Castrol Industrial Americas
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Technical Bulletin

WATER QUALITY AND METALWORKING FLUIDS

At least 90% of the water soluble cutting fluid your customer uses is composed of locally procured water. That is, less than 10% of the fluid that circulates through those machine tools yields a commission for you.

Typically, a gallon of your product has to cope with the vagaries of 20 gallons of indigenous water. That water may contain an amazing variety of dissolved chemicals and microorganisms, some of which may spell trouble for you. Naturally, when problems do develop, it isn't the local water department that has to provide the answers, it is you.

We might wish that all of our customer plants were blessed with moderately soft water, say 135 parts per million (8 US grains) hardness. If our wishes were granted, the foam problems we so often encounter with the very soft waters of New England and the Old South might disappear; the smut and emulsion stability problems we get with rock-hard waters in parts of the Midwest would be alleviated; and in southern California, our product recommendations would be somewhat less dicey. You could focus more on the work to be done and less on the chemical challenges to your cutting fluid.

Well, the word about water quality is getting around. Many of our customers, especially the large central system accounts, are beginning to do something about their water quality. They have a number of choices.

TYPICAL IMPURITIES

Generally, city water is of sufficient quality to mix with cutting and grinding fluid concentrate for the initial charge and in small pumps as make-up. However, if you are planning to keep a system running for years, or plan to recycle the fluid to reduce cost, you need to look at the quality of the water used for make-up.

Pure water is best, but it can be expensive. That is why it is not recommended for the initial charge or in small sumps that must be pumped within a month. We need to better understand water impurities and how these impurities affect the cutting and grinding fluid. The following are some typical impurities.

Hardness is caused by dissolved minerals such as calcium, magnesium, iron, aluminum and zinc. Calcium and magnesium are found in much larger quantities than the others. Hardness is calculated on the basis of 17 parts per million of calcium carbonate as being equal to one 'grain.' Hardness reacts with components of the cutting and grinding fluid, causing increased usage and the need for higher concentrations to produce the expected performance. As hardness builds due to the 'distillation effect' (see below), water evaporates from the sump. Residues increase and cleanliness, emulsion stability, corrosion protection, filtration and bioresistance all decrease.

Dissolved salts such as chlorides and sulfates increase corrosion on machines and parts. Chlorides, which are anionic halogens, produce stress corrosion cracking in materials such as high-strength steels, austenitic stainless steels, titanium alloys and other high-temperature alloys tested in high-temperature/high-stress environments. Sulfates also promote the growth of sulfate-reducing bacteria desulfovibrio desufuricans, which produce the 'rotten egg' odor. Phosphates and nitrogen act as fertilizer for bacteria and fungi.

Dissolved gasses (chlorine and sulfides), at levels that you can smell in the water, will cause severe corrosion on machine tools and their metal covers above the fluid. Chlorine can also lead to stress-corrosion, as above.

Bacteria and fungi are more common than you would think in water supplies. In agricultural areas during time of high dust or water run-off. bacteria and fungi find their way from the field to the rivers, lakes or wells. Levels as low as 10' can be a problem.

Why all the concern about a small amount of contaminants?

Sumps and central systems are stills. Water extended coolants lose 5-20% water per day through evaporation, depending on fluid type, agitation and severity of the operation. This water is then replaced with make-up in order to maintain the proper coolant concentration. Dissolved salts that are introduced with the initial charge are augmented through additions of make-up water. These salts do not evaporate with the water, so they remain in the system, resulting in a gradual buildup of water hardness in the system. This process is known as the distillation effect. Hardness and salt levels can increase three to four times in a month. As ionic concentrations increase over time, corrosion protection, coolant stability and coolant sump life can be degraded.

Where do these contaminants come from?

Hardness generally comes from minerals in the earth; however, hardness may come from work materials. Calcium and magnesium may be found in cast iron, cast aluminum alloys and concrete.

Dissolved salts generally come from minerals in the earth; however, they can come from process water treatments. Chlorides may come from water softener brine solution, regenerated DI units that were not properly rinsed, BUSAN 777 and products that contain BUSAN 77.

Dissolved gasses generally come from processed water, the water treatment process or water contaminated by chemicals such as acids or bleach.

Bacteria and fungi may be found in any water source. Deionized, reverse osmosis, process water, wells, lakes rivers and even municipal water sources can have bacteria and fungi in them. Bacteria and fungi grow rapidly in hard water environments. Phosphorus and nitrogen compounds in water promote growth.

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How do I know if there is a problem?

Some plants and all municipalities test their water on a regular basis. These reports are normally available upon request. Be sure the report is current. Water changes depending on the source and time of the year. Make observations such as odor, scale buildup in holding tanks, corrosion, residue, emulsion stability, etc. Send a sample to our lab in a clean bottle.

What should I look for?

Conductivity is a measurement of dissolved minerals and salts in water. The higher the conductivity, the poorer the water quality. Conductivity does not, however, distinguish between hardness and salts.

Hardness is measurable via several tests:

- Hardness test strips are available from Customer Service. Strips are not completely accurate, but they give you a good idea of water hardness.
- "Hach" hardness test kits are available from Customer Service. They are used in our lab and can be used in the field.
- ICP hardness tests are completed in our lab. This test will tell you the amount of calcium, magnesium and other dissolved metals.

Dissolved salts are measurable via test in our lab by ICPI.

Dissolved gasses are generally not a problem unless you can smell an odor. Chlorine has a swimming pool odor and sulfide a 'rotten egg' odor. Our lab can measure dissolved gasses if it is required.

Bacteria and fungi can be measured by the Agar Dipslide, which is used for metalworking fluids but does not measure below 10^3. Unless the water is excessively contaminated, it should be sent to our lab for a plate count. Millipore is one of a number of companies that make dipslides for water testing, but they require refrigeration and have a short shelf life.

METHODS OF TREATMENT

Many users of metalworking fluids today are using deionized and reverse osmosis water in their processes. The main benefits to using purified water are an increased sump life and a reduction in corrosion. First, let us define some terms.

Tap water is the initial water source or supply to a facility, such as an on-site well or municipal water supply. These sources will vary depending on geographic location, source (reservoir, well, lake, etc.) and treatment.

Chemical additives will temporarily eliminate the symptoms of hardness by complexing calcium and magnesium. Some additives increase sodium and/or alkalinity, causing other problems; all add dissolved solids to the water.

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Deionized water (DI water) is a chemical process whereby the dissolved ionic salts are removed from the water. The deionizing unit makes use of two ion exchange resins to remove both cations (positively charged ions) and anions (negatively charged ions) and replace them with hydronium (H^+) and hydroxyl (OH^-) ions respectively. Today, the most common deionizing unit is the mixed-bed design where both resins are contained in a single tank. The mixed-bed design can provide water quality equivalent to laboratory distilled water: less than one part per million per ionic species. The ionic activity of the water is near (ionic activity is directly proportional to the commonly measured quantity, conductivity, expressed as units of mhos which are reciprocal ohms). One problem associated with the DI water process is bacteria and fungi growing on the resin beds and filters. This can be corrected using ultraviolet (UV) light.

UV radiation is used very effectively in killing bacteria and fungi with any water source.

Water softeners utilize exchange resins which simply exchange one ionic species for another. In water treatment, the hard water mineral ions calcium (Ca^{+2}) and magnesium (Mg^{+2}) are exchanged for sodium (Na^+) ions. Since this is only an exchange of ions, the ionic activity or total dissolved solids (conductivity) remains nearly constant. Water softeners are used prior to reverse osmosis (RO) units. Be sure that the brine goes to the sewer, not to the metalworking fluids.

Reverse osmosis (RO) utilizes a membrane that allows water to cross freely but significantly retards charged ions. This allows the users to reduce the ionic content and ionic activity of the water by 90 to 95 percent. RO units utilize water softeners as a pretreatment to remove hard water minerals, reducing hardness and dissolved salts by 90 to 95 percent. This extends the life and performance of the RO membrane. RO units tend to filter out bacteria and fungi, but these organisms may grow on the membrane and, over time, can inoculate the water. The RO membrane should be sanitized every 6 to 12 months.

BENEFITS OF USING DEIONIZED AND REVERSE OSMOSIS WATER

DI and RO waters are better choices for make-up in central systems and recycling units over tap water due to their freedom from impurities, which can accumulate due to the distillation effect. Water softeners are not recommended for metalworking fluids. They use salt to exchange calcium and magnesium for sodium. Sodium salts are more soluble and reduce scaling, but tend to foam and reduce corrosion protection.

DI and RO water usage eliminated the main source of harmful ions, calcium, magnesium, sulfates and chlorides, which are related to corrosion and product stability problems. The presence of chlorides (Cl^-) and sulfates (CO_4^{-2}) in metalworking fluids increases the potential for corrosion in concentrations above 300 parts per million. Calcium (Ca^{+2}) and magnesium (Mg^{+2}) ions which are associated with hard water may cause instability problems with some metalworking fluid formulations, particularly when the calcium and magnesium concentrations exceed 425 parts per million (or 25 US grain) hardness.

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With the use of soluble oils, high hardness levels can degrade the emulsion stability of the mix. Synthetic fluids that contain fatty acids are also know to form insoluble hard water soaps. Semi-synthetic products can exhibit both phenomena. However, if a fluid system is charged with DI or RO water, foam problems may be experienced. We recommend that fresh charges be made with tap water if it is not excessively hard, and make-up additions be made with DI or RO water. The levels of calcium, magnesium, chlorides and sulfates should be well below tolerances, yet still provide good metalworking fluid foam break characteristics. In addition, charging a system with DI or RO water is typically not feasible or economical because the usual industrial DI or RO units do not have the capacity needed to charge a large fluid system.

ECONOMICS

Regarding the choice between a DI system and an RO system, the customer's needs and economic considerations must be the determining factors.

DI systems provide nearly complete removal of ions. However, this is not usually required with metalworking fluids. Typically, industrial DI systems are regenerated on-site and this requires the use of extremely acidic and caustic chemicals. The necessary concentrated hydrochloric (muratic) acid and 50% sodium hydroxide (caustic soda) solutions can pose problems with waste water effluent regulations and plant health and safety requirements. DI systems can usually be leased with service contracts that provide for low initial capital expenditure and moderate operating costs.

RO systems provide 90 to 95% reduction in ionic activity which, in most cases, is sufficient for use with metalworking fluids. RO systems do not generate very much waste effluent and the waste is not classified as hazardous since it is a brine solution. RO systems are typically purchased, so there is a large capital expenditure which is usually offset by the low operating cost of the process.

Water Quality
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