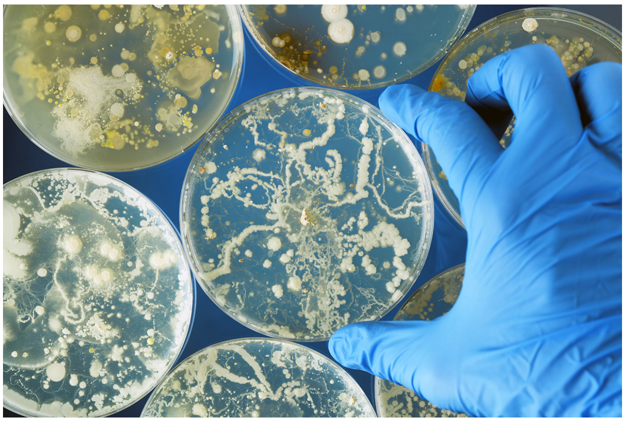
Technical Bulletin

The Control of Bacteria and Fungus in Metalworking Fluids

Because of the nature of metalworking fluids and the environment that they are used in, a certain amount of microbiological growth is inevitable. Sources for microbiological contamination include: the water used to mix them, the parts entering the machine, the air around the machine, the operator's hands, and sludge and residue in the sump, flumes or central system, and even "extraneous contaminations" (such as cigarette butts or "chew," food scraps, or other human waste). So the question is not one of "How do I run a system where there is no microbiological growth?" but rather "How do I control the microbiological growth below a level where it causes a problem?"



Some metalworking fluid problems where microbiological growth is to blame include:

1. Operator Health and Safety – There are very few pathogenic bacteria found in metalworking fluids. The cause of dermatitis, rashes, or infections is not the bacteria or fungus itself, but rather the metabolic acid and salt wastes produced by the bacteria or fungus in the fluid.
2. Dermatitis – This is normally not caused by bacteria except in instances where the working pH of the fluid is driven down to a very low level (less than 7.0), or the subject is sensitive to the organic salts produced by bacteria.
3. Respiratory Issues – In general, respiratory issues with MWFs have to do with sensitivity to the formula of a product rather than to a biological reaction. Research has found there to be significant, though very rare, exceptions to this. There is a theoretical, though unproven, connection between the presence of significant levels of mycobacteria (specifically mycobacterium immunogenum and its endotoxins) and hypersensitivity pneumonitis (HP). HP is an allergy caused by repeated exposure to high levels of an irritant over an extended period of time. (Allegedly, whether living or dead, mycobacterium immunogenum is one of these irritants.) Over time, the body becomes "sensitive" to the irritant and reacts strongly when it is exposed to the irritant at a later date.
4. Odor (referred to as "Monday morning stink") – Anaerobic bacteria excrete hydrogen sulfide ($H_2S\uparrow$) in their metabolic process. When fluid is stagnant and/or covered by a film of tramp oil, it accumulates hydrogen sulfide; when the machine and coolant delivery system is turned on, the fluid is disturbed and releases the hydrogen sulfide. This effect is similar to the effect of shaking a soda bottle before opening it.
5. Corrosion – Microbiological growth can contribute to corrosion in several ways. One of the preferred "foods" of bacteria are corrosion inhibitors. The organic acids and salts produced as part of the metabolic process can also cause corrosion if they become concentrated. This concentration often occurs when fluid is allowed to dry on a surface; the surface tension of the fluid causes it to form an increasingly smaller puddle, which in turn can allow very high concentrations of these materials to form.
6. Staining – Bacterial metabolic by-products of organic acids and salts can leave stains on the work piece. Often, dark brown or black stains are seen on "white or yellow" metals. The stain is a result, at least in part, of biological action.
7. Product Splitting (particularly an issue with soluble oils) – When bacteria grow at the oil water interface (one reason tramp oil is potentially such an issue), they consume the emulsifiers that stabilize the oil in water emulsions. As these emulsifiers are consumed, the oil droplets get bigger and the oil drifts to the surface.
8. Filtration – Breaking loose from their "moorings" on the system surface, "fungal mats" are usually filtered out by positive media filtration – causing frequent regeneration or filter changes. If not addressed, this problem can add to cost and lower productivity. When the filter media is examined, if there are quantities of "smelly" gray material, it is probably fungus which can be confirmed by laboratory analysis.
9. Fluid Delivery Problems – If large quantities of fungus or biomass grow on the IDs of system plumbing, the flow can be restricted. More often than not when we see this situation, it is a mixture of chips and swarf, residue, hard-water soaps, tramp oil, and bio or fungal growth.

AVOID PROBLEMS BY CONTROLLING BACTERIA AND FUNGAL GROWTH

One of the first principles of engineering is that in order to manage something, you need to be able to measure it. Measuring bacterial and fungal growth is as much an art as a science. The issue is further complicated by the fact that less

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than 1% of the microorganisms present in the machine tool sump are actually present in a circulating sample. Most of the bacteria and fungus are attached to the walls of the tank and plumbing or buried in the residue and chips at the bottom of the tank. When you find high levels of bacteria or fungus in a fluid, particularly if it bounces back quickly after treatment, you can be quite certain you have an area in the system that continues to re-contaminate the fluid. The solution then is to properly and thoroughly clean the entire system.

Bacteria and fungal levels are normally expressed as the number of colony forming units (individual microorganisms) present in a given volume of fluid. Because the numbers of microorganisms is so high, the number is normally expressed exponentially; rather than writing "there are 1,000,000 colony forming units of bacteria in each milliliter of working solution," you normally see bacteria level 10^6 CFUs/ml or 10^6 bacteria.

Preventing growth of microorganisms in MWFs is impossible, yet it is possible to control their growth so they do not presently cutting of noncutting problems in fluids. To do this it is necessary to:

1. Keep machines clean. Prevent build up of chips, swarf, and sludge in the machines, as this material is a major source of biological contamination.
2. Reduce organic contamination of the sump. Spit, tobacco juice, food particles, and "personal or farmyard biological waste" are all sources of contamination and food sources for microorganisms.
3. Reduce tramp oil contamination to as low a level as possible. Tramp oil provides a food source for some of the bacteria, allowing them to live at the oil water interface.
4. Maintain the recommended concentration. Generally, sump life is much better at higher concentrations, but allowing the concentration to wildly shift from rich to lean is very bad.
5. Keep the sump at the desired level and top it off at least every day; Every shift is even better.
6. Properly mix makeup product. That way you deliver all the "goodies" that you brought to the sump.
7. Use the best possible source of water to mix the fluid and makeup, as water can be a major source of bacterial and fungal contamination and the minerals present tend to feed bacteria.
8. Be judicious in the use of biocides and/or fungicides tank side.

It is important to recognize that there are many different species of bacteria. Those present break down into two broad classes: aerobic (those that grow in the presence of oxygen) and anaerobic (those that grow in the absence of oxygen). The aerobic do the most damage to fluid as they use emulsifiers, corrosion inhibitors, and EP additives as food sources and multiply very rapidly – dividing approximately every 20 minutes. While the anaerobic or sulfite reducing bacteria do relatively little damage to fluid as they "eat" oils (particularly free tramp oil), they excrete hydrogen sulfide ($H_2S\uparrow$) gas as metabolic waste. This is the rotten egg smell that causes us to dump the sumps.