

## Controlling Microbial Contamination in Metal Working Fluids

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### abstract

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Mounting concerns over operational and waste management costs, as well as the quality and safety of the work environment have provided increased impetus for both formulators and end-users to strive to improve coolant life. There are a number of alternative approaches to achieving this objective. In this paper, the concepts of bioresistance and biostatic are defined and compared. A discussion of both chemical and non-chemical treatment technologies follows. Non-chemical technologies considered include pasteurization, irradiation, sonication, and filtration. Coolant formulation strategies and biocide use are explored as illustrative chemical technologies. The discussion of biocide use includes remarks on alternative dosing tactics and biocide selection criteria.

### conference

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### index terms

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## INTRODUCTION

Despite increased focus on total quality management principles throughout the manufacturing industry, microbial contamination remains an insidious drain on the profitability of the metalworking industry. Fortunately, there is a continuing trend for chemical process operators and their managers at manufacturing plants to improve their understanding of the role of microbes in affecting the performance of their coolants. Moreover, coolant formulators have come to recognize that the longevity of fluid performance characteristics often determines their continued tenure at an account.

This heightened appreciation of microbial contamination problems has come at a time when people are becoming increasingly aware of their personal accountability for improving the quality of the work environment and for reducing the volume of industrial wastes. Formulators and coolant system managers are seeking a balance between costs and performance. Regulatory issues and safety concerns are being integrated with engineering and design strategies. This holistic approach to coolant system management is nothing less than revolutionary. It is imperative that personnel responsible for making decisions regarding coolant system operations be equipped with accurate and current information. That is why SME sponsors these annual clinics.

In this paper, I shall discuss a number of concepts which have been receiving increased attention in the coolant marketplace over the past several years. I shall discuss bioresistance, non-chemical treatments and the use of microbiocides. I will not reiterate the basic concepts of microbial contamination in metalworking fluids which have been presented at earlier SME clinics<sup>1</sup> and elsewhere<sup>2,3</sup>.

## TERMINOLOGY

### "Bioresistant" versus "Biostatic"

In Europe, and more recently in the United States, so-called bioresistant metalworking fluids are becoming increasingly popular. The impetus for this trend is two-fold. On one hand, there is a demand for products with extended functional lives in order to minimize waste generation and its associated disposal costs. At the same time, customers want to eliminate "toxic" components from coolants used in their plants. Since perception is often a greater consideration than reality, additive suppliers may feel pressured into labeling their non-U.S. EPA registered **biostatic** additives as **bioresistant**. The distinction between these two terms is significant, and should be understood by both formulators and end-users.

A material is **bioresistant** if, in the presence of an active microbial community, its structure and properties tend to remain unchanged. For example, glass is bioresistant, as are many xenobiotic (synthetic) organic chemicals (for example: polychlorinated biphenols). Molecules which resist bioconversion are sometimes referred to as **recalcitrant** molecules. Bioresistance is often concentration-dependent. Thus, a coolant formulation which is stable for several years in drums may degrade after a few weeks after having been diluted to working concentration. Note that the concept of bioresistance makes no assumptions about the survivability of the contaminating microbes. Microbes in direct contact with bioresistant surfaces, such as steel and concrete pipe-walls, may thrive on nutrients which they assimilate from the surrounding air or fluid.

The relative bioresistance of materials, including dilute coolants, is a function of the environment as well as properties of the materials themselves. It is not unusual for a "non-bioresistant" coolant in a well managed coolant system to outlast a bioresistant coolant in a poorly managed system. I've discussed my ideas regarding coolant system management at previous Metalworking Coolant Clinics<sup>4,5</sup>, and shall not reiterate them here. The point is that inhibition of microbial activity and/or proliferation is **not** a property of bioresistant materials.

In contrast, **biostatic** materials do inhibit either the growth or the proliferation of microbes. Understand the difference between growth and proliferation. **Growth** refers to the increase in the size or mass of an individual cell, whereas **proliferation** refers to the increase in the number of cells within a system. Growing cells produce enzymes and metabolites which may mediate significant biodeterioration even though the population density may not be

increasing. This is why process operators occasionally see indirect evidence of microbial activity (such as reduced pH, changes in emulsion stability, etc.) when dip-slide test results indicate that the coolant is "sterile"<sup>a</sup>.

Since, by definition, biostatic chemicals inhibit microbes, they are subject to the same requirement for U.S. EPA registration as are other biocides<sup>6</sup>. A **biocide** is a product used to kill microorganisms. There is a tendency to differentiate between **preservatives** (products used to prevent proliferation or growth) and **biocides** (products used to bring rampant contamination under control). This distinction is artificial.

Generally, antimicrobial products are used as preservatives at one dose range, and as **disinfectants** (products which destroy microbes) at some higher dose range. Consequently, the distinction is often dose-dependent. Figure 1 illustrates the **oligodynamic** effect of dose on the impact of a registered biocide on proliferation of a microbial population. At low doses, the product actually **stimulates** population growth. At somewhat higher concentrations, the effect is biostatic. Population density does not increase in the test system. Once the biocide concentration exceeds 125 ppm, microbial proliferation is inhibited completely. Therefore, we understand **biostatic** chemicals to be toxic and apply them with the same care and good judgement with which we use all antimicrobials.

### Potentiators

Some years ago, Prof. E. O. Bennett coined the term "biocide potentiator" to describe coolant additives which do not exhibit antimicrobial characteristics when used alone, but which improve the performance of biocides with which they might be used con-jointly.

Bennett uses persistence-of-effect as his criterion for evaluating potentiator-biocide blend performance. Arguably, speed-of-kill or spectrum-of-activity might be equally useful criteria for evaluating biocide potentiators. As with biocides, the performance of potentiators varies among coolant formulations.

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<sup>a</sup>**Sterile** is another often-misused term which refers to a product which is totally free of viable microbes. Zero counts on a dip-slide, or zero viable counts by any other culture method simply means that the sample did not have enough individuals of species capable of forming colonies on the solid medium (or cause turbidity in the liquid medium) which the person performing the test selected. A sample may have contained millions of microbes, which, for any of a number of reasons were unable to elaborate into colonies.