Lime Delivery and Methodology in Mining Impacted Water Treatment

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Abstract Improving lime precipitation efficiency lowers the cost of treating mining impacted water (MIW). This paper describes Ionic Water Technologies (IWT) lime delivery and treatment methods at different sites, representing common challenges and treatment goals found in the industry. The Rotating Cylinder Treatment System™ (RCTS™) is used as a replacement for reaction vessels, compressors, diffusers and agitators found in conventional treatment systems, while the IWT Lime Grinder Pump™ eliminates clogging of lime slurry delivery lines. Lime delivery methods differ due to site conditions and treatment goals. In each system the design goal was to limit required maintenance while providing reliable, continuous operation at the highest efficiency.

Key Words ARD, MIW, AMD, mining impacted water, acid rock drainage, acid mine drainage, water treatment, rotating cylinder treatment system, mining remediation, green remediation, lime precipitation, lime neutralization, lime efficiency, mining reclamation economics.

Introduction

Lime precipitation or lime neutralization is the most common form of active treatment for MIW. Lime is the most important chemical used throughout the world for pollution control (Hassibi 1999). The two most commonly used forms of lime are calcium oxide (CaO, "quicklime") and calcium hydroxide ($CaOH^2$, "hydrated lime"). Chemical consumption rates, site accessibility, treatment goals, chemical availability, and cost are factors in deciding which form of lime will be best suited for the site and application.

In MIW treatment, lime is delivered at concentrations to increase pH to near 8.0 s.u. At this pH, most metals will precipitate efficiently from solution. However, ferrous iron will not precipitate to a concentration at which it can be discharged unless it is oxidized and converted to ferric iron (USEPA 1983). Using conventional treatment methods, oxidation and mixing typically occurs in large reaction vessels in which air is bubbled into the water with compressors and diffusers. The bubbles are then broken up with mixers, which also provide the agitation for lime dissolution (USEPA 1983). The RCTS™ improves on conventional treatment methods by providing more oxidation, high lime efficiency with thorough mixing, and by decreasing labor requirements for system operation.

Hydrated Lime – 50lb. Bag Hand Mix

Seasonal treatment is often required due to high "runoff" or precipitation events during the spring and fall. Access and space limitations are common challenges. A small system footprint, which utilizes mobile equipment with low power and maintenance requirements, is a key advantage. Chemical delivery capabilities are also limited and can dictate hand mixing of bagged lime. The Leviathan Mine, located in the Sierra Nevada Mountains at an altitude of approximately 7,000 feet, is equipped with ponds to capture and hold MIW until conditions and access to the site improve, and summer seasonal treatment with a conventional system may begin. In high precipitation years temporary treatment has been necessary to prevent untreated AMD from overflowing from the holding ponds and discharging to Leviathan Creek.

A system design implemented during the 2006 RCTS™ seasonal treatment utilized two 500 gallon lime slurry make-up tanks with mixers, an IWT Lime Grinder Pump™, the RCTS-30HS rotating cylinder treatment system, a diesel powered generator, and the existing settling pond approximately 1 acre in size. A combination of water from multiple holding ponds and the existing settling pond, "batch treatment pond" are introduced to the RCTS™ where oxidation/aeration and lime mixing occurs. Lime slurry at a concentration of 15—25% by mass was hand mixed with MIW in the slurry tanks and delivered in pulses by the IWT Lime Grinder Pump™ controlled by a simple adjustable timer. Lime slurry was delivered directly to the RCTS™ unit without the need for a reaction or dosing tank. Titrations were performed periodically in order to adjust the timing,

Table 1 Calcium Hydroxide – Hand Mixing

Design Feature	Advantage
Small Footprint, Mobile Equipment	Remote site, limited access capabilities
Hydrated Lime – 50lb bag – Hand Mixing	Remote site delivery and handling, mixes easily
IWT Lime Grinder Pump™	Eliminates clogging in lime delivery lines due to lime scale in slurry tanks
RCTS™	Oxidation of Reduced Metals/Lime Mixing Efficiency
Low Power Requirements	Small Portable Generator
Settling Pond	Batch Treatment Capabilities and Sludge Capture

frequency, and concentration of chemical feed pulses to accomodate for changes in MIW chemistry and flow.

The system met regulatory compliance throughout the emergency treatment while inhibiting the flow of untreated MIW to Leviathan Creek. The project average labor was 4.6 hours per day, with the majority of labor required for continuous monitoring of discharge events. (Tsukamoto 2006).

While this method has been successfully implemented and demonstrated at multiple sites throughout the western U.S. (California, Colorado, Idaho, Nevada, Montana) extreme care must be taken when handling bagged lime and appropriate PPE should be worn at all times. The primary disadvantage to this method is a lack of automation in lime delivery, resulting in slightly increased labor costs, although typically not significant in most cases as constant system monitoring is usually required and system capital costs are greatly decreased.

Hydrated Lime – Continuous Feed

Maintenance and labor requirements are a major component of active lime precipitation systems. Limiting componentry is a key element to a continuous, reliable treatment system. A common problem with hydrated lime is the storage and delivery of material. Hydrated lime can be troublesome as it is not easily delivered from a silo storage system. As a fine dry powder many factors can make delivery unreliable. External moisture, compaction of the material in the silo, and material bridging all translate to system downtime and increased maintenance and labor costs.

In 2008, IWT mobilized a treatment system to Swift Gulch, Zortman-Landusky Mine, Northern Montana. Swift Gulch experiences high runoff due to spring, and fall precipitations. The mobile system was installed and operated throughout the 2008 and 2009 seasons. Multiple treatment systems at the site require maintenance and a key advantage for the client was the limited labor required to maintain treatment in Swift Gulch. Maintenance of the system during 2008 and 2009 consisted of hand mixing lime, and monitoring settling pond pH approximately every 4 days.

A refined design is being constructed and implemented during the 2010 season. The design will deliver hydrated lime continuously through the use of a Sodimate™ delivery system. The system will continuously feed between 0.05 lbs and 1.0 lbs per minute with the capability of increas-

Table 2 Calcium Hydroxide – Continuos Feed

Design Feature	Advantage
Hydrated Lime – Silo Storage	Limits Labor and Chemical Delivery Requirements
Sodimate™ Delivery System	Precise, Continuous, Hydrated Lime Feed
No Lime Pump or Lime Slurry Delivery Lines	Reduced Maintenance
Gravity Flow System	Reduced Power Costs, Eliminates System Components i.e.: pumps, level controls, pH probes
RCTS™	Oxidation of Reduced Metals/Lime Mixing Efficiency
Settling Pond	Batch Treatment Capabilities and Sludge Capture

ing to 3.0 lbs per minute. A lime slurry storage tank will recieve a limited portion of the MIW and the continuously fed hydrated lime. Lime slurry then gravity flows to a reaction tank where it is introduced to the remainder of the MIW to be treated. From the reaction tank, treated water gravity flows to the RCTS™ system, and from there to a settling pond. System pH control is acheived through historical trending, field titrations, and precise lime feed control.

IWT has utilized the Sodimate™ hydrated lime feed system in one other application with a significantly higher lime feed rate. Installation of the lime delivery system at the Swift Gulch site is scheduled for the summer/fall of 2010 and the performance of the system at a lower feed rate will then be evaluated.

Calcium Oxide – Continuous Feed, Low Feed Rate

When applicable, a calcium oxide or "quicklime" system may be preferred. Advantages of calcium oxide systems include reduced chemical cost, increased alkalinity by mass, bulk storage and delivery advantages. However, a "slaker" system is required to hydrate the calcium oxide to calcium hydroxide which then must be introduced and mixed into slurry for use in treatment. "Slakers" can be maintenance and labor intensive, increasing cost and decreasing system reliability.

At the Elizabeth Mine Site in Vermont, IWT with Weston Solutions implemented a treatment system design which utilizes a continuous feed calcium oxide delivery system with an average feed rate of 0.6 lbs per minute. Calcium oxide is delivered to a funnel system which combines with MIW prior to flowing into the IWT Lime Grinder Pump™. The grinder receives a combination of flows from the MIW to be treated and recirculated flow from the cone bottom of the lime slurry mix and storage tank. The grinder reduces particle size which promotes slaking, creating slurry prior to introduction to the RCTS™ system where aeration/oxidation and lime mixing are performed. Control of system pH is established through lime feed rate and monitoring of the system settling pond.

Although this system costs less than comparative methods, more equipment in any system equates to increased maintenance and support requirements. The IWT Lime Grinder Pump™ becomes a critical component in the system and redundant grinders are recommended.

Calcium Oxide – Continuous Feed, High Feed Rate

Treatment systems which require high lime feed rates almost exclusively utilize calcium oxide and slaker systems. Slakers are typically maintenance intensive and require attention for continuous operation.

Based on the Elizabeth Mine Site treatment system design and unique site features, IWT has implemented a system which continuously feeds calcium oxide at rates of up-to 24lbs/min. to a side-stream of water which is then introduced to a pit lake. The system is designed to provide addition and dissolution of as much calcium oxide as possible for applications which require the neutralization of large bodies of water, such as may be found in a pit lake or tailings impound-

Table 3 *Calcium Oxide – Continuous Feed, Low Feed Rate*

Design Feature	Advantage
Calcium Oxide	Reduced Cost, Ease of Delivery and Storage
IWT Lime Grinder Pump	Replaces "Slaker" System, Reducing Maintenance
Continuous Feed and Lime Delivery Control	Eliminates pH Probe Control and Maintenance
Settling Pond	Batch Treatment Capabilities and Sludge Capture

Table 4 *Calcium Oxide – Continuous Feed, High Feed Rate*

Design Feature	Advantage
Calcium Oxide	Reduced Cost, Ease of Delivery and Storage
IWT Lime Grinder Pumps	Replaces Slaker System, Reduced Maintenance
High Feed Rate	Operates at 24lbs per minute

ment. In this application pH control is not a concern at the lime delivery plant, rather lime mixing and efficiency must be optimal. Through the combination of IWT Lime Grinder Pumps™, RCTS™, calcium oxide lime silo and delivery equipment, the system is capable of achieving dissolution efficiencies on par with what can be expected when utilizing chemical grade calcium hydroxide.

Conclusions

Lime delivery methods and equipment are a key element in active lime precipitation systems. In many systems they are the "weak link", a leading cause of system downtime, and a principle factor in the labor and maintenance costs of a treatment system. These innovative lime delivery and treatment methods use a combination of site characteristics and limited components to minimize cost and increase reliability.

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