

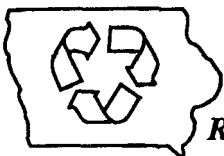
# **Cutting Fluid Management in Small Machine Shop Operations**



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Any trade names of commercial products referenced in this manual are not endorsed or recommended by the Iowa Waste Reduction Center or Kirkwood Community College.

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# I. Introduction

Machine shops and manufacturers with machining operations use and dispose of a significant amount of cutting and grinding fluid. The fluid is used as a coolant and lubricant in the cutting operations, as well as the vehicle to carry away chips and fines produced in the machining and cutting operations. There are several types of cutting and grinding fluids on the market, including both water soluble and non-soluble petroleum based oils. When these fluids lose their efficiency, they are generally disposed of, and the methods used for disposal are often environmentally unsound.

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Significant potential exists at the smaller machining and manufacturing operations to extend cutting and grinding fluid life, There is also a possibility of reclaiming, or recycling, spent fluids and possibilities for biological treatment and disposal.

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Proper management of cutting and grinding fluids will also prevent them from being declared a hazardous waste at the end of their useful life.

The majority of cutting and grinding fluids in use today are water soluble. Over time, these fluids can become rancid or contaminated with microbiological growth. With use, fluids lose their rust control capabilities, as well as their anti-foam characteristics. In addition, the fluids contain the chips and “fines” from the cutting/grinding operations. Oils called “tramp oil” accumulate from coatings on the metal and use of special petroleum based cutting and lubricating fluids. The fluid is disposed of once its efficiency is lost.

## Cutting Fluid Management in Small Machine Shop Operations

Many times this disposal is done in a manner that is damaging to the environment. Across the nation newspaper headlines have shown public and government concern for improper disposal.

### Federal Jurors Indict Firm on Dumping Count

#### *Judge Hauls in Chief Exec for Pollution Plea*

### Judge Reprimands Firm's Chief for Polluting Tacoma Waters

#### *Official Found Guilty In Ohio Waste Case*

The following is a newspaper article found in the Cedar Rapids Gazette on April 2, 1990. The unknown fluid was later identified as waste cutting fluid.

### **Sewer Substance Still Unidentified**

by Jeff Burham

Whoever dumped an oily substance into a southeast-side storm sewer may have to pay a tidy sum to clean it up.

The still unidentified milky-white substance presents no danger to the water supply near 32nd Street Drive and Emerald Avenue SE, according to District Fire Chief Robert Reynolds.

"But I sure wouldn't want my kids playing in it," said Reynolds, who inspected the scene for more than five hours Saturday night.

Neighbors spotted the substance through an opening in the storm sewer and called the Fire Department.

Reynolds said it may be "something like soluble oil." Health Department officials are testing the substance in hopes of making a positive identification.

If it is a soluble oil, Reynolds said, the substance will mix with water in Indian Creek and "eventually go away."

But he still wants to find out who dumped the substance because city ordinance would require the responsible party to pay to remove the mess. "And that could get into some really horrendous costs," Reynolds added, declining to estimate.

## Cutting Fluid Management in Small Machine Shop Operations

Through discussion with small machine shop operators we have learned that “backdoor” and “parking lot dumpings” appear to be common methods of disposal. Even when fluids are properly managed, fluid associated with chip removal can create problems. The chips and fines found in the machine coolant fluids are removed to adequately maintain the cutting fluid. Machine shops using improper removal techniques will end up with significant amounts of cutting fluid in the chips and “fines”. This fluid often ends up in the ground or washed into nearby waterways.

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*This manual will address three major areas of cutting and grinding fluid management. Selection of fluids, maintenance of fluids to obtain maximum fluid life expectancy, and disposal alternatives.*

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Good coolant management practices can go a long way toward solving coolant problems and making the most cost-effective use of your coolant.

# II. Functions of a Cutting Fluid

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Cutting fluids used in machine shops help to improve the life and function of cutting tools. The two most important functions of a cutting fluid are to provide cooling and lubrication. A good cutting fluid, in addition to prolonging cutting-tool life, should resist rancidity and provide rust control.

## Cooling

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Laboratory tests have proved that the heat produced during machining has a definite bearing on cutting-tool wear. Reducing cutting-tool temperature is important to tool life. Even a small reduction in temperature will greatly extend the life of a cutting tool. For example, if tool temperature were reduced only 50<sup>0</sup> F from 950<sup>0</sup> to 900<sup>0</sup> F, cutting tool life would be increased by five times, from 19.5 to 99 minutes. Water is the most effective agent for reducing the heat generated during machining. Since water alone causes rusting, soluble oils or chemicals which prevent rust and provide other essential qualities are added to make it a good cutting fluid.

## Lubricating

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The lubricating function of a cutting fluid is as important as its cooling function. The effective life of a cutting tool can be greatly lengthened if the heat and friction generated by the cutting process are reduced.

When cutting fluids are used, faster speeds and feeds can be used in the machining process resulting in increased production and a reduction in the cost per piece.

# Cutting Fluid Management in Small Machine Shop Operations

## **Rust Control**

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**Cutting fluids used on machine tools should inhibit rust from forming; otherwise machine parts and work will be damaged. Cutting oil prevents rust from forming but does not cool as effectively as water. Water is the best and most economical coolant but causes parts to rust unless rust inhibitors are added. All chemical cutting fluids now contain rust inhibitors, which inhibit or prevent the process of rusting.**

## **Rancidity Control**

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**In the early days of the industrial revolution lard oil was the only cutting fluid used. After a few days lard oil would start to spoil and give off an offensive odor. This rancidity is caused by bacteria and other microscopic organisms that grow and multiply. Modern synthetic fluids are susceptible to the same problem, therefore, most cutting fluids contain some type of bactericide which controls the growth of bacteria and makes the fluid more resistant to rancidity. Bactericides too high in concentration can be harmful to the skin.**

**No matter how good the engineering qualities of a coolant, if it develops an offensive odor, it can cause problems for management. The material may become a hazardous waste and may create disposal costs greater than the fluid's worth.**



## Cutting Fluid Management in Small Machine Shop Operations

The following is a list of characteristics a cutting fluid should possess to function effectively.

- Good cooling capacity
- Good lubricating qualities
- Rust resistance
- Stability - for long life
- Resistance to rancidity
- Nontoxic
- Transparent - to allow the operator to see the work clearly during machining
- Relatively low viscosity- to permit the chips and dirt to settle quickly
- Nonflammable- to avoid burning easily and should be noncombustible.

*In addition, it should not smoke excessively, form gummy deposits which may cause machine slides to become sticky, or clog the circulating system.*

# III. Cutting and Grinding Fluid Selection

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Most machining operations are performed with the aid of some fluid or lubricant to prolong tool life. Of the multitude that are available, the most common types can be classified into four groups:

## Cutting and Grinding Fluids

1. straight oils
2. Soluble oils
3. Synthetics
4. Semisynthetics

Some are suitable for many operations; others are best for a select few.

### Straight Oils (100% petroleum oil)

Straight oils, so called because they don't contain water, are basically petroleum or mineral oils with or without additives designed to improve specific properties. No additives are necessary for the easiest tasks-moderate cuts on free-cutting metals such as brass, for example. For more severe applications, straight oils are typically combined with up to 20% fatty oils, sulfur, chlorine, phosphorus or combinations of these ingredients. For extreme conditions, additives (primarily with chlorine and sulfurized fatty oils) exceed 20%.

The straight oils have not changed much since their introduction around the turn of the century, although some modifications have been made in recent years. Sulfur is now added in such a way that it won't stain copper, for example. The major advantage of straight oils is the lubricity or cushioning effect that they provide between the workpiece and cutting tool. On the other

hand, they are not especially effective in dissipating the heat generated by cutting and, thus, are usually limited to low-speed operations.

Products of different viscosities are available for each duty class. Viscosity can be thought of as a lubricant factor: the higher the oil's viscosity the greater its lubricity.

Highly viscous fluids, however, cling to the workpiece and tool, increasing coolant loss by dragout and necessitating lengthier and more costly cleanup procedures. Therefore, it can be more efficient to choose a low-viscosity oil that has been compounded to provide the same lubricity as a highly viscous one.

### **Soluble Oils (60-90% petroleum oil)**

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Emulsifiable, or soluble, oils are mineral oils containing a soaplike material (emulsifier) which makes them soluble in water and causes them to cling to the workpiece during machining. Soluble oils are suitable for light-and medium-duty operations. Although they do not match the straight oils in lubricity, they, like water-based fluids in general, are better at cooling. Because of their water content, however, they are usually formulated with additives for additional workpiece corrosion prevention and to resist microbial degradation and souring. Maintenance costs to retain these characteristics are relatively high.

The heavy-duty soluble oils are suitable for most of the cutting operations that the straight oils can handle. For example, broaching, trepanning, tapping, and of course,

## Cutting Fluid Management in Small Machine Shop Operations

light- and medium-duty operations. Soluble oils have been replaced in most operations with chemical synthetics.

### **Introduction of Chemical Cutting Fluids**

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Chemical cutting fluids, called synthetic or semisynthetics fluids, have been widely accepted since they were first introduced in about 1945. They are stable, preformed emulsions which contain very little oil and mix easily with water. Chemical cutting fluids depend on chemical agents for lubrication and friction reduction. Some types of chemical cutting fluids contain extreme-pressure (EP) lubricants, which react with freshly machined metal under the heat and pressure of a cut to form a solid lubricant. Fluids containing EP lubricants significantly reduce the heat generated during the cutting and grinding operations.

### **Synthetics (0% petroleum oil)**

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Synthetics were introduced in the late '50s and were much like soluble oils without the oil. These water-dilutable systems are designed for high cooling capacity, lubricity, corrosion prevention, and easy maintenance of composition. Synthetics tend to be preferred when clarity is important and less lubrication is needed. One drawback is that the synthetics tend to defat human skin and cause dermatitis.

The chemical agents found in most synthetic fluids include:

1. Amines and nitrites for rust prevention
2. Nitrates for nitrite stabilization
3. Phosphates and borates for water softening
4. Soaps and wetting agents for lubrication
5. Phosphorus, chlorine, and sulfur compounds for chemical lubrication
6. Glycols to act as blending agents
7. Germicides to control bacteria growth

As a result of the chemical agents which are added to enhance the cooling qualities of water, synthetic fluids provide the following advantages.

1. Good rust control
2. Resistance to rancidity for long periods of time
3. Reduction of the amount of heat generated during cutting
4. Excellent cooling qualities
5. Longer durability than cutting or soluble oils
6. Nonflammable, nonsmoking
7. Nontoxic
8. Easy separation from the work and chips, which makes them clean to handle
9. Quick setting of grit and fine chips so they are not recirculated in the cooling system
10. Prevents clogging of the machine cooling system

### **Semisynthetics (2-30% petroleum oil)**

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Semisynthetics contain small dispersions of oil in an otherwise organic water-dilutable system. Unlike most oil-in-water emulsions, which are milky and opaque, the semisynthetics are almost transparent, having only a slight haze. Most are also heat sensitive: unlike true solutions, they become less soluble in heated water as their extremely small molecules tend to gather around the cutting tool and provide more lubricity. As the solution cools, the molecules disperse again.

### **Application**

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Synthetics and semisynthetics are more broadly applicable than soluble oils and substantially easier to maintain. Like the straight oils and soluble oils, they may contain sulfur, chlorine and/or phosphorus. Overall, they offer cleanliness with less tendency to foam, good corrosion protection, and low cost.

Highly compounded straight oils are still preferred for severe cutting operations; crush grinding, severe broaching and tapping, and deep-hole drilling, for example; and for the more difficult-to-cut metals, such as certain stainless steels and many superalloys. Their cost is high, but, under such conditions, they provide the longest tool life. They are also easier to maintain, less likely to cause corrosion, and less likely to cause problems if misapplied.

At one time it was a common perception that synthetics were primarily for grinding, but heavy-duty synthetics have been introduced in the last few years that can handle most machining operations. Both synthetics and

semisynthetics have greater longevity and better cooling than straight oils. Yet straight oils are still recommended for some operations because they provide a better lubricating film.

Choosing the right cutting fluid for your operation can be confusing and time consuming. Testing coolants in your operation is an important process to improve products and manufacturing efficiency. Suppliers can be helpful by recommending fluids and thereby narrowing the choices. One thing that must be remembered when choosing fluids, in today's world you generally get what you pay for. Don't choose a fluid just on its initial cost but on the cost per gallon divided by its life expectancy.

### Fluid Cost Per Day Example

#### FLUID I

One 55 gallon drum \$230  
Life expectancy 60 days

$\$230 / 55 \text{ gal} = \$4.18 \text{ per gal}$   
 $\$4.18 / 60 \text{ day life} = \$0.07$

\$0.07 per gal per day

#### FLUID II

One 55 gallon drum \$450  
Life expectancy 180 days

$\$450 / 55 \text{ gal} = \$8.18 \text{ per gal}$   
 $\$8.18 / 180 \text{ day life} = \$0.045$

\$0.045 per gal per day

The lower priced fluid is close to twice the cost of the higher priced fluid.

# IV. Fluid Maintenance

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The key to extending fluid usefulness is proper fluid maintenance. To maintain a fluid it must be monitored to predict or anticipate problems. Monitoring includes determination of concentration using a refractometer or titration kits, and control of rancidity with pH measurement and/or dip slides.

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***Monitoring is only the first step in fluid maintenance.***

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It must be followed with maintenance in the form of fluid concentration adjustments, tramp oil removal, chips and fines removal through sump cleaning, biocide addition, and pH adjustment.

## **Water Quality**

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The quality of the water used to dilute fluid concentrate is important to the performance of the fluid. Fluid life, tool life, foam characteristics, product residue, corrosion control and stability are all affected by water quality.

During normal fluid use, evaporation of water increases the concentration of the working fluid. As new water is added to make up for evaporation loss additional minerals from the water are also added, minerals that are left in the fluid by evaporation. Hard water has more minerals or total dissolved solids than soft water and the higher the initial hardness of the water the faster the solids will increase in the working fluid.

Certain dissolved solids or minerals contribute more to problems with working fluids than others. Chloride



salts and sulfates contribute to corrosion at levels greater than 100 parts per million. Sulfates also promote growth of sulfate reducing bacteria that cause fluids to become rancid. In many areas drinking water may have sulfate concentrations of 50 to 100 ppm. Chloride levels are generally less than 10 ppm in untreated water but are greatly increased by common water softening.

If fluid life is a problem, it is important to have a water analysis completed. If the shop is served by a public water supply, the local supplier of water can provide the needed data. The fluid manufacturer may recommend some form of water treatment based on the water analysis. This may be use of deionized water from an inline tank much like a water softener, or a reverse osmosis unit. With some waters, distillation units are an option. Reverse osmosis may be a problem with high sulfate waters. Both types of units may need a common water softener preceding the treatment unit. Under no circumstances should water from a common home type water softener be used to treat make-up water for metalworking fluids.

### Coolant Concentration

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The concentration of your coolant must be monitored regularly. Weekly monitoring is the minimum, daily monitoring is suggested for small sumps or stand alone machines. Concentration is important because it is the measure of the amount of active ingredients present in the coolant. Rich concentrations can result in increased coolant cost and foam.

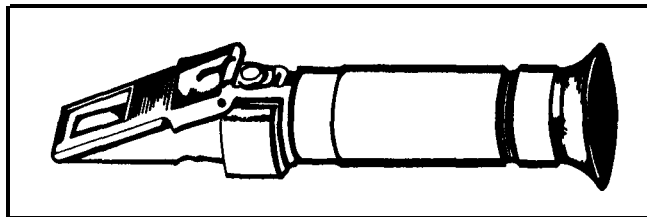
Dilute concentrations can result in shorter tool life, increased biological activity, and increased risk of rust on newly machined parts. Concentration is measured using a refractometer or by doing a chemical titration. Using a refractometer is fast, using a titration kit from the fluid supplier is more accurate.

### Refractometers

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Refractometers have recently found their way into the metal working industry. They are being used in determining total solubles in aqueous solutions of cutting fluids and quenching solutions used in heat treating. The term refractometer is principally applied to instruments used for determining the index of refraction of a liquid. The index of refraction is a measurement of how much light is bent as it passes through a liquid. With cutting fluids, as the refractometer reading increases so has the product's concentration. By measuring the concentration of a cutting fluid with a refractometer, water lost in the cooling process can be replaced, maintaining an optimum dilution of the fluid. Optimum dilution improves fluid life and maintains proper cooling and fluid characteristics.

#### Refractometer



One small machine shop uses an all-purpose cutting and grinding fluid that advertises to be a water dilutable semi-synthetic fluid used for ferrous and non-ferrous

metals. This product's benefits include: outstanding cleanliness, rust control, trouble-free performance on a wide variety of metals and operations, peak efficiency, long fluid life and low maintenance expense. One problem with the fluid is that it loses water as it is used and becomes more and more concentrated. This hinders its cooling capacity and shortens its life. The shop also found that if it tried to redilute the fluid it often over compensated leaving the fluid too dilute. The resulting fluid contained few of the desired characteristics of a good cutting fluid. This shop now uses refractometers to determine and maintain the proper dilution of their cutting fluids.

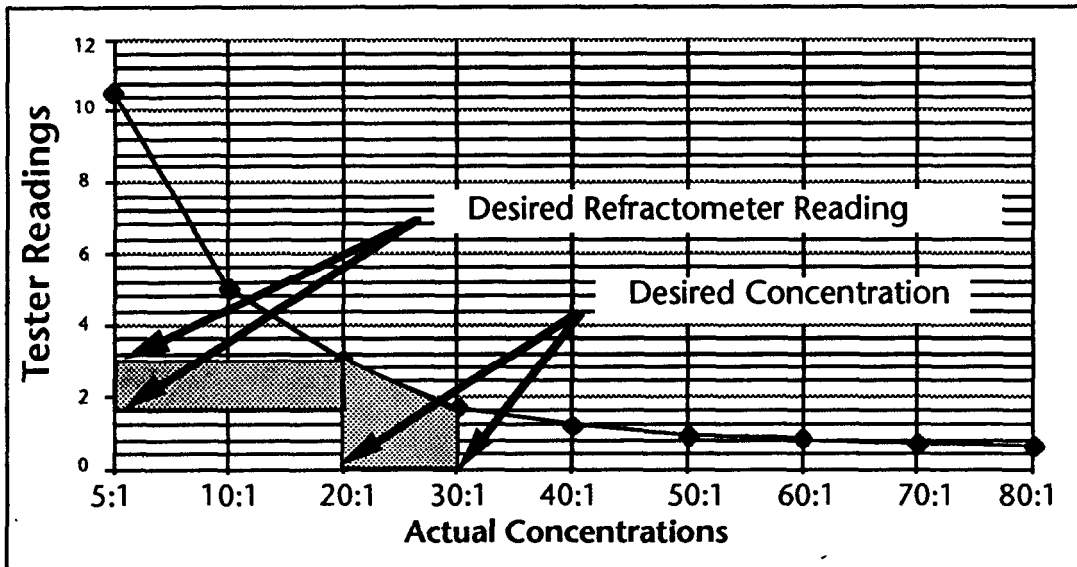
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***Optimum dilutions improve fluid life and maintain proper cooling and fluid characteristics.***

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Manufacturers recommend dilutions and corresponding refractometer readings for specific operations. For example, the fluid used for the above mentioned shop is used in a 20:1 to 30:1 dilution. The shop maintains the 20:1 to 30:1 dilution using a refractometer keeping the readings between 1.8 and 3.0.

## REFRACTOMETER / CONCENTRATION CHART



### Refractometer Operating Instructions

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1. Hold the instrument in a horizontal position. Lift the cover plate to expose the prism and, using the dipstick, place a few drops of the sample on the face of the prism. It is preferable to obtain the sample from the work area rather than from a reservoir so that any contaminants in the liquid will be better dispersed. To prevent scratching the prism face, always use the dipstick which is provided. In the absence of the dipstick, do not use glass, metal or the fingers. A common plastic stirring rod is a good substitute. Unfinished wood is not suitable since it may absorb some of the water in the specimen and give an incorrect reading. To reduce evaporation to a minimum, close the cover plate over the prism without delay.
2. To hold the instrument for reading, keep the cover plate in contact with the prism and point the instrument toward a window or other illuminating source. Look through the eyepiece and take the reading at the point where the dividing line between light and dark crosses the scale.

Until one has had sufficient experience to immediately recognize the optimum contrast obtainable between light and dark boundary, the instrument should be tilted with respect to the light source until best results are obtained. Good daylight or artificial light is adequate to illuminate the scale. Distant fluorescent light is sometimes inadequate.

3. Use a soft cloth or soft tissue paper moistened with water for wiping the prism and cover plate. Dry the prism and cover plate with a soft cloth or tissue. If the prism and cover plate is not well cleaned before the next sample is loaded an erroneous or fuzzy reading will result. Do not use hot water and never use gritty cleaning compounds to clean the prism.

**NEVER EXPOSE THE INSTRUMENT TO TEMPERATURES ABOVE 150<sup>0</sup>F.**

All instruments are factory calibrated and the adjustments are sealed. You may check the accuracy of your instrument by using distilled water as a sample. This should give you a reading of zero.

### **Titration Methods**

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Refractometer methods are fast but become less accurate when the fluid is contaminated with tramp oils. To overcome this problem vendors of fluids have developed titration kits to determine fluid concentration. The titration measures a specific chemical or group of chemicals and is less affected by interferences due to tramp oil or water quality.

The titration may be done by taking a measured volume of fluid, adding an indicator and then adding the titrant, drop by drop until a color change is noted. The coolant concentration is determined from the number of drops of titrant added.

### pH, Acidity

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The pH is the measurement of hydrogen ion concentration. The higher the pH the more alkaline the solution. Coolants should be maintained within a limited range of alkalinity, between 8.5 and 9.5. If pH of coolant in a sump falls below 8.5, the coolant loses efficiency, is prone to rusting, and biological activity will increase significantly. The pH usually remains constant and any rapid change in pH should be investigated and action taken to prevent damage to the coolant. Sudden downshifts in pH are usually indicative of increased biological activity or a sudden change in coolant concentration due to contamination. If coolant concentration and pH both jump downwards, the sump has been contaminated. If coolant concentration remains fairly constant and pH falls off, biological activity is more than likely increasing.

### pH Monitoring

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The pH or acidity can be measured in two ways. Low cost test papers give a quick estimate of the pH of a fluid. Test papers are accurate to plus or minus a full pH unit. Medium cost pH meters are accurate to plus or minus 0.2 pH units and high cost meters are accurate to hundredths of a pH unit. To determine the pH of a fluid, simple pH paper will do. To predict biocide failure a medium cost pH meter kit will be needed. pH meter kits can be obtained for one hundred to two hundred dollars. High cost pH meters that are highly accurate are of little use in fluid management.

### Tips on use of pH Meters and pH Testers

1. pH electrodes must be kept wet and clean. If one dries out, soak it in water for 24 hours.
2. pH meters and testers must be calibrated with buffer solutions. It is best to use two buffers such as pH 7 and pH 4 to make sure the meter is working properly.
3. Mix the solution, then let the meter reading stabilize for 10 to 20 seconds. Then take the measurement by immersing the tip of the electrode only 1 inch into the solution.
4. Do not be alarmed when white crystals form on the electrode, just soak the electrode in buffer or water.
5. When all else fails read the instructions that come with the meter or tester.

### Biological Growth Monitoring

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Reliable microbial growth dip slides are available. Tests cost less than ten dollars each and are useful in setting up biocide addition programs. When rancidity is a problem, microbial growth dip slide monitoring provides a chance to add biocide before problems arise. Dip slides are available from fluid suppliers and from laboratory supply houses.

### Fluid Controls

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For optimum fluid performance and life, fluid contaminants must be controlled. These contaminants can be minimized with good maintenance and housekeeping programs. With many machines lubricating oils and greases cannot be isolated from the fluid. These contaminants, as well as metal contaminants, are expected by-products.

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***Many of the contaminants that cause fluids to be disposed of frequently are foreign materials, such as floor sweepings, cleaners, solvents, dirt, tobacco, food etc.***

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If improved fluid life is a goal, it must start with education and revised shop practices. The first step in fluid control is improved housekeeping and sanitation. Only then will control of natural contaminants of oil, chips and fines, and bacteria be effective in improving fluid life.

### **Tramp Oil Removal**

---

Machine shops use coolants to transfer heat generated during the machining process away from cutting tools and parts being produced. The coolant is collected in and recirculated from a sump. During use the coolant collects lubricating oil from the machine lubricating system. This oil, called tramp oil, coats the coolant surface, contributes to the growth of anaerobic bacteria and makes the material unsuitable for disposal through a sewer system. Anaerobic bacteria produce hydrogen sulfide gas, which smells like rotten eggs and may irritate the skin. Anaerobic bacteria will shorten coolant life, and eventually force disposal of the coolant waste. It also produces acidic conditions that may dissolve chips and fines making the coolant a hazardous waste.



### **Tramp Oil Removal**

- 1. Absorbent Blankets, Fabrics or Pillows**
- 2. Disk me Oil Wheels**
- 3. Belt me Skimmers**
- 4. Rope Type Skimmers**
- 5. Porous Media Separators or Coalescers**
- 6. Centrifuges**

**Belt and disc skimmers to remove tramp oil from the surface of coolants are the most common and found to be cost-effective in large and some small operations.**

**For small sumps, oil absorbent fabrics or pillows can be used. Choose a fabric or pillow treated to repel water but absorb hydrocarbons. The fabric can be drawn across the sump pit removing tramp oil, or the pillows can float in the sump while absorbing oils.**

**A coalescer is a porous media separator. As the fluid passes through the coalescer media, the media attracts and separates the tramp oil from the fluid. The media is normally made of polypropylene which attracts oil to it in preference to water. The coalescer has no moving parts and is generally self cleaning. The oil separates to the top of the tank and is removed by a skimmer. Small shop coalescing units run from \$1,000 to \$5,000.**

**Coolant sumps, depending on maintenance practices, may require oil removal monthly or even weekly. The exact management scheme for waste oil is determined by the type of coolant, level of contamination, presence of regulated materials (metals, organic solvents) and availability of treatment.**

## Control of Microbial Growth

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Since the introduction of water-based technology early in this century, microbial contamination of the fluids has been of concern. As mentioned earlier the effects of microbial growth in fluids can significantly reduce fluid life. Successful control is a must.

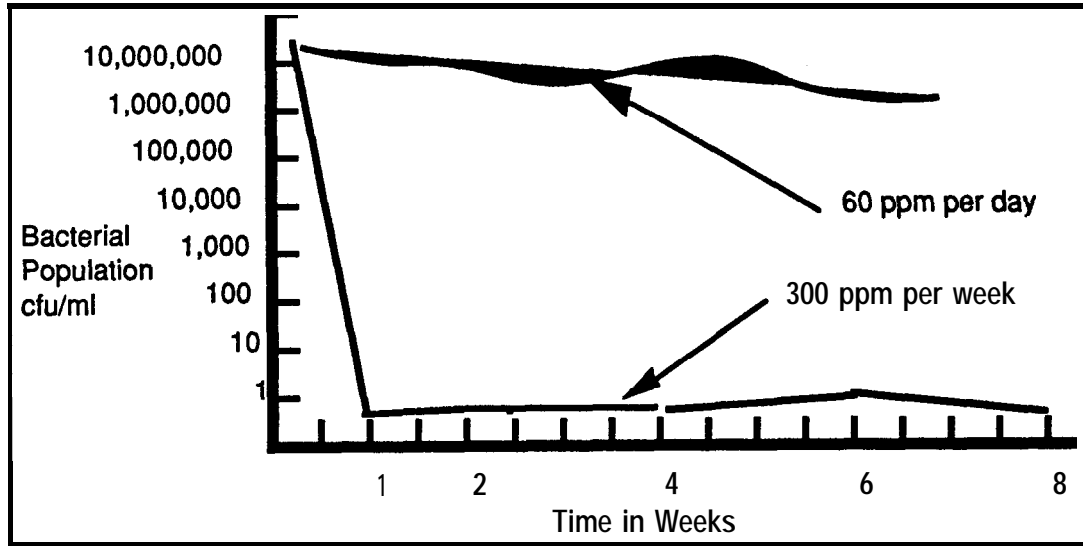
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***Bacterial growth can be controlled by routine cleaning of the sump and the use of biocides.***

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Studies have been done on the effect of biocide treatment patterns on antimicrobial efficacy in metalworking fluids. Fouled fluids were treated with a commercial biocide at various concentrations and frequencies, while microorganism populations were monitored. For all biocide application rates tested, the efficiency of antimicrobial control was found to vary widely with treatment pattern. Less frequent doses with higher concentrations of biocide were found to be much more effective than low-level, frequent doses. The reasons for this behavior were investigated, and found to be related to biocide residual concentrations, biocide consumption by microorganisms, and changes in the predominant species of bacteria which populated the fluids.

COMPARISON OF BIOCIDES DOSE RATES



Improper control of microbial growth will also alter the pH of the fluid. As the fluid becomes rancid or septic the pH drops; in other words, the solution becomes more acidic.

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*This acid produced by the bacteria will dissolve metal chips and fines and possibly cause the material to meet the Resource Conservation and Recovery Act (RCRA) definition of hazardous waste.*

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This is discussed in detail in the hazardous waste regulation section.

Failure to remove chips and fines from the sumps also promotes microbial growth. Biocides do not reach the fluids mixed in the fines and this sludge in the bottom of the sump becomes septic or rancid. Even if the majority of the fluid is free of bacteria the sludge in the bottom will harbor the bacteria, creating a septic condition. This promotes the dissolving of metals and increases the

toxicity of the fluid making disposal in the local wastewater treatment plants unacceptable.

## Fluid Recycling

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Self-contained recycling system units can be purchased that are specifically designed for smaller machine/grinding shops. These units provide a complete sump maintenance, coolant recycling system in one unit, portable and nonportable. It is recommended that coolants be recycled every two or three weeks on an average to keep coolants fresh and usable for extended periods of time. Use of fluid recycling units results in a significant reduction in waste disposal and related costs. Problems associated with rancidity and operator dermatitis are usually eliminated with improved coolant condition. Recycling equipment is usually easy to operate and maintain. These units also provide effective concentration control.

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*Facilities recycling fluids report fluid life of one to two years of more.*

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There is a wide variety of recycling systems or, as they are sometimes called, “contaminant removal systems”. For small shops the most effective method to extend fluid life or to recycle fluid for individual machines is the use of batch treatment systems. Such systems are capable of removing contaminants such as tramp oil, dirt, bacteria; and can readjust the fluid concentration before the fluid is returned to the individual machine. Batch treatment must be done on a frequent basis to minimize the contaminants in the fluid. Many shops find that, to keep fluid clean, batch treatment must be

months before it needs to be disposed, it will need to be batch treated monthly. If the fluid only lasts two or three weeks it will need to be batch treated weekly. Some of the more common treatment methods are listed below. Costs of small shop recycle systems run from \$7,500 to well over \$15,000 depending on equipment options.

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**CONTAMINANT REMOVAL SYSTEMS  
FOR BATCH OPERATIONS**

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<b><u>MEDIA BASED SYSTEMS</u></b>	<b><u>OIL</u></b>	<b>REMOVES</b>	
		<b><u>DIRT</u></b>	<b><u>BACTERIA</u></b>
Gravity Filtration		X	
Pressure Filter		X	
Vacuum Filter		X	
<b><u>NATURAL PROPERTY SYSTEM</u></b>			
Settling/gravity			X
Oil Skimmers	X		
Coalescers	X	X	
Aeration	X		
<b><u>MECHANICAL SEPARATION SYS.</u></b>			
Cyclones			X
Centrifuges	X	X	
Magnetic Separators		X	
<b><u>OTHER SYSTEMS</u></b>			
Pasteurization			X

## Fluid Change Procedure

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The following is an example of a coolant change practice used at one small machine shop and found to be the most efficient for extended coolant life.

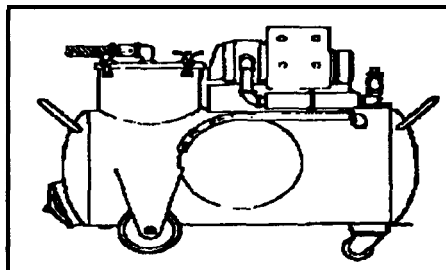
1. Skim all tramp oil from coolant surface
2. Pump coolant from sump
3. Vacuum chips from sump
4. Remove sump access covers
5. Vacuum chips from sump
6. Clean and vacuum sump (repeat until clean)
7. Replace sump access covers
8. Replace original coolant

The change practice was performed every 2-3 months and required an average of 5.21 hours to accomplish on a cast sump, 20-100 gallons. Sumps made of sheet metal take several hours less because corners are generally rounded and more easily cleaned. This coolant change practice, when combined with improved ongoing coolant maintenance, holds promise for extending coolant life;

---

*With proper maintenance of fluids, proper addition of bactericides and inhibitors, and maintenance of proper dilution, cutting fluids can last almost indefinitely.*

---



SUMP CLEANER/FILTER

# V. Fluid Disposal

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Proper care of cutting fluids is important if the maximum benefits of using water-based products are to be obtained. Prolonging cutting fluid life is a sound, economically justifiable policy and certainly the first step of any waste management program.

While prolonging the life of a cutting fluid is possible, extending it indefinitely is not. Eventually, it will have to be treated and disposed of as a waste.

Cutting fluid wastes are as varied as they are numerous. Their chemical components reflect not only their original makeup, but also the operations and conditions of their use. In fact, many cutting fluid wastes contain higher percentages of machine tool lubricating oils and/or suspended solids (dirt) than they do cutting fluid.

If all tramp oil is removed, and waste fluid is not allowed to become septic, and chips and fines are removed, water soluble and synthetic fluids can in many cases, with the approval of local wastewater authorities, be disposed of in the municipal sewer treatment system. If not treated properly waste can become toxic and will fall under hazardous waste regulations.

## Hazardous Waste Regulations

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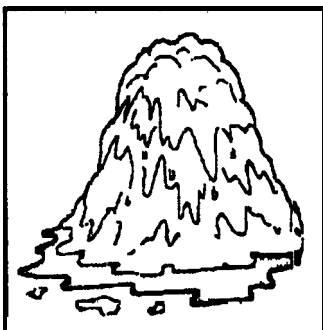
Congress defined the term “hazardous waste” in the Resource Conservation and Recovery Act (RCRA) as a “solid waste, or combination of solid wastes, which because of its quantity, concentration or physical, chemical or infectious characteristics may:

1. Cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness.
2. Pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.”

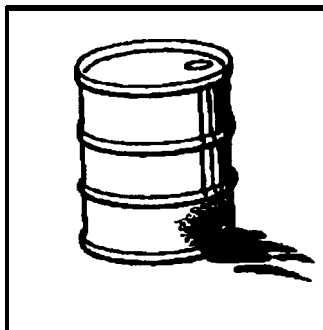
Note that hazardous wastes are defined in terms of properties of a solid waste. It should be stressed that a solid waste need not be a solid, it can also be a liquid, semisolid or a contained gaseous material.

### Hazardous Wastes May Be

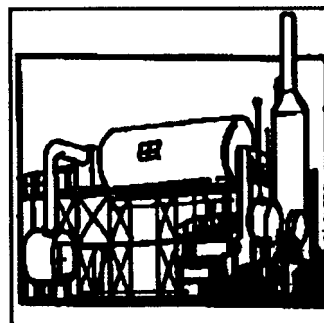
**SOLID**



**LIQUID**



**GAS**





## Cutting Fluid Management in Small Machine Shop Operations

A solid waste is hazardous if it meets one of three conditions:

1. Exhibits, on analysis, one or more characteristics (ignitability, corrosivity, reactivity or toxicity) of a hazardous waste.
2. Has been named as a hazardous waste and listed.
3. Is a mixture containing a listed hazardous waste and a non hazardous solid waste (unless the mixture is specifically excluded or no longer exhibits any of the characteristics of hazardous waste).

Four characteristics for hazardous wastes have been delineated by the federal Environmental Protection Agency (EPA). Any solid waste that exhibits one or more of them is classified as a hazardous waste. The characteristics are: ignitability, corrosivity, reactivity, toxicity.

### Hazardous Waste Classifications

Ignitable

Corrosive

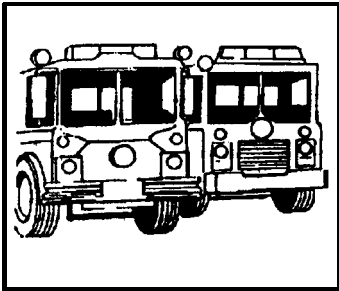
Reactive

Toxic



# IGNITABLE

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## 1. Ignitability-

A solid waste exhibits the characteristic of ignitability if a representative sample of the waste has any of the following properties:

- A. A liquid with a flash point less than 60°C (140° F), except for aqueous solutions containing less than 24 percent alcohol.
- B. A non-liquid capable, under normal conditions, of spontaneous and sustained combustion.
- C. An ignitable compressed gas per Department of Transportation (DOT) regulations.
- D. An oxidizer per DOT regulations.

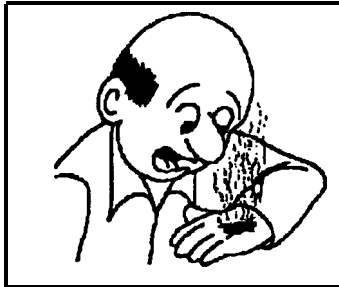
---

***EPA included ignitability as a characteristic of wastes that could cause fires during transport, storage, or disposal. Examples of ignitable wastes include many waste so/vents.***

---

## CORROSIVE

---



### 2. Corrosivity -

A solid waste exhibits the characteristic of corrosivity if a representative sample of the waste has any of the following properties:

- A. An aqueous material with a pH less than 2 or greater than 12.5 as determined by a pH meter using an EPA test method or an equivalent test method.
- B. A liquid that corrodes steel at a rate greater than 1/4 inch per year at a test temperature of 55<sup>0</sup> C (130<sup>0</sup> F).

---

***EPA selected pH as an indicator of corrosivity because wastes with high or low pH can directly affect human health or the environment or react dangerously with other wastes or cause toxic contaminants to migrate from certain wastes. Examples of corrosive wastes include acidic wastes and spent pickle liquor (used to clean steel during manufacture).***

---

# REACTIVE

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## 3. Reactivity -

A solid waste exhibits the characteristic of reactivity if a representative sample of the waste has any of the following properties:

- A. Normally unstable and undergoes violent change without detonating.
- B. Reacts violently with water.
- C. Forms a potentially explosive mixture with water.
- D. Generates toxic gases, vapor, or fumes when mixed with water.
- E. Contains cyanide or sulfide and generates toxic gases, vapors, or fumes at a pH between 2 and 12.5.
- E Listed by DOT as a forbidden explosive or as a Class A explosive or a Class B explosive.

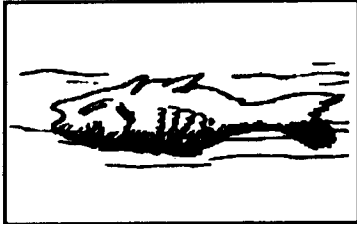
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***Reactivity is a characteristics that identifies unstable wastes that can pose a problem, such as an explosion, at any stage of the waste management cycle. Examples of reactive wastes include water from TNT operations and used cyanide solutions.***

---

# TOXIC

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## 4. Toxicity -

A solid waste exhibits the characteristic of toxicity if, by using designated test methods, the liquid waste or extract from a representative sample contains any of the contaminants listed below at concentrations greater than the following in milligrams per liter:

Contaminant	Conc EPA HW. mg/l	No.
Arsenic .....	5.0	D004
Barium .....	100.0	D005
Benzene .....	0.5	D018
Cadmium .....	1.0	D006
Carbon tetrachloride .....	.05	D019
Chlorobenzene.....	.100.0	D021
Chloroform .....	6.0	D022
Chromium .....	5.0	D007
o-Cresol .....	200.0	D023
m-Cresol .....	200.0	D024
p-Cresol .....	200.0	D025
Cresols (total) .....	.200.0	D026
1,4-Dichlorobenzene .....	.75	D027
1,2-Dichloroethane.....	.05	D028
1,1-Dichloroethylene.. ..	.07	D029
2,4-Dinitrotoluene.. ..	.013	D030
Hexachlorobenzene .....	.013	D032
Hexachloro-1,3-butadiene.. ..	.05	D033
Hexachloroethane .....	.3.0	D034

## Cutting Fluid Management in Small Machine Shop Operations

Lead .....	5.0	DO08
Mercury .....	0.2	DO09
Methyl ethyl ketone .....	200.0	DO35
Nitrobenzene .....	2.0	DO36
Pentachlorophenol .....	100.0	DO37
Pyridine .....	5.0	DO38
Selenium .....	1.0	DO10
Silver .....	5.0	DO11
Tetrachloroethylene .....	.0.7	DO39
Trichlorethylene .....	.0.5	DO40
2,4,5-Trichlorophenol.....	400.0	DO41
2,4,6-Trichlorophenol.....	2.0	DO42
Vinyl chloride.....	0.2	DO43

---

***The list identifies wastes likely to leach hazardous concentrations of toxic constituents into the ground water as a result of improper management.***

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Generators are responsible for determining if a particular solid waste is hazardous. They must either test the waste material using standard methods or have sufficient knowledge about the waste to assess whether it exhibits any of the characteristics of a hazardous waste.

## Heavy Metals

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Heavy metal is a term commonly found in the jargon of chemists and toxicologists and in environmental regulation. Heavy metals are hazardous due to their toxic effects on various body systems. Most of these materials do not break down readily in the body, and thus can accumulate over time. Many small businesses, for example machine shops, can produce a fluid containing heavy metals.

---

***A primary objective of cutting fluid management is to keep a fluid from becoming a hazardous waste.***

---

Fluids and other wastes that may contain small quantities of these metals have typically been considered hazardous waste according to the toxicity testing procedure.

## Disposal of Waste Cutting Fluids

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If the waste fluid is hazardous the major waste treatment and disposal options are contract hauling, chemical treatment, ultrafiltration, and evaporation. Method of disposal depends on volume generated, waste composition, availability and cost of options. If the waste is hazardous it can not be disposed of to a wastewater treatment plant.

Dilution was once regarded as sufficient treatment and most wastes were disposed of by emptying them directly into the nearest sewer or stream. With the advent of the Clean Water Act and the Environmental Protection Agency, such practices are restricted. To understand the

objectives of waste treatment it is important to realize that there are few direct answers for every problem and each situation demands individual attention.

---

***Minimizing waste by practicing effective coolant maintenance is the best approach to waste disposal.***

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### **Contract Hauling and Disposal Services**

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Contract disposal services and contract hauling costs are high and many large machine shops opt for in plant waste treatment. Studies have shown that for small volumes of waste (less than 200 gallons), extremely complex or highly toxic wastes, it may be cheaper to have it hauled away for chemical treatment or incineration.

### **Chemical Treatment**

---

Chemical treatment is the addition of chemicals which change the nature of the liquid waste. Elementary chemical treatment methods work well on some wastewater. But, metalworking wastes are too complex for most treatment processes . Chemical treatment beyond pH control is generally not an option for small facilities.

### **Ultrafiltration Systems**

---

Ultrafiltration systems were created for the metalworking industry to treat such wastes as used cutting fluids, detergents, parts-washer solutions, and other oily wastewaters . Strict environmental laws



require proper treatment prior to discharge.

Ultrafiltration systems provide effective treatment of this wastewater by separating the water from the oily waste. The quality of water is then ready for sewer disposal.

The concentrate from ultrafiltration may be processed for oil recovery or incinerated.

Ultrafiltration systems are usually better than chemical treatment, less expensive than incineration and contract hauling, easily operated and space efficient. Units process from 100 to 300 gallons per day and cost from \$5,000 to \$13,000.

## Evaporators

---

Evaporators are generally considered suitable for low volumes of waste, due to the enormous amount of energy required to evaporate even a small volume of material.

Used coolants are normally 90 to 95% water.

Evaporators can be used to remove the water from waste liquids, reducing the volume of waste, therefore reducing disposal costs. The advantages of evaporators include; they require very little chemical knowledge to operate, they use very little space, they are simple to operate, and the type of coolant used (synthetic, semisynthetic, or soluble oil) is not critical.

Evaporators do not eliminate waste, only reduce the volume of waste. Evaporators are also labor intensive when it comes to cleaning the units. Evaporators should be considered when other treatment systems do

not meet a shop's needs and waste must be disposed of by contract.

### **Centrifugation**

---

Centrifuges remove solids only and can be used for pretreatment. Centrifuges are expensive, and other methods such as oil skimmers are more economical for small volumes of fluids.

### **Disposal As Wastewater**

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Small amounts of spent cutting fluid can be disposed of as wastewater if it is not a hazardous waste.

Spent cutting fluids that:

1. Are water soluble
2. Receive regular biocide additions
3. Have not become septic
4. Have had the chips and fines removed
5. Have had the tramp oil absorbed to less than 100 mg/l
6. Have a pH between 6.0 and 9.0
7. Do-not contain toxic concentrations of heavy metal ions

can be disposed of in a municipal sewer but the local wastewater treatment plant operator should be contacted for approval prior to any disposal.

The long-term goal of waste treatment legislation is the complete elimination of pollution. The cost of complete control is enormous and such control is rarely practiced. Yet, the benefit of exercising some control of environmental contaminants is worthwhile, resulting in a cleaner environment.

# VI. Health Concerns

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The machining of metals involves human exposure to many chemicals. The biggest health concerns for coolants are dermatitis and respiratory problems. Most problems come from the contaminants instead of the ingredients of the coolant. Because human contact with coolants in the workplace is unavoidable, ingredients and potential health effects should be considered when selecting a cutting fluid. Most producers avoid using corrosive and irritating ingredients.

The use of straight oils can cause health and safety concerns. They create fire hazards, slippery floors and harmful oil mist.

Under the Hazard Communication Standard, Material Safety Data Sheets (MSDS) on all fluids purchased are required. These MSDS's contain important health and safety information. Consult your MSDS if any questions arise on toxicological components of the coolant.

# VII. Summary

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The economics of fluid use is changing rapidly. Emerging issues include improved fluid productivity, health and safety, and environmental concerns. There are many components when considering overall fluid use costs. As metalworking fluid needs change and costs increase, it is imperative for plants to implement a fluid management program.

Obtaining and maintaining a steady state condition of your cutting fluid are the most important parts of a fluid management program. This is done by proper fluid selection, proper pH monitoring, concentration control and biological activity monitoring.

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*Through careful fluid management, metalworking facilities can substantially improve fluid life, performance and reduce overall costs.*

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