Cutting Fluid Management

FACT SHEET

N.C. Division
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Environmental Assistance

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While cutting fluid purchase typically accounts for less than 0.5 percent of the total operating cost, disposal of spent cutting fluid can be very expensive and troublesome, especially with the increasingly tightened environmental regulations and fluid purchase and disposal cost. Fortunately, cutting fluid life can be extended significantly by implementing an effective fluid management program.

Benefits and Savings

A successful fluid management program provides:

- Longer fluid life;
- A cleaner, safer and more environmentally sound work environment;
- Improved productivity (less downtime);
- Reduced costs (increased machine and fluid life, reduced purchase and waste disposal cost);
- Reduced labor (fewer fluid change-out, less maintenance / repair);
- Environmental compliance and reduced environmental liability; and
- Consistently manufactured quality products.

A machine shop that installed a settling tank to remove contaminant from coolants is now saving more than $26,800 a year in reduced material, labor and disposal costs.

A shop that installed filter units for $9,000 to recycle the spent coolants has dropped its coolant use and disposal cost from $10,800 per year to $500. The shop also estimates another $10,000 annual savings on grinding wheels due to expended wheel life.

The four components of a successful fluid management program are:

- Product selection
- Inventory management and chemical handling
- Fluid monitoring
- Contamination removal and prevention

Product Selection

Minimizing the number of different cutting fluids used in the process can help benefit inventory control, eliminate extra storage space, and reduce coolant maintenance and disposal. Selecting the fluids most suitable for your application is the first step toward a successful coolant management program.

Calculating the true cost of fluid

Selecting a fluid solely based on its initial cost can be a great misrepresentation. The true cost of the fluid is the cost per gallon divided by its life expectancy. Although the initial cost of a premium product may seem higher, the long-term cost of the fluid will likely be lower because of its superior fluid life.

Factors to be considered when selecting a fluid

- Fluid’s cost and life expectancy;

- Fluid's cutting and grinding abilities;
- Fluid's resistance to bacterial attack;
- Chemical restrictions and reactivity of fluids;
- Biodegradability;
- Ease of fluid recycling and disposal;
- Ease of fluid maintenance and quality control;
- The corrosion protection the fluid offers;
- Speed, feed and depth of the cutting operation;
- Type, hardness and microstructure of the metal being machined;
- Ability to separate fluid from the work and cuttings;
- The product's applicable temperature operating range; and
- Optimal concentration and pH ranges.

Types of Cutting Fluids

The two types of cutting fluids most commonly used are:

- Oil-based fluids, including straight oils and soluble oils
- Water-based fluids, including synthetics and semi-synthetics

The advantages, disadvantages and applications of each fluid are summarized below.

	Advantages	Disadvantages
Straight Oils	Excellent lubricity; good rust protection; good sump life; easy maintenance; rancid resistant.	Poor heat dissipation; increased risk of fire; limited to low-speed cutting operation.
Soluble Oils	Good lubrication; improved cooling capability; suitable for light and medium- duty operations involving a variety of ferrous and nonferrous applications.	More susceptible to rust problems, bacterial growth, tramp oil contamination and evaporation losses.
Synthetics	Excellent microbial control and rancid resistant; relatively nontoxic; superior cooling qualities; easy maintenance; relatively long service life; capable of handling heavy-day cutting operations.	Reduced lubricity; may cause misting, foaming and dermatitis; may emulsify tramp oil; easily contaminated by other machine fluids.
Semi-synthetics	Good microbial control and rancid resistant; relatively nontoxic; superior cooling qualities; easy maintenance; relatively long service life.	Water hardness affects stability; may emulsify tramp oil; easily contaminated by other machine fluids.

Cutting fluid alternatives — Bio-based lubricants

Due to growing environmental concerns, regulatory impacts on coolants, and economic issues, the market and use of bio-based lubricants will increase during the next five to 10 years. Several new cutting fluids have been introduced, many of which are based on soybean oil or methyl soyate. Soy-based lubricants come from U.S.-grown soybeans, which is a renewable resource. Soy-based oils currently match the price and performance of petroleum or semi-synthetic oils. Advantages include improved surface finishes and centricity, readily biodegradable, easier to dispose, less hazardous in the work environment, reduced risk of fire, smoke and misting, and no chlorine or sulfur content.

Inventory Management and Chemical Handling

The fluid management/handling personnel should:

- Follow the storage instructions of all materials to prevent spoilage;
- Check materials for damage and expiration date upon receipt;
- Use spigots and funnels to reduce spills;
- Provide spill kits;
- Keep waste chemicals segregated to allow for reuse and recycling; and
- Establish a record-keeping system for machines that contain fluid.

Fluid Preparation

- Coolant mixture should be prepared according to manufacturer's direction.
- Mixing should always be done in a container outside the sump.
- Hardness and dissolved solids in water can cause corrosion problems and enhance microbial growth. Purification of water through deionization or reverse osmosis before mixing can help reduce these problems.

Fluid Monitoring

Over time, cutting fluids can become contaminated by chips and fines, tramp oil, bacteria and dissolved salts. Therefore, monitoring the pH, water hardness, specific component concentration (i.e. additives, tramp oil, biocide, etc) allows fluid management personnel to take the appropriate steps needed in time to prevent failure of the fluid.

Fluid Concentration

- Water evaporation should be monitored to ensure proper coolant-to-water ratio.
- Refractometers can provide accurate measurements of coolant-to-water ratio, and are fairly inexpensive and easy to operate.
- Coolant metering or feed pumps can improve the accuracy of coolant consumption and feed rate.
- Titration is an alternative for use of a refractometer. Titration is less affected by interferences from tramp oil or water quality.

pH

- The proper pH level is normally between 8.5 and 9.0.
- Sudden drop in pH indicates bacteria growth or sudden change in fluid concentration due to contamination.
- High pH may cause corrosion of metals.
- The pH level should be measured and recorded daily.
- Litmus paper provides a quick and low-cost means of fluid pH estimate.
- Portable pH meters are more expensive but can provide more accurate readings.

Microbial Growth

- Bacteria can cause the fluid to become rancid and produces a rotten-egg odor.
- Food source for bacteria includes tramp oils, particulates, minerals in the water and other contaminants.
- Two common tests for microbial monitoring are plate counts and dipslide tests.
- Dipslide monitoring provides a chance to add biocide before rancid problems occur.

Contamination Removal and Prevention

Bacteria

- **Sump Cleaning.** During a fluid change-out, the sump should be chemically or steam- cleaned to remove any residual bacteria.

- **Aeration.** A mixer or aeration device to circulate the coolant can help ensure an oxygen-enriched environment in the sump.
- **Biocides.** Many different biocides are available to control bacterial growth. Your coolant suppliers can help determine which type of biocide to use for your specific applications.
- **pH Control.** Controlling the pH can help reduce the need to use biocide. The pH can be raised using a caustic soda or sodium hydroxide solution.
- **Sump Hygiene.** Fluid management personnel should be instructed not to use sumps as trash receptacles. Waste food, cigarette butts, paper and other trash can contaminate the sump and aid bacterial growth.

Tramp Oil

Tramp oils not only provide a food source for bacteria, but also obstruct the cooling capability of the fluid and contribute to the formation of oil mist and smoke. The preventive measure is to perform routine maintenance on machine systems to prevent oil leaks from contaminating the fluid; however, some tramp oil contamination is inevitable even with the best prevention program. Many mechanical separation devices are available to remove tramp oils and are listed below.

	Contaminant Removal Process	Applications/Limitations
Skimmers	Tramp oil floats to the surface and is removed automatically by oil-attracting belts, floating ropes or wheels.	Ineffective for removing water miscible hydraulic oils or emulsified oils.
Settling Tank	Settling tanks use baffles and weirs to promote settling of heavy particulates to the bottom while allowing tramp oil and light particulates to float to the surface.	Normally used in conjunction with skimmers or automatic chip conveyors (see below).
Oil Absorbent Fabrics/Pillows	The fabric or pillows are allowed to float in the sump to absorb oils.	Only applicable for small sumps. Requires frequent disposal.
Dissolved Air Flotation	Waste stream is aerated. During aeration, the oils attach to the air bubbles, float to the surface, and are skimmed off.	Typically used after removal of larger and heavier particulates.
Coalescing	Tiny oil droplets are allowed to cling to a series of plates and form large droplets. Oil droplets then float to the surface and are skimmed off.	Ineffective for removing emulsified oils. May accumulate fine particulate matter.

Metal Chips and Fines

Excessive chip accumulation reduces sump volume and provides an environment for bacterial growth. Excessive solids buildup can also cause increased fluid temperature. The following equipment can be used for removal of chips and solid particulates.

	Contaminant Removal Process	Applications/Limitations
Screens and Conveyors	The metal screens and conveyors can help collect the majority of metal chips.	
Hydrocyclones	Coolant enters the hydrocylone at high speed. Clean coolant is drawn upwards while heavy solids are forced to flow downwards.	Can remove particles down to about 5 microns; however, hydrocyclones tend to emulsify tramp oils.
Centrifuges	Mechanical rotation to develop the centrifugal force needed for contaminant removal.	Capable of removing emulsified tramp oils.
Filtration Equipment	Filtration systems often used are bag and cartridge filters, vacuum, pressure and gravity filtration.	Depending on the desired level of particulate removal, a series of progressively finer filters may be necessary.
Magnetic Separators	Ferrous particulates are removed by magnets as the fluid flows over slowly rotating magnetic cylinders.	Other separation process is required for nonferrous metals removal.

- For the list of coolant maintenance equipment and supplies, please visit: http://mntap.umn.edu/mach/4-CoolantEquip.htm.

References

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Pollution Prevention Pays

The N.C. Division of Pollution Prevention and Environmental Assistance provides free, non-regulatory technical assistance and education on methods to eliminate, reduce, or recycle wastes before they become pollutants or require disposal. Contact DPPEA at (919) 715-6500 or (800) 763-0136 for assistance with issues in this fact sheet or any of your waste reduction concerns.

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