

11. MINE CLOSURE PLANNING IN METALLIFEROUS MINES

11.1 PREAMBLE

Mining is one of the industrial enterprises that are known to have in advance a finite life. It is, therefore, necessary to plan and design new mines with their closure in mind and in case of existing mines to revise their operational procedures to allow the Reclamation & Rehabilitation (R & R) measures, easier to achieve, that is, "to design for a closure". It is expected that all areas disturbed by the operations will be rehabilitated for proper use.

India being a developing country, the problems faced with respect to mine closure operations are not purely of economic concern but rather the use and familiarity with proper techniques, management policies and practices to reduce the environmental impact, for a sustainable development. Though the percentage of land affected by mining in India is relatively small, but their concentrations as well as location in some environmentally fragile areas make the situation grim and requires large-scale Reclamation & Rehabilitation (R&R) measures. The problems on land degradation are mainly due to quarrying, waste dumping and development of infrastructures with respect to their effect on forest growth, agriculture and water resources.

It is now realised that exploitation of the mineral deposit in Eco-friendly manner is possible with suitable R & R measures. Reclamation is the process by which pre-mining land use can be re-established under similar conditions, whereas the rehabilitation is the process used to mitigate impacts of mining on the environment.

11.2 REQUISITES AS PER MM (D&R) ACT

The Central Government vide Notification No. GSR 329 (E) dated 10.04.2003 and No. GSR 330 (E) dated 10.04.2003 amended the Mineral Concession Rules, 1960 and Mineral Conservation and Development Rules, 1988, respectively. As per these amendments all the existing mining lessees are required to submit the "Progressive Mine Closure Plan" along with prescribed financial sureties within 180 days from the date of notification. Further, the mining lessee is required to submit "Final Mine Closure Plan" one year prior to the proposed closure of the mine. In the notification, it has been enumerated that the "Progressive Closure Plan" and the "Final Closure Plan" should be in the format and as per the guidelines issued by the Indian Bureau of Mines.

Mine closure operation is a continuous series of activities starting from day one of the initiation of mining project. Therefore, progressive mine closure plan will be an additional chapter in the present mining plan and will be reviewed every five years in the Scheme of Mining. As progressive mine closure is a continuous series of activities, it is obvious that the proposals of scientific mining have included most of the activities to be included in the progressive mine closure plan.

Final mine closure plan as per statute, shall be considered to have its approval at least nine months before the date of proposed closure of mine. This period of nine months is reckoned as preparatory period for final mine closure operations. Therefore, all proposals for activities which have to be carried out after production of mineral from the mine or milling has ceased, shall be included in the final mine closure plan. The final mine closure plan will thus be a separate document.

4. Baseline data
5. Analysis of alternatives
6. Environmental impacts
7. Mitigation plan
8. Monitoring plan
9. Appendices

There are a number of consultants both in public and private sectors who undertake generation of environmental baseline data. Necessary information about the preparation of EIA and EMP have been furnished in Annexure-14. The Indian Bureau of Mines also undertake such assignments on payment of charges and for which enquiries may be addressed to the Controller General, Indian Bureau of Mines, Indira Bhawan, Civil Lines, Nagpur – 440 001.

10.8 ENVIRONMENTAL CONDITIONS THAT ARE OBSERVED TO BE NOT COMMONLY COMPLIED WITH

- Simultaneous reclamation of pits and quarries is not undertaken by most of the mines. Para 4.42 of National Forest Policy is reproduced below – Beneficiary mine owners should undertake reclamation of mines in accordance with established forestry practices as directed above.
- Proper demarcation of safety zone and its regeneration.
- Installation of effluent treatment plants.
- Opening of fuel wood depot in project areas.
- Planting of dwarf tree under transmission lines.
- Canal side planting.
- Mutation of compensatory afforestation land in favour of Forest Department.
- Roadside plantation.

The underground mining helps in reducing surface land degradation to certain extent and air pollution, it leads to subsidence, which is equally harmful to the flora and fauna. The water from these mines is pumped out constantly to avoid any accident and flooding in the underground mine. Discharge of mine water into streams leads to contamination of surface water. This must be rectified immediately.

In opencast mining, the ambient air quality is poor with high values of suspended particulate matter due to the plying of heavy trucks, dumpers and dozers. In addition, the blasting in the area, though controlled, leads to clouds of dust in the vicinity. Water sprinklers are essential in these areas to minimise dust pollution. Such facilities, however, are provided at a few areas. The major problem observed in opencast mines is an improper management of overburden dumps. One of the conditions of the clearance letter specifies maintenance of overburden dump below 28° slope. But due to non-availability of space at the sites or due to other reasons, the OB dumps go beyond 40° slope in certain mines. During heavy rains leaching from these dumps are polluting watercourses in the vicinity as the dumps have not been provided with garland drains. The topsoil removed is not properly managed or spread on top of the overburden dumps to raise plantations as prescribed in the environmental clearance. This must be strictly adhered to and rectified immediately.

The abandoned old underground mines in the fragile hilly region, especially in the eastern region, are causing great environmental concern, as there is a scope that these may collapse at any time due to subsidence or other natural disasters such as an earthquake.

11.3 OBJECTIVES FOR THE MINE CLOSURE

While formulating the closure objectives for the site, it is important to consider the existing or the pre-mining land use of the site and how the operation will effect this activity. Some operations such as mining in agricultural areas have clearly defined this objective of returning the land to viable agricultural purposes. In forested areas the aim may be to re-establish a self-supporting forest community. The primary aim is to ensure that the following broad objectives along with the abandonment of the mine can be successfully achieved:

- To create a productive and sustainable after-use for the site, acceptable to mine owners, regulatory agencies and the public.
- To protect public health and safety of the surrounding habited.
- To minimise environmental damage.
- To conserve valuable attributes & aesthetics.
- To overcome adverse socio-economic impacts.

The priorities for the regulatory agencies are that the future environmental conditions should not be compromised and that no financial liability falls upon them in the event of inadequate rehabilitation. They, therefore, require evidence that all important environmental, safety and health issues have been realistically addressed in these plans/programmes, which have to be successfully implemented and that adequate financial provisions have been made for this to be completed to an acceptable environmental standard.

Mine owners and operators also wish to eliminate future financial liabilities and long-term environmental management as far as possible. However, their immediate priority is to ensure that the quality of the rehabilitation undertaken is adequate to enable regulatory agencies to release them from any further obligations and to allow legal surveillance of their continuing interests in the mine site. Furthermore, an acceptable proposal for R & R of the mining area is now an important consideration for all international mining companies in their search for project finance.

11.4 MINE CLOSURE CRITERIA

The criteria involve determination of the required actions to meet the objectives and the monitoring required in terms of physical, chemical & biological stability of various environmental parameter to show that the abandonment has been successfully implemented.

Physical Stability:

All anthropogenic structures, which include mine workings, waste dumps, buildings, etc., remaining after mine abandonment should be physically stable. They should present no hazard to public health and safety as a result of failure or physical deterioration and they should continue to perform the functions for which they were designed. The design periods and factors of safety proposed should take full account of extreme events such as floods, hurricane, winds or earthquakes, etc. and other natural perpetual forces like erosion, etc.

Chemical Stability:

The resources within the mine site should be chemically stable. This means that the consequences of chemical changes or conditions leading to leaching of metals, salts or organic compounds should not endanger public health and safety nor result in the deterioration of environmental resources. If the pollutant discharge likely to cause adverse impacts are predicted in advance, appropriate mitigation measures like settling of suspended solids or passive treatment to improve water quality as well as quantity, etc. should be

planned. Monitoring should demonstrate that there are no adverse effects of pollutant concentrations exceeding the statutory limits on the water, soil and air qualities in the area around the closed mine.

Biological Stability:

The stability of the surrounding environment is primarily dependent upon the physical and chemical characteristics of the site, whereas the biological stability of the mine site itself is closely related to rehabilitation and final land use. Nevertheless, biological stability can significantly influence physical or chemical stability by stabilising soil cover, prevention of erosion/wash off, leaching, etc.

Establishment of a vegetation cover over the disturbed site is usually one of the main objectives of the rehabilitation programme, as vegetation cover is the best long-term method of stabilising the site. When the major earthwork components of the rehabilitation programme have been completed, the process of establishing a stable vegetation community begins. If top soiling of the areas and adequate erosion control with drainage net-work has been achieved, then this phase may simply require undertaking a seeding and fertilising programme and monitoring the performance of re-vegetation.

For re-vegetation, management of soil nutrient levels is an important consideration. Additions of nutrients are useful in three situations.

- Where the nutrient level of spread topsoil is lower than material *insitu* e.g. for development of social forestry.
- Where it is intended to grow plants with a higher nutrient requirement than those occurring naturally e.g. planning for agriculture.
- Where it is desirable to get a quick growth response from the native flora during those times when moisture is not limiting factor e.g. development of green barriers.

One or more of the above situations often apply and good responses have been achieved on natural soils with the use of fertilisers containing phosphorus. Fertiliser applications are cheap and a single application at the time of closure will suffice in all areas except those prone to artificially high soil leaching like tailing material.

11.5 ENVIRONMENTAL MONITORING REQUIRED FOR MEETING THE ABANDONMENT OBJECTIVES

An important part of abandonment is the monitoring required to demonstrate that the remedial and restoration work has been successful. The monitoring programme is designed to meet abandonment objectives and performance criteria, but integrated with operational monitoring (e.g. by using similar sampling locations, protocols and analytical procedures), so that results are comparable with the earlier data. Some sampling locations will probably be outside the boundaries of the mine site, so as to ensure that the surrounding environmental conditions are satisfactory. This monitoring may include three components as given below.

1. Mining Components

Where appropriate, strategies to address various aspects of the mine components furnished below should include in the mine closure plan. Each component should be considered in terms of their objectives and criteria as well as the likely effects on the natural resources. The effects of Reclamation operations themselves over the surrounding

environment should not be ignored. These involve activities such as earth moving, demolition of building, treatment plants etc. Under these activities, the potential effects of noise, dust and contaminated run-off should also be taken into account.

- **Underground Mine** : Seals to underground openings are to be secured so as to reach acceptable water quality levels in the aquifers adjacent to the backfill and in the quality of mine water discharge.
- **Open Pit**: There should be no deformation or erosion of slopes and benches. It should be ensured that the water management system and security arrangements in the mine function effectively.
- **Process Plant** : Re-profiling of the surface area to be done and it should also ensure that the re-vegetation is successful.
- **Waste Rock/ Overburden Dumps** : There should be no deformation or erosion of slopes. Acceptable drainage system should be established. It should be ensured that the surface water quality and quantity and the adjacent groundwater quality are acceptable and the re-vegetation is successful.
- **Tailings Management Facilities** : Provided the tailing geochemistry is analysed scientifically to an acceptable level (e.g. Leachet generation, Physical, Chemical & Biological deformations) and the dam has been adequately designed and correctly operated, de-commissioning should not present any major problems. As and when each lift is established, simultaneous rehabilitation of its outer slopes should be done. There should be no deformation or erosion of dam structure and the drainage system and surface water management system should remain effective. The surface and ground water qualities to be of acceptable level and it should be ensured that security arrangements are functioning properly. With this progressive reclamation, the work that remains to be done at the time of final closure, will be only the top surface treatment. In majority of cases, the physical nature or chemical composition of the tailings are such that some form of inert capping will be required on the top. Where topsoil is available, it can then be spread over this inert capping. If required heap-leaching operations need to be treated and measure must be taken to cover these facilities so as to establish a stable rehabilitated surface.
- **Landfill/Waste Disposal Facilities** : Strict procedures to be laid down to prevent deterioration in groundwater quality by percolation of pollutants from these disposal areas. The inert/soil cover spread over these areas should be properly secured and it should be ensured that the vegetation grown above their surfaces is successful.
- **Buildings & Equipment**: As far as possible, reuse of the abandoned buildings should be aimed after removing the equipment remained therein. Otherwise demolition, re-profiling and re-vegetation of the area should be made successful.
- **Infrastructure**: It should be ensured that re-profiling and re-vegetation of the area are effective and successful.
- **Exploration Areas**: The drill pads should be reinstated and secured over the top of bore-holes and access roads to these areas to be retained.

2. Natural Resources

The natural resources in the area around the mine are described in the environmental impact assessment (EIA) so as to characterise the specific natural resources likely to be affected. It is against this 'baseline study' that the success of mine closure measures will be judged. However, it is unrealistic to expect that the area around the mine site can be restored to the exact pre-mining condition. Mining activities always have some residual impacts that cannot be avoided, such as changes to landform from open pits or tailings impoundment or the waste dumps. Susceptible natural resources reflect local conditions, but should normally include the following possible impacts from different resources.

- *Surface Waters* : Effects of run-off on quality and quantity.
- *Ground Water* : Effects of seepage on aquifer quality & recharge.
- *Wildlife Habitats* : Effects on aquatic and adjacent terrestrial habitats and migration routes.
- *Flora & Fauna* : Specific effects on individual species, deterioration in feeding and breeding areas, growth rates, availability of water, changes in climatic conditions.
- *Land Use*: Changes in soil cover and land use for agriculture or forestry.

3. Socio-Economic Factors

When mining ceases, a serious economic decline in the area is inevitable unless alternative employment is available for the redundant mine workers. If the mine has been the major source of employment, the consequences of abandonment can be severe. It is not only those directly employed by the mine (i.e. workers and contractors) that suffer but many support services may no longer be viable.

The primary responsibility for managing the transition to other forms of employment should lie with the appropriate government agencies. It is unreasonable for the mining company to retain a commercial interest once mining has ceased. However, since closure can be planned in advance, co-operation between the mining company and government agencies can help attract alternative industry. Mine workers are highly trained and often have transferable skills. The mine site possesses facilities and infrastructure (e.g. power, water supply, and buildings) that may be valuable to other industries. Mines in remote areas are frequently centres for community facilities, especially medical and local transport facilities and also play a role in assisting emergency services (e.g. fire fighting, transport to specialist medical centres). Mining companies are usually willing to leave infrastructure behind, as this often makes abandonment easier to implement. Proposals for alternative industrial activities do not form part of the abandonment plan, although opportunities for re-use of the site or its facilities might be identified. Otherwise, it will be difficult to re-introduce these facilities in these areas and the Government investment made for this purpose will be wasteful.

11.6 PLANNING FOR MINE CLOSURE

Integrating mine closure aspects under the regular mine developmental planning has significant benefits. It minimises adverse environmental effects after the abandonment and avoids the need for a long-term environmental management of a closed mine site. The best means of mitigation of these environmental impacts is to address them well in advance and to incorporate them in the abandonment programme. Therefore, whenever feasible, progressive reclamation should be encouraged which provides the following advantages :

- Closure measures are integrated into daily operations, thus making them easier to tackle.
- Implementation and monitoring are incorporated into routine environmental management.
- Successful rehabilitation techniques can be incorporated into the Reclamation plan.
- Costs are spread over a longer period and recovered from mine revenues.
- Adverse environmental effects are minimised.
- The final abandonment period is shortened.

In some advanced countries a formal closure plan is a pre-requisite before granting a mining license. However, there is no universal agreement on the aspects that should be included in an abandonment plan or on the level of closure performance that can reasonably be expected. After-use of the mine site is often difficult to anticipate well in advance, as it depends on the factors prevailing at the time of abandonment. The ultimate land use should be compatible with the surrounding area, but at the same time any future industrial or commercial activities that are coming-up/proposed in this area should not be overlooked, because it can avail the infrastructure already available by the earlier mining activity. Therefore, while planning the closure activities, coordination between planning officials (district), mining officials and the mine owners is essential.

The abandonment of mining operations should involve the best means of planning and subsequently managing the environmental changes and socio-economic effects that occur when mining operations cease. Abandonment planning is therefore dynamic and needs to be evolved with the framework of mine design i.e. in the Mining Plan & Subsequent Schemes of Mining. For this, during the life of a mine, sequences of distinct stages have to be identified and addressed. They include:

- Initial closure design – prepared concurrent to the commencement of mining operations to demonstrate how closure can be achieved;
- Progressive rehabilitation – to be adopted during the mine development whenever possible.
- Interim closure plan – prepared following expansion of operations or changes to legislation;
- Final abandonment plan – prepared prior to abandonment of mining operations.

11.7 PLANNING FOR THE FINAL ABANDONMENT

Interim plans are essential for revising programmes and costs to take account of changing circumstances. However, the final abandonment plan and schedule of operations can only be prepared relatively late in the life of the mine when no further changes to operations are expected. At this point, the following four phases of actions should be considered to prepare the programme of work.

Active Care

As one of the primary targets of closure planning is to minimise the need for long-term management of the closed mine site, it is appropriate to channel the effort and resources into the restoration and rehabilitation work (active care). During this phase, the site is re-profiled and rehabilitation is undertaken, including all ancillary features such as tailings and waste dumps. In addition, all sources of potential pollution and contamination are identified, treated and made harmless. At sites where progressive rehabilitation has been carried out, these activities are also continued during the active care programme. Many types of operational environmental monitoring (e.g. for noise, vibration and atmospheric emissions from the process plant) will be discontinued and the monitoring programme will be adapted to reflect the new circumstances and longer-term requirements.

Passive Care

The main aim of passive care monitoring is to demonstrate that decommissioning and active care have been successful and that the objectives of mine abandonment have been achieved. Active care should be followed by a period of monitoring to demonstrate that this has been successful, prior to disposing of the site (closeout). This may extend to five years period prior to cessation of mining, during which site investigations, review with the regulatory authorities, estimates of final costs and contract preparation and tendering are to be undertaken. Any steps to encourage other industries to take over the mine site should be vigorously pursued during this period by the Government authorities so that the final abandonment plans reflect new ventures for the site.

Closeout

When conditions are deemed satisfactory, the mining company and the regulatory agencies should agree that the closeout state has been reached. Under this phase, the mining company prepares the closeout report and submits to the regulating authorities, the details of which follow separately. The mining company can then be released from any further obligations and is free to legally dispose of its interest in the site. In some mines, there is a clear need for ongoing management or maintenance work following closeout, e.g. periodic clearing of drainage ditches and spillways or seasonal cutting of wild growth. These activities need not be a reason for the mining company to continue to retain an interest in the site, provided adequate technical and financial arrangements have been made to carry out the work required.

Disposal of Site

After the regulators approve successful closure, finalise the closeout report, the mine abandonment and de-commissioning stage follows directly upon cessation of mining. This period requires careful planning to coordinate mine de-commissioning, demolition, dismantling and removal of buildings, plant and other infrastructure elements that are not required. These may be sold if they have a resale value, or disposed of as scrap. This phase marks a period of great change as the workforce diminishes in number and the appearance of the mine site changes dramatically. These activities overlap and are closely integrated with the active care phase. Finally the mine owner ceases their interests over the mine site.

11.7 Closeout Report

This report, already mentioned above, can be prepared by external consultants, (particularly where there is a requirement for an independent report), but can also be developed by in-house environmental personnel. These plans drawn up by the mining company, should be pragmatic and realistic, particularly in respect of programmes and costs.

At present there is no prescribed format for abandonment plans. Depending on the status of the plan (initial, interim or final), the following chapters should be included under this report.

- **Executive Summary** : It summarises all main issues and conclusions including closure objectives, programme and financial sureties.
- **Closure Criteria** : It should reflect the history of the company and the mining operations, objectives of closure and how these relate to the mine, its environmental and social setting, abandonment criteria and performance standards and after-use of the site.
- **Mine Components** : It should give detailed description of the mine development and operations, implications for abandonment, after-use of the site for each different component and results of progressive rehabilitation.
- **Environmental Resources** : It should include description of environmental and social characteristics of the area around the mine, detailed description of resources most susceptible to abandonment impacts and lessons to be learnt from progressive rehabilitation already completed.
- **Abandonment Planning** : It should describe the methods to decommission each mine component and the mitigation proposed to minimise adverse environmental effects. Further, details of active care programme, including site investigations, specialised treatment techniques, water management, rehabilitation and source of material for re-vegetation (e.g. soils, vegetation), management and maintenance, details of passive care programme, including monitoring schedules and specific performance standards for abandonment criteria, details of any long-term management and maintenance expected and proposed arrangements to undertake all these are to be followed.
- **Schedule of Abandoning Operations** : Description on detailed programme of work, including activity schedules, de-commissioning procedures and protocols, labour release programme, health and safety measures, contract procedures and systems, detailed budgets are to be furnished.
- **Abandonment Costs** : Costs to be estimated based on expected activities required, schedules of quantities and the standard rates.
- **Plans Showing Proposals** : Plans at appropriate scales to be prepared and enclosed so as to clearly visualise appropriate detail of proposals. These also should include the final arrangements for the site.
- **Technical Appendices** : Appendices should provide details of any specialised investigations, techniques, methods or innovative research undertaken or proposed to minimise the short term and long term pollution effects.

11.8 COSTS ON MINE CLOSURE AND FINANCIAL SURETIES

As mentioned in the closeout report, there should be a realistic and practical approach while estimating the cost on abandonment. Further, in India, there is no provision in the grant of mining leases, such as financial surety to indemnify the authorities against the reclamation and rehabilitation costs at the time of abandonment of mines. The results are the fate of most of the abandoned mines existing at present due to reckless and unscientific activities of the earlier mine owners, in which the Government has to be involved and spend public money for

their safety and environmental management of the areas. Therefore, a financial surety should come into force, if the operators or owners fail to meet their full obligations at the planned time of abandonment or in the event of premature and unplanned closure. These financial sureties should cover both technical and financial failure.

A number of financial options are available for the mining company to provide the necessary financial security like:

- a letter of credit;
- a performance or surety-bond;
- a parent company guarantee;
- the pledging of assets; and
- a trust fund.

The first four are primarily concerned with indemnifying the authorities against the failure of the mining company to properly rehabilitate the mine site, either by guaranteeing funds through company resources or by an arrangement with external financial institutions. However, only the trust fund actually provides funds to the company to undertake closure at the planned time. These are built up through annual contributions based on the expected final sum required for abandonment and any long-term management or maintenance. A legal arrangement is needed in this case so that both the mining company and the controlling authority control the trust fund. Neither can use the fund for any purpose other than abandonment without the agreement of each other. In the event of unforeseen closure, there are appropriate safeguards to ensure that funds revert to the regulatory authority so that it can arrange for proper closure to be completed, if necessary.

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