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**INCREASING THE LIFE OF CUTTING FLUIDS
USED IN THE LLNL MACHINE SHOP**

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INTRODUCTION

Cutting fluids in Building 321, the main machine shop at Lawrence Livermore National Laboratory (LLNL), are being discarded sooner than their manufacturers think is necessary. Since the Numerical Control/Precision Machine Shop of Building 321 machines uranium and beryllium parts, contaminated liquid wastes are a normal product of its operation. Steps to reduce this volume of contaminated cutting-fluid waste will lower disposal costs. In this study we looked for ways to extend the life of the cutting fluids/coolants and therefore reduce the volume of waste produced.

EXPERIMENTAL METHOD

First we gathered manufacturers' information on the five different cutting fluids used in our machine shops and reviewed each fluid's performance. In this examination the following items were considered: physical properties, proper mixing directions, and the compatibilities of coolants with the metals we machine. Next, we reviewed information on the equipment that controls and maintains the water-miscible cutting and grinding fluids (i.e., automatic deionizer, proportioning pump, and sump cleaner).

INCREASING CUTTING-FLUID LIFE

After our preliminary evaluation was completed, we decided to determine how the cutting fluids deteriorate with use. As a result of our discussions with the shop superintendent, we decided to check the characteristics of the various fluids being used in representative machines; we studied the characteristics of the fluids in nine different machines of Building 321. The pH, bacteria level, percent coolant concentrate, percent tramp oil, and total undissolved solids were monitored on a week-to-week basis for 6 weeks. During this time, the criteria and procedures used for changing the cutting fluids in the machines were also observed.

A portable pH meter, Markson Model 92, was used to measure the pH of the cutting fluid. A pH buffer was used to calibrate this instrument before each use. To measure the amount of bacteria in a given sample, an BASICUT-TTC bacteria test kit was used. (Practically all aerobic bacteria grow on the TTC agar slides.) The slides were simply dipped into the cutting fluid and incubated for 48 hours. The bacterial count per milliliter of the sample was determined by comparing the density of the colonies appearing on the slide with the densities shown on the model chart that came with each kit. The concentration of coolant was determined by American Optical's T/C Refractometer, Model 10440. We converted the number read on the meter to percent coolant concentrate from a previously determined calibration curve. To measure the percent tramp oil, we put samples of the cutting fluid into burets and let them sit for 24 hours; this was a very simple lab procedure to roughly find out how much tramp oil separates from the cutting fluid. To determine if centrifuging or filtering would separate out a significant amount of undissolved solids, the following procedure was performed. Forty-ml samples of cutting fluid were placed in an IEC clinical centrifuge and run at a speed of 7100 rpm (5125 times the force of gravity) for 25 minutes. Filtering was done with a Büchner funnel through a Whatman #5 filter paper.

REMOVING METALS FROM USED CUTTING FLUIDS

Reducing the cost of disposing of contaminated spent cutting fluid was a separate aspect of this project. The fluid could be disposed of less expensively---as industrial waste---if the uranium and beryllium could be filtered or centrifuged out. We tried to determine if uranium and beryllium are soluble in the cutting fluids over time; six different samples were prepared or collected for analysis. The first sample was of a fresh Trimsol dilution with D-38 filings; the second was a fresh Trimsol dilution with beryllium filings. Both samples were stirred for 8 hours and aerated for 4 hours to give the filings a chance to dissolve in the solution. The third and fourth samples, also Trimsol dilutions, were taken from specific machines in Building 321. The fifth and sixth were Cutzol dilutions taken from machines in Building 321. A fraction of each sample was centrifuged and another part filtered in order to determine which treatment is more effective in separating out any solid uranium or beryllium. Centrifuging was done at 7100 rpm for 25 minutes. Filtering was done through a Whatman #5 filter

paper. All solids were washed with water and acetone before weighing. Both the liquid and solid samples were given to the Hazards Control Analytical Laboratory for analysis of uranium, beryllium, copper, and chromium content.

RESULTS

INCREASING CUTTING-FLUID LIFE

Results from the 6-week study are not complete. It was difficult to determine when the cutting fluid in Building 321 machines was changed, because changes were unscheduled and unrecorded. A sample of the fresh batch was thus unobtainable, preventing the comparison of the new versus the used fluids. A coolant concentration of 4-5%, as recommended by the manufacturer, was found in only one of the samples analyzed. The pH in some cases was slightly acidic and should actually have been basic, between 9 and 10. Tramp oil, which stimulates growth of bacteria, was found in each sample. Bacteria tests were taken on two separate occasions, and the results ranged from 10^3 to 10^7 aerobic bacteria per milliliter of sample (10^4 being a slight infection of bacteria and 10^6 or more, a heavy infection). Bacteria feed on the cutting-fluid concentrate, reducing its lubricating value and causing stain, odor, and corrosion. The more important bacteria which are found in water-miscible cutting fluids are *Pseudomonas aeruginosa* and *Pseudomonas oleovorans*. To keep the bacteria level under control, the more alkaline the solution (the higher the pH) the better. However, a fluid of high alkalinity can very rapidly counteract the normal acid (pH 6.8) condition of the skin and cause dermatitis. We measured the undissolved solids in the first set of samples, but found the amount to be minimal, so we didn't pursue this step any further. For complete data see Table 1.

REMOVING METALS FROM USED CUTTING FLUIDS

In determining if uranium and beryllium are soluble in the cutting fluids, we could not conclude from our small number of samples that the fine particles did actually dissolve. We can say that the material contained in our filtered or centrifuged samples was either very finely divided particulates or in solution. This indicates that simple filtration or

TABLE 1. Comparison of physical properties of cutting fluids from machines in Building 321 over a 6-week period.

Machine No.	7/29/80			8/14/80			8/20/80			8/27/80			9/3/80			9/10/80		
	coolant conc.	tramp oil	pH	coolant conc.	tramp oil	pH	coolant conc.	tramp oil	pH	coolant conc.	tramp oil	pH	coolant conc.	tramp oil	pH	coolant conc.	tramp oil	pH
M-82	0.44	0.84	3.78	0.44	1.95	5.38	2.95	0.27	8.48	2.95	0.16	7.92	2.95	0.15	7.83	2.95	0.15	6.42
M-212	3.46	0	7.35	3.46	0.26	7.40	3.95	0.27	7.40	-	-	-	-	-	-	-	-	-
G-129	1.8	0	9.16	1.8	0	8.81	1.8	0	8.75	1.85	0	8.52	2.55	0.32	8.82	2.55	0.27	8.48
L-463	10.92	0.29	7.92	6.42	0.54	8.41	6.95	0.54	7.85	7.43	0.43	7.92	5.94	4.59	7.98	6.45	0.29	7.68
L-441	1.57	0.55	7.93	2.8	0.27	8.93	2.4	0.26	8.32	2.4	0.33	7.76	2.0	3.71	7.73	-	-	-
L-494	4.1	0	8.47	6.4	0	8.24	6.6	7.32	8.28	6.9	0	8.27	2.42	0	8.19	7.7	0	7.95
L-359	0.7	0.29	7.35	0.7	0.28	8.38	0.7	0	8.18	0.45	0.42	7.65	0.21	4.37	8.04	-	-	-
L-419	7.95	0.55	7.67	7.73	0.27	7.72	7.95	0.27	7.45	8.45	0.35	7.87	5.45	6.04	8.14	5.45	0.24	7.40
L-435	1.57	1.12	8.40	1.57	0.74	8.54	2.0	0.26	8.22	1.12	0.54	8.32	1.57	8.38	8.22	3.5	0.47	8.46

7/29/80 8/10/80

Machine No.	bacteria/ml	bacteria/ml
M-82	10 ⁵	10 ³
M-212	10 ⁶	-
G-129	10 ⁷	10 ⁴
L-463	10 ⁴	10 ⁵
L-441	10 ⁶	-
L-494	10 ⁵	10 ⁷
L-359	10 ⁷	-
L-419	10 ⁶	10 ⁶
L-435	10 ⁷	10 ³

centrifugation will not sufficiently remove the beryllium and D-38 contamination. Inconsistencies in our data point to a problem we were not able to eliminate: that is, representative sampling. Used cutting fluids are emulsions with tramp oil on the top and a viscous sediment on the bottom; it is very difficult to uniformly suspend this material in solution for representative sampling. The volume of our samples was N25 ml, so in a 55-gallon drum this problem will be considerable. For complete data see Table 2.

CONCLUSIONS

The objective of our study was to extend the useful life of cutting fluids used at LLNL. The following are recommendations which, if implemented and followed in Building 321 or elsewhere, should extend cutting-fluid life significantly.

- To properly use the cutting fluid it should be accurately diluted, preferably with deionized water. Minerals in hard water help the growth of bacteria and use up necessary chemicals in the cutting fluid. The concentration of the cutting fluid should be monitored with a refractometer on a regular basis. Adding a bactericide to the cutting fluid is recommended by some of the suppliers (Dipco, Rust Lick, Tapmatic, and Trans United Corporation). The Trans United Corporation also suggests adding their Oxcedot Treatment System to prevent the emulsifiers in the cutting fluid from eventually being destroyed with use. Both of these additives are worth using, especially the bactericides, since we found significant concentrations of bacteria in the cutting fluids we analyzed (see Table 1).

- An initial, thorough cleaning of the machine is highly recommended. Any oil leaks in the machine should be eliminated. If tramp oil is a problem, an oil wheel should be installed. A centrifuge can also be used to remove tramp oil for larger quantities, but it is more expensive. Filtering or centrifuging are suggested techniques for removal of small, solid particles.

- It is recommended that only one brand of cutting fluid be used throughout the shop. This will promote less confusion over which brand is needed for what operation, and there could be one central spot for accurate mixing. It would also be easier for the workers to remember the correct properties of the cutting fluid.

TABLE 2. Determination of dissolved solids in samples of cutting fluid.

Sample No. ^a	Fraction of sample	Chromium (ug)	Copper (ug)	Beryllium (ug)	Uranium (gross beta dpm ^b)	Uranium (gross alpha dpm)
A-1	Untreated	-	-	-	3425	2200
	Centrifugate	-	-	-	2050	1200
	Centrifuged solids	-	-	-	60	25
	Filtrate	-	-	-	2425	1350
	Filtered solids	-	-	-	100	58
B-1	Untreated	-	-	27	-	-
	Centrifugate	-	-	25	-	-
	Centrifuged solids	-	-	570	-	-
	Filtrate	-	-	29	-	-
	Filtered solids	-	-	550	-	-
L-264	Untreated	62	528	3687	1000	550
	Centrifugate	15.6	450	256	600	300
	Centrifuged solids	0	6.25	1562	120	55
	Filtrate	16.9	468	296	725	350
	Filtered solids	2.75	15.0	750	90	48
S-32	Untreated	53	143	375	4125	2475
	Centrifugate	15.6	131	265	3850	2050
	Centrifuged solids	1.25	1.25	221	625	3200
	Filtrate	19.4	140	281	4125	2350
	Filtered solids	6.00	12.5	212	450	220
L-435	Untreated	25.0	28.1	2.13	LOS ^c	LOS
	Centrifugate	22.2	65	4.69	LOS	LOS
	Centrifuged solids	0.25	0.50	0.13	LOS	LOS
	Filtrate	22.2	68.8	5.62	35	25
	Filtered solids	6.50	5.00	10.62	68	42
L-359	Untreated	34.3	62	3.44	LOS	LOS
	Centrifugate	16.9	59	2.34	LOS	LOS
	Centrifuged solids	0.25	1.75	0.063	LOS	LOS
	Filtrate	15.9	65	2.81	LOS	5
	Filtered solids	4.50	5.00	0.63	LOS	LOS

^aSamples L-264, S-32, L-435, and L-359 are from machines in Building 321. Samples A-1 and B-1 are unused fluid that had uranium and beryllium purposely added. Sampling error caused some of the results for the untreated fractions to be less than those for the treated fractions.

^bDisintegrations per minute.

^cLOS indicates that the activity level was less than the limit of sensitivity: LOS alpha = 4.2 dpm; LOS beta = 10.9 dpm.

Shop supervision must make the final decision of what cutting fluid should be used. The choice should be made on the basis of performance, long life, ease of disposal, and customer service.

We have provided a list of recommendations to the machine shop superintendent. The recommendations were based on the laboratory analysis of cutting fluids in use, a study of the cutting-fluid manufacturers' literature, discussions with several manufacturers, and visits to Los Alamos National Laboratory and the Rocky Flats Plant. These recommendations, if implemented, should extend the effective life of cutting fluid significantly. We were not able to remove sufficient beryllium or D-38 from used cutting fluids by centrifuging or filtering. The complex nature of this problem will require an extended study by those involved in cutting-fluid disposal.