THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

Concurrent Technologies Corporation

ETV JOINT VERIFICATION STATEMENT

TECHNOLOGY TYPE:	**MICROBIOLOGICAL OIL DIGESTION**
APPLICATION:	**AQUEOUS CLEANING APPLICATIONS**
TECHNOLOGY NAME:	**BioClean Biological Degreasing System**
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The United States Environmental Protection Agency (EPA) has created the Environmental Technology Verification Program (ETV) to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by substantially accelerating the acceptance and use of improved, cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations, stakeholder groups consisting of buyers, vendor organizations, and states, with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The ETV P2 Metal Finishing Technologies Program (ETV-MF), one of 12 technology focus areas under the ETV Program, is operated by Concurrent Technologies Corporation, in cooperation with EPA's National Risk Management Research Laboratory. The ETV-MF Program has evaluated the performance of a bath maintenance technology for the removal of oil and other organic contaminants. This verification statement provides a summary of the test results for the BioClean Biological Degreasing System.

VERIFICATION TEST DESCRIPTION

The BioClean Biological Degreasing System (BioClean System) was tested, under actual production conditions, at the National Manufacturing Company in Sterling, IL. Alkaline cleaning is performed on metal parts at different times during the manufacturing process to remove oils, coolants and other metalworking fluids prior to electroplating. The verification test evaluated the ability of the BioClean System to remove oils at three soil loading rates (High Oil Load – HOL, Low Oil Load – LOL, and Spiked Oil Load – SOL).

Testing was conducted during three distinct 3-day test periods:

- During the first test period (HOL – high oil load), the unit was operated with a normal soil loading rate from National Manufacturing's three zinc barrel plating lines. The soil was introduced into the system from metal parts.
- During the second test period (LOL – low oil load), the unit was operated on only one of National Manufacturing's zinc barrel plating lines. The soil was introduced into the system from metal parts.
- During the third test period (SOL – spiked oil load), the unit was operated with no metal parts entering the system. The soil was introduced into the system by adding three aliquots, in a short time frame, of a commonly used oil in National Manufacturing's process. The oil was added in its pure form.

Grab samples were collected from various parts of the system (cleaner tanks, BioClean holding tank and separator) during each test run. Historical operational data were taken from the testing facility in order to compare the labor and costs involved the parts cleaning operation.

TECHNOLOGY DESCRIPTION

The BioClean System employs an alkaline cleaning solution and control system that utilizes microbes in the solution to consume the oil/grease that is removed from parts during the cleaning process in the metal finishing industry. The system operates at relatively low temperatures (104ºF – 131ºF) (40ºC - 55ºC) and a pH range of 8.8 - 9.2, which is a viable habitat for these microorganisms. The cleaning process actually takes place in two separate operations. When parts come in contact with the solution, the oil and impurities are emulsified into micro-particulates. The particulates are then consumed by microorganisms, which are present in the bath or spray. The microbe consumption of the oil present in the bath, as its food source, results in the production of CO_2 as a by-product.

The Sterling facility has four plating lines that use a combination of rack and barrel plating technologies. Three of the four lines are zinc barrel plating, and the fourth is a multi-purpose (rack and barrel) line. The cleaning solutions from the four separate cleaning baths are pumped continuously into a holding tank that feeds the BioClean System. After BioClean treatment the cleaning solution is returned, by gravity, into the holding tank and then pumped back into the cleaner tanks. This operation is run in a continuous mode with level guards on the cleaner tanks that prevent overfilling. As a result of the dynamics of the BioClean process and the re-circulation of the bath solution, the consumption of oil by the microbes occurs throughout the BioClean Biological Degreasing System.

VERIFICATION OF PERFORMANCE

During verification testing, the oil concentration in the BioClean System was measured at the beginning and end of each test run at the separator and at each cleaner bath within the test area (baths 1-3 for HOL, bath 3 only for LOL and SOL). Oil entering the system was estimated by measuring the amount of oil on a representative set of parts and comparing the characteristics (part size, geometry, presence of threads) of the parts being cleaned during testing to similar parts from the measured part set. Oil concentration was

measured using a modified EPA 8015 procedure (the modifications are changes to the extraction solvent and Gas Chromatograph column and settings).

The performance of the BioClean System was similar during LOL and HOL testing. During the LOL test period, the BioClean System cleaned 28,549 ft^2 of metal parts that contained an estimated oil quantity of 79.7 kg. The greatest microbial growth response was seen during the HOL test. During that test period, the BioClean System cleaned 98,546 ft^2 of metal parts that contained an estimated oil quantity of 219.5 kg. Although a significant amount of oil was introduced into the system on the parts, the oil concentration in the BioClean System remained constant. The SOL test was conducted with no parts running through the Zinc Barrel Plating Line #3 and with its cleaning bath being fed into the BioClean System. The oil was introduced into the system in a short time frame through three aliquot additions. The system was spiked during the first hour of SOL Test Day #1. A total of 9.6 kg of oil was added to Cleaning Bath #3. The other cleaning baths were isolated from the BioClean System during the SOL test. An oil removal efficiency for the SOL is not presented in **Table i**, since the result would be less than the theoretical lower limit of zero. This may be due to the fact that the microbe concentration during the SOL test was approximately 1 percent of that during the HOL and LOL tests, and the oil was added as a bolus. It may be that oil must be emulsified prior to consumption by microbes. Additionally, the spike amount was relatively low with respect to the original oil content of the system. This result would also indicate the imprecision in determining oil consumption. A summary of the oil removal efficiency at the tested load rates is presented in **Table i**. The results of these short duration tests, however, do not reflect the fact that the BioClean System continues to digest oil during periods when production is not occurring.

	Initial Oil Content (Kg)	Oil Added (kg)	Final Oil Content (kg)	Oil Consumed (kg)	Removal Efficiency %
High Oil Load	52.1	219.5	156.9	114.7	42
Low Oil Load	25.9	79.7	60.9	44.7	42
Spiked Oil Load	52.0	9.6	76.6	-15.0	Not Calculated

Table i. Oil Removal Efficiency

Energy Use. Because the BioClean cleaner is maintained at 120-125°F as opposed to the previous soak clean temperature of 140-145°F there is a savings in the utility costs of the preplate cleaning cycle. A comparison of the energy requirements for the BioClean System versus the previous soak cleaner used at National Manufacturing is shown in **Table ii**. The heating costs were calculated using the formulae found in the Metal Finishing Guidebook and Directory chapter on immersion heaters. BioClean auxiliary equipment includes pumps and heaters for the BioClean separator and holding tank.

	BioClean (kWhr)	Soak Cleaner (kWhr)
Heat Required for Startup	12,300	17,200 (4 hr cycle, 50 cycle/yr)
Heat Required for Surface Loss	35,900	88,100
Heat Required for Tank Wall Loss	13,500	20,300
BioClean Aux. Equipment.	34,100	0
Total	95,800	125,600
Savings	29,800	
Savings ($.07/kWhr)	$2,086/year	

Table ii. Energy Requirements

Waste Generation. A waste generation analysis was performed using current data and historical records of the four plating processes that utilize the BioClean System at National Manufacturing. Implementation of the BioClean System has eliminated the requirement for periodic replacement of the alkaline soak clean baths; instead, an annual tank cleaning operation loses approximately 20 percent of each BioClean bath's contents. Additionally, the dump and remake frequency for the four electrocleaner baths was changed from eight times annually to four times per year. Overall, the amount of waste requiring treatment due to bath replacement is reduced from 34,400 gallons to 6940 gallons annually.

Operations and Maintenance Labor. Operating and Maintenance (O&M) labor requirements for the BioClean System were monitored during testing. The O&M labor requirement for the equipment was observed to be two hrs/wk. O&M tasks performed during the verification test include daily inspections of the unit and weekly cleaning of the tank and membrane. Daily unit supervision includes checking: the function of the air blower, the circulation of the degreasing baths through the Separator Module, the function of the metering pumps, the chemical drums for replenishment, the pH value, and the temperature value. Weekly maintenance includes checking the function of the level guards, cleaning and calibrating the pH electrode in the Separator Module, and removing the sludge at the bottom of the Separator.

Cost Analysis. A cost analysis of the BioClean System was performed using current cost factors and historical records from National Manufacturing. The installed capital cost (1998) of the unit was $47,569 (includes $27,625 for the BioClean unit, plus $19,944 for installation to four work-centers). The annual cost savings associated with the BioClean System at National Manufacturing is $86,192. The projected payback period is less than a year (0.6 yrs).

SUMMARY

The test results and a review of historical operating records at National Manufacturing show that the BioClean System provides an environmental benefit by eliminating the need for alkaline bath disposal, thereby extending the bath life and reducing the amount of liquid and solid wastes produced by the cleaning operation. The economic benefit associated with this technology is low operating and maintenance labor and reduced chemical costs, and a payback period of less than a year (0.6 yrs). As with any technology selection, the end user must select appropriate cleaning equipment and chemistry for a process that can meet their associated environmental restrictions, productivity, and cleaning requirement.

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