



# FLUID FUNDAMENTALS

*Shops will find that choosing the right metalworking fluids and properly analyzing the mixture ensures long tool life and reduces fluid-maintenance costs.*

**BY GREG FOLTZ, MILACRON INC.**

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**S**hops may think metalworking fluids aren't all that complicated. After all, their main job is to cool, lubricate, and flush chips or swarf away from cutting or grinding zones. But ensuring the performance and longevity of these fluids is another thing. Especially when it concerns water-soluble fluids. That's why it's important that shops understand fluid parameters and analyses.

Metalworking fluids come in four primary types: straight oils or "neat" oils, soluble oils, semisynthetics, and synthetics. Because the last three are diluted with water for use, they are usually called water-soluble metalworking fluids. Although there is much debate on the exact definition of each type of water-soluble fluid, *Metalworking Fluids*, edited by Jerry Byers (New York: Marcel Dekker, 1994), describes them as follows:

**Soluble oil:** A metalworking fluid with 50% to 80% oil content and little or no water content. As sold, it consists solely of oil, emulsifiers, oil-soluble lubricants, and corrosion inhibitors. When mixed with water, it creates an emulsion that is milky in appearance.

**Semi-synthetic fluid:** A metalworking fluid with a 5% to 30% content of mineral oil and 30% to 60% water content. It generally contains other ingredients such as emulsifiers, corrosion inhibitors, microbiocides, cleaners, and defoamers.

**Synthetic fluid:** A metalworking fluid that contains no mineral oil. Some synthetics are totally water soluble (chemical solutions), while others are emulsions of water insoluble, synthetically derived lubricants (synthetic emulsions). Various additive packages are formulated into the fluid to enhance the performance of these products.

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Shops perform different analyses on water-soluble metalworking fluid mixes to ensure low fluid-maintenance costs and consistently high tool life and part quality. They should consider specific product applications and systems when testing, since the fluid parameters may not be similar for all situations. It is also important to conduct the proper type of test, interpret the results correctly, and then use the information to properly maintain the fluid. This takes a lot of work, so shops often work closely with metalworking-fluid suppliers to determine the proper parameters for these different tests.

**Concentration** is the percentage of a metalworking fluid concentrate in the mix. The concentration can also be expressed as a ratio, the amount of metalworking fluid concentrate to the total volume of mix. For example, adding four gallons of concentrate to 96 gallons of water yields a 4% or 1:25 mix concentration. To get the most out of a metalworking fluid, shops should maintain the concentration within the recommended operating parameters. If the mix is too rich or too strong, they'll have various problems, such as foam and residue buildup. If the mix is too lean or too weak, they'll encounter other problems, including poor tool or grinding-wheel life, rancidity, and corrosion. Concentration is determined by several methods: refractometer, chemical titration, test strips, or various laboratory instrumental means.

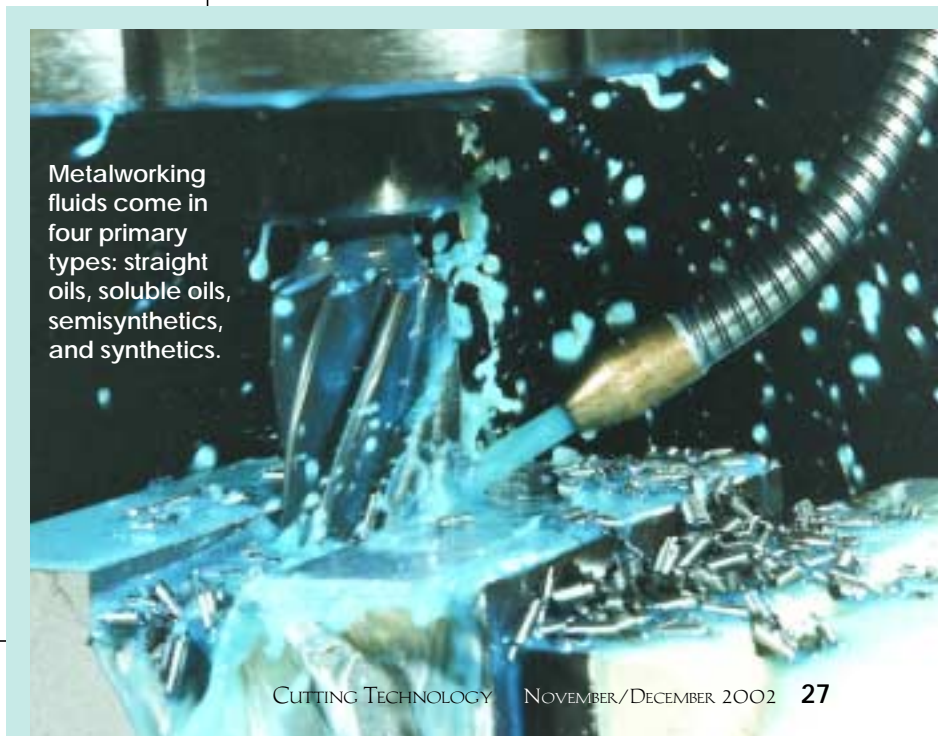
**pH** is a measure of the acidity or alkalinity of a metalworking fluid mix, and it is a sound indicator of the condition of the fluid mix. Each product has a specified pH range within which it operates most efficiently. Most metalworking fluids operate in a pH range of 8.5 to 9.2, although newer synthetics can go as low as 7.5. A low pH mix can lead to rancidity, ferrous corrosion, and mix instability. A high pH mix, on the other hand, affects a fluid's mildness and nonferrous-corrosion control. Maintaining the pH range specified by the fluid manufacturer avoids all these problems.

**Dirt volume** is the percentage of solids in a metalworking fluid mix that separates from the mix after settling or centrifuging. Dirt values should be less than 0.1% by volume. High dirt volumes usually indicate either inadequate fluid filtration or filter problems. A high dirt volume can degrade the performance of a metalworking fluid and lead to residue problems, poor part finish, unacceptable grinding wheel or tool life, and microbial growth.

**Free oil** is the percentage of oil or oil-like material that is not emulsified and floats on the surface of a metalworking-fluid mix. Free oil is usually the product of hydraulic fluids and way oils that leak into the mix. Free oil should be no greater than 0.5% or less because a high free-oil percentage in the mix leads to microbial growth, residue, and grinding-wheel loading. Also, significantly higher free oil than tramp oil value often indicates mix instability.

**Total oil** is the percentage of oil or oil-like material present in a metalworking-fluid mix. This value includes both product oil and tramp or extraneous oil.

**Tramp or extraneous oil** is the percentage of oil or oil-like material in the mix that is not product oil. Product oil is oil that comes from a metalworking-fluid concentrate. Shops determine the total oil in the mix by splitting the mix with acid in a specific laboratory test. They calculate the amount of oil that should



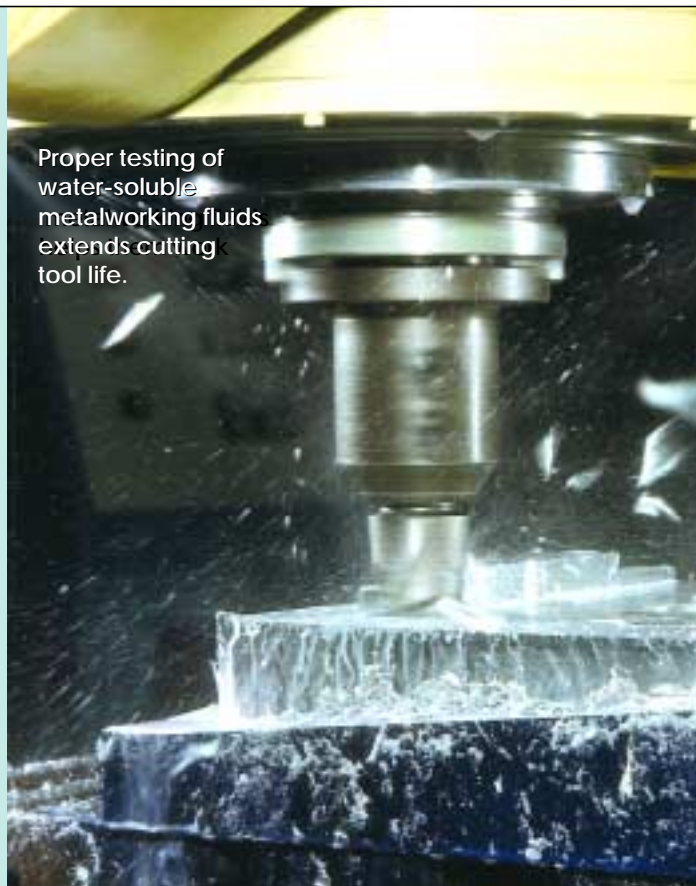
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be present for the product concentrate from the previous determination of product concentration. Subtracting these yields the tramp-oil percentage. The following equation calculates the tramp oil level in a fluid mix:

$$\text{Total oil \% in the mix} - [(\text{mix concentration \%}) \times (\text{amount of product oil})] = \text{tramp oil \%}$$

A high tramp-oil percentage can promote problems, such as residue, poor grinding and machining performance, and microbial growth. Significant negative tramp-oil values, such as less than -0.5%, indicates either mix instability or contamination by a material that is indicated by the concentration calculation. Shops can expect significant performance problems when tramp oil levels reach half the metalworking-fluid concentration.

**Bacteria counts** or standard plate counts are measures of the total bacteria in a metalworking-fluid mix. A high bacterial count leads to offensive odors and performance failure. Shops determine bacteria levels by plate counts or by using dip slides that are



Proper testing of water-soluble metalworking fluids extends cutting tool life.

Fluid parameters differ depending on the type of fluid and the application.



commercially available. Most metalworking fluids tolerate a bacteria count of  $1 \times 10^5$  or 100,000 per ml or less. Dissolved oxygen analysis is also a good measure of biological activity.

**Fungal counts** measure the fungi and mold in a metalworking fluid mix. A high fungal count causes offensive odors, plugged fluid lines, and fluid failure. Unlike bacteria tests, where the counts correlate well with the growth of bacteria in the system, fungal tests do not accurately quantify the fungi present in



or around the system. Fungi are more likely to cling to surfaces and, therefore, may be well established in a system without being detectable in the analysis of a small fluid sample.

**Total alkalinity** is a measure of alkaline materials, both inorganic and organic, in the metalworking-fluid mix. Significantly higher-than-normal total alkalinity promotes a skin-irritating mix, causes corrosion of nonferrous metals, and results in other

problems. Alkalinity often increases as equipment ages.

**Conductivity** is a measure of the electrical conductance of a metalworking fluid. It is expressed in milliSiemens per centimeter (ms/cm). As the amount of dissolved materials (calcium, magnesium, sodium, chlorides) increases, the conductivity of the fluid increases. Conductivity generally increases slowly over time. The rate of the increase depends on the quality and amount of water used and the types and concentrations of other contaminants. High levels of conductivity promote problems such as insoluble residues, mix instability, and performance loss. Emulsion instability usually occurs when conductivity reaches the 4 to 5 ms/cm range. CT

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Fluids best cool the cutting zone when regularly tested for concentration, pH, dirt volume, and bacteria.