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EPA **Project Summary**

Evaluation of the B.E.S.T.™ Solvent Extraction Sludge Treatment Technology Twenty-Four Hour Test

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A twenty-four hour sampling and analytical effort was conducted on Resources Conservation Co.'s Solvent Extraction Sludge Treatment Technology prototype full-scale commercial facility while operating at the General Refining Superfund site in Garden City, Georgia. The site was contaminated with oily residues resulting from waste oil rerefining and reclamation operations. The B.E.S.T.™* sludge treatment technology was tested to determine its suitability for application as a transportable on-site treatment technology for spill and waste site cleanups, with special potential for oily hazardous waste materials. The process separates oily sludges into their component oil, solids, and water fractions, and conditions them for disposal or for further treatment.

The test data confirm the system's capability to separate the sludges as predicted, often in efficiencies of over 98%. Comparison of laboratory simulation data to field data indicates that laboratory-scale simulations can be useful in predicting system performance.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the data evaluation, which are documented in the report.

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Introduction

B.E.S.T.™ solvent extraction sludge treatment technology data were generated during a twenty-four hour performance test conducted at the General Refining site in Garden City, Georgia. The test was conducted by the Resources Conservation Co. (RCC) with the assistance of EPA's Region X Environmental Services Division in cooperation with EPA's Region IV Emergency Response and Control Branch.

The General Refining site, located near Savannah, Georgia, was operated as

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a waste oil reclamation and rerefining facility from the early 1950s until 1975. Sulfuric acid used to treat the waste oil produced an acidic oily sludge, while process filtration produced an oily filter cake by-product. The sludge was disposed of in four unlined lagoons, and the filter cake was buried and stockpiled on-site. An additional unlined lagoon that had been used as an oil-water separator was backfilled with filter cake and sludge, and waste oil was stored in bulk tanks on-site.

To remedy the situation, site cleanup actions were initiated in the summer of 1986 to stabilize the site, secure the facility, and explore disposal alternatives. In evaluating disposal alternatives, consideration was given to on-site and off-site incineration, landfilling, and on-site solvent extraction. The B.E.S.T.™ solvent extraction process was chosen as the most suitable and cost-effective option.

In mid-1986 RCC mobilized and installed its prototype full-scale commercial solvent extraction sludge treatment system at the General Refining site. After shakedown and modification of the prototype 100 ton/day system, approximately 3,700 tons of oily sludges from the petroleum rerefining operations were treated. The B.E.S.T.™ system operation concluded in March 1987.

The initial sampling and analytical activity conducted during the removal operation was directed at verifying the composition of the product streams. RCC previously had evaluated petroleum industry sludges at the laboratory-scale level. These efforts resulted in data that tracked the isolation of contaminants into the oil, water, and solids fractions, and also determined EP toxicity and TCLP results for the solids residues. The General Refining operation provided the opportunity to compare a prototype full-scale commercial facility's data with the laboratory-scale data for treatment of hazardous waste sludges.

RCC, in cooperation with EPA's Region X, then developed and implemented a twenty-four hour sampling and analysis project to evaluate the system's performance and efficiency both in the separation of the feed components and in the isolation of contaminants into specific product streams.

The Technology Evaluation report is divided into six sections: introduction; summary and conclusion outlining the performance of the technology during the sampling effort; brief description of the General Refining site; description of the technology; discussion of the system operation and data collected during the test period; and quality assurance/quality control.

The General Refining site was used from the early 1950s to 1975 as a waste oil reclamation and rerefining facility. The site is located off Route 80, Chatham County, in Garden City, Georgia, west of Savannah. The total volume of waste generated was estimated to be in excess of 10,000 tons. Analysis of the waste oil, sludge, and filter cake performed during an early material characterization phase of the RCC project revealed the presence of petroleum compounds, heavy metals including lead and copper, PCBs, and low-pH sludges and water.

Composition of the sludges and soils at the site varied widely from point to point laterally and vertically within the lagoons. Nominal composition in weight percent was approximately 10% oil, 70% water, and 20% solids, but during actual operation oil ranged from 0-40%, water from 60-100%, and solids from 2-30%. During the twenty-four hour test period the feed was fairly consistent at 27% oil, 66% water, and 7% solids. Primary contaminants in the feed were PCBs ranging from 1 to 13 mg/kg, and lead ranging from 2200 to 7400 ppm.

The sludge at the site exhibited some unusual physical properties. The untreated sludge formed an emulsion that was hydrophobic and could not be mixed with water. The sludge was determined to be rheopectic, since mixing acted to increase its viscosity, changing it from a paste-like state to a semi-solid. Viscosity readings on several samples ranged from 490,000 to 530,000 centipoise Brookfield.

The site remediation involved neutralizing the sludge from the lagoons and then processing it through the B.E.S.T.™ solvent extraction system where it was separated into its oil, water, and solids product fractions. Some of the product oil was transported off-site with the remainder stored on-site for treatment by other methods; the product water was first treated on-site and then transported to a nearby industrial wastewater treatment system; and the product solids were stored on-site.

Procedure

The RCC.'s prototype full-scale commercial facility has a nominal capacity of 100 ton/day wet throughput. The system is modular, is capable of being transported to contaminated sites for operation and cleanup, and offers the capability to include all required on-site utilities except for electricity and potable water.

The B.E.S.T.™ sludge treatment system processes difficult-to-treat emulsified oily sludges by breaking the emulsion and physically separating the sludge into three separate fractions. These fractions--oil, water, and solids--then can be handled separately. As the fraction separations take place, certain contaminants can be removed from the original sludge and concentrated into a specific phase; for example PCBs concentrate in the product oil fraction, and metals in the product solids fraction. This separation permits a determination of the most appropriate methods for disposal and the suitability for recycling or reuse of the separated fractions.

The process uses one or more of a family of aliphatic amine solvents to break oil/water emulsions and release bonded water from the sludge. The solvent used at the General Refining site, triethylamine (TEA), becomes completely miscible with water when cooled below 20°C, but upon heating becomes immiscible. The process mixes refrigerated TEA solvent with the oily sludges releasing solids from the oil/water emulsion. The solids are removed by centrifugation and dried. Solvent is separated from the oil and water fractions using distillation techniques.

The oil product fraction is chemically unaltered by the process and has the same characteristics as the feed material. The objective is to recover and reuse this fraction as a fuel or process feedstock. The water product fraction, whose volume increases by approximately 20% due to steam condensation within the system, is able to be treated and discharged. The solids residual is powder dry and contains only traces of the oil.

Sludge feed limitations are primarily large particle size and reactivity with the process solvent. Process performance can be influenced by feed characteristics such as the presence of detergents and emulsifiers, or of low-pH material. Detergents can result in degraded separation efficiency resulting in increased concentrations of oil and grease in the product water, and increased water content in the product oil. Emulsifiers can affect organics separation from the water fraction. Low pH material must be neutralized to prevent reactions with and loss of the solvent.

During operations at the site, preprocessing treatment consisted of screening the filter cake and backfill material through a 1/4-inch hammermill, which crushed the material to the size desired for processing. Sludge from the ponds, often in excess of 1,000,000 centipoises, was pumped into a vibrating screen and placed into storage tanks to await processing. Since the sludge was highly acidic, it was neutralized with sodium hydroxide. A feedrate of approximately 40 ton/day was maintained during the test period. The oil product was discharged into an oil polisher to further separate water from the oil, the solids were discharged from the solids dryer through an exit chute into storage containers, and the water was further processed in an on-site treatment system.

Posttreatment requirements for the separated fractions vary between applications. Some product oil, water, or solids upgrading may be needed depending on the intended disposition of these materials. For example, if the solids are to be landfilled, some further treatment such as fixation may be required. PCBs can be isolated in the oil fraction and either can be chemically or thermally destroyed by subsequent treatment or used as fuel if the PCB contamination is within regulatory limits.

The product water is treated in an on-site water treatment plant prior to discharge. The water treatment plant is a modular facility using two-stage clarification. The first stage consists of acidifying the water and adding a flocculent and an oil/water emulsion breaker. Then lime is added to raise the pH and aid in precipitating lead (Pb), and a contact clarifier is used to settle out sludge materials.

The B.E.S.T.™ sludge treatment process is operated with the use of an automatic control system that monitors process conditions and makes process adjustments as required. A process operator monitors the control system and makes additional adjustments. Samples of the feed and product streams are collected periodically and analyzed to ensure proper system operation.

Since the General Refining site was an inactive site, RCC was required to supply all necessary utilities other than electricity and service water. RCC provided a mobile oil-fired boiler for steam generation, a cooling tower for cooling water, a cryogenic nitrogen (N_2) storage system, a water product treatment facility, and instrumentation air for process equipment operation.

Results and Discussion

The B.E.S.T.™ solvent extraction sludge treatment 100 ton/day prototype commercial facility operation at the General Refining site demonstrated the system's capability to separate oily feedstock into its oil, water, and solids product fractions and to concentrate certain contaminants into a specific product fraction. Separation efficiencies, defined as the amount of desired product less the amount of all undesired products times 100, often exceeded 98%. The solids product stream was shown to contain less than 0.5% moisture, with very little oil contamination; the oil product contained only 0.88% water; and the water product contained 0.0033% oil and less than .81% total solids.

After separation, the streams were analyzed for contaminant concentrations to ascertain that specific key contaminants had concentrated preferentially into a particular product fraction. The contaminants of interest were PCBs, lead, metals, volatiles, semivolatiles, and chlorinated dioxins and furans. In general the PCBs, volatiles, and semivolatiles concentrated in the oil fraction, with little contamination found in the solids and water product fractions. Metals mostly concentrated in the solids fraction, but lead concentrated into both the solid and oil fractions, suggesting that lead in the sludge feed was bound inorganically as well as organically. Chlorinated dioxins and furans were below detection limits in the raw sludge feed. On-site water treatment reduced most levels of contaminants in the discharged treated product water, maintaining about the same semivolatiles concentrations, slightly reduced volatiles, and significantly reduced metals concentrations.

Conclusions and Recommendations

The General Refining operation was the first full-scale test of the B.E.S.T.™ sludge treatment technology. The data indicate the system's capability to separate oily sludges as predicted, in efficiencies of over 98%, and to produce disposable product streams. In addition, comparisons of laboratory simulation data to field data indicate that laboratory-scale simulations can be useful in predicting system performance. Although the current data confirm the system's capability to perform as designed, further testing over an extended period of time should be undertaken when the system is operating at another site. Testing over a longer period of time can aid in the affirmation of the effectiveness of the process and in the development of operating and cost data.

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The complete report, entitled "Evaluation of the B.E.S.T.™ Solvent Extraction Sludge Treatment Technology Twenty-Four Hour Test," (Order No. PB 88-245 907/AS; Cost: $19.95, subject to change) will be available only from:
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