Correlation of Coliform Activity and Anaerobic Sulfate Reduction with Deterioration of

CUTTING FLUIDS

by H. W. Rossmoore,
Department of Biology
Wayne State University, Detroit, Michigan

The coliforms are the third most prevalent group of organisms found in cutting fluid emulsions. In addition, it has been the experience of a large industrial plant that the presence of these organisms in large numbers preceded emulsion spoilage. Samples of used emulsions from 5 central sumps (7,800 to 59,000 gallons) using 4 different products were collected weekly for 11 weeks. Each sample was cultured separately for total counts, coliform counts, and sulfate reducers. The in-plant condition of the installations was checked with bacteriological results. The presence of large amounts of sulfate reducers correlated with deterioration of the emulsion. Reexamination after prolonged refrigeration showed that sulfate reducer levels were maintained while coliform and total counts were considerably depressed. The data reveal that correlation of coliform numbers with spoilage was not significant and that size of the pit, nature of the coolant, and the job being performed must be considered.

The frequency of occurrence of both fecal and non-fecal coliforms in soluble cutting fluids has convinced many workers that these organisms are indigenous to this milieu (4, 8). A study by a large automotive company over a ten year period has resulted in establishing coliform number as an index of deterioration and germicide efficiency. However, there is disagreement as to the actual role of this organism in spoilage. Pivnick and Fabian (7) found that Pseudomonads, a major inhabitant of cutting fluids, were antagonistic to coliforms when both were grown together in fresh material. In addition, Bennett and Wheeler (3) showed that coliform survival in various cutting emulsions did not exceed 59 days. The most recent evidence incriminates anaerobic sulfate reducers as one of the major producers of emulsion spoilage (1), and it seems clear that these organisms need help from some aerobic groups, probably Pseudomonads (2, 5). The overall problem of emulsion spoilage is a subjective as well as an objective one. Frequently the odor from a coolant pit is strong enough to cause a walk-out at the plant. Although the odor is doubtless indicative of deterioration, the emulsion is often functional for a long period of time. Sometimes with less odor the emulsion separates into its oil and water phases. Because of results implicating various groups of organisms, this study was undertaken as a preliminary investigation to correlate the presence of the coliform group with anaerobic sulfate reduction and emulsion deterioration.

MATERIALS AND METHODS

Samples of used coolants were collected weekly from 5 central sumps selected to include the three major types of cutting fluids—straight soluble oil, heavy duty soluble oil, and oil-free synthetic solution. Informal request was made of responsible plant personnel concerning the condition of each coolant, as far as performance, stability and odor were concerned. As soon as possible after collection, aliquots of coolant were inoculated into violet red bile agar (VRBA), tryptose glucose extract agar (TGEA) and into a synthetic medium (6) for the estimation of anaerobic sulface reducers (Table 1).

Counts were made at 18 and 48 hours, respectively, for the VRBA and TGEA plates after incubation at 37 C. The scheme for evaluation of sulfate reducers appears in Table 2. The time of H_2S appearance and the size of the samples used were the criteria for quantitation for this procedure. Under normal operating conditions, all the sumps were used 5 days a week for 16 hours a day. The coolant was circulated at approximately 10% of total volume per minute during working hours. Except for Pit A, where germicide was added one week only, germicide additions were made weekly (approximately 0.1%) on the day before pick-up.

TABLE 1.—Synthetic Medium and Protocol for Estimation of Anaerobic Sulfate Reducers

REAGENT	AMOUNT
K_2HPO_4	0.2 g
$MgSO_4 \cdot 7H_2O$	0.2 g
$(NH_4)_2 SO_4$	1.0 g
Na_2SO_3	0.1 g
Calcium Lactate	3.5 g
Ascorbic Acid	0.1 g
$Fe SO_4(NH_4)_2 SO_4 \cdot 6H_2O$	0.1 g
Peptone	1.0 g
Yeast Extract	1.0 g
Tap Water	1000.0 ml

Put 15.0 ml of medium in duplicate screw-top test tubes and sterilize.

Inoculate one set with 0.1 ml used coolant
" " " " 0.5 ml " "
" " " " 1.0 ml " "
" " " " 2.5 ml " "
" " " " 5.0 ml " "

TABLE 2.—Key for H_2S Production in MIOE Medium

SAMPLE SIZE	POSITIVE IN	INCUBATION TIME 24 HR	48 HR	72 HR	120 HR
0.1		4+	3+	2+	+
0.5		3+	2+	2+	+
1.0		3+	2+	+	+
2.5		2+	2+	+	+
5.0		2+	+	+	+

RESULTS AND DISCUSSION

PIT A (Table 3). Coliform counts were high; only twice did the level go below 12,000. H_2S production was moderately high, stability good and, despite the high incidence of all three groups of organisms, this coolant performed adequately over a 14 week period. There were minor odor complaints, especially on Monday mornings when the pumping began after weekend shutdowns.

PIT D (Table 4). H_2S production was constant and not quite so high as Pit A. Coliform counts were low—none exceeded 4,000. However, the total count averaged over 20,000,000 for the ten week test period. Performance during this period was as expected.

TABLE 3.—Comparison of Coliforms and Sulfate Reducers in Synthetic Coolant—Large Sump

DESCRIPTION—Pit A
SPEED OF OPERATION: High
TYPE OF OPERATION: Machining and turning Medium Alloy steel forgings
CAPACITY OF PIT: 35,000 gal
GERMICIDE USED: 2-Mercaptobenzothiazole and Na Dimethyldithio-carbamate

RESULTS

WEEK	TOTAL	COLIFORM	H_2S
1	40×10^6	86×10^3	+
2	7×10^3	31×10^3	++++
3	35×10^6	27×10^3	+++
4	44×10^6	95×10^3	++
5	28×10^6	43×10^3	++
6	77×10^6	49×10^3	+++
7	50×10^6	70×10^3	+++
8	90×10^6	4×10^3	++
9	160×10^6	3×10^3	+++
10	400×10^6	12×10^3	+++

TABLE 4.—Comparison of Coliforms and Sulfate Reducers in Synthetic Coolant—Small Sump

DESCRIPTION—Pit D
SPEED OF OPERATION: Medium
TYPE OF OPERATION: Turning and tapping Medium carbon low alloy steel forgings
CAPACITY OF PIT: 7,800 gal
GERMICIDE USED: O-Phenylphenol

RESULTS

WEEK	TOTAL	COLIFORM	H_2S
1	12×10^6	100	++
2	68×10^6	4×10^3	++
3	23×10^6	200	+
4	14×10^6	100	+
5	2×10^6	10	+
6	7×10^6	10	+
7	65×10^6	3×10^3	+
8	9×10^6	20	++
9	4×10^6	50	+
10	20×10^6	300	++

PIT B (Table 5). Except for one week, the coliform counts were negligible. Sulfate reduction was high. This correlated well with many complaints of H_2S odor in the plant. Performance records of the machines serviced by this pit were not up to par.

PIT E (Table 6). H_2S production was moderate, coliform counts negligible, total counts never inordinately high. On the eighth week, all three tests were at a minimum. Oddly enough, performance and stability were sufficiently poor to warrant dumping the pit at this date.

PIT C (Table 7). This pit was probably the most troublesome, from the standpoint of in-plant conditions. The coliform and total counts were very high, but H_2S production was not as high as in the other pits. Five minutes after collection, the emulsion samples from this pit would separate and crack. The main odor at this pit was not H_2S but was fecal in nature. It is this pit alone that apparently is suffering from coliform growth more than from any other group.

It had been demonstrated previously (3) that virgin coolant inoculated with coliforms and then incubated could not support such growth in excess of 59 days. Those coolants that routinely showed high coliform counts (A and C) were stored in the refrigerator (10 C) for four weeks at which time all the three tests were repeated (Figs. 1 and 2). It can be readily seen that only the anaerobic sulfate reducers survive in appreciable numbers. This fact and the previous work of Bennett and Wheeler (3) should be convincing evidence that continued survival of these organisms in coolants is dependent upon the addition of fresh inocula and nutrients.

TABLE 6.—Comparison of Coliforms and Sulfate Reducers in Soluble Oil Coolant—Small Sump

DESCRIPTION—Pit E
SPEED OF OPERATION: Medium
TYPE OF OPERATION: Grinding medium alloy steel forgings
NATURE OF COOLANT: Soluble Oil
CAPACITY OF PIT: 8,900 gal
GERMICIDE USED: O-Phenylphenol

RESULTS

WEEK	TOTAL	COLIFORM	H_2S
1	15×10^6	100	+
2	19×10^6	4800	++
3	23×10^6	200	++
4	10×10^6	900	++
5	5.2×10^6	100	+
6	15.5×10^6	10	++
7	12×10^6	40	++
8	1×10^6	0	—
9	0.2×10^6	0	—
10	15×10^6	300	++

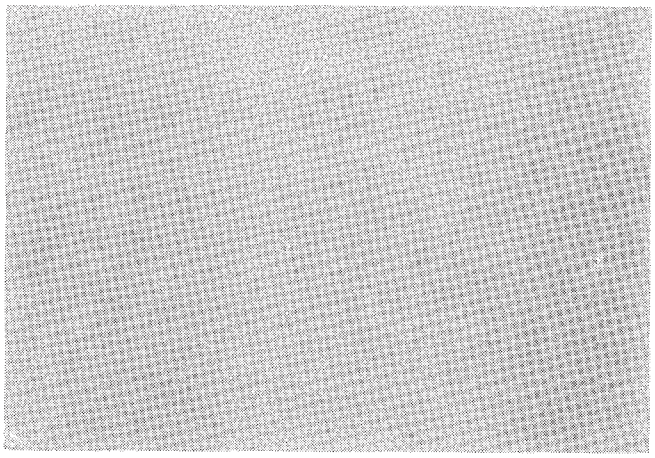

TABLE 5.—Comparison of Coliforms and Sulfate Reducers in Soluble Oil Coolant—Large Sump

DESCRIPTION—Pit B
SPEED OF OPERATION: Medium
TYPE OF OPERATION: Turning and drilling Malleable iron casting
NATURE OF COOLANT: Soluble Oil
CAPACITY OF PIT: 59,000 gal
GERMICIDE USED: O-Phenylphenol

RESULTS

WEEK	TOTAL	COLIFORM	H_2S
1	10×10^6	100	+
2	5×10^6	2100	+++
3	500×10^6	100	+++
4	12×10^6	400	+++
5	3.9×10^6	800	++
6	2×10^6	90	++
7	7.5×10^6	40	+++
8	1×10^6	80	++
9	50×10^6	50	++
10	20×10^6	10×10^3	++

TABLE 7.—Comparison of Coliforms and Sulfate Reducers in Heavy Duty Soluble Oil Coolant

DESCRIPTION—Pit C
SPEED OF OPERATION: Medium
TYPE OF OPERATION: Turning and drilling Low carbon steel
CAPACITY OF PIT: 25,000 gal
GERMICIDE USED: Tris (Hydroxymethyl) Nitromethane

RESULTS

WEEK	TOTAL	COLIFORM	H_2S
1	41×10^6	260×10^3	+++
2	65×10^6	214×10^3	++++
3	19×10^6	10×10^3	—
4	335×10^6	290×10^3	+
5	127×10^6	180×10^3	+
6	9.5×10^6	80×10^3	±
7	250×10^6	400×10^3	+++
8	90×10^6	20×13^3	+
9	20×10^6	30×10^3	+
10	50×10^6	30×10^3	+

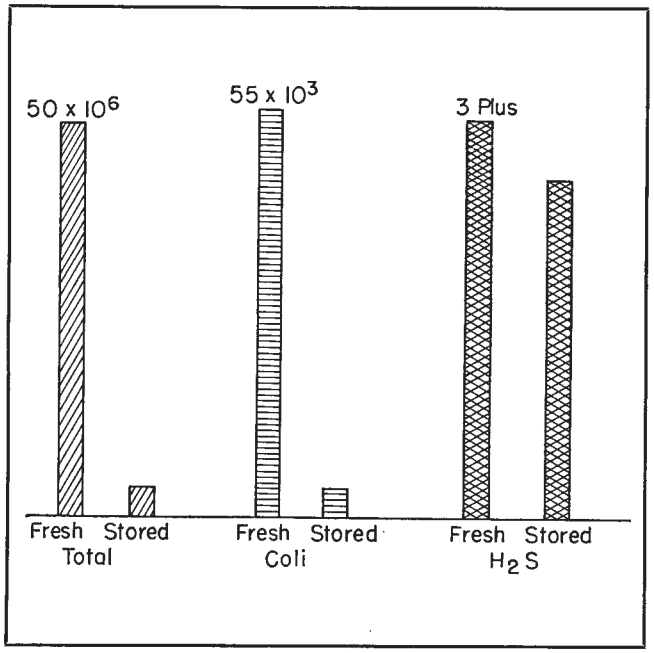

Fig. 1. Effect of storage at 10 C for 4 weeks on the bacterial content (anaerobic sulfate reducers represented by hydrogen sulfide) of a synthetic coolant—average of 6 samples.

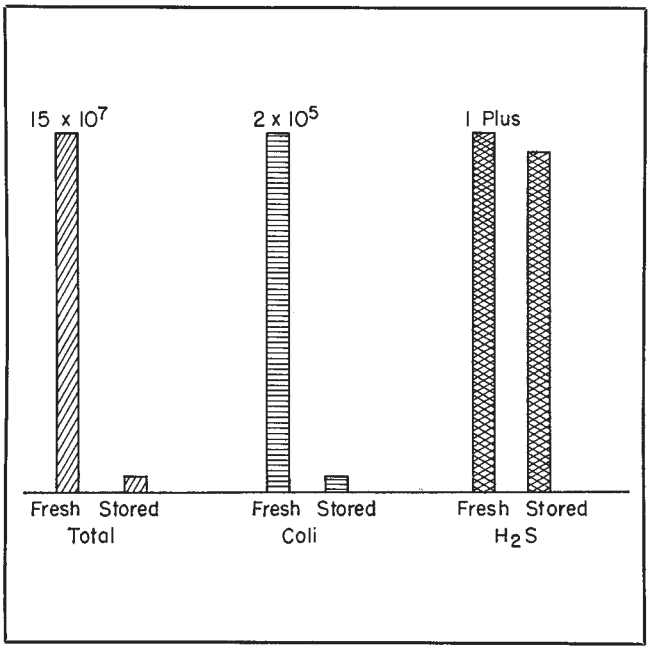

Fig. 2. Effect of storage at 10 C for 4 weeks on the bacterial content (anaerobic sulfate reducers represented by hydrogen sulfide) of a heavy duty soluble oil coolant—average of 6 samples.

Many factors contribute to emulsion breakdown. It is not the intention of this paper to minimize the role of microbial activity in spoilage, but to point out that it is difficult to generalize about specific activity in coolants. Such factors as heat stability, tramp oil acceptance, fine retention, corrosiveness, all relate to coolant life. If an emulsion consistently supports large numbers of bacteria, its eventual breakdown is certain. The importance of any single group in this process, specifically the coliforms, cannot be generalized. The size of pit, the type of operation, coolant formulation all must be considered. It is apparent from the results obtained here that the coliforms, even when present in large numbers, do not play a major role in the breakdown of all these emulsions. What their significance is, either from an ecological or public health standpoint, is still in doubt.

SUMMARY

A study conducted on five central coolant sumps over a period of ten weeks has revealed a low order correlation between coliform numbers and deterioration. Conversely, anaerobic sulfate reducers were much in evidence in spoiled and malodorous emulsions. Storage at 10 C for four weeks greatly reduced total and coliform counts but had no appreciable effect on H_2S production.

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