Coolant Management & Trouble Shooting.

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About this presentation -

This presentation will assist you in the "sometimes- confusing" task of selecting and maintaining metalworking fluids for peak performance.

We have included a review of the functions and basic types of metalworking fluids as well as a section on coolant maintenance which defines the procedures needed for proper sump clean-out, machine charging and concentration control.

Included also are recommendations on ways to prolong fluid life by minimizing contamination from dirt, tramp oils and other extraneous materials.

Metalworking fluids or coolants play a critical role in most machining processes.
The main functions of a metalworking fluid are:

- **COOLING.** • **LUBRICATION.** • **CHIP REMOVAL.**
- **PROTECTION AGAINST CORROSION.**

COOLING VS. LUBRICATION

Every operation has its own specific requirements for cooling versus lubrication.
By varying the mixing ratio of a water based coolant, you can alter the balance of cooling and lubrication.
In general, the more the water (leaner mix), the better the cooling;
the more the concentrate(richer mix), the better the lubrication provided.
When machining, the requirements for lubrication are generally greater, hence a richer concentration is used.
When grinding, the requirements for cooling are greater; hence a more lean concentration is used (but not so lean as to cause rust).
But there are exceptions.
Some high-speed machining can be performed well with rather lean mixes, and some grinding applications, such as form or creep-feed grinding require a rich mixture for high lubricity.
Each operation should be evaluated on its own to determine proper concentration.

Classifications of Metalworking Lubricants

Neat or Straight Oils

• Neat oils are made up primarily of naphthenic or paraffinic base oils with extreme pressure additives such as chlorine, sulfur and fats. Neat oils will not emulsify with water nor do they contain any water.

Soluble Oils

• Greater than 30% mineral oil and no water in concentrate. Dilution appears milky and not translucent.

Semi-Synthetics

• Less than 30% mineral oil content in concentrate and the concentrate contains water. Dilution appears translucent.

Synthetics

• Zero mineral oil content. Dilution looks transparent and is a true solution with no droplet formation like semi-synthetics and soluble oils.

Soluble Oil

Advantages

• More economical than straight or neat oils; dilution with water lowers cost without sacrificing a great deal of tooling effectiveness.
• Soluble oils cool 2 to 3 times better than straight oils.
• Emulsions of soluble oils are very versatile and can be used in most machining and grinding applications on a wide variety of materials.
• Soluble oils have better health and safety aspects with respect to the shop environment vs. straight oils; no fire hazard, reduced oil misting and fogging.
• Of all the water based metal removal fluids soluble oils are the most tolerant of concentration fluctuations and poor management .
• Residues created by soluble oils are generally oily and not sticky.

Disadvantages

• Higher disposal costs due to high percentage of oil versus synthetics or semi-synthetics.
• Emulsions are milky; therefore the work-piece is not visible through fluid.
• Less cooling in high-speed applications vs. synthetics or semi-synthetics.
• May tend to pick up tramp oils due to partial mechanical emulsification from circulation through the coolant pump.

Semi-Synthetics

Advantages

- Leaves oily film on machine and parts for protection.
- Tend to reject tramp oils.
- Very stable emulsion, long lasting.
- Better cooling allows higher cutting speeds.
- Semi-synthetics offer the best of both technologies; soluble oils and synthetics.
- Semi-synthetics emulsions offer micro size oil droplets that have advantages in single point turning applications where optimal cooling and less lubrication is required.
- Semi-synthetics are ideal for powder metals components, cast iron and metals that when cut don't create chips but rather sand-like swarf that can clog filters and form sump clinkers.
- Semi-synthetic coolants are great for cleanliness and work-piece visibility.

Disadvantages

- Low oil content reduces the physical corrosion film that is needed in some applications.
- Mists, smoke or disposal may be a problem due to oil.
- Semi-synthetics are very sensitive to concentration fluctuations and rust and corrosion could be the results of poor fluid management.

Synthetics

Advantages

- Rapid heat dissipation.
- Excellent work-piece visibility.
- Total rejection of tramp oils possible.
- Usually easy to measure and control concentration.
- Bacterial attack may be easier to control.
- Usually stable and potentially long-lasting.
- No oil mist problem; no oil disposal concerns.
- Easily filterable.
- Recycling or reclaiming is usually highly effective.
- Low consumption due to the fact that synthetics are true solutions with no droplet formation adding to carry off issues.

Disadvantages

- High performance products can be expensive.
- Residual films may be tacky or sticky, which may cause gumming in the moving parts of the machine.
- Compared to oils, they have significantly reduced corrosion protection.
- Less tolerant to poor fluid management scenarios and require tighter control of concentration ratios to protect against rust and corrosion.

COOLANT MAINTENANCE

This section contains suggestions for proper maintenance and control of coolant that the customer can perform.

• Frequent testing and adjustment of coolant is feasible on large central systems where the cost of these procedures is easily justified in the control of 10,000 litres of coolant. It is not as easy to justify detailed analysis of a 100 litres sump.

Unfortunately small systems are subject to much more rapid changes and greater fluctuations and therefore actually should be checked *more frequently than large tanks to* maintain good control.

These factors make the choice of coolant particularly critical for small sumps.

• Small coolant systems normally use less effective equipment for filtration and oil separation than those found on central systems.

This requires that the coolant in small systems be more tolerant of contamination from metal fines, tramp oils and other materials or contaminants.

COOLANT LIFE

• Many factors are involved in the success or failure of a metalworking coolant.

We will attempt to address the most frequently encountered factors,

and also offer tips and techniques for maximizing the performance of your fluid.

<u>These guidelines should be strictly adhered to for optimal results.</u>

PREPARING THE MACHINE

- The most important step in maximizing coolant life is to start with a clean sump.
- Any bacteria, fungus, dirt and/or sludge left from the previous coolant can decrease the life of the new fluid.
- Thoroughly cleaning with a good machine cleaner is recommended before the introduction of any new coolant.

TIPS:

Use a low-foam alkaline cleaner designed to remove process oils, gummy deposits of oil, grease, swarf and normal shop soils from machines.

It should be able to penetrate deep into compacted chips and swarf, and render the machine neutral of bacteria and fungus and sanitize the sump.

At the same time it should be mild enough on the operator’s skin that there is no operator discomfort during the 24 hour cleaning cycle.

MACHINE CLEANOUT PROCEDURE.

1. If the system is severely contaminated or rancid, add an appropriate amount of conditioner approved for use in coolants and allow it to circulate as per manufacturer's instructions before initiating cleanout procedure.
2. Drain sump or system as far as possible. And remove any solids from sump.
3. Add the prescribed amount of machine cleaner to tap water and allow the fluid to circulate for at least 4 hours.
4. While the fluid is circulating, use a rag or brush to remove hard deposits on machine surfaces. Allow the fluid to wash the material into the machine sump.
5. Remove the fluid and any further solids from the sump.
6. Fill the sump to normal operating level with water, add a litre of sanitizer and circulate for at least 1/2 hour as a final rinse.
7. Drain this solution from the machine sump.

When production absolutely cannot be interrupted for the following method may be substituted with good results:

1. Add the cleaning liquid directly to old coolant at 1-3% of volume of sump.
2. Run production 1-2 shifts to allow the built up residues to release from the most difficult to reach areas of the machine.
3. Drain system. Use a sump sucker to pull out all of the free tramp oils off first and then the solids.
4. Rinse sump and flush coolant lines. Remove rinse water.
5. Recharge the machine with fresh coolant at the suggested and recommended concentration ratio %.

MACHINE CHARGING PROCEDURE

• For best coolant life and successful coolant management program follow these methods to recharge a freshly cleaned machine.

1. When mixing coolant, it is best to use an automatic proportioner which accurately and thoroughly mixes coolant.
2. **Always replenish the coolant with a mixture of coolant and water, not just coolant or water.**

Never add coolant concentrate directly to the sump.

3. Add the mix to the sump to the proper level.
4. Start the pump and allow the fluid to circulate for at least 1/2 hour.
5. Check concentration with refractometer and make necessary corrections before machining.

Note: Fresh emulsions will continue to clean a sump and system after the initial charge. This may result in:

• A temporary flush of odors from loosened deposits

• A temporary spike in bacteria levels

Don't be alarmed if the appearance of floating masses of sludge which have been dislodged from the inaccessible areas of the sump and or system. These are considered normal and will usually occur within the first two weeks of use of a fresh charge.

Once removed these floating masses should not reappear.

Concentration Control

Once a new coolant is in, concentration control is the most important parameter for a coolant user to monitor. It is imperative for long coolant and tool life.

As a rule of thumb: Concentration consistency can be achieved by never adding straight water or straight concentrate to the machine sump; always add a weak dilution half of the goal concentration. If the goal concentration is 7% always add 3.5% concentration.

The reason for this is that the water evaporation rate versus additive and component depletions correspond to the above formula.

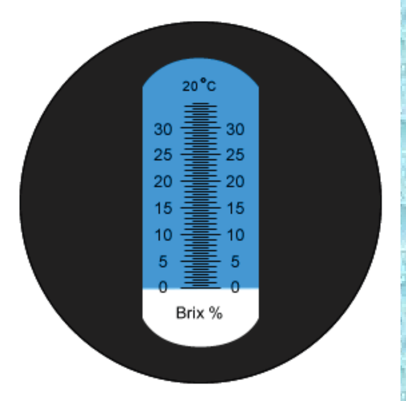
Low concentration is the most common cause of coolant problems that customers experience.

A lower concentration even for a short period, could lead to problems such as machine and Work-piece corrosion, poor tool life and rancidity of the in-service coolant.

Automatic Coolant Mixing Pump.

CONCENTRATION CONTROL

Refractometer: Designed for measuring the concentration of an aqueous solution, can be used for checking cutting and grinding fluid concentrations.
Hand refractometers are useful for day-to-day control of concentration and are much faster than the laboratory procedure.
To use a refractometer, you simply place one or two drops of the coolant solution onto the prism surface, close the cover plate, look through the eyepiece (facing the light) and read the scale.
Compare this reading with the Brix chart for your coolant to get actual concentration.
It is important to ensure that your refractometer reads zero on water alone.
This is accomplished by placing a drop of water on the prism and reading the results normally. If the reading is not zero, an adjustment screw must be turned to calibrate the unit.



CONTAMINATION

TRAMP OILS

• An important factor in coolant life is control of tramp oils. **This term refers to any oils which are not part of the original coolant formulation**, including way lubes, hydraulic oil, gear lubes, etc. which find their way into the coolant.

• These tramp oils carry their own contaminants, such as sulfur, phosphorous or solvents, which can be damaging to the coolant, either by destabilizing the emulsion or by providing food for bacteria.

If tramp oil is allowed to cover and "seal off" the surface of the sump, bacteria will grow and multiply rapidly, producing the "rotten egg" odor familiar to many machinists.

Keeping the level of floating oils to a minimum will prevent this.

• Another problem with tramp oils is the potential for dermatitis caused by skin contact with these oils, which may contain irritating components.

They should be skimmed from the surface of the sump by any of a variety of methods, such as oil wheels, rope-type skimmers, absorbent pads or even shop vacuums.

SOLIDS CONTAMINATION

• An area for concern that is so often overlooked is the level of chips, fines or swarf in the sump. Quantities of these small **particles can provide an enormous surface area for bacteria to attach themselves to while at the same time creating "dead areas" where coolant cannot circulate.**

There are many methods available for removal of these particulates such as magnetic wheels, conveyors or indexable filters.

In general, the less solid material in the sump or system, the better.

Due to the nature of manufacturing facilities today, it is rare that only one type of material would be machined. Because of the numerous types of metal chips that conglomerate at the bottom of the sump, there is a potential to create galvanic reactions, which could harm the coolant emulsion and result in shortening the coolant life span. Corrosion is also possible.

Water Quality

• Due to normal evaporation, a metalworking sump acts like a kettle and any minerals in the water will remain behind as the water evaporates. Over time the mineral build-up can result in poor emulsion (mix) stability, heavy residue on machine surfaces, corrosion problems and a host of undesirable conditions.

•A good rule of thumb is to use tap water for the initial charge and the purest water available for makeup solutions, thus minimizing the level of mineral buildup. (**A certain amount of water hardness can actually help suppress foam levels.**)

Bacterial Contamination

Bacteria exists as both aerobic and anaerobic.
While aerobic bacteria survives in air, anaerobic bacteria thrives in water, in the absence of oxygen.
They consume the oil and secrete acid giving rise to bad odor and skin irritation.
Floating oil prevents entry of oxygen helping bacteria to multiply every 20 minutes.
Ultimately the emulsion breaks.

Daily In-service Coolant Management

Tramp Oil: Run oil skimmers to remove excess tramp oil from coolant. These are generally more efficient if run during down time, when the coolant is still and the oils can float to the surface. A wet/dry vacuum can also be used to remove floating oils. Dispose of as waste oil.

Concentration: Circulate coolant and check concentration with a refractometer. Maintain fluid level. Add rich or lean pre-mixture of coolant and water where needed.

Check pH. If pH starts to fall, add coolant to bring up concentration.

If pH does not stabilize, it is time to replace coolant.

If coolant needs to be replaced, dump old coolant, clean machine and charge with fresh coolant.

Record data on a machine check sheet (See example). This can be used to follow trends of a particular machine.

Check all filters, chip strainers and canister filters.

Aeration/Ozonation: Provide aeration of coolant during extended periods of idle time. An air lance with 5 psi pressure allowed to bubble *gently in an idle sump is often* sufficient to prevent excessive anaerobic bacteria formation.

Daily Coolant Report Card

Here is a sample machine check sheet which can be used to track the condition of a particular machine or system in regards to evaporation rates over a period, deterioration based on pH, and record of cleanouts.
Other fields may be added, including bacterial and fungal levels, water hardness, conductivity and TDS.

DATE	Appearance	BRIX	pH	Coolant Added. Liters.	Water Added Liters.	Date Last Changed	Initials

COOLANT ANALYSIS

Your coolant supplier may be able to offer regular analysis of condition of coolants. These analyses include checks for concentration, pH, biological activity and contaminant levels, etc. Upon completion of analysis, full reports with any recommended actions are forwarded to the customer.

A full description and explanation of coolant analysis follows.

M/C No & Coolant Brand.	Brix.	pH	Conc 6-11%	Tramp Oil	Dirt %	Bacteria CFU	Fungus	Conductivity MHO	H_2O Hardness PPM
Sample No.	4.5	8.7	9.0	0.0	0.0	NIL	NIL	1756	120

BRIX:

This is simply the refractometer reading (Brix scale). The value can be converted to % concentration using Brix charts from the product label or the product data sheet.

pH:

A measure of the acidity or alkalinity of a system. Most fresh dilutions will be between 8.5 and 9.5 pH. This will normally decrease over time. The decrease may be accelerated by contaminants or excessive bacterial growth.

CONCENTRATION:

A measure of percent of coolant in the submitted sample based on titration, refractive index or other analytical method.

TRAMP OIL:

Tramp oil refers to any process oil **not part of the initial coolant formulation,** which makes its way into the coolant system. Floating tramp oils can seal the surface of a sump, excluding oxygen and accelerating the growth of damaging anaerobic bacteria.

DIRT:

Refers to any insolubles in the submitted sample, determined by filtration through a 15 micron glass fiber filter. These can be metal fines and/or grinding swarf, as well as other materials.

When these solids settle to the bottom of the sump they can create dead spaces which are good for bacteria to grow.

BACTERIA: Expressed in colonies per milliliter

Refers to the level of bacterial activity in the submitted sample, determined by dip-slide. A level of 105 colonies/ml is considered the upper acceptable limit for the non-bio stable products.

FUNGUS: Expressed as negative, slight, moderate or heavy.

Refers to the level of fungal activity in the coolant. A fungal presence is not generally acceptable, as it can plug screens, filters, lines and pumps if not addressed in time. Unlike bacteria, which disintegrate as they die, a fungal mass will remain intact and must be physically removed.

CONDUCTIVITY: Expressed in micro mhos (μmho)

This is a measure of how well a particular coolant conducts electricity. This indicates the potential for electrical activity such as corrosion and rusting, although it is also a function of coolant concentration, i.e.: high concentration will cause a corresponding increase in conductivity. A high conductivity without a high concentration of coolant indicates a higher potential for corrosion due to metal ion buildup.

WATER HARDNESS: Expressed as parts per million of $CaCO_3$ (calcium carbonate.

A measure of the level of hardness minerals dissolved in the water phase of the submitted sample. Most fluid sumps will act as stills, evaporating pure water while leaving hardness minerals behind in the coolant. As the water is replaced (by more mineral-containing water) the level of minerals increases, which can result in sticky, hard or crystalline residue on the machine surfaces.

RECYCLING

Coolants are a major expense, for any metal working industry like yours.
Most coolants can be recycled and may be treated with biocides, if necessary.
These treated coolants may be reused after treatment, generally at a ratio of 50/50 with fresh coolant, **provided the pH of the used coolant has not dropped below 7.5.**
If this has happened, indicating acidic contamination of the coolant, the best recommendation would be to dispose of the coolant rather than contaminate a fresh batch and risk early rancidity.

KleenCOOL Coolant Recycling System

Vacuums
chips & sludge
with coolant,
Completely from sumps.

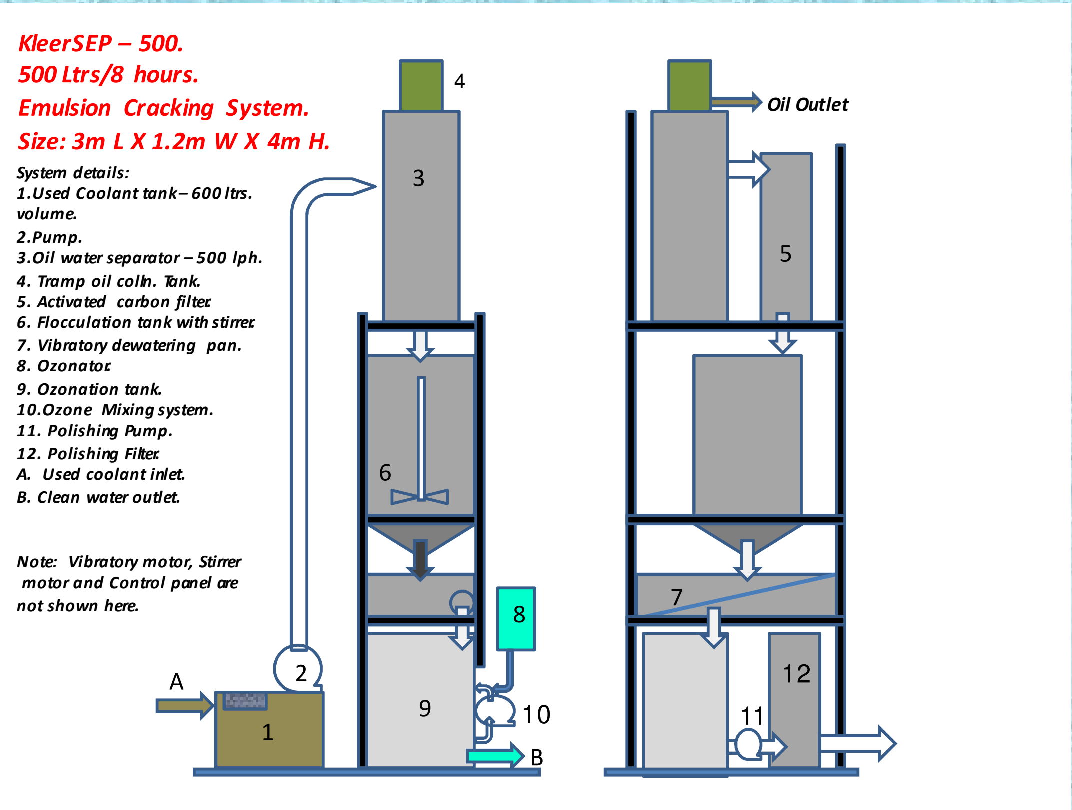
Removes
Tramp Oil,
Solid Particles,
Sludge,
Bacteria and
Bad Odor.

Recycles coolant
for reuse 2 to 3 times

Recover 80% per recycle

Disposal

If the decision is made to dispose of the coolant, an acid-alum, polymer or de-emulsifier type split procedure is recommended to separate the oil phase from the water portion. Upon approval from the local waste water treatment facility, the water phase may generally be sent to ETP, with the oil phase being handled by an authorized waste oil reclaiming facility.



Troubleshooting Coolants

Problem :
Coolant foaming excessively.
Solution :
The first thing to check is coolant concentration. A mix that is too rich can contribute to foaming, just as a strong soap solution will foam more than a weak one. Check concentration with a refractometer and adjust as necessary.

- Another factor that can influence foaming is water quality.

Coolant mixed with city water or well water will foam much faster than if mixed with deionized or otherwise demineralized water.

- A third factor is the possibility of mechanical problems.

If there is a leak on the suction or around the shaft seals of a coolant pump, air can be drawn in and become entrained in the fluid, resulting in a very slow-breaking layer of dense foam. This same condition can occur if the sump is run low and air is drawn into the intake.

- A fourth possibility is contamination with foam-generating materials such as cleaners which may have been inadvertently added to the sump.
- Another important contributor to foam generation is the velocity and pressure at which the coolant is delivered to the cutting zone.

High-pressure, high-velocity delivery generates much more foaming activity in a coolant than low-pressure, low-volume delivery.

Problem : Rusting of parts
Solution : Coolant mix too lean.
Check concentration with refractometer and adjust if necessary.
• pH too low for effective corrosion control, either through contamination or bacterial degradation. Check pH with paper or meter.

Problem : Short sump life
Solution : Concentration not maintained at high enough level.
Check with refractometer and adjust concentration if necessary to product parameters.
• Tramp oil sealing surface of sump, excluding oxygen and allowing rapid growth of anaerobic bacteria. Take steps to reduce or remove floating tramp oil.
• Excessive contamination of sump by dirt, fines or other extraneous materials, such as trash. Provide filtration for coolant and receptacles for garbage.

Problem : Heavy or sticky residues
Solution : Coolant concentration too rich.
Check concentration with refractometer and adjust with water if necessary.
• Water too hard. High levels of minerals can build up over time due to evaporation, resulting in hard, crystalline residues. Use treated water, such as that obtained with D.I. (deionizer) or R.O. (reverse osmosis) units.
• Excessive tramp oil contamination. Tramp oils can build up and coat machine surfaces. Take steps to reduce or remove floating tramp oil.

Problem : Dermatitis or Skin Irritation

Solution : Since many factors can contribute to dermatitis in the metalworking industry, determining a specific cause can sometimes be very difficult.

Some of the main factors are:

• The strength of the cutting fluid solution and the consequent condition of the skin that results from too-frequent contact with strong solutions.

• The type of metal being machined may result in the presence of sensitizing elements such as nickel or chromium dissolved in the solution.
These can result in an allergic reaction.

• Any grinding or metalworking process will result in small, sharp particles of metal or abrasive materials being circulated where they can come into contact with and damage unprotected skin. Damaged skin then becomes a route of entry for contaminants and irritants, whether at work or at home.

• Other causes of dermatitis can be such things as hydraulic fluids or way lubes which may find their way into a sump. These products are often designed without human contact in mind, and may contain components which can initiate or worsen a dermatitis condition.

• Washing hands with pumice or grit containing soaps can actually contribute to dermatitis, by creating small cuts on the skin and delaying or preventing healing in the presence of metalworking fluids.