

Controlling Bacteria in Industrial Applications

The what, why, and how of industrial bacteria control in aqueous storage of synthetic diamond suspensions or non-organic suspensions.

RON ABRAMSHE, PH.D.

Needs Identification

The requirements to control bacteria in industrial applications where water suspensions and solutions are used are essential. Of special concern is when solids are used in a process and are in a suspension of particles 0.5 μ and finer. Many bacterial species are around the size of 0.5 μ and finer. Viruses, by comparison, are generally in the angstrom size range.

Many industrial systems such as hard disk texturing, planarization of sapphire disks, polishing of silicon carbide wafers, or super-finishing of medical prostheses, require sub-micron abrasives in a suspension. In some cases, multiple production lines are used, with miles of tubing and pumps delivering exact amounts of slurried suspensions to a silicon carbide wafer, hard disk or a computer read/write head.

In most cases, all these suspensions must pass through a filter before they are deposited onto the workpiece. These filters are usually 0.5 μ or 0.75 μ absolute in filtering capacity. Any particles that could quickly clog these filters, or to a greater detriment, pass through these filters, will lead to disastrous results. The bacteria in aqueous solutions are in the size range of these filters and can multiply rapidly during their reproductive cycle.

The mechanisms for disastrous results are two fold:

1. Bacteria that pass through filters can multiply in "dead areas" of a production system (e.g. elbows, tight curves, and low spots or sumps) or be allowed to multiply during tooling or product changeover. If left unchecked, when the process is resumed, the "bloom" of bacteria is usually deposited onto the work piece and either destroyed by the process, leaving a disagreeable bio-film, usually in the form of lipoproteins or polysaccharide glycocalyx, which

are difficult to clean, or the surviving bacterium is passed on to the next manufacturing cycle to repeat its reproduction. If passed onto an end user, the bacteria may lie dormant until conditions are right for reproduction at the customer's facility.

2. Bacteria that are not passed through the filtering systems can be so numerous that they require frequent filter changes creating a potential maintenance nightmare, in which it becomes impossible to sustain a production schedule and orders cannot be met.

In the high end-manufacturing world, delivery schedules are tighter than deadlines in the daily newspaper business. Any delays, chronic or acute, in the production and delivery process inevitably create disastrous bottlenecks and poor results.

Sometimes there is a dollar penalty for late deliveries. With ever tightening margins and reputations on the line, on time or ahead of schedule deliveries become very important.

Bacterial infestations are more common in areas of the world where there is a good deal of humidity and moderate temperatures. However, they are not limited solely to those sections of our globe. Once an infestation begins, it is very difficult to eliminate and remain infestation free. It becomes paramount to ensure that the products manufactured and shipped in aqueous form are bacteria free.

Much like the common cold, once one production line is infected, they usually all become infected.

In order to control a bacterial infestation, one must understand its sources. Bacterium, both good and bad, is all around us. The vector for infestation is usually through an outside source. Some examples are: a new chemical is added; process water is used that is untreated; ungloved human hands spread contamination; heating or air conditioning systems are turned on without cleaning; good management practices of employees are not practiced; or stored deionized water is not adequately treated, and so on.

Much like the common cold, once one production line is infected, they usually all become infected. The cost of replacing hundreds of feet of tubing per machine, e.g., breaking down and scrubbing metering pumps, wiping down the working elements of a production machine with sanitary wipes that cost \$1.00/foot, results in production downtime and other costly activities.

Contamination Control

Some typical problems that are found in manufacturing and storage facilities include environmental contamination, such as insufficient space for receiving and storing incoming products before testing and inspection. A production facility is prone to many sources of contamination such as elements/particulates from cardboard dust, byproducts from slitting or cutting operations, microorganisms generated by workers or ambient humidity, temperature, static electricity, and more. All these require manufactures to employ contamination control procedures.

Ideally, buildings should be appropriately constructed or remodeled to prevent, reduce, and control potential contaminants and support the environmental control program as discussed later. For example, simple control of dust may require that driveways and parking lots be paved.

Crowding or congestion may cause mistakes resulting in inadvertent contamination. Designated areas should be assigned for various production activ-

ities such as receiving, inspection/testing, manufacturing, disinfection, labeling, packaging, record keeping, etc. Traffic by personnel who do not work in or manage the designated areas should be held to a minimum.

Short and Long Term Approaches

The control of contamination involves both long and short term plans.

Short term (6 to 12 months): Employ Clean in Place (CIP) methodology. This procedure does not involve the additional use of chemicals or processes that may present the opportunity for providing a vector for bacterial growth or a vehicle for particle contamination. The process involves:

1. CIP using pasteurization techniques, e.g., pasteurization of vessels, mixers, all filling and transfer tubing, and centrifuge jars. Fortunately, it is not necessary to boil water to pasteurize it. Heating water to 65° C for six minutes will kill all bacteria, viruses, and parasites. This means that, other than storage vessels, we can eliminate bacteria from the systems at lower temperatures. For storage vessels, you can use slightly higher temperatures for a longer period. It is suggested that 80° C for ten minutes is more than adequate.

3. Clean all work surfaces using approved sanitizing cleansers and train employees in their use.
4. Require all employees to wash their hands frequently and to wipe down all surfaces using approved cleaners such as non-ionic surfactants.

Long term (12 months and beyond): Good Management Practices (GMPs) can be established with regard to sanitation, equipment, processes, and handling. Strive to follow the FDA regulations for the food industry specifically (21 CFR 110). The process involves:

1. Continue the pasteurization of aqueous diamond suspension products in vessels by the techniques stated above.
2. Test the diamond suspension products using an inoculation loop and a solution of agar-agar in an incubator to test for either gram positive or gram-negative bacterial contamination within 24 hours.
3. Purchase a commercial-duty dish washer and use approved cleansers as quaternary ammonium compounds, acid ionic, or iodophors on the following items: tubing, centrifuge jars and lids, spoons, ladles, and beakers. Provide a hydrogen peroxide final rinse to all equipment. (Note that it has been shown ➤

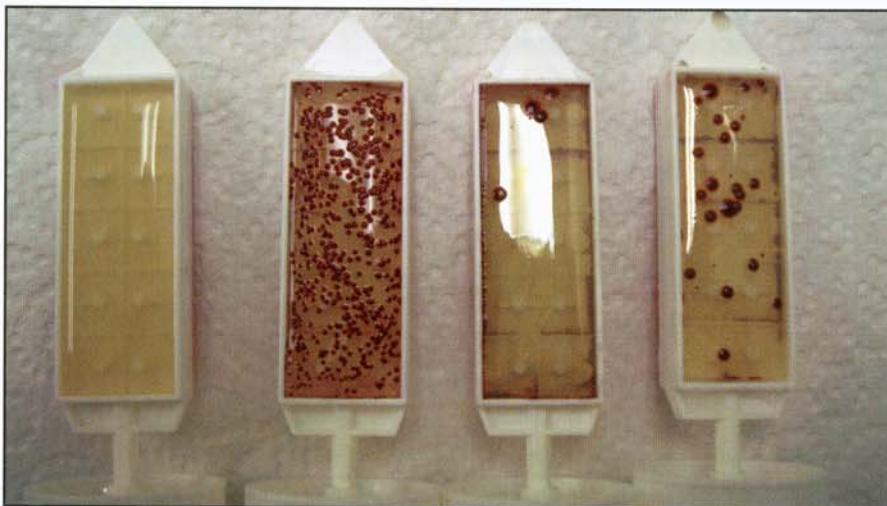


Figure 1: From left to right, the first bug stick is free of any bacterial contamination while the remaining three reveal various stages of contamination. Each dot represents a colony count of 10,000 "bugs!"

