Waste Minimization and Wastewater Treatment of Metalworking Fluids

Coolant Management: A Users' Introduction and Guide to Waste Minimization

a publication of the
Independent Lubricant Manufacturers Association
Research and Development Committee
651 South Washington Street
Alexandria, Virginia 22314
Phone 703/684-5574
Fax 703/836-8503

Research & Development Committee Chair
Ralph Kelly, Cincinnati Milacron

Research & Development Committee Vice Chair
Paul Dacko, Ideas, Inc.

Research & Development Project Director
Raymond M. Dick, Cincinnati Milacron

Reprinted with permission from the Independent Lubricant Manufacturers Association.
Coolant Management: A Users' Introduction
And Guide To Waste Minimization

George L. Hoobler
Master Chemical Corporation

"Something was wrong" at a large midwestern transmission plant. Worried accountants came to the manager of maintenance systems with an "urgent problem." Their "figures" weren't coming out right. Was there computer trouble? Were perishable tools charged to the wrong account? The "trouble" turned out to be that the facility was "significantly under budget on cutting tools ..." We'd all love to have a "problem" like that!

The good news is, any metalworking firm that uses water-based cutting or grinding fluids can indeed enjoy such savings through Coolant Management.

Briefly defined, "Coolant Management" is the maintenance and recycling of coolant fluids for greatly extended use. Its immediate advantages are reducing purchases of costly coolants, and dramatically reducing, even eliminating, expensive disposal of spent coolants. The latter makes it a prime managerial tool for minimizing not only waste but exposure to permanent legal liability for environmental damage under federal and state environmental statutes.

As will be shown, maintaining clean and effective cutting fluids improves performance in virtually every aspect of metalworking. At the same time, it reduces machine and coolant system clean-outs, downtime, and lost production. The net effect can be, and typically is, significant improvement in overall productivity, reduced costs and higher profits. Accordingly, coolants should always be treated as a production rather than a mere maintenance item, and should be controlled by higher-level management. This guide will explain the basic whys and hows of Coolant Management and show you how to put it to work.

Here's how it improved performance at the 1,500,000-square foot plant for making industrial and automotive transmissions. Only three months earlier, management had corrected a costly headache in a machining line by installing a Coolant Management system. (In that short time, the system was already saving enough money to make the accountants jittery about their books!) Consider their previous dilemma — the same situation is all too often the case in metalworking facilities of any size, even those with but a handful of machines:

The plant used the cheapest available coolants; no thought was given to recycling them for indefinite life.

"The coolants we used left gummy, sticky residues on our machines and caused mechanical malfunctions and mislocation of parts, with high machine repair and broken tool replacement costs," said the maintenance manager. "We knew lubricating and hydraulic oils which leaked into our coolants reduced tool life and promoted bacterial growth. But all we could do about it was try to skim off whatever floated to the surface of our central system. It wasn't enough. Our maintenance and tool costs kept increasing."

If this sounds too familiar, it is because all of these troubles and many more have afflicted industry from "day one." However, there have been strong incentives in recent years to do it right. These include:

- The rising cost of coolants, labor, machines and cutting tools;
- Sharply increased foreign competition, which should prompt more modernization here;
- Increased concern (and legal liability) for operator safety;
- And perhaps most pressing, the growing insistence on sound environmental practices and waste minimization.

This last concerns us in particularly important ways: not only in meeting ever more stringent environmental regulations and in the soaring costs of legal exposure and of waste disposal, but in recognizing that with today's technology, responsible pollution control is in every way compatible with profit maximization. This is one area where business and the EPA are on the same side. We now have the means, previously unavailable, to prevent coolant failure, hence the dumping of hundreds or thousands of gallons of contaminated fluid per year for every metalworking machine.

The same Coolant Management recovers metalworking chips, fines and recyclable tramp oils. This is at once the right and the cost-effective thing to do, and it begins with careful management. It should be planned, not imposed by circumstance. Again, the EPA agrees: waste minimization "is a job best done when companies set their own goals and objectives." Management that fails to employ the new tool of Coolant Management is sure to be at a competitive disadvantage in coming years.
Given the facts, it is very puzzling that so many completely avoidable problems persist. Some of this is due to the age-old but false attitude that "coolants are a necessary nuisance and you can’t do anything about them." Yes you can! More important is simply a managerial failure to investigate all avenues of improved productivity. We saw this in the case of the transmission maker: "...for years the plant used the cheapest available coolants; no thought was given to recycling them..." This is equally true in many other plants even today.

It is certainly understandable. Coolants are the lowest-cost item in the metalworking budget: a tiny 0.46% of the overall estimated cost. On a cost basis alone, this appears to be the last place to look for productivity gains. But this is a serious mistake. Management cannot afford to overlook seemingly small details, because they may have major effects in profitability—as is the case here. A sounder view has long been advocated by Dr. W. Edwards Deming, an internationally-known expert on quality control. Managers, he emphasizes, should be "controlling the manufacturing process so thoroughly that one cannot make bad products."³

Managers following Dr. Deming’s principle have found that coolant fluids, though small in relative cost, have a large effect on productivity; that is, a leveraged effect many times their cost. Thus a dollar invested in Coolant Management may well yield a twenty dollar improvement, or more, in profits. We understand this only if we look at basic metalworking processes and relationships instead of analyzing exclusively in terms of isolated direct cost.

It is at exactly this point that communication seems to break down. Those who are most aware of coolant problems (from machine operators to chemical engineers) have neither accounting nor high-level managerial responsibilities. And top managers in turn too often know little about the technical side: what might be done to improve operations, with what effect on productivity. This guide hopes to shed a little light for both sides, in nontechnical language.

The Characteristics and Functions of Coolants

Dry machining, as a rule, uses too much energy and produces too much heat and metal distortion for efficient work. Therefore it has long been standard practice to bathe the cutting tool, at its point of contact with the workpiece, in a cutting fluid. The primary purposes of the fluid are to lubricate the cut, reducing friction and energy consumed; and to cool it, by drawing off some of the heat produced in cutting, for efficiency and reduced metal distortion. The fluids are commonly called "coolants" because of this.

The bases for coolants range from pure water, which has the best cooling ability but offers no lubrication at all, to oils, which have the best lubricity but inferior cooling. In practice, commercial coolants often lie in between. Plain water would rust the machines and iron alloys, so is never used. Approximately half the cutting fluids sold are straight oils, for applications that need maximum lubrication, at whatever loss in cooling.

The rest of the commercial coolants are water-based, with various chemical agents added to improve lubrication. The generic term for them is "water-miscible," simply meaning mixable in water.⁴ Note well that regardless of the application, there is no perfect coolant. This is due to the differing qualities of oil and water in cooling and lubricating. When lubricity goes up, cooling goes down, and vice versa. All commercial coolants are compromises between the strong points of one or the other. But they are very good compromises, with an enormous amount of engineering knowledge to back them up, and plenty of choices for the user to meet his particular needs. The coolant supplier can and should analyze the technical requirements of a given machining operation and recommend the best coolant for it. Should problems develop later, the supplier can analyze these also, and adjust the coolant formulation.

High quality coolants serve many other purposes than those directly involved in cutting. They should prevent corrosion or rust in both cutting tools and workpieces. They should be resistant to bacterial degradation of the fluid (this is called "bioreistance"). They should leave a protective residual film on the machined surface, itself easily dissolvable later, be free of gumminess or crystalline residues, and should protect the piece from later rust and corrosion. Coolants should be nonflammable whenever possible (all water-based coolants are). They should be cleanable through filtration. Grinding in particular is highly dependent upon very clean fluids. Perhaps most important, the coolants absolutely must be nontoxic and must promote a healthy and pleasant work environment.

You, as a user of coolants, have a right to expect, and to demand, all of these safeguards in the cutting fluids you buy. You can be sure that you will not get them if you take the cheapest option on your lowest budget item, coolants, not knowing all the headaches and excessive costs that will follow. High quality coolants are more expensive, due to the engineering built into their formulation and the purity of their ingredients. But they alone can best handle the many functions needed in a cutting fluid. As we will see, there could hardly be a better example of false economy than buying an inferior coolant because it seems to cost less in the beginning. In the long run, poor quality coolants cost far more. How important this is, and what can go wrong using less than full-function coolants, is what we will look at next.

How Coolants Fail

Even if you haven’t seen it, you can well imagine how easily the cooling fluid circulating through a metalworking machine gets dirty. There is a sump, or reservoir, underneath the machine, from which fluids are pumped back onto the cutting tool, and then are drained off back to the sump. In
the process, the fluid may pick up metalworking chips and other residues, leaked or spilled oil, airborne bacteria, shop dirt, food scraps, cigarette butts, spit and other contaminants. Some facilities use local tap water instead of purified water in their coolants, which in most cases adds a heavy (and rapidly increasing) dose of minerals to the coolant. Certain oils can also add minerals such as sulfur or nitrates, and some tramp tapping fluids can add active chlorine or sulfur, creating corrosive acids in the coolant.

The sludge and gunk that accumulate in the process are bad enough, but the worst — and unavoidable — danger is bacteria. There are two kinds, aerobic (which reproduce in the presence of oxygen), and anaerobic (which reproduce where oxygen is absent). Anaerobic bacteria usually do little damage, mainly because their effects are so intolerable that correction is immediate. They produce the horrible “rotten egg” gas that machine operators dread. If they were allowed to persist, they would ruin machines through acidic corrosion. Aerobic bacteria do much more damage without being so vividly noticeable. They are introduced by, or feed on, every one of the contaminants mentioned above. They reproduce like crazy, quadrupling in number every hour! In the process they produce harmful acids and other substances that corrode or gum up the machine, cutting tools and workpieces, and break down the coolant fluid. The fluid turns rancid and "splits out" into an unusable mess. At that point, the coolants must be discarded and trucked to a landfill, at an ever-increasing cost in hauling and disposal fees, not to mention laboratory test costs and penalty rates should the waste contain, for instance, halogens, phenols or BOD/COD substances (hard-to-treat compounds with high Biochemical or Chemical Oxygen Demand).

Just to make matters worse, the two kinds of bacteria work in harmony, neither interfering with the other. The aerobic ones multiply when the fluid is circulating, full of oxygen and food. The anaerobic ones grow when the machine is shut down and the fluid is not circulating, especially in the machine sump, turning the coolant into black slime. Chips and machine waste in the sump are a breeding ground for bacteria, one nearly impossible to penetrate with germicides. Note: Some coolant manufacturers advertise that their cutting fluids are “biodegradable,” which sounds like a good thing environmentally. Not so! What they are really saying is that their fluids are susceptible to bacterial attack, which often leads to bigger pollution problems and always leads to higher coolant costs.

The end result is the failure of the coolant — and all that it is supposed to do. It is gone for good. There is no way to restore failed coolant. The only medicine here is preventive medicine. Either you prevent coolant failure through Coolant Management, or you lose it. And at that point you have to pump it all out and clean the machine by hand, laboriously, and haul the waste off to a dump that is charging two to five times as much as it did for disposal a few years ago (and in some cases far more).

In the meanwhile, the failing coolant has been wreaking havoc on your machines, cutting tools and workpieces, causing all the problems we saw at the large transmission plant and more, all adding to cost. Cutting tool and wheel life is reduced and is erratic. Machining tolerances also become erratic, with poor finish and size control. Workpieces are subject to rust or corrosion, and if on automatic conveyors, may mislocate before being cut; both factors cause a high fail rate. Machine downtime is high, both for cleaning and repairs. Failing coolants also harm the workplace environment. Tramp oils cause a smoky atmosphere around the machine. Dirty coolant can become irritating both to touch and inhalation resulting in operator discomfort. Such coolant could be deemed "hazardous" under EPA rules, and is that much harder and more expensive to dispose of. Cleaning it all up is labor-intensive, not to mention unpleasant, and costly in both downtime and labor. Finally, the machine must be fully recharged with new coolant, which will start going downhill almost as soon as it is poured in. Then the cycle will repeat.

Every one of these problems is avoidable through managerial control of fluids. Doesn’t it make more sense to you to keep the coolant clean and effective and at work indefinitely, instead of just letting it fail over and over and over?

Doing It Right

Everyone understands that a machine won’t work optimally unless its moving parts are correctly lubricated. It is time that all management understood that the same is true of coolants: a metalworking machine cannot work optimally unless it has a clean and correctly formulated cutting fluid. For years, much of the metalworking industry has suffered sub par performance caused by faulty coolants, perhaps thinking it normal or unavoidable. The kinds of problems we detailed above are widespread. This marks a managerial failure: managers are often unaware that they have a problem, or how easily it can be solved. Let us put things simply. If your metalworking facility is not using Coolant Management for its water-based coolants, you do have a problem.

Poor performance is not normal and is not inevitable. For nearly twenty years it has been possible to maintain coolants in a clean and effective condition. Where faulty coolants were causing headaches, Coolant Management restores optimal machine performance. Overall productivity improves, and costs go down. But it won’t happen until management makes it happen. That’s why we stress that the first step in Coolant Management is managerial commitment to the program.

The benefits of good Coolant Management are many and represent positive performance in every case that we have seen where good records are kept. Machines stay much cleaner and function correctly, with less maintenance and repair. Cutting tools are more reliable and have a longer life. Machining tolerances improve, so finish and size control are better, and fewer (very expensive) rejects ensue. There
is much better in-process corrosion protection. Coolant purchases typically drop to 40% of previous levels, and coolant disposal costs can be cut even more dramatically — savings of 80% are normally achieved, with near total elimination possible. In many applications, undiluted coolant concentrate may be substituted for oil lubricants in gear boxes, hydraulic oils, brush-on tapping or threading compounds or machine way oils, so that when spills or leakage occur, the cutting fluid is enriched rather than contaminated. Little "tricks of the trade" like this lead to big savings later on in waste minimization and quality control.

Such waste minimization wins rave reviews by the EPA, but for our purposes, it's great because it saves a lot of money and bother. The messy chore of hand-cleaning machines and sumps is eliminated (which delights operators!). Indeed, the most noticeable result of Coolant Management is a far cleaner work environment, not least the air. Foul odors are eliminated, as are most dermatitis problems, with the added intangible benefit of improved morale and operator satisfaction. Clean-up costs go down too. In sum, the whole manufacturing process becomes faster, smoother, more efficient and more predictable: a benefit every manager will especially appreciate. Work scheduling can thus be controlled much better. Given the modern understanding that "in-process" inventory is costly, hence the trend to "just-in-time" manufacture, reliable scheduling is a necessity. Unscheduled interruptions and breakdowns cannot be tolerated.

Coolant Management is not magic. It is a tool available to managers to improve overall performance. Its track record is astonishingly good if the tool is used correctly. Those who have adopted it are enthusiastic about their results. Those who have not yet examined this option may wish to ponder the following few figures.

It is estimated that for every $1 in coolants, the industry spends $1.10 for abrasives, $4.60 for cutting tools and $214 for labor and overhead. Suppose that while adopting Coolant Management your relative coolant costs rise 50%. A modest and not-unusual 5% gain in productivity would return $10.70. A conservative 10% reduction in tool and abrasive costs would return another 57 cents, for a total return of $11.27 on 50 cents in increased relative coolant costs. Would you spend one dollar to get back $22.54, year after year?

Management at the midwestern transmission plant had no trouble making that decision. The system they adopted is the one we describe next. Moreover, where we picked up the story, they had only adopted it for one machining line. Given the positive results, they quickly installed Coolant Management for the whole plant. Soon, even their nervous accountants were enjoying it.

How to Install a Coolant Management System

The essence of Coolant Management is the introduction and subsequent maintenance of a high quality, stable, bioreistant coolant. The fluid must be correctly formulated for the job at hand, and must be maintained in the correct concentration. Most of all, it must be kept clean through a rigorously scheduled, periodic recycling process. It is up to management to make sure that personnel are trained and that the necessary procedures are carried out without fail.

In keeping the coolant clean, there are only three basic factors to be addressed: impurities in the water supply; tramp oils; and workplace contaminants. Control of these factors will in turn inhibit the growth of coolant-destroying bacteria, which feed on all of them.

At a minimum, an effective Coolant Management system will need the following:

1) A source of chemically pure water. Removal of minerals or impurities is done with a deionizer.

2) Positive-displacement coolant proportioning equipment. In plain English, this is a device for mixing coolant concentrate with pure water in extremely accurate proportions. The device is necessary because the coolant must be kept at the correct and unvarying concentration; otherwise it is vulnerable to bacterial attack and may otherwise become ineffective also.

3) Effective, portable equipment for cleaning and recharging sumps, in batch systems. A well-known mobile suction pump on the market answers this need perfectly. Operators like it because it turns machine clean-up into an easy, 15-minute job instead of the messy one- to-three hour misery it used to be.

4) A high-speed, disc bowl centrifuge to remove tramp oils, bacteria and particulate matter from the coolant. Very desirable also is a skimmer to remove oils that float to the surface. But only the centrifuge can remove machine-emulsified oils. (The tramp oils recovered by either may then be sold to recyclers.) The equipment must be able to reduce tramp oils to 0.5% or less of the coolant.

There is equipment available that combines the deionizer, proportioning device, skimmer, centrifuge and filtration system in one palletized package. This offers a complete and effective recycling center. Whether you use a central coolant system or a batch system of cleaning individual machines, the dirty coolant is pumped out and processed to remove all contaminants, recharged with water and new coolant concentrate, and returned to use. This should be done no less than once a month, sometimes more often.
Coolant recycling equipment costs vary, but the best on the market (and it is penny wise, pound foolish to buy less) has been found, in numerous Coolant Management installations, to typically pay for itself in from four to twelve months, depending on conditions. From then on this equipment contributes a monthly profit to the bottom line. Returns on investment (R.O.I.) of 100% to 200% are not unusual for this type of equipment. However, the equipment capital investment is no longer the only option if Coolant Management is adopted. In many areas, coolant recycling companies now offer mobile services, and they are thriving. These services truck their own recycling equipment to your plant, purify and recharge the coolant in your machines, then go on to their next customer. This is particularly useful to small metalworking shops that cannot afford the capital costs of recycling equipment. Such services are, in a way, a striking proof of the impressive economic benefits of Coolant Management. They profit by recycling your coolant and you profit in waste minimization and improved productivity. The sum of profits, in effect, is the economic gain available from Coolant Management.

Space does not permit giving you here complete instructions for selecting, installing and operating a Coolant Management system. But there is no need to. A reputable coolant supplier can — and should — provide everything you need, from initial analysis of your operations, to cost-savings projections, to day-to-day operating instructions, to advanced technical support on a continuing basis. A single-source supplier of both coolants and recycling equipment is best because, should the system fail, the source of failure and means of correction will be known without doubt or controversy. Such a company has made its own commitment to do things right. It knows that in helping you undertake Coolant Management, it will actually sell you much less of its coolant. But it also knows that minimizing waste is good for its clients' business as well as environmentally right. As you prosper, it prospers.

Coolant Management can upgrade productivity and solve waste disposal problems in your company. Find out who is doing it right, check their references, and inspect systems they have installed. If you like what you see, have them conduct a thorough plant survey for you with projected savings and R.O.I. A reputable supplier should also offer a post audit service a year or so following installation of Coolant Management, to validate those forecasted savings. Then you can be confident that Coolant Management has delivered the benefits you expected.

Notes
4. This term is used whether the mixture is a solution, a colloidal suspension or an emulsion.
5. It is not practical to machine under sterile conditions, so the cutting fluid is continuously inoculated by bacteria from contaminants, including those in the air.

George L. Hoobler
Vice President
Corporate Services
Master Chemical Corporation
501 West Boundary
P.O. Box 220
Perrysburg, OH 43551-0220
Phone 419/874-7902
Fax 419/874-0684

George L. Hoobler joined Master Chemical in June 1977. Before joining Master, he was with Warner & Swasey Co. for ten years, and prior to that he spent nearly twenty years with International Nickel Co. Mr. Hoobler is a graduate of the U.S. Naval Supply Corps School, received his B.S.M.E. from Marquette Univ. and his M.S.M.E. from NJ Institute of Technology.

Master Chemical manufactures metalworking fluids and related equipment for worldwide markets. It markets a complete range of products including water miscible cutting and grinding fluids, specialty cutting oils, washing compounds, rust preventatives, EDM oils, stamping and drawing compounds and tapping fluids under the TRIM® brand name. Its related hardware includes XYBEX® recycling systems, Hydroflow filters and other fluid handling equipment. Master Chemical Corporation is a Regular Member of the Independent Lubricant Manufacturers Association.