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Microbrewery Shines with Safer Cleaning and Sanitizing Technology

Merrimack Ales of Lowell Tests and Scores with Safer Alternatives

Merrimack Ales is located at 92 Bolt Street in Lowell, MA. The microbrewery is owned and operated by Adam Pearson of Westford. One other full time employee works in the facility. In the 6,000 square foot facility, Merrimack Ales brews a variety of beers currently distributed throughout the Merrimack Valley.

Merrimack Ales received two small business grants from the Toxics Use Reduction Institute (TURI) during fiscal years 2016 and 2017 to test alternative technologies and processes for cleaning and sanitizing their brewing and fermenting vats. The objective was to identify and implement materials better for worker health and safety and the environment.

Baseline before testing: The brewery used a cleaning- and sanitizing-in-place process using chemicals common in food applications. Merrimack Ales used powdered brewers wash (or PBW) for cleaning their tanks. The PBW was mixed with 30 gallons of heated water to a 1.5% (by weight) concentration. PBW contains 30% Sodium Metasilicate with the pH of a 1% solution of 11-12. The sanitization process was completed using Saniclean, a product containing phosphoric acid at 29% and sulfonated oleic acid at 10% with a pH of 1. The sanitizing solution was diluted with 15 gallons of water to a 2.3% concentration and used at room temperature.

Overview

Three testing phases took place over the two-year period.

Phase I: The first phase of the testing involved electrochemical activation technology (ECA) – running electricity through salted water to generate free chlorine – to generate two separate cleaning and sanitizing liquids. The cleaning liquid (detergent) is a weak (approximately 400 ppm) sodium hydroxide solution with a pH of greater than 11.4. The sanitizing liquid is a hypochlorous acid and sodium hypochlorite mixture with a pH of 6.8 and 190 ppm of free available chlorine. The results of that phase are summarized in a previous case study published by TURI. Test results demonstrated that this process, while showing promising results, was not economically feasible. Specifically, the ECA device used was not available with the right capacity at the right price point. Based on the potential for proper cleaning and sanitizing, however, the brewery wished to pursue additional testing.

Phase II: In this phase, a different ECA device typically used for janitorial applications was evaluated. This ECA system uses proprietary salts and electricity to generate a detergent and sanitizer. The salts used to generate the detergent contain potassium carbonate at <0.3% with a pH of 10-11. The salts used to generate the sanitizing agent contained acetic acid at <2.5% with a pH of 2.75. The use of the detergent from the ECA device did not result in adequate cleaning. However, mixing PBW with this ECA detergent produced better results. In addition, reducing the total volume of cleaner and sanitizer by half (from 30 gallons to 15 of each) was shown to produce acceptable results. An attempt to reduce the volume even further by using an electrostatic sprayer to apply the sanitizer was evaluated and determined to be impractical because the spray applicator could not reach all necessary inside surfaces.

Phase III: Having reduced the volume and temperature of the PBW cleaning mixture, the brewery decided to stick with the PBW cleaning process. However, based on other TURI cleaning and sanitizing projects, the brewery next tried a different approach to sanitization by generating a sanitizing solution using NaDCC (sodium dichloroisocyanurate) tablets. With this method, hypochlorous acid is generated by dissolving the tablets in five gallons of water and then diluting with another ten gallons.

Outcome: Based on positive cleaning results from Phase II and Phase III the brewery has chosen to implement cleaning using the original PBW, though in smaller quantities, and sanitization using the NaDCC process. Because of this change in process, Merrimack Ales is realizing improved worker health and safety benefits by using less hazardous ingredients, and reduced material handling and water use.

Overview Summary			
Phase	***Function***	***Product & Ingredients***	***Characteristics***
Baseline	Detergent	PBW: 30% Sodium Metasilicate	pH 11-12
	Sanitizer	Saniclean: 29% phosphoric acid and 10% sulfonated oleic acid	pH 1
Phase I: Cleaning and Sanitization using ECA – large capacity	Detergent	Catholyte: weak sodium hydroxide	400 ppm NaOH pH >11.4
	Sanitizer	Anolyte: hypocholorous acid and sodium hypochlorite	190 ppm free available chlorine pH 6.8
Phase II: Cleaning and Sanitization using ECA – janitorial capacity	Detergent	Potassium carbonate mixture at <0.3%	pH 10-11
	Sanitizer	Acetic acid <2.5%	pH 2.75
Phase III: Sanitization with NaDCC tablets	Detergent	PBW: 30% Sodium Metasilicate	pH 11-12
	Sanitizer	NaDCC tablets generating hypochlorous acid	100-200 ppm free available chlorine

Testing Detail by Phase

Phase I:

The ECA technology tested in Phase I generated two solutions – a detergent, catholyte, which is a weak sodium hydroxide solution of approximately 400 ppm and a pH of greater than 11.4. The second is a disinfectant, anolyte, a hypochlorous acid and sodium hypochlorite mixture with a pH of 6.8. The anolyte has 190 ppm of free available chlorine.

This technology has been implemented successfully at industrial breweries but only in bottling operations. It had not yet been tested in brewing tanks and fermenters. Testing at Merrimack Ales included four trials of the cleaning and sanitizing process. ATP meter readings were taken between each step in the process.

Merrimack Ales concluded that the catholyte solution could partially replace the current caustic detergent in use and the anolyte could completely replace the products used for sanitization. However, the ECA unit currently available is cost prohibitive for a microbrewery the size of Merrimack Ales. Therefore, the microbrewery pursued additional options. Full details of this phase of testing can be read in a previous TURI case study.

Phase II:

Phase II testing involved a smaller ECA device than the one used in Phase I, one marketed for janitorial use. The smaller ECA system also generated separate cleaning and sanitizing liquids. Two dedicated totes were filled with about 60 gallons of water, one for the cleaner and one for the sanitizer. Proprietary salt mixtures provided by the vendor were mixed with the water at a designated ratio. The salts added to the cleaner also included a green dye to differentiate it as the cleaning solution. An electrically charged wand was hung in each tote for a fixed period of time to generate the prescribed concentration of chlorine for the cleaner and a higher concentration for the sanitizer.

Once the solutions were generated, their efficacy for cleaning and sanitization were tested on the brewing and fermenting vats. As part of the testing, two bacterial monitoring methods were used to evaluate the degree of cleanliness and sanitization achieved in the tank interiors:

1. For in-field measurements, adenosine triphosphate (ATP) monitoring was conducted using a handheld ATP meter. This ATP test rapidly measures actively growing microorganisms. For this test, a swab was used to wipe a consistent location within the tank and was then inserted into the ATP meter, which provided a result within 15 seconds (as shown counting down on photo). A reading under 10 was considered acceptable; however, a reading under 5 was preferred in this case and a reading of zero was ideal.

Demonstrating use of the ATP meter

2. The second method involved off-site lab testing of a swab sample taken from the same location within the tank interior. The swab was kept cold and sent to a third party lab for bacterial analysis. The lab prepared plate cultures to determine if any bacteria grew on the sample taken from the tank interior.

Demonstrating swab preparation for off-site analysis

To understand how well the solutions had cleaned or sanitized, baseline measurements were made on the mashtun, brew kettle, and fermenter, as noted in the table below. The results showed that after rinsing and cleaning the mashtun using the original rinsing and cleaning process, bacteria was present. (After initial testing on the mashtun, a decision was made to focus on the brew kettle and fermenter, given that wort coming from the mashtun would be exposed to a minimum 60-minute full boil and another 30 minutes above pasteurization temperature. Risks for post-boil parts of the process were more of a concern.) The brew kettle monitoring indicated ATP readings below five throughout the process as well as no detection of bacteria from the samples sent off site for testing. For the fermenter, the ATP readings dropped throughout the rinsing, cleaning, and sanitizing processes to five counts or less. There was no detectable bacterial growth detected for the off-site swab samples.

A second round of baseline measurements was conducted on the brew kettle and fermenter. The brew kettle had significant bacterial cultures after rinsing only, but this was likely because the kettle sat over the weekend prior to cleaning.

Having collected the baseline measurements, the second phase of ECA testing took place using the smaller janitorial system. The results of that sampling are also included in the table below. The testing took place on the fermenter as that is the easiest component to clean and sanitize. These initial results would determine if moving on to more difficult cleaning tasks would be worthwhile. The results showed that there were bacteria present after rinsing, cleaning, and sanitizing. However, the ATP results dropped to zero after re-washing with a 50/50 mix of the ECA detergent and the original cleaning product (powdered brewers wash or PBW) at 130 degrees F. The final ATP and bacterial cultures were at an acceptable level after final sanitization.

"We are very interested in making our processes safer for us and the environment. TURI is a great resource for us to learn about technologies we didn't know about and the opportunity to pursue this safer alternative is fantastic."

Adam Pearson, Owner, Merrimack Ales

Limitations noted with this method were that this process used up to 30 gallons of cleaning and sanitizing solutions per test, and that the results were only acceptable if the ECA cleaner was mixed at a 50:50 ratio with the PWB.

To address the first limitation, the vendor suggested that the volume of product used could be significantly reduced using an electrostatic sprayer to create a mist of the solutions to clean and sanitize the tanks. Cleaning and sanitizing solutions were therefore poured into the sprayer's quart-sized reservoir and the sprayer was held up at the inlet at the top of the fermenter to determine if the spray could reach all of the interior surfaces of the tank. Unfortunately, it was difficult to administer a steady mist that did not form droplets before entering the tank. The sprayer modification was therefore deemed to be not technically feasible.

As the cleaning process seemed to work best with a 50/50 mixture of PWB and the ECA detergent, the safety data sheet of the PWB was revisited. The hazardous ingredient in the PWB is sodium metasilicate at 30%. This is a corrosive chemical with a lower overall hazard rating (per NFPA) than more traditionally used chemicals like NaOH and NaOCl. With proper use of personal protective equipment (such as gloves) it is considered a good option. Given this evaluation, testing moved forward with a focus on finding alternatives for the more hazardous acids and caustics usually used in the sanitization process, often at high temperatures.

Baseline and Phase II ECA Testing Results									
Equipment/Stage	***Baseline 1***			***Baseline 2***			***Phase II ECA***		
	ATP	Colony Count[1]	CFU	ATP	Colony Count	CFU	ATP	Colony Count	CFU
Mashtun									
Upon emptying	11		ND						
After cleaning	254	GNR: 15 GPC: 2 GPR: 14	3100						
Brew Kettle									
After emptying	2		ND						
After rinsing	0		ND		GNR: 548[2]	548,000,000			
After acid						ND			
After cleaning	4		ND			ND			
After sanitizing						ND			
Fermenter									
After emptying	1259		ND						
After rinsing	223		ND	95		ND	8475		ND
Upon cleaning	32		ND	2		ND	155[3]		ND[4]
After sanitizing	2		ND	5		ND	3	GNR: 2	200

[1] GNR = gram-negative rods; GPC = gram-positive cocci; GPR = gram-positive rods.

[2] Kettle sat over the weekend before cleaning.

[3] Dropped to 0 after re-cleaned with 50/50 mix of ECA detergent and powdered brewers wash (original cleaner) at 130°F.

[4] Stayed at ND when sampled after 50/50 cleaning as noted in footnote 3.

Phase III:

After completing these tests of the ECA cleaning and sanitizing method, TURI then drew on its experience from other cleaning and sanitizing projects. Specifically, the TURI lab has assisted other organizations, such as day care facilities and food service operations, shift from the use of bleach-based sanitizing methods to sanitizing using a system that relies on the generation of hypochlorous acid using NaDCC (sodium dichloroisocyanurate) tablets (trade name Bru-Tab or Pur-Tab).

Encouraged by the success observed at these other operations, the brewery moved on to test NaDCC for the sanitizing the fermenter. The objectives of this test were to confirm the effectiveness of the tablets in sanitizing a recently cleaned tank and testing for the presence or absence of detectable chlorine after sanitizing and rinsing.

Demonstrating use of the NaDCC tablets

Before using the tablets for sanitizing, the cleaning process was initiated (now using less cleaning solution and at a lower temperature testing):

- The fermenter was emptied of product and room temperature water was used to rinse the tank to remove gross debris.
- The tank was washed with 140°F degree water mixed with powdered PBW – mixed at 0.75 oz PBW per gallon of water. Fifteen gallons of this solution was used to wash the tank for 10 minutes.
- The tank was rinsed and flushed for five minutes with room temperature water.

The new sanitization process, using the NaDCC tablets, consisted of the following steps:

- Mixed 6 tablets with 5 gallons of room temperature water to dissolve the tablets, creating a solution with 100-200 ppm detectable chlorine.
- Emptied the bucket into the fermenter and added an additional 10 gallons of tap water.
- Recirculated the sanitizer in the closed fermenter for five minutes by pumping through a spray ball at the top of the tank.
- Flush rinsed the tank with room temperature water for five minutes.

Adding sanitizer to the fermenter

Testing was performed during the cleaning and sanitizing to evaluate the effectiveness of the tablets in sanitizing the tank:

- The tank was wiped with a test swab to both gain an ATP meter reading and to send for off-site analysis. The tank was swabbed in the same location at each step (inside the tank, on the left side, near the manway opening at approximately five feet off the bottom of the tank).
- The off-site lab swab was administered followed by the ATP swab. The lab swab was taken to the refrigerator to keep for shipping on ice once all swabs were collected. The ATP results were then recorded (it takes approximately 15 seconds to get a reading on the ATP).
- A chlorine meter was then held inside the tank at roughly the same location of the swab test area.

The results of the testing are recorded in the table below:

NaDCC Tablet Results				
Sample Taken	***Date/Time***	***ATP[1]***	***Chlorine Meter[2]***	***Lab[3]***
After cleaning and rinsing	5/17/17, 11:30 AM	2	No alarm	None detected
After sanitizing	5/17/17, 11:40 AM	0	Alarm	None detected
After flush rinse	5/17/17, 11:52 AM	0	No alarm	None detected

[1] ATP reading of <10 is acceptable, <5 is preferred, and 0 is ideal.

[2] Chlorine meter threshold is set to alarm at concentrations at or above 0.5 ppm.

[3] A bacterial count result of "none detected" is desirable.

Conclusions

Based on the results seen using the NaDCC tablets, Merrimack Ales decided to transfer their operations from the old sanitization method to the use of the NaDCC tablets. Merrimack continued to collect ATP data as they made this transition so that, with enough data, they would be confident that there would be no contamination in their brewing process.

Prior to this project the brewery used a product called Saniclean to sanitize the tanks. Saniclean contains a solution of phosphoric acid and sulfonated oleic acid at 29% and 10% respectively. Phosphoric acid is also irritating to skin and eyes, as is the sodium metasilicate in the PBW. However, it also has an increased potential to cause birth defects, impact other organs, and damage the nervous system of people exposed to it.

The tablets are also handled minimally in the sanitizing process. They are removed from the container and dissolved in the bucket of water, using appropriate chemically-resistant gloves. Chlorine gas was detected at low concentration inside the tank after sanitizing, but this is a closed loop system and there was no chlorine detected outside the tank, so the risk of worker chlorine exposure is minimal.

Cost Comparison

For the cleaning operations, the brewery decided to continue to use the PWB. However, they were able to find a new vendor that sold a comparable product at significant savings. Analyzing the cleaning process in the kettle and the fermenter, a savings of $190 annually is achieved by using the cleaning product from the new vendor.

For the sanitizing operations, the brewery has switched to the NaDCC tablets. The product is actually more expensive than the previously used sanitizer, and there is an increase in annual costs of $96. However, there are additional non-monetary benefits as noted above to drive this change.

Essentially, the changes Merrimack Ales has made are cost-neutral. The advantages of a safer work environment, reduced water usage and materials handling, however, have made this change very attractive.

Moving Forward

Based on the testing results obtained during this phase of the project, the brewery is confident about moving to the NaDCC tablets for their sanitization process. They would also recommend the product for others.

However, based on the initial testing of the ECA technology in Phase I of the project, the brewery is still interested in using an ECA cleaner and sanitizer. By doing so, they could use less cleaner. The original ECA technology also only relied on salt and electricity – easily obtainable and relatively inexpensive ingredients, whereas the second ECA system required vendor-provided salt mixture packets. If the original vendor manufactured a unit with a payback of 12-15 months, the brewery would switch to that technology. It would be advantageous for the brewery to use the ECA system to generate a batch of cleaner and sanitizer at the start of the week, and during off hours, and have it ready to use during the week. The unit could also be easily scaled up for use as the brewery grows.

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