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SAMPLE METALWORKING FACILITY FINAL REPORT

MICROBIAL CONTAMINATION SURVEY – XYZ MACHINING PLANT

PREPARED FOR:
XYZ, INC.
ROUGH ROAD
ANYWHERE, GLOBE

PREPARED BY:
BCA, INC.
PRINCETON, NJ 08543-3659
05 MAY

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EXECUTIVE SUMMARY

XYZ, Anywhere, Globe, initiated full plant operations in January. Within weeks after start-up, recurrent coolant problems were noted in the plant's two central xx,000-gallon recirculating coolant systems. Although some microbial contamination was reported, the primary issue has been coolant emulsion stability. A number of remedial steps have been taken since January, however the problem has not been resolved completely.

This report is divided into seven primary sections and two appendices. The **Executive Summary** captures the essence of the body of the report. The **Background** presents information either made available before the survey, or otherwise not based on observations made as part of the survey. The **Narrative** summarizes the events of my two-day site visit. The survey process and test methods are presented in the **Materials and Methods** and in **Appendix A**. I report my observations in the **Results** section and **Appendix B**. The latter is the photographic record of the gross observations presented under **Results**. The **Discussion** section deals primarily with coolant management program design and implementation as it pertains to XYZ, Inc. Under **Conclusions and Recommendations** I summarize my major findings and suggest action items for XYZ to consider.

On 01 May, I visited the XYZ plant. During my visit I had discussions with project stakeholders to review the current state of affairs and events that led here. My POC and I toured the plant observing potential trouble spots and collecting samples for analysis.

We ran several tests on-site and sent the samples to the support lab for additional testing. The results provide no evidence of significant or uncontrolled microbial contamination.

My observations led me to conclude that there are a number of significant opportunities for improvement. Details are provided in the **Discussion** and **Conclusions and Recommendations** sections.

- The Operation line sump-boxes and the mist collection systems are both potential problem areas, some redesign is needed in both systems.
- XYZ should implement a formal coolant management program
- XYZ should stop the practice of reintroducing waste oils in to the recirculating system
- Coolant and additives should be thoroughly pre-blended before being dispensed into the system.

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OBJECTIVES

The objective of this site survey was to assist in completing a root cause analysis of coolant system performance problems at the XYZ facility.

BACKGROUND

XYZ, Anywhere, Globe, facility began full operations in January, 1900. Three primary production lines are serviced by a central, recirculating coolant system charged with emulsifiable oil at approximately 10% concentration. Initially, the XXX line was to have been serviced by one xx,000 gallon ZZZ Filter system (North Unit - ZZN) and two other lines (Operations A & B| and Operations C & D) were to have been serviced by a second xx,000 gallon ZZZFilter system (South Unit – ZZS). However, the two ZZZ units are currently cross-connected, and are consequently functioning as a single 2 x xx,000 gallon system. The decision to cross-connect the ZZZs was driven by the need to compensate for the relative the flow imbalance cause by the ZZN side-stream flow through the pre-filter units described below. The cross-connect decision was made before XYZ management discovered that casting sand contaminates the XXX-line coolant. This sand now has contaminated coolant in both ZZZ reservoirs.

Two pre-filter particulate filtration units augment the ZZZs. Each pre-filter unit contains a 25 µm mesh-screen filter. The units are operating in parallel, drawing approximately 1,500 gpm coolant off ZZN clean-side (total coolant flow is approximately 500 gpm). Approximately 1,380 gal of filtrate feeds into the clean coolant header coming off the ZZN. The balance (~120 gpm) recycles into the dirty-coolant return line. Until the past day, or so, the filtrate also fed into the dirty chute.

The entire facility is dedicated to machining cast aluminum engine components (valve blocks). The XXX-line performs sawing and milling operations on the rough castings the plant receives. Waste includes casting blocks (approximately 2 in. x 5 in.), large chips and sand. Line A/B and C/D are all drilling and tapping operations, generating smaller turnings and tailings. There are also a number of individual machines with their own reservoirs.

The XXX line has a 1,500 gallon sump into which the return coolant flows. Pumps pull coolant from this sump into the coolant return header which discharges into the ZZN reservoir. Depending on the coolant level in the sump, coolant entering from the return sluice may cascade three to six feet before landing in the “bulk” coolant.

The 1,500 gal, below-ground, steel sump rests in a concrete box, the diameter of which is approximately 1.5 ft greater than that of the sump. Floor-washing spillage and coolant splash are pulled from the box periodically (approximately once monthly), using a portable vacuum unit (sump-sucker).

An identical sump-in-box unit serves the C/D line return sluice. The Operation A and Operation B lines each have a dedicated sump, also identical to the one described above.

Prior to the past week, or so, coolant concentrate was added to the system at the Operation B sump during active operations. It was assumed that the energy imparted by the recirculation process would be sufficient to fully emulsify the coolant. Before the centrifuge was installed, a deep blue invert emulsion was observed coming out with the chips from the ZZZ filtration units. After an Alfa-Laval centrifuge was installed, coolant concentrate separated with the tramp oil. Starting approximately a week ago, plant personnel started pre-diluting COOLANT in water in totes. The diluted material is then drained directly into the ZZZ (dirty-side) reservoirs. This is accomplished by lifting the tote over the reservoir with a fork-lift, and opening the tote-bin's discharge valve.

XYZ has no in-house facility or capability for routine coolant condition monitoring.

XYZs building ventilation includes exhaust fans installed in the ceiling at one end of the building and "passive" vents at the other end. Although this creates a significant draft when the fans are operating, airflow is not uniform. Mist and vapors tend to accumulate in the vicinity of the XXX line, which appears to be situated in an airflow eddy.

Mist collection systems were installed over the Operation A/B and Operation C/D lines in mid-March. XYZ has not yet defined a routine maintenance (PM) program for the mist collectors. Both mist collector systems exhaust into the plant. The Plant Manager (XYZ) wasn't certain about the mist collector design. We don't know whether these units include activated carbon filter-beds or HEPA-filters.

The shop superintendent reported that he had been getting a major build-up of chips on the clean side of the Pre-filter units. The piping realignment seems to have solved this problem. He also reported that initially, significant split coolant volumes accumulated in the Pre-filter unit, clean-side reservoir. Moreover, the 25 μm pore-size polyester bag filters (PEG2S-25) are blanking-off very prematurely (at least daily). Bag filters are installed upstream of each high-pressure (HP) pump in the recirculating system. Each HP pump also has a 100 μm mesh screen protecting its intake.

Initially, XYZ used a COOLANT-incompatible BRAND X hydraulic fluid. Early after plant start-up, the Mobil product was replaced with a compatible XYZ hydraulic fluid. However stable foam accumulation, emulsion instability and slime build-up in splash zones of the ZZZ units have made early coolant management efforts particularly challenging.

Dr. Mystery Chemist became involved in the root-cause analysis (RCA) effort in early February. When he first visited the plant (approximately four-weeks after initial start-up) XYZ performed a pump and dump. All of the ZZS system coolant was transferred to the

ZZNN system. The south system tanks and Pre-filter housings were drained and cleaned. After approximately two-days, the product was pumped back into the ZZS system from the ZZN reservoir. Notably, one operator (XYZ) reported strands of threads (disassembled rags) in samples Dr. Chemist had sent him. Pre-pump and dump samples also contained paint chips, welding slag and other indicators that the system hadn't been flushed thoroughly before its initial charge.

Dr. Chemist has sent a number of additional coolant samples to the lab for testing. Based on the test results, Dr. Chemist treated the system with 250 ppm (as supplies – a.s.) Sodium Omadine 40% on 05 April.

Dr. Chemist has confirmed that the bag filters aren't being over-burdened with chip. Instead, a slimy film appears to be causing the problem.

Dr. Chemist has also concluded that stable aluminum-fatty acid soap formation is a significant cause of the stable invert-emulsion formation. Although analytical results are still pending, and consequently there are no data to confirm his conclusion, XYZ has modified the COOLANT formulation to reduce its susceptibility to Al-soap formation. This should also reduce foaming. XYZ has also installed two coolant conditioning sub-systems to augment the ZZZ units. A centrifuge was installed in mid-March. The centrifuge processes a coolant side-stream off the ZZS. This appears to be removing tramp oil effectively. Invert emulsion and blue sludge build-up on the ZZS chip-auger have diminished substantially since the centrifuge has been in service.

Although the coolant is designed to be used at 5 – 8 % in end-use emulsions, XYZ and XYZ have agreed that 10 % is preferred for XYZ's applications (actually, XYZ would like to use 12 % concentrate). The target pH range is 8.9 to 9.0. Control levels for bacteria and fungi are 10^3 to 10^5 CFU bacteria/mL and <10 CFU fungi/mL, respectively[1]. XYZ has not set control limits of specifications for alkalinity, total dissolved solids (conductivity), foaming characteristics or emulsion stability.

XYZ uses city water for initial blending and make-up. City water is relatively soft (87 to 123 ppm $CaCO_3$); conductivity ranges from 31 to 35 µS. Dr. Chemist hasn't seen any evidence of hardness increasing.

During the weekend of 29 and 30 April, XYZ personnel reported nuisance-level ammonia odors. When a local account representative arrived early on 01 May, she noted a very strong ammonia odor. By 0930, the odor had dissipated.

Pursuant to conversations I've had with the Plant Manager, Dr. Chemist and I had a conversation regarding his experience at the XYZ facility. We agreed that it made sense for me to visit the site and conduct the survey reported in this document.

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[1] CFU – colony forming unit. The lower detection limit using dip slides is 10 CFU/mL.

NARRATIVE

I visited XYZ's City, USA plant on Monday, 01 May 2000. The local representative met me at the door and briefed me on the ammonia-blush incident that had occurred over the weekend and earlier on 01 May. She also showed me on of the sump pits a possible odor generating locus, according to a theory advanced by one of the XYZ plant employees. During most of the morning, Stakeholders discussed system history and current operations. The material presented in the **Background** section of this report captures my understanding of the information I was provided during this conversation.

After lunch, Dr. Chemist and I performed two plant tours. During the first, I made gross observations, made sure I had a clear understanding of the coolant recirculation system and its component sub-systems, identified locations from which I wanted to collect samples, and took photographs of critical locations. During the second tour, Dr. Chemist and I collected samples.

Once we had collected the desired samples, we set up a make-shift lab on one of the lunch-room tables. I ran dissolved oxygen (DO) and catalase tests. Dr. Chemist ran coolant concentration, pH and total dissolved solids (TDS).

Dr. Chemist retained the samples in order to record overnight emulsion stability and ship them to the lab for follow-up laboratory testing.

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METHODS

Summary

Coolant condition monitoring methods fall into four categories:

- Gross observations – sight, touch and smell data that can be obtained without additional supplies or instrumentation
- Physical tests – indicators of the coolant's general condition, for example emulsion stability
- Chemical tests – basic chemical state of coolant, including coolant concentration, pH, alkalinity, oxygen demand, and total dissolved solids.
- Microbiological tests – determine the coolant's bioburden, or microbial load through chemical measurement (catalase test) or culture (dip-slides)

This section and Appendix A provide procedures for recommended routine tests, including those performed during the site visit and several test methods that were not performed during the site visit.

Corrosive chemicals are used in several of these tests. This section does not detail all appropriate safety precautions. Personnel performing these tests should follow good laboratory practices and be familiar with MSDS for all chemicals and reagents used. Appropriate safety clothing should be worn in the laboratory. Disinfect dip-slides and other culture media by soaking in a 0.5% sodium hypochlorate (household bleach) solution overnight before disposal.

Gross Observations

Systems

Objective

To record general appearance of sumps and areas around machines.

Materials

Notepad
Camera

Procedure

Approaching individual machines, look for pools of removed metal (swarf, turnings, tailings, etc.), coolant, way oil, hydraulic fluid or any combination of the above. Report presence or absence of these materials under or around the machine.

Inspect the sump for tramp oil accumulation and unusual odors. Also check for slime build-up on sump walls. With the machine in stand-by, inspect the machining booth and tool magazine for slime or chip accumulation. Report conditions. Use this opportunity to note any safety discrepancies.

Inspect ZZZ Filter spillways, slash zones, chip drag-stages and hoppers for odor, corrosion and slime accumulation.

Inspect coolant return sluices and sumps for corrosion, excessive foaming, tramp oil accumulation, slime streamers, slime coating over surfaces and odor.

Coolant

Objective

To determine general condition of coolant

Materials

Clean, wide-mouth sample jars, 500 mL minimum
Shop rags
Marking pen

Procedure

Uncover sample jar and dip it, mouth-down into coolant sump.
Tip jar so that mouth is just below coolant surface
Remove jar from sump, dry it and label it.
Report coolant color and presence of distinct phases (tramp oil layer, cream layer, solids/sediment layer) as percentages of total sample volume.
Repeat this observation after 4 to 6 hours. Note changes.
Report any atypical (ammonia, sulfide or musty) odors.

Physical Tests

Emulsion stability

Objective

To determine whether emulsion stability differs significantly from that of freshly prepared emulsion.

Materials

Coolant concentrate

Tap water
Graduated cylinder (250 or 500 mL)

Procedure

Control

Prepare dilute coolant at specified end-use concentration (10%) in accordance with manufacturer's recommendations.
Decant into calibrated test jar of graduated cylinder
Observe after 4, 8 and 24 hours and daily thereafter until coolant separates into two or more distinct phases, and oil phase equals at least 2% of the total volume).
Record the time require for this phase separation to occur. This is your baseline value.

Test

Decant 200 mL of coolant into a 250 mL graduated cylinder (or 400 mL into a 500 mL graduated cylinder).
Cover the cylinder and agitate vigorously by shaking for 30 seconds.
Let the cylinder stand.
Observe after 4 hours and a time period equal to one-half the baseline time interval.
Report the percent volume of each phase: oil, cream, emulsion and sediment.

Chemical Tests

Test methods for pH and alkalinity are provided in Appendix A.

Oxygen Demand

Objective

To determine the decrease in dissolved oxygen concentration during a two-hour interval, reflecting biological activity in the coolant.

Materials

Dissolve oxygen (D.O.) meter & probe
Replacement D.O. probe membranes
D.O. probe filling solution (potassium hydroxide)
D.O. Zero oxygen standard solution
Wheaton bottles or 50 mL centrifuge tubes
Distilled (deionized) water in rinse bottle
Clean tissue
D.O. probe polishing compound

Procedure

Set up, condition and calibrate D.O. probe and meter according to manufacturer's instructions.
Transfer coolant sample to centrifuge tube or Wheaton bottle, filling halfway.
Cover and agitate sample vigorously by hand for 30 seconds.
Read D.O. for time zero (T_0) (note: to get an accurate reading you need to swirl the sample gently while taking your reading).
Record reading in mg O_2 per liter (L).
Rinse probe with distilled water and gently wipe with tissue. Be careful not to damage Teflon membrane at probe's base.
Cover sample and let stand for two-hours.
Remove cover and, **without agitating sample**, re-measure D.O. (it's okay to swirl the sample gently while taking the reading).
Record D.O. for time two-hours (T_{2h})[2].
Determine the change in D.O.: Δ D.O. = D.O.$_{T0}$ – D.O.$_{T2h}$
Compute percent D.O. change: % ΔD.O. = (ΔD.O./D.O.$_{T0}$) x 100

Emulsifiable Oil Concentrate Concentration by Acid-Split

Objective

To determine the concentration of emulsifiable oil in the coolant emulsion. This test can be used as a check against refractometer readings, especially when the refractometer does not present a clear refractive index line.

Materials

Reagent A: Sulfuric acid (H_2SO_4), concentrated
Reagent B: Salt solution
    50 g table salt (NaCl)
    to 1.0 L tap water
Graduated cylinder, 100 mL, stoppered
Pipette, volumetric, 5 mL
Pipette bulb

Procedure

Observe sample that has been sitting for at least 30 minutes.
If phase-separation (split) has occurred, record % of total volume that is straight oil (see *Emulsion Stability* test)

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[2] Although I recommend 2-hours as a good time period, increasing or decreasing the incubation period is okay, as long as the period is standardized. The kinetics of biochemical oxygen demand change over time. This means that a plot of DO versus time won't be a straight line. On 01 May, I took the second DO reading after 1-hour. Although instructive for the purpose of this survey, the data shouldn't be compared directly with two-hour ΔDO data that might be generated in the future.

Pour 50 mL of coolant emulsion into graduated cylinder (add emulsion exactly to 50 mL mark).
Using pipette bulb and volumetric pipette, add 5 mL of Reagent A to the emulsion.
Stopper the cylinder and mix by shaking gently.
Remove stopper and add Reagent B to the 100 mL mark.
Replace stopper and shake vigorously for 30 seconds.
Let stand for 30 min.
Record number of mL of oil on surface of liquid column.
Multiply this value by two.
This is your % concentrate.

NOTE:

If you observed and recorded an oil-layer over the original sample, subtract the % oil-layer (tramp oil) from the total oil volume determined from the acid-split. This will give you a corrected value for actual coolant concentration in your working emulsion.

Microbiological Tests

Test methods for the microbiological parameters are provided in Appendix A.

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RESULTS

Gross Observations

Systems

Metalworking

System gross observations are illustrated in Figures 1 through 21, found in Appendix B. Besides the installation of the ZZZ units, there isn't very much evidence of tremendous thought having been given to coolant management in the system design. There is a 1,500-gallon, in-ground sump at the end of each Operation-line (figure 1). Each sump rests in a concrete sump-box (figure 2). Sump overflow and splash, as well as floor cleaning fluid can accumulate in the sump-boxes. There is no installed plumbing with which to remove fluid accumulating in the boxes. Fluid may stagnate in the boxes for periods of up to a month, or longer. There is no pre-determined fluid removal schedule. Moreover, the Shop Foreman indicated that when the boxes are vacuumed dry, the fluid is returned to the recirculating system. We can only hope that the foreman is misinformed.

As indicated in the **Background** section, XYZ has no installed subsystem for pre-blending coolant emulsion. Apparently the initial assumption was that the energy imparted to fluid cascading from the return sluice into the sump (figure 1) would be sufficient to create a stable emulsion. When coolant levels in the sumps are low, as in figure 1, this may be a realistic expectation. However, when coolant levels in the sumps are high, as in figure 3, the cascade is unlikely to provide enough energy to create a stable emulsion. Presumably, the process of being drawn through the high pressure pumps' 25µm screens is sufficient to emulsify the COOLANT concentrate. However, operational evidence suggests otherwise.

Although COOLANT is well protected antimicrobially, slime is already accumulating on splash zone surfaces throughout the system (for example see figure 4).

Figure 5 is a photograph of one of two mist collectors that XYZ has installed within the last two-weeks. One unit draws air from each of the Operation A/B machines. The other services the Operation C/D machines. Other than the mist collection unit in the background, it's unclear what additional air polishing devices the unit contains. In particular, we don't know whether the units are equipped with carbon beds for scrubbing organic vapors from the air as it transits through the unit. Nor do we know whether the mist collectors' exhaust air is HEPA-filtered. We do know that the mist collectors exhaust into the plant. There is no routinely scheduled maintenance planned for the mist collectors.

Two Pre-filter (figure 6) units operate in parallel, working off a ZZN side stream. These 25 µm pore-size, 1,500 gpm capacity units remove fines that may make it through the ZZZ filters. The logic of installing both units to draw off of one of the ZZZs is unclear, but one consequence of that system alignment was a flow imbalance in the ZZN system. Apparently, one of the effects of the side-stream system was to reduce the net, clean-side flow returning to the machines. This causes the coolant volume in the ZZN reservoir to fall. Apparently, last week, XYZ decided to fix the reservoir level problem by opening the valve cross-connecting the ZZN and ZZS reservoirs. Apparently, XYZ was not aware that as they enter the XXX-line, components are still covered with sand from the forging process. Previously, this suspended sand was restricted to XXX-line coolant. Now sand has been transported throughout both central systems. Moreover, the two, formerly independent xx,000 gallon systems are now functioning as a single 2 x xx,000 gallon system. It's not clear why each of the ZZZs wasn't equipped with one Pre-filter unit.

Operation 100/110 was between jobs when we inspected the 100/110 sump (figure 7). According to the Shop Foreman, although the sumps have level-control switches, these switches are generally over-ridden so that the sumps operate continually. The pump was not operating at the time this photograph was taken, nor am I convinced that it would have not overheated had it continued to run for any extended period once the fluid level was below the pump's suction inlet. Coolant cascading the full depth of the sump is likely to form mist that won't be captured by the mist collection systems.

Considerable coolant pooling on work-area floors (figures 9 through 11) call to question XYZ's industrial hygiene program. I did notice a "Zamboni-like " floor-cleaning machine making its rounds between shifts, but it's unlikely that the Zamboni could get to the locations where we saw these coolant pools. Periodically the floor is hosed down and at least some of the runoff accumulates in the sump-boxes, as noted earlier.

Machine NN is a stand-alone unit used for experimental machining processes. The three cigarette butts found in the machine's chip hopper (figure 12) suggest that greater industrial hygiene awareness could pay dividends at XYZ. Machine NN was not in operation when we surveyed it. The still coolant in the unit's tank was nearly ¾ covered with tramp oil or split emulsion (figure 13).

Figures 15 through 19 illustrate the slime stringers accumulating within the ZZZ unit coolant splash zones. Antimicrobials present in the recirculating coolant will become depleted quickly once that coolant has splashed onto a surface where microbes can proliferate. The mucilaginous texture of the gray slime accumulating on the I-beams suggests that bacteria are a major component of the slime population. The coolant in the ZZZ units had a noticeable ammonia odor.

There appears to be an excessive volume of oil accumulating in the ZZS chip bin (figure 20). This suggests that the COOLANT emulsion is still not as stable as we'd like.

Because a maintenance worker reported that the 25µm HP pump bag pre-filters were plugging at least daily, and that they didn't seem to be carrying excessive swarf loads, we inspected a used filter (figure 21). The swarf cake is barely formed (figure 21, right-side), and the inside surface is oily to the touch.

Samples

During my site visit, I collected a total of 9 samples. Table 1 lists the samples, their source and provides identifying descriptive information.

Table 1. Sample Inventory, XYZ, 01 May

Sample ID	Source	Remarks
01	ZZZ Filter South, clean tank surface grab	Blue emulsion, single phase. MB reported no significant phase-separation overnight.
02	ZZZ Filter North, clean tank surface grab	Blue emulsion, single phase. MB reported no significant phase-separation overnight.
03	XXX-line sluice, just upstream (approximately 1 m) of sump. Surface grab.	Blue emulsion, single phase. MB reported no significant phase-separation overnight.
04	Operation A sluice, approximately 1 m upstream of sump. Surface grab.	Blue emulsion, with approximately 2 mm cream top-layer. MB reported no significant additional phase-separation overnight.
05	ZZZ Filter South, clean tank , SW corner dead zone. Slime scraping.	See figure 17. Gray slime growing just above fluid level. Sample was taken from vertical surface in center of photograph.
06	ZZZ Filter North, clean tank, spillway flange, NE corner. Slime scraping.	See figure 18. Gray slime growing on horizontal surface of support beam, upper right-hand corner of photograph.
07	ZZZ Filter South, chip drag conveyor surface slime scraping.	Gray slime from vertical and horizontal surface of chip drag stage.
08	ZZZ Filter North, chip drag conveyor surface slime scraping	See figure 19. Collected slime from vertical and horizontal surfaces of chip-drag stage.
09	PEG2S-25 bag filter from bag disposal drum. 6 cm square section cut out of filter.	See figure 21. Cut 6 cm (approximate) square for microbiological testing.

All of the coolant samples appeared to be in good condition.

All four gray slime samples had similar appearance and texture as describes earlier.

Physical Testing – Coolant Samples

There was no indication of emulsion instability. All four samples remained stable at least overnight.

Chemical Testing

Chemical testing included coolant concentration, pH, conductivity (total dissolved solids – TDS) and dissolved oxygen. The test results appear in Tables 2 and 3.

Coolant Concentration

Designed primarily for ferrous metal applications, COOLANT's target concentration is normally 5 to 8%. XYZ and XYZ have agreed that 10% is a more appropriate target concentration for the Canton facility. Coolant concentration was determined three-time for each coolant sample. A hand-held refractometer was use on-site (Table 2 data). At XYZ, both a bench top refractometer and acid split were used (Table 3). Although fuzzy interfaces made precise refractometer readings difficult to obtain, the on-site and in-lab refractometer data agree fairly well. COOLANT was present within the target concentration range. Acid split data (Table 3) indicate that below target coolant concentrations are in stable emulsion form in the fluid.

Table 2. XYZ, 05 May Coolant Chemistry

Sample ID	Coolant Chemistry							
	Conc.[a] (%)	Conc.[b] (%)	pH	D.O. (mg/L)				TDS g/L
				T_0	T_{1h}	Δ D.O.	Δ D.O. %	
01	10 ±[c]	8.8	8.48	11.1	8.7	2.4	22%	1.68
02	5 to 11	8.7	8.42	11.2	8.3	2.9	26%	1.55
03	8±	8.7	8.41	12.4	7.9	4.5	36%	1.58
04	8±	8.8	8.43	11.6	8.9	2.7	23%	1.67

Notes:

a - Coolant concentration as determined by refractometer.

b - Coolant concentration as determined by acid-split. Includes floating tramp oil cream-layer oil and oil split from stable emulsion.

c - X ± - Refractive index line "fuzzy" due to non-uniform emulsion droplet sizes. Reported value is M.B.'s best estimate of the middle of the haze-zone.

Table 3. XYZ Coolant Analysis Performed by Lab

Sample 050100 Astro Cut C	Brix	pH	Conc.	% Floating Tramp Oil	% Total Oil	% Dirt	Bac-teria	Fungus	Conduct-ivity μMHO	Water Hard. PPM
1. South ZZZ System (Clean)	13.2	8.8	11.6%	4.3	8.8	0	Neg.	Neg.	3000	120
2. North ZZZ System (Clean)	12.7	8.8	11.1%	8.0	8.7	0	Neg.	Neg.	3600	120
3. XXX Sluice	13.5	8.8	11.7%	4.5	8.7	0	Neg.	Neg.	3600	120
4. OP A Sluice	11.7	8.8	10%	4.5	8.8	0	Neg.	Neg.	3300	120

Alkalinity and pH

Alkalinity, not tested in this survey, is a fluid's resistance to decreasing pH. As noted above, biological activity and rust inhibition both deplete the coolant's alkalinity. In MWF, alkalinity will generally decrease substantially before pH starts dropping off. This is because acids formed initially are neutralized by the coolant's components that provide its alkalinity (neutralizing amines are the most commonly used MWF components used to control alkalinity).

Alkalinity is generally reported as mg calcium carbonate ($CaCO_3$) per liter. This is calculated from the volume of a known titrant (for example 1.8N sulfuric acid) needed to reduce the pH of a known volume of sample to pH 5.2 (total alkalinity).

Freshly emulsified COOLANT has a pH of 8.9 TO 9.0. On-site pH readings (Table 2) yielded values ranging from 8.41 to 8.48, approximately ½ unit below the target level. Laboratory readings (Table 3) were much closer to the specified range, but still low. Without alkalinity data, we can determine whether the coolants buffering capacity has been diminished.

Conductivity and Total Suspended Solids

Conductivity is measured in microsiemens per meter (μS). A siemen is also called a mho, the reciprocal of the resistance term, ohm. One μS is equal to one-millionth of a siemen. Conductivity is a measure of a fluid's ability to support the flow of electrons between two electrodes when d-c voltage is applied. Since this electron flow is dependent on the presence of ions (dissolved solids; the conductivity of deionized water approaches zero), conductivity is directly proportional to TDS. TDS values are recorded in Table 2 and conductivity values are listed in Table 3. Either one of these parameters will suffice for routing monitoring. Increased TDS content reflects coolant aging. It’s therefore useful to compare new and used coolant TDS (conductivity). We do not have data for freshly prepared emulsion, but the values in Tables 2 & 3 appear to be slightly elevated. Clean coolant conductivity is generally <1,000 µS. The > 3000 µS (>1.5 g TDS/L) results from the XYZ emulsion samples may partially explain the emulsion instability. There does not appear to be any water hardness build-up (Table 3).

Dissolved Oxygen

Coolant recirculation in machine systems should keep it well aerated. Well aerated coolant can hold approximately 10 to 11 mg oxygen (O_2) per liter (mg O_2/L). When dissolved oxygen (DO) readings are in this range, the coolant is *oxygen-saturated*. Although chemical reduction reactions in coolants deplete some O_2, biological activity consumes O_2 at a much greater rate. This is the basis of the 5-day biochemical oxygen demand (BOD) test used in wastewater management. In wastewater management the BOD is compared with the chemical oxygen demand (COD; the total concentration of oxidizable matter in the wastewater). The closer the BOD/COD approaches 1.0, the easier it is to treat the wastewater biologically. Clean water has both BOD and COD levels approaching zero.

To evaluate MWF for biological contamination quickly, we can determine the two-hour BOD, instead of waiting the five days called for by the waste treatment folks. In MWF with few, or inactive, microbes the DO change over a two-hour period (ΔDO) will generally be less than 10%. In MWF where microbes are active, ΔDO will generally exceed 80%. Due to time constraints, we obtained the second DO measurement at one-hour during the 01 May site visit.

Table 2 presents DO at time zero and one-hour, ΔDO and % ΔDO, respectively. The 22 to 33% losses during the one-hour quiescent period are equivocal. Clearly there is a significant oxygen demand, but it’s not sufficient to be conclusive of an active microbial contaminant community.

Microbiological Testing

We ran two types of microbiological tests on coolant samples. The catalase test measures the concentration of an enzyme that is present in most of the microbes that grow in MWF. Three factors affect catalase activity:

- Types of microbes present
- Number of microbes present
- Vigor of microbes present

The microbes that require oxygen for life (aerobes) all use catalase, as do many of those that can survive with or without oxygen (facultative anaerobes). Those that require an oxygen-free environment (obligate anaerobes) do not have the enzyme, catalase. Since bacteria are smaller than fungi, they have less catalase per cell. A fungal cell may have 100 times as much catalase as a bacterial cell.

It follows, that the more organisms present, the more catalase will be found in the sample. Although we didn't employ the method during the site survey, we can distinguish between bacteria and fungi by passing our sample through an 8.0 μm filter. Fungi will be held back, and bacteria will pass through. Catalase activity that doesn't make it through with the filtered coolant is associated with fungi.

The second test method used was *viable recovery*. The support lab performed viable tests. Viable recovery methods estimate how many microbes were present in the sample, by coating nutrient-rich gel with the sample. Different sets of nutrients can be used to recover different types of microbes. The concept depends on the ability of each microbe to start dividing (reproducing) on the growth medium (the gel). After approximately twenty doublings (generations) you wind up with a cluster containing tens of millions of individuals. This cluster, now visible with the naked eye is called a *colony*.

Viable recover methods can be useful, if you understand their limitations. First of all, it make take two or three days before the population has divided enough time to form a visible colony. By that time, rancid odors may obviate the need for colony counts. Secondly, many microbes that may be perfectly content to grow in the coolant, won't grow on any single growth medium. Viable recovery tests generally underestimate the number of living microbes by a factor of 1,000 or more (for every 1,000 living cells in the sample fewer than one will eventually form a colony). Moreover, clusters of cells (for example a colony of microbes attached to a swarf particle) will form a single colony. However, if run routinely, viable counts can provide useful trend data.

The critical value for the catalase test results is P_{bio}. The test measures the pressure built-up within the reaction tube during the test. Two tests are run together. One tube "50R" contains only the hydrogen peroxide-based **Oxidizing** Reagent. The second tube is pre-treated with chelator to prevent test interference from metal ions. This means that P_{bio} is the number due solely to catalase activity.

In a biologically clean fluid, catalase activity in negligible ($\Delta P \leq 1.0$ psig). A fluid with a moderate but controlled microbial load will have ΔP ranging from 1.0 to 2.5. Values between 2.5 and 5.0 indicate the need for preventive treatment with an antimicrobial agent. Values > 5.0 reflect uncontrolled microbial contamination. Often systems need to be cleaned in order to bring contamination back under control.

The microbiological data are presented in Table 4. None of the coolant grab samples had significant catalase activity. These negative results suggest that the $\Delta\ DO_{1h}$ data reflected chemical rather than biochemical oxygen demand. This interpretation is further supported by the low viable count recoveries from the fluid samples.

Table 4. XYZ, 01 May Microbiological Data

Sample	Microbiology				
ID	Catalase Activity (P = psig)			Bacteria[b] CFU/mL	Fungi
	50R	+50C	P_{bio}[a]		
01	2.4	0.0	<1	<1	<1
02	3.3	0.1	<1	<1	<1
03	3.9	0.2	<1	<1	<1
04	3.4	0.3	<1	<1	<1
05	N.A.	N.A.	N.A.	<1	Mod.
06	N.A.	N.A.	N.A.	4	Slight
07	N.A.	N.A.	N.A.	3	Mod.
08	N.A.	N.A.	N.A.	4	Mod.
09	N.A.	N.A.	N.A.	<1	Mod.

Notes:

a - P_{bio} - Pressure in catalase activity reaction tube due to biological activi
Only P > 1.0 is significant.

b - Log values are reported. < 1 = < 10; 4 = 10^4, etc.
Fungal data are semi-quantitative.

Bill Davis observed the solid samples (samples 05 through 09) microscopically. Table 5 summarizes his observations.

Bill reported fungal filaments visible in all of the samples. Coupled with the Table 4 data, these results confirm the initial assessment reported under *Gross Observations*. The slime streamers are comprised of a mixed bacterial and fungal population. The bio-slime these microbes produce traps both oil and particulates.

The absence of slime-like material from Bills notes regarding the bag filter, suggests that some mechanism other than bioburden is causing these filters to blank prematurely. There may be some sort of ionic interaction between the recirculating coolant, free radicals in solution and the filter polymer chemistry. The filter manufacturer should be able to test this theory using bench equipment.

Table 5. XYZ, 01 May Microscopic Observations

Sample	Remarks
05	Oils and fungal filaments
06	Oils, fungal filaments and some fine grit
07	Oils, fungal filaments, aluminum chips and fine grit
08	Oils, fungal filaments, aluminum chips and fine grit
09	Small amount of fungal filaments, very small aluminum flakes, some fine grit.

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DISCUSSION

Overview

The recirculating COOLANT appears to be in reasonably good condition. Microbial contamination is well controlled and the emulsion is stable.

However, the twin central coolant systems were not designed with fluid management in mind. Since the system has only recently been installed (in fact installation is still in progress) there may be some unique opportunities to improve some of the design features that most affect coolant performance.

It appears that no consideration was given to the continuing on-site requirement for coolant and lubricant condition monitoring. Although the plant began trial operations in late 19xx, and full operations in January, there is no facility for performing the most fundamental condition monitoring tests. XYZ should be able to meet the challenge of maintaining high coolant performance levels in an under-designed system. That’s standard practice in our industry. However, someone must be able to manage the system. This means the XYZ needs to set up a space where routing testing can be performed.

System Design

Install a coolant premix tank along with appropriate piping, valving and pumps to deliver pre-blended coolant and additives to the central systems and portable dispensing units used to service individual tanks. There is no other way to ensure consistent emulsion quality for freshly prepared emulsion. Without consistent emulsion to start out with, the challenge of diagnosing subsequent stability problems increases dramatically.

The sand-bearing XXX line should be isolated from all other operations. Sand provides both surface area and cation exchange capacity, both of which can degrade emulsion stability and promote biological activity. Current conditions suggest that the sand particles do not fall out as quickly as chips. It may be possible to install a cyclone subsystem between the dirty coolant reservoir and the ZZZ filter to pull out sand. The ZZN system may simple need closer monitoring than the ZZS.

Re-pipe the Pre-filter units so that each one provides dedicated side-stream filtration for one ZZZ unit. This will obviate the need to balance reservoir levels between the two ZZZs.

Ensure that the mist collectors are equipped with carbon and HEPA filters, or re-pipe the mist collector exhaust so that it vents outside the plant. The coalesced oil and water trapped in the mist collector reservoirs rapidly becomes a breeding ground for microbes.

These microbes can become aerosolized by the air flow through he collectors and infect recirculating coolant. Aerosolized microbes may cause undesirable exposure to allergens and opportunistic pathogens. Endotoxins, associated with the cell walls of gram-negative bacteria, contribute to sick building syndrome and respiratory disorders.

The mist collectors don't trap malodorous gases. By exhausting de-misted machine space air into the plant, the mist collectors concentrate malodorous gases that may be evolving in the machines.

Improve general plant ventilation. There appear to be pockets of relatively slow-moving air within the facility, particularly around the XXX line. Mist and odors concentrate in this area. Installation of auxiliary fans should eliminate this problem.

Operations

No standard operating procedures (SOP) have been implemented for coolant condition monitoring, mist collector maintenance, or sump-box sanitation. It's not clear to me whether the support services the XYZ expects from the XYZ- E&R team have been defined in writing. My impression is that XYZ is expecting XYZ and E&R to provide fairly comprehensive coolant management support.

Mist collectors are designed to solve a specific problem. If they are not properly maintained, their contribution to health and operational problems may far exceed their remedial value. Collector traps must be drained at regular intervals, determined by the rate of condensate accumulation and tendency towards stagnation. Mist collector condensate should be treated as hazardous waste and disposed of accordingly. It should not be reintroduced into the recirculating coolant system. Similarly, carbon and HEPA filters, if installed should be checked and replaced routinely, in accordance with the manufacturer's instructions.

Sump-boxes should be drained at least weekly. I recommend dosing the boxes with an antimicrobial such as triazine, to control microbial growth in the accumulating fluid. Fluid drawn from sump boxes should be treated as hazardous waste and disposed of accordingly. It should not be reintroduced into the recirculating coolant system.

Housekeeping practices need some review. During my site visit I observed several substantial coolant pools under machines and the above ground coolant return sluices. There is no apparent provision for floor drainage to waste treatment. Vacuum units can be used to pick up leaked, splashed and spilled coolant quickly before it becomes a slip hazard and breeding ground for microbes.

Whether the function is provided by XYZ personnel, XYZ/E&R representatives or a combination of the two, XYZ needs a well defined fluid management program. The following discussion reviews the value and basic elements of such a program.

Cost of Quality Reduction

The opportunity to reduce XYZ’s costs of quality may be quite substantial. However, at present the folks with whom I spoke, during my site visit have not identified the basic operational parameters that are affected by coolant management. Coolant management should be the responsibility of a chartered coolant management team (CMT). An empowered CMT will include representation from plant management, plant industrial hygiene, purchasing, waste management, maintenance, engineering, and the XYZ-E & R service team. I will use this section to address some of the most critical aspects of a successful coolant management program.

First Things First

I often compare recirculating coolant systems to the human body. The recirculating pumps are like our hearts. The devices used to remove particles and tramp oil are like our kidneys. The agitation from recirculation acts like our lungs. Just as a healthy circulatory system enables our bodies to function optimally, a healthy coolant system enables our machines to function optimally. Improved coolant management translates into increased tool life, reduced numbers of rejected and reworked parts, longer coolant life, better working environment and improved productivity. This all goes straight to the bottom line: **increased profitability**.

However, to deliver any of these benefits, a coolant management program must be based on intimate knowledge. First, a CMT must thoroughly identify current conditions, quantifying them to the extent possible. For example, to understand tool costs you need to know:

- Cost per tool
- Parts (operations) per tool
- Production rate (parts per day)
- Production time lost per tool replacement
- Hourly, loaded salary for machinist operating the machine (performing the tool change)

Other operational parameters affected directly by coolant management include:

- Coolant concentrate consumption (gal[3] per day)
- Water consumption (gal per day)
- Other lubricant consumption rates (way oils, hydraulic fluids, etc)
- Percentage of parts rejected or reworked, identified by cause
- Waste generation (tramp oil, spent coolant concentrate, water, chips – kg/day)
- Mist concentration
- Plant odors

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[3] Use units that make sense in terms of plant operations. Substitute liters, pounds, kilograms, etc for gallons; hours, weeks, or months for days. The idea is to use units that give you values between 1 and 100 for easy computation.

- Health complaints – dermatitis, respiratory problems, slow healing wounds, sick-days, etc.
- Unscheduled maintenance costs – parts, labor, lost production, waste handling/disposal
- Routine maintenance costs – same categories as above
- Custodial costs – same categories as above.

This list is not exhaustive, but provides some direction of the types of information that enable a CMT to understand the current status and identify "low fruit" opportunities for process improvement.

The preceding list illustrates that although it's critical, coolant condition monitoring performed in isolation from all of the other factors that either affect coolant quality or are affected by coolant quality is not going to provide the same return on effort as a more global approach.

Coolant Condition Monitoring

Not that we recognize that coolant condition monitoring must be done in context with other plant operational data, we can focus on condition monitoring itself. Two requirements drive condition monitoring:

- Keep coolant properties within formulator's specifications
- Develop data to help formulator make product improvements

A close partnership among XYZ, XYZ and E & R is essential to successful coolant management. Considerable science and art go into coolant formulation. No single formulation is optimal for more than a few different operations. Operational variables that affect coolant performance include:

- Metalworking process (grinding, tapping, reaming, extrusion, etc.)
- Alloy being worked
- Machine design
- Tool design and material
- Coolant application pattern (nozzle position and configuration)
- Water quality
- Coolant reconditioning process (tramp oil and chip removal sub-systems)
- Evaporation and drag-out losses
- Exposure to incidental contamination (floor sweepings, food, human and animal wastes, etc.)

Products like COOLANT are formulated based on the compounder's best understanding of these variables and the demands they are likely to place on the coolant at working (end-use) concentrations. Consequently, the better information XYZ provides the compounder, the better the formulation the compounder is able to supply XYZ.

Operating to Specifications

The compounder's specifications for COOLANT are listed in the **Background** section of this report. They define the minimum number of tests that a CMT should be performing routinely:

- Concentration
- pH

All data should be entered into either a manual (hard record) or electronic database. Supplement your data tables with graphs to help you see data variability and trends. Periodically, compute data variability. Remember that one objective is to reduce variability, however you need to be aware of the cost-benefit trade-off involved. You don't want to spend $50 each week in order to reduce your weekly costs by $5, but a $5 effort with a $50 (ten-fold) return is a good investment.

Data graphs also help you to spot the difference between random variation (common cause variation – process limitations) and special cause variation (the system is moving out of process specifications because something is not right). **Special cause variation needs prompt corrective action to bring the system under control. Identifying and reducing common cause variation provides long-term opportunities for increased productivity and profitability.**

Operating for Coolant Management Process Improvement

The four basic parameters that define the coolant's operating specifications do not provide sufficient information to help you understand the forces that cause the coolant to fail. To gain that understanding, you need to monitor more parameters. As in the 01 May survey, these parameters fall into four categories:

- Gross observations
- Physical tests
- Chemical tests
- Microbiological tests

It's not possible to know which parameters will provide the most useful coolant management information at the outset of a monitoring program. Consequently I recommend stating with a more comprehensive program, culling out parameters that don't provide useful information. **Useful information is information that you can use to better manage the coolant.**

Gross Observations

Gross observations should include:

- Color
- Odor
- Fresh-sample phase separation

- Work-station appearance: slime accumulation, coolant or chip pools around work area, etc.

Develop codes for “translating” qualitative, subjective observations into quantitative values. For example, create an odor ranking system from 0 to 5. **Make sure everyone responsible for making observations agrees on what the numbers mean.** You can keep a jar of rancid coolant available to “calibrate” odor ratings. You can use photographs to illustrate ratings of slime coverage, pool volumes, etc. The key here is to ensure that there’s internal consistency among data collectors.

Physical Tests

Physical tests should include:

- Specific gravity
- Total dissolved solids (may also be considered a chemical test)
- Foaming tendency
- Emulsion stability
- Total suspended solids (swarf, chips, etc., by particle size)

Coupled with the gross observations these tests provide a good indication of the coolant’s basic ability to do its job.

Chemical Tests

The chemical and microbiological tests help you to understand why the coolant’s gross or physical properties are changing. Chemical tests should include:

- Coolant concentration
- ∆DO
- pH
- Alkalinity

Additional tests may also be needed periodically:

- Corrosivity
- Specific component concentration (for example, antimicrobial pesticide, EP additive or corrosion inhibitor concentration)

These non-routine tests may need to be performed by Yuma or an outside, specialty laboratory.

Microbiological Tests

Uncontrolled microbial growth is a leading cause of coolant failure. Consequently, it’s important to track microbial loads in the system. I recommend viable recovery (bacteria and fungi) and at least one bioactivity test, such as ∆DO or catalase activity.

Test Frequency

As a general rule, each parameter should be checked at intervals of approximately one-third the period between anticipated significant change. For example, assume that you’ve decided that a coolant concentration change of >0.5% is significant and that you generally lose 0.5% over the course of three weeks. You'd then check coolant concentration weekly.

This testing frequency guideline begs two questions:

- How do you define a significant change? and,
- How do you know the normal, or expected rate of change?

At the outset, you may not have satisfactory answers to either question. However, your previous experience can generally provide you with at least starting definitions for significant changes for most of the parameters you'll be monitoring. **Ultimately you'll want to define relationships between coolant condition properties and operational data.** For example, imagine that the data show a close, direct relationship between emulsion stability and waste volume. You've found that you begin to see increased waste volume once emulsion stability decreases by >10%. You may then define a 10% emulsion stability loss as significant, or you may choose to build a "safety" margin into your definition and define a 5% loss as significant. You need to repeat this process for each parameter that you monitor.

When you start a monitoring program, you need to run tests frequently. In order to define normal test variability, you need to determine test repeatability and reproducibility. Using splits from a single sample, each employee who will perform the test should run the test at least five times. This exercise will define the test's error term, or the variability due to the test itself, not variation in the sample's condition. **You must not define significant changes in test parameters that are smaller than the error term.**

Once you've determined your error terms for each test parameter, you should pull samples and run tests hourly for the course of one workday (two shifts). Choose two freshly charged systems so that you develop a baseline of data to define "good" conditions. Also take samples from two our more sampling points so that you can determine if samples from one point provide better predictive data that samples from elsewhere.

Collect data for all of the parameters you've identified as being important to the coolant management program (production rates, tool-life, etc. as well as the coolant condition parameters).

After the hourly sampling and testing effort, continue sampling daily for at least one-week (preferably one-month).

By the end of the first month, you'll have developed a sufficient database to enable you to define the following:

- Normal operation conditions
- Rate of change for each parameter
- Best location for grabbing sample

- Relationships between coolant condition and operational parameters
- Speed and simplicity of each test

Armed with this information you can design your condition-monitoring program.

Standard Condition-Monitoring Program Design

Sampling and Testing

The first step is to examine the relationships between the coolant condition and operational parameters. Reject any condition parameters that aren't related to any operational parameters.

Next, you need to define testing frequencies. I recommend an echelon approach. You'll want to run the easiest tests that are most predictive of operational change most frequently. Compute correlation coefficients (r-value) between each coolant condition test and each operational parameter. Also compute r-values between each test parameter and r-values between operational parameters.

Examine the r-values and identify those test parameters that have the highest absolute r-values (largest number, ignoring whether its positive or negative) with one or more operational parameters. Identify the fastest, easiest tests from among the high r-value group. These will become your **first-echelon** tests; the tests you'll perform most often.

Determine whether some sub-set of the operational parameters can be used to predict overall operational efficiencies (for example does waste-volume predict coolant consumption and tool-life?). Are certain operational parameters more critical than others from a cost or safety consideration? Based on these analyses, select the operational parameters that you want to monitor most frequently. They will become part of your first- echelon data set.

Review the relationships between test and operational data to confirm your definitions of significant changes. Also use these data to set upper and lower control limits for each parameter.

For each test and operational parameter that you've decided to include in your first-echelon data set, look at the data and define the change-rate. Divide this number by three to determine how frequently you should run this test or record the operational data.

Study the data to identify likely cause and effect relationships. Since first-echelon tests are primarily "red-flags" that problems are cropping up, you will generally need to collect additional data to complete root-cause analysis when one of the first-echelon tests moves outside its control limits. Consequently you need to decide which tests are appropriate follow-ups based in the first-echelon data. You may decide to define several additional tiers of testing (second-echelon, third-echelon, etc.) in order to have a sufficient, but minimal number of tests to unequivocally determine each problem's root cause.

Root causes are the fundamental changes that underlie symptom (parameter) changes. For example, either suspended solids or water hardness can destroy emulsion stability. Emulsions will insufficient or excess coolant concentration will also be unstable. Consider the following. You've selected tramp oil accumulation as one of your first-echelon tests. Tramp oil accumulation may reflect emulsion instability or lubricant leakage. Consequently, your **second-echelon** test series might include emulsion stability and visual inspection for hydraulic and way-oil leaks[4].

Now suppose that your second-echelon tests show that emulsion stability has deteriorated. We know that this can be caused by inappropriate coolant concentration, excessive water-hardness, biosurfactants (detergent-like chemicals produced by microbes), or high suspended solids concentrations. You'll need to run a series of **third-echelon** tests: TDS, TSS and microbiology. The results of this series may indicate the need for on or more **forth-echelon** tests (coupling agent concentration, antimicrobial pesticide concentration, etc). Typically, forth-echelon tests are beyond the in-house lab's capabilities.

Root Cause Definitions

You can create a list of most likely root causes based on in-house and formulator's experience. In this report, we've identified many of the most common problems and their root causes. The CMT should brainstorm to develop this list. Make certain that each item identified as a root cause cannot be caused by another cause on the list. For example, uncontrolled microbial contamination may seem like a root cause problem at first. But it's generally the result of inadequate contamination control.

A short list of root causes includes:

- Inadequate water quality management
- Inadequate microbial contamination control
- Inadequate housekeeping
- Inadequate materials management (as in too much or too little coolant concentrate added, or the wrong concentrate added)

The definitions for "inadequate" in each of these cases depend on your performance objectives, and may change over time. Most commonly, standard operating procedures

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[4] In this an all following illustrations, recognize that it's not unusual to discover a combination of root causes contributing to the problem, rather than a single cause. In this case the excess tramp oil may be from both leaks and emulsion instability.

(SOP)are insufficient to enable personnel to achieve the desired objectives, not followed, or unclear. The process of defining root causes should also be used to improve SOP.

Condition Monitoring Standard Operating Procedure

At this point you are ready to draft a Condition Monitoring SOP. This document should include:

- Sampling and observation frequency for each test
- Sampling procedure
- Test methods
- Reporting and recording procedures
- Flow diagrams showing root cause analysis process
- Actions to be taken once root cause is identified
- Instructions for recommending improvements to the SOP or processes it covers

The flow diagrams are particularly important. Data are useless unless used for system management. Flow diagrams enable the analyst to easily identify the next step required, based on the test result. They facilitate training, and help ensure that root cause analysis follows a technically sound logic.

The SOP should be a living document, subject to continual review and improvement, as the coolant management program develops in its repeated cycle of process improvement.

Summary

If the company makes the commitment to do coolant management, you must be prepared to invest considerable up-front effort to understand current conditions and the relationships among parameters that currently may seem unrelated. They will help to integrate the compounder into XYZs operations and build dependence on he compounder’s unique ability to fill XYZs coolant requirements.

For you to derive full benefit from its coolant management program, you need to follow the basic steps I’ve outlined in this section. This process will uncover often-surprising opportunities for improving plant productivity, employee welfare and profitability for all parties.

CONCLUSIONS and RECOMMENADTIONS

The current coolant instability problems, as reflected by high concentrate consumption rates, do not appear to be caused by uncontrolled microbial contamination. XYZ is already making some formulation changes to address the problem. Installation of a pre-mix tank and associated plumbing would also help considerably.

Although ammonia blush is most commonly due to microbial activity, the 29 April to 01 May ammonia blush does not appear to be due to uncontrolled microbial contamination. The below detection limits viable count and catalase test results suggest that bacterial contamination control may be too rigorous. Over treatment with triazine may lead to ammonia release unless the excess amine is reacted. Other additives known to cause ammonia blush include oleic acid diethanolamide, Hostacor TP 2125 and Hostacor 2732. Excessive aeration or agitation has also been implicated in the ammonia blush phenomenon. When return sluices, with coolant flowing at >1,500 gpm, cascade > 3 feet into their respective sumps, both aeration and agitation may become excessive. Sodium perborate is reportedly effective in controlling ammonia odors once a blush ahs occurred.

Process control needs to be implemented for coolant management. Critical parameters are unmeasured. ZZZ filter indexing rates, reflective of coolant dirt loadings, are unknown. Water and concentrate consumption rates are unknown. Hydraulic fluid and way oil consumption (loss) rates are unknown. The relative role of evaporation and coolant drag-out are unquantified. In the words of the immortal W. Edwards Deming, you can control what you don’t measure. I strongly recommend chartering a CMT and implementing a comprehensive and effective coolant management program. It will pay tremendous dividends for XYZ and XYZ.

The April Sodium Omadine treatment effectively controlled fungal contamination in the recirculating coolant. Periodic direct application of a 125 ppm Sodium Omadine solution to splash zones should control growth in these areas.

XYZ should encourage XYZ to review their ventilation and mist collection systems. Current configurations are probably contributing to problems that will worsen over time.

XYZ should also encourage XYZ to review their industrial hygiene plan. Ill-conceived sanitation efforts will create continual coolant management problems and may contribute to employee health problems.

DISCLAIMER

All of the observations reported in this document are based on written and oral, anecdotal and documented information provided by XYZ Fluid Technology, XYZ, E & R or directly observed by me during my 01 May site visit. BCA has no way of independently verifying the accuracy of this information. The opinions provided in this document are based on the information obtained during the course of the survey and the author's many years of industrial microbiology experience.

The information contained in this report includes confidential, XYZ-specific data and recommendations as well as generic, industry-recognized good practices. All XYZ-specific information will remain client-confidential until and unless XYZ releases such information in a public forum, or provides BCA with written approval to use such information.

With regard to the services to be performed by BCA pursuant to the terms of this agreement, BCA shall not be liable to XYZ or to anyone who may claim any right due to his/her relationship with XYZ, for any acts or omissions in the performance of said services on the part of BCA or on the part of the agents or employees of BCA except when said acts or omissions of BCA are due to their willful misconduct. XYZ shall hold BCA free and harmless from any obligations, costs, claims, judgments, attorney's fees and attachments arising from or growing out of the services rendered to XYZ pursuant to the terms of this agreement or in any way connected with the rendering of said services, except when the same shall arise due to the willful misconduct of BCA, and BCA is adjudged to be guilty of willful misconduct by a court of competent jurisdiction.

Date: 05 May

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