

Multilateral Investment Guarantee Agency

Environmental Guidelines for

Base Metal and Iron Ore Mining

Industry Description and Practices

This document addresses the mining of base metal ores (copper, lead and zinc) and iron ores. The mining of precious metals, bauxite, and coal are covered in separate documents.

Major phases in mine development are:

(a) exploration; (b) mine development; (c) extraction (underground and open pit) and mine operation; (d) ore beneficiation; (e) storage and transport of ore; and (f) mine closure and reclamation. Fires may result from the oxidation of sulfide-bearing materials and these can present a significant hazard. This document focuses on the development, operation and closure phases. Further processing of these ores is covered in separate documents.

Waste Characteristics

The volume of solid waste generated (including tailings from processing) is one of the main concerns. Removal of overburden to access the ore can pose major problems in storage and reclamation. The overburden ratio for surface mining of metal ores generally ranges from 2:1 to 8:1 (waste:ore) depending on local conditions. Solid wastes from underground mining are typically 0.2:1. Where concentration or other processing of the ore occurs on-site, then the tailings generated also have to be managed. Ores with a low metal content, for example, of less than 0.4 percent, generate significant quantities of tailings.

In certain mines with ores with high sulfur content, drainage from mine workings and

waste heaps can become highly acidic and contain dissolved high concentrations of heavy metals. This Acid Mine Drainage (AMD) can have a pH of 3 or lower; sulfate levels of 800-1800 milligrams per liter (mg/L); copper levels up to 50 milligrams per liter (mg/L); iron levels up to 1000 milligrams per liter (mg/L); lead levels up to 12 milligrams per liter (mg/L); zinc levels up to 1700 mg/L, and cadmium levels of several milligrams per liter depending on the contents of the ore. The tailings pond effluent may also contain concentrations of chromium of several milligrams per liter. Base metal mining tailings decant may also contain high concentrations of thiosalts. Chemicals used in metal concentration (floatation and other) processes could also pose toxicity when released in effluents.

Surface runoffs may also pose significant environmental problems through erosion and carry-over of tailings and other mining residues. Explosives, such as ammonium nitrate, may also be present in surface runoff. Contamination of surface water can also occur from transport of mined material and from machinery maintenance and repair.

Significant levels of dust, above to 3 kilogram per ton (kg/t) (with a range of 0.003 to 27 kg/t) of ore mined, may be generated. This dust can be generated by extraction activities, crushing, ore beneficiation, transportation and traffic, and by wind borne losses. Significant releases of metal (including mercury) containing dust may result from the drying of the ore concentrate.

Pollution Prevention and Control

The critical factors in good environmental performance for mining are adequate planning, effective management and implementation. Specific responsibilities should be assigned for the implementation and monitoring of environmental measures. Before mining begins, a mining plan and a mine closure and reclamation plan must be prepared and approved. These plans should be updated regularly as mining progresses.

Development Plans

These plans define the sequence and nature of extraction operations and detail the method to be used in closure and restoration. At a minimum, the plans must address the following:

- Removal, proper storage and management of topsoil.
- Early restoration of worked-out areas and of spoil heaps to minimize the extent of open areas.
- Identification of potential areas for AMD generation and planning for successive remediation of pyrites to reduce AMD generation.
- A water management plan focusing on the effective use of mine water for operations (and recirculation of process water) and post-closure.
- Extraction methods in relation to subsidence and to surface use.
- Development of suitable restoration and vegetation methods, appropriate to the specific site conditions.
- Blasting methods which minimize noise and vibrations.

The Development Plan would normally have specific sections dealing with:

Erosion and Sediment Control

An erosion and sediment control plan should be prepared and should include measures or methods appropriate to the situation to intercept, divert, or otherwise reduce the stormwater runoff from exposed soil surfaces, tailings dams, and waste rock dumps. Both vegetative and non-vegetative soil stabilization measures should be an integral part of the

erosion control plan. Sediment control structures (for example, detention/retention basins) should be provided to intercept and treat surface runoff prior to discharge. All erosion control and sediment containment facilities must receive proper maintenance during the project life.

Tailings Disposal

Tailings must be managed to optimize human safety and environmental protection. On-land tailings impoundment systems must be designed and constructed in accordance with internationally recognized engineering practices, local seismic conditions, and precipitation conditions (to accommodate surface run-on). These should address the structural integrity of the tailings dams/deposits even during post-closure. On-land disposal systems should be designed to isolate acid leachate-generating material from oxidation and percolating water. Marine and riverine discharges are normally not acceptable and should be considered only when on-land disposal would pose an environmental risk and it can be demonstrated that such discharges will not have a significant adverse effect on downstream coastal or riverine resources. Riverine discharges are only acceptable when justified based on the environmental analysis of alternatives, and effects on aquatic resources and downstream users of riverine resources.

The design of the tailings management system must address post-closure issues such as: (a) long-term geotechnical stability of the impoundment; (b) chemical stability of the tailings; (c) long-term surface and groundwater management, including the provision for long-term spillway capacity requirements; and (d) restoration requirements.

Mine Closure and Restoration Plan

The plan should include reclamation of tailings deposits, waste rock deposits, any open pit areas, 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 acceptable uses.

- Elimination of significant adverse effects on adjacent water resources.
- Use of waste rock for backfill and topsoil (or other acceptable materials) for reclamation to the extent feasible.
- Contouring of slopes to minimize erosion and runoff.
- Planting of native and other species of vegetation which are environmentally acceptable to prevent erosion and to encourage self-sustaining development of a productive ecosystem on the reclaimed land.
- Post-closure and management of AMD and tailings. Reduce AMD formation by sealing of pyrite containing waste from oxidation and percolating water.
- 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.

Operating Measures

Other recommended pollution prevention measures include:

- Using progressive backfilling to minimize land disturbances.
- Use dust control equipment on dryers. Use pressure-air driers instead of fuel-based drum driers for the drying of concentrations.
- Provide covers or control devices for crushing and milling to avoid the generation of dust.
- Minimizing generation of AMD by reducing disturbed areas and isolating drainage systems.

- Diverting and managing leachates from waste heaps to avoid contact with, and contamination of, surface and groundwater.
 - Minimizing fresh water intake; recycling tailings decant water and wastewater from the concentration process to minimize contaminated discharges to the extent feasible.
 - Collect leachates from tailings pond and treat before discharge. Provide sufficient residence time in the tailings pond to ensure thiosalt oxidation. Provide buffer capacity for raining season.
- Divert surface runoff away from tailing ponds using ditches.
 - Using dust suppression measures such as: wetting of work areas, roads, and storage piles; installing equipment covers; minimizing drop distances by using adjustable height conveyors; and using dust hoods and shields.
 - Collecting and recycling waste oils and lubricants.
 - Minimizing chemical (including ammonium nitrate, if used in blasting operations) spills.
 - Providing appropriate storage areas for chemicals and fuels.
 - Avoid the use of toxic floatation agents.
 - Controlling noise through the use of berms and mufflers; controlling noise and vibrations by sequenced blasting.

Treatment Technologies

Filters for crushers, grinding mills, and driers are used to control dust emissions.

Treatment of AMD and wastewaters typically includes physical-chemical treatment techniques such as neutralization, precipitation, flocculation, coagulation, settling, and filtration. In some cases, cyanide oxidation and ion exchange may also have to be performed. Chrome reduction may be needed for floatation water.

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.

Liquid Effluents

The following effluent levels should be achieved during operation and after mine closure:

Effluents from Base Metal and Iron Ore Mining

<i>Parameter</i>	<i>Maximum value milligrams per liter (mg/L)</i>
PH	6-9
Total suspended solids	50
Oil and grease	10
Cyanide	
• Free	0.1
• Weak acid dissociable (WAD)	0.5
• Total	1.0
COD	150
Arsenic	0.1
Cadmium	0.1
Chromium (hexavalent)	0.1
Copper	0.5
Iron	3.5
Lead	0.2
Mercury	0.01
Nickel	0.5
Zinc	2
Total metals	10

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

Receptor	Maximum Allowable L _{eq} (hourly), in dB(A)	
	Daytime	Nighttime
	07:00 - 22:00	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

Liquid effluents (including tailings dam outflows) should be monitored daily for pH and suspended solids. Metals should be monitored on a monthly basis and when appropriate, for thiosalts and floatation chemicals. If treatment is required for soluble metals control, metals and other parameters such as turbidity should be monitored on a more frequent basis. Frequent sampling may be required during start-up and upset conditions.

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 emissions requirements.

- Develop a comprehensive environmental and mine management plan to include:
 - Restoration and rehabilitation of disturbed areas.
 - Identification and management of AMD sources.
 - Water management for operations and post-closure conditions.
 - Management and sealing of tailings.
- Develop and implement a post-closure plan to include:
 - Restoration of disturbed areas.
 - Long-term geotechnical and chemical stability of tailings.
 - Adequate spillway capacity for the tailings pond overflow.
 - Management of AMD, water drainage, and surface runoff.

Further Information

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

United Nations Environment Programme (UNEP). 1993. "Environmental Management of Nickel Production." Technical Report No. 15.

UNEP. 1991. "Environment Aspects of Selected Non-ferrous Metals (Cu, Ni, Pb, Zn, Au) Ore Mining." Technical Report Series No. 5.

Warhurst, Alyson. 1994. *Environmental Degradation from Mining and Mineral Processing in Developing Countries: Corporate Responses and National Policies*. Organisation for Economic Co-operation and Development, Paris.

World Bank, Environment Department. 1996. "Pollution Prevention and Abatement: Base Metal and Iron Ore Mining." Technical Background Document.