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Phosphate Fertilizer Plants

Industry Description and Practices

Phosphate fertilizers are produced by adding acid to ground or pulverized phosphate rock. If sulfuric acid is used, single or normal, phosphate (SSP) is produced, with a phosphorus content of 16–21% as phosphorous pentoxide (P_2O_5). If phosphoric acid is used to acidulate the phosphate rock, triple phosphate (TSP) is the result. TSP has a phosphorus content of 43–48% as P_2O_5.

SSP production involves mixing the sulfuric acid and the rock in a reactor. The reaction mixture is discharged onto a slow-moving conveyor in a den. The mixture is cured for 4 to 6 weeks before bagging and shipping.

Two processes are used to produce TSP fertilizers: run-of-pile and granular. The run-of-pile process is similar to the SSP process. Granular TSP uses lower-strength phosphoric acid (40%, compared with 50% for run-of-pile). The reaction mixture, a slurry, is sprayed onto recycled fertilizer fines in a granulator. Granules grow and are then discharged to a dryer, screened, and sent to storage.

Phosphate fertilizer complexes often have sulfuric and phosphoric acid production facilities. Sulfuric acid is produced by burning molten sulfur in air to produce sulfur dioxide, which is then catalytically converted to sulfur trioxide for absorption in oleum. Sulfur dioxide can also be produced by roasting pyrite ore. Phosphoric acid is manufactured by adding sulfuric acid to phosphate rock. The reaction mixture is filtered to remove phosphogypsum, which is discharged to settling ponds or waste heaps.

Waste Characteristics

Fluorides and dust are emitted to the air from the fertilizer plant. All aspects of phosphate rock processing and finished product handling generate dust, from grinders and pulverizers, pneumatic conveyors, and screens. The mixer / reactors and dens produce fumes that contain silicon tetrafluoride and hydrogen fluoride. Liquid effluents are not normally expected from the fertilizer plant, since it is feasible to operate the plant with a balanced process water system. The fertilizer plant should generate minimal solid wastes.

A sulfuric acid plant has two principal air emissions: sulfur dioxide and acid mist. If pyrites ore is roasted, there will also be particulates in air emissions that may contain heavy metals such as cadmium, mercury, and lead. Sulfuric acid plants do not normally discharge liquid effluents except where appropriate water management measures are absent. Solid wastes from a sulfuric acid plant will normally be limited to spent vanadium catalyst. Where pyrite ore is roasted, there will be pyrite residue, which will require disposal. The residue may contain a wide range of heavy metals such as zinc, copper, lead, cadmium, mercury, and arsenic.

The phosphoric acid plant generates dust and fumes, both of which contain hydrofluoric acid, silicon tetrafluoride, or both.

Phosphogypsum generated in the process (at an approximate rate of about 5 tons per ton of phosphoric acid produced) is most often disposed of as a slurry to a storage / settling pond or waste heap. (Disposal to a marine environment is practiced at some existing phosphoric acid plants.)

Process water used to transport the waste is returned to the plant after the solids have settled out. It is preferable to use a closed-loop operating system, where possible, to avoid a liquid effluent. In many climatic conditions, however, this is not possible, and an effluent is generated that contains phosphorus (as PO_4), fluorides, and suspended solids. The phosphogypsum contains trace metals, fluorides, and radionuclides (especially radon gas) that have been carried through from the phosphate rock.

Pollution Prevention and Control

In a fertilizer plant, the main source of potential pollution is solids from spills, operating upsets, and dust emissions. It is essential that tight operating procedures be in place and that close attention be paid to constant cleanup of spills and to other housecleaning measures. Product will be retained, the need for disposal of waste product will be controlled, and potential contamination of stormwater runoff from the property will be minimized.

The discharge of sulfur dioxide from sulfuric acid plants should be minimized by using the double-contact, double-absorption process, with high efficiency mist eliminators. Spills and accidental discharges should be prevented by using well-bunded storage tanks, by installing spill catchment and containment facilities, and by practicing good housekeeping and maintenance. Residues from the roasting of pyrites may be used by the cement and steel manufacturing industries.

In the phosphoric acid plant, emissions of fluorine compounds from the digester/reactor should be minimized by using well-designed, well-operated, and well-maintained scrubbers. Design for spill containment is essential for avoiding inadvertent liquid discharges. An operating water balance should be maintained to avoid an effluent discharge.

The management of phosphogypsum tailings is a major problem because of the large volumes and large area required and because of the potential for release of dust and radon gases and of fluorides and cadmium in seepage. The following measures will help to minimize the impacts:

- Maintain a water cover to reduce radon gas release and dust emissions.
- Where water cover cannot be maintained, keep the tailings wet or revegetate to reduce dust. (Note, however, that the revegetation process may increase the rate of radon emissions.)
- Line the tailings storage area to prevent contamination of groundwater by fluoride.
- Where contamination of groundwater is a concern, a management and monitoring plan should be implemented.

Phosphogypsum may find a use in the production of gypsum board for the construction industry.

Target Pollution Loads

Implementation of cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following production-related targets can be achieved by measures such as those described above. The numbers relate to the production processes before the addition of pollution control measures.

In sulfuric acid plants that use the double-contact, double-absorption process, emissions levels of 2–4 kilograms of sulfur dioxide per metric ton (kg/t) of sulfuric acid can be achieved, and sulfur trioxide levels of the order of 0.15–0.2 kg/t of sulfuric acid are attainable.

Treatment Technologies

Scrubbers are used to remove fluorides and acid from air emissions. The effluent from the scrubbers is normally recycled to the process. If it is not possible to maintain an operating water balance in the phosphoric acid plant, treatment to precipitate fluorine, phosphorus, and heavy metals may be necessary. Lime can be used for treatment. Spent vanadium catalyst is returned to the supplier for recovery, or, if that cannot be done, is locked in a solidification matrix and disposed of in a secure landfill.

Opportunities to use gypsum wastes as a soil conditioner (for alkali soil and soils that are deficient in sulfur) should be explored to minimize the volume of the gypsum stack.

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 following guidelines 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

The emissions levels presented in Table 1 should be achieved.

Liquid Effluents

The effluent levels presented in Table 2 should be achieved.

Ambient Noise

Noise abatement measures should achieve either the levels given below or a maximum increase in 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 (07:00–22:00)	Night (22:00–07:00)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Table 1. Air Emissions from Phosphate Fertilizer Production

(milligrams per normal cubic meter)

Pollutant	Maximum value
Fertilizer plant	
Fluorides	5
PM	50
Sulfuric acid plant	
Sulfur dioxide	2 kg/t acid
Sulfur trioxide (SO_3)	0.15 kg/t acid
Phosphoric acid plant	
Fluorides	5
PM	50

Table 2. Effluents from Phosphate Fertilizer Production

(milligrams per liter, except for pH)

Pollutant	Maximum value
pH	6–9
TSS	50
Phosphorus	5
Fluoride	20
Cadmium	0.1

Note: Effluent requirements are for direct discharge to surface waters.

Monitoring and Reporting

Fluoride and particulate emissions to the atmosphere from the fertilizer plant should be monitored continuously. In the sulfuric acid plant, sulfur dioxide and acid mist in the stack gas should be monitored continuously.

Liquid effluents should be monitored continuously for pH. All other parameters may be monitored monthly.

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. The results should be reported to the responsible authorities and relevant parties, as required.

For land storage of phosphogypsum, the following monitoring parameters and frequency are recommended for the stack drainage and runoff:

continuously for pH; daily for fluorides; and monthly for phosphorus, sulfates, and gross alpha-particle activity.

Key Issues

The key production and control practices that will lead to compliance with emissions requirements can be summarized as follows:

- Achieve the highest possible sulfur conversion rate; use the double-contact, double-absorption process for sulfuric acid production.
- Consider the use of phosphogypsum to produce gypsum board for the construction industry.
- Design and operate phosphogypsum disposal facilities to minimize impacts.
- Maximize product recovery and minimize air emissions by appropriate maintenance and operation of scrubbers and baghouses.
- Eliminate effluent discharges by operating a balanced process water system.
- Prepare and implement an emergency preparedness and response plan (required because of the large quantities of sulfuric and phosphoric acids and other hazardous materials stored and handled on the site).
- Consider providing pyrite-roasting residues to the cement- or steel-making industry.

Sources

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