# Manage fluids to fight corrosion

## *Solutions for water-based coolants*

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Effective heat removal, which is one of the most important functions of a metalworking fluid, yields good tool life and dimensional accuracy of parts. Water has greater capacity for removing heat than oil; however, water alone in contact with freshly machined metal leads to corrosion. Thus, corrosion is a problem faced by every user—and manufacturer—of water-diluted metalworking fluids. Corrosion can occur even with dry cutting and is not simply due to the use of water-based fluids.

By definition corrosion is the partial or complete wearing away, dissolving, or softening of any metal—ferrous or non-ferrous—by chemical action. The term "rust" is often misapplied or misused, as it applies only to iron and steel.

Most corrosion is electrolytic in nature. Placing two pieces of dissimilar metal (the electrodes) in a glass of acid, or even tap water, forms a battery cell. A meter connected across the metal electrodes registers current and voltage. Connect the electrodes to each other, a short results, and one of the metals is eaten away.

The same phenomenon occurs when a drop of water stands on a piece of cast iron. The drop absorbs oxygen from the air, which surrounds it. Since the oxygen diffuses into the drop at a finite rate, there is a stronger concentration of oxygen at the outer edge of the metal surface around the rim of the drop than exists at the center of the drop. Again, the result is an electrolytic chemical action. Iron ions go into solution at the center and hydroxides form at the rim of the drop. The two ions come together, and if conditions are just right, a ring of rust occurs.

### Seasonal protection

Corrosion can occur at any time during the year, but it occurs more often during July, August, and September when temperatures and the relative humidity are high. If the concentration of the fluid, which provided rust protection during the fall and winter months, does not provide protection when the humidity climbs, an adjustment in the fluid concentration is necessary. If a fluid user objects to increasing the concentration of his central system mix for reasons such as foam and potential skin problems, it may be necessary to increase rust protection with the use of additives, which are selected according to the type of metal(s) involved, the user's chemical restrictions, additive availability, and the fluid used.

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### Controlling pH

The pH of a metalworking fluid is a factor in controlling corrosion. A high pH, greater than 9, will protect ferrous metals but will adversely affect the corrosion control of non-ferrous metals, such as aluminum, brass, and bronze.

When the pH is low in an individual machine, the easiest remedy is to dump, clean, and recharge with a new mix of the fluid product at the recommended concentration. If treating a central system mix, which is being used on ferrous metals, adjust the pH to between 8.8 and 9.2 with the proper additives. Excessively high mix pHs are usually a sign of contamination and the mix should be dumped and recharged.

If non-ferrous metals are being machined or ground, and staining or pitting is a problem, check the product information to determine if the product was designed for use with non-ferrous metals.

### Aggressive water

Chemicals in the water used to make up and maintain the mixes can increase the rate of corrosion. All water contains ions, some of which are aggressive and can cause corrosion of most metals.

Waters that contain more than 100 ppm chloride, more than 100 ppm sulfate, or 50 ppm nitrate are considered aggressive waters. Chlorides, sulfates, and nitrates cause corrosion by breaking down the protective barriers on the surface of the metal, opening the way to corrosion.

If aggressive water is suspected, take a sample of the water and have it completely analyzed by the fluid supplier or another reputable laboratory with specific water analysis capability. When a central system fluid is suspected of causing corrosion, submit a sample of the mix for ion determination. If the chloride, sulfate, or nitrate content is higher than the acceptable limits, the user may have to change sources of water. It may become necessary, for example, to change to a blend of deionized or distilled water with the regular water. A change to another metalworking fluid with superior corrosion control may also be an answer.

Chip removal is an important function of coolants in metalcutting processes like drilling.

Many desirable properties of metalworking fluids can be literally destroyed by chemical reaction with dissolved water solids. The most familiar example of this is the effect of "water hardness," which is essentially the calcium and magnesium content of the water. The divalent ions react with soaps, wetting agents, and emulsifiers to form compounds with limited solubility. The formation of these insolubles depletes rust inhibitors, resulting in rusty parts and machines.

Conductivity is another means of determining the quantity of dissolved ions in the mix. Higher conductance promotes corrosion, mix instability, and residue. Conductivities greater than 4 MilliSiemens per cm are considered high.

If the chloride, sulfate, nitrate or water hardness content is higher than acceptable limits, it may be necessary to change to a blend of deionized or distilled water with the regular water. A change to products that are less affected by water hardness or conductivity is another approach.

## Bacteria counts

High bacteria counts in the metalworking fluid mix can lead to corrosion. Bacteria consume metalworking fluid components, and the byproducts of this activity can lower the mix pH. The metabolic products include mild organic acids, which lower the pH of the fluid, compromising the corrosion resistance of the fluid. Also, if left unchecked, bacteria can split emulsions.

If an individual machine's mix has a high bacteria count, again the easiest remedy to the problem is to dump the old fluid, clean the sump with a good machine cleaner, rinse with fresh water, and then recharge with a new fluid mix at the recommended concentration. If it is impractical to dump the charge, treat with an appropriate microbicide. In a central system, use preventive measures including the correct use of microbicides to prevent and control bacterial growth.

## Lean concentration

Ingredients in a metalworking fluid are designed to be effective within a specified dilution range. If the fluid becomes leaner than the specified range, the leaned out ingredients may not be able to perform their designed jobs. This also applies to rust inhibitors, which may not be able to protect the newly ground or machined parts from corrosion.

Check fluid concentration frequently and routinely. Titration methods and refractometers are the best methods of determining concentration. Add concentrate to obtain the recommended dilution. Do not attempt to balance the fluid in individual machines with the use of additives. Dump and recharge.

Normal in-process rust protection is up to 72 hours, provided that the metalworking fluid product is used at the recommended concentration. Most fluid products provide in-process rust control for a variety of metals from high alloy steels to cast iron. At the proper concentration, it is reasonable to expect 48 hours protection for cast iron and 72 hours for high alloy steels. If corrosion protection beyond these time limits is required, then the use of a longer term rust preventive is recommended.

## Dirt recirculation

Small metal particles in a metalworking fluid are sometimes referred to as "dirt" or "swarf." Swarf deposited on the part and not properly washed away forms a galvanic cell, and rust will occur underneath the swarf. Correct the dirt recirculation in an individual machine by having the machine dumped, cleaned, rinsed with fresh water, and charged with a fresh fluid mix at the recommended concentration.

In a central system, dirt recirculation could mean a malfunction of the filter. To help settle swarf, select the settling aid or clarifying agent compatible with the fluid and filter sstem. Check the pressure at the coolant nozzle to determine if the lack of coolant pressure is causing the swarf to build up on fixtures or workpieces. Normal coolant pressure is 20 psi.

## Bimetallic corrosion

Bimetallic corrosion is the corrosion of two different metals in contact with each other. An example is clamping an aluminum workpiece to a cast iron fixture or table. Bimetallic corrosion occurs when a transfer of electrons from one metal to another takes place with the cutting fluid acting as a conductor. This problem is solved by getting a nonconductive material between the two different metals. This may require switching to a fluid that has better bimetallic corrosion prevention properties, such as a premium soluble oil. Water proof greases or a thin plastic sheet can also be used between the contacting surfaces.

## Broken emulsion

Rust can happen if an emulsion breaks down, in which case rust inhibitors will be ineffective.

If the emulsion appears watery and the sample shows stratification, the emulsion may be unstable or broken. To solve this problem, the best remedy would be to dump, clean the machine, rinse with fresh water, and recharge.

Broken and unstable emulsions are often caused by hard excessive bacterial contamination. It is important to determine the cause of the broken emulsion before taking corrective action. When dealing with a central system, it may be possible to use an additive which is an emulsifier to re-emulsify the product. If time permits, send samples to the fluid supplier for tests. If time does not permit, then run jar tests on site to determine what additives to use and the proposed dilution ratio.

There are many additives available that can boost corrosion protection. The determination of which one to use depends upon the fluid in use, chemical restrictions, etc. Care should be taken when using any additives to protect against misuse or overuse. Always consult with your fluid supplier before making any additions.

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