A)
4. The total sound power level of a DG set, at the user's end, shall be within 2 dB(A) of the total sound power level of the DG set, at the manufacturing stage, as prescribed under (A).
5. Installation of a DG set must be strictly in compliance with the recommendation of the DG set manufacturer.
6. A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

Order of the Lt. Governor of Delhi in respect of D.G. Sets (5th December, 2001)

In exercise of the powers conferred by section 5 of the Environment (Protection) Act, 1986, (29 of 1986), read with the Government of India, Ministry of Home Affairs notification S.O. 667 (E) bearing No. F.No. U-11030/J/91-VTL dated 10th September, 1992, the Lt. Governor of Government of National Capital of Delhi hereby directs to all owners/users of generators sets in the National Capital Territory of Delhi as follows :-

1. that generator sets above the capacity of 5 KVA shall not be operated in residential areas between the hours of 10.00 PM to 6.00 AM;
2. that the generator sets above the capacity of 5 KVA in all areas residential/commercial/industrial shall operate only with the mandatory acoustic enclosures and other standards prescribed in the Environment (Protection) Rules, 1986;
3. that mobile generator sets used in social gatherings and public functions shall be permitted only if they have installed mandatory acoustic enclosures and adhere to the prescribed standards for noise and emission as laid down in the Environment (Protection) Rules, 1986.

The contravention of the above directions shall make the offender liable for prosecution under section 15 of the said Act which stipulates punishment of imprisonment for a term which may extend to five years with fine which may extend to one lakh rupees, or with both, and in case the failure of contravention continues, with additional fine which may extend to five thousand rupees for every day during which such failure or contravention continues after the conviction for the first such failure or contravention and if still the failure or contravention continues beyond a period of one year after the date of contravention, the offender continues beyond a period of one year after the date of contravention, the offender shall be punishable with imprisonment for a term which may extend to seven years.

Order Dated: 21st June, 2002

In exercise of the powers conferred by section 5 of the Environment (Protection) Act, 1986 (29 of 1986) read with the Govt. of India, Ministry of Home Affairs notification S.O. 667(E) bearing No. U-11030/J/91-VTL dated the 10th September, 1992, the Lt. Governor Govt. of the National Capital Territory of Delhi hereby makes the following amendment/modification in his order dated the 5th December, 2001 regarding the operation of generator sets, namely:-

Amendments/modifications

In the above said order, for clause(1), the following shall be substituted, namely:-

“(1) that the generator sets above 5KVA shall not be operated in residential areas between the hours from 10.00 p.m. to 6.00 a.m. except generator sets of Group Housing Societies and Multi-storey residential apartments”.

DIESEL GENERATOR SETS: STACK HEIGHT

The minimum height of stack to be provided with each generator set can be worked out using the following formula:

$$H = h + 0.2 \times \sqrt{KVA}$$

H = Total height of stack in metre

h = Height of the building in metres where the generator set is installed

KVA = Total generator capacity of the set in KVA

Based on the above formula the minimum stack height to be provided with different range of generator sets may be categorized as follows:

For Generator Sets	Total Height of stack in metre
50 KVA	Ht. of the building + 1.5 metre
50-100 KVA	Ht. of the building + 2.0 metre
100- 150 KVA	Ht. of the building + 2.5 metre
150-200 KVA	Ht. of the building + 3.0 metre
200-250 KVA	Ht. of the building + 3.5 metre
250-300 KVA	Ht. of the building + 3.5 metre

Similarly for higher KVA ratings a stack height can be worked out using the above formula

Source: Evolved By CPCB

[Emission Regulations Part IV: COINDS/26/1986-87]

ANNEXURE III
Form 1 (Application for Obtaining EIA Clearance)

FORM 1

(I) Basic Information

S. No.	Item	Details
1.	Name of the project/s	
2.	S.No. in the schedule	
3.	Proposed capacity/area/length/tonnage to be handled/command area/lease area/number of wells to be drilled	
4.	New/Expansion/Modernization	
5.	Existing Capacity/Area etc.	
6.	Category of Project i.e., 'A' or 'B'	
7.	Does it attract the general condition? If yes, please specify.	
8.	Does it attract the specific condition? If yes, Please specify.	
9.	Location	
	Plot/Survey/Khasra No.	
	Village	
	Tehsil	
	District	
	State	
10.	Nearest railway station/airport along with distance in kms.	
11.	Nearest Town, city, District headquarters along with distance in kms.	
12.	Village Panchayats, Zilla Parishad, Municipal Corporation, Local body (complete postal addresses with telephone nos. to be given)	
13.	Name of the applicant	
14.	Registered Address	
15.	Address for correspondence:	
	Name	
	Designation (Owner/Partner/CEO)	
	Address	
	Pin Code	
	E-mail	
	Telephone No.	

S. No.	Item	Details
	Fax No.	
16.	Details of alternative Sites examined, if any location of these sites should be shown on a toposheet.	Village-District-State 1. 2. 3.
17.	Interlined Projects	
18.	Whether separate application of interlined project has been submitted	
19.	If yes, date of submission	
20.	If no, reason	
21.	Whether the proposal involves approval/clearance under: if yes, details of the same and their status to be given. (a) The Forest (Conservation) Act, 1980 ? (b) The Wildlife (Protection) Act, 1972 ? (c) The C.R.Z. Notification, 1991 ?	
22.	Whether there is any Government Order/Policy relevant/relating to the site?	
23.	Forest land involved (hectares)	
24.	Whether there is any litigation pending against the project and/or land in which the project is propose to be set up (a) Name of the Court (b) Case No. (c) Orders/directions of the Court, if any and its relevance with the proposed project.	

(II) Activity

1. **Construction, operation or decommissioning of the Project involving actions, which will cause physical changes in the locality (topography, land use, changes in water bodies, etc.)**

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
1.1	Permanent or temporary change in land use, land cover or topography including increase in intensity of land use (with respect to local land use plan)		
1.2	Clearance of existing land, vegetation and		

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
	buildings?		
1.3	Creation of new land uses?		
1.4	Pre-construction investigations e.g. bore houses, soil testing?		
1.5	Construction works?		
1.6	Demolition works?		
1.7	Temporary sites used for construction works or housing of construction workers?		
1.8	Above ground buildings, structures or earthworks including linear structures, cut and fill or excavations		
1.9	Underground works including mining or tunneling?		
1.10	Reclamation works?		
1.11	Dredging?		
1.12	Offshore structures?		
1.13	Production and manufacturing processes?		
1.14	Facilities for storage of goods or materials?		
1.15	Facilities for treatment or disposal of solid waste or liquid effluents?		
1.16	Facilities for long term housing of operational workers?		
1.17	New road, rail or sea traffic during construction or operation?		
1.18	New road, rail, air waterborne or other transport infrastructure including new or altered routes and stations, ports, airports etc?		
1.19	Closure or diversion of existing transport routes or infrastructure leading to changes in traffic movements?		
1.20	New or diverted transmission lines or pipelines?		
1.21	Impoundment, damming, culverting, realignment or other changes to the hydrology of watercourses or aquifers?		
1.22	Stream crossings?		
1.23	Abstraction or transfers of water form ground or surface waters?		

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
1.24	Changes in water bodies or the land surface affecting drainage or run-off?		
1.25	Transport of personnel or materials for construction, operation or decommissioning?		
1.26	Long-term dismantling or decommissioning or restoration works?		
1.27	Ongoing activity during decommissioning which could have an impact on the environment?		
1.28	Influx of people to an area in either temporarily or permanently?		
1.29	Introduction of alien species?		
1.30	Loss of native species or genetic diversity?		
1.31	Any other actions?		

2. Use of Natural resources for construction or operation of the Project (such as land, water, materials or energy, especially any resources which are non-renewable or in short supply):

S.No.	Information/checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
2.1	Land especially undeveloped or agricultural land (ha)		
2.2	Water (expected source & competing users) unit: KLD		
2.3	Minerals (MT)		
2.4	Construction material – stone, aggregates, sand / soil (expected source – MT)		
2.5	Forests and timber (source – MT)		
2.6	Energy including electricity and fuels (source, competing users) Unit: fuel (MT), energy (MW)		
2.7	Any other natural resources (use appropriate standard units)		

3. Use, storage, transport, handling or production of substances or materials, which could be harmful to human health or the environment or raise concerns about actual or perceived risks to human health.

S.No	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
3.1	Use of substances or materials, which are hazardous (as per MSIHC rules) to human health or the environment (flora, fauna, and water supplies)		
3.2	Changes in occurrence of disease or affect disease vectors (e.g. insect or water borne diseases)		
3.3	Affect the welfare of people e.g. by changing living conditions?		
3.4	Vulnerable groups of people who could be affected by the project e.g. hospital patients, children, the elderly etc.,		
3.5	Any other causes		

4. Production of solid wastes during construction or operation or decommissioning (MT/month)

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
4.1	Spoil, overburden or mine wastes		
4.2	Municipal waste (domestic and or commercial wastes)		
4.3	Hazardous wastes (as per Hazardous Waste Management Rules)		
4.4	Other industrial process wastes		
4.5	Surplus product		
4.6	Sewage sludge or other sludge from effluent treatment		
4.7	Construction or demolition wastes		
4.8	Redundant machinery or equipment		
4.9	Contaminated soils or other materials		
4.10	Agricultural wastes		
4.11	Other solid wastes		

5. Release of pollutants or any hazardous, toxic or noxious substances to air (kg/hr)

S.No	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
5.1	Emissions from combustion of fossil fuels from stationary or mobile sources		
5.2	Emissions from production processes		
5.3	Emissions from materials handling including storage or transport		
5.4	Emissions from construction activities including plant and equipment		
5.5	Dust or odours from handling of materials including construction materials, sewage and waste		
5.6	Emissions from incineration of waste		
5.7	Emissions from burning of waste in open air (e.g. slash materials, construction debris)		
5.8	Emissions from any other sources		

6. Generation of Noise and Vibration, and Emissions of Light and Heat:

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data with source of information data
6.1	From operation of equipment e.g. engines, ventilation plant, crushers		
6.2	From industrial or similar processes		
6.3	From construction or demolition		
6.4	From blasting or piling		
6.5	From construction or operational traffic		
6.6	From lighting or cooling systems		
6.7	From any other sources		

7. Risks of contamination of land or water from releases of pollutants into the ground or into sewers, surface waters, groundwater, coastal waters or the sea:

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
7.1	From handling, storage, use or spillage of hazardous materials		
7.2	From discharge of sewage or other effluents to water or the land (expected mode and place of discharge)		
7.3	By deposition of pollutants emitted to air into the land or into water		
7.4	From any other sources		
7.5	Is there a risk of long term build up of pollutants in the environment from these sources?		

8. Risk of accidents during construction or operation of the Project, which could affect human health or the environment

S.No	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
8.1	From explosions, spillages, fires etc from storage, handling, use or production of hazardous substances		
8.2	From any other causes		
8.3	Could the project be affected by natural disasters causing environmental damage (e.g. floods, earthquakes, landslides, cloudburst etc)?		

9. Factors which should be considered (such as consequential development) which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality

S. No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
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9.1	Lead to development of supporting facilities, ancillary development or development stimulated by the project which could have impact on the environment e.g.: <ul style="list-style-type: none"> ▪ Supporting infrastructure (roads, power supply, waste or waste water treatment, etc.) ▪ housing development ▪ extractive industries ▪ supply industries ▪ other 		
9.2	Lead to after-use of the site, which could have an impact on the environment		
9.3	Set a precedent for later developments		
9.4	Have cumulative effects due to proximity to other existing or planned projects with similar effects		

(III) Environmental Sensitivity

S.No.	Areas	Name/ Identity	Aerial distance (within 15 km.) Proposed project location boundary
1	Areas protected under international conventions, national or local legislation for their ecological, landscape, cultural or other related value		
2	Areas which are important or sensitive for ecological reasons - Wetlands, watercourses or other water bodies, coastal zone, biospheres, mountains, forests		
3	Areas used by protected, important or sensitive species of flora or fauna for breeding, nesting, foraging, resting, over wintering, migration		
4	Inland, coastal, marine or underground waters		
5	State, National boundaries		
6	Routes or facilities used by the public for access to recreation or other tourist, pilgrim areas		
7	Defence installations		
8	Densely populated or built-up area		
9	Areas occupied by sensitive man-made land uses (<i>hospitals, schools, places of worship,</i>		

	<i>community facilities)</i>		
10	Areas containing important, high quality or scarce resources (<i>ground water resources, surface resources, forestry, agriculture, fisheries, tourism, minerals</i>)		
11	Areas already subjected to pollution or environmental damage. (<i>those where existing legal environmental standards are exceeded</i>)		
12	Areas susceptible to natural hazard which could cause the project to present environmental problems (<i>earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions</i>)		

(IV) PROPOSED TERMS OF REFERENCE FOR EIA STUDIES

“I hereby given undertaking that the data and information given in the application and enclosures are true to the best of my knowledge and belief and I am aware that if any part of the data and information submitted is found to be false or misleading at any stage, the project will be rejected and clearance give, if any to the project will be revoked at our risk and cost.

Date: _____

Place: _____

Signature of the applicant
With Name and Full Address
(Project Proponent / Authorized Signatory)

NOTE:

1. The projects involving clearance under Coastal Regulation Zone Notification, 1991 shall submit with the application a C.R.Z. map duly demarcated by one of the authorized agencies, showing the project activities, w.r.t. C.R.Z. (at the stage of TOR) and the recommendations of the State Coastal Zone Management Authority (at the stage of EC). Simultaneous action shall also be taken to obtain the requisite clearance under the provisions of the C.R.Z. Notification, 1991 for the activities to be located in the CRZ.
2. The projects to be located within 10 km of the National Parks, Sanctuaries, Biosphere Reserves, Migratory Corridors of Wild Animals, the project proponent shall submit the map duly authenticated by Chief Wildlife Warden showing these features vis-à-vis the project location and the recommendations or comments of the Chief Wildlife Warden thereon (at the stage of EC).”
3. All correspondence with the Ministry of Environment & Forests including submission of application for TOR/Environmental Clearance, subsequent clarifications, as may be required from time to time, participation in the EAC Meeting on behalf of the project proponent shall be made by the authorized signatory only. The authorized signatory should also submit a document in support of his claim of being an authorized signatory for the specific project.”

ANNEXURE IV
Critically Polluted Industrial Areas and Clusters/Potential Impact
Zones

**Table 1: Details of Critically Polluted Industrial Areas and Clusters / Potential Impact Zone
(Ref: Office Memorandum No. J-11013/5/2010-IA.II(I) Dated 13.1.2010)**

S. No.	Critically Polluted Industrial Area and CEPI	Industrial Clusters/ Potential Impact Zones
1.	Ankeshwar (Gujarat) CEPI-88.50(Ac_Wc_Lc)	<ul style="list-style-type: none"> ▪ GIDC Ankeshwar and GIDC, Panoli
2	Vapi (Gujarat) CEPI-88.09(Ac_Wc_Lc)	<ul style="list-style-type: none"> ▪ GIDC Vapi
3	Ghaziabad (Uttar Pradesh) CEPI-87.37(Ac_Wc_Lc)	<p>Sub-cluster A</p> <ul style="list-style-type: none"> ▪ Mohan nagar industrial area ▪ Rajinder nagar industrial area ▪ Sahibabad industrial area <p>Sub-cluster B</p> <ul style="list-style-type: none"> ▪ Pandav nagar industrial area ▪ Kavi nagar industrial area ▪ Bulandshahar road industrial area ▪ Amrit nagar ▪ Aryanagar industrial area <p>Sub-cluster C</p> <ul style="list-style-type: none"> ▪ Merrut road industrial are <p>Sub-cluster D</p> <ul style="list-style-type: none"> ▪ Loni industrial area ▪ Loni Road industrial area ▪ Roop nagar industrial area <p>Sub-cluster E</p> <ul style="list-style-type: none"> ▪ Hapur Road industrial area ▪ Dasna ▪ Philkura <p>Sub-cluster F (Other scattered industrial areas)</p> <ul style="list-style-type: none"> ▪ South side of GT road ▪ Kavi Nagar ▪ Tronica city ▪ Anand Nagar ▪ Jindal Nagar ▪ Prakash Nagar ▪ Rural industrial estate
4	Chandrapur (Maharashtra) CEPI-83.88 (Ac_Wc_Lc)	<ul style="list-style-type: none"> ▪ Chandrapur (MIDC Chandrapur, Tadali, Ghuggus, Ballapur)
5	Kobra (Chhatisgarh) CEPI-83.00 (Ac_Ws_Lc)	<ul style="list-style-type: none"> ▪ Industrial areas and their townships of NTPC, BALCO, CSEB (East) & CSEB (West) ▪ Korba town
6	Bhiwadi (Rajasthan) CEPI-82.91 (Ac_Wc_Ls)	<ul style="list-style-type: none"> ▪ RIICO industrial areas Phase I to IV ▪ Bhiwadi town ▪ Other surrounding industrial areas: Chopanki, Rampura Mundana, Khuskhera Phase I to III
7	Angul Talcer(Orissa) CEPI-82.09 (Ac_Wc_Lc)	<ul style="list-style-type: none"> ▪ MCL Coal mining area, Augul – Talcer region ▪ Industrial area (60 km x 45 km) <p>Following blocks of Augul district:</p> <ul style="list-style-type: none"> ▪ Kohina block ▪ Talcher block

		<ul style="list-style-type: none"> ▪ Angul block ▪ Chhendipada block ▪ Banarpal block ▪ Odapada block of Dhenkamal district
8	Vellore (North Arcot) (Tamil Nadu) CEPI-81.79 (Ac_Wc_Lc)	<ul style="list-style-type: none"> ▪ Ranipet, SIPCOT industrial complex
9	Singrauli (Uttar Pradesh) CEPI-81.73 (Ac_Wc_Ls)	<p>Sonebhadra (UP)</p> <ul style="list-style-type: none"> ▪ Dala-Tola ▪ Obra ▪ Renukoot ▪ Anpara ▪ Renusagar ▪ Kakri ▪ Dudhichuwa ▪ Bina ▪ Khadia ▪ Shakti nagar ▪ Rihand nagar ▪ Bijpur <p>Sigrauli (Madhya Pradesh)</p> <p>Vindhyachal nagar and Jaynat, Nigahi, Dudhichua, Amlohri & Jhingurdah townships</p>
10	Ludhiana (Punjab) CEPI-81.66 (Ac_Wc_Ls)	<p>Ludhiana municipal limits covering industrial clusters:</p> <ul style="list-style-type: none"> ▪ Focal point along with NH-I- Total eight phase ▪ Industrial area-B- from sherpur chowk to Gill road & Gill road to Miller Kotla road (left side of road) ▪ Mixed industrial area – right side of Gill road ▪ Industrial area –C (near Juglana village) ▪ Industrial area A & extension: area between old GT road and Ludhiana bypass road ▪ Industrial estate: near Dholwal chowk ▪ Mixes industrial area (MIA) Miller gunj ▪ MIA – bypass road ▪ Bahdur industrial area ▪ Tejpur industrial complex
11	Nazafgarh drain basin, Delhi CEPI-79.54 (As_Wc_Lc)	<ul style="list-style-type: none"> ▪ Industrial areas: Anand Parvat, Naraina, Okhla and Wazirpur
12	Noida (Uttar Pradesh) CEPI-78.90 (Ac_Wc_Lc)	<p>Territorial Jurisdiction of:</p> <ul style="list-style-type: none"> ▪ Noida Phase-1 ▪ Noida Phase-2 ▪ Noida Phase-3 ▪ Surajpur industrial area ▪ Greater Noida industrial area ▪ Village- Chhaparaula
13	Dhanbad (Jharkhand) CEPI-78.63 (Ac_Ws_Lc)	<p>Four blocks of Dhanbad district:</p> <ul style="list-style-type: none"> ▪ Sadar (Dhanbad Municipality) ▪ Jharia (Jharia Municipality, Sindri industrial area) ▪ Govindpur (Govindpur industrial estate) ▪ Nirsa
14	Dombivalli (Maharashtra) CEPI-78.41 (Ac_Wc_Ls)	<ul style="list-style-type: none"> ▪ MIDC Phase- I, Phase- II

15	Kanpur (Uttar Pradesh) CEPI-78.09 (Ac_Wc_Ls)	Industrial areas: <ul style="list-style-type: none"> ▪ Dada nagar ▪ Panki ▪ Fazalganj ▪ Vijay nagar ▪ Jajmau
16	Cuddalore (Tamil Nadu) CEPI-77.45 (As_Wc_Lc)	<ul style="list-style-type: none"> ▪ SIPCOT industrial complex, Phase I & II
17	Aurangabad (Maharashtra) CEPI-77.44 (Ac_Wc_Ls)	<ul style="list-style-type: none"> ▪ MIDC Chikhalthana, MIDC Waluj, MIDC Shendra, and Paithan road industrial area
18	Faridabad (Haryana) CEPI-77.07 (Ac_Ws_Lc)	<ul style="list-style-type: none"> ▪ Sector 27-A, B, C, D ▪ DLF phase- 1, sector 31,32 ▪ DLF phase- 2, sector 35 ▪ Sector 4, 6, 24, 27, 31, 59 ▪ Industrial area Hatin ▪ Industrial model township
19	Agra (Uttar Pradesh) CEPI-76.48 (As_Wc_Ls)	<ul style="list-style-type: none"> ▪ Nunihai industrial estate, Rambag nagar, UPSIDC industrial area, and Runukata industrial area
20	Manali (Tamil Nadu) CEPI-76.32 (Ac_Ws_Ls)	<ul style="list-style-type: none"> ▪ Manali industrial area
21	Haldia (West Bengal) CEPI-75.43 (As_Wc_Ls)	<ul style="list-style-type: none"> ▪ 5 km wide strip (17.4 x 5.0 km) of industrial area on the southern side of the confluence point of Rivers Hugli and Rupnarayan, covering ▪ Haldia municipal area & Sutahata block – I and II
22	Ahmedabad (Gujarat) CEPI-75.28 (Ac_Ws_Ls)	<ul style="list-style-type: none"> ▪ GIDC Odhav ▪ GIDC Naroda
23	Jodhpur (Rajasthan) CEPI-75.19 (As_Wc_Ls)	<ul style="list-style-type: none"> ▪ Industrial areas including Basni areas (phase-I & II), industrial estate, light & heavy industrial areas, industrial areas behind new power house, Mandore, Bornada, Sangariya and village Tanwada & Salawas. ▪ Jodhpur city
24	Greater Cochin (Kerala) CEPI-75.08 (As_Wc_Ls)	<ul style="list-style-type: none"> ▪ Eloor-Edayar industrial belt, ▪ Ambala Mogal industrial areas
25	Mandi Gobind Garh (Punjab) CEPI-75.08 (Ac_Ws_Lc)	<ul style="list-style-type: none"> ▪ Mandi Govindgarh municipal limit and khanna area
26	Howrah (West Bengal) CEPI-74.84 (As_Ws_Lc)	<ul style="list-style-type: none"> ▪ Liluah-Bamangachhi region, Howrah ▪ Jalan industrial complex-1, Howrah
27	Vatva (Gujarat) CEPI-74.77 (Ac_Wc_Ls)	<ul style="list-style-type: none"> ▪ GIDC Vatva, Narol industrial area (Villages Piplaj, Shahwadi, Narol)
28	Ib Valley (Orissa) CEPI-74.00 (Ac_Ws_Ls)	<ul style="list-style-type: none"> ▪ Ib Valley of Jharsuguda (Industrial and mining area)
29	Varansi-Mirzapur (Uttar Pradesh) CEPI-73.79 (As_Wc_Ls)	<ul style="list-style-type: none"> ▪ Industrial estate, Mirzapur ▪ Chunar ▪ Industrial estate, Chandpur, Varansi ▪ UPSIC, industrial estate, Phoolpur ▪ Industrial area, Ramnagar, Chandauli
30	Navi Mumbai (Maharashtra) CEPI-73.77 (Ac_Ws_Ls)	<ul style="list-style-type: none"> ▪ TTC industrial area, MIDC, Navi Mumbai (including Bocks-D, C, EL, A, R, General, Kalva)

31	Pali (Rajasthan) CEPI-73.73 (As_Wc_Ls)	<ul style="list-style-type: none"> ▪ Existing industrial areas: Mandia road, Puniyata road, Sumerpur ▪ Pali town
32	Mangalore (Karnataka) CEPI-73.68 (Ac_Ws_Ls)	<ul style="list-style-type: none"> ▪ Baikampady industrial area
33	Jharsuguda (Orissa) CEPI-73.34 (Ac_Ws_Ls)	<ul style="list-style-type: none"> ▪ Ib valley of Jharsuguda (Industrial and mining area)
34	Coimbatore (Tamil Nadu) CEPI-72.38 (Ac_Ws_Ln)	<ul style="list-style-type: none"> ▪ SIDCO, Kurichi industrial Clusters
35	Bhadravati (Karnataka) CEPI-72.33 (Ac_Ws_Ln)	<ul style="list-style-type: none"> ▪ KSSIDC Industrial area, Mysore paper mill & VISL township complex
36	Tarapur (Maharashtra) CEPI-72.01 (Ac_Ws_Ls)	<ul style="list-style-type: none"> ▪ MIDC Tarapur
37	Panipat (Haryana) CEPI-71.91 (As_Ws_Ls)	<ul style="list-style-type: none"> ▪ Panipat municipal limit and its industrial clusters
38	Indore (Madhya Pradesh) CEPI-71.26 (As_Ws_Ls)	<p>Following 09 industrial area:</p> <ul style="list-style-type: none"> ▪ Sanwer road ▪ Shivaji nagar ▪ Pologround ▪ Laxmibai nagar ▪ Scheme no.71 ▪ Navlakha ▪ Pipliya ▪ Palda ▪ Rau <p>Indore city</p> <p>Other surrounding industrial areas: Manglia, Rajoda, Asrawad, Tejpur Gadwadi</p>
39	Bhavnagar (Gujarat) CEPI-70.99 (As_Ws_Ls)	<ul style="list-style-type: none"> ▪ GIDI Chitra, Bhavnagar
40	Vishakhapatnam (Andhra Pradesh) CEPI-70.82 (As_Ws_Ls)	<ul style="list-style-type: none"> ▪ Bowl area (the area between Yarada hill range in the south to Simhachalam hill range in the north and sea on the east and the present NH-5 in the west direction)
41	Junagarh (Gujarat) CEPI-70.82 (As_Ws_Ls)	<p>Industrial areas:</p> <ul style="list-style-type: none"> ▪ Sabalpur ▪ Jay Bhavani ▪ Jay Bhuvneshwari ▪ GIDC Junagarh (I&II)
42	Asansole (West Bengal) CEPI-70.20 (As_Ws_Ls)	<ul style="list-style-type: none"> ▪ Bumpur area surrounding IISCO
43	Patancheru - Bollaram (Andhra Pradesh) CEPI-70.07 (As_Ws_Ls)	<p>Industrial area:</p> <ul style="list-style-type: none"> ▪ Patancheru ▪ Bollaram

Note:

Names of identified industrial clusters/potential impact zones are approximate location based on rapid survey and assessment and may alter partially subject to the detailed field study and monitoring. Detailed mapping will be made available showing spatial boundaries of the identified industrial clusters including zone of influence/ buffer zone, after in depth field study.

ANNEXURE V
Pre-Feasibility Report: Points for Possible Coverage

Pre- feasibility Report: Points for Possible Coverage

S. No.	Contents	Points of Coverage in Pre-feasibility Report
I.	Executive Summary	<ul style="list-style-type: none"> ▪ A miniature report of entire pre feasibility report.
II.	Project Details	
	Need/Justification of the Project	<ul style="list-style-type: none"> ▪ Current demand scenario of the products (ferrous and non-ferrous metals) of metallurgical industry ▪ Alternatives to meet the demand ▪ Post project scenario on residual demand
	Capacity of Metallurgical Industry	<ul style="list-style-type: none"> ▪ Production capacity of the industrial units ▪ Sustainability of raw material supply and quality ▪ Optimization of plant capacity
	Process technology	<ul style="list-style-type: none"> ▪ Analysis of available/advanced technologies, etc. ▪ Analysis of possible configurations for each technology or a combination of these technologies ▪ Broad specifications for the proposed industrial units including process technologies/equipments
	Resources/raw materials	<ul style="list-style-type: none"> ▪ Details on raw material, by products ▪ Water <ul style="list-style-type: none"> - Water requirement for process, utilities, domestic, gardening etc. - Source of construction water and potable water - Source of circulating/consumptive water - Quality of raw water, treated water - Water budget calculations and effluent generation - Approved water allocation quota (drinking, irrigation and industrial use) and surplus availability - Feasible ways of bringing water to site indicating constraints if any. - Lean season water availability and allocation source in case main source not perennial. ▪ Manpower ▪ Infrastructure ▪ Electrical power ▪ Construction material like sand, brick, stone chips, borrow earth <i>etc.</i>
	Rejects (Pollution potential)	<ul style="list-style-type: none"> ▪ Air emissions (VOCs, HAPs, Dioxins and furans, metals, Chlorides and fluorides, <i>etc.</i>) ▪ Water pollution ▪ Solid / hazardous waste (slag, steel skulls, waste refractories, sludge, <i>etc.</i>) ▪ Noise ▪ Odour
	Technical profile	<ul style="list-style-type: none"> ▪ Construction details <ul style="list-style-type: none"> - Estimated duration - Number of construction workers including migrating workers - Construction equipment - Vehicular traffic - Source, mode of transportation and storage of construction material ▪ Traffic that would arise during different phases of the project and transportation mechanism to handle such traffic

		<ul style="list-style-type: none"> ▪ New facilities needed ▪ Technical parameters of the plant & equipments to be used ▪ Product storage and associated transportation system ▪ Product demand & supply position data on regional basis
	Project schedule	<ul style="list-style-type: none"> ▪ Project implementation schedule
	Future prospects	<ul style="list-style-type: none"> ▪ Ascertain the costs and benefits of the proposed project for project life ▪ Technical and logistic constraints/ requirements of project sustainability
III.	Selection of site based on least possible impacts	
i.	Choice of site selection	
	Major techno-economic feasibility considerations	<ul style="list-style-type: none"> ▪ Land availability & its development ▪ Product demand around the selected site ▪ Access to site for transportation of equipments/ construction machinery, material, etc. ▪ Raw material availability and its transportation ▪ Water availability and consumptive use ▪ Product transportation ▪ Infrastructure availability at selected site ▪ Inter-state issue, if any
	Incompatible landuse and ecologically sensitive attributes with respect to identified suitable sites	<ul style="list-style-type: none"> ▪ If any incompatible land-use attributes fall within the study area, the following details has to be provided: <ul style="list-style-type: none"> - Public water supply areas from rivers/surface water bodies, from groundwater - Scenic areas/tourism areas/hill resorts - Religious places, pilgrim centers that attract over 10 lakh pilgrims a year - Protected tribal settlements (notified tribal areas where industrial activity is not permitted); CRZ - Monuments of national significance, World Heritage Sites - Cyclone, Tsunami prone areas (based on last 25 years); - Airport areas - Any other feature as specified by the State or local government and other features as locally applicable, including prime agricultural lands, pastures, migratory corridors, etc. ▪ If ecologically sensitive attributes fall within the study area, please give details. Ecologically sensitive attributes include <ul style="list-style-type: none"> - National parks - Wild life sanctuaries Game reserve - Tiger reserve/elephant reserve/turtle nesting ground - Mangrove area - Wetlands - Reserved and protected forests - Endangered species of flora and fauna - Any other eco-sensitive areas <i>etc.</i>
	Social aspects	<ul style="list-style-type: none"> ▪ Corporate social responsibilities ▪ Employments and infrastructure added in the vicinity of the plant ▪ Status of land availability, current and post project land use variation ▪ Social sensitivity and likely project affected people

ii.	Details of selected site	
	Land details	<ul style="list-style-type: none"> ▪ Land requirement and availability ▪ Land ownership details such as Government, private, tribal, non-tribal, etc. ▪ Total area of the project/site ▪ Prevailing land cost details
	Location	<ul style="list-style-type: none"> ▪ Geographical details - Longitude & latitude, village, taluka, district, state ▪ Approach to site – roads, railways and airports ▪ Distance from nearest residential and industrial areas ▪ Distance from nearest water bodies such as river, canal, dam, etc ▪ Distance from ecologically sensitive areas ▪ In case of flood prone areas, HFL of the site ▪ In case of seismic areas, seismic zone, active faults, occurrence on earthquakes, <i>etc.</i> ▪ Proximity from infrastructural facilities
	Physical characteristics	<ul style="list-style-type: none"> ▪ Demography ▪ Meteorological data ▪ Landuse pattern such as agricultural, barren, forest, etc. and details thereof ▪ Topography of the area ▪ Drainage patterns ▪ Soil condition and soil investigation results ▪ Ground profile and levels
IV.	Anticipated impacts based on project operations on receiving environment	<ul style="list-style-type: none"> ▪ Population ▪ Flora and fauna ▪ Water ▪ Soil ▪ Air ▪ Climate ▪ Landscape, etc.
V.	Proposed broad mitigation measures which could effectively be internalized as project components to have environmental and social acceptance of the proposed site	<ul style="list-style-type: none"> ▪ Preventive measures ▪ Source control measures ▪ Mitigation measures at the receiving environment ▪ Health and safety measures, etc.
VI.	An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the developer in compiling the required information.	

The above listing is not exhaustive. Thus the proponent may provide additional necessary information, felt appropriate, to include in the pre-feasibility study report in support of selecting the site for the proposed developmental activities. The Concerned EAC/SEAC during scrutiny, may specifically ask for any additional information/data required to substantiate the requirement to prescribe the ToR for EIA studies. However, it is to make clear that all the required further information by EAC/SEAC may be mentioned in one single letter, within the prescribed time.

ANNEXURE VI
Types of Monitoring and Network Design Considerations

TYPES OF MONITORING AND NETWORK DESIGN CONSIDERATIONS

A. Types of Monitoring

Monitoring refers to the collection of data using a series of repetitive measurements of environmental parameters (or, more generally, to a process of systematic observation). The environmental quality monitoring programme design will be dependent upon the monitoring objectives specified for the selected area of interest. The main types of EIA monitoring activities are:

- Baseline monitoring is the measurement of environmental parameters during the pre-project period for the purpose of determining the range of variation of the system and establishing reference points against which changes can be measured. This leads to the assessment of the possible (additional available) assimilative capacity of the environmental components in pre-project period w.r.t. the standard or target level.
- Effects monitoring is the measurement of environmental parameters during project construction and implementation to detect changes which are attributable to the project to provide the necessary information to:
 - verify the accuracy of EIA predictions; and
 - determine the effectiveness of measures to mitigate adverse effects of projects on the environment.
 - Feedback from environmental effect monitoring programs may be used to improve the predictive capability of EIAs and also determine whether more or less stringent mitigation measures are needed
- Compliance monitoring is the periodic sampling or continuous measurement of environmental parameters to ensure that regulatory requirements and standards are being met.

Compliance and effects monitoring occurs during the project construction, operation, and abandonment stages. The resources and institutional set-up should be available for the monitoring at these stages. All large-scale construction projects will require some construction stage monitoring. To control the environmental hazards of construction as specified in the EIA, a monitoring program should be established to ensure that each mitigation measure is effectively implemented. There are numerous potential areas for monitoring during operations.

It is meaningful to perform baseline monitoring at those stations where the effects monitoring is to be performed so that the change from baseline due to the project as predicted by models can be validated and rectification can be performed even after the project starts functioning. It is therefore necessary to select the base line stations at those places where the predicted effects will be maximum. The scope of monitoring topics discussed in this chapter is limited to Baseline and Effects monitoring. In addition, this chapter will also discuss the Compliance monitoring during the construction phase. Post-project monitoring requirements are discussed in the EMP.

Before any field monitoring tasks are undertaken there are many institutional, scientific, and fiscal issues that must be addressed in the implementation of an environmental monitoring program. Careful consideration of these issues in the design and planning stages will help avoid many of the pitfalls associated with environmental monitoring programs. Although these issues are important but the discussions here are confined to the monitoring network design component.

B. Network Design

Analysis of Significant Environmental Issues

At the outset of planning for an environmental monitoring network, the EIA manager may not know exactly what should be monitored, when monitoring should begin, where it should monitor, which techniques should be employed, and who should take responsibility for its conduct. Because there are usually a number of objective decisions associated with network design to be made, it is important to start with an analysis of environmental issues. The scoping phase of an EIA is designed to identify and focus on the major issues. Scoping should provide a valuable source of information on the concerns that need to be addressed by the monitoring network design. These are project specific as well as specific to the environmental setting of the location where the project is proposed to be located

Hence, the network designs are associated with questions like:

- What are the expected outputs of the monitoring activity?
- Which problems do we need to address to? *etc.*

Defining the output will influence the design of the network and optimize the resources used for monitoring. It will also ensure that the network is specially designed to optimize the information on the problems at hand

What to Monitor?

The question of what to monitor is associated with the identification of VECs.

VECs are generally defined as environmental attributes or components of the environment that are valued by society as identified during the scoping stage of the project. They are determined on the basis of perceived public concerns. For example, changes to water quality and quantity could have implications on fish by affecting habitat, food supply, oxygen, and contaminant uptake. Similarly, employment and business, and economies are both VECs that serve as pathways.

The choice of VECs is also related to the perceived significant impact of the project implementation on important environmental components. In general, the significance or importance of environmental components is judged based on:

- legal protection provided (for example, rare and endangered species)
- political or public concerns (for example, resource use conflicts and sustainable development)
- scientific judgment (for example, ecological importance); or
- commercial or economic importance

However, in addition to their economic, social, political or ecological significance, the chosen VEC should also have unambiguous operational ease, be accessible to prediction and measurement; and be susceptible to hazard. Once the VECs are defined, the VECs may be directly measured (for example, extent of habitat for an endangered species). In cases where it is impossible or impractical to directly measure the VECs, the chosen measurement endpoints or environmental indicators must correspond to, or be predictive of assessment endpoints.

The chosen environmental indicators must be: 1) measurable; 2) appropriate to the scale of disturbance/ contamination; 3) appropriate to the impact mechanism; 4) appropriate and proportional to temporal dynamics; 5) diagnostic; and 6) standardized; as well as have: 1) a low natural variability; 2) a broad applicability; and 3) an existing data series.

C. Site Selection

This normally means that for designing a monitoring programme in an (study) area which might have an impact, several monitoring stations are needed for characterizing the baseline conditions of the impacted area. When considering the location of individual samplers, it is essential that the data collected are representative for the location and type of area without the undue influence from the immediate surroundings. In any measurement point in the study area the total ambient concentration is the representative of:

- natural background concentration
- regional background
- impact of existing large regional sources such as Industrial emissions

To obtain the information about the importance of these different contributions it is therefore necessary to locate monitoring stations so that they are representative for different impacts. In addition to the ambient pollution data, one would often need other data governing the variations such as meteorological data for air pollution, to identify and quantify the sources contributing to the measurements. When considering the location of individual samplers, it is essential that the data collected are representative for the location and type of area without undue influence from the immediate surroundings. For example, for measuring natural background concentration, if a dust sampler is located adjacent to a dusty road at road level, this will read occasional traffic pollution rather than the general background dust level of the area. As such a proper QA/QC must be followed to locate stations. USEPA guidelines are available for this.

Where, How and How Many Times to Monitor?

These are the other components of Monitoring Network Design. These questions are best answered based on local field conditions, capacity and resources available, prevailing legal and regulatory priorities, *etc.* For this screening or reconnaissance Surveys of the study area also necessary. This may also include some simple inexpensive measurements and assimilative/dispersion modeling. The data will give some information on the prevailing spatial and temporal variations, and the general background air pollution in the area. The number of monitoring stations and the indicators to be measured at each station in the final permanent network may then be decided upon based on the results of the screening study as well as on the knowledge of the sources of the proposed development and prevailing local environmental/meteorological conditions. The best possible definition of the air pollution problem, together with the analysis of the resources: personnel, budget and equipment available, represent the basis for the decision on the following questions:

- What spatial density (number) of sampling stations is required?

It is evident that the more is the number of stations selected in the study area, the more representative is the data and the more is the cost of monitoring. Therefore this needs optimization. For example, for optimum results as per the present practice, for metallurgical industry, the study area is a circle of 10 km radius from the plant centre; the number of AAQ stations are at least 10; the number of meteorological station may be 1 in case the study area falls in a single air shed having similar meteorological conditions and more in case the study area falls in more than one air sheds; the

number of surface water quality stations will depend on the number of surface water bodies present in the study area and likely to get polluted; the number of ground water stations may be at least 6 to 8; the number of noise monitoring stations will depend upon the number of residential, commercial and sensitive areas likely to get affected due to the noise from the plant operation and its services facilities like transport; the number of soil monitoring stations will be those agricultural lands where the dust fall from the plant is likely to be high; the number of ecological monitoring stations will depend upon the number of ecologically sensitive spots etc. Qualitative and quantitative models may be used to defend the decision. However, these optimum figures are not statutory requirements and may change from time to time as more scientific and credible information becomes available. For details refer Annexure A4

- How many samples are needed and during what period (sampling (averaging) time and frequency)?

These are mostly governed by statutory stipulations made in the E(P) Act/ EIA Notification/ EIA questionnaire. These must be presented in the ToR before costly monitoring exercise is started to save repetitions. Generally, the sampling averaging time must be compatible with the norms e.g., 24 hrs average for AAQ for SPM/RPM/SO₂/NO_x/HC/Pb and 1/8 hrs for CO; twice a week for at least one full season of 3 months except monsoon equally spaced. Met data should be hourly to be compatible with dispersion models. Water samples should be grab or composite for flowing water collected over the sampling period of one full season and ground water for pre and post monsoon to give more representative data. LEQ noise should be collected on limited days over 24 hours to obtain night time and day time values. Dust fall should be collected monthly for 3 months of monitoring period. As work zone, stack, ecological and socio economic monitoring are not much season oriented, they may be collected at the earliest. For details refer Annexure A4

- Where should the stations be located?

As described, the location should be the worst affected areas due to plant operation. As such for AAQ monitoring, a qualitative or quantitative screening model may be used to identify inhabited localities/ sensitive locations/ areas under surveillance with limited met and emission data where GLC due to plant operation will be maximum; for surface water monitoring all static water bodies, upstream and down stream of flowing water bodies from locations of probable discharges; all upstream and downstream ground water bodies from probable locations of leaching possibilities (for this ground water contours of the area should be pre determined); all ecologically sensitive areas; residential/commercial/sensitive locations for noise monitoring; prime agricultural lands for dust fall monitoring etc. In general, there must be a scientific basis for selecting locations. For details refer Annexure A4

- What kind of equipment and methods should be used?

The CPCB guidelines describe such equipment and methods in details. In addition, standard literatures/ handbooks like USEPA/APHA handbooks may be referred. For details refer Annexure A4

- What additional background information is needed?

- Published meteorological data from IMD's nearest station
- Topography from Survey of India/ satellite imageries

- population density from latest government publications
 - emission sources and emission rates of plant proper/ other nearby plants affecting study area
 - effects and impacts
 - ground water contours
 - data on forest and ecology from forest deptment
 - upper air data
 - any other secondary information
- How will the data be made available/communicated?
All raw data must be preserved. Adequate QA/QC may be followed. Summary data may be included in the EIA.

ANNEXURE VII
Guidance for Assessment of Baseline Components and Attributes

GUIDANCE FOR ASSESSMENT OF BASELINE COMPONENTS AND ATTRIBUTES*

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
A. Air				
<ul style="list-style-type: none"> ▪ Meteorological ▪ Wind speed ▪ Wind direction ▪ Dry bulb temperature ▪ Wet bulb temperature ▪ Relative humidity ▪ Rainfall ▪ Solar radiation ▪ Cloud cover 	<p>Minimum 1 site in the project impact area requirements</p> <p>Other additional site(s) are required depending upon the model applied or site sensitivities</p>	<p>Min: 1 hrly observations from continuous records</p>	<p>Mechanical / automatic weather station</p> <p>Rain gauge</p> <p>As per IMD</p> <p>As per IMD</p>	<p>IS 5182 Part 1-20 Sit-specific primary data is essential</p> <p>Secondary data from IMD, New Delhi for the nearest IMD station</p>
<p>Pollutants</p> <ul style="list-style-type: none"> ▪ SPM ▪ RPM ▪ SO₂ ▪ NO₂ ▪ CO ▪ H₂S* ▪ NH₃* ▪ HC* ▪ Fluoride* ▪ Pb* ▪ VOC-PAH* ▪ Mercury* <p>(parameters to be proposed by the proponent, in draft ToR, which will be reviewed and approved by EAC/SEAC)</p>	<p>10 to 15 locations in the project impact area</p>	<p>24 hrly twice a week</p> <p>8 hrly twice a week</p> <p>24 hrly twice a week</p>	<ul style="list-style-type: none"> ▪ Gravimetric (High – Volume) ▪ Gravimetric (High – Volume with Cyclone) ▪ EPA Modified West & Gaeke method ▪ Arsenite Modified Jacob & Hochheiser ▪ NDIR technique ▪ Methylene-blue ▪ Nessler’s Method ▪ Infra Red analyzer ▪ Specific Ion meter 	<p>Monitoring Network</p> <ul style="list-style-type: none"> ▪ Minimum 2 locations in upwind side, more sites in downwind side / impact zone ▪ All the sensitive receptors need to be covered <p>Measurement Methods</p> <p>As per CPCB standards for NAQM, 1994</p>
B. Noise				
Hourly equivalent noise levels	Same as for Air Pollution	At least one day continuous in	Instrument : Sensitive Noise	Min: IS: 4954- 1968 as adopted

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
	along with others Identified in study area	each season on a working and non-working day	level meter (preferably recording type)	by CPCB
Hourly equivalent noise levels	Inplant (1.5 m from machinery or high emission processes)	Same as above for day and night	Instrument : Noise level metre	CPCB / OSHA
Hourly equivalent noise levels	Highways (within 500 metres from the road edge)	Same as above for day and night	Instrument : Noise level meter	CPCB / IS : 4954-1968
Peak particle velocity	150- 200m from blast site	Based on hourly observations	PPV meter	
C. Water				
Parameters for water quality <ul style="list-style-type: none"> ▪ Ph, temp, turbidity, magnesium hardness, total alkalinity, chloride, sulphate, nitrate, fluoride, sodium, potassium salinity ▪ Total nitrogen, total phosphorus, DO, BOD, COD, Phenol ▪ Heavy metals ▪ Total coliforms, faecal coliforms ▪ Phyto plankton ▪ Zooplankton ▪ Fish & other aquatic flora & fauna (parameters are given in ToR for EIA studies based on nature of project, raw material & process technology, location-nature/activities within of air basin)	Set of grab samples during pre and post-monsoon for ground and surface water for the whole study zone. For lab. Analysis the samples should be preserved for transport safe	Diurnal and season-wise	Samples for water quality should be collected and analyzed as per: IS: 2488 (Part 1-5) methods for sampling and testing of industrial effluents Standard methods for examination of water and waste water analysis published by American Public Health Association. International standard practices for benthos and aquatic flora & fauna	
For Surface Water Bodies				
<ul style="list-style-type: none"> ▪ Total Carbon ▪ PH ▪ Dissolved Oxygen 	Monitoring locations should include up-stream, on site, down stream of	Yield & impact on water sources to be measured during critical	Samples for water quality should be collected and	Historical data should be collected from relevant offices such as central water

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
<ul style="list-style-type: none"> ▪ Biological Oxygen Demand ▪ Free NH₄ ▪ Boron ▪ Sodium Absorption ratio ▪ Electrical Conductivity 	<p>proposed discharge point. Besides sampling should cover width of the river in case water quality modeling is proposed.</p> <p>Standard methodology for collection of surface water (BIS standards)</p> <p>At least one grab sample per location per season</p>	<p>season</p> <p>River Stretch within project area be divided in grids (say 1 km length and 1/3 width) and samples should be from each grid at a time when the wastewater discharged by other sources of pollution is expected to be maximum</p>	<p>analyzed as per:</p> <p>IS: 2488 (Part 1-5) methods for sampling and testing of industrial effluents</p> <p>Standard methods for examination of water and wastewater analysis published by American Public Health Association.</p>	<p>commission, state and central ground water board, Irrigation dept.</p>
Parameters for wastewater characterization				
<ul style="list-style-type: none"> ▪ Temp, colour, odour, turbidity, TSS, TDS ▪ PH , alkalinity as CaCO₃, p value, M value, total hardness as CaCO₃, chloride as cl, sulphate as SO₄, Nitrate as NO₃, Fluoride as F, Phosphate as PO₄, Chromium as Cr (Hexavalent, total) Ammonical Nitrogen as N, TKN, % sodium, BOD at 20 C, COD, DO, total residual chlorine as Cl₂, oil and grease, sulphide, phenolic compound 	<p>Implant Source depending upon the different waste streams the parameters can be optimized</p> <p>Grab and composite sampling representing avg of different process operations as well as worst emission scenario should be represented</p>	<p>Different operational cycles as well as raw material variations should be reflected in the analysis</p>	<p>Samples for water quality should be collected and analyzed as per:</p> <p>IS: 2488 (Part 1-5) methods for sampling and testing of industrial effluents</p> <p>Standard methods for examination of water and wastewater analysis published by American Public Health Association.</p>	<p>All plant sources categorized as:</p> <ul style="list-style-type: none"> ▪ Different Process waste streams as well as run-off conditions ▪ ETP wastewater ▪ Domestic/ sanitary wastewater
D. Land Environment				
<ul style="list-style-type: none"> ▪ Soil ▪ Particle size distribution ▪ Texture ▪ pH ▪ Electrical conductivity ▪ Cation exchange capacity 	<p>One surface sample from each landfill and/or hazardous waste site (if applicable) and prime villages, (soil samples be collected as per BIS</p>	<p>Season-wise</p>	<p>Collected and analyzed as per soil analysis reference book, M.I.Jackson and soil analysis reference book by C.A. Black</p>	<p>The purpose of impact assessment on soil (land environment) is to assess the significant impacts due to leaching of wastes or accidental releases and contaminating</p>

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
<ul style="list-style-type: none"> ▪ Alkali metals ▪ Sodium Absorption Ratio (SAR) ▪ Permeability ▪ Porosity 	specifications) in the study area			
Landuse / Landscape				
<ul style="list-style-type: none"> ▪ Location code ▪ Total project area ▪ Topography ▪ Drainage (natural) ▪ Cultivated, forest plantations, water bodies, roads and settlements 	At least 20 points along with plant boundary and general major land use categories in the study area.	Drainage once in the study period and land use categories from secondary data (local maps) and satellite imageries	<ul style="list-style-type: none"> ▪ Global positioning system ▪ Topo-sheets ▪ Satellite Imageries (1:25,000) ▪ Satellite Imageries (1:25,000) 	<p>Drainage within the plant area and surrounding is very important for storm water impacts.</p> <p>From land use maps sensitive receptors (forests, parks, mangroves etc.) can be identified</p>
E. Hazardous Waste				
<ul style="list-style-type: none"> ▪ Permeability and porosity ▪ Moisture pH ▪ Electrical conductivity ▪ Loss on ignition ▪ Phosphorous ▪ Total nitrogen ▪ Caution exchange capacity ▪ Particle size distribution ▪ Heavy metal ▪ Ansonia ▪ Fluoride 	Grab and Composite samples. Recyclable components have to analyzed for the recycling requirements	Process wise or activity wise for respective raw material used.	<p>Analysis</p> <p>IS 9334 : 1979</p> <p>IS 9235 : 1979</p> <p>IS 10158 : 1982</p>	Impacts of hazardous waste should be performed critically depending on the waste characteristics and place of discharge. For land disposal the guidelines should be followed and impacts of accidental releases should be assessed
F. Biological Environment Aquatic				
<ul style="list-style-type: none"> ▪ Primary productivity ▪ Aquatic weeds ▪ Enumeration of phytoplankton, zooplankton and benthos 	Considering probable impact, sampling points and number of samples to be decided on established guidelines on ecological	Season changes are very important	Standards techniques (APHA et. Al. 1995, Rau and Wooten 1980) to be followed for sampling and measurement	<p>Seasonal sampling for aquatic biota</p> <p>One season for terrestrial biota, in addition to vegetation studies during monsoon season</p>

Attributes	Sampling		Measurement Method	Remarks
	Network	Frequency		
<ul style="list-style-type: none"> ▪ Fisheries ▪ Diversity indices ▪ Trophic levels ▪ Rare and endangered species ▪ Sanctuaries / closed areas / Coastal regulation zone (CRZ) ▪ Terrestrial ▪ Vegetation – species, list, economic importance, forest produce, medicinal value ▪ Importance value index (IVI) of trees ▪ Wild animals 	<p>studies based on site eco-environment setting within 10/25 km radius from the proposed site</p> <p>Samples to collect from upstream and downstream of discharge point, nearby tributaries at down stream, and also from dug wells close to activity site</p>			<p>Preliminary assessment</p> <p>Microscopic analysis of plankton and meiobenthos, studies of macrofauna, aquatic vegetation and application of indices, viz. Shannon, similarity, dominance IVI etc</p> <p>Point quarter plot-less method (random sampling) for terrestrial vegetation survey.</p>
<p>Avifauna</p> <ul style="list-style-type: none"> ▪ Rare and endangered species ▪ Sanctuaries / National park / Biosphere reserve 	<p>For forest studies, chronic as well as short-term impacts should be analyzed warranting data on micro climate conditions</p>			<p>Secondary data to collect from Government offices, NGOs, published literature</p> <p>Plankton net</p> <p>Sediment dredge</p> <p>Depth sampler</p> <p>Microscope</p> <p>Field binocular</p>
G. Socio Economic				
<ul style="list-style-type: none"> ▪ Demographic structure ▪ Infrastructure resource base ▪ Economic resource base ▪ Health status: Morbidity pattern ▪ Cultural and aesthetic attributes 	<p>Socio-economic survey is based on proportionate, stratified and random sampling method</p>	<p>Different impacts occurs during construction and operational phases of the project</p>	<p>Primary data collection through R&R surveys (if require) or community survey are based on personal interviews and questionnaire</p>	<p>Secondary data from census records, statistical hard books, toposheets, health records and relevant official records available with Govt. agencies</p>

* Project Specific concerned parameters needs to be identified by the project proponent and shall be incorporated in the draft ToR, to be submitted to the Authority for the consideration and approval by the EAC/SEAC.

ANNEXURE VIII
Sources of Secondary Data

Annexure VIA: Potential Sources of Data For EIA

Information	Source
Air Environment	
1. Meteorology- Temperature, Rainfall, Humidity, Inversion, Seasonal Wind rose pattern (16 point compass scale), cloud cover, wind speed, wind direction, stability, mixing depth	<ul style="list-style-type: none"> ⊗ Indian Meteorology Department, Pune
2. Ambient Air Quality- 24 hourly concentration of SPM, RPM, SO ₂ , NO _x , CO	<ul style="list-style-type: none"> ⊗ Central Pollution Control Board (CPCB), ⊗ State Pollution Control Board (SPCB), ⊗ Municipal Corporations ⊗ Ministry of Environment and Forests (MoEF) ⊗ State Department of Environment (DoEN)
Water Environment	
3. Surface water- water sources, water flow (lean season), water quality, water usage, Downstream water users Command area development plan Catchment treatment plan	<ul style="list-style-type: none"> ⊗ Central Water Commission (CWC), ⊗ Central Pollution Control Board (CPCB), ⊗ State Pollution Control Board (SPCB), Central Water and Power Research Institute (CWPRS), Pune ⊗ State Irrigation Department ⊗ Hydel Power generation organizations such as NHPC, State SEBs
4. Ground Water- groundwater recharge rate/withdrawal rate, ground water potential groundwater levels (pre monsoon, post monsoon), ground water quality, changes observed in quality and quantity of ground water in last 15 years	<ul style="list-style-type: none"> ⊗ Central Ground Water Board (CGWB) ⊗ Central Ground Water Authority (CGWA) ⊗ State Ground Water Board (SGWB) ⊗ National Water Development Authority (NWDA)
5. Coastal waters- water quality, tide and current data, bathymetry	<ul style="list-style-type: none"> ⊗ Department of Ocean Development, New Delhi ⊗ State Maritime Boards ⊗ Naval Hydrographer's Office, Dehradun ⊗ Port Authorities ⊗ National Institute of Oceanography (NIO), Goa
Biological Environment	
6. Description of Biological Environment- inventory of flora and fauna in 7 km radius, endemic species, endangered species, Aquatic Fauna, Forest land, forest type and density of vegetation, biosphere, national parks, wild life sanctuaries, tiger reserve, elephant reserve, turtle nesting ground, core zone of biosphere reserve, habitat of migratory birds, routes of migratory birds	<ul style="list-style-type: none"> ⊗ District Gazetteers ⊗ National Remote Sensing Agency (NRSA), Hyderabad ⊗ Forest Survey of India, Dehradun ⊗ Wildlife Institute of India ⊗ World Wildlife Fund ⊗ Zoological Survey of India ⊗ Botanical Survey of India ⊗ Bombay Natural History Society, (BNHS), Mumbai ⊗ State Forest Departments ⊗ State Fisheries Department ⊗ Ministry of Environment and Forests ⊗ State Agriculture Departments ⊗ State Agriculture Universities
Land Environment	
7. Geographical Information-Latitude, Longitude, Elevation (above MSL)	<ul style="list-style-type: none"> ⊗ Toposheets of Survey of India, Pune ⊗ National Remote Sensing Agency (NRSA), Hyderabad ⊗ Space Application Centre (SAC), Ahmedabad

Information	Source
8. Nature of Terrain, topography map indicating contours (1:2500 scale)	<ul style="list-style-type: none"> ⊗ Survey of India Toposheets ⊗ National Remote Sensing Agency (NRSA), Hyderabad ⊗ State Remote Sensing Centre, ⊗ Space Application Centre (SAC), Ahmedabad
9. Hydrogeology- Hydrogeological report (in case of ground water is used/area is drought prone/wastewater is likely to discharged on land) Geomorphological analysis (topography and drainage pattern) Geological analysis (Geological Formations/Disturbances- geological and structural maps, geomorphological contour maps, structural features, including lineaments, fractures, faults and joints) Hydrogeological analysis (disposition of permeable formations, surface-ground water links, hydraulic parameter determination etc) Analysis of the natural soil and water to assess pollutant absorption capacity	<ul style="list-style-type: none"> ⊗ NRSA, Hyderabad ⊗ Survey of India Toposheets ⊗ Geological Survey of India ⊗ State Geology Departments ⊗ State Irrigation Department ⊗ Department of Wasteland Development, Ministry of Rural Areas ⊗ National Water Development Authority (NWDA)
10. Nature of Soil, permeability, erodibility classification of the land	<ul style="list-style-type: none"> ⊗ Agriculture Universities ⊗ State Agriculture Department ⊗ Indian Council for Agriculture Research ⊗ State Soil Conservation Departments ⊗ National Bureau of Soil Survey and Landuse Planning ⊗ Central Arid Zone Research Institute (CAZRI), Jodhpur
11. Landuse in the project area and 10 km radius of the periphery of the project	<ul style="list-style-type: none"> ⊗ Survey of India- Toposheets ⊗ All India Soil and Landuse Survey; Delhi ⊗ National Remote Sensing Agency (NRSA), Hyderabad ⊗ Town and County Planning Organisation ⊗ State Urban Planning Department ⊗ Regional Planning Authorities (existing and proposed plans) ⊗ Village Revenue Map- District Collectorate ⊗ Directorate of Economics and Statistics-State Government ⊗ Space Application Centre, Ahmedabad
12. Coastal Regulation Zones- CRZMP, CRZ classification, Demarcation of HTL and LTL*	<ul style="list-style-type: none"> ⊗ Urban Development Department ⊗ State Department of Environment ⊗ State Pollution Control Board ⊗ Space Application Centre* ⊗ Centre for Earth Sciences Studies, Thiruvanthapuram* ⊗ Institute of Remote Sensing, Anna University Chennai* ⊗ Naval Hydrographer's Office, Dehradun* ⊗ National Institute of Oceanography, Goa* ⊗ National Institute of Ocean Technology, Chennai ⊗ Centre for Earth Science Studies

* Agencies authorized for approval of demarcation of HTL and LTL

Information	Source
Social	
13. Socioeconomic - population, number of houses and present occupation pattern within 7 km from the periphery of the project	<ul style="list-style-type: none"> ⊗ Census Department ⊗ District Gazetteers- State Government ⊗ District Statistics- District Collectorate ⊗ International Institute of Population Sciences, Mumbai (limited data) ⊗ Central Statistical Organisation
14. Monuments and heritage sites	<ul style="list-style-type: none"> District Gazetteer Archeological Survey of India, INTACH District Collectorate Central and State Tourism Department State Tribal and Social Welfare Department
Natural Disasters	
15. Seismic data (Mining Projects)- zone no, no of earthquakes and scale, impacts on life, property existing mines	<ul style="list-style-type: none"> ⊗ Indian Meteorology Department, Pune ⊗ Geological Survey of India
16. Landslide prone zone, geomorphological conditions, degree of susceptibility to mass movement, major landslide history (frequency of occurrence/decade), area affected, population affected	<ul style="list-style-type: none"> ⊗ Space Application Centre
17. Flood/cyclone/droughts- frequency of occurrence per decade, area affected, population affected	<ul style="list-style-type: none"> ⊗ Natural Disaster Management Division in Department of Agriculture and Cooperation ⊗ Indian Meteorological Department
Industrial	
18. Industrial Estates/Clusters, Growth Centres	<ul style="list-style-type: none"> ⊗ State Industrial Corporation ⊗ Industrial Associations ⊗ State Pollution Control Boards ⊗ Confederation Indian Industries (CII) ⊗ FICCI
19. Physical and Chemical properties of raw material and chemicals (Industrial projects); fuel quality	<ul style="list-style-type: none"> ⊗ Material and Safety Data Sheets ⊗ ENVIS database of Industrial Toxicological Research Centre, Lucknow ⊗ Indian Institute Petroleum
20. Occupational Health and Industrial Hygiene-major occupational health and safety hazards, health and safety requirements, accident histories	<ul style="list-style-type: none"> ⊗ Central Labour Institute, Mumbai ⊗ Directorate of Industrial Safety ⊗ ENVIS Database of Industrial Toxicological Research Centre, Lucknow ⊗ National Institute of Occupational Health, Ahmedabad
21. Pollutant release inventories (Existing pollution sources in area within 10 km radius)	<ul style="list-style-type: none"> ⊗ Project proponents which have received EC and have commenced operations
22. Water requirement (process, cooling water, DM water, Dust suppression, drinking, green belt, fire service)	<ul style="list-style-type: none"> ⊗ EIA Reports ⊗ National and International Benchmarks

Annexure VIB: Summary of Available Data with Potential Data Sources for EIA

Agency	Information Available
1. Archaeological Survey of India Department of Culture Government of India Janpath, New Delhi - 110011 Asi@del3.vsnl.net.in	<ul style="list-style-type: none"> ⊙ Inventory of monuments and sites of national importance- Listing and documentation of monuments according to world heritage, pre historic, proto historic and secular, religious places and forts
2. Botanical Survey Of India P-8, Brabourne Road Calcutta 700001 Tel#033 2424922 Fax#033 2429330 Email: envis@cal2.vsnl.net.in . RO - Coimbatore, Pune, Jodhpur, Dehradun, Allahabad, Gantok, Itanagar, Port Blair	<ul style="list-style-type: none"> ⊙ Photodiversity documentation of flora at National, State and District level and flora of protected areas, hotspots, fragile ecosystems, sacred groves etc ⊙ Identification of threatened species including endemics, their mapping, population studies ⊙ Database related to medicinal plants, rare and threatened plant species ⊙ Red data book of Indian plants (Vol 1,2, and 3) ⊙ Manual for roadside and avenue plantation in India
3. Bureau of Indian Standards Manak Bhawan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002 Tel#3230131, 3233375, 3239402 (10 lines) Fax : 91 11 3234062, 3239399, 3239382 Email- bis@vsnl.com	<ul style="list-style-type: none"> ⊙ Bureau of Indian Standards Committees on Earthquake Engineering and Wind Engineering have a Seismic Zoning Map and the Wind Velocity Map including cyclonic winds for the country
4. Central Water Commission (CWC) Sewa Bhawan, R.K.Puram New Delhi - 110066 cmanoff@niccwc.delhi.nic.in RO- Bangalore, Bhopal, Bhubaneshwar, Chandigarh, Coimbatore/Chennai, Delhi, Hyderabad, Lucknow, Nagpur, Patna, Shillong, Siliguri and Vadodara	<ul style="list-style-type: none"> ⊙ Central Data Bank -Collection, collation and Publishing of Hydrological, Hydrometeorological, Sediment and Water Quality data- ⊙ Basin wise Master Plans ⊙ Flood atlas for India ⊙ Flood Management and Development and Operation of Flood Forecasting System- CWC operate a network of forecasting stations Over 6000 forecasts are issued every year with about 95% of the forecasts within the permissible limit. ⊙ Water Year Books, Sediment Year Books and Water Quality Year Books. ⊙ Also actively involved in monitoring of 84 identified projects through National, State and Project level Environmental Committees for ensuring implementation of environmental safeguards
5. Central Ground Water Board (HO) N.H.IV, New CGO Complex, Faridabad - 121001 RO - Guwahati, Chandigarh, Ahemadabad, Trivandrum, Calcutta, Bhopal, Lucknow, Banglore, Nagpur, Jammu, Bhubneshwar, Raipur, Jaipur, Chennai, Hyderabad, Patna	<ul style="list-style-type: none"> ⊙ surveys, exploration, monitoring of ground water development

¹⁶ Based on web search and literature review

6.	Central Pollution Control Board Parivesh Bhawan, CBD-cum-Office Complex East Arjun Nagar, DELHI - 110 032 INDIA E-mail : cpcb@alpha.nic.in	<ul style="list-style-type: none"> ⊗ National Air Quality Monitoring Programme ⊗ National River Water Quality Monitoring Programme- Global Environment Monitoring , MINARS ⊗ Zoning Atlas Programme ⊗ Information on 17 polluting category industries (inventory, category wise distribution, compliance, implementation of pollution control programmes)
7.	Central Arid Zone Research Institute, Jodhpur Email : cazri@x400.nicgw.nic.in Regional Centre at Bhuj in Gujarat	<ul style="list-style-type: none"> ⊗ AGRIS database on all aspects of agriculture from 1975 to date ⊗ Also have cell on Agriculture Research Information System; ⊗ Working on ENVIS project on desertification ⊗ Repository of information on the state of natural resources and desertification processes and their control ⊗ The spectrum of activities involves researches on basic resource inventories; monitoring of desertification, rehabilitation and management of degraded lands and other areas
8.	Central Inland Capture Fisheries Research Institute, Barrackpore- 743101, Tel#033-5600177 Fax#033-5600388 Email : cicfri@x400.nicgw.nic.in	<ul style="list-style-type: none"> ⊗ Data Base on Ecology and fisheries of major river systems of India. Biological features of commercially important riverine and estuarine fish species. Production functions and their interactions in floodplain wetlands. ⊗ Activities - Environmental Impact Assessment for Resource Management ; Fisheries Resource surveys
9.	Central Institute of Brackish Water Aquaculture 141, Marshalls Road, Egmore , Chennai - 600 008, Tel# 044-8554866, 8554891, Director (Per) 8554851 Fax#8554851,	<ul style="list-style-type: none"> ⊗ Repository of information on brackish water fishery resources with systematic database of coastal fishery resources for ARIS ⊗ Agricultural Research Information System (ARIS) database covers State wise data on soil and water quality parameters, land use pattern, production and productivity trends, ⊗ Social, economic and environmental impacts of aquaculture farming, ⊗ Guidelines and effluent standards for aquaculture farming
10.	Central Marine Fisheries Research Institute (CMFRI), Cochin	<ul style="list-style-type: none"> ⊗ Assessing and monitoring of exploited and un-exploited fish stocks in Indian EEZ ⊗ Monitoring the health of the coastal ecosystems, particularly the endangered ecosystems in relation to artisanal fishing, mechanised fishing and marine pollution ⊗ The institute has been collecting data on the catch and effort and biological characteristics for nearly half a century based on scientifically developed sampling scheme, covering all the maritime States of the country ⊗ The voluminous data available with the institute is managed by the National Marine Living Resources Data Centre (NMLRDC)
11.	Central Water and Power Research Station, Pune Tel#020-4391801-14; 4392511; 4392825 Fax #020-4392004,4390189	<ul style="list-style-type: none"> ⊗ Numerical and Physical models for hydro-dynamic simulations
12.	Central Institute of Road Transport, Bhosari, Pune 411 026, India. Tel : +91 (20) 7125177, 7125292, 7125493, 7125494	<ul style="list-style-type: none"> ⊗ Repository of data on all aspects of performance of STUs and a host of other related road transport parameters

13. Department of Ocean Development	<ul style="list-style-type: none"> ⑨ Assessment of environment parameters and marine living resources (primary and secondary) in Indian EEZ (Nodal Agency NIO Kochi) ⑨ Stock assessment, biology and resource mapping of deep sea shrimps, lobsters and fishes in Indian EEZ (Nodal agency-Fisheries Survey of India) ⑨ Investigations of toxical algal blooms and benthic productivity in Indian EEZ (Nodal agency- Cochin University of Science and technology) ⑨ Coastal Ocean Monitoring and Prediction System (COMAP) - monitoring and modelling of marine pollution along entire Indian coast and islands. Parameters monitored are temp, salinity, DO, pH, SS, BOD, inorganic phosphate, nitrate, nitrite, ammonia, total phosphorus, total nitrite, total organic carbon, petroleum hydrocarbons, pathogenic vibrios, pathogenic E.coli, shigella, salmonella, heavy metals (Cd, Hg, Pb) and pesticide residues (DDT, BHC, Endosulfan). Monitoring is carried out along the ecologically sensitive zones and urban areas (NIO Mumbai- Apex coordinating agency). ⑨ Sea Level Measurement Programme (SELMAM)- sea level measurement at selected stations (Porbandar, Bombay, Goa, Cochin, Tuticorin, Madras, Machilipatnam, Visakhapatnam, Paradeep, Calcutta and Kavaratti (Lakshadweep Island)) along Indian coast and islands using modern tide gauges ⑨ Detailed coastal maps through Survey of India showing contour at 1/2 a metre interval in the scale of 1:25000. (Nellore- Machhalipatnam work already over) ⑨ Marine Data Centre (MDC) IMD for Ocean surface meteorology, GSI for marine geology, SOI for tide levels, Naval Hydrographic Office for bathymetry, NIO Goa for physical chemical and biological oceanography, NIO Mumbai for marine pollution, CMFRI for coastal fisheries, Institute of Ocean Management Madras for coastal geomorphology ⑨ DOD has setup Indian National Centre for Ocean Information Services (INCOIS) at Hyderabad for generation and dissemination of ocean data products (near real time data products such as sea surface temperature, potential fishing zones, upwelling zones, maps, eddies, chlorophyll, suspended sediment load etc). MDC will be integrated with INCOIS ⑨ Integrated Coastal and Marine Area Management (ICMAM) programme - GIS based information system for management of 11 critical habitats namely Pichavaram, Karwar, Gulf of Mannar, Gulf of Khambat, Gulf of Kutch, Malvan, Cochin, Coringa mangroves, Gahirmata, Sunderbans and Kadamat (Lakshadweep) ⑨ Wetland maps for Tamil Nadu and Kerala showing the locations of lagoons, backwaters, estuaries, mudflats etc (1:50000 scale) ⑨ Coral Reef Maps for Gulf of Kachch, Gulf of Mannar, Andaman and Nicobar and Lakshadweep Islands (1:50,000 scale) indicating the condition of corals, density etc
14. Environment Protection Training and Research Institute Gachibowli, Hyderabad - 500 019, India Phone: +91-40-3001241, 3001242, 3000489 Fax: +91-40- 3000361 E-mail: info@eptri.com	<ul style="list-style-type: none"> ⑨ Environment Information Centre- has appointed EPTRI as the Distributed Information Centre for the Eastern Ghats region of India. EIC Collaborates with the Stockholm Environment Institute Sweden Database on Economics of Industrial Pollution Prevention in India Database of Large and Medium Scale Industries of Andhra Pradesh Environmental Status of the Hyderabad Urban Agglomeration Study on 'water pollution-health linkages' for a few Districts of A.P

		<ul style="list-style-type: none"> ⑨ Environment Quality Mapping <ul style="list-style-type: none"> Macro level studies for six districts in the State of Andhra Pradesh Micro level studies for two study zones presenting the permissible pollutant load and scoping for new industrial categories Zonation of the IDA, Parwada which helped APIIC to promote the land for industrial development Disaster management plan for Visakhapatnam Industrial Bowl Area
15.	<p>Forest Survey of India (FSI) Kaulagarh Road, P.O., IPE Dehradun - 248 195 Tel# 0135-756139, 755037, 754507 Fax # 91-135-759104 E-Mail : fsidir@nde.vsnl.net.in fsihq@nde.vsnl.net.in</p> <p>RO- Banglore, Calcutta, Nagpur and Shimla</p>	<ul style="list-style-type: none"> ⑨ State of Forest Report (Biannual) ⑨ National Forest Vegetation Map (Biannual exercise) (on 1: 1 million scale) ⑨ Thematic mapping on 1:50,000 scale depicting the forest type, species composition, crown density of forest cover and other landuse National ⑨ Basic Forest Inventory System ⑨ Inventory survey of non forest area ⑨ Forest inventory report providing details of area estimates, topographic description, health of forest, ownership pattern, estimation of volume and other growth parameters such as height and diameter in different types of forest, estimation of growth, regeneration and mortality of important species, volume equation and wood consumption of the area studied
16.	<p>Geological Survey of India 27 Jawaharlal Nehru Road, Calcutta 700 016, India Telephone +91-33-2496941 FAX 91-33-2496956 gsi_chq@vsnl.com</p>	<ul style="list-style-type: none"> ⑨ Environmental hazards zonation mapping in mineral sector ⑨ Codification of base line information of geo-environmental appreciation of any terrain and related EIA and EMP studies ⑨ Lineament and geomorphological map of India on 1:20,000 scale. ⑨ Photo-interpreted geological and structural maps of terrains with limited field checks.
17.	<p>Indian Council of Agriculture Research, Krishi Bhawan, New Delhi, Tel#011-338206</p> <ul style="list-style-type: none"> - ICAR complex, Goa- Agro metrology - Central Arid Zone Research Institute- Agro forestry - Central Soil salinity Research Institute, - Indian Institute of Soil Science - Central Soil and Water Conservation Research and Training Institute - National Bureau of Soil Survey and Landuse Planning 	<ul style="list-style-type: none"> ⑨ A total of 80,000 profiles at 10 kms grid across the country were analyzed to characterize the soils of India. ⑨ Detailed soil maps of the Country (1:7 million), State (1:250,000) and districts map (1:50,000) depicting extent of degradation (1:4.4 millions) have been prepared. ⑨ Thematic maps depicting soil depth, texture drainage, calcareousness, salinity, pH, slope and erosion have been published ⑨ Agro-climate characterization of the country based on moisture, thermal and sunshine regimes ⑨ Agro-ecological zones (20) and sub-zones (60) for the country were delineated based on physiography, soils, climate, Length of Growing Period and Available Water Content, and mapped on 1:4.4 million scale. ⑨ Digitization of physiography and soil resource base on 1:50,000 scale for 14 States have been completed. ⑨ .Soil fertility maps of N,P,K,S and Zn have also been developed ⑨ Water quality guidelines for irrigation and naturally occurring saline/sodic water ⑨ Calibration and verification of ground water models for predicting water logging and salinity hazards in irrigation commands
18.	<p>Indian Bureau of Mines Indira Bhawan, Civil Lines Nagpur Ph no - 0712-533 631, Fax- 0712-533 041</p>	<ul style="list-style-type: none"> ⑨ National mineral inventory for 61 minerals and mineral maps ⑨ Studies on environmental protection and pollution control in regard to the mining and mineral beneficiation operations ⑨ Collection, processing and storage of data on mines, minerals and mineral-based industries, collection and maintenance of world mineral intelligence, foreign mineral legislation and other related matters

19.	Indian Meteorology Department Shivaji nagar, Pune 41100 RO- Mumbai, Chennai, Calcutta, New Delhi, Nagpur, Guwahati	<ul style="list-style-type: none"> ⊙ Meteorological data ⊙ Background air quality monitoring network under Global Atmospheric Watch Programme (operates 10 stations) ⊙ Seismicity map, seismic zoning map; seismic occurrences and cyclone hazard monitoring; list of major earthquakes ⊙ Climatological Atlas of India , Rainfall Atlas of India and Agroclimatic Atlas of India ⊙ Monthly bulletin of Climate Diagnostic Bulletin of India ⊙ Environmental Meteorological Unit of IMD at Delhi to provide specific services to MoEF
20.	INTACH Natural Heritage, 71 Lodi Estate, New Delhi-110 003 Tel. 91-11-4645482, 4632267/9, 4631818, 4692774, 4641304 Fax : 91- 11-4611290 E-mail : nh@intach.net	<ul style="list-style-type: none"> ⊙ Listing and documentation of heritage sites identified by municipalities and local bodies (Listing excludes sites and buildings under the purview of the Archaeological Survey of India and the State Departments of Archaeology)
21.	Industrial Toxicology Research Centre Post Box No. 80, Mahatma Gandhi Marg, Lucknow-226001, Phone: +91-522- 221856,213618,228227; Fax : +91- 522 228227 Email: itrc@itrcindia.org	<ul style="list-style-type: none"> ⊙ Activities include health survey on occupational diseases in industrial workers, air and water quality monitoring studies, ecotoxicological impact assessment, toxicity of chemicals, human health risk assessment ⊙ Five databases on CD-ROM in the area of environmental toxicology viz: TOXLINE, CHEMBANK, POISINDEX, POLTOX and PESTBANK. The Toxicology Information Centre provides information on toxic chemicals including household chemicals ⊙ ENVIS centre and created a full-fledged computerized database (DABTOC) on toxicity profiles of about 450 chemicals
22.	Indian Institute of Forest Management Post Box No. 357, Nehru Nagar Bhopal - 462 003 Phone # 0755-575716, 573799, 765125, 767851 Fax # 0755-572878	<ul style="list-style-type: none"> ⊙ Consultancy and research on joint forest management (Ford Foundation, SIDA, GTZ, FAO etc)
23.	Indian Institute of Petroleum Mohkampur , Dehradun, India, 248005 0135- 660113 to 116 0135- 671986	<ul style="list-style-type: none"> ⊙ Fuel quality characterisation ⊙ Emission factors
24.	Ministry of Environment and Forest	<ul style="list-style-type: none"> ⊙ Survey of natural resources ⊙ National river conservation directorate ⊙ Environmental research programme for eastern and western ghats ⊙ National natural resource management system ⊙ Wetlands conservation programme- survey, demarcation, mapping landscape planning, hydrology for 20 identified wetlands National wasteland identification programme
25.	Mumbai Metropolitan Regional Development Authority	<ul style="list-style-type: none"> ⊙ Mumbai Urban Transport Project ⊙ Mumbai Urban Development Project ⊙ Mumbai Urban Rehabilitation Project ⊙ Information on MMR; statistics on councils and corporations Regional Information Centre- Basic data on population, employment, industries and other sectors are regularly collected and processed

26.	Municipal Corporation of Greater Mumbai	<ul style="list-style-type: none"> ⊙ Air Quality Data for Mumbai Municipal Area ⊙ Water quality of lakes used for water supply to Mumbai
27.	Ministry of Urban Development Disaster Mitigation and Vulnerability Atlas of India Building Materials & Technology Promotion Council G-Wing, Nirman Bhavan, New Delhi-110011 Tel: 91-11-3019367 Fax: 91-11-3010145 E-Mail: bmtpc@del2.vsnl.net.in	<ul style="list-style-type: none"> ⊙ Identification of hazard prone area ⊙ Vulnerability Atlas showing areas vulnerable to natural disasters ⊙ Land-use zoning and design guidelines for improving hazard resistant construction of buildings and housing ⊙ State wise hazard maps (on cyclone, floods and earthquakes)
28.	Natural Disaster Management Division in Department of Agriculture and Cooperation	<ul style="list-style-type: none"> ⊙ Weekly situation reports on recent disasters, reports on droughts, floods, cyclones and earthquakes
29.	National Bureau Of Soil Survey & Land Use Planning P.O. Box No. 426, Shankar Nagar P.O., Nagpur-440010 Tel#91-712-534664,532438,534545 Fax#:91-712-522534 RO- Nagpur, New Delhi, Bangalore, Calcutta, Jorhat, Udaipur	<ul style="list-style-type: none"> ⊙ NBSS&LUP Library has been identified as sub centre of ARIC (ICAR) for input to AGRIS covering soil science literature generated in India ⊙ Research in weathering and soil formation, soil morphology, soil mineralogy, physicochemical characterisation, pedogenesis, and landscape-climate-soil relationship. ⊙ Soil Series of India- The soils are classified as per Soil Taxonomy. The described soil series now belong to 17 States of the country. ⊙ Landuse planning- watershed management, land evaluation criteria, crop efficiency zoning ⊙ Soil Information system is developed state-wise at 1:250,000 scale. Presently the soil maps of all the States are digitized, processed and designed for final output both digital and hardcopy. The thematic layers and interpreted layers of land evaluation (land capability, land irrigability and crop suitability), Agro-Ecological Zones and soil degradation themes are prepared. ⊙ Districts level information system is developed for about 15 districts at 1: 50, 000 scale. The soil information will be at soil series level in this system. Soil resource inventory of States, districts water-sheds (1:250,000; 1:50,000; 1:10,000/8000)
30.	National Institute of Ocean Technology, Velacherry-Tambaram main road Narayanapuram Chennai, Tamil Nadu Tel#91-44-2460063 / 2460064/ 2460066/ 2460067 Fax#91-44-2460645	<ul style="list-style-type: none"> ⊙ Waste load allocation in selected estuaries (Tapi estuary and Ennore creek) is one the components under the Integrated Coastal and Marine Area Management (ICMAM) programme of the Department of Ocean Development ICMAM is conducted with an IDA based credit to the Government of India under the Environmental Capacity Building project of MoEF (waste assimilation capacity of Ennore creek is over) ⊙ Physical oceanographic component of Coastal & Ocean monitoring Predictive System (COMAPS) a long term monitoring program under the Department of Ocean Development ⊙ Identification of suitable locations for disposal of dredge spoil using mathematical models & environmental criteria ⊙ EIA Manual and EIA guidelines for port and harbour projects
31.	National Institute of Oceanography, Goa RO- Mumbai, Kochi	<ul style="list-style-type: none"> ⊙ Coastal Ocean Monitoring and Predictions(COMAP)-Monitoring of coastal waters for physicochemical and biological parameters including petroleum hydrocarbons, trace metals, heavy metals, and biomass of primary (phytoplankton) and secondary (zooplankton, microbial and benthic organisms) ⊙ Marine Biodiversity of selected ecosystem along the West Coast of India

32.	National Botanical Research Institute, Post Box No 436 Rana Pratap Marg Lucknow- 226001, Tel: (+91) 522 271031-35 Fax: (+91) 522 282849, 282881 Lucknow	<ul style="list-style-type: none"> ⊗ Dust filtering potential of common avenue trees and roadside shrubs has been determined, besides studies have also been conducted on heavy-metals accumulation potential of aquatic plants supposedly useful as indicators of heavy metal pollution in water bodies and capable of reducing the toxic metals from water bodies. ⊗ Assessment of bio-diversity of various regions of India
33.	National Geophysical Research Institute, Uppal Road, Hyderabad Telephone:0091-40-7171124, FAX:0091-40-7171564	<ul style="list-style-type: none"> ⊗ Exploration, assessment and management of ground water resources including ground water modelling and pollution studies
34.	National Environmental Engineering Research Institute, Nagpur RO- Mumbai, Delhi, Chennai, Calcutta, Ahmedabad, Cochin, Hyderabad, Kanpur	<ul style="list-style-type: none"> ⊗ National Air Quality Monitoring (NAQM) for CPCB ⊗ Database on cleaner technologies of industrial productions
35.	National Hydrology Institute, Roorkee RO- Belgaum (Hard Rock Regional Centre), Jammu (Western Himalayan Regional Centre), Guwahati (North Eastern Regional Centre), Kakinada (Deltaic Regional Centre), Patna (Ganga Plains North Regional Centre), and Sagar (Ganga Plains South)	<ul style="list-style-type: none"> ⊗ Basin studies, hydrometeorological network improvement, hydrological year book, hydrological modelling, regional flood formulae, reservoir sedimentation studies, environmental hydrology, watershed development studies, tank studies, and drought studies.
36.	National Institute Of Urban Affairs, India Habitat Centre, New Delhi	<ul style="list-style-type: none"> ⊗ Urban Statistics Handbook
37.	National Institute of Occupational Health Meghaninagar, Ahmedabad RO- Banglore, Calcutta	<ul style="list-style-type: none"> ⊗ epidemiological studies and surveillance of hazardous occupations including air pollution, noise pollution, agricultural hazards, industrial hazards in organised sectors as well as small scale industries, carcinogenesis, pesticide toxicology, etc ⊗ WHO collaborative centre for occupational health for South East Asia region and the lead institute for the international programme on chemical safety under IPCS (WHO)
38.	NRSA Data Centre Department of Space, Balanagar, Hyderabad 500 037 Ph- 040-3078560 3078664 sales@nrsa.gov.in	<ul style="list-style-type: none"> ⊗ Satellite data products (raw data, partially processed (radiometrically corrected but geometrically uncorrected), standard data (radiometrically and geometrically corrected), geocoded data(1:50,000 and 1:25000 scale), special data products like mosaiced, merged and extracted) available on photographic (B&W and FCC in form of film of 240 mm X 240mm or enlargements/paper prints in scale varying between 1:1M and 1:12500 and size varying between 240mm and 1000mm) and digital media (CD-ROMs, 8 mm tapes)
39.	Rajiv Gandhi National Drinking Water Mission	<ul style="list-style-type: none"> ⊗ Database for groundwater using remote sensing technology (Regional Remote Sensing Service Centre involved in generation of ground water prospect maps at 1:50,000 scale for the State of Kerala, Karnataka, AP, MP and Rajasthan for RGNDWM)
40.	Space Application Centre Value Added Services Cell (VASC) Remote Sensing Application Area Ahmedabad 380 053 079-676 1188	<ul style="list-style-type: none"> ⊗ National Natural Resource Information System ⊗ Landuse mapping for coastal regulation zone (construction setback line) upto 1:12500 scale ⊗ Inventory of coastal wetlands, coral reefs, mangroves, seaweeds ⊗ Monitoring and condition assessment of protected coastal areas

	Fax- 079-6762735	<ul style="list-style-type: none"> ⊙ Wetland mapping and inventory ⊙ Mapping of potential hotspots and zoning of environmental hazards ⊙ General geological and geomorphological mapping in diverse terrain ⊙ Landslide risk zonation for Tehre area
41.	State Pollution Control Board	<ul style="list-style-type: none"> ⊙ State Air Quality Monitoring Programme ⊙ Inventory of polluting industries ⊙ Identification and authorization of hazardous waste generating industries ⊙ Inventory of biomedical waste generating industries ⊙ Water quality monitoring of water bodies receiving wastewater discharges ⊙ Inventory of air polluting industries ⊙ Industrial air pollution monitoring ⊙ Air consent, water consent, authorization, environment monitoring reports
42.	State Ground Water Board	
43.	Survey of India	<ul style="list-style-type: none"> ⊙ Topographical surveys on 1:250,000 scales, 1:50,000 and 1:25,000 scales ⊙ Digital Cartographical Data Base of topographical maps on scales 1:250,000 and 1:50,000 ⊙ Data generation and its processing for redefinition of Indian Geodetic Datum ⊙ Maintenance of National Tidal Data Centre and receiving/ processing of tidal data of various ports. ⊙ Coastal mapping along the Eastern coast line has been in progress to study the effect of submergence due to rise in sea-level and other natural phenomenon. Ground surveys have been completed for the proposed coastal region and maps are under printing. ⊙ District planning maps containing thematic information (135 maps) have been printed out of 249 maps covering half the districts of India. Districts planning maps for remaining half of the area are being processed by National Atlas and Thematic Mapping Organisation (NATMO)
44.	Town and Country Planning Organisation	<ul style="list-style-type: none"> ⊙ Urban mapping - Thematic maps and graphic database on towns (under progress in association with NRSA and State town planning department)
45.	Wildlife Institute of India Post Bag No. 18, Chandrabani Dehradun - 248 001, Uttaranchal Tel#0135 640111 -15, Fax#0135 640117 email : wii@wii .	<ul style="list-style-type: none"> ⊙ Provide information and advice on specific wildlife management problems. ⊙ National Wildlife Database
46.	Zoological Survey of India Prani Vigyan Bhawan 'M' Block, New Alipore Calcutta - 700 053 Phone # 91-33-4786893, 4783383 Fax # 91-33-786893 RO - Shillong, Pune, Dehradun, Jabalpur, Jodhpur, Chennai, Patna, Hyderabad, Canning, Behrampur, Kozikode, Itanagar, Digha, Port Bliar, Solan	<ul style="list-style-type: none"> ⊙ Red Book for listing of endemic species ⊙ Survey of faunal resources

ANNEXURE IX
Impact Prediction Tools

Table 1: Choice of Models for Impact Prediction: Air Environment *

Model	Application	Remarks
ISCST 3	<ul style="list-style-type: none"> ▪ Appropriate for point, area and line sources ▪ Application for flat or rolling terrain ▪ Transport distance up to 50 km valid ▪ Computes for 1 hr to annual averaging periods 	<ul style="list-style-type: none"> ▪ Can take up to 99 sources ▪ Computes concentration on 600 receptors in Cartesian on polar coordinate system ▪ Can take receptor elevation ▪ Requires source data, meteorological and receptor data as input.
AERMOD with AERMET	<ul style="list-style-type: none"> ▪ Settling and dry deposition of particles; ▪ Building wake effects (excluding cavity region impacts); ▪ Point, area, line, and volume sources; ▪ Plume rise as a function of downwind distance; ▪ Multiple point, area, line, or volume sources; ▪ Limited terrain adjustment; ▪ Long-term and short-term averaging modes; ▪ Rural or urban modes; ▪ Variable receptor grid density; ▪ Actual hourly meteorology data 	<ul style="list-style-type: none"> ▪ Can take up to 99 sources ▪ Computes concentration on 600 receptors in Cartesian on polar coordinate system ▪ Can take receptor elevation ▪ Requires source data, meteorological and receptor data as input.
PTMAX	<ul style="list-style-type: none"> ▪ Screening model applicable for a single point source ▪ Computes maximum concentration and distance of maximum concentration occurrence as a function of wind speed and stability class 	<ul style="list-style-type: none"> ▪ Require source characteristics ▪ No met data required ▪ Used mainly for ambient air monitoring network design
PTDIS	<ul style="list-style-type: none"> ▪ Screening model applicable for a single point source ▪ Computes maximum pollutant concentration and its occurrences for the prevailing meteorological conditions 	<ul style="list-style-type: none"> ▪ Require source characteristics ▪ Average met data (wind speed, temperature, stability class <i>etc.</i>) required ▪ Used mainly to see likely impact of a single source
MPTER	<ul style="list-style-type: none"> ▪ Appropriate for point, area and line sources applicable for flat or rolling terrain ▪ Transport distance up to 50 km valid ▪ Computes for 1 hr to annual averaging periods ▪ Terrain adjustment is possible 	<ul style="list-style-type: none"> ▪ Can take 250 sources ▪ Computes concentration at 180 receptors up to 10 km ▪ Requires source data, meteorological data and receptor coordinates
CTDM PLUS (Complex Terrain Dispersion Model)	<ul style="list-style-type: none"> ▪ Point source steady state model, can estimate hrly average concentration in isolated hills/ array of hills 	<ul style="list-style-type: none"> ▪ Can take maximum 40 Stacks and computes concentration at maximum 400 receptors ▪ Does not simulate calm met conditions ▪ Hill slopes are assumed not to exceed 15 degrees ▪ Requires sources, met and terrain characteristics and receptor details
UAM (Urban Airshed Model)	<ul style="list-style-type: none"> ▪ 3-D grid type numerical simulation model ▪ Computes O₃ concentration short term episodic conditions lasting for 1 or 2 days resulting from NO_x and VOCs ▪ Appropriate for single urban area having 	<ul style="list-style-type: none"> ▪

Model	Application	Remarks
	significant O ₃ problems	
RAM (Rural Airshed Model)	<ul style="list-style-type: none"> Steady state Gaussian plume model for computing concentration of relatively stable pollutants for 1 hr to 1 day averaging time Application for point and area sources in rural and urban setting 	<ul style="list-style-type: none"> Suitable for flat terrains Transport distance less than 50 km.
CRESTER	<ul style="list-style-type: none"> Applicable for single point source either in rural or urban setting Computes highest and second highest concentration for 1hr, 3hr, 24hr and annual averaging times Tabulates 50 highest concentration for entire year for each averaging times 	<ul style="list-style-type: none"> Can take up to 19 Stacks simultaneously at a common site. Unsuitable for cool and high velocity emissions Do not account for tall buildings or topographic features Computes concentration at 180 receptor, circular wing at five downwind ring distance 36 radials Require sources, and met data
OCD (Offshore and coastal Dispersion Model)	<ul style="list-style-type: none"> It determines the impact of offshore emissions from point sources on the air quality of coastal regions It incorporates overwater plume transport and dispersion as well as changes that occur as the plume crosses the shore line Most suitable for overwater sources shore onshore receptors are below the lowest shore height 	<ul style="list-style-type: none"> Requires source emission data Require hrly met data at offshore and onshore locations like water surface temperature; overwater air temperature; relative humidity <i>etc.</i>
FDM (Fugitive Dust Model)	<ul style="list-style-type: none"> Suitable for emissions from fugitive dust sources Source may be point, area or line (up to 121 source) Require particle size classification max. up to 20 sizes Computes concentrations for 1 hr, 3hr, 8hr, 24hr or annual average periods 	<ul style="list-style-type: none"> Require dust source particle sizes Source coordinates for area sources, source height and geographic details Can compute concentration at max. 1200 receptors Require met data (wind direction, speed, Temperature, mixing height and stability class) Model do not include buoyant point sources, hence no plume rise algorithm
RTDM (Rough Terrain Diffusion Model)	<ul style="list-style-type: none"> Estimates GLC is complex/rough (or flat) terrain in the vicinity of one or more co-located point sources Transport distance max. up to 15 km to up to 50 km Computes for 1 to 24 hr. or annual average concentrations 	<ul style="list-style-type: none"> Can take up to 35 co-located point sources Require source data and hourly met data Computes concentration at maximum 400 receptors Suitable only for non reactive gases Do not include gravitational effects or depletion mechanism such as rain/ wash out, dry deposition
CDM(Climatologically Dispersion Model)	<ul style="list-style-type: none"> It is a climatologically steady state GPM for determining long term (seasonal or annual) Arithmetic average pollutant concentration at any ground level receptor in an urban area 	<ul style="list-style-type: none"> Suitable for point and area sources in urban region, flat terrain Valid for transport distance less than 50 km Long term averages: One month to one year or longer

Model	Application	Remarks
PLUVUE-II (Plume Visibility Model)	<ul style="list-style-type: none"> ▪ Applicable to assess visibility impairment due to pollutants emitted from well defined point sources ▪ It is used to calculate visual range reduction and atmospheric discoloration caused by plumes ▪ It predicts transport, atmospheric diffusion, chemical, conversion, optical effects, and surface deposition of point source emissions. 	<ul style="list-style-type: none"> ▪ Require source characteristics, met data and receptor coordinates & elevation ▪ Require atmospheric aerosols (back ground & emitted) characteristics, like density, particle size ▪ Require background pollutant concentration of SO₄, NO₃, NO_x, NO₂, O₃, SO₂ and deposition velocities of SO₂, NO₂ and aerosols
MESO-PUFF II (Meso scale Puff Model)	<ul style="list-style-type: none"> ▪ It is a Gaussian, Variable trajectory, puff superposition model designed to account for spatial and temporal variations in transport, diffusion, chemical transformation and removal mechanism encountered on regional scale. ▪ Plume is modeled as a series of discrete puffs and each puff is transported independently ▪ Appropriate for point and area sources in urban areas ▪ Regional scale model. 	<ul style="list-style-type: none"> ▪ Can model five pollutants simultaneously (SO₂, SO₄, NO_x, HNO₃ and NO₃) ▪ Require source characteristics ▪ Can take 20 point sources or 5 area source ▪ For area source – location, effective height, initial puff size, emission is required ▪ Computes pollutant concentration at max. 180 discrete receptors and 1600 (40 x 40) grided receptors ▪ Require hourly surface data including cloud cover and twice a day upper air data (pressure, temp, height, wind speed, direction) ▪ Do not include gravitational effects or depletion mechanism such as rain/ wash out, dry deposition

Table 2: Choice of Models for Impact Modeling: Noise Environment *

Model	Application
FHWA (Federal Highway Administration)	Noise Impact due to vehicular movement on highways
Dhwani	For predictions of impact due to group of noise sources in the industrial complex (multiple sound sources)
Hemispherical sound wave propagation Air Port	Fore predictive impact due to single noise source For predictive impact of traffic on airport and rail road

Table 3: Choice of Models for Impact Modeling: Land Environment *

Model	Application	Remarks
Digital Analysis Techniques	Provides land use / land cover distribution	
Ranking analysis for soil suitability criteria	Provides suitability criteria for developmental conversation activities	Various parameters viz. depth, texture, slope, erosion status, geomorphology, flooding hazards, GW potential, land use <i>etc.</i> , are used.

Table 4: Choice of Models for Impact Modeling: Water Environment *

Model	Application	Remarks
QUAL-II E	Wind effect is insignificant, vertical dispersive effects insignificant applicable to streams Data required Deoxygenation coefficients, re-aeration coefficients for carbonaceous, nitrogenous and benthic substances, dissolved oxygen deficit	Steady state or dynamic model
	The model is found excellent to generate water quality parameters Photosynthetic and respiration rate of suspended and attached algae	
	Parameters measured up to 15 component can be simulated in any combination, e.g. ammonia, nitrite, nitrate, phosphorous, carbonaceous BOD, benthic oxygen demand, DO, coliforms, conservative substances and temperature	
DOSAG-3, USEPA: (1-D) RECEIV – II, USEPA	Water quality simulation model for streams & canal A general Water quality model	Steady-state
Explore –I, USEPA	A river basin water quality model	Dynamic, Simple hydrodynamics
HSPE, USEPA	Hydrologic simulation model	Dynamic, Simple hydrodynamics
RECEIVE-II, USEPA	A general dynamic planning model for water quality management	
Stanford watershed model	This model simulates stream flows once historic precipitation data are supplied The major components of the hydrologic cycle are modeled including interception, surface detention, overland inflow, groundwater, evapo-transpiration and routing of channel flows, temperature, TDS, DO, carbonaceous BOD coliforms, algae, zooplanktons, nitrite, nitrate, ammonia, phosphate and conservative substances can be simulated	
Hydrocomp model	Long-term meteorological and wastewater characterization data is used to simulate stream flows	Time dependant (Dynamic)

Model	Application	Remarks
	and stream water quality	
Stormwater Management model (SWMM)	Runoff is modeled from overland flow, through surface channels, and through sewer network Both combined and separate sewers can be modeled. This model also enables to simulate water quality effects to stormwater or combined sewer discharges. This model simulates runoff resulting from individual rainfall events.	Time Dependent
Battelle Reservoir model	Water body is divided into segments along the direction of the flow and each segment is divided into number of horizontal layers. The model is found to generate excellent simulation of temperature and good prediction of water quality parameters. The model simulates temperature, DO, total and benthic BOD, phytoplankton, zooplankton, organic and inorganic nitrogen, phosphorous, coliform bacteria, toxic substances and hydrodynamic conditions.	Two Dimensional multi-segment model
TIDEP (Turbulent diffusion temperature model reservoirs)	Horizontal temperature homogeneity Coefficient of vertical turbulent diffusion constant for charge of area with depth negligible coefficient of thermal exchange constant Data required wind speed, air temperature, air humidity, net incoming radiation, surface water temperature, heat exchange coefficients and vertical turbulent diffusion coefficients.	Steady state model
BIOLAKE	Model estimates potential fish harvest from a take	Steady state model
Estuary models/ estuarial Dynamic model	It is simulates tides, currents, and discharge in shallow, vertically mixed estuaries excited by ocean tides, hydrologic influx, and wind action Tides, currents in estuary are simulated	Dynamic model
Dynamic Water Quality Model	It simulates the mass transport of either conservative or non-conservative quality constituents utilizing information derived from the hydrodynamic model Bay-Delta model is the programme generally used. Up to 10 independent quality parameters of either conservative or non-conservative type plus the BOD-DO coupled relationship can be handled	Dynamic model
HEC -2	To compute water surface profiles for steady, gradually: varying flow in both prismatic & non-prismatic channels	
SMS	Lake circulation, salt water intrusion, surface water profile simulation model	Surface water Modeling system Hydrodynamic model
RMA2	To compute flow velocities and water surface elevations	Hydrodynamic analysis model
RMA4	Solves advective-diffusion equations to model up to six non-interacting constituents	Constituent transport model
SED2D-WES	Model simulates transport of sediment	Sediment transport model
HIVEL2D	Model supports subcritical and supercritical flow	A 2-dimensional

Model	Application	Remarks
	analysis	hydrodynamic model
MIKE-II, DHI	Model supports, simulations of flows, water quality, and sediment transport in estuaries, rives, irrigation systems, channels & other water bodies	Professional Engineering software package

Table 5: Choice of Models for Impact Modeling: Biological Environment *

Name	Relevance	Applications	Remarks
Flora			
Sample plot methods	Density and relative density	Average number of individuals species per unit area	The quadrant sampling technique is applicable in all types of plant communities and for the study of submerged, sessile (attached at the base) or sedentary plants
	Density and relative dominance	Relative degree to which a species predominates a community by its sheer numbers, size bulk or biomass	
	Frequency and relative frequency importance value	Plant dispersion over an area or within a community	Commonly accepted plot size: 0.1 m ² - mosses, lichens & other mat-like plants
		Average of relative density, relative dominance and relative frequency	0.1 m ² - herbaceous vegetation including grasses
			10.20 m ² – for shrubs and saplings up to 3m tall, and
			100 m ² – for tree communities
Transects & line intercepts methods	Cover	Ratio of total amount of line intercepted by each species and total length of the line intercept given its cover	This methods allows for rapid assessment of vegetation transition zones, and requires minimum time or equipment of establish
	Relative dominance	It is the ratio of total individuals of a species and total individuals of all species	Two or more vegetation strata can be sampled simultaneously
Plot-less sampling methods	Mean point plant	Mean point – plant distance	Vegetation measurements are determined from points rather than being determined in an area with boundaries
	Mean area per plant	Mean area per plant	
	Density and relative density		Method is used in grass-land and open shrub and tree communities
	Dominance and relative dominance		It allows more rapid and extensive sampling than the plot method
	Importance value		Point- quarter method is commonly used in woods and forests.
Fauna			

Name	Relevance	Applications	Remarks
Species list methods	Animal species list	List of animal communities observed directly	Animal species lists present common and scientific names of the species involved so that the faunal resources of the area are catalogued
Direct Contact Methods	Animal species list	List of animals communities observed directly	This method involves collection, study and release of animals
Count indices methods (Roadside and aerial count methods)	Drive counts Temporal counts	Observation of animals by driving them past trained observers	Count indices provide estimates of animal populations and are obtained from signs, calls or trailside counts or roadside counts
	Call counts	Count of all animals passing a fixed point during some stated interval of time	These estimates, though they do not provide absolute population numbers, Provide an index of the various species in an area
			Such indices allow comparisons through the seasons or between sites or habitats
Removal methods	Population size	Number of species captured	Removal methods are used to obtain population estimates of small mammals, such as, rodents through baited snap traps
Market capture methods	Population size estimate (M)	Number of species originally marked (T) Number of marked animals recaptured (t) and total number of animals captured during census (n) $N = nT/t$	It involves capturing a portion of the population and at some later date sampling the ratio of marked to total animals caught in the population

Table 6: Choice of Models for Impact Predictions: Social Environment *

Relevance		
Name	Application	Remarks
Extrapolative Methods	A prediction is made that is consistent with past and present socio-economic data, e.g. a prediction based on the linear extrapolation of current trends	
Intuitive Forecasting (Delphi techniques)	Delphi technique is used to determine environmental priorities and also to make intuitive predictions through the process of achieving group consensus	Conjecture Brainstorming Heuristic programming Delphi consensus
Trend extrapolation and correlation	Predictions may be obtained by extrapolating present trends Not an accurate method of making socio-economic forecasts, because a time series cannot be interpreted or extrapolated very far into the future	Trend breakthrough precursor events correlation and regression

Relevance		
Name	Application	Remarks
	with out some knowledge of the underlying physical, biological, and social factors	
Metaphors and analogies	The experience gained else where is used to predict the socio-economic impacts	Growth historical simulation commonsense forecasts
Scenarios	Scenarios are common-sense forecasts of data. Each scenario is logically constructed on model of a potential future for which the degrees of “confidence” as to progression and outcome remain undefined	Common-sense
Dynamic modeling (Input- Out model)	Model predicts net economic gain to the society after considering all inputs required for conversion of raw materials along with cost of finished product	
Normative Methods	Desired socio-economic goals are specified and an attempt is made to project the social environment backward in time to the present to examine whether existing or planned resources and environmental programmes are adequate to meet the goals	Morphological analysis technology scanning contextual mapping - functional array - graphic method Mission networks and functional arrays decision trees & relevance trees matrix methods scenarios

* **NOTE:** Project-specific proposed prediction tools need to be identified by the project proponent and shall be incorporated in the draft ToR to be submitted to the Authority for the consideration and approval by the concerned EAC/SEAC.

ANNEXURE X

**Form through which the State Governments/Administration of
the Union Territories Submit Nominations for SEIAA and SEAC
for the Consideration and Notification by the
Central Government**

Form for Nomination of a professional/expert as Chairperson / Member / Secretary of the SEIAA / EAC / SEAC						
1 Name (in block letters)						
2 Address for communication						
3 Age & Date of Birth (Shall be less than 67 years for the members and 72 years for the Chairman)						
4 Area of Expertise (As per Appendix VI)						
5	Professional Qualifications (As per Appendix VI)	Qualification(s)	University	Year of passing	Percentage of marks	
6	Work experience (High light relevant experience as per Appendix VI)	Position	Years of association		Nature of work. If required, attach separate sheets	
			From	to		Period in years
7	Present position and nature of job	Serving Central / State Government Office?			Yes/No	
		Engaged in industry or their associations?			Yes/No	
		Associated with environmental activism?			Yes/No	
		If no is the answer for above three, please specify the present position and name of the organization				
8	Whether experienced in the process of prior environmental clearance?	Yes/No. If yes, please specify the experience in a separate sheet (Please restrict to 500 words)				
9	Whether any out-standing expertise has been acquired?	Yes/ No If yes, please provide details in a separate sheet (Please restrict to 500 words).				
10	Any other relevant information?	May like to attach separate sheets (Research projects, consultancy projects, publications, memberships in associations, trainings undergone, international exposure cum experience etc.)				

The Government of.....is pleased to forward the Nomination of Dr./Sh. for the position of Chairperson / Member / Secretary of the SEIAA / SEAC / EAC to the Ministry of Environment & Forests, the Government of India for the Notification.

(Authorized Signature with Seal)

ANNEXURE XI
Composition of EAC/SEAC

Composition of the EAC/SEAC

The Members of the EAC shall be Experts with the requisite expertise and experience in the following fields /disciplines. In the event that persons fulfilling the criteria of “Experts” are not available, Professionals in the same field with sufficient experience may be considered:

- Environment Quality Experts: Experts in measurement/monitoring, analysis and interpretation of data in relation to environmental quality
- Sectoral Experts in Project Management: Experts in Project Management or Management of Process/Operations/Facilities in the relevant sectors.
- Environmental Impact Assessment Process Experts: Experts in conducting and carrying out Environmental Impact Assessments (EIAs) and preparation of Environmental Management Plans (EMPs) and other Management plans and who have wide expertise and knowledge of predictive techniques and tools used in the EIA process
- Risk Assessment Experts
- Life Science Experts in floral and faunal management
- Forestry and Wildlife Experts
- Environmental Economics Expert with experience in project appraisal

ANNEXURE XII
Best Practices available and reference

Technological Aspects

Clean technologies

In the middle of the 1960s environmental groups started pressing for cleaner environment. The metallurgical industry responded in a variety of ways. The steel industry closed open hearth furnaces and switched over to other cleaner technology. The aluminium industry switched over from Soderberg to pre-baked electrodes in the electrolytic cells. The copper industry abandoned the reverberatory furnace to a flash smelting technology. Tall stacks were constructed to dispose of SO_2 , but the zinc industry eliminated SO_2 emissions

completely by using pressure leaching technology which may well be applied to other nonferrous industries.

Beside government legislation against pollution, residents in many communities now protest against the erection of industrial plants in their regions. The construction of tall stacks has been a new development in the past decades. The problem of dust has been generally solved by adding efficient scrubbers and electrostatic precipitators. This not only improved the local environment but also allowed the recovery of valuable particulates. In most cases the value of these particulates offsets the capital investment in the dust recovery system. The metallurgist is now trying to cope with the environmental problems by adding new equipment in existing plants that would abate pollution, by improving equipment design, and in some cases is forced to develop new processes that are less polluting than the conventional ones. Closely related to these attempts is the need to conserve the national resources through recycling of scrap metal, valorization of mineral waste, and recovery of metals that would otherwise be lost in process streams

Clean technologies in iron and steel

Considerable advancement in the field of clean technologies has taken place in the iron & steel sector. The following clean technologies are possible in the iron & steel sector:

1) Sintering

Sinter plant heat recovery

Description: Heat recovery at the sinter plant is a means for improving the efficiency of sinter making. The recovered heat can be used to preheat the combustion air for the burners and to generate high pressure steam, which can be run through electricity turbines. Various systems exist for new sinter plants (e.g. Lurgi Emission Optimized Sintering (EOS) process) and existing plants can be retrofit.

Energy/environment/cost/other benefits:

- Retrofitted system at Hoogovens in the Netherlands:
- Fuel savings in steam and coke of 0.55 GJ/T sinter, with increased electricity use of 1.5 kWh/T sinter
- NO_x, SO_x and particulate emissions reduced
- Capital costs of approximately \$3/T sinter
- Wakayama sintering plant trial operation in Japan:
 - 110-130 kg/T of sinter recovered in steam
 - 3-4% reduction in coke
 - 3-10% reduction in SO_x
 - 3-8% reduction in NO_x
 - About 30% reduction in dust
 - Increased productivity, yield, and cold strength
- Taiyuan Steel in Japan:
 - Recovered exhaust heat equaled 15 t/h (or 12,000 KL/year crude oil)
 - SO₂ reduced

2) Dust emissions control

Description: Production increase leads to increased dust generation, thereby increasing particulate emissions. These emissions - off/waste gas – are dust-laden, containing a wide

variety of organic and heavy metal hazardous air pollutants (HAPs). Total HAPs released from individual sinter manufacturing operations may exceed ten tonnes per year. By sending waste gas to Electrostatic Precipitators (ESPs) through negatively charged pipes, the particulate matter (PM) in the waste stream becomes negatively charged. Routing the stream past positively charged plates will then attract and collect the negatively charged PM, thereby producing clean waste gas and increasing the quantity of steam recovery. Course dusts are removed in dry dust catchers and recycled.

Energy/environment/cost/other benefits:

- Can achieve over 98% efficiency, reducing dust load in off-gas of a typical plant from 3,000 mg/m³ to about 50 mg/m³
- ESP removal of fine dust may reduce PM emission levels at sinter plants to about 50 – 150 mg/m³ depending on actual specific dust resistivity and/or sinter basicity
- ESPs can be installed at new and existing plants
- ESPs cause increased energy consumption of about 0.002 to 0.003 GJ/T sinter
- Kashima Steel Works in Japan installed ESP

3) Exhaust gas treatment through denitrification, desulphurization, and activated coke packed bed absorption

Description: Sintering exhaust gas contains SO_x, NO_x, dust and dioxins. These contaminants are processed, absorbed, decomposed and/or collected as non-toxic by-products to increase the quantity of steam recovery, and improve total fuel savings. Treatment methods to achieve these include:

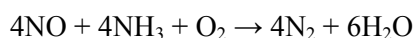
- (1) Denitrification Equipment
- (2) Desulphurization Equipment
- (3) Activated Coke Packed Bed Absorption

Energy/environment/cost/other benefits

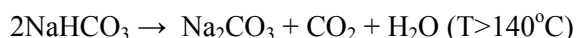
- SO_x is absorbed and recovered as useful by-product
- NO_x is decomposed to nitrogen, water and oxygen by ammonia
- Dust is collected in activated coke
- Dioxins are collected or absorbed in activated coke and decomposed at 400°C with no oxygen
- Activated coke absorption removes dioxins to <0.1 ng-TEQ/m³N, dust to <10 mg/m³N, and SO_x to <65 % absorbing ratio.

4) Exhaust Gas Treatment through Selective Catalytic Reduction

Description: SO_x and dioxins contained in the sinter flue gas are removed in this process by adding sodium bicarbonate and Lignite. NO_x is removed by the selective catalytic reduction reaction at around 200~450°C:



For SO_x removal the reactions are:





Lignite Injection produces dioxin < 0.2 ng-TEQ/Nm³.

Energy/environment/cost/other benefits

- High SO_x and NO_x removal efficiency

5) Exhaust Gas Treatment through Low-Temperature Plasma

Description: Active radicals of low-temperature plasma remove SO_x, NO_x and HCl simultaneously. Dioxin also decreased with the addition of Lignite to the process. Reliability and stability have been proven (over five years of operation). Core technology includes full-scale magnetic pulse compressor, stabilizing pulse width and rising time, proper reactor capacity design, and energy saving technology through additives.

Energy/environment/cost/other benefits

- Low cost with high pollutants removal efficiency
- Compact - less space required than other technologies
- A commercial scale plant installed at an incinerator in Kwang Works showed a substantial reduction of Sox (>70%), NO_x (>95%) and HCl (>99%)
- Dioxin also decreased to less than 0.2 ng-TEQ/Nm³

6) Improvements in Feeding Equipment

Description: An additional screen is installed on the conventional sloping chute, which promotes a more desirable distribution of granulated ore on the palette.

Energy/environment/cost/other benefits

- The screen with a sloping chute places coarser granulated ore in the lower part of the palette and finer ore on the upper part, which achieves high permeability

7) Segregation of raw materials on pellets

Description: Segregation and granulation reinforcement of raw materials on sintering pellets improve permeability and decrease return rate to sintering pellets, thus increasing productivity and saving energy.

Energy/environment/cost/other benefits:

- Effective in improving permeability and decrease return rate to sintering pellets
- Increases productivity and saves energy

8) Multi-slit burner in ignition furnace

Description: Multi-slit burners produce one wide, large stable flame, which eliminates “no flame” areas and supplies minimum heat input for ignition, therefore saving energy.

Energy/environment/cost/other benefits

- Total heat input for ignition was reduced by approximately 30% in Wakayama Steel Works of Sumitomo Metals in Japan

9) Equipment to reinforce granulation

Description: A high-speed mixer and a drum mixer are added to the conventional systems for producing granulated ore.

Energy/environment/cost/other benefits

- Reinforced granulation at Wakayama Steel works found:
 - Productivity increased from 34.7 to 38.3 t/day m²
 - Water content increased from 7.0 to 7.3%
 - Granulation rate increased by 45%
 - Permeability increased by 10%
 - Flame front speed increased by 10%
 - Return fine rate decreased less than 1%

10) Biomass for iron and steel making

Description: Biomass utilization practices for iron and steelmaking are being developed to replace coke breeze in the sintering process. Charcoal has been found to be an effective fuel and reductant as high rank coals for the bath smelting of iron ores and wood char has been shown to be a suitable replacement for coke breeze in the sintering process, resulting in process improvements and reduction of acid as levels in process emissions.

Energy/environment/cost/other benefits

- Substantial reductions in CO₂ emissions
- Reductions in acid gas emissions
- Improved carburization rates and increased product quality
- Reduced demand for fluxing agents
- Lower slag volume and levels of process wastes
- Higher productivity through use of more reactive carbon

11) Coke ovens

Coke dry quenching

Description: Coke dry quenching is an alternative to the traditional wet quenching of the coke. It reduces dust emissions, improves the working climate, and recovers the sensible heat of the coke. Hot coke from the coke oven is cooled in specially designed refractory lined steel cooling chambers by counter-currently circulating an inert gas media in a closed circuit consisting of a cooling chamber, a dust collecting bunker, a waste heat boiler, dust cyclones, a mill fan, a blowing device (to introduce the cold air from the bottom) and circulating ducts. Dry coke quenching is typically implemented as an environmental control technology. Various systems are used in Brazil, Finland, Germany, Japan, India and Taiwan, but all essentially recover the heat in a vessel where the coke is quenched with an inert gas (nitrogen). The heat is used to produce steam, which may be used on-site or to generate electricity.

Dry Coke Quenching - CDM Benefits

As described in the TGM, sensible heat of hot coke is lost in wet quenching as steam. In dry quenching, this can be used to produce steam in waste heat recovery boilers and then can be used to produce electricity. Such energy conservation projects are permitted to be taken as CDM projects, where Certified Emission Reduction (CERs) will be issued by UNFCCC to encourage such voluntary energy conservation efforts. CERs can be traded in the international market at the prevailing market rate of carbon (carbon trading). Each CER is issued for saving 1 t of CO₂ emission, directly or indirectly. For CDQ projects, the CO₂ reduction is indirect, as it will replace power needs from grid and therefore burning of coal and consequently emission of CO₂ at the grid connected power plants, which is a predominant fuel in Indian power sector. The project activity contributes significantly to the sustainable development in the following ways:

- Reclaim the sensible heat of red coke, improve the quality of coke, reduce the air pollution caused by the traditional wet quenching, increase the energy utilization efficiency, reduce the energy loss and protect environment
- Prevent the dust pollution caused by the general wet quenching technology
- Reduce the rely on fossil fuel
- Reduce the pollution emission caused by burning fossil fuel
- Reduce the greenhouse gas emission caused by burning the fossil fuel
- Reduce the demand from the power grid, thus mitigate the electricity shortage
- Provide working opportunity for local residents and increase their income

Energy/environment/cost/other benefits

- Energy recovered is approximately 400-500 kg steam/T, equivalent to 800-1200 MJ/T coke. Others estimate energy conservation through steam generation (0.48T/T coke) for Electricity generation.
- New plant costs are estimated to be \$50/T coke, based on the construction costs of a recently built plant in Germany; retrofit capital costs depend strongly on the lay-out of the coke plant and can be very high, up to \$70 to \$90/GJ saved
- Decreased dust, CO₂ and SO_x emissions
- Increased water efficiency
- Better quality coke produced, improved strength of coke by 4%

Pollution problems from the by-product recovery type coke ovens

- The gaseous emissions from the coke ovens during the coking process are drawn off and are subjected to various operations for separating ammonia, coke oven gas, tar, phenol, light oil (benzene, toluene, and xylene), and pyridine. After separation, these gases become a potential energy source for other areas of the steel plant. However, if the coke oven gas is not desulfurized, the combustion process will emit SO₂.
- The cleaned coke oven gases are taken to a by-product plant for extraction of by-products. The major solid wastes and by products generated are tar, ammonia products, sulphur, light oil, ammonia still sludge and sludge from the biological treatment plant.
- Waste water generated in the by-product plant is mostly treated by biological processes.

- In case of by-product recovery type coke ovens, USEPA developed a model treatment process which mixes benzol plant waste waters, naphthalene crystallizer blow down, and final cooler blow down and are treated with waste pickle liquor. This effluent is combined with other by-product plant wastewaters and treated with lime in ammonia still to remove both free and fixed ammonia. The ammonia recovered from the still is injected into the coke oven gas stream. The pH of the effluent is lowered by addition of acid and treated in a two stage biological reactor with sludge recycle.

Waste minimization and pollution prevention opportunities in by-products plant:

- Usage of caustic soda rather than lime in the ammonia still; though more costly, it minimizes sludge formation, reduces down time due to scaling problems, and may solve disposal problems.
- Indirect cooling of the coke oven gas to eliminate any contact of the process water with pollutants in the coke oven gas with the exception of flushing liquor.
- Elimination of the recovery of naphthalene and the naphthalene sump.
- The use of an indirect type system for light oil recovery eliminates process wastewater streams since no water comes into contact with the gas, the wash oil, the light oil or the final cooler.
- All pumping stations, oil storage tanks and oil transfer points should be located on impervious, dyked pads with the pad effluent directed to the waste ammonia liquor stream for treatment in order to prevent contamination of ground water.
- Wet oxidation sulphur removal processes for coke oven gas has created highly contaminated waste water streams. Alternative processes like Zimpro Modified Wet Air Oxidation Process, the Dofasco Fixed Salts Recovery Process, or the Nippon Steel HIROHAX process exists.
- Tar by products should be recycled in-plant after processing (*e.g.*, for use as a fuel) or sold as a by-product.
- Sludge generated by the biological treatment system can be recycled to the coke oven.
- Tar decanter sludge can be circulated through a solvent grinding pump and then sprayed onto the coal prior to charging into oven.

12) Coal moisture control

Description: Coal moisture control uses the waste heat from the coke oven gas to dry the coal used for coke making. The moisture content of coal varies, but it is generally around 8-9% for good coking coal. Drying further reduces the coal moisture content to a constant 3-5%, which in turn reduces fuel consumption in the coke oven. The coal can be dried using the heat content of the coke oven gas or other waste heat sources.

Energy/environment/cost/other benefits:

- Fuel savings of approximately 0.3 GJ/T 8, 9
- Coal moisture control costs for a plant in Japan were \$21.9/T of steel
- Coke quality improvement (about 1.7%)
- Coke production increase (about 10%)
- Shorter cooking times
- Decrease in water pollution (ammonia reduction)

13) High pressure ammonia liquor aspiration system

Description: The High Pressure Ammonia Liquor Aspiration System (HPALA) is effective for controlling charging emissions in coke oven batteries. In this system, the ammoniacal liquor, which is a byproduct in the coke oven, is pressurized to about 35-40 bar and injected through special nozzles provided in the gooseneck at the time of charging. This creates sufficient suction inside the oven, thereby retaining pollutants from being released into the atmosphere. The system consists of high-pressure multistage booster pumps, sturdy pipe-work, specially designed spray nozzles, suitable valves and control instruments.

Energy/environment/cost/other benefits

- Emissions control
- High reliability and simplicity of operation
- Low operational and maintenance costs
- Appreciable saving in quantity of process steam required and increased raw gas yield/byproducts generation, due to elimination of gases vented into the atmosphere

14) Modern leak-proof door

Description: Coke oven leaking doors can be a major source of pollution. With the advent of recovery type ovens, the design of oven doors has gone through a process of evolution, beginning from luted doors to the present generation self-regulating zero-leak doors. The important features of the leak-proof door include: (1) a thin stainless steel diaphragm with a knife edge as a sealing frame built in between the door body and the brick retainer, (2) spring loaded regulation on the knife edge for self-sealing, (3) provision for air cooling of the door body, and (4) large size gas canals for easier circulation of gas inside oven.

Energy/environment/cost/other benefits

- Minimization of door leakage
- Regulation free operation
- Longer life due to less warping of the air cooled door body
- Reduced maintenance frequency
- Conventional doors can be replaced by leak-proof doors without altering battery/door frame design

15) Land-based pushing emission control system

Description: The smoke and fumes produced during the pushing of red hot coke contains a huge amount of coke dust (estimated at 11% of the total pollution in the coke oven). Land based pushing emission control systems mitigate this pollution. It consists of three parts: (1) a large gas suction hood fixed on the coke guide car and moving with the coke guide, sending fumes to the coke side dust collecting duct; (2) the dust collection duct; and (3) the final equipment for smoke purification on the ground (ground piping, accumulator cooler, pulse bag dust collector, silencer, ventilation unit, stack, etc). The large amount of paroxysmal high-temperature smoke produced during coke discharging is collected under the hot float fan into the large gas suction hood installed in the coke guide car, and enters the dust collection duct through the other equipment. The air is dissipated into the atmosphere after purification by the pulse dust collector and after being cooled by the accumulator cooler. The total de-dusting system is controlled by PLC.

Energy/environment/cost/other benefits

- Elimination of pushing emission up to the large extent

16) Iron making

Blast Furnace Iron making

Top pressure recovery turbine

Description: Top pressure recovery turbine (TRT) is a power generation system, which converts the physical energy of high-pressure blast furnace top gas into electricity by using an expansion turbine. Although the pressure difference is low, the large gas volumes make the recovery economically feasible. The key technology of TRT is to secure the stable and high-efficiency operation of the expansion turbine in dusty blast gas conditions, without harming the blast furnace operation.

Energy/environment/cost/other benefits

- Generates electric power of approximately 40-60 kWh/T pig iron
- Japanese Integrated Steel Works:
 - Generates more than 8% of electricity consumed in Japanese ironworks (about 3.33 TWh)
- Excellent operational reliability, abrasion resistant
- Suitable for larger furnaces and higher temperature gases compared to Bag filter systems
- Wet TRT System (US):
 - Typical investments of about \$20/T power recovery of 30 kWh/T hot metal
 - No combustion of BF gas
- Dry TRT System, *e.g.*, Venturi Scrubber- Electrostatic Space Clear Super (VS-ESCS):
 - Lower water consumption compared with wet type
 - Raises turbine inlet temperature, increasing power

17) Pulverized coal injection (PCI) system

Description: PCI replaces part of the coke used to fuel the chemical reaction, reducing coke production, thus saving energy. The increased fuel injection requires energy from oxygen injection, coal, and electricity and equipment to grind coal. The coal replaces the coke, but coke is still used as a support material in the blast furnace. The maximum injection depends on the geometry of the BF and impact on the iron quality (*e.g.*, sulphur).

Energy/environment/cost/other benefits

- Reduces emissions of coke ovens
- Increased costs of oxygen injection and maintenance of BF and coal grinding equipment offset by lower maintenance costs of existing coke batteries and/or reduced coke purchase costs, yielding a net decrease in operating and maintenance costs, estimated to be \$15/T, but a cost savings of up to \$33/T are possible, resulting in a net reduction of 4.6% of costs of hot metal production

- Decreased frequency of BF relining
- Improved cost competitiveness with cost reduction of hot metal
- Investment of coal grinding equipment estimated at \$50-55/T coal injected
- High reliability and easy operation
- Increased productivity
- Uniform transfer of pulverized coal
- No moving parts in injection equipment
- Even distribution to Tuyeres

18) Blast Furnace Heat Recuperation

Description: Recuperation systems, *e.g.*, Hot Blast Stove, BFG Preheating System, *etc.*, are used to heat the combustion air of the blast furnace. The exit temperature of the flue gases, approximately 250°C, can be recovered to preheat the combustion air of the stoves.

Energy/environment/cost/other benefits

- Hot blast stove
 - Fuel savings vary between 80-85 MJ/T hot metal
 - Costs are high and depend strongly on the size of the BF, estimated at \$18-20/(GJ saved), equivalent to \$1.4/T hot metal
 - Efficient hot blast stove can run without natural gas
- BFG Preheating System at POSCO in Korea:
 - Anti-corrosion technology with high surface temperatures
 - Economic recovery for low to medium temperature grade heat
 - 102 kcal/kWh reduction in fuel input; thermal efficiency increase of 3.3%
 - Energy savings of 3-5% for boiler, with payback period of within 1.5 years
 - Proven reliability and stability for more than 10 years of operation

19) Improve blast furnace charge distribution

Description: Charging systems of old blast furnaces and new blast furnaces are being retrofitted or equipped with the Paul Wurth Bell Less Top (BLT) charging systems. Input materials like coke and sinter are screened before charging. Proper distribution of input materials improves the coking rate and increases production.

Energy/environment/cost/other benefits

- Increased fuel efficiency
- Reduced emissions
- Increased productivity
- Improved coking rate

20) Blast furnace gas and cast house dedusting

Description: When blast furnace gas leaves the top of the furnace it contains dust particles. Dust particles are removed either with a conventional wet type dedusting system or a dry type dedusting system. Both systems consist of a gravity dust catcher to remove dry large particulate from the BFG stream. The wet fine particulate is then removed in wet type dedusting with a two stage Venturi or Bisholff scrubber, whilst dry type

dedusting does not require water scrubbing and instead employs an electro-precipitator or a bag filter to clean the BFG.

Energy/environment/cost/other benefits

- Dust catcher removes about 60% of particulate from BFG
- Wet Type Dedusting:
 - Produces gas containing less than 0.05 grams/m³ of particulate
 - Pressure and noise control devices not necessary
- Dry Type Dedusting:
 - 30% increase in power generated with dry-type TRT system compared to wet type dedusting
 - 7-9 Nm³/T HM reduction in recirculated water consumption, of which 0.2m³ is fresh water
 - Eliminates generation of polluted water and slurry
 - Improved gas cleanness with dust content of <5mg/Nm³
 - 50% less occupied land area than wet type dedusting
 - Minimized investment cost and accelerates project construction, as only accounts for 70% in investment compared to wet type dedusting

21) Cast house dust suppression

Description: The primary source of blast furnace particulate emissions occurs during casting. Molten iron and slag emit smoke and heat while traveling from the taphole to ladle, or the slag granulator to pit. The cast house dust suppression system is designed to contain emissions. “Dirty” air is drawn through the baghouse, which contains separate collection chambers each with a suction fan, and is then exhausted into the atmosphere. The system has multiple collection hoods: overhead hoods above each taphole and skimmer, and below-floor hoods above each tilting spout.

Energy/environment/cost/other benefits

- Individual baghouse collection chambers can be shut down without affecting operation

22) Direct iron making

Smelting Reduction Processes

Description: Smelting reduction processes, including Aumelt Ausiron®, HIsmelt®, CCF, DIOS and COREX, involve the pre-reduction of iron ore by gases coming from a hot bath. The pre-reduced iron is then melted in the bath, and the excess gas produced is used for power generation, production of direct reduced iron (an alternative iron input for scrap), or as fuel gas. In this way, smelting reduction eliminates the need for coke and sintering, and future processes will also eliminate ore preparation.

Energy/environment/cost/other benefits:

- Low capital and operating costs:
 - 5-35% below production cost of conventional route
 - Direct use of iron ore fines/steel plant dusts and thermal coals
 - No coke ovens, sinter plants, blending yards

- Single furnace with direct waste energy recovery
- Low environmental impact:
 - No coke-oven or sinter plant emissions, and reduced CO₂, SO₂ and NO_x, no production of dioxins, furans, tars or phenols
 - Recycling of steel plant dusts and slag, making effective uses of coal energy
- High quality iron product, with impurities reported to the slag not the metal
- Greater flexibility in the range of raw materials accepted, including steel plant wastes and high phosphorous ores

23) Direct reduction processes

Description: Direct reduced iron (DRI) is produced through the reduction of iron ore pellets below the melting point of the iron. This is achieved with either natural gas (MIDREX® process) or coal-based (FASTMET® process) reducing agents. The DRI produced is mainly used as a high quality iron input in electric arc furnace (EAF) plants.

Energy/environment/cost/other benefits

- Pre-treatment of raw material not necessary
- Eliminates coke oven
- Low capital and operating costs
- FASTMET® Process:
 - Faster speed and lower temperatures for reduction reaction
 - Fuel usage can be reduced; not necessary to recover and reuse exhaust gases as secondary combustion of close to 100% is achieved in the rotary hearth furnace
 - Low heat loss, as reduced iron is fed to the melting furnace for hot metal production without cooling
 - Low emissions – 0.3-1.5 kg/THM NO_x, 2.4 kg/THM SO_x, and 0.3 kg/THM PM10 (-particulate matter less than 10.0 microns in diameter)
 - Energy consumption is 12.3 GJ/T-hot metal less than mini blast furnace; CO₂ is reduced by 1241 kg/T hot metal

24) Corex process

The chief source of metallic iron today, globally, is through Blast furnace, as the technology is most established, energy efficient, and versatile both technologically and economically. However, due to metallurgical coal to produce BF grade coke, and setting up of coke ovens which pollutes the environment with its NO_x and SO_x emissions, and rigid quality BF has become highly capital intensive. The economic, environmental and cost pressures led to the development of Smelting-Reduction processes like COREX, ROMELT, HISMELT, DIOS, AUSMELT *etc.* COREX is the only Smelting-Reduction process so far commercialized and in India has been adopted by Jindal Vidyanagar Steel Limited.

COREX consists of two reactors, the reduction shaft to produce DRI and the melter-gasifier to produce hot metal. The reduction shaft is placed above the melter-gasifier and reduced iron bearing material descends by gravity. The hot DRI at around 600-800°C along with partially calcined limestone and dolomite are continuously fed into the melter-gasifier through DRI down pipes. The hot metal and slag are collected in the hearth. The stable and highly successful operation of four COREX plants (POSCO, Korea, JVSL, India, SALDANHA, South Africa) confirms that COREX process is a proven and viable alternative to conventional blast furnace technology.

Thus in COREX, liquid hot metal is produced from DRI, whereas in Sponge Iron plants solid DRI in the form of sponge iron is produced.

25) Steel making

Electrochemical dezincing – dezincing of steel scrap improves recycling

Description: This electrochemical dezincing process provides an environmentally friendly economic method of removing zinc from steel scrap to reuse both the steel and zinc. With the use of zinc-coated scrap increasing, steelmakers are feeling the effect of increased contaminant loads on their operations. The greatest concerns are the cost of treatment before disposal of waste dusts and the water associated with remelting zinc-coated scrap. This technology separates steel scrap into dezincing steel scrap and metallic zinc in two basic steps:

- dissolving the zinc coating from scrap in a hot, caustic solution, and
- recovering the zinc from the solution electrolytically. Through a galvanic process, the zinc is removed from the steel and is in solution as sodium zincate ions rather than zinc dust. The steel is then rinsed with water and ready for reuse. Impurities are removed from the zinc solution, and then a voltage is applied in order to grow metallic zinc via an oxidation-reduction reaction. All waste streams in this process are reused.

Energy/environment/cost/other benefits

- The removal of zinc from steel scrap increases the recycleability of the underlying steel, decreases steelmaking dust, and decreases zinc in waste-water streams.
- Reduction of steelmaking dust to air and wastewater streams
- Removing zinc prior to processing of scrap saves time and money in disposal of waste dusts and water; without the zinc, this high quality scrap does not require extra handling, blending or sorting for remelting in steelmaking furnaces
- Improves the quality of steel scrap
- Produces 99.8% pure zinc for resale

26) BOF steelmaking

Increase thermal efficiency by using BOF exhaust gas as fuel

Description: BOF gas and sensible heat recovery (suppressed combustion) is the single most energy-saving process improvement in this process step, making the BOF process a net energy producer. By reducing the amount of air entering over the converter, the CO is not converted to CO₂. The sensible heat of the off-gas is first recovered in a waste heat boiler, generating high-pressure steam. The gas is cleaned and recovered.

Energy/environment/cost/other benefits

- Energy savings vary between 535 and 916 MJ/T steel, depends on the way in which the steam is recovered; with increased power of 2 kWh/T the total primary energy savings is 136%
- CO₂ reduction of 12.55 kg C per tonne crude steel
- \$20 per tonne crude steel investment costs and increased operations and maintenance costs

- Significant reduction of CO and PM emissions, as well as dust which can be recycled in the sinter or steel plant

27) Use enclosures for BOF

Description: BOF enclosures operate by covering mixer shop filling, mixer pouring, de-slagging station, converter charging, converter tapping and bulk material handling system on BOF top platform. On the charging top side, a dog house enclosure captures secondary fumes generated during charging. Rectangular high pick-up velocity suction hoods above charging side are connected to duct lines below the operating platform. Suction hoods capture dust during tapping operations above the receiving ladle. Deflector plates guide fumes towards suction hoods. Below the operating platform is a header duct that connects to a centralized fume extraction system of electrostatic precipitators, fans and a stack. Capacity varies between 1,000,000 m³/h to 2,600,000 m³/h, depending on heat capacity and operating sequence. Space can sometimes be a limited factor for this technology.

Energy/environment/cost/other benefits

- Better working conditions in terms of temperature and dust control
- Visibility of steel making operation and safety improves
- Accumulation of dust over building roofs can be avoided
- Collected dust can be recycled in steel plant

28) Control and automatization of converter operation

Description: As converters have become larger, operational control and automatic operation have been promoted with various advantages, which are discussed below. Along with the advancement of processing computers and peripheral measuring technology, blowing control for converters has shifted from a static control system to a dynamic or fully automatic operational control system. Indirect measurement of the exhausted gas method is employed in Europe and the United States, whereas direct measurement by the sublance method – direct measurement of the temperature of molten steel simultaneously during blowing – is employed in Japan. Sublance is used for bath leveling, slag leveling, measurement of oxygen concentration and slag sampling.

Energy/environment/cost/other benefits

- Increase productivity and product quality
- Decreased labor
- Improved working environment

29) OG-boiler system (non-combustion)/dry-type cyclone dust catcher

Description: Since steel refining is conducted in a short period of time, about 35 minutes per charge, the dust concentration is very high. In non-combustion-type converters with a gas recovery function, the dust concentration is 70-80g/m³N at the inlet of the first dedusting device. Non-combustion-type converters, without combusting CO gas, manage the volume of intake air from the throat, and control the concentration to below the explosion limit, thereby recovering CO as fuel. Exhaust gas treatment consists of an exhaust gas cooling system and a cleaning system. Non-combustion-type systems can be largely divided into the OG-type and the IC (IRSIDCAFL) type. The OG-type system basically has no space between the throat and the hood skirt, and controls pressure at the closed throat. The IC-type system has a gap of several hundred millimeters between the

throat and the hood skirt (which has a slightly larger diameter than that of the throat), and controls pressure at the throat opening. The non-combustion type system keeps gas temperature low and shuts out combustion air; therefore, the cooling device and dedusting device installed in the system are smaller than those installed in the combustion-type system. Since the system handles gas that mainly consists of CO, attention is paid to sealing for the flux and coolant input hole and the lance hole, and leak control at the periphery of devices, as well as purge at the gas retention part.

As the volume of converters increases, exhaust gas treatment equipment becomes larger.

Large converters adopt the non-combustion-type system for various reasons, such as the relatively small size of the system as a whole, ease of maintenance, and stable dedusting Efficiency. The OG-type system is frequently used because of its operational stability.

The OG-type cooling system makes it possible not only to recover the sensible heat of exhaust gas as steam, but also to increase the IDF efficiency by lowering the temperature of the exhaust gas by use of a cooling device.

Energy/environment/cost/other benefits

- OG-boiler system recovers 65% of the sensible heat of the total exhaust gas, about 70 kg/T
- Increases the IDF efficiency by lowering the temperature of the exhaust gas, achieving high-speed oxygen feeding

30) Casting - Castrip® technology

Description: The Castrip® process has been developed to allow the direct casting of thin strip from liquid steel, in gauges currently ranging from 0.8mm to 2.0 mm.

Energy/environment/cost/other benefits

- Potential energy savings of 80 to 90% over conventional slab casting and hot rolling methods
- More tolerant of high residual elements without loss of quality, enabling greater flexibility in ferrous feed sourcing
- Higher scrap recycling rates potential and less dependence on pig iron and HBI

31) Reducing fresh water use

Description: To reduce steel works dependence on fresh water, the following efforts have been made at Port Kembla Steelworks, Australia:

- Municipal waste-water reclamation – The treatment of sewerage water using microfiltration and reverse osmosis technology for re-use as industrial water, up to 20 ML/day
- Internal waste-water recycling schemes – Cooling tower blowdown water from the hot strip mill and slab casters does not go to the drain, but is treated and reused for dust collection in steelmaking
- Stormwater containment initiatives – 13ML synthetic lined water recovery basin in coke ovens area collects rainwater, coal stockpile run-off water, and spent water from coke quenching for re-use at gas processing and coke quenching

Energy/environment/cost/other benefits

- Using recycled sewerage water has reduced fresh dam water use on site by 20ML/day
- Hot strip mill and slab caster blowdown water saves steelmaking 0.5ML/day
- Recycling reduces fresh dam water use from 2.3kL/slab tonne to 1.0kL/slab tonne

32) Rotary hearth furnace dust recycling system

Description: Dust recycling in the rotary hearth furnace (RHF) was applied at Nippon Steel's Kimitsu Works in 2000. The dust and sludge, along with iron oxide and carbon, are agglomerated into shaped articles and the iron oxide is reduced at high temperatures. Zinc and other impurities in the dust and sludge are expelled and exhausted into off-gas.

Energy/environment/cost/other benefits

- DRI pellets made from the dust and sludge have 70% metallization and are strong enough to be recycled to the blast furnaces
- Waste reduction and decreased disposal costs
- Extended landfill life
- Recovery of unused resources (recycling iron, nickel, zinc, carbon, *etc.*)
- Increase in productivity: 1kg of DRI charged per tonne of BF smelt pig iron
- Decrease in fuel ratio to BF to 0.2kg/T-pig
- Decrease in coke ratio by charging DRI to BF

33) Activated carbon absorption

Description: Use of activated carbon to remove high pollutant concentrations has been proven successful in many cases. In coke making, activated carbon absorption system is used not only to eliminate the yellow brown color typical of coke wastewater (which may cause complaints from stakeholders) but also to reduce the COD of the secondary wastewater treatment plant.

Energy/environment/cost/other benefits

- Eliminate the yellow brown color of coke wastewater
- Significant reduction of COD of the secondary wastewater treatment plant to below 5 mg/l
- Heavy metals removal

34) Variable speed drives for flue gas control, pumps and fans

Description: Variable speed drives (VSDs) better match speed to load requirements for motor operations. VSD systems are offered by many suppliers and are available worldwide.

Energy/environment/cost/other benefits

- Based on experience in the UK:
 - Electricity savings of 42% are possible through the use of VSDs on pumps and fans
 - Payback of 3.4 years, assuming an electricity price of 3pence/kWh, under U.S. 1994 conditions
 - Costs of \$1.3/T product

35) Regenerative Burner

Description: A regenerative burner is a heat recovery system that recovers the waste heat of the furnace exhaust gas to heat-up the combustion air of the furnace. The regenerative burner uses heat reservoirs and dual heat-recovering generators at each burner to channel heat more efficiently. During combustion, one side of a burner combusts fuel while the other accumulates the exhaust heat into the heat-recovering generator. Then the burners switch so that the one accumulating heat combusts the fuel and the other now accumulates exhaust heat.

Energy/environment/cost/other benefits

- 20-50% of energy reduction possible, depending on types of furnace and condition of fuel
- Up to 50% NO_x reduction possible with high temperature combustion
- Excellent operational reliability, with introduction of regenerative burner systems in over 540 furnaces in various Japanese industries

36) Technology for Effective Use of Slag

- Description: Slag is a by-product of iron and steelmaking, not a waste. The fresh SMS slag absorbs moisture and expands. Thus its use for Road making and as rail ballast gets restricted unless it is matured. Slag which is already dumped outside and exposed to rain loses this characteristic and is useful if broken from large uneven lumps to required sizes by installing crushers at old dump sites. This is being practiced and SMS dump sites have started declining. However, the process needs to be made scientifically acceptable including the measures for control of leaching from the dumps.
- SMS slag is also partly used in blast furnaces as input/charging material.
- Fresh SMS slag, which is at 600-800°C can be directly pulverized in automatic pulverizers by spraying water on it. The water spray produces steam, which reacts with free calcium oxide and magnesium oxide. Consequently, the slag is pulverized due to the volume expansion, thus separating steel from slag, and steel falls through a chute. Pulverized slag is sucked through a slag separator by an exhaust fan and collected for use as road materials, construction and rail ballast.

Slag is also used for applications beyond steel making, *e.g.*, in water/bottom muck purification materials to reduce phosphate concentration in red tides and as marine block to help grow seaweed. Slag can be employed for various applications i.e.

- Converting slag as a purification catalyst can help restore ecosystems in water areas.
- In concrete and as a low-quality aggregate
- For land improvement
- In Japan, through an emerging technology, techniques for formation of carbonates of steel slag are under development. Carbonates of steel slag are formed when slag solidifies by absorbing CO₂ in a carbonation reactor. Then can be used as marine blocks, which help grow sea weeds. The process of carbonization of slag is shown in Figure.

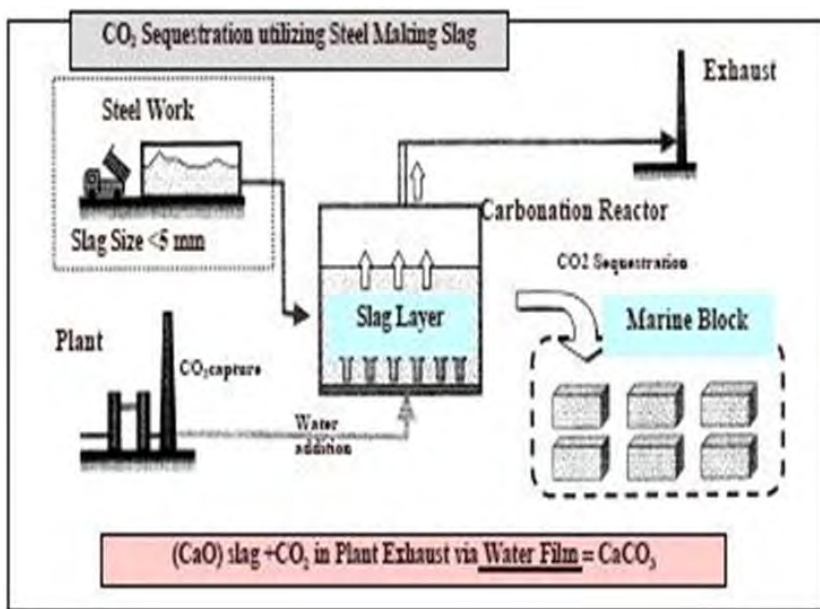


Figure 3-19: Carbonization of slag

Energy/environment/cost/other benefits

- Around 3.8 million t/year of scrap steel is recovered from slag produced
- Revenue generated is equivalent to 3.8 billion Yuan/year, based on 1,000 Yuan (\$130 2006 US)/T scrap steel
- Substitute for cement in building industry, thereby minimizing CO₂ emissions generated by cement production
- Land area occupied by piled slag minimized by slag reutilization
- Application of slag in Japan (marine block and water/bottom much purification materials)
 - Reduce phosphate concentration that causes red tide
 - Fix hydrogen sulphide (cause of blue tide)
 - Grow seaweed to restore lost shallows in seaweed beds
- Slag usage in marine applications is a new field with huge potential for shoreline improvement and restoration of lost shallows and seaweed beds
- Using BF slag in cement manufacturing helps to reduce energy use by eliminating granulation and heating [340 kg-CO₂/T slag]

Other applications include concrete aggregate, railroad ballast, agricultural use, sewage trickling filters, and construction.

37) Hydrogen production

Description: Coke oven gas (COG), a byproduct gas of the iron-making process, contains around 55% hydrogen. It is easy to produce hydrogen with high purity from COG by a very simple process called pressure swing adsorption (PSA). Significant efforts to recover sensible heat of COG as hydrogen enrichment are under way. Developing proper catalysts is the key to success.

Energy/environment/cost/other benefits:

- Hydrogen is expected to be an important energy carrier for fuel cells

- Because of its ease of production, its abundance, and its distribution, COG is one of the major candidates for a hydrogen source in the future

38) Carbonation of steel slag

Description: Carbonates of steel slag are formed when slag solidifies by absorbing CO₂. This sequesters the CO₂ in the slag, which can then be used in marine applications.

Energy/environment/cost/other benefits

- Steel slag carbonates can be used to make “marine blocks” which can improve the coastal environment by helping to grow seaweed [which improves sea surroundings]
- Marine blocks are also used for coral nursery beds, which may help to revive dead coral areas

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