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EVALUATION OF ZYMO BACTERIA-BASED PARTS CLEANER

1. Purpose. The purpose of this Public Works Technical Bulletin (PWTB) is to transmit findings in the evaluation of a bacteria-based aqueous cleaner to determine its effectiveness and applicability for cleaning vehicular parts on military installations.

2. Applicability. This PWTB applies to all U.S. Army facilities engineering/public works and environmental activities.

3. References.

a. Aberdeen Test Center Report No. ATC-8204, TECOM Project No. 8-CO-160-000-048, "Aqueous Based Bacterial Cleaner Evaluation Support to Corps of Engineers Research Laboratory," William W. Newton.

b. The Resource Conservation and Recovery Act (RCRA); 42 U.S.C. s/s 6901 et seq. (1976).

c. Memorandum received 1 February 2000 from Leroy Metker, Program Manager, Toxicity Evaluation, Center for Health Promotion and Preventive Medicine, subject: Surgeon General Toxicological Clearance for the Zymo Bacterial Cleaner for Maintenance and Repair Cleaning of U.S. Army Materiel.

d. 40 CFR 261 - Identification and Listing of Hazardous Waste, Subpart C - Characteristics of Hazardous Waste, parts 261.21 (Characteristics of ignitability) and 261.22 (Characteristics of corrosivity).

4. Background.

a. Increased awareness of the health, safety, and environmental issues surrounding the use and disposal of

traditional parts cleaning solvents has stimulated a search for alternatives. One acceptable alternative is non-hazardous, aqueous cleaners. However, cleaners that are non-hazardous when fresh often create hazardous waste streams as they are used. As contaminants are removed from the parts, they are transferred to the cleaning solution. Bacteria based cleaners offer a potential solution to some of these problems. These cleaners contain bacterial colonies that remove contaminants from the solution and convert them into harmless compounds, theoretically eliminating the hazardous waste problem. The purpose of this study was to evaluate one such cleaner to determine both its ability to remove contaminants and its cleaning effectiveness.

b. The U.S. Army Engineer Research and Development Center's Construction Engineering Research Laboratory (CERL) reviewed literature from several bacterial cleaner manufacturers to determine which cleaners were most applicable for testing. One cleaner was selected for evaluation based on cost, ease of use, potential for effectiveness, and willingness of the vendor to participate in the study. Zymo™ Parts Washers (ABS, Inc., Duluth, GA) were selected.

c. The Zymo™ 20022 parts washer was purchased and installed at the automotive repair facility, building 338, at Aberdeen Test Center (ATC), MD. Shop personnel operated the unit as necessary and recorded use information. Personnel at ATC sampled the cleaner every 2 weeks and analyzed for Total Petroleum Hydrocarbons, hazardous waste characteristics, relative solvency, and standard bacterial plate count. ATC personnel were responsible for maintenance during the entire test period. The report prepared by ATC and provided to CERL is listed above as reference a.

d. The Zymo™ 20022 Bacterial Cleaning System is a parts washing system that combines an aqueous cleaner, a bioremediation element, and a freestanding parts washer. The aqueous cleaner is a heavy-duty concentrate with a rust inhibitor. The bioremediation element consists of non-pathogenic microbes that digest oils and greases removed from parts cleaned by the aqueous cleaner. The microbes digest the hydrocarbons and break them down into carbon dioxide and water. The freestanding parts washer is a heavy-duty plastic system with a control panel, recirculation pump, heating element, and an overhead light.

e. Dimensions of the washer are 32½" W x 26" D x 40½" H. The system holds 25 gallons of the cleaning solution. The government price for the 20022 model is $1868.00. This price includes 25 gallons of fluid and a long-life filter. Additional cleaner with rust inhibitor is $252.27 per case (packaged as 4

bottles, each makes 5 gallons when diluted to working concentration for a total of 20 gallons).

5. Discussion.

a. *Cleaning Performance and Operational Evaluation.*

(1) The Zymo™ system was set up in accordance with vendor's instructions in the automotive repair facility. A data log (Table 1) was established to track system use during the evaluation. The system was used 28 times throughout the 3-month evaluation period by 9 different mechanics. The system performed well throughout the test period.

(2) The system was not large enough to handle some of the larger items for this particular application. The basin was not large enough for tracked vehicle sprockets, roadarms, and other suspension-related items. This required that the mechanics use another cleaning system in the facility, and led to lower usage rates for the system than expected.

(3) Maintenance requirements for the Zymo™ system were relatively low during the test period. Twenty gallons of additional cleaning solution were added during the test period, due to evaporation and drag-out. A button-type switch on the unit broke twice during the initial portion of the test. The vendor redesigned the button and there were no additional failures. No other maintenance was required during the test period.

(4) Because the test period for this study was brief, CERL contacted another military installation using the product to determine long-term maintenance requirements and user satisfaction. Personnel from Redstone Arsenal, AL installed a Zymo™ system in one of their maintenance shops approximately 3 years ago. The machine is used on an average of once per week to clean bearings. They are pleased with the performance of the system and state that, while it does not clean as well as a solvent based system, it is acceptable for their application. Maintenance requirements for the system have been relatively low over the past 3 years. Five gallons of replacement solvent are added every 6 months. Their unit also contains a bag filter that has been changed twice.

Date	Start Time	Stop Time	Item Cleaned (code)	Principle Contaminant (code)	Operator Name	Comments
20-Apr-99	1430	1445	E	A,F	Ownes	Worked well, smells good
21-Apr-99	0730	0800	E	A,B,F	Williams	Seems Ok
29-Apr-99	1400	1415	B	A,B,F	Tabasco	Ok
30-Apr-99	0730	0830	B	A,B,C	Tabasco	Ok Smell, Good
3-May-99	0930	0950	B	A,B,F	Tucker	Ok
3-May-99	1430	1530	A,B	A,B,F	Tabasco	Smells Good
10-May-99	**0900**	**0915**	**N/A**	**N/A**	**Retrossa**	**Added 5 Gallons**
12-May-99	0800	0830	E	A,B	Retrossa	Good
17-May-99	0850	0905	A	A,F	Goodman	Good
26-May-99	0720	0730	B	B,F	Owens	Good
26-May-99	1045	1050	E	B	Williams	No Comment
2-June-99	1415	1420	B	A	Latham	No Comment
7-June-99	**0830**	**0845**	**N/A**	**N/A**	**Retrossa**	**Added 5 Gallons**
7-June-99	0900	0905	E	B	Owens	Good
8-June-99	1400	1430	E	C	Williams	Ok
9-June-99	1300	None	E	D	Williams	No Comment
12-June-99	0900	0915	E	B	Hill	No Comment
16-June-99	1030	1045	E	A,B,F	Owens	Ok
17-June-99	1300	1305	C	A	Goodman	Ok
22-June-99	0900	0905	E	A	Williams	Ok, Parts Clean
23-June-99	1040	1050	E	A	Owens	Ok
24-June-99	1045	1100	E	A	Owens	Ok
24-June-99	1320	1400	A	A	Williams	Ok
28-June-99	0900	0910	D	D,F	Williams	Ok
30-June-99	1410	1430	B	B,F	Williams	Ok, Seems Low
30-June-99	**1500**	**1515**	**N/A**	**N/A**	**Retrossa**	**Added 5 Gallons**
1-July-99	1125	None	B	B	Tucker	Ok
12-July-99	1002	1015	B	B	Maxfield	No Comment
13-July-99	0900	0910	E	A,F	Owens	No Comment
13-July-99	**0930**	**0945**	**N/A**	**N/A**	**Retrossa**	**Added 5 Gallons**
21-July-99	1000	1010	B	B	Latham	No Comment
29-July-99	0815	0816	C	F	Williams	No Comment
3-Aug-99	1500	None	B	B	Latham	No Comment
6-Aug-99	1400	1420	B	B,C	Williams	No Comment
Codes		**A**	**Suspension Parts**	**Grease**		
		B	**Engine Parts**	**Oils**		
		C	**Hull Parts**	**Fuel**		
		D	**Hydraulic Parts**	**Hydraulic Fluid**		
		E	**Miscellaneous**	**Antifreeze**		
		F	**N/A**	**Dirt/Mud**		
		G	**N/A**			

Table 1

b. *Chemical Analysis.* The cleaner was sampled eight times throughout the study and tested to determine hazardous characteristics and the effects of use on the cleaner itself. This testing is discussed below.

(1) *Toxicity Characteristic Leaching Procedure (TCLP) Metals.* Each sample was analyzed for TCLP metals to determine the levels of metals regulated by the Resource Conservation and Recovery Act (RCRA). Samples with metal levels exceeding RCRA limits cause the spent fluid to be considered a hazardous waste. Three of the eight samples collected exceeded the RCRA limit for cadmium. Additionally, several samples exceeded local discharge limits for cadmium and zinc. Of the eight samples collected during the evaluation period, the cadmium limit was exceeded four times and the zinc limit seven times. This would prohibit the discharge of spent cleaner to the installation's wastewater treatment system. Table 2 shows all sample results.

(a) The cadmium source is most likely from the parts being washed in the system. Many U.S. Army automotive systems have cadmium-coated materials in areas of high load or hot environment such as engine and suspension items.

(b) Sources for the zinc can be from the parts washed, the contaminants (greases), or the Zymo™ Surfzyme Heavy Duty cleaner. The two largest spikes in the analysis occurred on days when replenishment fluid was added to the system. It is believed that the fluids were added after the sampling, but that information was not recorded on those days. The original baseline sample also contained an elevated level of zinc, which might indicate the presence of zinc in the Zymo™ Surfzyme Heavy Duty cleaner (the exact composition is proprietary). The initial aqueous cleaner was mixed using the concentrate and tap water from building 338 per the vendor's instructions. The tap water from the building was tested to rule out high zinc levels.

(c) Because metals are often washed from parts along with greases, oils, and other contaminants, the level of metals in the cleaning solution would be expected to rise gradually over time. However, sample results show metal levels fluctuating throughout the study. The cadmium level, for example, started out at <0.20 mg/L. It rose to 1.86 mg/L approximately 6 weeks into the study; was 3.3 mg/L at 8 weeks; dropped to 0.28 mg/L at 12 weeks; and was 2.18 mg/L at the end of the study. The fluctuating analytical results are likely attributed to the organic binding of the metals by the microbes in the system. The organics have the propensity to take up the metals and organically bind them. This binding would potentially show up as a lowered level of the metal in the

sample analysis. However, this possibility does not alter the basic nature of the metal. After the organic material dies and degrades, the metal will be released back to the environment unchanged.

Sample Number	AG (mg/L)	AS (mg/L)	BA (mg/L)	CD (mg/L)	CR (mg/L)	CU (mg/L)	NI (mg/L)	PB (mg/L)	SE (mg/L)	ZN (mg/L)
1063	<0.20	<0.010	<1.00	<0.20	<0.10	0.061	<0.25	<0.10	<0.010	3.97
1168	<0.20	0.104	<1.00	0.433	<0.10	0.46	<0.25	0.398	0.154	4.42
1243	<0.20	<0.10	<1.00	<0.20	0.105	1.11	<0.25	<0.10	<0.10	11.87
1381	<0.10	<0.10	1.234	1.86	0.41	1.37	<0.25	0.33	0.35	7.01
1432	<0.10	<0.10	1.76	3.3	0.73	2.07	<0.25	0.48	0.449	13.72
1533	<0.10	0.255	1.695	0.88	0.158	0.229	0.034	0.171	0.204	2.88
1857	<0.10	0.451	0.913	0.28	0.039	0.14	<0.025	<0.050	0.012	0.463
1976	<0.025	<0.20	1.17	2.18	0.25	0.709	<0.006	0.185	0.36	2.87
Limits										
Wastewater	**0.2**	**N/A**	**N/A**	**0.69**	**2.77**	**3.38**	**3.98**	**0.69**	**N/A**	**2.61**
RCRA	**5.00**	**5.00**	**100.0**	**1.00**	**5.00**	**N/A**	**N/A**	**5.00**	**1.00**	**N/A**

AG = Silver **NI = Nickel** **NA= Not Applicable**
AS = Arsenic **PB = Lead**
BA = Barium **SE = Sesium** **Exceeds Wastewater limits**
CD = Cadmium **ZN = Zinc** **Exceeds RCRA limits**
CR = Chromium
CU = Copper

Table 2

(2) *Flash point.* A flash point of less than 60 °C (140 °F) exhibits the characteristic of ignitability and would be considered a hazardous waste according to 40 CFR 261.21. All cleaner samples were heated to 100 °C (212 °F) and tested to determine the flash point. No flash point was detected in any of the samples.

(3) *pH.* The pH of the samples was measured throughout testing. A pH of # 2 or ∃ 12.5 results in the material being classified as hazardous (40 CFR 261.22). The pH of the cleaner in the system stayed close to neutral for the entire evaluation. Values ranged from 7.70 to 8.09 and are within the acceptable range for disposal as a non-hazardous waste.

(4) *Total Petroleum Hydrocarbons (TPH).* The objective of this test was to determine the effectiveness of the oil-eating microbes. TPH levels were measured in each sample to determine if the microbes were able to digest the oil that had accumulated in the system. The TPH levels for all samples were less than 1.3 percent oil and grease. This indicates that the microbes

were able to keep up with the petroleum loading and "eat" the oil as advertised. However, due to the low level of system use, it is not clear how the system would handle higher petroleum loading situations. Table 3 includes sample results from the TPH testing.

Sample Number	Sample Date	Total Petroleum Hydrocarbons (% Oil and Grease)
1063	12-April-1999	1.2
1109	16-April-1999	* Not Tested
1168	26-April-1999	1.3
1243	10-May-1999	0.6
1381	24-May-1999	0.6
1432	7-June-1999	0.5
1533	21-June-1999	0.4
1857	6-July-1999	0.5
1976	19-July-1999	0.7

Table 3

(5) *Standard bacterial plate counts.* Standard bacterial counts were also checked to determine how the use of the system affected the health of the colonies. Low usage of the system did not seem to effect the health of the microbial colony. The system maintained the colony throughout the evaluation.

(6) *Relative solvency.* The Tank and Automotive Command (TACOM) has developed cleaning criteria that specifies that a cleaner should not have a relative solvency less than that of P-D-680 (II). Relative solvency is a measure of the time required to remove grease from a metal test coupon. The cleaning time for P-D-680 during this evaluation was 20 to 25 minutes. Of the 24 samples taken from the Zymo™ system, 6 samples had cleaning times between 80 and 100 minutes. The remaining samples had cleaning times of over 100 minutes. Therefore, the system did not meet the TACOM established criteria for relative solvency.

(7) *Toxicity clearance.* ATC suggested that a toxicity clearance be obtained from the U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM) before the cleaner was recommended for general Army use. CHPPM has granted a Toxicity Clearance to the Zymo™ system (reference 3c).

6. Conclusions and Recommendations.

a. In general, the Zymo™ system works well in vehicle maintenance applications and performed well during the test period. Despite poor relative-solvency test results for the

cleaning solution, the mechanics felt that the system cleaned well and were pleased with its performance. They also liked the non-solvent-like smell. The Zymo™ system would work well in most vehicle maintenance applications. However, TACOM approval should be received before use on any tactical vehicles. For more information on TACOM approval, contact William Newton, (410) 278-7460, at the Army Test Center (ATC) at Aberdeen Proving Ground, MD.

b. The machine evaluated was too small to accommodate many of the parts cleaned at this site (tracked vehicle sprockets, roadarms, and other suspension-related items). This resulted in a lower usage level than was expected. The vendor manufactures a larger unit that may be more applicable for large vehicle maintenance shops. Dimensions of that unit are 39" W x 30¼" D x 43" H. Before purchasing, the user should determine the size of the biggest part to be cleaned in the system and only order this larger unit if the part will fit. Users who need to clean extremely large pieces of equipment or machinery should consider alternative cleaning methods.

c. While the system did effectively keep petroleum levels low, metals levels in the cleaner were frequently above regulatory limits, requiring the cleaner to be disposed as hazardous waste. So, while the cleaner is non-hazardous in its initial state, it can become hazardous as it is used if the materials being cleaned contain RCRA regulated metals or will otherwise adversely affect the characteristics of the cleaner.

d. Maintenance requirements for the system are low. Redstone Arsenal has used the system for approximately three years, and the addition of replacement solvent and occasional filter changes are the only required maintenance.

7. Points of Contact. Questions and/or comments regarding this subject, which cannot be resolved at the installation level, should be directed to:

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