Coal Mining and Production

Industry Description and Practices

Coal is one of the world's most plentiful energy resources, and its use is likely to quadruple by the year 2020. Coal occurs in a wide range of forms and qualities. There are two broad categories: (a) hard coal, which includes coking coal (used to produce steel) and other bituminous and anthracite coals used for steam and power generation; and (b) brown coal (sub-bituminous and lignite), which is used mostly as on-site fuel. Coal has a wide range of moisture (2-40%), sulfur (0.2-8%), and ash content (5-40%). These can affect the value of the coal as a fuel and cause environmental problems in its use.

The depth, thickness, and configuration of the coal seams determine the mode of extraction. Shallow, flat coal deposits are mined by surface processes, which are generally less costly (per ton of coal) than underground mines of similar capacity. Strip mining is one of the most economical surface processes. Here removal of overburden and coal extraction proceed in parallel strips along the face of the coal deposit, with the spoil being deposited behind the operation in the previously mined areas. In open pit mining, thick seams (tens of meters) are mined by traditional quarrying techniques. Underground mining is used for deep seams. Underground mining methods vary according to the site conditions, but all involve the removal of seams followed by more or less controlled subsidence of the overlying strata.

Raw coal may be sold as mined or may be processed in a beneficiation/washing plant to remove noncombustible materials (up to 45% reduction in ash content) and inorganic sulfur (up to 25% reduction). Coal beneficiation is based on wet physical processes such as gravity separation and flotation. Beneficiation produces two waste streams: fine materials that are discharged as a slurry to a tailings impoundment, and coarse material (typically greater than 0.5 millimeters (mm) that is hauled away as a solid waste.

Waste Characteristics

Key impacts of surface mining are typically massive disturbances of large areas of land and possible disruption of surface and groundwater patterns. In some surface mines, the generation of acid mine drainage (AMD) is a major problem. Other significant impacts include fugitive dust and disposal of overburden/waste rock.

In underground mines, the surface disturbance is less obvious, but the extent of possible subsidence can be very large. Methane generation and release can also be a problem under certain geological conditions. If groundwater systems are disturbed, the possibility of serious pollution from highly saline or highly acidic water exists. Impacts may continue long after mining ceases.

The following table presents the levels of liquid effluents, solid waste, and dust generated for the major mining techniques.

Beneficiation plants produce large volumes of tailings and solid wastes. Storage and handling of coal generates dust at rates which can be 3 kilograms (kg) per metric ton of coal mined, with the ambient dust concentration ranging from 10 to 300 micrograms per cubic meter ($\mu g/m^3$) (above the background level) at the mine site.

Loads Per Unit of Production*

Parameter	*Surface mining (t/1000t coal produced)*		*Underground mining (t/1000t coal produced)*	
Mining Techniques	*Contour*	*Area*	*Conventional*	*Longwall*
Liquid effluents	0.24	1.2	1	1.6
Solid waste	10	10	3	5
Dust	0.1	0.06	0.006	0.01

Source: Based on Edgar, 1983

* (Note: Local conditions will form the basis for choosing the appropriate mining method)

Pollution Prevention and Control

Early planning and careful design of operations are the key to minimizing pollution associated with mining activities. Specific responsibilities should be assigned for the implementation and monitoring of environmental measures. Before mining begins, a mining plan and a mine closure and restoration plan must be prepared and approved. These plans define the sequence and nature of extraction operations and detail the methods to be used in closure and restoration. These plans should be updated regularly (every three to five years) as mining progresses.

Development Plan

This plan defines the sequence and nature of extraction operations and details the methods to be used in closure and restoration. At a minimum, the plan must address the following:

- Removal and proper storage of topsoil.
- Early restoration of worked-out areas and of spoil heaps to minimize the extent of open areas.
- Diversion and management of surface and groundwater to minimize water pollution problems. Simple treatment to reduce the discharge of suspended solids may also be necessary. (Treatment of saline groundwater may be difficult.)
- Identification and management of areas with high potential for AMD generation.
- Minimize the of generation of AMD by reducing disturbed areas and isolating drainage streams by avoiding contacts with sulfur bearing materials.
- A water management plan for operations and post-closure including minimization of liquid wastes by methods such as recycling water from tailings wash plant.
- Minimization of spillage losses by proper design and operation of coal transportation and transfer facilities.
- Reduction of dust by early revegetation and by good maintenance of roads and work areas. Specific dust suppression measures may be required for coal handling and loading facilities such as minimizing drop distances, covering equipment, and wetting storage piles. Release of dust from crushing and other coal processing and beneficiation operations should be controlled.
- Controlling the release of chemicals (including floatation chemicals) used in beneficiation processes.
- Minimization of the effects of subsidence by careful extraction methods in relation to surface uses.
- Control of methane, a greenhouse gas, (to less than one percent by volume) to minimize the risk of explosion in closed mines. Recover methane where feasible. When methane content is above 25 percent by volume, it normally should be recovered.
- Development of suitable restoration and revegetation methods, appropriate to the specific site conditions.
- Proper storage and handling of fuel and chemicals used on-site to avoid spillages.

Mine Closure and Restoration Plan

The plan should include reclamation of open pits, waste piles, beneficiation tailings, sedimentation basins, and abandoned mine, mill, and camp sites. Mine reclamation plans should incorporate the following:

- Return of the land to conditions capable of supporting prior land use, equivalent uses, or other environmentally acceptable uses.
- Use of overburden for backfill and topsoil (or other plant growth medium) for reclamation.
- Contour slopes to minimize erosion and runoff.
- Plant native vegetation to prevent erosion and encourage self-sustaining development of a productive ecosystem on the reclaimed land.
- Management of post-closure AMD and beneficiation tailings.
- Budget and schedule for pre- and post-abandonment reclamation activities.

Upon mine closure, all shaft openings and mine adits should be sealed or secured.

There is a need to reserve money over the life of the mine to cover the costs associated with mine closure. The amount of money and the type of financing required will depend on a number of factors such as the projected life of the mine, the nature of the operations, the complexity of environmental issues, the financial and environmental management capacity of the borrower/project sponsor, and the jurisdiction in which the mine is located. The mine reclamation and closure plan, the timing of its submission, and its financing should be discussed and agreed with the borrower/sponsor as early as possible.

Target Pollution Loads

Implementation of cleaner production processes and pollution prevention measures can provide both economic and environmental benefits. The target loads presented in the Waste Characteristics Section should be used as a guide for pollution prevention purposes. The figures relate to each of the production processes before the addition of pollution control measures.

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Emission Guidelines

Emission levels for the design and operation of each project must be established through the Environmental Assessment (EA) process, based on country legislation and the *Pollution Prevention and Abatement Handbook* as applied to local conditions. The emission levels selected must be justified in the EA and acceptable to MIGA.

The following guidelines present emission levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance, including MIGA guarantees; any deviations from these levels must be described in the project documentation.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable.

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

Air Emissions

Controls may be required on individual sources such as ventilation exhausts if they have a significant effect on ambient particulate levels. If coal crushers or dryers are used, fabric filters or other systems should be used to recover coal and reduce particulate emissions to levels below 50 milligrams per normal cubic meter (mg/Nm^3).

Liquid Effluents

Settling ponds to catch stormwater and to reduce suspended solids should be provided for all effluent before discharge from the site.

Where treatment of AMD or other effluents is required, the following effluent levels should be achieved during operation and after mine closure.

Acid Mine Drainage and Liquid Effluents from Coal Mining

Parameter	*Maximum value milligrams per liter (mg/L) except for pH)*
pH	6 - 9
Total suspended solids*	50
Oil and grease	10
Iron	3.5
Total metals	10

* A level of 35 mg/L should be the monthly average.

Ambient Noise

Noise abatement measures should achieve either the following levels or a maximum increase in background levels of 3 dB(A). Measurements are to be taken at noise receptors located outside the project property boundary.

Ambient Noise

	Maximum Allowable L_{eq} (hourly), in dB(A)	
Receptor	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

The emission requirements given here can be consistently achieved by well-designed, well-

operated and well-maintained pollution control systems.

Monitoring and Reporting

Frequent sampling may be required during start-up and upset conditions. All wastewater discharges from the operations should be monitored weekly for pH, total suspended solids, and oil and grease. A full analysis covering iron and other trace metals should be carried out quarterly. Where salinity is a potential problem, appropriate parameters (chloride, total dissolved solids (TDS), conductivity) should be monitored.

Ambient air levels of particulate material, including PM_{10} (particles less than 10 microns in size), in and around mining operations should be measured quarterly. Methane levels should be monitored where appropriate, at least annually even after mine closure.

Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. These should be reported to the responsible authorities and relevant parties, as required, and provided to MIGA if requested.

Key Issues

The following box summarizes the key production and control practices that will lead to compliance with emission guidelines**.**

- Develop and implement a comprehensive environmental and mine management plan to include:

- Restoration and rehabilitation of disturbed areas.
- Minimize land subsidence.
- Identification and management of AMD sources.
- Water management for operations and post-closure conditions.
- Management and sealing of pyrite containing piles to reduce AMD formation.
- Develop and implement a post-closure plan to include:

- Restoration of disturbed areas.
- Long-term geotechnical and geochemical stability of waste piles.
- Restoration of acceptable long-term surface- and groundwater flow patterns.

Further Information

The following are suggested as sources of additional information (these sources are provided for guidance and are not intended to be comprehensive):

Edgar, T.F. 1983. *Coal Processing and Pollution Control*. Houston: Gulf Publishing.

Hartman, Howard L. (ed.) 1992. *SME Engineering Handbook*. 2nd ed., Vol.2. Littleton, Colorado: Society for Mining, Metallurgy, and Exploration.

World Bank, Environment Department. 1996. "Pollution Prevention and Abatement: Coal Mining." Technical Background Document.