European Bank
for Reconstruction and Development

Sub-sectoral Environmental and Social Guidelines: Mineral Processing

PROCESS DESCRIPTION

Mineral processing is the process of extracting valuable minerals from their ores and is also known as beneficiation. (NB. smelting of metals is covered by the Iron & Steel Production for ferrous metals and Base Smelting & Refining for non-ferrous metals). A number of operations will be combined which exploit the difference in the physical properties of the minerals in the ore. Four general types of operation are carried out:

1. **Comminution** – particle size reduction by dry crushing of "run-of-mine" ore followed by grinding of dry or slurried material;

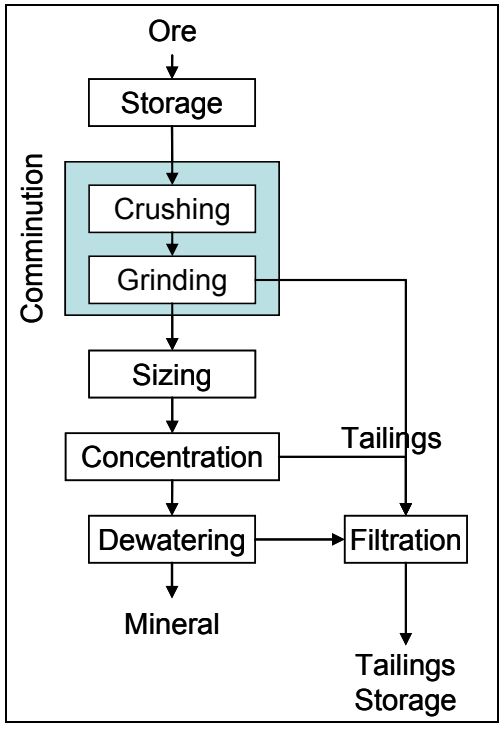
2. **Sizing** – the separation of particles by size, either by screening, or by classification. Classification exploits the differences in settling velocities due to size;

3. **Concentration** – based on physical and chemical properties, e.g. froth flotation, gravity concentration, electrostatic separation, magnetic separation;

4. **Dewatering** using a mixture of screens, thickeners and cyclones.

Gravity concentration methods include the use of heavy or dense media separation, jigging or washing the ore down inclined planes, spirals, or shaking tables so that mineral and waste fractions settle in different areas.

Beneficiation processes typically take place very close to the mine to reduce the cost of transportation.



Other techniques may be used for specific minerals, e.g. alumina, precious metals.

- Alumina - Bauxite ore is digested (dissolved) under pressure in high temperature sodium hydroxide to yield aluminium hydrate. The insoluble materials are separated and water is added to the aluminium hydrate to form a slurry and dried to produce alumina.

- Complex sulphides of precious metals typically occur at very low concentrations where only processes such as leaching are economically viable.

Leaching is performed either in leach tanks or in heaps on a leach pad lined with an impermeable membrane. Leaching uses

chemicals such as cyanide (for gold) or sulphuric acid (for copper) to dissolve the metal into an aqueous medium. This is followed by separation of the solution from any residues and recovery of the metal from the solution.

KEY ENVIRONMENTAL, HEALTH & SAFETY RISK/LIABILITY ISSUES

Dust

Dust will be emitted from roadways, stockpiles, waste areas, vehicles, conveyor belt drop-offs, crushers and classifiers. Emissions can be controlled by wetting, enclosing the process area, reducing drop heights and by the use of air filters.

Rock dust may cause lung disease in exposed workers. It may also be naturally radioactive.

Tailings

Tailings are the materials left over after the process of separating the valuable fraction from the worthless fraction of an ore (also known as gangue). Tailings can include heavy metals, mill reagents, sulphides, and be of extreme pH or radioactive. Environmental impacts include:

- Seepage of contaminated water/leachate from tailings to ground and surface waters;
- Sedimentation of drainage networks;
- Dust;
- Instability and failure of heaps and dams.

A tailings management strategy complying to best practice specifications e.g. ICOLD[1] or internationally recognised standards should be adopted.

Tailings are normally deposited in heaps or in ponds. All such structures should be planned, designed and operated to minimise the risk of landslides, rockfalls, face slumping or land collapse. These structures must be managed during the mine lifecycle to protect health, safety and the environment as the geotechnical properties will change as the material weathers. Additional levels of safety should be applied in active seismic areas and those exposed to extreme weather events. Systematic monitoring and review of geotechnical stability data is required.

The final heap design should be agreed with the authorities and the communities with the aim of creating landscape integrated structures. Delivery is carried out by a conveyor belt or trucks.

Bauxite processing to produce alumina produces a residue known as red mud. This is highly alkaline but can be processed to recover the caustic substance leaving a concentrated red mud cake, which is low in caustic allowing environmentally friendly disposal.

Leaching

Heap leaching systems have the potential to contaminate groundwater. Infiltration of leach solutions must be prevented with the use of appropriate liners and sub-surface drainage systems to collect and recycle

[1] International Commission on Large Dams

solution for treatment. Pipelines should be provided with secondary containment and leak detection equipment should be installed. Impoundments to hold dirty water or untreated process effluents must also be lined. Groundwater monitoring for contamination levels and quality must be carried out.

Gold processing operations must comply with the principles and standards of the voluntary International Cyanide Management Code.

Wastewater Management

Wastewater arising from processing may contain a range of contaminants depending on the beneficiation process used, e.g. heavy metals, sediment, reagents, hydraulic oils used in the mining operation. A permit is likely to be required to discharge wastewater to the environment, i.e. stormwater, leach pad drainage and process effluents. This discharge must be closely monitored and managed to meet the conditions of the permit.

Treatment options may range from settlement in open ponds to constructed treatment plants depending upon the contamination present. Clarified water from ponds or from wastewater treatment can be reused within the processing plant.

Permitting Requirements

- Within the EU, the screening criteria for determining whether an environmental impact assessment must be conducted before a mineral processing operation can be established are set nationally. However, these generally require an EIA for all developments except new small-scale ancillary buildings. Similar requirements will exist in non-EU countries. Because of the potential extent of environmental and social impact, and the requirement for consultation, the process of gaining planning permission in some circumstances may take several years.

- Under the EU Mining Waste Directive 2006/21/EC), no extractive industry waste facility may operate without a permit issued by the competent authorities. The directive specifies a number of requirements to ensure protection of the environment and human health, depending on the risks posed by the type of waste. Operators are required to provide a waste management plan for the minimisation, treatment, recovery and disposal for all extractive waste regulated by the directive.

- Mineral storage and processing operation in the EU are subject to national regulations under the Seveso II (1996/82/EC) as amended by (2003/105/EC) which aims to control the major accident hazard from these activities such as the failure of tailing impoundments and the storage and use of large quantities of hazardous chemicals. Operations outside the EU will still be subject to local regulation.

Land Use & Biodiversity

The land area required for the dumping of waste materials could destroy surface features of economic, cultural and nature conservation value. Consultation with key

stakeholders will be required to understand any conflicting land use requirements, the communities' dependency on natural resources and any conservation requirements.

Habitat alteration should be minimised to the extent feasible and critical habitats must be protected and preserved. The implementation of a Biodiversity Action Plan and biodiversity offset projects may be required by the regulatory authorities.

Gaseous Emissions

The main sources of gaseous emissions are from the combustion of fuel to generate power and from drying operations.

Inorganic hazardous air pollutants (e.g. arsenic, beryllium, cadmium chromium, copper, mercury, manganese, nickel, lead, thorium and uranium) may be present in trace quantities in the ore and be released during processing operations. Emissions should be controlled with wet scrubbers or bag filters.

Hydrogen cyanide may be released to air during the gold leaching process.

Energy Consumption

The most significant energy consuming activities are transport, conveying, grinding, crushing, milling, and drying. Energy usage has a direct correlation to the operating costs of the company and energy generation and consumption may be regulated or taxes/levies applied to reduce energy use and associated emissions of gases such as carbon dioxide.

OTHER ENVIRONMENTAL, HEALTH & SAFETY RISK/LIABILITY ISSUES

Collision

This often takes the form of people being hit by vehicles or moving, flying or falling objects.

Manual Handling

Many injuries are associated with handling, lifting and carrying heavy or unconventional shaped objects.

Trips and Falls

Slips, trips and falls are regular occurrences in industry and result in many injuries. Typically, these are because of uneven ground and poor housekeeping.

Electrical Hazards

High voltage electrical supplies may be required to operate machinery such as crushers, conveyors and screening equipment.

Polychlorinated Biphenyls (PCBs) and Asbestos

- PCBs are a group of substances which are good electrical insulators. Typically, PCBs may be present as constituents of hydraulic oils or dielectric fluids in electrical switchgear, transformers and fluorescent light starters. PCBs are extremely toxic and become concentrated within the food chain. Any products that may contain PCBs must be

disposed of by licensed contractors in accordance with national regulations.

- Asbestos was used on a large scale for many years as a fire proofing and insulation materials and may be encountered in a wide range of forms within the fabric of older mine buildings. Asbestos fibres, which are extremely hazardous when inhaled (causing mesothelioma and fibrous thickening in the lungs), may be released when the asbestos containing material is disturbed during maintenance or demolition.

Particular attention should be given to buildings constructed before the 1980s.

Noise

Noise and vibration will be generated by loading and unloading of rock, crushing and conveying operations, and vehicle movements and may reach levels that are hazardous to health.

KEY SOCIAL, LABOUR & COMMUNITY RISK/LIABILITY ISSUES

Tailing Dams

Wet containment facilities, e.g. tailing impoundments and dams are a potential risk depending on their location with respect to human settlements and other community resources.

Water Abstraction

Large quantities of water can be used in processing plants and for dust suppression. Consultation with key stakeholders including the local community is necessary to understand potentially conflicting demands and/or conservation requirements. Lowering of the water table may affect supplies of water to farmers and sensitive environments such as rivers and wetlands and industrial abstractors of groundwater.

Visual Impact

The tailings and waste rock heaps will be a negative visual impact. A profile should be agreed with the competent authorities and landscaped on completion. Screening with vegetation or earth bunds may minimise the visual impact during operation. Progressive restoration/revegetation should be incorporated into the operation phase.

Consultation with the local community should be conducted regarding post-closure land use.

OTHER SOCIAL, LABOUR & COMMUNITY RISK/LIABILITY ISSUES

Dust Nuisance

Fugitive dust emissions can be a nuisance to neighbouring properties and communities. A combination of containment and suppression techniques and appropriate location of processes can mitigate this problem.

Noise Nuisance

Noise may reach or exceed nuisance levels, particularly on sites where activities involve physical processing (e.g. screening crushing, sorting). Careful location of operations and

shielding by embankments can minimise the impacts.

Transport

Disturbance from traffic may arise due to the transfer of minerals between extraction and processing sites or from the processing site to the nearest port, inland waterway or railway station.

FINANCIAL IMPLICATIONS

- Major increases in operation and investment costs could be necessary where outdated facilities at the site need to be replaced to satisfy a more stringent regulatory environment. Poor environmental performance may accelerate the demands for more stringent regulatory control.
- Provisions may have to be made for site decommissioning and rehabilitation costs including areas possibly affected by past activities. For this reason, it is necessary to understand the company's portfolio of closed as well as active processing sites.
- Failure of the spoil heaps or tailings dam has the potential to cause loss of life with associated financial liabilities.
- Exposure of employees to occupational hazards may result in health compensation claims.
- Fees and fines will be applied by regulatory authorities for discharges to air and waters above statutory levels.

IMPROVEMENTS

Environmental, Health and Safety Improvements

- Conduct environment, health and safety training for all employees and contractors;
- Good housekeeping should be maintained at all times in all areas to prevent accidents and incidents and reduce waste and visual impact;
- Implement **dust control** measures e.g.
  - Wetting with water or suppressants;
  - Wind management with fencing, bunding etc;
  - Appropriate location away from residential areas or other sensitive receptors;
  - Containment of process equipment and storage areas, e.g. dust covers;
  - Reduce drop heights;
  - Abatement technology, e.g. bag filters;
  - Wheel/vehicle washing;
  - Control vehicle speeds.
- **Water Management:** Minimise the consumption of water in the process and equipment cleaning;
- Use dry cleaning methods wherever practicable for solids, e.g. vacuum

extraction, wipe down equipment that is accessible rather than washing and rinsing it;

- Where possible recycle wastewater back into the processes or to secondary uses such as for cleaning;
- Segregate process wastewaters and rainwater to reduce the hydraulic loading to wastewater treatment plants or sewers;
- Ensure clean and dirty waters are segregated. Dirty water will require treatment prior to discharge depending on the nature of the contaminants;
- Maintain on site abatement equipment and wastewater treatment plant;
- Reduce sediment loading of drainage ditches by:
    - Reducing exposure of soil and rock to wind or water, e.g. by re-vegetating exposed surfaces;
    - Use settling ponds and silt fences to prevent sediment transport;
    - Establish streamside vegetation;
    - Use design and construction techniques to minimise water runoff, e.g. countering, terracing, slope reduction, drainage installation;
- Control acid leachate production and run-off by preparing and implementing ore and waste management programs for monitoring and preventive actions;
- **Geotechnical Stability:** Implement systematic monitoring and regular review of geotechnical stability data on all structures;
- **Storage of materials and pollution control:** Bulk containment (e.g. oil storage tanks) must be:
    - inspected regularly to prevent leakage;
    - provided with secondary spill containment;
    - installed with automatic alarms and shut off systems.
- **Emergency Preparedness:** Introduce accident, fire and explosion precautions and emergency response procedures.
- Emergency storage lagoons may be needed to prevent contaminated firewater reaching surface water or ground waters;
- Reduce **noise and dust** emissions by
    - Use of stockpiles and pit walls as sound barriers/screening bunds to protect sensitive areas;
    - Use of conveyors in place of dump trucks;
    - Enclose noisy machines to isolate people from the noise where practicable;
    - Locate potential noise and dust sources away from sensitive receptors.

- Reduce exposure times for people working near noisy machinery and provide personal protective equipment where people have to enter noisy areas;

- **Industrial Safety:** Provision of personal protective equipment (PPE) that is fit for the task to prevent injury and maintain hygiene standards. Staff should be trained in the correct selection, use and maintenance of PPE;

- Redesign manual processes to avoid heavy lifting/repetitive activities;

- Install mechanical lifting aids where possible and rotate work tasks to reduce repetitive activities;

- Separate people from vehicles and machinery were practicable;

    - Ensure that the process layout reduces opportunities for process activities to cross paths;

    - Installation of safeguards on moving parts of conveyor belts to reduce risk of entrapment of employees;

    - Ensure appropriate signage is in place to separate people from moving vehicles;

    - Install walkways to separate people from vehicle movements to reduce risk of collision.

- Construct walkways of non-slip materials;

- **Fire & Explosion:** Control the effect of fires and explosions by segregating process, storage, utility and safe areas;

- Avoid potential sources of ignition including banning smoking in and around facilities;

- Use explosion-proof equipment and conductive materials and ensure that equipment is grounded and bonded;

Social Community and Labour Improvements

- Implement a programme of assessment of routine monitoring of worker health;

- Develop (or review) a Reclamation and Closure Plan which includes post closure monitoring. Ensure that a sustainable source of funding is allocated that is sufficient to implement the plan. This may be mandatory in some countries;

- Implement a grievance/dispute resolution mechanism for workers and members of the community to raise issues with the Company;

- Undertake prompt rehabilitation of disturbed areas that are most visible and screen processing plant and haulage routes to reduce the visual impact and improve relations with the local community.

GUIDE TO INITIAL DUE DILIGENCE SITE VISITS

During the initial site visit, the issues will vary according to the type of process being used and depending on the level of

environment, health, safety and social management already introduced. While visiting the site it is important to discuss and review the following:

- Confirm organisational responsibilities and systems for environment, health, safety and social issues;
- Confirm what process and chemicals are used?
- Note signs of poor housekeeping, inadequate/untidy storage areas and poor drum labelling;
- Note the noise levels at the site. Is there any evidence of noise/dust abatement measures being used?

Dust Management

- Are there any dust control measures? Do these work and are these used? Is there any build-up of dust on machinery or other surfaces?
- Is ore moved around the site by conveyor or by vehicle?

Water Abstraction & Management

- What amounts and quality of water are required? Where is the water obtained from? Is the water recycled?
- Is there a permit for abstraction?

Liquid Waste Management

- What liquid effluents are produced? What discharge control measures are employed?
- Is effluent and wastewater treated before discharge? If so, check the condition of the treatment plant and location of discharge points for effluent and wastewater from the facility;
- What does the quality of these discharges look like? Note the colour and appearance of adjacent watercourses;
- Note whether the wastewater treatment plant discharges to ground, a local watercourse or the municipal wastewater treatment works. Higher environmental risks will be associated with facilities discharging to water courses without adequate treatment;
- Is the water quality tested? What are the waters tested for? Where are the samples taken from, how often? Do the discharges have to meet set standards?
- Efficiency of wastewater treatment (facility/municipal) is critical - check type, effectiveness, monitoring, final effluent and sludge disposal. Confirm regulatory compliance with discharge consents, enforcement and costs;
- Is the industrial sewer system able to capture all process wastewater?
- Are there any other discharges of wastewater from the site?
- Check drainage systems, note particularly if any are blocked by fines, sludge or other waste.

Tailings & Waste Rock Management

- Is any waste rock sold as a product to other industries?
- Are dumps constructed in terraces or with very steep slopes? Do they appear to be heavily eroded or slumping?
- Is rock dumped near surface water bodies or areas of cultural or environmental value?
- Are dumps surrounded by surface drains to collect run-off for treatment?
- Are dump and tailings storage facilities regularly monitored for physical integrity and water quality?
- Is any reclamation work in progress?
- Does the emergency preparedness plan include responses for catastrophic release of tailings or supernatant (overlying clarified) waters?

Solid Waste Management

- Note the nature of solid waste disposal;
- Check that solid waste storage equipment is in good condition;
- Check that waste storage areas are clear of debris and that skips are covered to prevent waste escaping, for example, check that waste containers have lids or are stored in an area with a roof;
- Check for damaged flora/vegetation zones near storage sites.

Transport of Prepared Mineral off the Site

- Is this by rail, road or water or a combination of these?
- Where are the areas for loading/unloading of material located? Are they located near any water bodies or other possibly sensitive features? Is there any containment to prevent run-off of contaminated water?
- Does road haulage cause excessive traffic through any neighbouring residential areas?

Storage

- Check the condition of storage facilities for raw ore, prepared mineral and fuel?
- Are there any underground fuel storage tanks?
- Evaluate the potential for spillages and leakages to enter soil or stormwater drainage system. Are surface tanks and usage areas hard surfaced and contained? Are these in good condition? Is the volume of the contained area adequate to contain the stored materials? Are they regularly cleaned and inspected?

Health & Safety

- Are staff wearing Personal Protective Equipment?
- Check signage around the site:
    - Does it convey the health and safety risks?

  - Are fire exits and/or evacuation routes clearly marked?
  - Are there demarcated routes for pedestrians and vehicles?

- Is fire fighting and first aid equipment available? Is there a trained and competent fire fighting resource on site?
- Check the age and condition of equipment, look for signs of wear and tear, degradation, leaks and breaks;
- Check for automatic safeguards on machinery to prevent accidental injury;
- Is there a worker health monitoring programme? What does it check for?

Incident Management

- Have there been any recent incidents on site such as fatalities, fires/explosions, spills?
- Assess emergency response to fires and major spills;
- Does the organisation have insurance to cover any significant damage to the environment/community/operations (this may be covered by public liability insurance or the organisation may be part of an industry insurance scheme). Review the terms of the cover.

Inspections & Regulation

- Check the conditions and duration of validity for all permits;
- Have the premises been inspected recently by the regulatory authorities for health, hygiene and environment? What were their findings?
- Has the organisation been subject to environment, health and safety or quality audits by customers/insurers? What was the outcome of these audits?
- Review historical and projected trends for environmental fees and fines. It is also suggested that contact is made with local regulatory agencies to determine compliance and whether complaints have been made by the public.

Investment

- Does the business plan have line items for environment, health and safety improvements as well as asset management and maintenance?
- If investment or refinancing will lead to restructuring of the organisation what will be the potential impacts on health and safety at the operation and wider community? Have these been considered and assessed by the company?
- If the company plans to invest in new technology, what will be the impacts and benefits for human resources?

Social, Labour and Community

- Check that labour standards, contracting and remuneration are in line with national law and are consistent with the average for the sector;

- Check that hours worked, including overtime, are recorded and staff should receive written details of hours worked and payment received;
- Check that wages and working hours are consistent with the average for the sector and national standards;
- Has the Company received inspections from the local labour inspectorate in the previous three years? Have these resulted in any penalties, fines, major recommendations or corrective action plans?
- Does the organisation have a grievance mechanism which allows employees to raise workplace concerns?
- Are employees free to form, or join, a worker's organisation of their choosing?

ACTION PLANS

Dependent on the individual business, select appropriate improvements from the list above to include in the action plan. As a minimum, any business should be required to have the following in place:

- Operational procedures to manage environmental, health, safety and social risks;
- Monitoring programmes;
- Improvement objectives, targets and project plans;
- Training for personnel;
- Regular inspections, checks and audits with records to demonstrate achievement of the required level of performance against legal requirements and improvement action;
- Emergency plans for environment, health and safety accidents. The plan should be prepared in accordance with the guidance of United Nations Environment Programme (UNEP) APELL[2] for Mining;
- Management review/demonstrated involvement in environment, health, safety and hygiene management;
- Waste management plan (waste minimisation, re-use, recycling, monitoring);
- Closure and Remediation Plan;
- Stakeholder Engagement Plan.

[2] Awareness and Preparedness for Emergencies at the Local Level

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