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TREATMENT OF ACIDIC MINE DRAINAGE

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The correct choice of a mine drainage treatment unit is dependent upon several parameters. Primary consideration should be given to (1) the level of acidity, (2) the concentration of manganese, (3) availability of power, (4) the sulfate concentration, and (5) the time period over which the facility will be used (depreciation period on the capital investment if the facility is not mobile). After the above variables have been considered, the economics of the equipment cost and operating expense (chemicals, electricity, sludge removal and manpower) can be considered.

The typical request for information on a treatment system consists of the question of which treatment is the least expensive. Since each of the different systems available works differently and/or treats different acidic properties, the above question cannot be directly answered. After additional questioning, it is found that the operator has never measured the acidity in mg/l. as $CaCO_3$ or the sulfate concentration because these parameters are not required in his NPDES permit. Frequently the operator does not know the range and average flowrates of the water to be treated. Based on the above lack of information, it is impossible to specify the correct and most economical system for the location. This situation is compounded by two very significant facts: (1) most treatment system

sales firms handle one type of system and suggest to the operator that this system is the one to correctly solve their problem, and (2) most consulting firms in the mining industry are not knowledge able about the whole range of treatment systems.

In choosing an acidic treatment system, it must be remembered that the parameters in violation (pH, iron, or manganese) are not necessarily the same parameters that must be measured to determine the appropriate system. In general, the following are the parameters that should be monitored before deciding upon which system is the most appropriate.

NPDES/OSM Parameters in Violation

pH
Iron
Manganese

Additional Parameters Required to Determine the Most Appropriate System

- Acidity
- Alkalinity
- Net Acidity
- Acidity to pH 10.0
- Ferrous Iron
- Sulfate
- Flowrate

With the above analytical concentrations determined or eliminated because of certain background information that was available, the operator is now prepared to determine the correct system for his application.

The operator has a choice of five basic chemicals to use in his system: calcium carbonate (limestone), calcium oxide, calcium hydroxide (hydrated lime), sodium carbonate (soda ash), and sodium hydroxide. For the purpose of this discussion, these compounds can be divided up according to whether they are calcium or sodium compounds, and carbonate or hydroxide compounds. (Calcium oxide is converted to hydrated lime in the treatment system and therefore only affects the economic choice.) The above classification of.the available neutralizing compounds is presented below:

	CALCIUM	SODIUM
CARBONATE	LIMESTONE	SODA ASH
HYDROXIDE	HYDRATED LIME	SODIUM HYDROXIDE

The calcium compounds are much less expensive than the sodium compounds, but they have a low solubility (react in water very slowly). As a result the calcium compounds are generally used in larger more permanent installations when electricity is available and greater capital cost can be justified to increase the reactivity of the calcium compounds. Calcium compounds also result in the formation of insoluble gypsum if the sulfate concentration is in excess of 2000 mg/l. This can result in the solidification of pipes, etc., if this water is used in a preparation plant downstream. The calcium compounds also result in a greater hardness than the sodium compounds which can result in calcium carbonate scale in pipes.

The hydroxide neutralizing compounds can result in a higher pH than what is achieved with the carbonate compounds. The carbonate compounds generally do not produce a pH higher than 8.5, while the hydroxide compounds can result in a pH greater than 10.0. This difference in the final pH influences the capability of removing the metals (iron and manganese) from the system. These metals are frequently present in the acidic water in solution and are removed by causing them to solidify (precipitate) and settle to the bottom of the settling basin or thickner. This solidification occurs at different pH values for the different metals: ferric iron converts to the solid ferric hydroxide (yellow boy) at a pH of 5.5 or greater, ferrous iron converts to the solid ferrous hydroxide (green) from a pH of 4.5 to 9.5, and manganese solidifies to manganese hydroxide at a pH of 10.0. Therefore, if your only metal problem is iron in the ferric state, you can treat with carbonate neutralizing compounds. If manganese concentrations are in violation, a hydroxide neutralizing material must be used. If the iron violation is a result of ferrous iron, the ferrous iron can either be oxidized to ferric iron and solidified (precipitated) at a pH of 5.5 or completely solidified as ferrous hydroxide at a pH of 9.5.

The above properties of the neutralizing materials must be considered in the choice of the most appropriate system. Once these properties have been considered, the amount of neutralizing material necessary, the availability of electricity, and the life of the installations must be determined. If electricity is not available, the utilization of the more economical hydrated lime should be eliminated. The only exception to this is the utilization of hydrated lime for a one time or short term neutralization of a pond. Therefore, for short term installations (1 to 5 years) where electricity is not available, you are normally limited to the usage of one of the more soluble sodium compounds (soda ash or sodium hydroxide). If manganese is not a problem, a gravity feed soda ash briquette system is generally the most economical. is present, a sodium hydroxide system is normally used. With the simplified sodium hydroxide system, a liquid solution is used which will burn the skin and the solution can freeze (sodium hydroxide commericially available for this use generally has a small amount of anti-freeze added in the winter months). Both the soda ash and sodium hydroxide systems are fairly mobile and are therefore ideal for the surface operation. If, based on the flow and net acidity, the system uses more than 500 lbs. per day of the neutralizing chemical and the installation will be used for more than three years, the more capital intensive but cheaper chemical cost, hydrated lime system should be investigated. There are now bulk hydrated lime systems available that can be moved on a flat-bed truck, but they do require electicity (some are gasoline operated) and normally a concrete pad and mixing tank. The more expensive hydrated lime systems usually have an automatic pH controller for running the facility while the soda ash briquette and sodium hydroxide systems must be manually controlled.

The normal installations of a treatment system consists of four separate parts: raw water holding system, neutralization, oxidation/aeration (if necessary), and solids or sludge separation (settling basin or thickner). In small surface mine installations (0-100 gpm), the installations normally consist of the neutralization system followed by a settling basin. Periodically it will be necessary to install a flow equalization and raw water holding basin, and aeration system.

As can be determined from the above presentation, it is necessary to study several different parameters and be familiar with the different neutralization systems before choosing a system. The problems currently being encountered by many of the smaller operators suggest a more thorough technology transfer program must be developed in this area.