LIME SYSTEM UPGRADE AT BUNDAMBA ADVANCED WATER TREATMENT PLANT

Paper Presented by:

Scott Johnson

Author:

Scott Johnson, *Operator/Maintainer (Electrical),*

Veolia Water Australia

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ABSTRACT

This paper highlights the modifications to the Hydrated Lime dosing system at the Bundamba Advanced Water Treatment Plant (BAWTP).

The original system was designed to be a two lime silo batching system, used to stabilise the 66 MLD of RO permeate. The high lime slurry batch concentration (a minimum of 4%) resulted in an unreliable and unstable dosing system, with frequent blockages, equipment failures, instrument failure and regular cleaning out of the Treated Water Tank's feed well. Varying production rates amplified the systems shortcomings, as well as creating difficulty controlling chlorine and pH levels in the final product water. The plant design did not allow for a duty/standby configuration of critical equipment and the automatic flushing of the slurry dosing system after shutdown.

The physical of the original system created safety issues, such as trip hazards, manual handling problems and flexible dosing hose failure.

After implementing pipework and control modifications, only one lime batching system is required for full plant production of 66 MLD.

The plant reliability and maintenance requirements are also improved with reducing slurry dosing pipe size from 50 mm to 25 mm dia., eliminating lime build up and blockages, trip hazards and manual handling problems. In addition, the batch concentration of the slurry can be reduced down to 1.5%, improving reliability of downstream instruments and final water quality.

1.0 INTRODUCTION

The Bundamba AWTP lime system was designed to stabilise 66ML/d of purified recycle water.

The Lime system is an integral part of the process, it is dosed to stabilise the RO permeate and this is accomplished by dosing lime to add hardness and alkalinity and Carbon Dioxide to adjust the pH to meet the contract requirements for the treated water produced.

The effect of each chemical is described below:

- Lime (CaOH) adds Calcium ions to the water and increases pH.
- Carbon Dioxide (CO_2) which reacts with the lime to produce Calcium Carbonate and reduces pH.

This is done to protect the pipeline from corrosion and scaling.

The following paper will discuss the common problems with the lime dosing components and how they were addressed to improve plant uptime, water quality and process stability.

2.0 PROCESS DESCRIPTION

The lime system currently consists of two lime silos each 35 tons with a variable speed screw feeder to dispense lime powder into a mixing tank. A simplified process schematic is shown below in Figure 1. The batch tank has a service water filling valve to maintain a level set point in the tank. The slurry in the batch tank is targeted to maintain a constant slurry concentration (circa 4-5%), hence the rate at which lime powder enters the tank is in proportion to the rate at which service water enters the tank. The lime slurry is delivered to the treated water process by a centrifugal pump via a pair of valves which control both the volumetric flow rate of lime slurry to the dosing point and the amount that is recirculated back to the tank. In this way the lime dose volumetric flow rate is controlled by the dosing valves.

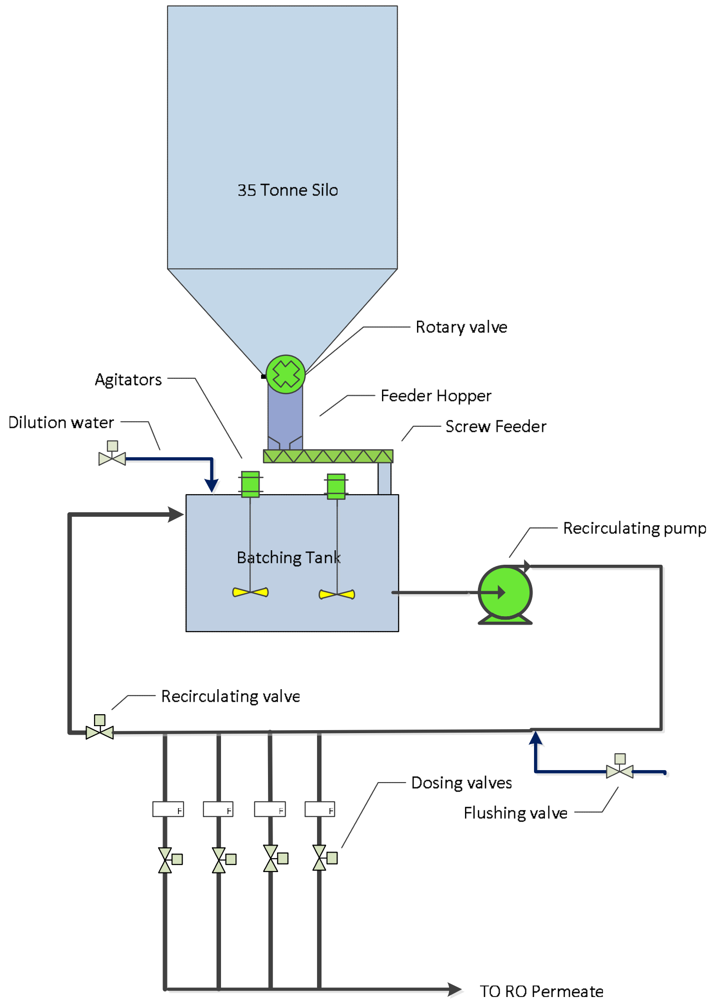

Figure 1: ***Lime System Schematic***

2.1 Lime Volumetric Feeder System

An intermediate feeder hopper is used to feed uniform material onto the screw feeder which supplies a controlled volumetric feed to the batch tank. The feeder hopper is also fitted with load cells which provided local indication. The lime feeder hopper level is maintained by a rotary valve triggered by a paddle type level sensor (high and low) to start and stop the valve respectively; this arrangement normally prevents flooding and provides a constant head of product on the feeder for repeatable flow characteristics. However, paddle type limit switches frequently failed contributing to flooding, overfilling the hopper and choking the Breather Sock, this results in varying volumetric flow to the batching tank and contributing to erroneous slurry batch makeup.

To improve reliability of volumetric feeding and calibration of volumetric screw feeder (as lime density can change with different batches), the local load cells for the feeder hopper was used to trigger the rotary valve and intelligently confirm mass flow deviations and batch concentration.

Another problem was the chute blockage between screw feeder and batch tank normally encountered during the rainy season. This was prevented by installing a clamp on vibrator was installed on the chute to assist in breakup of any product build-up.

2.2 Batch Tank

A baffled batch tank, split into two compartments, batching and maturation, each with its own agitator.

The batching tank has a filling valve (using service water) to maintain a level set point in the tank via load cells. The slurry in the batch tank is targeted to maintain a constant slurry concentration (circa 4 - 5%); hence the rate at which lime powder enters the tank is in proportion to the rate at which service water enters the tank.

One of the problems with this design is that the baffle slots that allowed the slurry to pass from the batching section to the maturation section became blocked with the lime and grit solids, thus needing frequent tank cleanouts.

In order to rectify this, the intermediate baffle was removed; this reduced the frequency of tank cleanouts and certainly improved the tank mixing.

2.3 Slurry Feed System

The lime slurry pumps are fixed speed centrifugal pumps, which are designed to provide excess slurry flow allowing significant recirculation flow back to the batch tank to reduce settling in the slurry lines. Slurry is pumped from the slurry tank to a header where dosing valves control the flow rate of slurry to the dosing points and a recirculation valve on the slurry tank controls the recirculation flow back to the slurry tank. Each batching tank has a slurry pump and a duty/standby dosing valve. Pipework consist of quick connect flexible hoses for easy cleanout of any blockages.

A major problem is the rapid blockage of dosing valve lines with slugs of lime. All large diameter (50mm) hoses fall from the pump header and rise to the valve header, providing a settling area and compacting at the base of the loop. This settling occurs during off-cycles and when the next start-up cycle occurs, the compacted sludge is pushed to the control valve connection which reduces from a 50mm to 20mm and these results in the control valve blockages and will not clear. Therefore, before any start-up cycle, it’s an operator’s task to manually disconnect hoses and flush these lines to prevent rapid blockage and plant down-time. With the plant having to start-up daily, a high number of operating hours was allocated to prevent lime failures.

Operating with high slurry concentrations creates high wear rates in the dosing valves and the recirculating pump. This high wear rate in the valves and pump also affects the lime slurry dose rates, adding to the existing control system's problems. When dosing a high slurry concentration into the RO permeate water the lime solution has had less than ONE minute to react and the undissolved lime would rapidly gravitate to the bottom of the feed well due to the superficial velocity being < 0.6 m/s, the poor design of the feed well created low velocity areas where the particles can settle and build-up, especially at low flow rates (again the design expected the plant to operate > 22.5MLD). Therefore, during periods of low flow (≤ 22MLD = 3 RO Units), the undissolved lime settles in the feed well and builds up to an equilibrium level in the chamber, when flow rates do increase above 3RO units these solids will rise and creates turbidity, pH and free chlorine spikes fouling instruments and effecting chemical dose rates for lime and sodium hypochlorite.

These issues were reduced by implementing pipework configuration changes, pipe-lengths were minimised, loops were removed, batch tank concentration was reduced from 5% to 2.5% slurry and in addition an automated inline flush cycle was introduced after plant shutdown to prevent slugs of lime sludge settling out in pipework.

To increase batch tank reliability, critical equipment such as slurry pumps and dosing valves were made redundant for allocation to either batching system.

2.4 Control System Upgrade

The initial method for pH correction of treated water used a fixed rate of carbon dioxide and a variable rate dosing of lime, at a set strength in a bulk batch, which is then dosed into the water stream at a flow rate controlled in relation to the pH of the treated water feed well. A disadvantage of using variable lime dose is that the response time to changes in water quality will be longer than if CO_2 were used as variable dose rate.

The control system was then upgraded to include the option to allow fixed lime dosing and pH control by the adjustment of CO_2. In addition to the functionality of the TRIM controller, the PID function is to be suspended (Trim-off) when there are significant and rapid process flow changes detected. As it is, the transient flow delivers non-representative sample to instruments resulting in erroneous feedback on water quality.
The original control system did not have any dosing limits, and sometimes attempted to push the dosing valves beyond their maximum flow rates. There were also no discrepancy alarms for the batching and dosing volumes, allowing variable batching and dosing volumes to pass on unchecked or corrected. This led to poor control of treated water pH and chlorine.

Alarms were then introduced to provide adequate time for the operator to respond before the plant shuts down on pH deviations viz., lime dose discrepancy with a blocked dosing valve, device failures on the batching system other than critical devices.
The high concentration of the lime slurry created problems in the instrumentation of the purified recycle water. The free chlorine, total chlorine and pH sample cells would have an accumulation of fine lime in them, contaminating the probes and causing excessive wear.

With the high concentration of lime slurry, a build-up of fine lime on the floor of the weir boxes in each of the Treated Water Tanks required regular cleaning by commercial divers.

2.5 Treated Water Quality Comparison

The following graphs, Figure 2 and 3 compares pH and free chlorine improvement after the lime system upgrade. In addition, the free chlorine analyser has no pH compensation, and therefore will always provide an erroneous dose of hypochlorite during extreme pH events and thus be unable to meet purified water chlorine, requiring manual dosing of sodium hypochlorite. In the graph below, the free chlorine SP is at 1.2 mg/l.

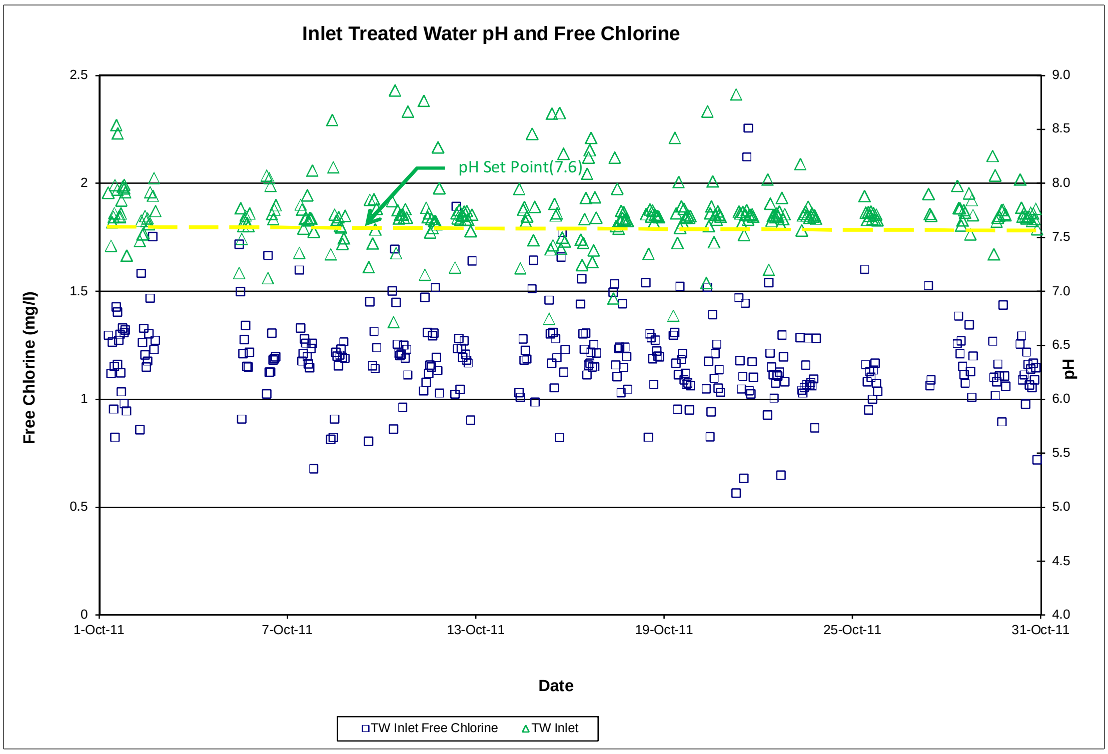

Figure 2: ***Treated Water pH and Free Chlorine before Upgrade***

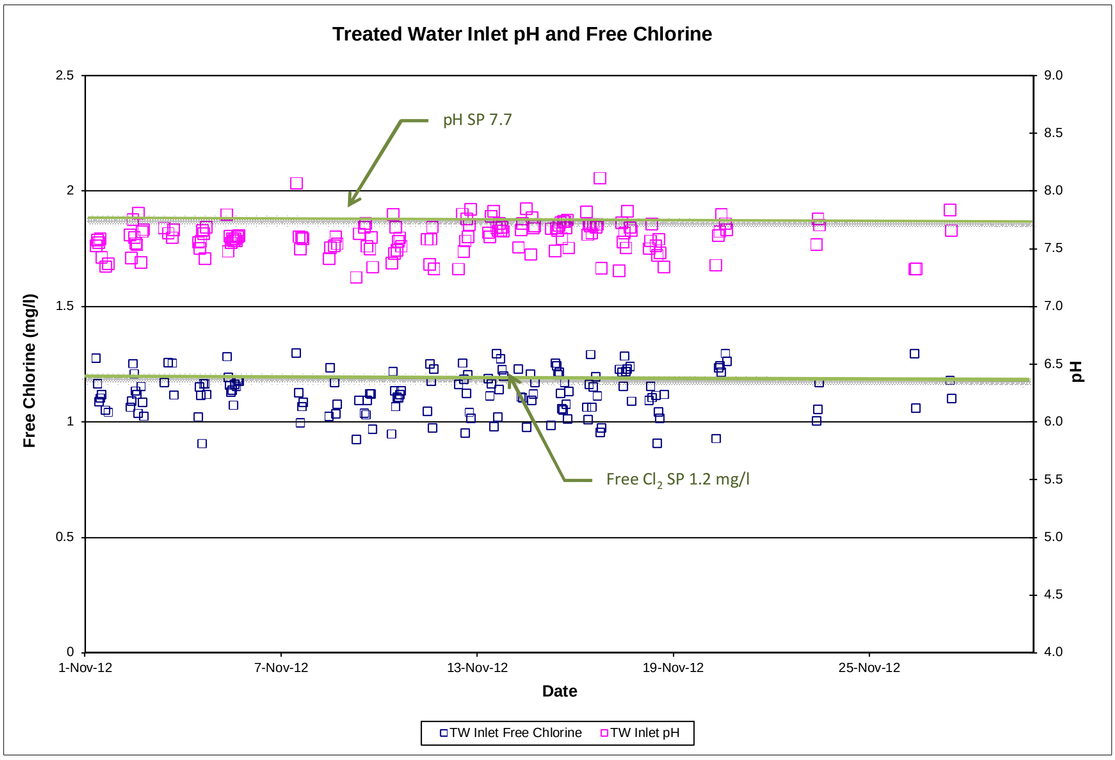

Figure 3: ***Treated Water pH and Free Chlorine after Upgrade***

3.0 CONCLUSION

Lime systems are plagued with problems and require frequent maintenance and operator attention, however, these problems can be minimised by incorporating remedial measures at a reasonable cost and these are detailed in Table 1 below:

Table 1: ***Lime Dosing System with Summary of Problems and Remedies***

Problem	**Remedy**
Inconsistent batching	Use load cells for accurate metering of powder
High wear in pumps and flow meters	Reduce batch concentration to < 2.5%
Clogging of slurry dosing valves and transport lines	Install efficient pipe configuration and implement auto flushing when system shut down
Instrument fouling and poor response to change	Design feed wells with low HRT and provide a representative sample to analysers

4.0 ACKNOWLEDGEMENTS

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