Reduction and Treatment Options
For Water Soluble Coolant

1986 Summer Intern Report

By Laura Newcombe

Project Conducted at
Perkin Elmer
Minneapolis, MN
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References to specific systems which the company may have chosen or recommendations made by an intern for equipment or supplies have not been deleted. However, their inclusion should not be considered in any case as a recommendation by MnTAP staff. For any waste reduction project, the evaluation of all suitable vendors should be part of the initial review.
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ACKNOWLEDGEMENTS

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ABSTRACT

An analysis was undertaken at Perkin-Elmer's two machine shops to determine alternatives for disposing of spent machine coolants as well as ways the coolants could be recycled.

Currently 20 drums per year of Trim-Sol and Hangsterfer coolants, which are used in the Vacuum Products and Physical Electronics shops respectively, are disposed of as a hazardous waste and are not recycled.

The two machine shops have very different contamination problems. The Hangsterfer coolant has both lead and copper contamination, whereas the Trim-Sol coolant has only lead as a contaminant. While tramp oil is present in both coolants, it does not pose a disposal problem since it can be easily removed by skimming.

After reviewing many recycling options, a disc type oil skimmer with a filter and pump was determined to be the most efficient way to remove oil and chips from the coolants. This coolant recycling equipment would cost $543.00.

Since the Trim-Sol coolant has only lead as a contaminant, substituting a non-lead containing metal for the free cutting brass has the potential to eliminate the disposal problem. Treatment of Hangsterfer coolant must include reduction in copper concentration from average level of around 9 ppm. A treatment procedure developed by Beckart Engineering can reduce metal concentrations to levels acceptable for sewering. This system would cost $6000 and have a payback period of 1.5 years when compared to the current disposal costs, and presuming a reclamation system is not implemented.
EXECUTIVE SUMMARY

A study of waste reduction and disposal options for machining coolant has been completed. This study involved the two machine shops at Physical Electronics Division, Perkin-Elmer's facility in Eden Prairie, Minnesota. The shop in the Surface Science Department (commonly referred to as the PHI shop) uses Hangsterfer coolant for machining. Each month, approximately 80 gallons of this coolant is drummed for disposal. This coolant, which has been contaminated with tramp oil, lead and copper; is shipped off-site as a hazardous waste. The shop in the Vacuum Products Department (VPD) uses Trim-Sol coolant in its machining operations. The amount of waste Trim-Sol generated each month varies from 0 to 30 gallons. Contaminated with tramp oil and lead, both the Trim-Sol and Hangsterfer coolant are shipped off-site for disposal.

Once the types of contaminants, the amounts of each and their source were determined, methods for reducing the amount of coolant waste could be examined. Recycling the coolant by removing the tramp oil and metal chips has the potential to extend the life of the coolant and thus reduce the amount of waste generated.

The methods examined for recycling coolant included use of: bacteriacides, oil sorbents, vacuum sump cleaners, filtration hydrocyclones, centrifuges and oil skimmers. The criteria that a recycling system had to meet were included: (1) it had to remove the majority of oil and chips (2) it had to be safe and easy, and (3) it had to be cost-effective and inexpensive. Based on these criteria, a combination of a filter and oil skimmer were chosen
as the best method for recycling the coolants at Perkin-Elmer.

When the coolant can no longer be recycled, disposal of the coolant is necessary. Ideally, the coolant would be chemically treated so that the majority of it could be sewered. The disposal options evaluated were: acid alum split, Oakite's Dispoz-Aid EB, Koal's Eliminator B, sodium sulfite treatment, and the Beckart Engineering system. The criteria used for evaluating these methods included: (1) reduce metal concentrations to levels acceptable for sewering, (2) break the coolants emulsion, (3) safe and easy to use, and (4) inexpensive.

The acid alum split failed all of the above criteria and was immediately removed from the list of options. Oakite's dispoz-Aid EB did not break the emulsion in either coolant; Koal's Eliminator B increased the metal concentration in solution; and sodium sulfite did not reduce copper to acceptable levels. The Beckart system best met the above requirements even though it requires the highest capital investment.
INTRODUCTION

Perkin-Elmer is a world leader in the manufacture of highly sophisticated electronic equipment and vacuum chambers. Headquartered in Connecticut, it also has offices throughout the United States as well as in Japan and Germany. The Eden Prairie facility has three main departments: Surface Science (commonly referred to as PHI) - Physical Electronics, Vacuum Products (VPD), and Molecular Beam Epitaxy (MBE). Each make equipment that can be found in many laboratories throughout the world. Many of the parts that go into each piece of equipment are manufactured in one of the two machine shops at Perkin-Elmer’s Eden Prairie facility. During this process, the coolant used for machining becomes contaminated with machining oil and heavy metals.

Ways of reducing the amount of coolant waste generated at Perkin-Elmer was studied as well as alternatives to the current method of disposal.

The amount of coolant waste generated can be reduced by removing the oil and chips from the coolant and hence extend its life from a minimum of one month to perhaps six months.

On-site treatment of the coolant waste would provide an acceptable alternative to the current method of shipping spent coolant as a hazardous waste. An on-site treatment program would break the coolant emulsion to separate the oil and would also need to remove heavy metals from solution.

This report discusses the types of contaminants found in the coolants, the amount of each and their source. Recycling and disposal options are also evaluated for their effectiveness, simplicity and cost.
WASTE SURVEY

The coolant used in most machining operations performs two primary functions: it removes heat and reduces friction. Heat removal is necessary so that tools do not warp or distort the parts being machined. Water, with its high heat capacity, is an excellent heat remover and is the main ingredient in many coolants. When properly diluted, most aqueous-based coolants are 95-98% water. The lubricating properties of the emulsified oil give the coolant its friction reduction ability. Friction reduction gives that machined parts a better finish, extends tool life, and also reduces heat.

The coolants also perform two secondary functions which are: protection against rust and washing away chips from parts as they are being machined. Most undiluted water soluble coolants, such as the ones used at Perkin-Elmer, contain mineral oil emulsifiers, and dyes. Many also contain corrosion inhibitors, bacteriacides, and antifoaming agents (2).

At Perkin-Elmer's Eden Prairie facility, there are two machine shops: one in the Surface Science Department, the other in the Vacuum Products Department. The Surface Science Department shop, which makes components for Auger instruments, x-ray sources, ion guns and various other analytical instruments, requires a sulfur free environment. To achieve this, Hangsterfer coolant was chosen per section 4.2.1 of physical electronics machining specification #608171 (see Appendix A p.26). In the PHI shop, monthly changes of coolant are done as well as daily checks on its concentration with a refractometer, as required by section 4.2.2 of specification #608171. Changing the coolant
generates close to 80 gallons of waste Hangsterfer per month.

The vacuum products (VPD) shop, which makes parts for sophisticated vacuum chambers, has no requirements for coolant selection or maintenance. Thus, the coolant is virtually never changed; nor are attempts made to monitor its concentration which changes as water is evaporated during machining. Trim-Sol coolant, which is a very stable emulsion, is the coolant used in the VPD shop. It can withstand harsh conditions without breaking down. The sporadic nature of Trim-Sol's maintenance makes characterizing the amount of waste coolant generated much more difficult. Based on the amount of waste coolant generated in a six month period and on conversations with the shop foreman, the amount of waste coolant generated in the VPD shop is between 0 and 30 gallons per month. (see Table 1 for a comparison of shops).

At the present time, the 100-120 gallons per month of the two coolants are collected in drums and shipped off-site as a hazardous waste. The facility receiving the coolant treats it so that the largest fraction which is mostly water can be sewerred.

The types of contaminants that have been found in the coolants at Perkin-Elmer include: tramp oil, lead, copper and zinc. Tramp oil is oil picked up during machining operations. Upon standing this oil tends to float on top of the coolant. While tramp oil was known to be a contaminant which could easily be removed, the concentration of various metals which may pose a disposal problem had yet to be determined.
<table>
<thead>
<tr>
<th></th>
<th>Surface Science (PHI) shop</th>
<th>Vacuum Products (VPD) shop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coolant used</td>
<td>Hangsterfer</td>
<td>Trim-Sol</td>
</tr>
<tr>
<td>concentration of coolant</td>
<td>20:1</td>
<td>20:1</td>
</tr>
<tr>
<td></td>
<td>(95% water, 5% coolant concentrate)</td>
<td></td>
</tr>
<tr>
<td>gallons of waste coolant per month</td>
<td>80</td>
<td>0-30</td>
</tr>
<tr>
<td>maintenance of coolant</td>
<td>Daily refractometer readings, monthly coolant changes</td>
<td>none</td>
</tr>
<tr>
<td>lead concentration in waste drums</td>
<td>5.9 ppm</td>
<td>7.6 ppm</td>
</tr>
<tr>
<td>zinc concentration (on line)</td>
<td>1.95 ppm</td>
<td>3.15 ppm</td>
</tr>
<tr>
<td>copper concentration (on line)</td>
<td>8.9 ppm</td>
<td>1.2 ppm</td>
</tr>
</tbody>
</table>

Table 1 summarizes the waste in the two machine shops.
To characterize the metal concentration of the coolants, an atomic absorption spectrometer was used. Analysis of a waste drum of Hangsterfer coolant revealed a concentration of 5.9 ppm lead. This is above the 5 ppm lead needed to classify the coolant as a hazardous waste and well above 1 ppm, the limit for sewering. (see Table 2). If the lead concentration were to be reduced, it would be necessary to know the source. Some possible sources of lead were: the raw coolant, the machine parts, the waste coolant drums, or the metal that was machined. Of these choices, the last one seemed the most likely, and a test of this hypothesis was planned. A sample of Hangsterfer coolant taken from a machine that routinely cuts a mixture of non-lead containing metals was tested for lead. It showed a lead concentration of 0.5 ppm. The same coolant showed a lead concentration of 6.9 ppm after machining a small amount of leaded bronze. This indicated that the source of lead in the Hangsterfer coolant was the leaded bronze, which contains 2.5% lead.

When results of tests commissioned by NEI showed the possibility of copper and zinc contamination, further analysis was done on the atomic absorption spectrometer to determine whether these metals were in fact being leached into the coolant. A sample of Hangsterfer coolant showed 1.95 ppm zinc and 8.9 ppm copper. This indicates that zinc is not leached into the Hangsterfer coolant at any appreciable amount, but that copper is being leached into the coolant. (see Appendix B p. 29 for test results).
Table 2

METROPOLITAN WASTE CONTROL COMMISSION

Effluent Limitations

<table>
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<tr>
<th>Parameters</th>
<th>MWCC Local Limitations on Total Discharge (mg/l or other specified units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium (Cd)</td>
<td>2.0</td>
</tr>
<tr>
<td>Chromium-total (Cr)</td>
<td>8.0</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>6.0</td>
</tr>
<tr>
<td>Cyanide-total (CN)</td>
<td>4.0</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>1.0</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>0.1</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>6.0</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>8.0</td>
</tr>
<tr>
<td>pH-max. (units)</td>
<td>10.0</td>
</tr>
<tr>
<td>pH-min. (units)</td>
<td>5.0</td>
</tr>
</tbody>
</table>

MWCC local limitations for metals are the maximum for any operating day.

pH limitations are instantaneous values.

Table 2 shows the local discharge limits for various metals.
WASTE REDUCTION OPTIONS

In evaluating waste reduction options for coolant waste, two different needs were identified. The first need was to identify options for recycling the coolant. Even if a system is set up which satisfactorily prolongs the life and use of the coolant, a time comes when the coolant will no longer function satisfactorily. Therefore, the second need was to identify options appropriate for treating the waste coolant which can no longer be satisfactorily recycled. Treatment would be conducted to allow the major water fraction to be sewered.

Coolant Recycling

As coolant concentrate and disposal costs skyrocket, and new regulations on waste disposal become more stringent, recycling coolant is becoming almost a necessity in a modern machine shop. In addition, other reasons for reclaiming coolant regularly include longer tool life, leading to less downtime for machines due to tool changes; improved surface finish; and cleaner, odorless working conditions for the machinists (16).

Ideally a machine will have fresh coolant in its sump. This coolant is pumped from the sump to the machine where it comes in contact with the metal being processed. At the same time, oil, which is part of the machine lubrication, drips down and mixes with the coolant. The coolant, oil and metal chips are returned to the sump by gravity. The chips tend to settle at the bottom of the sump while the coolant and oil are recirculated back to the machine. This process continues until the coolant is deemed to be unusable by the operator. (see Figure 1). This occurs
The Trim-Sol coolant was also analyzed for its metal content. A sample of coolant from the waste Trim-Sol drum was found to contain 7.6 ppm lead. After reviewing all the metals machined with Trim-Sol coolant, the only one found to contain lead was the free cutting brass, containing 3% lead. As with the Hangsterfer coolant, additional samples of Trim-Sol were tested for copper and zinc. The zinc concentration was found to be 3.15 ppm and the copper 1.2 ppm. This indicates that neither copper nor zinc is a contaminant in the Trim-Sol coolant. Since lead is the only contaminant in the Trim-Sol coolant, and since only approximately 1% of all machining is done on free cutting brass, substituting a non-lead containing metal could be done easily. (see Appendix C p.36 for list of alternatives).

Theoretically, the Trim-Sol could be sewer ed after removing the oil.

The Hangsterfer coolant, with both lead and copper contamination, cannot be dealt with so easily. Copper comprises 15% of machining done in the PHI shop, so substituting other metals is not a viable option and therefore treatment is necessary before disposal in the sewer.
when the coolant goes sour or becomes rancid.

The main cause of coolant rancidity, which renders the coolant unusable, is bacteria. The anaerobic type of bacteria, which thrives in the absence of air, can enter the system from several sources. One possible source is airborne fungi which grow on equipment surfaces, another is parasites that are carried in on material handling skids or packing (3). Bacteria are also responsible for the rancid odor in coolants. When feeding on the sulfides found in oils and coolants, the bacteria will generate acids such as hydrogen sulfide ($\text{H}_2\text{S}$). These acids, in addition to creating the rotten egg odor, can cause the coolants emulsion to break. Removal of conditions that are favorable for bacterial growth (i.e. oil and chips) should extend the life of the coolant.

Some options considered for extending the coolant life at Perkin Elmer were bacteriacides, oil sorbents, vacuum sump cleaners, filtration, hydrocyclones, centrifuges or oil skimmers.

Bacteriacides are generally organic compounds which are added to coolant to kill bacteria and prevent their growth. Bacteriacides are only a preventative measure and will not render spent coolant usable again. Many bacteriacides contain phenols as their antibacterial agent. Phenol, known to present consequences from chronic exposure could create new disposal problems for the coolant.

Oil sorbents are a cloth like material specially designed to absorb only oil and no water. Since the coolant contains emulsified oil, it is also absorbed.
1 oil (from machine lubrication)

2 metal

3 recirculating solvent

4 fresh coolant

5 spent coolant

Figure 1 shows how the coolant becomes contaminated.
A vacuum sump cleaner will remove chips, but not oil. It can however be used to transfer the coolant to a recycling system. As they typically cost $6000, this would be an expensive investment for removal of chips only.

Filtration will remove metal chips from the coolant but will not remove the oil. Ultrafiltration, which uses a polymeric membrane to filter very small particles can be used to separate oil, but its $16,000 price tag make this option less attractive.

Hydrocyclones are cone shaped chambers in which the fluid inside is rotating and the chamber itself remains stationery. The vortex forces the lighter liquid (coolant) out of the top of the cone. The heavier solids are forced out at the bottom. The main disadvantage of the hydrocyclone is its inability to separate tramp oil from coolants. Also, small metal particles can be carried out with the liquid at the top.

Centrifuges are much like hydrocyclones except the chamber is rotating as well as the contents. It can develop forces several times that of gravity and maintain them for extended periods of time. The centrifuge can separate both chips and oil from the coolant, making it the most effective piece of equipment for cleaning coolants, but also the most expensive (most models are more than $20,000).

Oil skimmers come in many different shapes and sizes but most work on one of two principles. The first is decantation, which uses an internal tube to remove the light oil layer from the top of the coolant. The coolant then flows out at a lower level. The second type of oil skimmer relies on the attraction of oil for certain materials (i.e. plastic). The oil is pulled
toward the plastic as the skimmer breaks through the surface of
the liquid. In one kind, the oil is carried upward where wiper
blades remove it, allowing it to flow through a trough to a waste
oil collection vessel (see Figure 2). Small amounts of coolant,
dependent upon the viscosisty of the oil, will also be picked up
by the skimmer and carried to the collection vessel with the oil.
The coolant can be removed from this oil by allowing the
container to sit undisturbed for 24 hours and then draining the
coolant off the bottom.

Based on the fact that there are two small machine shops at
opposite ends of the building and several machines each with
their own sump, the following criteria was established for
evaluating recycling systems: it must remove the majority of oil
and chips; it must be safe and easy to use; and it must be
inexpensive. A combination of an oil skimmer and a filter would
be the only system to meet all of the above requirements.

Several oil skimmers have been evaluated for their
advantages and disadvantages. A summary of these is given in
Table 3.

Of the seven oil skimmers evaluated, the Abanaki, Turbo
conveyor, and the Encylon models were seen in operation at 3
different machine shops. All seemed to be effective in removing
oil from the coolant, and all seemed both safe and easy to use.
The last criterion - being inexpensive, would best be met with
the Encyclon oil skimmer.

None of the oil skimmers evaluated would fit in the smaller
(5 gal) sumps, therefore, pumping the coolant to a holding tank
for cleaning and then back again is necessary. To transfer the
Figure 2 demonstrates how a typical oil skimmer operates.
<table>
<thead>
<tr>
<th>SYSTEM AND MANUFACTURER</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbo Conveyors “CPS Jr” $2156 Mobile Unit $980 Stationary Unit</td>
<td>1. Have a mobile unit 2. No moving parts</td>
<td>1. High cost for mobile unit 2. Must have a minimum volume of coolant in separating tank.</td>
</tr>
<tr>
<td>Encyclon “Little Tramp” Oil Wheel $205</td>
<td>1. Low Cost 2. Lightweight (7 lb)</td>
<td>1. Will not tolerate changes in liquid level 2. Will remove small amount of coolant with the oil.</td>
</tr>
</tbody>
</table>

Table 3 summarizes the advantages and disadvantages of several oil skimmers.
Coolant from the various sumps to a 55 gallon drum for cleaning, an air driven diaphragm pump would be the best choice because it can handle liquids with a high solids content and also can pump the sumps dry. To remove the chips from the coolant and to protect the diaphragms, a strainer type basket filler should be placed on the suction side of the pump. The Viking Lid-Ease strainer offers easy removal and simple cleaning of the basket.

As stated above, the choice of an inexpensive method for removing oil and chips was made because the shops are located in two separate areas and because of the small amount of waste generated. If the shops were merged in the future or the volume of waste increased significantly, one of the more expensive recycling options (such as a centrifuge) might become more feasible.

**Coolant Treatment and Disposal**

For any coolant, even those using a recycling system, there comes a time when the coolant is no longer usable and must be disposed of. This waste can either be treated on-site or shipped off-site for disposal. The choice of how to dispose of spent coolant is an important one since hazardous waste regulations make the generator liable for a waste material even years after it has been disposed of. Some of the reasons to use on-site treatment are:

1. The company has control over waste disposal.
2. Utilization of the company’s own technical people and equipment.
3. Control over costs.
Sometimes on-site treatment prior to disposal is not feasible - examples of this are when the company has no technical resources, when it wants an inactive role in waste disposal, or when the volume of waste generated is so small that a treatment program would be too expensive (1).

At this time Perkin-Elmer sends its coolant waste off-site for disposal. At current levels of generation, this amounts to $3500.00 annually. Perkin-Elmer felt they wanted to reduce both the cost of disposal and the amount disposed of. Before this could be done the criteria for evaluating treatment systems had to be determined.

The criteria established for evaluating treatment options include:

1. Metal concentrations must be reduced to levels acceptable for sewering. The levels that must be met are shown in Table 2, p 7.

2. The coolant's emulsion must be broken. This is necessary to remove any emulsified oil. If this is not done, a strength charge will be levied. The amount of this charge depends on the volumetric flow rate, the suspended solids and the chemical oxygen demand (COD) (see Appendix D, p. 31 for details)

3. The method must be safe and easy to use. This is a necessary criterion since it is ultimately a machinist who will be handling the treatment of the coolant. Any treatment that is too complicated has the potential to be done incorrectly and unsafely.
4. The method must be inexpensive. This criterion is necessary since the volume generated is small.

Since off-site disposal is becoming more expensive subject to strict regulations, and liability is high, the options evaluated are all on-site methods. The treatment systems evaluated were: traditional acid-alum split, Oakite’s Dispoz-Aid EB, Koal’s Eliminator B, sodium sulfite treatment, and the Beckart Engineering system. Table 4 summarizes the advantages and disadvantages of each option.

The manufacturer of the Trim-Sol coolant, Master Chemical, provided directions for using the traditional acid-alum split to break coolant emulsions. However, when the procedure was followed, and repeated several times, it did not work effectively in breaking the emulsion of either coolant.

Oakite’s Dispoz-Aid EB is a clear liquid which is added to the coolant as a 2% solution to break its emulsion. When tested on samples of Hansterfer and Trim-Sol coolant, it failed to break the Trim-Sol’s emulsion. Even when ten times the recommended amount was added, the Trim-Sol’s emulsion would not break. The other disadvantage of this treatment option is that it does not remove heavy metals. Oakite does, however, have a product that is supposed to precipitate heavy metals from solution. It was not tested because the Dispoz-Aid EB did not work satisfactorily.

Koal’s Eliminator B is a granular type product which acidifies the coolant in order to break its emulsion. It broke the emulsion in both coolants, but did not reduce the metal concentration. In fact, the acidic environment actually increased the amount of metal in solution. For example, both
<table>
<thead>
<tr>
<th>TREATMENT SYSTEM</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
</table>
| BECKART ENGINEERING   | 1. SIMPLE, REFINED PROCESS  
2. LOW RAW MATERIAL COSTS  
3. EFFECTIVE IN REMOVING OIL  
4. EFFECTIVE IN REMOVING METALS  
5. VERY LITTLE LABOR TIME  
6. ONLY 12% WASTE  
7. WASTE RECOVERED AS A SOLID | 1. EQUIPMENT IDLE FOR MUCH OF THE YEAR  
2. HIGHER CAPITAL COSTS  
3. THREE CHEMICALS TO ADD  
4. PH SENSITIVE |
| OAKITE'S DISPOZ-AID EB | 1. FAIRLY SIMPLE  
2. FAIRLY LOW RAW MATERIAL COST | 1. WILL NOT BREAK BOTH COOLANTS EMULSIONS  
2. MORE LABOR TIME  
3. WON'T REMOVE METALS  
4. NEED OWN TANK  
5. LIQUID |
| SODIUM SULFITE         | 1. SIMPLE  
2. LOW RAW MATERIAL COSTS  
3. EFFECTIVE IN BREAKING EMULSION  
4. EFFECTIVE IN REMOVING LEAD  
5. SOLID | 1. PROCESS HAS'NT BEEN REFINED  
2. NEED SPECIAL TANK  
3. CAN HAVE LARGE VOLUME OF WASTE |
| KOAL'S ELIMINATOR B    | 1. LOW COST  
2. EFFECTIVE IN BREAKING EMULSION  
3. SOLID | 1. PUTS MORE METAL INTO SOLUTION  
2. WON'T REMOVE METALS  
3. MUST ADJUST PH  
4. STRONG ACID |

TABLE 4 summarizes the advantages and disadvantages of on-site disposal options.
coolants were below the acceptable discharge limits for zinc, but upon addition of Eliminator B, the zinc concentration increased enough to put them both out of compliance.

Sodium sulfite was discovered as a potential treatment option by accident. When experimenting with sodium sulfite as a means of precipitating lead, it was found that it also works very well as an emulsion breaker. Sodium sulfite was effective in reducing the concentration of lead, where the amount of reduction seemed to be directly proportional to the amount of sodium sulfite added. One disadvantage of this option was: the amount of waste that would have to be disposed of after treatment varied from 10 to 50% of the original volume of coolant. The biggest disadvantage of this treatment was that it did not significantly reduce the copper concentration in the coolants. Therefore, it was not considered for further study.

The Beckart Engineering treatment uses either aluminum or ferric sulfate to add ions to the coolant, lime to adjust the pH to approximately 6, and polymer B-20 (a polyelectrolyte) as a flocculant. A sample of Trim-Sol coolant which had approximately 15 ppm lead was sent to Beckart Engineering for treatment. The water-clear sample that returned had less than 1 ppm lead. In subsequent tests at Perkin-Elmer on both the Hangsterfer and Trim-Sol coolants, much the same results were obtained for lead and copper. The level of clarity was never as good as that achieved by Beckert however. The Trim-Sol proved the more difficult coolant to treat with the Beckart chemicals. Its stable emulsion was very difficult to break but after several attempts the correct "recipe" for breaking its emulsion was
found. The amount of oil and metals that are contained in the flocculent and will be removed by filtering, is estimated to be 12% of the original coolant volume. This allows 88% of the coolant to be discharged into the sewer. In the engineered equipment these three chemicals are added to the spent coolant in the first tank of the system (see Figure 3) and mixed well. An air pump is then turned on to float the floc, which contains the metals and oil, to the top of the tank. This is necessary because the floc would blind the filter paper almost immediately if allowed to remain suspended in solution and hence very little of the treated coolant could be discharged. When the valve on the bottom of the first tank is opened, the treated coolant passes through a filter while the oil and metal floc remain on the filter. This floc, when dry, has the potential to be landfilled. A leach test of the filter paper would be required before landfilling to ensure compliance with hazardous waste regulations.

Of the four treatment options, the one that satisfies all the criteria is the Beckart system. This system would handle the entire amount of coolant waste generated currently and allow for expansion in the future.
Figure 3 shows how the Beckart system operates.

1. Spent Coolant
2. Chemicals
3. Oil and Metals
4. Treated Coolant
5. Clean Effluent
CONCLUSIONS AND RECOMMENDATIONS

The coolants used on Perkin-Elmer's two machine shops are Hangsterfer (in the PHI shop) and Trim-Sol in the VPD shop.

The approximately 80 gallons per month of Hangsterfer coolant was found to contain 5.9 ppm lead and 8.9 ppm copper in addition to tramp oil. The Trim-Sol coolant on the other hand, showed a lead concentration of 7.6 ppm and virtually no copper.

A recycling system should remove tramp oil and chips effectively and simply. An Encyclon disc type oil skimmer in combination with a Viking basket type filter can achieve this at a cost of $205.00 and $63.00 respectively. A pump which would satisfactorily transfer the coolant from individual sumps would cost $275.00. The frequency of using this system will depend on the amount of oil and chips present, and how often the machine is used. All machines would not be required to follow the same schedule for recycling. For example, machines that tend to drip quite a bit of oil could use the skimmer in their sumps during their downtimes in addition to the weekly or biweekly cleaning. Machines that will sit idle for more than 1 day, should have the oil and chips removed prior to their shut down. A biweekly cleaning and recycling of the coolant should be done on all machines until a recycling schedule is determined. Experience will dictate how often cleaning will be necessary.

When the coolant can no longer be recycled, a method of separating emulsified oil and removing heavy metals must be used. Beckart Engineering offers a system that will remove both oil and heavy metals as a solid. This allows close to 90% of the coolant waste which is treated to be sewered. Even at a cost of $6,000,
this system offers a reduction in disposal costs - making it more economically feasible than off-site treatment. The cost evaluation for implementing the recycling system and the treatment system is provided in Table 5.

The combined recycling and disposal system would extend the life of the coolant and provide an effective way to remove contaminants. Since the volume of waste to be treated for disposal depends on how well the recycling system works, implementing the combined system might not be necessary. Also, since the low capital investment of the recycling system could potentially come out of the operating budget, implementing just the recycling system at this time might be the most feasible option. After the recycling system has been in operation for six months to a year, the need for a disposal system could be evaluated again.

Conversations with the Production Engineering Supervisor have indicated that the investment required to set-up the system for reclaiming the coolant on-site would not be difficult to justify. While it is unclear at this time if Perkin-Elmer will invest in the suggested equipment for treatment, the recycling opportunity is expected to be implemented.
**Table 5**

Cost Analysis

I  **Current Costs**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposal Cost</td>
<td>$3500/yr</td>
</tr>
<tr>
<td>Coolant concentrate (PHI shop)</td>
<td>$829/yr</td>
</tr>
<tr>
<td>(VDP shop)</td>
<td>$414/yr</td>
</tr>
</tbody>
</table>

II  **Projected Costs**

1. **Recycling System**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Skimmer</td>
<td>$205.00</td>
</tr>
<tr>
<td>Diaphragm Pump</td>
<td>$275.00</td>
</tr>
<tr>
<td>Filter</td>
<td>$63.00</td>
</tr>
</tbody>
</table>

Total fixed capital investment/shop $543.00

Operating Costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor [(1.66 hrs/change) x ($12.20/hr)]</td>
<td>$487/yr shop</td>
</tr>
<tr>
<td>Energy costs are negligible</td>
<td></td>
</tr>
</tbody>
</table>

2. **Treatment System**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment</td>
<td>$6000.00</td>
</tr>
<tr>
<td>Treatment Chemicals</td>
<td>$110.00/yr</td>
</tr>
<tr>
<td>Labor [(0.33 hr/change) x ($12.20/hr)]</td>
<td>$96.60/yr</td>
</tr>
</tbody>
</table>

Energy costs are negligible

III  **Payback Period**

1. Recycling system only**          0.80 yrs
2. Treatment system only***         1.50 yrs
3. Combination recycling and treatment** 2.40 yrs

*See Appendix E p. 38 for more complete breakdown and calculations.

**Calculations are based on coolant usage in VPD shop paralleling usage in the PHI shop if recycling is implemented but the current volume requiring disposal is used in calculation of payback.

***Calculations for operating costs and payback are based on current volume which requires disposal.
References

1. Chemical Engineering, August 6, 1984, p. 53


5. Standard's Alloy Data Book #2, Copper Development Association, 1973

6. Tooling and Production, October, 1985
1.0 PURPOSE

This standard establishes the requirements for machining, cleaning and handling fabricated parts so that the parts will serve their intended use, free of sulfur and chloride contaminants.

2.0 SCOPE

Applies to precision metallic fabricated parts. If there is a conflict between the requirements of this specification and the master drawing, the master drawing takes precedence.

3.0 DEFINITIONS

3.1 Fabricated Parts

PHI designed parts and not off the shelf items.

4.0 REQUIREMENTS

4.1 General

It should be assumed that all fabricated parts referencing this standard will be required to function in an environment where cleanliness is of utmost importance and contaminants will become evident when subjected to the very high vacuum conditions the parts may be subjected to.

4.2 Machining

All cutting fluids, coolants and lubricants shall be sulfur free. This applies not only to those chemicals used during machining, but also those used in maintaining any equipment which may directly or indirectly contaminate the fabricated part. The chemicals listed in 4.2.1 are ones that comply with our requirements and they or an equivalent are recommended for use. The recommended maintenance of these fluids (4.2.2) should also be adhered to.

4.2.1 Recommended Cutting Fluids, Coolants and Lubricants

<table>
<thead>
<tr>
<th>Trade Name &amp; Manufacturer</th>
<th>Used On/For</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HARD CUT #525</td>
<td>Cutting oil for hand-screw machines.</td>
</tr>
<tr>
<td>Hangsterfer Co. Mantua, New Jersey</td>
<td></td>
</tr>
</tbody>
</table>
2. J-1 THINNING OIL  
Hangsterfer Co.  
Mantua, New Jersey  
| Thinner for non-water soluble cutting oils. |

3. HY-KUT 3015  
Pillsbury Chemical & Oil Inc.  
Detroit, Michigan  
| Synthetic machining and grinding fluid. General use. |

4. KOOl KUT 5584 CTH  
Pillsbury Chemical & Oil Inc.  
Detroit, Michigan  
| Heavy duty synthetic machining and grinding fluid for magnetic core irons. |

5. JON-DRAW 722  
S.C. Johnson & Son, Inc.  
Racine, Wisconsin  
| Wax to drill and tap metals. |

6. TELLUS OIL 32  
Shell Oil Co.  
Houston, Texas  
| Light oil for spindles and general lubricating purpose. |

7. VACTRA OIL #2  
Mobil Oil Co.  
New York, N.Y.  
| Machinery way oil. |

8. HI-PRESSURE LUBE #3  
Chicago Mfg. Co.  
Woodstock, IL  
| High pressure lube for lathe centers. |

### 4.2.2 Recommended Maintenance of Cutting Fluids

To achieve optimum desirabel performance of chemical fluids, the following basic guidelines should be observed:

1. Storage of barrels of concentrates (water miscible) should be at temperatures between 50 - 120 F.

2. Mixing  - use deionized water (D.W.). Emulsions or concentrates should always be added into D.W. and agitated thoroughly for best results. A dilution of 25:1 is recommended for most PHI Machine Shop operations. Monitor concentrations twice daily with refractometer. Refresh coolant with deionized water or concentrate if necessary.

3. Cleaning cutting fluid tanks and systems always should be done at scheduled intervals. Remove all contaminants, chips, tramp oil before fresh coolant mixture is added.
4. Scheduled change and maintenance should be done at the following intervals.

A. Cutting oil (diluted) in hand screw machine - six months.

B. Emulsion type (D.W. miscible) coolant and tanks should be maintained and changes at four weeks.

4.3 Cleaning

Parts shall be cleaned of all contaminants resulting from the machining and fabrication process. Shop soils, including grease, oil, grit and metal chips, and lubricant residues shall be removed. Specific attention shall be given to blind tapped holes. After cleaning leave a light coating of the cleaning fluid on the part and blow dry. The chemicals listed in 4.3.1 and 4.3.2 are ones that comply with our requirements and they or an equivalent are recommended for use.

4.3.1 Approved Cleaning Fluids

<table>
<thead>
<tr>
<th>Trade Name &amp; Manufacturer</th>
<th>Used On/For</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mineral Spirits,</td>
<td>Solvent or cleaning fluid used for final wash</td>
</tr>
<tr>
<td>Desulfurized</td>
<td>in cleaning tanks(s).</td>
</tr>
<tr>
<td>Rollins Oil Co.</td>
<td></td>
</tr>
<tr>
<td>St. Paul, MN</td>
<td></td>
</tr>
</tbody>
</table>

4.3.2 Recommended Equipment Cleaner

1. Shop 500
   S.C. Johnson & Son Inc.
   Racine, Wisconsin

   Machinery and equipment cleaner, degreaser concentrate. Used for periodical machine cleaning.

4.3.3 Recommended Maintenance of Chemical Fluids

Solvent for washing/cleaning parts should be changes at one month intervals or sooner if it becomes visibly dirty or contaminated.

4.4 Handling

All parts shall be packaged or transported in a manner that will insure their arrival at their ultimate destination in a clean (4.3) undamaged condition. Any special packaging to protect close tolerance features, knife edges and surface finishes shall be provided by the fabricator.
APPENDIX B
Absorbance vs lead concentration

Key:
- O - standards
- A - Trim-Set Coolant
- B - Hangfeder coolant

concentration (ppm)
Key

\( \bigcirc \) standards

A - Trim set acculant

B - Wangsterer acculant

Absorbance

Concentration (ppm)
Absorbance vs zinc concentration

Key:
- O - Standards
- A - Trim-Sol coolant
- B - Hangsterfer coolant

Absorbance

Concentration (ppm)
**WAYNE LABORATORY**

**ORGANICS ANALYSIS DATA SHEET**

**2. VOLATILE COMPOUNDS - SCAN**

<table>
<thead>
<tr>
<th>Source</th>
<th>Chicago Facility</th>
<th>TEST METHOD: (GC Headspace)</th>
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</thead>
<tbody>
<tr>
<td>Sample ID Number</td>
<td>CHI-2836</td>
<td>GC/MS-624</td>
</tr>
<tr>
<td>Sample Matrix</td>
<td>Aqueous</td>
<td>Report Date: 6/4/86</td>
</tr>
<tr>
<td>Sender</td>
<td>Ellen</td>
<td>Reported To:</td>
</tr>
<tr>
<td>Date Sample Received:</td>
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<td>Concentration: Low</td>
</tr>
<tr>
<td>Date Extracted/Prepared:</td>
<td>6/2/86</td>
<td>Medium (Circle One)</td>
</tr>
<tr>
<td>Date Analyzed:</td>
<td>6/3/86</td>
<td>Conc/Dil Factor:</td>
</tr>
<tr>
<td>Percent Moisture:</td>
<td></td>
<td>pH</td>
</tr>
<tr>
<td>Percent Moisture (Decanted):</td>
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</table>

<table>
<thead>
<tr>
<th>CAS Number</th>
<th>Compound</th>
<th>ug/l or ug/Kg (Circle One)</th>
</tr>
</thead>
<tbody>
<tr>
<td>74-87-3</td>
<td>Chloromethane</td>
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<td>74-83-9</td>
<td>Bromomethane</td>
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<tr>
<td>75-01-4</td>
<td>Vinyl chloride</td>
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<td>75-00-3</td>
<td>Chloroethane</td>
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<td>75-09-2</td>
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<td>67-64-1</td>
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<tr>
<td>75-15-0</td>
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<td>1,1-Dichloroethane</td>
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<td>67-66-3</td>
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<td>56-23-5</td>
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<td></td>
<td>1,2-Dichloroethane</td>
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<td>ND</td>
</tr>
<tr>
<td></td>
<td>Total Xylenes</td>
<td>ND</td>
</tr>
</tbody>
</table>

LABORATORY MANAGER - Vijayamohan Palat
DATE: 6/4/86
### CHI# 2836

**CHEM-CLEAR**

11800 S. Stony Island Avenue
Chicago, Illinois 60617
(312) 646-6202

**WASTE SOURCE** National Electric

**WASTE GENERATOR** Perkin Elmer

**WASTE DESCRIPTION** Water Solution Coolant Oil 86418

**RECEIPT DATE**

**WASTE CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Test</th>
<th>As Rec.</th>
<th>LEACH.</th>
<th>Test</th>
<th>As Rec.</th>
<th>LEACH.</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.7</td>
<td></td>
<td>Ag, ppm</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>% TOTAL SOLIDS</td>
<td>3.17</td>
<td></td>
<td>As, ppm</td>
<td>&lt;2.0</td>
<td></td>
</tr>
<tr>
<td>% DISSOLVED SOLIDS</td>
<td>0.03</td>
<td></td>
<td>Ba, ppm</td>
<td>0.5</td>
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<tr>
<td>% SUSPENDED SOLIDS</td>
<td></td>
<td></td>
<td>Cd, ppm</td>
<td>0.1</td>
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</tr>
<tr>
<td>% SETTLEABLE SOLIDS</td>
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<td></td>
<td>Cr, ppm</td>
<td>0.8</td>
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<td>FLUID POINT °C</td>
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<td>Cr (Hex), ppm</td>
<td>-</td>
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</tr>
<tr>
<td>OIL AND GREASE, ppm</td>
<td>0.20</td>
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<td>Cu, ppm</td>
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<tr>
<td>TYENOLS, ppm</td>
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<td></td>
<td>Hg, ppb</td>
<td>&lt;2.0</td>
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<tr>
<td>CHLORIDE, ppm</td>
<td></td>
<td></td>
<td>Ni, ppm</td>
<td>0.7</td>
<td></td>
</tr>
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<td>BROMIDE, ppm</td>
<td></td>
<td></td>
<td>Pb, ppm</td>
<td>25.4</td>
<td>7.1</td>
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<tr>
<td>PHOSPHATE, ppm (TOTAL)</td>
<td></td>
<td></td>
<td>Sr, ppm</td>
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<td>COD, ppm</td>
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<td>Zn, ppm</td>
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<td>BOD, ppm</td>
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<td></td>
<td>Fe, ppm</td>
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<tr>
<td>ACIDITY mg/l as CaCO₃</td>
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<td></td>
<td></td>
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<td>ALKALINITY, mg/l as CaCO₃</td>
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<td>CYANIDE, ppm (TOTAL)</td>
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<td>CYANIDE, ppm (RELEASE)</td>
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<td>SULFIDE, ppm (TOTAL)</td>
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<td>SULFIDE, ppm</td>
<td>rel</td>
<td>&lt;10</td>
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</tbody>
</table>

**COMMENTS**

THIS REPORT HAS BEEN PREPARED FOR THE EXCLUSIVE USE AND BENEFIT OF CHEM-CLEAR, INC. NO REPRESENTATION CONCERNING SAMPLE VALIDITY OR ANALYTICAL COMPLETENESS IS HEREBY MAED TO ANY OTHER PERSON RECEIVING THIS REPORT.
**WASTE SOURCE**  National Electric  
**WASTE GENERATOR**  Perkin Elmer  
**WASTE DESCRIPTION**  Water solution Coolant Oil 86418  
**RECEIPT DATE**  

**WASTE CHARACTERISTICS**

<table>
<thead>
<tr>
<th>COLOR/APPEARANCE</th>
<th>Light green</th>
<th>WATER MISCELLIBILTY</th>
<th>+</th>
</tr>
</thead>
<tbody>
<tr>
<td>% FLOATER</td>
<td></td>
<td>% OIL ON ACIDIFICATION</td>
<td>-</td>
</tr>
<tr>
<td>% FREE OIL</td>
<td>5%</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>TEST</th>
<th>As Rec.</th>
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<th>TEST</th>
<th>As Rec.</th>
<th>LEACH.</th>
</tr>
</thead>
<tbody>
<tr>
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<td>8.3</td>
<td>Ag, ppm</td>
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<td>4.2</td>
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</tr>
<tr>
<td>% TOTAL SOLIDS</td>
<td>3.32</td>
<td>As, ppm</td>
<td></td>
<td>&lt;0.1</td>
<td></td>
</tr>
<tr>
<td>% DISSOLVED SOLIDS</td>
<td>0.06</td>
<td>Ba, ppm</td>
<td></td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>% SUSPENDED SOLIDS</td>
<td></td>
<td>Cd, ppm</td>
<td></td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>% SETTLEABLE SOLIDS</td>
<td></td>
<td>Cr, ppm</td>
<td></td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>FLASH POINT °C</td>
<td></td>
<td></td>
<td>Cr (Hex), ppm</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>OIL AND GREASE, ppm</td>
<td>13,525.0</td>
<td>Cu, ppm</td>
<td></td>
<td>38.0</td>
<td></td>
</tr>
<tr>
<td>PHENOLS, ppm</td>
<td>200.0</td>
<td>Hg, ppb</td>
<td></td>
<td>&lt;2.0</td>
<td></td>
</tr>
<tr>
<td>CHLORIDE, ppm</td>
<td></td>
<td>Ni, ppm</td>
<td></td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>BROMIDE, ppm</td>
<td></td>
<td>Pb, ppm</td>
<td></td>
<td>29.8</td>
<td>5.5</td>
</tr>
<tr>
<td>PHOSPHATE, ppm (TOTAL)</td>
<td></td>
<td>Ss, ppm</td>
<td></td>
<td>&lt;0.1</td>
<td></td>
</tr>
<tr>
<td>COD, ppm</td>
<td>160,000.0</td>
<td>Zn, ppm</td>
<td></td>
<td>15.0</td>
<td></td>
</tr>
<tr>
<td>BOD, ppm</td>
<td></td>
<td>Fe, ppm</td>
<td></td>
<td>40.0</td>
<td></td>
</tr>
<tr>
<td>ACIDITY mg/l as CaCO₃</td>
<td></td>
<td></td>
<td>B, ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALKALINITY, mg/l as CaCO₃</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CYANIDE, ppm (TOTAL)</td>
<td></td>
<td></td>
<td></td>
<td>6.25</td>
<td></td>
</tr>
<tr>
<td>CYANIDE, ppm (RELEASE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SULFIDE, ppm (TOTAL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SULFIDE, ppm rel</td>
<td>&lt;10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**COMMENTS**  THIS REPORT HAS BEEN PREPARED FOR THE EXCLUSIVE USE AND BENEFIT OF  
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ANALYTICAL COMPLETENESS IS HEREBY MADE TO ANY OTHER PERSON RECEIVING  
THIS REPORT.
Appendix C

Alternatives to lead containing copper alloys

Metals are rated for their machinability. Free cutting brass (copper alloy #360), the standard to which others are compared, has a machinability of 100. Leaded bronze (copper alloy #314) has a machinability of 80. Some possible alternative alloys and their machinability are:

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Machinability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper 145 (has small amount of Tellurium)</td>
<td>85</td>
</tr>
<tr>
<td>Copper 147 (sulfur bearing)</td>
<td>85</td>
</tr>
<tr>
<td>Copper 191</td>
<td>75</td>
</tr>
</tbody>
</table>

Source: Standard's Alloy data book #2
Appendix D

METROPOLITAN WASTE CONTROL COMMISSION

1985 STRENGTH CHARGE SYSTEM

\[ SC = (V)(SS-250)(8.34)(0.072) + (V)(COD-500)(8.34)(0.036) \]

where,

- \( SC \) = Strength charge, in dollars
- \( V \) = Volume, in million gallons per reporting period
- \( SS \) = Suspended Solids, in mg/l (SS \geq 250)
- \( COD \) = Chemical Oxygen Demand, in mg/l (COD \geq 500)
- \( 250 \) = SS base, in mg/l
- \( 500 \) = COD base, in mg/l
- \( 8.34 \) = Conversion Factor, to convert to pounds
- \( 0.072 \) = SS rate, in $/pound of excess SS
- \( 0.036 \) = COD rate, in $/pound of excess COD

In other words, the strength charge will be calculated by adding the product of the pounds of excess COD times the COD rate to the product of the pounds of excess SS times the SS rate.

Strength charges are computed and billed after each reporting period.

Strength charges for 1985 are final charges; i.e., there will be no end-of-year adjustments.
Appendix E
Economic Evaluation for Changes in Coolant Management

I. CALCULATION OF CURRENT COSTS

Disposal costs per year

\[ 20 \text{ drums} \times \frac{\$175}{\text{drum}} \times \frac{1}{\text{yr}} = \$3500 \]

Perkin-Elmer records indicated 10 drums of coolant were shipped in a 6 month period.

Raw Material costs per year

\[ \text{PHI shop: } 8 \text{ gal} \times \frac{12 \text{ mo}}{\text{yr}} \times \frac{\$475}{55 \text{ gal}} = \$829 \]

Usage in PHI shop was obtained from shop records and conversations with the shop foreman. One half of the amount is for make-up purposes.

\[ \text{VPD shop: } 4 \text{ gal} \times \frac{12 \text{ mo}}{\text{yr}} \times \frac{\$475}{55 \text{ gal}} = \$414 \]

VPD shop uses concentrate mainly for make-up purposes.

\[ \text{TOTAL ANNUAL COSTS} = \$4743 \]

II. PROJECTIONS OF COSTS ASSOCIATED WITH CHANGES IN COOLANT MANAGEMENT

A. INSTALLATION OF RECYCLING SYSTEM

Capital costs per shop

\[ 12'' \text{ disc type oil skimmer} \quad \$205 \]

[Quote from Warner Industrial Supply]

\[ \text{Wilden Model M-1 polypropylene compressed air double diaphragm pump} \quad \$275 \]

[Quote from Edelmann and Associates]

\[ \text{Viking Lid-Ease strainer filter} \quad \$63 \]

[Quote from Edelmann and Associates]

\[ \text{TOTAL CAPITAL COSTS PER SHOP} = \$543 \]

*Assumes that coolant is repeatedly recycled satisfactorily and that coolant disposal is necessary two times per year.

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Annual Operating Costs

Labor

\[
\text{Labor} = \$974
\]

\[
\begin{align*}
10 \text{ machines} \times \frac{.166 \text{ hr}}{\text{change}} \times \frac{\$12.20 \times 24 \text{ changes}}{\text{yr}} \times \text{shop} = \$487
\end{align*}
\]

\[
\$487 \times 2 \text{ shops} = \$974
\]

Utilities

\[
\text{Utilities} = \$0
\]

Costs calculated were less than $10 per year because motors are rated at .50 hp or less. Therefore, a utility cost has been excluded.

Tramp oil disposal

\[
\begin{align*}
16 \text{ gal tramp oil}\text{a} \times 12 \text{ mo} \times \frac{\$175\text{b}}{\text{yr drum}} \times \frac{55 \text{ gal}}{\text{drum}}
\end{align*}
\]

\text{a}Tramp oil volume assumes 10% of volume to be recycled is oil and that the oil removed contains 10 percent coolant.

\text{b}An assumption is made that disposal costs for tramp oil would be the same as for spent coolant disposal. It is possible the tramp oil would be acceptable as waste oil in which case disposal costs would be greatly reduced.

Spent coolant disposal

\[
\begin{align*}
2 \text{ shops} \times 80 \text{ gal}\text{a} \times 2 \text{ changes} \times \frac{\$175}{\text{yr 55 gal}}
\end{align*}
\]

\text{a}Assumption made that at least twice per year coolant can no longer be recycled satisfactorily and therefore disposal is necessary.

\text{Volume assumes coolant is changed in VPD shop in manner similar to present practice in PHI shop.}

TOTAL ANNUAL OPERATING COSTS = \$2603

*Calculations assume coolant usage in the VPD shop would parallel current coolant usage in the PHI shop if a recycling system is implemented.
Annual Savings

Coolant disposal costs $3500

20 drums x $175 yr

Raw material costs $345

20 gal x $475
0.5 yr 55 gal

[Savings of 20 gal assumes that only the amount for make up is required each month except in months when disposal occurs, thus requiring fresh coolant to be made. If disposal occurs every sixth month, coolant saved equals 5 month x 4 gal/mo in PHI shop.]

TOTAL ANNUAL SAVINGS = $3845

Payback (Recycling System Only)

Depreciable fixed capital investment

\[
\text{Payback}^* = \frac{2 \text{ shops} \times 543/\text{shop}}{1086} = 108 + (3845 - 2603) = 1350
\]

Payback = .80 year

B. INSTALLATION OF BOTH RECYCLING AND TREATMENT SYSTEMS

Capital Costs

Recycling System (See capital costs, bottom p. 36) $1086

Treatment System $6000

[Quote from Beckart Engineering Co.
F.O.B. - Illinois]

TOTAL CAPITAL COSTS = $7086

*The payback equation is taken from Peters and Timmerhaus, p. 316.
**Straight line depreciation with no salvage value was assumed.
***The lifetime of the equipment is estimated to be ten years.

For these economic evaluations, ave. profit/yr = ave. savings/yr.
Annual Operating Costs

Labor

- for recycling
  (See operating costs, labor; top p. 39) $974
- for treatment:
  8 batches* \times \frac{.33 \text{ hr}}{\text{batch}} \times $12.20 \text{ hr} 
  \quad \text{yr} 
  \quad \text{batch} 
  \quad \text{hr} 
  \quad $32.20 

*Assumes 2 batches/6 month in PHI shop
and 2 batch/6 month in VPD shop
**Manufacturer's estimate of labor time
for treatment of 1 batch

Utilities

Costs calculated were less than $10 per year
because motors are rated at .25 hp or less.
Therefore, a utility cost has been omitted.

Treatment Chemicals

$32

0.10* \times 80 \text{ gal coolant} \times 2 \text{ changes} \times 2 \text{ shops}
\text{gal} \quad \text{yr}
\text{shop}

*Manufacturer's estimate of treatment costs
per gallon.

Tramp oil disposal

$611

Calculations and assumptions are the same as
outlined under tramp oil disposal page 39.

Treated coolant disposal

$0

Two assumptions are made:
- Wastewater after treatment can be sewered
  with approval
- Oil and floc collected on filter paper at
  time of treatment have negligible volume and
  may even be acceptable for disposal with the
  solid waste

TOTAL ANNUAL OPERATING COSTS = $1641

Annual Savings

$3845

Calculations and assumptions are the same as
outlined on page 40, top.

Payback (Recycling and Treatment)

\begin{align*}
\text{Payback} &= \frac{7086}{709 + (3845-1641)} \\
&= \frac{7086}{2913}
\end{align*}

Payback = 2.4 years
C. INSTALLATION OF TREATMENT SYSTEM ONLY

Capital Cost $6000

[Quote from Beckart Engineering Co.  
F.O.B. – Illinois ]

Annual Operating Costs based on current levels of generation

Labor $ 96.60

$2 batches x .33 hr x 12.20 x 12 mo  
month batch hr 1 yr

[Generation of 20 drums of waste per year means  
90 gallons per month; a quantity of waste which  
can be treated in two batches. ]

Utilities $ 0

[Costs calculated were less than $10 per year  
because motors are rated at .50 hp or less.  
Therefore, a utility cost has been omitted. ]

Treatment Chemicals $ 110

$0.10 x 55 gal x $20 drums  
gal drum yr

Treated coolant disposal $ 0

[Assumptions are the same as outlined under  
treated coolant disposal costs page 41 ]

TOTAL ANNUAL COSTS = $ 206.60

Annual Savings

Coolant disposal costs $3500

20 drums x $175  
yr drum

TOTAL ANNUAL SAVINGS = $3500

Payback (Treatment only)

\[
\frac{6000}{6000} = \frac{6000}{600 + (3500 - 206.6)} = 3893
\]

Payback = 1.5 years