CHEMICAL OVERDOSING – THE NEGLECTED WATER TREATMENT RISK?

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ABSTRACT

Chemical addition in the water treatment plant is a critical process in the provision of safe drinking water. This process step presents the very real and often underrated risk of chemical overdosing in the water supply system.

This risk was highlighted to Barwon Water after two separate near misses involving chemical overdosing to the potable water supply. Barwon Water subsequently conducted investigations to establish the root cause of each event and developed and implemented control measures to eliminate each hazard.

Following this, a comprehensive chemical dosing system review was conducted at each water treatment plant to assess, establish and implement effective control measures to manage the risks presented by chemical addition at each site.

1.0 INTRODUCTION

Barwon Water has a responsibility to provide safe drinking water to its customers under the Safe Drinking Water Act 2004. To meet these obligations, Barwon Water has developed a drinking water quality risk management plan and maintains Hazard Analysis Critical Control Point (HACCP) certification for the supply of drinking water.

Water treatment plant Critical Control Points (CCPs) and Process Control Points (PCPs) provide for control of the treatment plant process during normal plant operation. Historically these control points have particularly focused on hazards present in the incoming water (e.g. pathogens). This has rightly given prominence to the filtration step (measured by Turbidity) and disinfection step (measured by chlorine residual) to minimise the microbial risk. A significant amount of effort has been spent at Barwon Water on managing these risks, and they have been managed effectively for some time now.

In recent years Barwon Water has had two near misses with chemical overdosing in the potable water supply. These near misses highlighted the need for a greater emphasis on managing risks *introduced* at each process, of which chemical addition is the most significant. This includes pH correction with chemicals such as Sulphuric Acid and Sodium Hydroxide, Disinfection using Chlorine gas or Sodium Hypochlorite, and fluoridation.

2.0 DISCUSSION

2.1 Chemical Overdosing Event #1

The Event

In 2011 a chemical system upgrade was taking place. The upgrade involved the decommissioning of a Chlorine Gas dosing system, and the commissioning of the new Sodium Hypochlorite dosing system on the treated water supply.

Commissioning of the new Sodium Hypochlorite dosing equipment took place on a Tuesday, after which time the treatment plant was shut down. The following Friday the

treatment plant was restarted using the Chlorine Gas dosing system. Upon plant start up a high chlorine residual was observed on the treated water analyser. The high residual was then confirmed on a portable instrument from a grab sample and the treatment plant was immediately shutdown. Investigation into the cause of the high chlorine residual revealed the Sodium Hypochlorite had on the previous shutdown, syphoned from the bulk storage tank and into the treated water main connecting to the CWS basin.

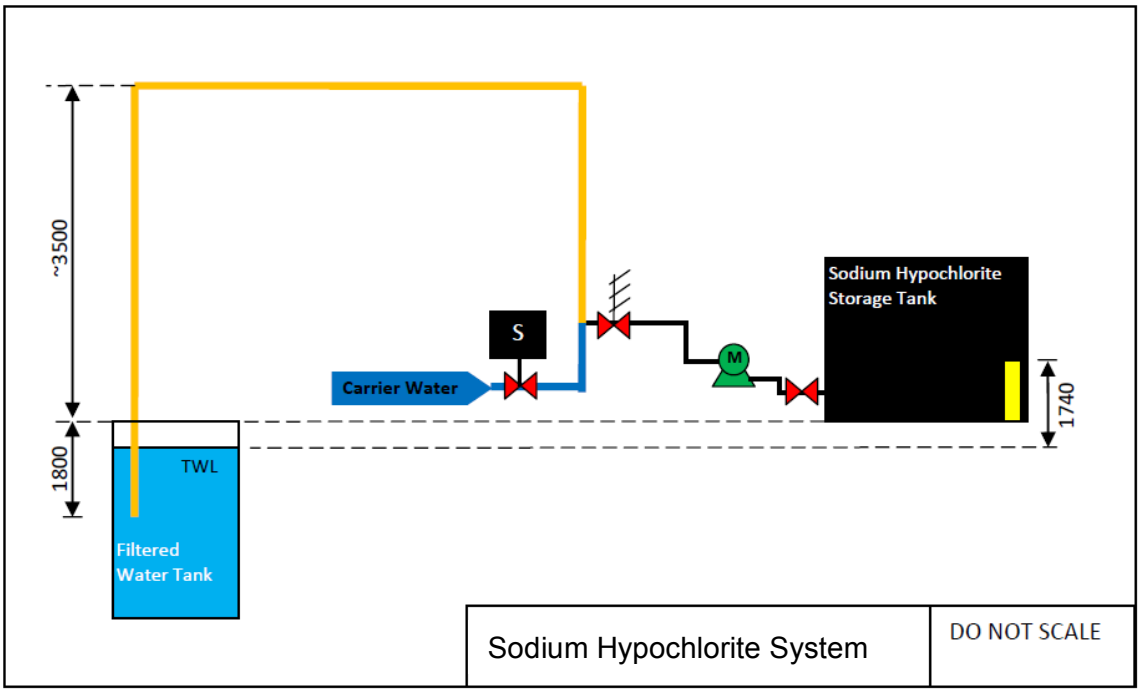

Figure 1: ***A Schematic of the Sodium Hypochlorite Dosing Configuration.***

The control that worked

The existing control systems in place that worked and helped in preventing the overdosed water from reaching customers were:

- Continuous online Chlorine residual monitoring and alarming of the treated water and the CWS basin alerting the operator to a high chlorine residual.
- SCADA controls which automatically shut down the treatment plant process on the high treated water Chlorine residual.
- The onsite operator's knowledge and understanding of the system to quickly contain and isolate the overdosed water.
- Prompt escalation of the incident through a chain of command which allowed the establishment of a recovery plan to resolve the situation.
- The planning of upgrade works in the off peak season to avoid high demand periods.

Other factors that contributed to a good outcome

Several other factors during the near miss also helped prevent customers receiving the overdosed water. These factors were:

- The CWS basin is an isolated storage and does not feed the reticulation directly. It has to be pumped from the basin to other storages into the reticulation.
- The transfer pumps were not transferring any water from the clear water storage at the time of the event and were shut down and isolated once the high chlorine residual was discovered.

Recovery

The entire volume of the CWS basin had to be pumped to waste to remove the overdosed

water. The pumping process began at 12 pm and continued through to 8am the following morning, a total of 20 hours. The transfer to waste had to be done over a long period of time to avoid any overloading on the system. The treatment plant was brought back online at 8am on the Saturday and resumed normal operation and began refilling the CWS basin.

Key lessons

Following the near miss an investigation into the incident was conducted, and the following key lessons were gained:

- New chemical dosing systems need to have documented design and control narratives that are reviewed prior to commissioning. No formal design or control narrative was in place for the new dosing equipment defining equipment specification, system pre conditions and start permissive details. If the formal design was in place specific equipment could have been selected to eliminate syphoning, and increase control measures to eliminate the equipment operating without prestart conditions being met.
- New chemical dosing systems need documented commissioning plans, even if done in house. In this instance, a commissioning plan would have established specific details of the sequence of commissioning, controls for associated risks, system isolations and defined responsibilities of all parties involved.
- Chemical flow meters on critical dosing systems provide an excellent control for overdosing, both when on and offline.

2.2 Chemical Overdosing Event #2

The Event

In November 2012, a maintenance task was being undertaken to replace a sample water pump for the delivered water Chlorine residual monitoring at the treatment plant. The sample pump also had a secondary function as a carry water pump for the Sodium Hypochlorite dosing on the outlet of the CWS basin. The installation of the new sample pump took four hours to complete. During this time the Sodium Hypochlorite dosing pump continued to operate and dose into a static carrier water line. As the sample pump had been shut off the analysers monitoring the delivered water pH and Chlorine residual were isolated. Once the sample pump was replaced it was test run for ten seconds to confirm the correct operation. This resulted in a neat slug of Sodium Hypochlorite being sent directly into the delivered water main. Normal operation of the sample/carry water pump commenced shortly after and the online instrumentation sample flows resumed. The online Chlorine residual analyser detected a spike above 5mg/l. This was immediately noticed by the operator and it was identified that the neat slug of Sodium Hypochlorite had entered the delivered water main.

The controls that worked

The existing control systems in place that worked and helped in preventing the overdosed water from reaching customers were:

- The online Chlorine residual monitoring that sent out an auto dialler alarm.
- The planning of maintenance in the off peak season to avoid high demand periods
- The PCP exceedance prompter sheet being followed correctly alerting the Senior Process Engineer quickly.

Other factors that contributed to a good outcome

Other factors during the near miss also helped prevent customers receiving the overdosed

water were:

- A maintenance crew was in the area conducting mains scouring in the reticulation.
- The long length of water main before the first customer allowing time to develop a systematic approach.

Recovery

The volume and location of overdosed water was established based on current pipe size and demand flow in the delivered water main. This information then was then used to establish a strategic mains scouring program in the reticulation to remove the overdosed water before it reached any customers. The scour points were established and during the scouring of each point grab sampling of the Chlorine residual was done to confirm the overdosed water had been removed from the reticulation.

Key lessons

Following the near miss an investigation into the incident was conducted, and the following key lessons were gained:

- A clear understanding and labelling of sample and chemical dosing systems is critical, particularly at older facilities. The operator was unaware that the sample pump also doubled as a carrier water pump, and so the risk of turning this off was not identified.
- When doing maintenance at treatment plants, up front planning is critical. If a systematic plan had been developed, it would likely have taken into account the entire carry/sample water line and ancillary equipment. This would have identified the Sodium Hypochlorite dosing pump and stated control measures to isolate it.
- Control permissive linking dosing pumps to carrier water systems are critical. No controls in place to prevent the Sodium Hypochlorite pump from running if the carry water pump was shutdown.
- Control permissive linking dosing pump operation and measured chlorine residual are important. No control was in place to stop the Sodium Hypochlorite pump from running if a high Chlorine residual was detected.
- Long lag time between the dosing point and the sample analyser can delay appropriate response to plant issues, and should be eliminated where possible.
- Chemical flow meters on critical dosing systems provide an excellent control for overdosing, both when on and offline.

2.3 Changes Made to All Systems as a Result

The near misses at the two treatment facilities had some unique characteristics associated with the particulars of those systems and plants. However, many of the key lessons applied to all water treatment plants.

In light of this of this, rigorous audits were conducted across each of the water treatment plants to assess and identify the hazards associated with each chemical installation and developed a scope of works to prevent chemical overdosing. The audit identified key improvements to be made across all sites from administrative controls to elimination of the risk. These included:

- The installation of chemical flow meters on all critical treated and delivered water dosing applications (chlorination and pH correction).

- The installation of instrument flow monitoring with shutdowns on all treated and delivered water chlorine and pH instruments. If there is no measurement, there is

no way of guaranteeing there is not an overdose event happening.

- The production of delivered 'water time charts to first customer' with scour locations to assist with prompt response in the event of an overdosing event.
- The programming of plant shut down on high Chlorine and high/low pH
- The installation of process water flow monitoring with shut down function.
- Installation of pressure sustaining valves (backpressure) on each chemical dosing point to prevent negative pressures that favour chemical syphoning.
- Programmed alarm and control testing for all critical quality measurements that are linked to chemical dosing
- The automatic isolation of bulk chemical storages when treatment plants are offline to prevent syphoning.

Figure 2: ***A Sodium Hypochlorite dosing system incorporating dosing pumps, flow meter, backpressure valve, pressure gauge, carrier water supply and check valves.***

Figure 3: ***A Flow Sensor on a Sample Water Pipe.***

Figure 4: ***A Sodium Hypochlorite dosing installation showing the chemical flow meters, backpressure valves and carry water pipe work.***

3.0 CONCLUSION

Water treatment plant operation is all about managing hazards associated with drinking water. Some of these hazards enter the WTP with the raw water, and others are introduced by the process of treating and managing the hazards associated with the raw water.

Traditionally water treatment risk management focused on incoming risks, and particularly pathogen control via filtration which is measured by turbidity, and disinfection, measurable by Chlorine contact time. These controls rightly take prominence in the treatment risk management plan. Unfortunately some introduced hazards in the treatment process, such as chemical overdosing, are often unrecognised, underestimated and not adequately controlled. This came to Barwon Water's attention after two near misses involving chemical overdosing of the potable water supply.

As a result of the near misses, Barwon Water implemented a number of changes across all of its water treatment plants to manage the hazards presented by chemical addition. The changes varied from plant to plant but common upgrades included improvements to SCADA systems, the introduction of routine alarm testing, installation of chemical flow monitoring, flow monitoring of carry water and sample water streams and bulk chemical storage tank automated isolation valves.

These new control measures have successfully mitigated the risk of chemical overdosing and have strengthened an already robust drinking water quality risk management system.

4.0 ACKNOWLEDGEMENTS

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