MINING INDUSTRY ABSTRACT

INTRODUCTION

Mining operations can be found all over the globe, from the arctic circle to Central Africa. Mines have to be built where ore, diamonds and coal is found in the earth. A large number of mines are built in remote parts of the world.

Mining often involves a fully self-reliant site production operation. Repair/rebuild facilities and living quarters or a town-site with water supply, power, waste disposal, hospital, emergency services, fire protection and communications, are needed. The utilities are provided for the town population as well as for industrial production. A dam and reservoir may be constructed near the site to generate hydroelectric power. On-site electric power generating facilities are common.

Mining economically extracts a useful natural resource from the earth. High-grade vein ore is extracted by underground methods, such as; stope mining removes ore through shaft sinking, drift driving and stope drilling to follow the vein. Underground coal seams are also mined through vertical shafts and horizontal adits or tunnels, although different excavation patterns, such as room and pillar, are used for breaking the coal.

Low grade metallic ore is mined underground by caving or from the surface by open pit mining. In both cases, large volumes of material are handled. Some materials, including sand, gravel, trap rock, coal and limestone, may need little or no further processing. Materials, such as phosphates and potash soils for fertilizer, receive minimal processing and drying. Iron and aluminum require additional or alternate processing as discussed in separate PRC Guidelines.

MAJOR PROCESSES

Mining involves unique, mobile and sometimes massive equipment, including vehicles, drill equipment, rock moving devices, crushers, power shovels, loaders and draglines. Other equipment, critical to continuing production, may be customized for power generation and distribution, water purification, mine ventilation, mine dewatering, belt conveyors, dryers, concentrators and refiners. Figure 1 is a simplified flow chart.

Drilling and blasting in a mine is a daily operation. The use of explosives is common in the industry. Storage is well away from the mine and its operations.

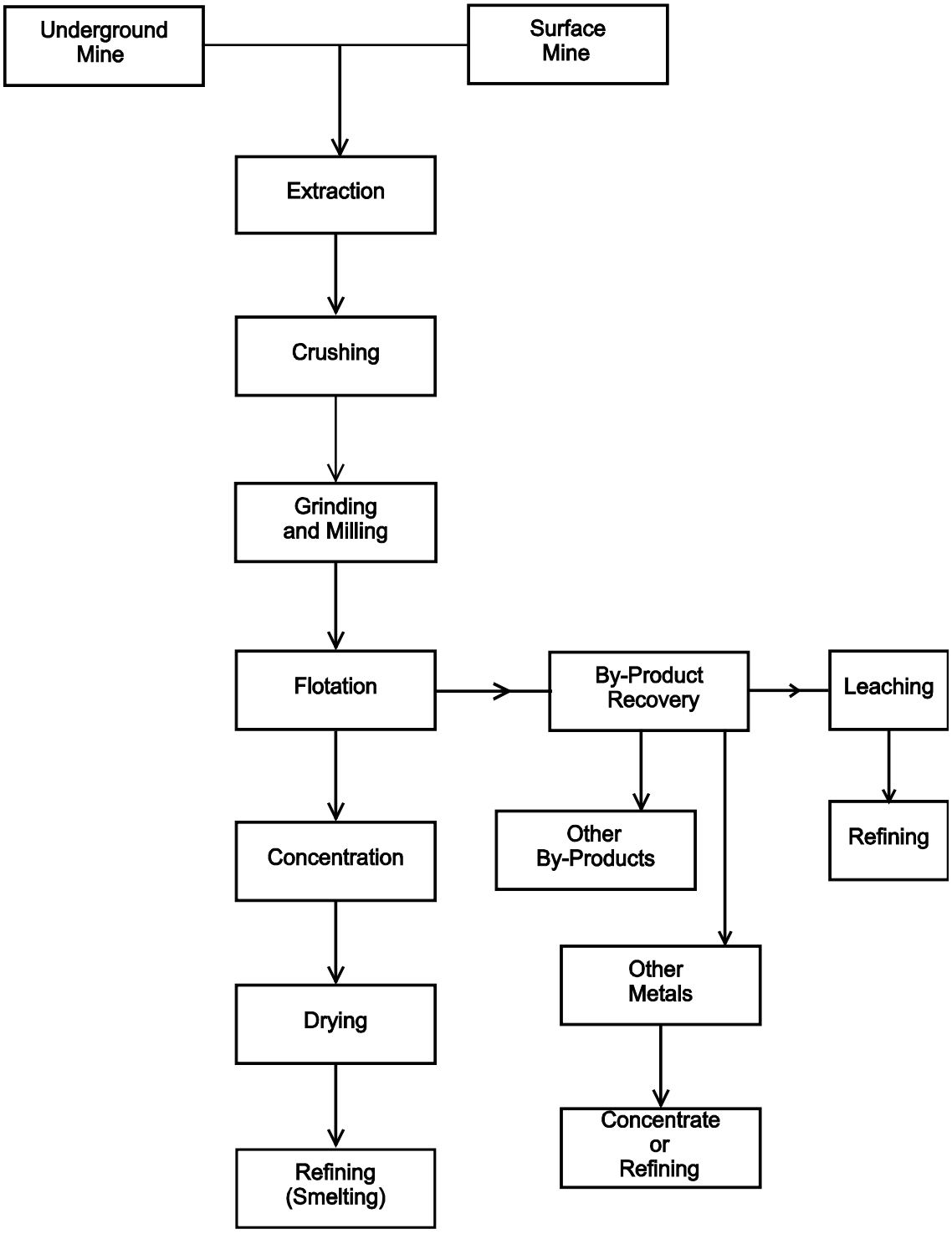

Figure 1: Mining Industry Abstract.

Mining processes have high energy needs. High voltage and dependable electric power are necessary to run the large electric drive motors and drive gear sets. A facility may purchase primary electric power from a public utility grid. Electricity also may be provided by hydro or steam generators, or part purchased/part self-generated. Mining companies may sell excess capacity. Power to equipment is distributed by plant-owned transformers, switchgear and distribution equipment throughout the site to motor control centers.

One adverse condition of the mining industry, particularly within the physical confines of the mine, is a tendency to accept “temporary” installations. For example, high voltage power lines are necessary to power electric power shovels in an open pit mine. The shovels relocate as the excavation advances during mine development, and electric power must follow.

Surface Mining

Surface mining puts no limitation on the size of equipment and vehicles and allows large scale mechanization. Ventilation in a surface mine is not a problem as in an underground mine. Two types of surface mining are the open pit and the quarry. The basic procedure is similar. The face of ore in an open pit or rock in a quarry is broken by blasting and hauled away. Excavation works the mine in horizontal levels, step fashion, from the top of the face downward. As a bench level is cut back, a step down cut is made to the next lower level. At each cut, the hauling distance lengthens and the mining depth increases. The pits can be several miles (kilometers) in diameter or length and up to ½ mi (1 km) deep.

Usable material is moved to crushers, transfer piles or belt conveyors that carry material to mills for additional processing. Primary and secondary ore crushing may occur within the mine to ease handling, storage and transportation of ore. Waste material is removed to a dump.

Large electrical and mechanical equipment move large quantities of material. Large electric power shovels and draglines require high voltage electrical equipment and cables. Ore haulage trucks are also large and uniquely constructed. Mobile and temporarily installed equipment can be damaged by vibration.

Underground Mining

Underground mining for high grade vein ore consists of sinking shafts, and driving tunnels, drifts and rises to stopes to access veins or seams for drilling and blasting the ore face. Using caving techniques, large, underground, low grade ore bodies may be mined. Caving consists of undercutting the ore body and allowing the ore to fall or “cave.” Tools and equipment, such as air hammers, drills, slushers, haul trains and bucket hoists, may be customized for use in a specific underground mine. An underground primary crusher typically is used, because smaller dimensioned ore is easier to handle, especially in bucket hoists. Conveyors are normally used underground except at inclined shaft mines.

Air ventilation and water pumping are two critical services required. Ventilation air compressors and electric power generators are usually located above ground in the surface shop and service buildings area. However, substations, switchgear and converters of the distribution system will be underground. The hoist and headframe building will be located at the main shaft, with ore handling transfer stations, conveyors, bins and train loading points located nearby.

The rest of ore processing is similar to that for surface mining.

Grinding Milling

Crushing and grinding involves rotating and tumbling ore to increasingly smaller sizes. The primary and secondary crushers comprise the coarse crushing process. Once the desired ore has been mined and crushed, the metal bearing mineral must be extracted.

Milling grinds the ore to free the mineral particles. Grinding takes place in a succession of grinding mills. In autogenous mills the crushing is caused by ore colliding with itself, in semi-autogenous mills crushing is caused by the ore colliding with itself and other objects such as steel balls or steel rods

(Ball Mills or Rod Mills). Tumblers, which contain steel rods, are called rod mills. If they contain steel balls, they are called ball mills.

Coarse ore slurry is charged into the rod mill. Tumbling action grinds the ore between the steel rods and the sides of the mill. The ore slurry is then charged into the ball mill for continued grinding to smaller grain size. The grinding action of balls being tumbled results in a fine grained slurry from which the mineral can be separated. The pulp then flows from the mills to sizing devices (classifiers). Fines move to the flotation process while coarser material is returned to the mills for regrinding.

Copper, molybdenum, titanium, gold and silver usually occur in high grade mineralized veins and fracture zones or are disseminated in hard rock. Grinding and pulverizing reduces ore to a mixture of minerals and waste rock.

Flotation Process

The flotation process separates the mineral from the useless rock (waste tailings). Frothing agents, reagents or other chemicals are mixed with the ore slurry when it is transferred to the flotation cells. Combustible agents are used in some cases.

Frothing produces a stable bubble to which the mineral adheres. Adherence results in a mineral laden froth that rises to the surface of the pulp, then overflows out of the flotation cell. This material is collected and filter pressed (excess water is vacuum extracted) into cake concentrate and then dried to a powder form in oil or gas fired drum dryers. The concentrate is transported to an on-site smelter furnace for refining, or shipped off site as final product.

The waste is directed to settling tanks. The settled waste sludge is then pumped to a sludge or tailing pond for leaching or disposal. Water is recycled.

Concentrator

The concentrator reduces the bulk of material. Milled mineral slurry concentrate is fed into a filter press where the mixture is vacuum separated. The liquid is drawn off, and solids are pressed onto filter cloth to form a cake (concentrate mud). The cake is scraped from the cloth and sent to a dryer. Powdered concentrate is stored in steel bins for batching to the smelter furnace or bulk shipped, usually by rail.

Mechanical equipment and electrical drive motors are subject to typical loss perils. A conveyor may be used to transport cake from the filter house to the storage bin. Occasionally with sulfide minerals, hot spots may develop within the storage bin. If the concentrate is not drawn out of the bin or the bin surface is not cooled, the sidewalls are subject to warp as localized heat intensifies.

Leaching

Leaching recovers the metal content of extremely low grade ores (1% or less) and “high grade” tailings (0.01% or more). Water or a weak chemical is pumped and sprayed in large quantities to the top of the pile or onto a bed of the material to be leached. The water percolates through the tailings, dissolves and entrains the soluble minerals to become what is called a pregnant leach solution. The pregnant solution is collected in ponds and pumped to an extraction process for recovery by cost effective means, such as electrolysis.

Electrowinning or electroextraction of metals is the electrolysis of the pregnant solution derived from the chemical or acid leaching process. The solution tends to act in a corrosive manner. Plastic tanks and/or plastic tank linings, piping and fittings can be used in the handling of pregnant solutions. The fire hazard introduced by the use of plastics is significant. A small fire in some types of plastic (PVC for example) will generate large amounts of highly corrosive, combustible products. Losses have occurred where the solution in the plastic tank was being heated, it ignited and destroyed the tank. The solution is to use non-combustible tanks and linings or do not heat the solution, thus eliminating the ignition source related to tank heating devices. However, a Where the solution is heated, follow the guidelines and recommendations of PRC.9.5.1. The hazard is severe when the tank is drained, out of service and under maintenance procedures that may involve cutting and welding.

Embankment dams and impoundments, constructed for tailings and leaching operations, do not usually qualify as recognized “dam” or “containment” structures. They present an exposure to environmental contamination and product loss if impoundments fail.

Tailings Dam

Waste material (tailings) and slurry from processing and leaching is dumped on-site in a large tailings dam. The dam itself can be built from tailings and reach significant heights. In case of dam break the tailings slurry will be released and can cause major physical destruction when flowing to lower laying areas and can cause major environmental contamination.

Pit Wall

Collapse of the wall of a deep pit mine is a major threat. The wall and slope of the wall must be properly designed. The wall must be continuously monitored for movement and changes in hydrological conditions. Blasting operations and their impact on the pit wall stability must be properly evaluated.

Electrical Switchgear and Transformers

Because of the size and distribution of equipment at mine properties, there may be moderate to large motor control centers in unusual areas. The transformers can be located outside the room or building, with only electrical switchgear inside. Transformers and switchgear could also be in adjacent cut-off rooms.

Switchgear rooms tend to accumulate storage which increases fire exposure.

Transportation Network

Mines can be located in remote parts of the world and transportation network (roads and railway) to the nearest harbor can be several hundred miles (kilometers) long making the mine highly dependent on intact infrastructure. Shipping of ore or coal is typically done via railway. The tracks can be exposed to flood damage from heavy rains and storms. Major equipment used in the mine is typically received at the nearest harbor and then has to be dismantled in smaller parts and trucked overland to the mine.

PRODUCTION HAZARDS

A wide variety of hazards are encountered in the mining industry.

Conveyors with combustible belts (usually rubber) are one of the most serious loss exposures because of their size and location. In addition, these belts are typically inclined or elevated as high as 150 ft (46 m) in the air. This makes manual firefighting nearly impossible.

Trucks can carry a payload of up to 450 tons and have a significant volume of combustible liquids in their engine bay. Trucks have a long delivery time and transportation from the manufacturing plant to the mine might be challenging.

Crushers and grinding mills have high horsepower, 2500 hp – 5000 hp (1265 kW – 3730 kW), electric drive motors and large drive gear sets.

The flotation process, in some cases, uses flammable and/or combustible liquids which must be handled with care to avoid fire. Flotation cells will have a thin surface layer of combustible or flammable liquid bubbles. The underside of the building roof may be coated with combustible residue.

The natural gas or oil fired dryers and the massive gear drives, electrical switchgear, and power source equipment present severe electrical and mechanical equipment exposures.

LOSS PREVENTION AND CONTROL GUIDELINES

Loss prevention and control programs are essential in mining operations. The operating environment of the mining industry requires good housekeeping, preventive and predictive maintenance programs, well informed supervisors and trained employees. *OVERVIEW* provides sample procedures and guidelines to assist in development of a customized comprehensive management loss control program.

At some locations it is necessary for the mine operator to provide mobile fire fighting equipment for fire brigade use.

Special extinguishing systems are required for remote hazards such as individual substations.

A reliable water supply adequate to supply both sprinkler and hose demands for fire protection for a minimum of 3 h is required. It is not uncommon for water supplies at mining properties to be combination systems with fire protection reserve, elevated tank, or pumping supply, power supply(ies) and redundancy of pumps must be carefully evaluated.

Further recommendations are:

- Provide an underground supply main distribution system using looped yard mains with two-way yard hydrants at 250 ft (76 m) intervals.
- Locate sectional control valves to impair no more than five fire protection devices by a single break.
- Space hose connections approximately 100 ft (30 m) apart along galleries and equip them with 100 ft (30 m) of !/2 in. (3.8 cm) woven-jacketed, lined fire hose and adjustable spray nozzles in areas of combustible loading. The hose connections can be supplied from the overhead sprinklers or separate riser.
- Dike, drain and trap oil reservoirs. Crushers and ball mills will have hydraulic and lube oil systems which require spot sprinkler protection over reservoirs and lines. Protect hydraulic and lube oil reservoirs in accordance with NFPA 15. Because of the general lack of heating for concentration facilities, dry pipe system installations should be contemplated.

Sprinkler Systems

Provide wet or dry pipe sprinkler systems in areas of combustible occupancy, per current NFPA 13, 15, 16, and PRC.12.1.1.0 and PRC.12.3.1.1.

Provide water spray sprinkler protection for the oil reservoir tanks and critical lines at 0.25 gpm/ft2 (10.2 L/min/m2) over the entire area. (See PRC.9.2.4.)

Provide automatic sprinkler protection density of 0.20 gpm/ft2 (0.8 L/min/m2) for the flotation building. If large quantities of flammable liquid are present, as in uranium extraction, higher densities, foam or deluge protection may be applicable.

Provide automatic sprinkler protection in the electrowinning building when plastic tanks and/or plastic lined tanks are used.

Provide automatic sprinkler protection inside of critical, high valued plastic process equipment or environmental control equipment including connecting ductwork.

Explosives

Store and handle explosives in accordance with Bureau of Mines regulations and NFPA 495.

Equipment

Protect belt conveyors in accordance with PRC.9.3.1. Conveyors are critical to production because they need to transfer materials through the production stages. The belt length can range from a few hundred to several thousand feet; the width, 2 ft – 4 ft (0.6 m – 1.2 m).

Provide fuel fired equipment with combustion safeguards per NFPA 85 and PRC.4.0.1 based on Btu input rating and fuel utilized.

Protect electrical generating equipment in accordance with NFPA 850 and PRC.17.12.1.

Flammable and Combustible Liquids

Handle flammable and combustible liquids in safety containers and keep only a one day's supply for production use. Protect bulk storage tanks in accordance with NFPA 30 and PRC.8.1.0 depending upon size and value of storage area.

Install fixed extinguishing systems for important mobile equipment, such as electric power shovels, drill rigs and ore haulage. Minimal protection includes portable equipment, such as dry chemical or CO_2 extinguishers. Size, placement and type depend upon mobile equipment power sources, operating devices and mechanical operation.

MINING INDUSTRY ABSTRACT GLOSSARY

GLOSSARY

Adit – a horizontal or near-horizontal passage driven from the Earth's surface into the side of a ridge or mountain for the purpose of working, ventilating, or removing water from a mine.

Caving - a system of mining in which a large block of ore is allowed to cave or fall.

Concentrator - facilities where metal (mineral) is separated from ore or associated rock to increase the percent of metal (mineral) in a given volume of material.

Disseminated (ore) - ore carrying fine particles of minerals scattered through the rock.

Drift – a near-horizontal passageway in a mine, following the bed or vein of ore. A drift may or may not intersect the ground surface. This type of mining is usually done when the rock or mineral is on the side of a hill.

Electrowinning - also called electroextraction, is the electro-deposition of metals from their ores that have been put in solution or liquefied.

Leaching - the removal in solution of soluble minerals by percolating water.

Shaft - a nearly vertical passage of small area opening compared to depth from the surface to underground workings.

Smelter - facilities where ore is melted or fused to separate impurities from metal.

Stope - an underground excavation from which ore, such as vein ore, is extracted, as opposed to a caving gallery.

Trailings – waste rock that has been separated from the ore.

Vein - an occurrence of mineral having a more or less regular development in length, width and depth.