Technical Bulletin

Master Fluid SOLUTIONS

Background on Bacteria and Fungus in Metalworking Fluids

There are more than 2,000 known species of bacteria on earth. They are of interest to us in the management of metalworking fluids because bacterial actions alter fluid by destroying lubricants and corrosion inhibitors, and by generating corrosive organic acids, and salts. Some are responsible for the "Monday morning stink" that causes us to dump the system. It is critical to understand that, at any given time, only a relatively small percentage of bacteria present in a given system is suspended in the fluid. Most microorganisms found in typical metalworking fluid systems are stuck to the side or bottom of the sump or mixed with chips, swarf, and residue in the bottom of the tank or delivery and return plumbing.

The majority of bacteria need oxygen (are aerobic) for growth; they reproduce by dividing in half approximately every 20 to 30 minutes. So, if we start with one bacterium and calculate the numbers resulting from "splitting" every 20 minutes, the following table shows the approximate population that would result (providing none would die during that time).

1 Hour	8
3 Hours	512
6 Hours	262,000 or $2.62X10^5$
9 Hours	134,000,000 or $1.34X10^8$
10 Hours	268,000,000 or $2.68X10^8$
11 Hours	516,000,000 or $5.16X10^8$
12 Hours	1,032,000,000 or $1.03X10^9$

Because a system could not be stable or give consistent, predictable results with this kind of bacteria load, controlling its growth is critical for the long-term success of a coolant management program.

With more than 2,000 species of bacteria present in our environment, there are less than a dozen found in water miscible fluids. They vary in the degree in which they grow in these fluids and include:

1. Bacteria with limited growth in a few products – mycobacterium immunogenum, salmonella typhosa, staphylococcus aureus
2. Those which grow abundantly in many products – escherichia coli, klebsiella pneumoniae, paracolabactrum species, proteus vulgaris
3. Bacteria which grow abundantly in virtually all products – pseudomonas aeruginosa, and pseudomonas oleovorans

These are known as "facultative" aerobic bacteria, meaning they prefer air (oxygen) for optimal growth. In the absence of oxygen, they stagnate or grow very slowly; when oxygen is reintroduced, they assume normal rates of reproduction. Generally, more than one type of bacteria is present at any one time in the fluid.

The two most troublesome aerobic bacteria are pseudomonas oleovorans and pseudomonas aeruginosa. Pseudomonas oleovorans prefer oil as a food source, so they tend to grow rapidly in machines that leak substantial amounts of lubricating and hydraulic oil. Consequently, everything should be done to reduce such oil leakage, but if it cannot be prevented, such oils should be skimmed off the surface or centrifuged from the fluid.

Pseudomonas aeruginosa can live on practically anything: minerals in the water, coolant concentrate, discarded food, or oils. Note that pseudomonas oleovorans and pseudomonas aeruginosa are both aerobic and facultative and are the two species present in all water miscible fluids. Of all known bacteria, they are also two of the most difficult to kill.

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There is another class of bacteria known as anaerobic, or sulfate reducers, that grow in the absence of oxygen. These bacteria grow much more slowly than the aerobic, dividing once every four hours and the result of their growth can be very objectionable. These bacteria will usually not grow until the fluid has been attacked by the aerobic bacteria.

The anaerobic bacteria, Desulfovibrio desulfurican, grows in nearly all water miscible fluids. It produces a very strong odor of rotten eggs (hydrogen sulfide, H_2S, or "Monday morning stink") and can cause severe, dark staining on machines and work pieces. In the presence of iron, it eventually can make the fluid turn black in color.

In one way or another, all these bacteria use the lubricating and anticorrosion chemistry built into the fluids. Bacterial action can quickly and substantially reduce fluid performance. These bacteria also produce organic acids and salts which cause corrosion. The more rapidly the bacteria grow, the faster they attack the fluid. So, the rate of bacterial growth is important. If fewer bacteria grow in a given length of time, harmful effects of their growth can be substantially minimized.

To control or reduce the rate of bacterial growth, you must:

1. Select a fluid made from chemistry that the bacteria like least (an inherently bio-resistant fluid).
2. Use a fluid that contains a biocide or add biocides tank side on an as needed basis.
3. Properly mix and maintain the fluid, such as ensuring proper concentrations, low to no mineral water, tramp oil control, and such.
4. Keep the machines as clean as possible to reduce food for bacteria. Remove chips and swarf that may harbor high levels of bacteria that continually re-inoculate the fluid with bacteria.

Central systems present particular challenges for several reasons. They generally use three to five times more fluid than that of individual machines of similar capacity. So while bacteria in a central system grows at the usual rate, the lower makeup ratio or percentage means that on "average" fluid in the central system is "older" than in an individual machine. Central system tanks are typically less turbulent, so bacteria can settle to the bottom of the tank when fine metal particles and other silt settles. This combination helps anaerobic bacteria grow best, where it is farthest away from air (oxygen). These factors and more make it more difficult to control bacterial growth in large central systems than in individual machine sumps. However, with proper fluid selection, system cleaning and maintenance, bacterial control in central systems is not a major problem.

Fungus

Fungus (mold) contamination can also be a problem because it grows as "mats" which are attached to the surface of the sump. The delivery system and machine fungus can generate very definite problems with the machine. Typically, by the time fungus is found in a working solution sample it is well established. Like the bacteria-laden "garbage" found in the bottom of sumps, fungal mats need to be removed physically rather than chemically. Biocides and fungicides alone can only kill organisms they come in contact with. If they are part of a fungal mat or a bacterial film, biocides will not reach most of the system. In general, minerals in water help to feed mold (fungi) just as they do bacteria, so removal of minerals from the water also helps to keep mold growth to a minimum.

Note:

1. Interestingly, chemical (synthetic) coolants are more susceptible to mold infection than are emulsion coolants. Emulsions, on the other hand, are more susceptible to bacterial infections than are chemical coolants.