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PASTEURIZED EQUIVALENT WATER BY ULTRAVIOLET LIGHT

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Abstract

The Grade "A" Pasteurized Milk Ordinance (PMO) is the regulatory gold standard for the U.S. dairy industry. Developed from a collaboration among industry, government, and academia, the PMO sets minimum standards and requirements for everything related to the production, processing, and packaging of milk.

As with most food industry regulations, the PMO is a living document. It's reviewed and revised every two years to incorporate new scientific research and new technologies. One of the recent updates, which first appeared in the 2009 PMO, was the approval of ultraviolet (UV) disinfection to create pasteurized equivalent water for use in cleaning and rinsing applications. This represented a major shift, as previously, much of the water in dairy plants was pasteurized using traditional heat treatments.

To learn more about how UV disinfection works and the different UV options available for dairy processing, we spoke with Ismail Gobulukoglu, the chief scientist at Aquafine Corporation, which is the industrial arm of Trojan Technologies. Aquafine has been in the business since 1949, developing UV solutions for total oxidizable carbon (TOC) reduction, chlorine and chloramines destruction, ozone destruction, and disinfection.

Gobulukoglu has been with the company for 15 years, focusing primarily on the treatment of water for the inactivation of microorganisms. In particular, he specializes in the disinfection of water to meet PMO requirements.

What is UV light and how does it work to disinfect water?

UV light is the type of electromagnetic radiation emitted by the sun. The wavelengths of UV light range from 10 to 400 nanometers (nm), putting them between x-rays (←10 nm) and visible light (400 to 700 nm) on the electromagnetic spectrum.

UV light kills cells by initiating a reaction that damages their DNA. That's why we should wear sunscreen, and it's also what makes UV a powerful disinfection mechanism for water. UV light can kill pathogenic microorganisms between 200 and 400 nm. The sweet spot for disinfection is 254 nm. (Learn more about the science of ultraviolet light).

Benefits of UV light:

- It's fast-acting — the DNA-damaging reaction occurs almost instantly.
- It doesn't create any disinfection byproducts that could be harmful.
- It's chemical-free, sustainable, and doesn't harm the environment in any way.
- It doesn't alter the water chemistry or properties (pH, taste, odor, color, etc.)
- It's less energy-intensive than traditional heat-based treatments.
- It's widely used in many industries.

The PMO lays out the criteria for using UV light to produce pasteurized equivalent water, which is water that is considered equivalent to pasteurized water. Specifically, the regulation states:

UV light shall be applied so that the entire volume of water receives at least the following dose when used as pasteurized water.

- *Low pressure UV at 2,537 Angstrom (254 nanometers) at 186,000 microwatt-seconds per square centimeter or a 4 log adenovirus equivalent.*
- *Medium pressure UV at 120,000 microwatt-seconds per square centimeter or a 4 log adenovirus equivalent.*

Other requirements include various control elements to ensure all water receives the minimum dose of UV light, real-time monitoring to ensure the dose is consistent, and cleaning protocols to ensure the system always works at peak performance. The goal, Gobulukoglu notes, is to ensure the sanitary quality of the water used for cleaning and rinsing so that no contaminants are transmitted to the equipment it comes into contact with.

Low pressure vs. medium pressure UV lamps

As you can see from the PMO requirements, there are a couple of different types of UV lamp technologies that are effective: low pressure and medium pressure. Both low pressure and medium pressure lamp technologies are currently available for dairy applications, and Gobulukoglu's talk at PROCESS EXPO will focus on the relative advantages and disadvantages of each. Here, we'll just give a brief overview of the main points. (Find more info here).

Low pressure lamps

Low pressure UV lamps are monochromatic. This means they have a single disinfection peak that occurs at 254 nm. These lamps operate at a low temperature (~105°F/40°C), and about 40% of the electrical energy that goes into the lamp comes out as UV energy. Due to the low temperature, fouling of the quartz sleeves (an issue inherent in UV lamps) is minimal, which means the cleaning requirements are minimal as well.

Medium pressure lamps

Medium pressure UV lamps are polychromatic, meaning that their output spectrum encompasses multiple wavelengths. They operate at a much higher temperature (~1470°F to 1650°F/800°C to 900°C), and only 11 to 12% of the energy they consume becomes UV light between 220 and 280 nm. They also emit wavelengths outside of this range, but those don't work for disinfection. Because of the higher temperatures, fouling is a much bigger problem, so these systems require much more intensive cleaning regimens.

Overall, low pressure lamps have the several advantages:

- They are more efficient.
- They cost less to operate.
- The maintenance is relatively low.
- They don't require a built-in cleaning system.

Some applications require other wavelengths for treatment, such as 185 nm, not just a single peak at 254 nm. Gobulukoglu will go into much more detail in his talk. The key takeaway for now is that there are multiple solutions available, and they each have benefits and limitations depending on the application.

Energy efficiency = cost savings

A major advantage that all UV light technologies offer for dairy processing is cost savings through lower equipment price tags and energy efficiency.

Gobulukoglu notes that traditional heat pasteurization is expensive. The equipment itself is pricey, and the operating costs are high because of the cost of energy is high. In contrast, UV technologies cost less upfront and "UV light is not different power-wise from long fluorescent tubes used in houses." The result is that the cost of producing pasteurized equivalent water is just a fraction of that of pasteurizing water with heat.

That's why when dairy processors plan new installations, most are choosing to go with UV immediately. "They aren't even considering heat pasteurization," Gobulukoglu says. "They're putting in new lines, they're aware of the PMO, and they know what they want. So, they tell us their requirements and we provide equipment that meets those requirements."

Looking into the future, Gobulukoglu predicts that this trend will continue to grow. "Going from traditional pasteurization to UV technology has great advantages for cost savings, both for equipment and operating costs," he says. "There won't be a return to a heat system."

Like all manufacturers, food processors are always on the lookout for ways to save money and make their operations more efficient, while also complying with regulations and ensuring the quality of their products. Using UV light treatment to produce pasteurized equivalent water enables dairy processors to achieve all of these goals.

To learn more about these technologies, and for the opportunity to ask any questions you might have, check out Gobulukoglu's talk at PROCESS EXPO 2017.

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