

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 2020. Coal occurs in a wide range of forms and qualities; but 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 (subbituminous and lignite), which is used mostly as onsite fuel. Coal has a wide range of moisture content (2–40%), sulfur content (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 mined 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) that is hauled away as a solid waste.

Waste Characteristics

The main impacts of surface mining are, in general, 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 and waste rock.

In underground mines, the surface disturbance is less obvious, but the extent of 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.

Table 1 presents the levels of liquid effluents, solid waste, and dust generated by the major mining techniques.

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

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

Table 1. Loads Per Unit of Coal Production, by Mining Technique*(tons per 1,000 tons coal produced)*

Waste characteristic	Surface mining		Underground mining	
	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

Note: Local conditions will form the basis for choosing the appropriate mining method.

Source: Based on Edgar 1983.

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. The plans should be updated regularly (every 3 to 5 years) as mining progresses.

Development Plan

The development plan defines the sequence and nature of extraction operations and describes in detail 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.
- Minimization of AMD generation by reducing disturbed areas and isolating drainage streams from contact with sulfur-bearing materials.
- Preparation of a water management plan for operations and postclosure that includes minimization of liquid wastes by methods such as recycling water from the tailings wash plant.
- Minimization of spillage losses by proper design and operation of coal transport and transfer facilities.

- Reduction of dust by early revegetation and by good maintenance of roads and work areas. Specific dust suppression measures, such as minimizing drop distances, covering equipment, and wetting storage piles, may be required for coal handling and loading facilities. Release of dust from crushing and other coal processing and beneficiation operations should be controlled.
- Control of 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 1% by volume, to minimize the risk of explosion in closed mines; recovery of methane where feasible. (When methane content is above 25% by volume, it normally should be recovered.)
- Development of restoration and revegetation methods appropriate to the specific site conditions.
- Proper storage and handling of fuel and chemicals used on site, to avoid spills.

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 measures:

- 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 of topsoil (or other plant growth medium) for reclamation

- Contouring of slopes to minimize erosion and runoff
- Planting of native vegetation to prevent erosion and encourage self-sustaining development of a productive ecosystem on the reclaimed land
- Management of postclosure AMD and beneficiation tailings
- Budgeting and scheduling of 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 or 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 on with the borrower or 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 loads presented in Table 1 can 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.

Emissions Guidelines

Emissions levels for the design and operation of each project must be established through the environmental assessment (EA) process, on the basis of country legislation and the *Pollution Prevention and Abatement Handbook* as applied to local conditions. The emissions levels selected must be justified in the EA and acceptable to the World Bank Group.

The guidelines given below present emissions levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance. Any deviations

from these levels must be described in the World Bank Group project documentation. The emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems.

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/Nm³).

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 effluent levels presented in Table 2 should be achieved during operation and after mine closure.

Ambient Noise

Noise abatement measures should achieve either the levels given below or a maximum increase in

Table 2. Acid Mine Drainage and Liquid Effluents from Coal Mining

(milligrams per liter, except for pH)

<i>Parameter</i>	<i>Maximum value</i>
pH	6–9
TSS ^a	50
Oil and grease	10
Iron	3.5
Total metals	10

a. Monthly average, 35 milligrams per liter.

background levels of 3 decibels (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

Receptor	Maximum allowable log equivalent (hourly measurements), in dB(A)	
	Day	Night
	(07:00–22:00)	(22:00–07:00)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

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, and conductivity) should be monitored.

Ambient air levels of particulate material, including PM₁₀, in and around mining operations should be measured quarterly. Methane levels should be monitored, where appropriate, at least annually even after mine closure.

Key Issues

The key production and control practices that will

lead to compliance with emissions guidelines can be summarized as follows.

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

- Restoration and rehabilitation of disturbed areas
- Minimization of land subsidence
- Identification and management of AMD sources
- Water management for operations and postclosure 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 water and groundwater flow patterns.

References and Sources

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