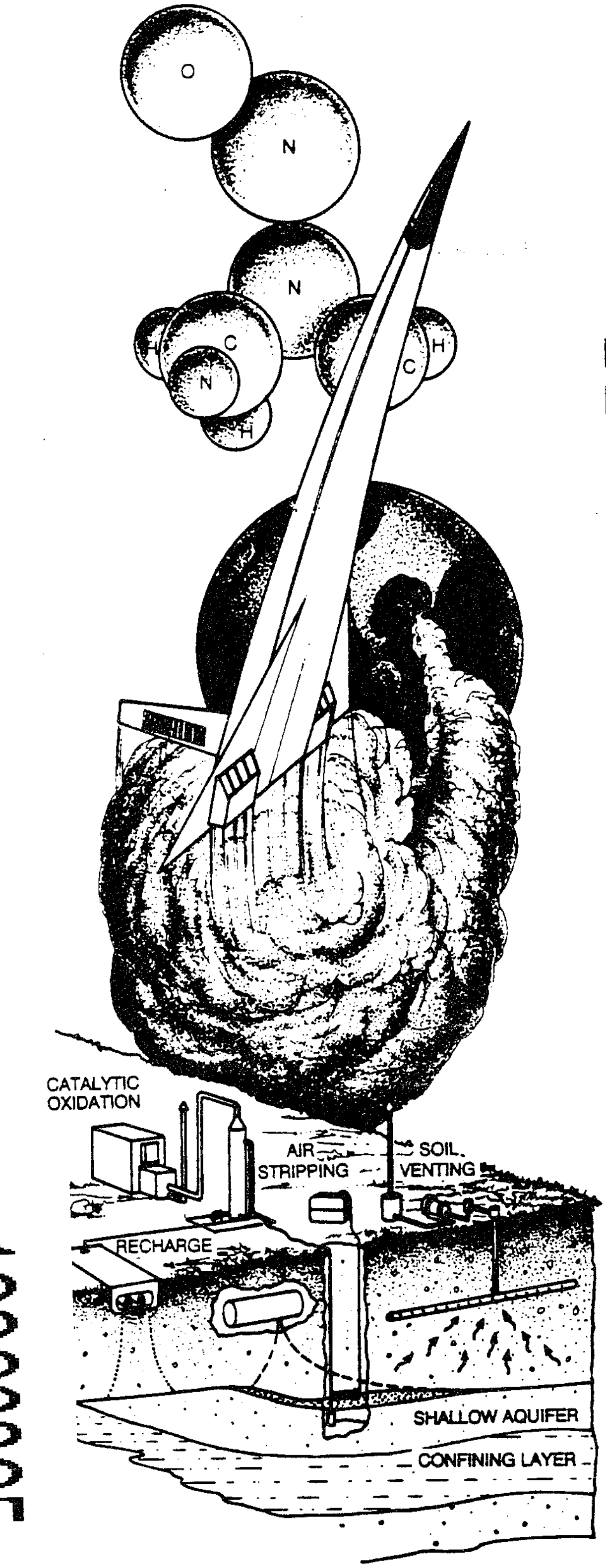

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VOL 1

BICARBONATE OF SODA STRIPPING, PHASE I - VOL 1

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13. ABSTRACT *(Maximum 200 words)*
This technical report is divided into two volumes. Volume I explains the study and results of the treatment of Bicarbonate of Soda Stripping (BOSS) waste sludge generated in paint-stripping operations, while volume II contains the supporting data of the study. The study of Bicarbonate of Soda Stripping determined chemical and physical differences between the fresh and spent sodium bicarbonate paint-stripping media. The study evaluated core technologies for treatment of Bicarbonate of Soda Stripping (BOSS) waste sludge generated in paint-stripping operations using bicarbonate paint-stripping media. Detailed physical and chemical analysis were completed of new and spent media. The particles showed evidence that the media was physically altered during the stripping process. Paint stripping is treatable with commercially-available equipment typically used for solid-liquid separations. Vertical leaf pressure filtration was determined a superior technology when judged by the selection criteria used. This study encourages the use of a precoat filter aid (e.g., diatomaceous earth) with the vertical leaf pressure filter system for treatment of spent sodium bicarbonate paint-stripping media.

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PREFACE

This report was prepared by Idaho National Engineering Laboratory, EG&G Idaho, Inc., P.O. Box 1625, Idaho Falls, Idaho 83415-2050, DE-AC07-76ID01570, for the U.S. Department of Energy (DOE) and the Air Force Civil Engineering Support Agency (AFCESA), Suite 2, 139 Barnes Drive, Tyndall Air Force Base, Florida 32403-5319.

This report presents the results of an Idaho National Engineering Laboratory (INEL) study of Bicarbonate of Soda Stripping which determined chemical and physical differences between the fresh and spent sodium bicarbonate paint-stripping media. The study evaluated core technologies for treatment of Bicarbonate of Soda Stripping (BOSS) waste sludge generated in paint-stripping operations using bicarbonate paint-stripping media. Vertical leaf pressure filtration was determined a superior technology when judged by the selection criteria used. This study encourages the use of a precoat filter aid (e.g., diatomaceous earth) with the vertical leaf pressure filter system for treatment of spent sodium bicarbonate paint-stripping media.

This technical report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nations.

This report has been reviewed and is approved for publication.

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EXECUTIVE SUMMARY

A. OBJECTIVE

The objective of this program was to first determine the physical and chemical differences between the fresh and spent sodium bicarbonate paint-stripping media. Then based upon this information, core technologies for the treatment of Bicarbonate of Soda Stripping (BOSS) waste sludge generated in aircraft part, paint-stripping operations that use the sodium bicarbonate paint-stripping media were evaluated.

B. BACKGROUND

Abrasive blasting processes are being investigated as alternatives to chemical paint-stripping to reduce worker exposure to hazardous chemicals and the volume of hazardous waste produced in the paint-stripping process. One such process uses a formulated sodium bicarbonate compound as the abrasive in a wet blasting process. This process produces a spent sodium bicarbonate sludge that contains paint chips and small amounts of other insoluble solids such as dirt, grit, and very fine metal chips. These solid particles are too small to be treated with the existing waste handling technology that was developed for the chemical paint-stripping wastes. Methods of collection, transportation, treatment, and disposal of these solid particles are needed to solve this problem.

C. SCOPE

This program was developed to characterize the spent sodium bicarbonate waste, investigate technologies to separate the spent media from the other contaminants, and determine collection and transportation methods for the waste streams.

D. METHODOLOGY

The overall rationale for this program was to first determine any differences in the physical properties and chemical composition of the fresh and spent sodium bicarbonate media. Then using this information, evaluate technologies to separate paint and metal chips from the spent sodium bicarbonate paint-stripping media and determine collection and transportation methods for the waste streams.

E. MEDIA CHARACTERIZATION DESCRIPTION

Chemical and physical characterization of the fresh sodium bicarbonate media were performed to provide a baseline. The baseline data were compared with the spent media analysis results to determine bicarbonate media changes resulting from the blasting process in terms of particle size, structure, and composition. In addition, samples of the fresh and spent media were separated into nine different size fractions to determine if the contaminants fall within a given size fraction and to detect changes in the particle size distribution resulting from the paint-stripping process.

Physical analysis of the new and spent media included paint and metal chip density determination, particle size distribution, scanning electron microscopy (SEM), and optical microscopy.

Chemical analysis of the fresh and spent paint-stripping media included dehydration to determine water content, titration to determine sodium bicarbonate composition, solvent extraction to determine wax content, and inductively coupled plasma analysis (ICP) to determine the metal composition (Lead, Chromium, Zinc, Cadmium, Aluminum, and Iron). The remaining insoluble solids, silica, paint particles, and other flow additives present in the media were determined by dissolving the samples in water and then using the density differences to isolate and weigh each type of solid.

F. CHARACTERIZATION RESULTS

The spent sodium bicarbonate sample characterized is representative of paint-stripping media that has been washed down a drain to a sump or holding tank. The sample had been physically altered by chemical equilibria to produce an amorphus substance that can not be recycled and reused in the paint-stripping process. This made it difficult to separate the media into size fractions that accurately portrayed the change in size distribution caused by the blasting process. Because the media had agglomerated, the size distribution obtained for the spent media was more a result of the amount of physical work required to break the media down than any natural size distribution of the media.

The particles showed evidence that the media was physically altered during the stripping process. The spent media particles did not have the crystalline structure of the fresh media, but was made up of a conglomerated mass of damaged subparticles, paint chips, and other contaminants. In addition, the solid samples analyzed did not show any indication that the metals accumulated in a given size fraction. This means that the paint and metal chips in any given size fraction are really smaller than the aggregate size and are fairly evenly dispersed amongst all the size fractions.

The carbonate titration results are useful in determining the amount of acid needed to neutralize the spent media. However, caution must be taken in drawing any conclusions from these results. The titration analysis indicated that an additional base was present other than the bicarbonate and carbonate in the sample. hence, the results do not accurately portray the amount of sodium bicarbonate in the sample. The additional base could come from a second base present in the stripping media or some contaminant picked up during the stripping process.

G. CONCLUSIONS

Based on vendor testing and recommendations, paint-stripping media from BOSS operations is treatable with commercially-available equipment typically used for solid-liquid separations. The technology evaluation revealed that vertical leaf pressure filtration is a superior technology when judged by the selection criteria used here. Contributing to the superior score of pressure filtration are the following factors: (1) separation between solids and liquid is not density dependent, (2) reasonable capital costs, (3) versatility, and (4) positive vendor testing and recommendation.

In addition, the transportation and handling of the wastes can be accomplished by using standard process equipment as described in the performance specification. The primary effluent streams exiting the proposed treatment/handling scheme are: (1) approximately 20 to 25 gallons per minute (gpm) of clarified liquid effluent of pH≈4 that will be piped to the Industrial Waste Treatment Plant (IWTP) at Kelly AFB, and (2) a solids cake containing no free liquid that is ready to be placed in disposal containers.

H. RECOMMENDATIONS

We recommend that a vertical leaf pressure filter system be installed at Kelly AFB for the purpose of treating the spent depainting media resulting from BOSS operations. The use of a precoat filter aid (e.g., diatomaceous earth) is strongly encouraged, as it was recommended as a result of vendor testing.

The corrosion inhibited sodium bicarbonate paint-stripping formulation contains sodium silicate, which is more soluble than sodium bicarbonate and has a greater affinity for the hydronium (H^+) ion. When sodium silicate reacts with acid, it forms a silica gel that could cause problems with any filtration devices downstream of the acidification process. Currently, the Air Force is not planning on using the corrosion inhibited paint-stripping formulation. However, it is recommended that the process selected to treat the spent sodium bicarbonate media consider placement of the acidification step downstream of any filtration devices in the event that the Air Force decides to use the corrosion inhibited formulation in the future.

We recommend that the equipment and methods presented in the process flow diagram and described in the performance specification be chosen for BOSS waste treatment and transportation. In so doing, Kelly AFB will produce a clarified acidic liquid stream (pH≈4) that can be sent to their IWTP with minimal impact on the IWTP.

Finally, vendor testing is highly recommended once final equipment selection has been made by Kelly AFB for the BOSS waste treatment. This testing should be performed on various BOSS waste samples provided by the United States Air Force, and the test results should be thoroughly reviewed before equipment purchases.

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LIST OF ABBREVIATIONS

AFESC	Air Force Engineering and Services Center
BOSS	Bicarbonate of Soda Stripping
CC	Capital Costs
FWF	Final Waste Form(s) and Effluent Purity
G	Gram(s)
gpm	Gallons per minute
HP	Horse Power
ICP	Inductively coupled plasma
IWTP	Industrial Waste Treatment Plant.
LDRA	Level of Development, Risk, and Availability
max.	Maximum
Mgpd	Million gallons per day.
min.	Minimum
mL	Milliliters
NPDES	National Pollution Discharge Elimination System
NTIS	National Technical Information Service
ppm (wt)	Parts per million, weight basis
RCM	Reliability, Complexity, and Maintenance
RCRA	Resource Conversation and Recovery Act
RPM	Revolutions Per Minute
scf	Standard Cubic Feet at 60°F and 1 Atmosphere
SEM	Scanning electron microscopy
SG	Specific Gravity
sol	Solution
TSS	Total Suspended Solids
UF	Ultrafiltration
UR	Utility Requirements (energy, water, chemical, etc.)
V&R	Versatility and Robustness

LIST OF SYMBOLS

H_2SO_4	sulfuric acid
HCl	hydrochloric acid
HNO_3	nitric acid
KHP	potassium hydrogen phthalate
Na_2CO_3	sodium carbonate
$NaHCO_3$	sodium bicarbonate
NaOH	sodium hydroxide

GLOSSARY OF TERMINOLOGY

Aliquot - A portion of a sample contained an exact number of times in the total sample.

Alkaline - Having a pH greater than 7.

Amorphous - Lacking distinct crystalline structure.

Aqua Regia - A mixture of three parts by volume of concentrated nitric acid and one part concentrated hydrochloric acid.

Biological Digester - A tank or basin in which organic contaminants in wastewater are broken down by digestion by bacteria and other microorganisms.

Brownian Motion - Random movements of small suspended particles caused by statistical pressure fluctuations over the particle.

Carcinogen - An agent that incites development of a malignancy.

Coagulation - The destabilization and initial aggregation of finely divided suspended matter by addition of a floc-forming chemical.

Density - Concentration of matter measured by mass per unit volume.

Dewatering - A process used to concentrate a slurry by removing water, for example, a plate and frame filter press or a belt press.

Diaphragm Pump - A pump in which a flexible diaphragm is used to impart motive force to the fluid. When the diaphragm is raised, suction is exerted, and when it is depressed, the fluid is forced through the discharge valve.

Diatomaceous Earth - A siliceous material derived chiefly from diatom remains that is used as a filter or filter aid, such as a filter precoat.

Effluent - Wastewater or other liquid, partially or completely treated, flowing out of a reservoir or treatment plant.

Filter Cake - The solids removed from a slurry and retained by a filter.

Filtrate - The clarified liquid that passes through a filter from which suspended solids have been removed.

Flocculent - A reagent added to a dispersion of solids in a liquid to agglomerate fine particles.

Flocculation - The agglomeration of finely divided particles after coagulation by mechanical or hydraulic means.

Freeboard - The vertical distance between the normal maximum (max) liquid level in a tank or basin and the top of the sidewalls.

GLOSSARY OF TERMINOLOGY (concluded)

Molarity - Measure of the number of gram-molecular weights of a compound in one liter of the solution.

Molar Solution - An aqueous solution that contains one gram-molecular weight of solute in one liter of the solution.

Mutagenic - Property of agent that raises the frequency of mutation above the spontaneous rate.

Nanopure Water - Water with less than one part per billion contaminants.

pH - A symbol denoting the negative logarithm of the hydrogen ion concentration. pH values range from 1 to 14. A neutral solution has a pH of 7.

Polishing Filter - A filter used to remove the suspended solids remaining in an effluent from another solids-liquid separation process which has removed the bulk of the suspended solids.

Precoat - A material used to coat the surface of a filter medium before introduction of the slurry to be filtered to enhance filtering rate and run length, for example, diatomaceous earth.

Sedimentation - The process of deposition of suspended matter by gravity.

Size Fraction - Fraction of a given sample that falls within a given particle range.

Slurry - A free-flowing, pumpable suspension of fine solid material in a liquid.

Specific Gravity - The ratio of the weight of a specific volume of a liquid substance to the weight of an equal volume of water.

Sump - A tank or pit that receives drainage for temporary storage.

Suspended Solids - Solids in suspension in wastewater.

Teratogenic - Property of an agent causing formation of a congenital anomaly.
Titrant A substance, such as a solution, of known concentration used in titration.

Titrate - To analyze the composition of a solution by adding known amounts of a standardized solution until a given reaction is produced.

Turndown Ratio - The ratio of design throughput rate to the lowest throughput rate for which the process can be adequately operated and controlled.

SECTION I
INTRODUCTION

A. OBJECTIVE

The objective of this program is to first determine the physical and chemical differences between the fresh and spent sodium bicarbonate paint-stripping media. Then based upon this information, evaluate core technologies for Kelly AFB that pertain to the treatment of Bicarbonate of Soda Stripping (BOSS) waste sludge generated in aircraft part paint-stripping operations using sodium bicarbonate paint-stripping media.

B. BACKGROUND

The Air Force maintains thousands of aircraft in their inventory. The paint is remcved several times during the life of these airplanes. This is done for a variety of reasons, including replacement of coatings, changes in camouflage schemes, and for structural inspections.

The paint formulations have become more complex as technology advances to improve corrosion protection, thermal protection, camouflage schemes, and erosion resistance. Current coating systems of epoxy primers and aliphatic polyurethane are chemically resistant and make traditional solvent-type strippers ineffective.

The most common method of removing the paint from the aircraft has been the use of chemical strippers that contain activators to facilitate the paint removal. Current paint strippers contain methylene chloride, phenol, formic acid, and sodium chromate. These chemicals have proven to be toxic to humans, even at low levels, and are classified as mutagenic, teratogenic, or poisonous to humans and animals. All of these chemicals are known carcinogens. Methylene chloride and phenol will be regulated by the EPA under the Clean Air Act and their presence requires that paint-stripping waste be handled as a hazardous waste, as set forth by guidelines in the Resource Conservation and Recovery Act (RCRA). Hence, disposal and waste treatment costs associated with these paint strippers continue to rise.

Abrasive blasting processes are being investigated as alternatives to chemical paint stripping, with these goals in mind: (1) reduction of human exposure to hazardous chemicals and (2) reduction of the volume of hazardous waste produced in the paint-stripping process. One such abrasive blasting process uses a formulated sodium bicarbonate compound manufactured by Church and Dwight Co., Inc. of Princeton, New Jersey as the abrasive in a wet blasting process. This process produces a spent sodium bicarbonate sludge that contains paint chips, as well as small amounts of dirt, grit, oil, and fine metal chips. The paint chips in the spent media are smaller than the typical paint chips obtained in the chemical stripping process. Innovative methods of collection, transportation, treatment, and disposal need to be integrated into a process that will solve potential waste treatment problems.

C. SCOPE

This program was developed to characterize the spent sodium bicarbonate waste, investigate separation technologies to separate the spent media from the other contaminants, and determine methods to collect and transport the waste streams. The following scope of work has been established for the BOSS Project:

- Fresh Material and Waste Characterization
  - Characterize the physical and chemical properties of the unused material
  - Characterize the physical and chemical properties of the spent material
  - Determine the amount of impurities imparted through use in paint-stripping.

- Waste Material Separation Methods Evaluation
  - Identify separation methods
  - Evaluate separation technologies
  - Prepare performance specifications for preferred separation technology

- Spent Material Collection and Transportation Methods
  - Identify spent material collection and transportation methods.
  - Determine physical methods for capturing wastes and removing them from the process area to the treatment area for disposal or recovery.
  - Evaluate methods for collection of the spent material and transportation from processing area.
  - Prepare performance specifications for the preferred collection and transportation technology.

- Site Visits
  - Conduct project reviews
  - Interface with Air Force personnel
  - Perform task activities.

- Reports
  - Provide intermittent progress reports for Air Force review and to inform the Air Force of current status.
  - Provide a final technical report in Air Force format for publication of the test results. Data, conclusions, and recommendations will be included.

SECTION II
RATIONALE AND METHODOLOGY

A. PROGRAM APPROACH

The overall rationale for this program was to first determine any differences in the physical properties and chemical composition of the fresh and spent sodium bicarbonate media. Then using this information, evaluate technologies to separate paint and metal chips from the spent sodium bicarbonate paint-stripping media and determine collection and transportation methods for the waste streams.

B. CHARACTERIZATION OF SODIUM BICARBONATE MEDIA

Chemical and physical characterization of the fresh sodium bicarbonate media were performed to provide a baseline. The baseline data were compared with the spent media analysis results to determine the bicarbonate media changes resulting from the blasting process in terms of particle size, structure, and composition.

The physical analysis of the new and spent media included: (1) paint and metal chip density, (2) particle size distribution, (3) scanning electron microscopy (SEM), and (4) optical microscopy. Particle density analysis of the paint and metal chips will aid in evaluating separation technologies for these contaminants by density gradients. Particle size distribution, SEM, and optical microscopy analysis allows for the determination of the extent of damage to the media done by the paint-stripping process. Analysis of the fresh and spent media size fractions will detect changes in the particle size distribution, while SEM and optical microscopy will detect changes in particle geometry and crystalline shape.

Chemical analyses of the fresh and spent paint-stripping media were used to determine the amount of water, silica, sodium bicarbonate, wax, heavy metals, paint particles, and other flow additives present in the media. This information was used to determine the chemical differences between the fresh and spent media. In addition, chemical analyses were performed on each spent media size fraction to determine if the contaminants are accumulating in any particular fraction.

C. EVALUATION OF SEPARATION, RECYCLE, AND RECOVERY TECHNIQUES

The technology evaluation is based on a decision-matrix approach, where each technology is scored according to a set of screening criteria and criteria weighting factors. From this quantitative evaluation, Kelly AFB will be able to decide which technologies are most appropriate for their applications. This evaluation was a precursor to the development of the performance specification written for the recommended technology.

SECTION III
EXPERIMENTAL PROCEDURES

A list of chemicals, materials, and equipment used to conduct the experiments is summarized in Appendix A.

A. MOISTURE ANALYSIS

This procedure was used to determine the amount of moisture in the fresh and spent sodium bicarbonate paint-stripping media.

Four replicates of approximately 100 grams (g) (weighed to the nearest tenth of a milligram) of fresh and spent sodium bicarbonate paint-stripping media were placed in individual 100 milliliters (mL) beakers. The eight samples were placed in the drying oven at 26.7-37.8°C (80-100°F) to dry. After several days, the beakers were removed from the drying oven and placed in a desiccator to cool. The cool beakers were weighed on the analytical balance to the nearest tenth of a milligram to determine the amount of moisture lost from the media.

B. PARTICLE SIZE DISTRIBUTION

The procedure outlined was used to separate the fresh and spent sodium bicarbonate paint-stripping media into size fractions for further physical and chemical analysis.

Approximately 1,500 g of the fresh and 1,940 g of spent paint-stripping media were weighed on the top loading balance, spread out on a separate sheets of aluminum foil, and placed in the drying oven at 26.7-37.8°C (80-100°F) to dry. (Note: The spent media required periodic stirring to break the media into small pieces during the drying process and to keep the media from forming a single solid mass.) After several days of drying, the media was removed and separated into size fractions, 250 ± 0.02 g at a time, using the U.S. Standard sieves. Each size fraction was collected and weighed to the nearest tenth of a milligram, placed into the appropriate 250 mL polypropylene sample bottle, and then placed in a desiccator for use in the other evaluations listed below.

C. STANDARD AND SCANNING ELECTRON MICROSCOPY

Optical microscopy and SEM were used to determine the particle geometry and crystalline shape for each size fraction of the fresh and spent media.

A three-dimensional analysis was performed with a scanning electron microscope using 0.5- to 2-g samples of each size fraction for the fresh and spent sodium bicarbonate paint-stripping media. Samples were carbon-coated and a coating of gold was splattered on the surface to achieve a good conductive surface. Photomicrographs were taken of each size fraction of spent and fresh sodium bicarbonate paint-stripping media. In addition, an optical microscope with a Polaroid camera was used to take photographs of the crystal shape and geometry of the fresh and spent sodium bicarbonate media for each size fraction.

D. PARTICLE DENSITY OF THE PAINT AND METAL CHIPS

This procedure was used to determine the density of the paint and metal chips contained in the spent sodium bicarbonate paint-stripping media.

Spent sodium bicarbonate paint-stripping media was dissolved in nanopure water and the solution was filtered to obtain a sufficient quantity of small paint and metal chips for the evaluation. Several small paint and metal chips were placed in each of the four 50 mL beakers with approximately 20 mL of carbon tetrachloride. Methylene iodide was slowly added to each beaker and thoroughly mixed until the first few paint chips remained suspended in the liquid when allowed to stand without agitation. Ten mL of each solution was poured into preweighed 10 mL volumetric flasks and weighed on the analytical balance to the nearest tenth of a mg. The solutions were then returned to the appropriate 50 mL beakers and methylene iodide was again added until the last few particles of paint and metal chips remained suspended in the liquid when allowed to stand without agitation. At this point there were no more solids on the bottom of the beaker. Ten mL of each solution was poured into preweighed 10 mL volumetric flasks and weighed on the analytical balance to the nearest tenth of a milligram to obtain a measurement of the density.

E. SILICA ANALYSIS

This procedure was used to determine the amount of silica in the fresh sodium bicarbonate stripping media.

Approximately 15 g of fresh media was weighed on the analytical balance to the nearest tenth of a milligram for each of the 250 mL beakers. Approximately 30 mL of nanopure water was added to the media in each beaker and mixed thoroughly. Five percent hydrochloric acid (HCl) solution by volume was added to each beaker until all the sodium bicarbonate had reacted with the acid as determined by the point at which the fizzing stopped. The beakers were heated until the solution boiled to melt the wax and free any silica that may have been stuck to the wax.

It was our initial intent to decant the wax off into a 125 mL separatory funnel for use in the wax analysis below. The remaining solution was to be filtered through a preweighed filter paper, the filter paper dried in the oven at 26.7-37.8°C (80-100°F) for 24 hours, and weighed on the analytical balance to the nearest tenth of a milligram. However, this was not done because no silica was detected in the experiment.

F. WAX ANALYSIS

This procedure was used to determine the amount of wax in the fresh sodium bicarbonate stripping media.

Thirty mL of hexane was added to one of the 250 mL beakers containing wax from the silica experiment to extract the wax out of solution. The contents were mixed well and allowed to stand so the solvent would separate from the aqueous solution. A sample of the solvent was extracted and a gas chromatograph (GC) analysis performed to determine how effective the solvent was in extracting the wax. This procedure was repeated using the methylene chloride and trichloroethylene solvents. No further work continued on this test since the GC analysis indicated that no wax was extracted into any of the solvents.

G. SODIUM BICARBONATE AND FILTERABLE SOLIDS ANALYSIS

This procedure was used to determine the amount of carbonate and bicarbonate in the fresh and spent sodium bicarbonate stripping media.

A standard 0.3753 molar potassium hydrogen phthalate (KHP) solution was made in a 250 mL volumetric flask. An approximate 1 molar sodium hydroxide (NaOH) solution was obtained by mixing 10 g of NaOH with 250 mL of nanopure water in a 250 mL volumetric flask. An approximate 1 molar HCl solution was obtained by mixing 82.6 mL of HCl with nanopure water in a 250 mL volumetric flask.

Twenty mL of NaOH solution was transferred into a 100 mL beaker using a pipet. The NaOH solution was titrated with the KHP solution and the pH was recorded with each addition of titrant in order to determine the molarity of the NaOH solution.

Twenty mL of HCl solution was transferred into a 100 mL beaker using a pipet. The HCl solution was titrated with the NaOH solution and the pH was recorded with each addition of titrant in order to determine the molarity of the HCl solution.

Approximately 2 g of media was placed in a 250 mL beaker. Fifty mL of nanopure water was added to the beaker using a pipet and mixed thoroughly. The solids were filtered out using a preweighed filter paper. The beaker was rinsed with an additional 50 mL of nanopure water using a pipet. The 100 mL filtrate was collected and titrated with the HCl solution while recording the pH with each addition of titrant.

H. METALS ANALYSIS

This procedure was used to determine the amount of Lead (Pb), Chromium (Cr), Zinc (Zn), Cadmium (Cd), Aluminum (Al), and Iron (Fe) in the fresh and spent sodium bicarbonate stripping media.

A 0.7 - 1.0 g aliquot of the sample was weighed into a platinum crucible, placed into a cold muffle furnace, slowly heated to 200°C (392°F) and held for 1 hour to convert all sodium bicarbonate ($NaHCO_3$) to sodium carbonate (Na_2CO_3). This was done to avoid excess splattering and bubbling upon further heating. The furnace was then heated to 700°C (1,292°F) and held to scinter the sample for approximately 1 hour. Scintering at this temperature is sufficient to destroy all organic material. The samples were cooled, poured into a Teflon™ beaker and dissolved with 20 mL of nanopure water and 10 mL of aqua regia. To dissolve any sample remaining in the platinum crucible, five mL nanopure water and 5 mL nitric acid (HNO_3) were added to the crucible and the resulting solution was added to the Teflon™ beaker. The sample was diluted to 100 mL in a volumetric flask. Each sample was prepared in quadruplicate and analyzed using the inductively coupled plasma instrument (ICP).

All calibration standards were prepared containing 10 percent aqua regia plus an additional 5 percent HNO_3. A matrix check was performed by preparing a sample of reagent grade $NaHCO_3$ and a similar sample spiked with Al, Pb, Fe, Cr, Zn, and Cd. Additionally, a spiked sample was prepared from one of the actual sample dissolutions.

SECTION IV
EXPERIMENTAL RESULTS AND DISCUSSION

The spent sodium bicarbonate sample characterized is representative of paint-stripping media that has been washed down a drain to a sump or holding tank. The sample had been physically altered by the chemical equilibrium process, where the spent media came in contact with a concentrated solution of dissolved sodium bicarbonate. Under these conditions, the particles of sodium bicarbonate, paint, and metal chips get cemented together by the sodium bicarbonate precipitating out of solution to produce an amorphous substance that cannot be recycled and reused in the paint-stripping process.

A. MOISTURE ANALYSIS

The fresh sodium bicarbonate paint-stripping media had the appearance of a fine white powder. The moisture analysis was run in quadruplicate and the results are shown in Table 1. The average moisture content of the fresh media was 4.82 weight percent water.

The spent sodium bicarbonate paint-stripping media was received in 1-gallon cans. When the cans were opened the spent media, gray in color, had settled to the bottom of the cans and a 3-inch water layer had formed over the top. As the media was spooned out of the can it would become rigid and take on the appearance of a moist solid. Once placed into beakers, the media would appear to soften and start to flow. If allowed to sit, the media would settle to the bottom of the beaker and a new water layer would form over the top. In order to obtain consistent moisture analysis results, the beakers were allowed to sit until the water layer had formed on top and then the water layer was poured off before the initial weighing. The moisture analysis was run in quadruplicate and the results are shown in Table 1. The average moisture content of the spent media was approximately 27.38 weight percent water.

TABLE 1. MOISTURE ANALYSIS FOR FRESH AND SPENT SODIUM BICARBONATE PAINT-STRIPPING MEDIA.

Fresh Paint-Stripping Media					Spent Paint-Stripping Media				
Run	Wet(g)	Dry(g)	Water(g)	%H2O	Run	Wet(g)	Dry(g)	Water(g)	%H2O
1	100.0027	95.0341	4.9686	4.9685	1	126.6305	92.2719	34.3586	27.1330
2	100.1056	95.5642	4.5414	4.5366	2	141.1633	103.0195	38.1438	27.0210
3	99.7364	94.9575	4.7789	4.7915	3	122.3439	88.3046	34.0393	27.8226
4	99.9955	95.0376	4.9579	4.9581	4	106.8196	77.4121	29.4075	27.5301
			Average	4.8137				Average	27.3767

B. PARTICLE SIZE DISTRIBUTION

The particle size distribution for the fresh sodium bicarbonate paint-stripping media was run in quadruplicate and the size fractions of each run were totaled to obtain an average overall distribution, as shown in Table 2. Note that each size fraction listed in the table includes a range of particles from that size fraction up to the next size indicated. The results indicate that the fresh media has been formulated so that over 90 percent of the media falls in the 150- to 250-micron size fraction.

The particle size distribution for the spent sodium bicarbonate paint-stripping media was run in quadruplicate and the size fractions of each run were totaled together to obtain a average overall distribution, as shown in Table 2. Two different batches of spent media are represented in the data. The first two runs came from the first batch of spent media while the last two runs came from the second batch of spent media. The difference in the two

TABLE 2. PARTICLE SIZE DISTRIBUTION FOR FRESH AND SPENT SODIUM BICARBONATE PAINT-STRIPPING MEDIA.

Fresh Paint-stripping Media

Micron size	Run 1 (g)	Run 2 (g)	Run 3 (g)	Run 4 (g)	Total (g)	Distribution Ave. Wt%
1000	0.000	0.000	0.000	0.000	0.000	0.000
600	0.394	0.268	0.322	0.421	1.405	0.144
425	2.491	1.691	2.334	2.464	8.980	0.921
250	204.446	199.491	198.789	198.219	800.946	82.110
150	21.450	20.122	18.902	17.989	78.462	8.044
106	4.373	2.998	4.961	4.493	16.825	1.725
75	5.454	3.680	7.648	8.292	25.074	2.570
45	5.851	4.864	6.266	5.962	22.943	2.352
<45	2.849	7.328	4.872	5.767	20.816	2.134
Total	247.309	240.442	244.094	243.607	975.451	100.000

Spent Paint-stripping Media

Micron size	Run 1 (g)	Run 2 (g)	Run 3 (g)	Run 4 (g)	Total (g)	Distribution Ave. Wt%
1000	1.435	0.562	68.583	62.430	133.010	13.265
600	56.155	45.422	40.222	40.782	182.581	18.209
425	9.792	8.589	7.548	8.649	34.577	3.448
250	30.922	30.851	28.027	27.287	117.087	11.677
150	80.306	98.045	69.395	74.326	322.072	32.121
106	37.870	39.781	20.556	19.613	117.820	11.750
75	17.492	14.992	8.562	10.927	51.973	5.183
45	7.985	5.544	3.832	3.959	21.319	2.126
<45	9.324	6.035	4.778	2.118	22.256	2.220
Total	251.280	249.821	251.502	250.091	1002.694	100.000

batches is the amount of time required to physically break the media into size fractions. The first batch dried into one large solid mass and required repetitive moistening and physical fracturing with a spatula to break the media into size fractions. This extensive working of the media required several days. A second batch of spent media was prepared because of concern that the extensive working of the media may have altered the natural size distribution. The second batch of media was physically broken into size fractions during the drying process rather than waiting until the media was dry. This was a much simpler process and required a fraction of the time to break the media down as was required by the first batch. The data clearly show that the media that required several days to process has been altered such that the particle distribution was shifted to the smaller size fractions.

A size distribution evaluation was performed in FY 90, using an older sodium bicarbonate paint-stripper formulation. At that time, the size distribution of the fresh and spent media was compared; it was observed that the fresh media fractured during the paint-stripping process, as evidenced by the shift in the particle size distribution to the smaller size fractions (see Figure 1). The size distribution of the spent media shown in Table 2 seems to be more a result of the amount of physical work required to break the media down than any natural size distribution of the media.

C. STANDARD AND SCANNING ELECTRON MICROSCOPY

Photomicrographs were taken of each size fraction of spent and fresh sodium bicarbonate paint-stripping media using the scanning electron microscope. In addition, an optical microscope with a Polaroid camera was used to take photographs of the crystal shape and geometry of the fresh and spent sodium bicarbonate media for each size fraction. Three conclusions can be drawn from the observation of these photographs.

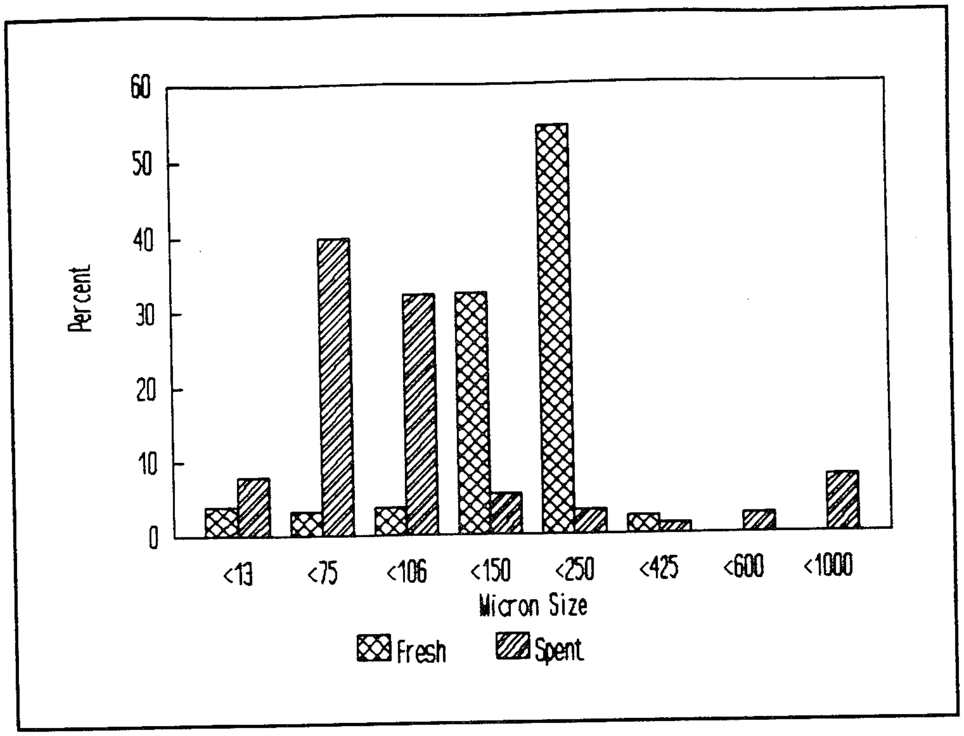


Figure 1. Particle Size Distribution for the Old Fresh and Spent Sodium Bicarbonate Stripper Formulation Evaluated in FY 90.

The first conclusion is that the sample distribution has been altered by the physical attempts to break the media into size fractions. Evidence of this can be seen by the crushed edges and shaved outer surface of the spent media particle shown in Figure 2.

The second conclusion is that the structure of the fresh sodium bicarbonate paint-stripping media is destroyed in the paint-stripping process. This can be seen by comparing the crystalline structure of the fresh media shown in Figure 3 with the conglomerated mass of damaged subparticles and contaminants seen in the spent media shown in Figure 4.

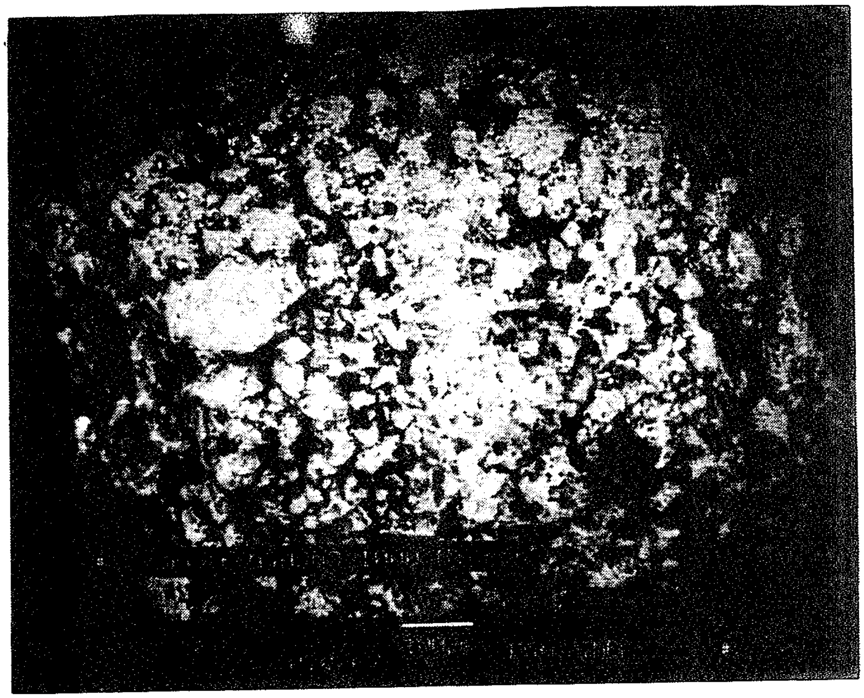


Figure 2. Photomicrograph of Physical Damage that Occurred to the Spent 1,000 Micron Sodium Bicarbonate During the Sample Preparation.

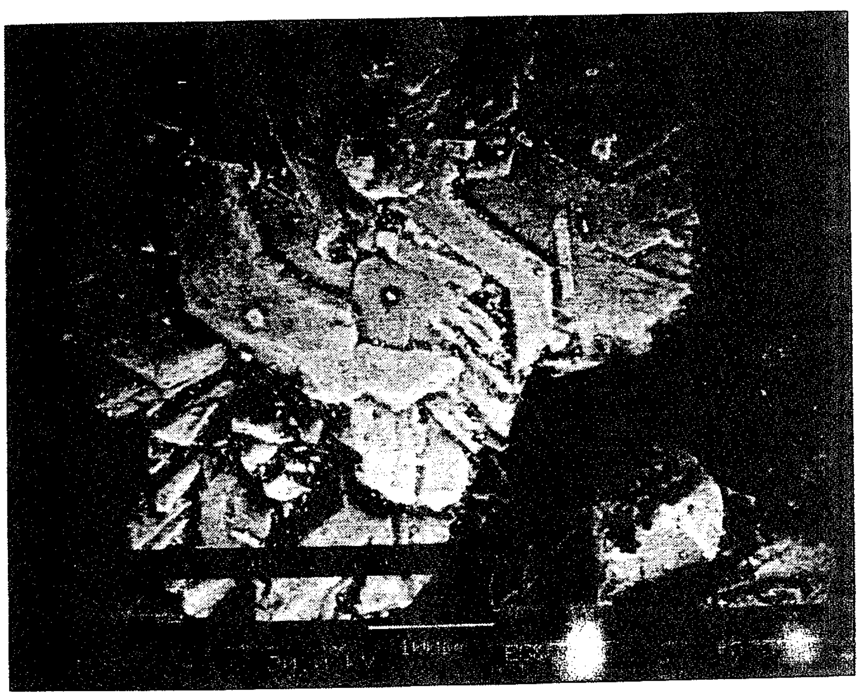


Figure 3. Photomicrograph of the Crystalline Structure of Fresh Sodium Bicarbonate Paint-Stripping Media.

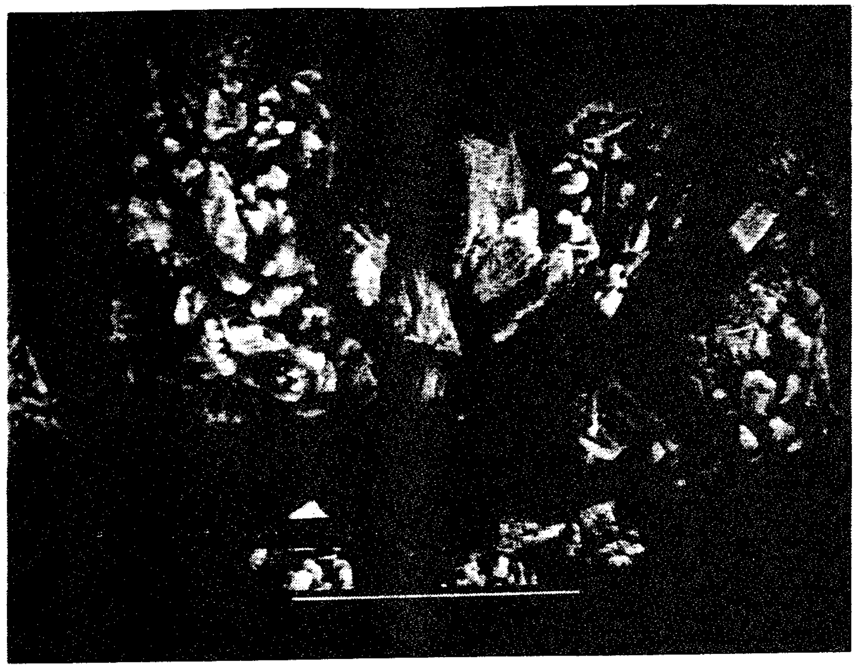


Figure 4. Photomicrograph of the Conglomeration of Damaged Subparticles and Contaminants of Spent Sodium Bicarbonate Paint-Stripping Media.

The third conclusion is derived from the fact that the particles are composed of smaller subparticles of bicarbonate and contaminants as shown in Figure 4. It is obvious from this photograph that many of the contaminants in a given size fraction are actually smaller than the aggregate size. This means that the paint chips in any given size fraction are really smaller than the size fraction being analyzed. In order to get a better picture of how these smaller particles would affect the separation equipment selected, an additional settling test was run on a portion of the spent BOSS sludge. The sample was mixed with excess water, stirred and then allowed to remain unagitated and without the aid of flocculents or coagulation agents to determine the rate of settling of the solids. After over 1 hour, there was still appreciable turbidity of the sample, indicating a significant quantity of smaller paint chips (less than 50 micrometer size) that had not settled. Based on these results, samples of the spent media were sent to representative vendors for process evaluations.

D. PARTICLE DENSITY OF THE PAINT AND METAL CHIPS

The density of the paint and metal chips in the spent sodium bicarbonate paint-stripping media ranged from 1.619 to 1.697 g per mL (see Table 3). It was noted that the paint chips were affected by static charge. The chips would all float to the top when the beaker was set on the counter and would sink to the bottom when the beaker was picked up. The paint chips were also susceptible to the static charge whenever anyone even touched the beaker. The problem was minimized by using a stand and clamp to hold the beaker away from equipment and laboratory surfaces.

E. SILICA ANALYSIS

Only a white wax-like substance was observed floating on top of the nanopure water when the fresh sodium bicarbonate paint-stripping media was dissolved. A discussion on this substance is given below in the wax experiment. No silica was detected in the experiment.

F. WAX ANALYSIS

When the fresh sodium bicarbonate paint-stripping media was dissolved in nanopure water, a white wax-like substance was observed floating on the surface. However, this substance did not melt when the water temperature was elevated to the boiling point, nor did the substance dissolve into any of the solvents. The manufacturer was contacted to see if they could give us any information that would aid in analyzing this substance. We were informed that the substance is a proprietary silica-based flow enhancer that does not dissolve in water or hydrocarbons and is nonreactive with either acids or bases. However, this substance can be filtered out with a 0.45-micron filter. This substance makes up one-half percent (wt) of the fresh sodium bicarbonate paint-stripping formulation.

TABLE 3. UPPER AND LOWER PARTICLE DENSITY OF THE PAINT AND METAL CHIPS IN THE SPENT SODIUM BICARBONATE PAINT-STRIPPING MEDIA.

Paint and Metal Chip Lower Density				Paint and Metal Chip Upper Density			
Run	Liquid Wt (g)	Flask Vol (mL)	Density	Run	Liquid Wt(g)	Flask Vol (mL)	Density
1	16.3133	10.00	1.631	1	18.0323	10.00	1.803
2	16.2121	10.00	1.621	2	16.6040	10.00	1.660
3	16.1397	10.00	1.614	3	16.3583	10.00	1.636
4	16.0787	10.00	1.608	4	16.8931	10.00	1.689
		Average	1.619			Average	1.697
		Standard Deviation	0.007			Standard Deviation	0.074

The manufacturer also informed us that the corrosion inhibited sodium bicarbonate paint-stripping formulation contains sodium silicate. Sodium silicate is more soluble than sodium bicarbonate and has a greater affinity for the hydronium (H^+) ion. When this substance reacts with acid it forms a silica gel that could cause problems with any filtration devices downstream of the acidification process. Currently the Air Force is not planing on using the corrosion inhibited paint-stripping formulation. However, the process selected to handle the spent sodium bicarbonate media will need to consider placing any acidification process downstream of filtration devices in the event that the Air Force decides there is a need to use the corrosion inhibited formulation at a later date.

G. SODIUM BICARBONATE AND FILTERABLE SOLIDS ANALYSIS

The titration curve for carbonate goes through two endpoints. The first endpoint is the point at which all carbonate in the solution has been converted to bicarbonate. The second endpoint is the point at which all the carbonate that was converted to bicarbonate in order to reach the first endpoint, as well as the bicarbonate that was in the original solution is converted to carbonic acid, which readily converts to carbon dioxide and water. This is represented by the chemical equations below.

$$CO_3^{-2} + H^+ \text{ ---> } HCO_3^-$$

$$HCO_3^- + H^+ \text{ ---> } H_2O + CO_{2(g)}$$

Therefore, the equivalents of acid required to get to the first endpoint is equal to the equivalents of carbonate in the sample. Hence the moles, grams, and weight percent of the carbonate in the original sample can be calculated from the first endpoint by using the equations below.

$$XCO_3^{-2} = \left[EP1 \text{ (mL HCl solution)} \right] \left[MHCl \frac{\text{(moles HCl)}}{\text{(mL HCl sol)}} \right] \left[\frac{\text{(mole } CO_3^{-2})}{\text{(mole HCl)}} \right]$$

$$GCO_3^{-2} = \left[XCO_3^{-2} \text{ (moles } CO_3^{-2}) \right] \left[105.99 \frac{\text{(grams } CO_3^{-2})}{\text{(moles } CO_3^{-2})} \right]$$

$$WCO_3^{-2} = \left[\frac{GCO_3^{-2}}{Gsample} \frac{\text{(grams } CO_3^{-2})}{\text{(grams sample)}} \right] 100$$

Where:

EP1 = first titration endpoint

GCO_3^{-2} = grams of CO_3^{-2} in the sample analyzed

Gsample = grams of sample analyzed

MHCl = molarity of HCl solution used in titration of sample

WCO_3^{-2} = weight percent CO_3^{-2} in the sample analyzed

XCO_3^{-2} = moles of CO_3^{-2} in the sample analyzed.

The equivalents of acid required to get from the first endpoint to the second endpoint is equal to the equivalents of total carbonate and bicarbonate originally present in the sample. Hence the moles, grams, and weight percent of bicarbonate in the original sample can be found by using the equations below.

$$X_T = \left[EP2\text{-}EP1 \text{ (mL HCl sol)} \right] \left[MHCl \frac{\text{(moles HCl)}}{\text{(mL HCl sol)}} \right] \left[\frac{\text{(mole total carbonate)}}{\text{(mole HCl)}} \right]$$

$$XHCO_3^- = X_T - XCO_3^{-2}$$

$$GHCO_3^- = \left[XHCO_3^- \text{ (moles } HCO_3^-\text{)} \right] \left[84.00 \frac{\text{(grams } HCO_3^-\text{)}}{\text{(moles } HCO_3^-\text{)}} \right]$$

$$WHCO_3^- = \left[\frac{GHCO_3^-}{Gsample} \frac{\text{(grams } HCO_3^-\text{)}}{\text{(grams sample)}} \right] 100$$

Where:

EP1 = first titration endpoint

EP2 = second titration endpoint

$GHCO_3^-$ = grams of HCO_3^- in the sample analyzed

Gsample = grams of sample analyzed

MHCl = molarity of HCl solution used in titration of sample

$WHCO_3^-$ = weight percent HCO_3^- in the sample analyzed

XCO_3^{-2} = moles of CO_3^{-2} in the sample analyzed

$XHCO_3^-$ = moles of HCO_3^- in the sample analyzed

X_T = total moles of carbonate (HCO_3^- and CO_3^{-2}) in the sample analyzed.

The results from the carbonate analysis for the fresh and spent sodium bicarbonate paint-stripping media are shown in Table 4. The 250 pages of titration graphs and data that were used to determine the endpoints shown in Table 4 are not included as part of this document. This information is available upon request from Tyndall AFB.

Table 4 was used to determine the amount of acid need to neutralize the spent media. However, caution must be taken in interpreting the results any further. The titration results do not accurately portray the amount of sodium bicarbonate in the sample. The information in Table 4 shows instances where there is a negative amount of sodium bicarbonate present in the sample. This could be caused by the presence of an additional base in the media other than

TABLE 4. CARBONATE ANALYSIS FOR FRESH AND SPENT SODIUM BICARBONATE PAINT-STRIPPING MEDIA.

Sample	Sample Wt (g)	Endpoints (mL HCL) 1st	Endpoints (mL HCL) 2nd	Molarity HCl	Moles CO3-2	Moles Na2CO3	Moles NaHCO3	Weight Percent Na2CO3	Weight Percent NaHCO3	Weight Percent Solids	Weight Percent Recovery
Fresh Sodium Bicarbonate Paint-Stripping Media											
Total Media #1	2.0561	8.148	28.711	0.981	0.0202	0.0080	0.0122	41.20	49.76	3.78	94.74
Total Media #2	2.0331	8.208	27.584	0.981	0.0190	0.0081	0.0110	41.98	45.27	5.12	92.36
Total Media #3	2.0164	8.308	27.638	0.981	0.0190	0.0082	0.0108	42.84	45.04	5.50	93.38
Total Media #4	2.0284	7.820	28.161	0.981	0.0200	0.0077	0.0123	40.09	50.87	4.35	95.31
Average	2.0335	8.121	28.024	0.981	0.0195	0.0080	0.0116	41.53	47.73	4.69	93.95
600 Micron #1	0.9566	6.828	15.646	0.981	0.0087	0.0067	0.0020	74.22	17.14	0.40	91.76
425 Micron #1	2.0948	11.777	30.140	0.981	0.0180	0.0116	0.0065	58.46	25.91	2.40	86.76
425 Micron #2	1.9911	12.154	28.305	0.981	0.0158	0.0119	0.0039	63.47	16.54	3.26	83.27
425 Micron #3	1.9531	10.319	27.159	0.981	0.0165	0.0101	0.0064	54.93	27.51	4.49	86.94
Average	2.0130	11.417	28.535	0.981	0.0168	0.0112	0.0056	58.95	23.32	3.38	85.66
250 Micron #1	2.0350	5.711	24.280	0.961	0.0178	0.0055	0.0124	28.58	51.00	1.94	81.53
250 Micron #2	2.0226	5.071	23.917	0.961	0.0181	0.0049	0.0132	25.54	54.98	2.45	82.97
250 Micron #3	2.0230	9.693	24.019	0.961	0.0138	0.0093	0.0045	48.80	18.49	1.97	69.26
250 Micron #4	2.0153	6.120	23.310	0.961	0.0165	0.0059	0.0106	30.93	44.34	2.47	77.74
Average	2.0240	6.649	23.881	0.961	0.0166	0.0064	0.0102	33.46	42.20	2.21	77.87
150 Micron #1	2.0974	10.758	25.536	0.961	0.0142	0.0103	0.0039	52.24	15.47	3.61	71.33
150 Micron #2	2.0059	9.915	24.633	0.961	0.0141	0.0095	0.0046	50.35	19.33	3.30	72.97
150 Micron #3	2.0848	9.854	25.692	0.961	0.0152	0.0095	0.0058	48.14	23.17	3.30	74.62
150 Micron #4	2.0812	9.677	25.296	0.961	0.0150	0.0093	0.0057	47.36	23.05	4.39	74.80
Average	2.0673	10.051	25.289	0.961	0.0146	0.0097	0.0050	49.52	20.25	3.65	73.43
106 Micron #1	1.9711	12.972	28.502	0.961	0.0149	0.0125	0.0025	67.03	10.48	5.40	82.91
106 Micron #2	1.9964	13.737	29.141	0.961	0.0148	0.0132	0.0016	70.09	6.74	4.79	81.62
106 Micron #3	2.0451	13.146	29.132	0.961	0.0154	0.0126	0.0027	65.47	11.21	6.87	83.55
106 Micron #4	2.0771	15.645	30.888	0.961	0.0146	0.0150	-0.0004	76.72	-1.56	2.57	77.72
Average	2.0224	13.875	29.416	0.961	0.0149	0.0133	0.0016	69.83	6.72	4.91	81.45
75 Micron #1	2.0335	11.253	30.036	0.961	0.0181	0.0108	0.0072	56.37	29.89	3.55	89.81
75 Micron #2	2.0032	15.250	30.497	0.961	0.0147	0.0147	-0.0000	77.54	-0.01	1.70	79.23
75 Micron #3	1.9918	11.287	30.033	0.961	0.0180	0.0108	0.0072	57.72	30.23	2.86	90.81
75 Micron #4	2.0175	11.203	30.692	0.961	0.0187	0.0108	0.0080	56.56	33.15	2.20	91.91
Average	2.0115	12.248	30.315	0.961	0.0174	0.0118	0.0056	62.05	23.32	2.58	87.94

TABLE 4. CARBONATE ANALYSIS FOR FRESH AND SPENT SODIUM BICARBONATE PAINT-STRIPPING MEDIA (continued).

Sample	Sample Wt (g)	Endpoints (mL HCL) 1st	Endpoints (mL HCL) 2nd	Molarity HCl	Moles CO3-2	Moles Na2CO3	Moles NaHCO3	Weight Percent Na2CO3	Weight Percent NaHCO3	Weight Percent Solids	Weight Percent Recovery
45 Micron #1	2.0856	17.216	33.488	0.961	0.0156	0.0165	-0.0009	84.08	-3.65	7.10	87.53
45 Micron #2	2.0078	16.974	32.763	0.961	0.0152	0.0163	-0.0011	86.11	-4.76	6.45	87.80
45 Micron #3	2.1430	15.818	34.412	0.961	0.0179	0.0152	0.0027	75.18	10.46	6.98	92.62
45 Micron #4	2.0868	15.758	33.328	0.961	0.0169	0.0151	0.0017	76.91	7.01	5.73	89.65
Average	2.0808	16.442	33.498	0.961	0.0164	0.0158	0.0006	80.57	2.26	6.56	89.40
<45 Micron #1	2.0092	16.216	33.102	0.961	0.0162	0.0156	0.0006	82.21	2.69	6.54	91.44
<45 Micron #2	2.0150	16.728	33.511	0.961	0.0161	0.0161	0.0001	84.56	0.22	7.21	91.99
<45 Micron #3	2.0022	16.634	33.498	0.961	0.0162	0.0160	0.0002	84.62	0.93	4.09	89.63
<45 Micron #4	2.0260	17.176	34.339	0.961	0.0165	0.0165	-0.0000	86.35	-0.05	5.25	91.55
Average	2.0131	16.689	33.613	0.961	0.0163	0.0160	0.0002	84.43	0.95	5.77	91.15
NaHCO3 Chem	1.2532	12.352	23.240	0.961	0.0105	0.0119	-0.0014	100.39	-9.43	1.89	92.85
Na2CO3 Chem	1.9778	19.155	36.551	0.961	0.0167	0.0184	-0.0017	98.65	-7.18	0.94	92.40
Spent Sodium Bicarbonate Paint-Stripping Media											
Total Media #1	2.0025	17.803	35.521	0.984	0.0174	0.0175	-0.0001	92.72	-0.35	4.98	97.35
Total Media #2	2.0074	17.808	35.709	0.984	0.0176	0.0175	0.0001	92.52	0.38	4.75	97.65
Total Media #3	2.0053	10.143	27.745	0.984	0.0173	0.0100	0.0073	52.75	30.75	4.18	87.68
Total Media #4	2.0045	9.741	28.214	0.984	0.0182	0.0096	0.0086	50.68	36.01	7.96	94.65
Average	2.0049	13.874	31.797	0.984	0.0176	0.0137	0.0040	72.17	16.70	5.47	94.33
1000 Micron #1	1.8810	16.633	33.105	0.984	0.0162	0.0164	-0.0002	92.22	-0.71	4.48	96.00
1000 Micron #2	1.9935	4.292	25.009	0.984	0.0204	0.0042	0.0162	22.45	68.10	2.92	93.48
1000 Micron #3	1.9939	4.616	25.026	0.984	0.0201	0.0045	0.0155	24.14	65.47	3.40	93.02
1000 Micron #4	2.0032	4.729	25.590	0.984	0.0205	0.0047	0.0159	24.62	66.56	0.85	92.03
Average	1.9679	7.567	27.182	0.984	0.0193	0.0074	0.0119	40.86	49.86	2.91	93.63
600 Micron #1	2.0092	17.570	35.086	0.984	0.0172	0.0173	-0.0001	91.20	-0.22	6.72	97.70
600 Micron #2	2.0365	17.241	35.047	0.984	0.0175	0.0170	0.0006	88.30	2.29	8.48	99.07
600 Micron #3	2.0210	17.423	35.253	0.984	0.0175	0.0171	0.0004	89.91	1.66	5.10	96.68
600 Micron #4	2.0177	17.578	35.247	0.984	0.0174	0.0173	0.0001	90.86	0.37	6.17	97.40
Average	2.0211	17.453	35.158	0.984	0.0174	0.0172	0.0002	90.07	1.03	6.62	97.71
425 Micron #1	2.0111	14.508	32.920	0.984	0.0181	0.0143	0.0038	75.24	16.05	7.02	98.30
425 Micron #2	2.0079	12.630	32.076	0.984	0.0191	0.0124	0.0067	65.60	28.06	6.44	100.10
425 Micron #3	2.0002	12.843	31.370	0.984	0.0182	0.0126	0.0056	66.97	23.49	6.07	96.53
425 Micron #4	2.0121	12.477	31.407	0.984	0.0186	0.0123	0.0063	64.67	26.51	5.28	96.46
Average	2.0078	13.115	31.943	0.984	0.0185	0.0129	0.0056	68.12	23.53	6.20	97.85

TABLE 4. CARBONATE ANALYSIS FOR FRESH AND SPENT SODIUM BICARBONATE PAINT-STRIPPING MEDIA (concluded).

Sample	Sample Wt (g)	Endpoints (mL HCL) 1st	2nd	Molarity HCl	Moles CO3-2	Na2CO3	NaHCO3	Weight Percent Na2CO3	NaHCO3	Solids	Recovery
250 Micron #1	2.0370	14.425	31.858	0.984	0.0172	0.0142	0.0030	73.86	12.21	3.01	89.08
250 Micron #2	2.0931	14.722	33.080	0.984	0.0181	0.0145	0.0036	73.36	14.36	3.67	91.39
250 Micron #3	2.0157	16.760	31.611	0.984	0.0146	0.0165	-0.0019	86.72	-7.83	2.06	80.95
250 Micron #4	2.0047	12.293	29.883	0.984	0.0173	0.0121	0.0052	63.95	21.84	4.59	90.38
Average	2.0376	14.550	31.608	0.984	0.0168	0.0143	0.0025	74.47	10.14	3.34	87.95
150 Micron #1	2.0203	3.233	23.896	0.984	0.0203	0.0032	0.0172	16.69	71.31	3.69	91.69
150 Micron #2	2.0308	3.600	24.622	0.984	0.0207	0.0035	0.0171	18.49	70.91	3.14	92.54
150 Micron #3	2.0079	7.505	24.947	0.984	0.0172	0.0074	0.0098	38.98	40.91	5.99	85.87
150 Micron #4	2.0163	6.731	25.480	0.984	0.0184	0.0066	0.0118	34.82	49.27	4.42	88.50
Average	2.0188	5.267	24.736	0.984	0.0192	0.0052	0.0140	27.24	58.10	4.31	89.65
106 Micron #1	2.0161	6.159	26.509	0.981	0.0200	0.0060	0.0139	31.76	58.00	4.87	94.64
106 Micron #2	2.0313	6.782	27.190	0.981	0.0200	0.0067	0.0134	34.72	55.28	4.26	94.26
106 Micron #3	2.0061	6.621	22.880	0.981	0.0160	0.0065	0.0095	34.32	39.59	3.60	77.51
106 Micron #4	2.0167	8.792	27.950	0.981	0.0188	0.0086	0.0102	45.33	42.36	3.95	91.64
Average	2.0176	7.088	26.132	0.981	0.0187	0.0070	0.0117	36.53	48.81	4.17	89.51
75 Micron #1	2.0261	12.911	29.889	0.981	0.0167	0.0127	0.0040	66.26	16.54	5.01	87.81
75 Micron #2	2.0730	14.298	31.121	0.981	0.0165	0.0140	0.0025	71.71	10.04	4.81	86.56
75 Micron #3	2.0520	13.811	31.757	0.981	0.0176	0.0135	0.0041	69.98	16.61	4.70	91.28
75 Micron #4	2.0002	13.971	30.751	0.981	0.0165	0.0137	0.0028	72.63	11.57	4.98	89.18
Average	2.0378	13.748	30.880	0.981	0.0168	0.0135	0.0033	70.14	13.69	4.88	88.71
45 Micron #1	2.0129	17.627	33.752	0.981	0.0158	0.0173	-0.0015	91.05	-6.15	5.34	90.24
45 Micron #2	2.0215	15.963	33.661	0.981	0.0174	0.0157	0.0017	82.11	7.07	6.53	95.71
45 Micron #3	2.0463	17.143	34.570	0.981	0.0171	0.0168	0.0003	87.11	1.14	6.54	94.79
45 Micron #4	2.0056	17.175	33.849	0.981	0.0164	0.0168	-0.0005	89.04	-2.06	6.80	93.78
Average	2.0216	16.977	33.958	0.981	0.0167	0.0167	0.0000	87.33	0.00	6.30	93.63
<45 Micron #1	2.0300	21.939	36.556	0.981	0.0143	0.0215	-0.0072	112.37	-29.72	6.45	89.10
<45 Micron #2	2.0213	17.724	35.104	0.981	0.0170	0.0174	-0.0003	91.17	-1.40	6.52	96.29
<45 Micron #3	2.0127	17.437	35.176	0.981	0.0174	0.0171	0.0003	90.08	1.24	6.59	97.91
<45 Micron #4	2.0837	17.761	35.695	0.981	0.0176	0.0174	0.0002	88.63	0.68	8.73	98.05
Average	2.0369	18.715	35.633	0.981	0.0166	0.0184	0.0018	95.56	-7.30	7.07	95.33

sodium bicarbonate and sodium carbonate. The additional base could be caused by a second base present in the stripping media or from some contaminant, such as the formation of aluminum hydroxide in a basic solution from fine aluminum particles picked up during the stripping process. The manufacturer was contacted to discuss this situation, but no information to confirm the concept of an additional base in the original formulation was obtained.

H. METALS ANALYSIS

The results from the metals analysis are summarized in Table 5. The solid samples analyzed do not show any indication that the metals accumulate in a given size fraction. This is further evidence that the contaminants in a given size fraction are actually smaller than the aggregate size and are fairly evenly dispersed amongst all the size fractions.

The liquid samples analyzed for metals content were acidified fresh and spent paint-stripping media samples obtained from the titration tests and the liquid that was above the spent sodium bicarbonate sample when it was received from Kelly AFB. The metals content of the acidified spent media will be similar to the metals content of the liquid from a pretreatment process where the spent media has been dissolved in water, filtered, acidified, and sent to the industrial waste treatment plant (IWTP) . The metals content of the liquid above the spent sodium bicarbonate sample is similar to the metals content of the liquid above the spent media that is contained in a sump or holding tank for batch treatment.

TABLE 5. SODIUM BICARBONATE PAINT-STRIPPING MEDIA METAL ANALYSIS.

Solid Samples Analyzed

Material	Cr	Zn	Pb	Fe	Al	Cd
	Concentration in µg/g					
Sodium Bicarbonate (Chemical)	<0.8	<0.3	<5.3	<1.3	<10.6	<0.6
Sodium Bicarbonate (Chemical)	<0.8	<0.3	<5.3	2.7	<10.6	0.2
Total Fresh Media	<1.0	<0.4	<6.0	<1.4	<12.0	<0.6
Total Fresh Media	<1.0	<0.4	<6.1	<1.5	<12.2	<0.7
Total Fresh Media	<0.7	<0.3	<4.1	<1.0	<8.2	0.1
Total Fresh Media	<0.9	<0.4	<5.8	<1.4	<11.6	<0.6
Average	NA	NA	NA	NA	NA	NA
Spent Media <45 Micron	75.9	29.8	7.2	34.6	566.3	4.6
Spent Media <45 Micron	75.7	31.6	5.6	35.6	526.8	4.8
Spent Media <45 Micron	74.2	29.8	5.0	31.3	513.5	4.8
Spent Media <45 Micron	71.2	27.9	4.7	30.7	462.0	4.4
Average	74.2	29.8	NA	33.1	517.1	4.6
Spent Media 45 Micron	68.8	26.1	<6.1	31.1	452.5	4.0
Spent Media 45 Micron	69.8	25.4	<7.6	31.2	435.1	4.1
Spent Media 45 Micron	67.3	25.5	<7.7	30.2	400.9	3.6
Spent Media 45 Micron	67.9	25.4	<14.2	30.2	404.7	5.2
Average	68.4	25.6	NA	30.7	423.3	4.3
Spent Media 75 Micron	66.9	19.9	<5.9	31.6	367.6	3.8
Spent Media 75 Micron	67.6	22.6	<6.5	33.6	361.1	4.7
Spent Media 75 Micron	69.7	21.7	<6.0	30.9	348.3	4.4
Spent Media 75 Micron	72.7	21.0	<6.3	40.4	405.8	4.7
Spent Media 75 Micron Spike	196.3	151.0	116.4	165.6	637.2	129.7
Spent Media 75 Micron	66.9	19.5	<6.3	34.2	330.5	4.4
Average	68.8	20.9	NA	34.2	362.6	4.4

TABLE 5. SODIUM BICARBONATE PAINT-STRIPPING MEDIA METAL ANALYSIS (continued).

Solid Samples Analyzed

Material	Cr	Zn	Pb	Fe	Al	Cd
	Concentration in μg/g					
Spent Media 106 Micron	70.4	16.9	<5.8	31.3	359.6	4.4
Spent Media 106 Micron	70.7	19.5	<7.1	38.4	355.8	4.6
Spent Media 106 Micron	75.6	19.3	<6.6	36.4	345.4	4.9
Spent Media 106 Micron	63.4	16.3	<6.1	30.2	293.5	5.0
Average	70.0	18.0	NA	34.1	338.6	4.7
Spent Media 150 Micron	73.4	18.0	<5.6	41.8	358.9	5.5
Spent Media 150 Micron	74.1	18.6	<7.3	45.1	358.9	5.8
Spent Media 150 Micron	76.8	19.3	<5.9	41.0	336.5	5.9
Spent Media 150 Micron	70.4	22.7	<6.1	42.8	316.7	5.7
Average	73.7	19.6	NA	42.7	342.7	5.7
Spent Media 250 Micron	75.6	20.1	<5.6	49.2	387.5	6.9
Spent Media 250 Micron	75.5	19.7	<5.1	46.1	368.3	6.9
Spent Media 250 Micron	79.0	20.6	<6.2	44.6	381.4	6.9
Spent Media 250 Micron	74.5	19.5	<5.9	53.6	331.6	7.0
Average	76.1	20.0	NA	48.4	367.2	6.9
Spent Media 425 Micron	76.6	21.2	<5.4	44.7	358.7	7.6
Spent Media 425 Micron	75.2	22.0	<5.9	46.9	356.6	7.4
Spent Media 425 Micron	78.0	20.9	<5.4	38.5	353.8	7.3
Spent Media 425 Micron	73.5	25.5	<5.2	42.1	333.9	7.9
Average	75.8	22.4	NA	43.1	350.8	7.6

TABLE 5. SODIUM BICARBONATE PAINT-STRIPPING MEDIA METAL ANALYSIS (concluded).

Solid Samples Analyzed

Material	Cr	Zn	Pb	Fe	Al	Cd
	Concentration in μg/g					
Spent Media 600 Micron	74.5	21.8	<6.3	37.9	351.3	8.3
Spent Media 600 Micron	71.6	19.0	<5.8	38.0	472.5	8.7
Spent Media 600 Micron	71.5	17.1	<5.5	28.3	324.3	7.3
Spent Media 600 Micron	71.4	19.9	<5.9	35.3	309.2	8.2
Average	72.2	19.5	NA	34.9	364.3	8.1
Spent Media 1000 Micron	59.5	18.3	<6.6	33.7	275.4	5.5
Spent Media 1000 Micron	52.8	13.5	<5.7	26.5	260.6	4.8
Spent Media 1000 Micron	48.5	12.9	<4.4	24.7	234.4	4.6
Spent Media 1000 Micron	55.4	16.1	<4.3	27.9	233.3	5.3
Average	54.0	15.2	NA	28.2	250.9	5.1

Liquid Samples Analyzed

Material	Cr	Zn	Pb	Fe	Al	Cd
	Concentration in μg/mL					
Acidified Total Fresh Media	<0.03	6.6	<0.2	0.2	1.1	<0.02
Acidified Total Fresh Media	<0.03	8.2	<0.2	0.2	0.9	0.03
Acidified Total Fresh Media	<0.03	7.9	<0.2	0.2	0.5	0.03
Acidified Total Fresh Media	0.03	6.7	<0.2	0.2	0.5	0.02
Average	NA	7.4	NA	0.2	0.8	0.03
Acidified Total Spent Media	0.04	12.3	<0.2	0.2	1.3	0.03
Acidified Total Spent Media	0.04	13.8	<0.2	0.3	1.4	0.02
Acidified Total Spent Media	0.07	15.7	<0.2	0.2	1.2	0.03
Acidified Total Spent Media	0.05	12.8	<0.2	0.2	1.4	0.04
Average	0.05	13.7	NA	0.2	1.3	0.03
Liquid Above Spent Media Sample	3.3	3.0	<0.5	1.7	2.5	0.18
Liquid Above Spent Media Sample	3.0	2.5	<0.5	1.2	3.2	0.17

SECTION V
SUMMARY WASTE STREAM DESCRIPTION

A. GENERAL DESCRIPTION

The waste stream generated by a Bicarbonate of Soda Stripping (BOSS) process is a sludge-like stream containing the spent-stripping media, paint chips, and very small amounts of dirt, grit, and oil. This stream is formed as the stripping media is drained and washed from the aircraft parts, and is typically held in a storage tank or sump before treatment. The waste stream is slightly alkaline, with a pH between 7.5 and 9.0. A small portion of the sodium bicarbonate ($NaHCO_3$) in the spent media may be converted to sodium carbonate (Na_2CO_3), but the extent of conversion is difficult to predict since it is time-dependent. If the relative amounts of the bicarbonate and carbonate salts in the sludge need to be known before treatment, appropriate analyses should be performed (e.g., titration analysis).

B. SUMMARY CHARACTERIZATION OF SPENT BICARBONATE SLUDGE

The following section summarizes the results from chemical and physical analyses performed by EG&G Idaho on a typical spent BOSS media from an aircraft parts cleaning facility.

1. Waste Form

The spent BOSS media is a sludge-like material consisting of water, sodium bicarbonate, sodium carbonate, paint chips, dissolved heavy metals, an inert flow additive, and trace amounts of dirt, grit, and oil. The flow additive is a proprietary food-grade material. The sodium salts are only partially dissolved, and constitute the majority of the solid material.

2. Moisture Content of Sludge

In practice, the moisture content will be variable, as it will depend on the amount of water that is used to rinse the spent-stripping media from the aircraft parts. It is anticipated that the moisture content will be less than is needed to totally dissolve the spent sodium bicarbonate.

3. Relative Average Amount of Paint Chips

The relative average amount of paint chips was found to be 0.055 g paint chips per gram dried sludge.

4. Approximate Heavy Metal Analysis of Dried Sludge

Heavy Metal	µg/g
Cr..............	70.4
Zn..............	21.2
Cd..............	5.7
Pb..............	6.2
Other Metals	
Fe..............	36.6
Al..............	368.6

5. Approximate Heavy Metal Analysis of Decanted Liquid

Heavy Metal	µg/g
Cr..............	3.14
Zn..............	2.78
Cd..............	0.18
Pb..............	0.24
Other Metals	
Fe..............	1.46
Al..............	2.85

6. Liquid Specific Gravity (SG)

The approximate specific gravity of the liquid was found to be 1.07, relative to water.

7. Paint Chip Specific Gravity

The specific gravity of the paint chips ranged from 1.61 to 1.69, relative to water.

8. Particle Size Distribution of Paint Chips

Size, microns	Wt%
>1,000	8
600-1,000	26
425-600	5
250-425	8
150-250	30
106-150	11
75-106	6
45-74	3
<45	3
	100

9. Settling Test Results

Settling tests were performed by both EG&G Idaho and vendors, the results of which are discussed below.

EG&G Idaho's settling tests are described as follows. A portion of the spent BOSS sludge was mixed with excess water and stirred. The sample was then allowed to remain unagitated to determine the rate of settling of the solids. After over 1 hour, there was still appreciable turbidity of the sample, as there apparently were significant quantities of smaller paint chips (less than 50 micrometer size) that had not settled even though the paint chip density exceeded that of the surrounding solution; this may have been caused by Brownian motion, net surface charge phenomena, or other electrostatic effects. No flocculents or coagulation aids were used in the settling tests.

Samples of the spent BOSS sludge were also tested by two vendors (Parkson Corporation and the Sharples division of Alfa-Laval), who determined that flocculent addition could improve the settling rates of the suspended solids in solution. Parkson Corporation was able to lower the total suspended solids to less than 60 ppm by the addition of a polyelectrolyte flocculating aid (10 ppm American Cyanamid Magnifloc 1598C). Sharples was able to remove 99 percent of the total suspended solids through the use of flocculents with centrifugation. Both vendors noted that settling of the solids was slow and less complete whenever flocculation was not used.

The above settling tests allow qualitative judgements to be made on how effective gravity-based separation technologies would be in treating waste from BOSS depainting operations. These results show that flocculents should be used in conjunction with gravity-based technologies.

SECTION VI
TECHNOLOGY EVALUATION

A. INTRODUCTION

This section evaluates core separation technologies for the treatment of Bicarbonate of Soda Stripping (BOSS) waste sludge from a typical aircraft parts cleaning operation using sodium bicarbonate paint-stripping media.

The technology evaluation is based on a decision-matrix approach, where each technology is scored according to a set of screening criteria and criteria weighting factors. From this quantitative evaluation, Kelly AFB will be able to decide which technologies are most appropriate for their applications. This section is a precursor to the performance specification, which is written for the recommended technology.

B. SCREENING CRITERIA AND WEIGHTING FACTORS

A decision-matrix evaluation was chosen as the basis for assessing the relative merit of technologies considered for the BOSS waste treatment. Six criteria were chosen to screen candidate technologies, and are listed in Table 6 with their respective weighting factors.

To quantify the evaluation for a given technology, each weighting factor will be multiplied by a number between 1 and 10, where 1 indicates the likelihood of poor performance and the lowest recommendation, and 10 indicates superior performance and the highest recommendation. The sum of these multiplied weighting factors (a number between 1 and 10) will then be used to represent the relative performance of a given technology, where a total score of 10 indicates the highest performance and recommendation.

TABLE 6. CRITERIA CHOSEN FOR THE BOSS TECHNOLOGY EVALUATION.

Criteria	Abbreviation	Weighting Factor
Level of Development, Risk, and Availability	LDRA	0.25
Final Waste Form(s) and Effluent Purity	FWF	0.20
Reliability, Complexity, and Maintenance	RCM	0.20
Versatility and Robustness (V&R)	V&R	0.15
Utility Requirements (UR) (energy, water, chemical, etc.)	UR	0.10
Capital Costs	CC	0.10

C. EXPLANATION OF CRITERIA

1. Level of Development, Risk, and Availability (LDRA)

The technology to be used to treat the BOSS waste should have a proven record of successful performance for like applications, that is, it should have a low technical risk as applied to treating the BOSS waste. Fully developed and commercially-available technologies will be given higher scores, while experimental or developmental technologies will be given lower scores.

2. Final Waste Form(s) and Effluent Purity (FWF)

This criterion reflects the ability of a technology to achieve the overall goal of separating the waste into a more manageable, safer, and/or acceptable forms (e.g., solids from liquid) and the optional goal of providing an effluent stream pure enough for either recycle/reuse or discharge. Volume minimization of the solid waste is an important aspect that will be considered, as it will impact disposal costs. The final waste form(s) should be compatible with the prevailing disposal methods and standards, such as state and local landfill restrictions.

3. Reliability, Complexity, and Maintenance (RCM)

Technologies sought should be highly reliable and require a minimum expense of time and money for maintenance and other downtime. Also, technologies are desired that possess a reasonably low level of complexity, in that they can be operated at design conditions without requiring excessive supervision by the operator(s). Finally, higher scores will be given to those technologies that could be used as stand-alone treatments of the BOSS waste.

4. Versatility and Robustness (V&R)

The ability of a technology to process and treat a waste stream under varying conditions is represented by this criterion. High scores will be given to those technologies that have fewer operational limitations, and that maintain satisfactory performance for a wide range of inlet waste stream conditions, such as flow rates, types of solids, and concentrations of solids.

5. Utility Requirements (UR)

Utility requirements include electrical, water, air, steam, chemical, and other utilities that are required by a technology as applied to a given throughput of the BOSS waste stream. This criterion represents operating costs, minus the costs for manpower and maintenance. As expected, technologies that require lesser overall utilities will receive higher scores.

6. Capital Costs (CC)

This final criterion serves as an estimate for the equipment costs for a particular technology, and is usually obtained from vendor quotes or literature. If vendor information is not available, these costs are approximated from conventional capital cost estimate methods. Whenever possible, capital cost estimates are based on the same throughput of the BOSS waste stream, to ensure consistency during comparison. Also, cost estimates may not be very accurate, since vendor quotes may include hidden charges and costing equations may be notably inaccurate. However, these estimates should serve as good indicators of relative capital costs.

D. TECHNOLOGIES EVALUATED

1. Preliminary Listing of Candidate Technologies

Technologies that were considered for treatment of the BOSS effluent are listed below.

- Gravity Settling
  - solids contact clarifier
  - inclined plate separator
- Centrifugation
  - solid bowl centrifuge
- Froth Flotation
- Continuous Screening
  - continuous rotary screen
- Ultrafiltration (UF)
- Hydrocyclone Separation
  - two-stage hydrocyclone
- Bag Filtration
  - felt strainer bags
- Vacuum Filtration
  - rotary drum vacuum filter
- Gravity Filtration
  - self-advancing fabric filter
- Granular Media Filtration
- Cartridge Filtration
- Pressure Filtration
  - vertical leaf filtration
  - tubular membrane filtration
  - plate and frame filter/belt press filtration

Three comments should be made regarding this list. First, some of these technologies will be evaluated in tandem (for example, continuous screening plus polishing filter/dewatering steps), since a single technology may not serve as an adequate stand-alone treatment option. Second, since a given technology may be composed of several subcategories, a specific type of each technology is considered whenever feasible. Third, it was not possible to obtain vendor test results for a sample of the BOSS waste for all of the technologies listed; thus, generic vendor literature and/or engineering texts and methods were used whenever actual vendor test results are unavailable. (References 1, 2, and 3).

2. Final Listing of Candidate Technologies

Once sufficient information was gathered for the BOSS effluent and the technologies listed above, a final listing of technologies was formulated to represent those separation technologies that should be seriously considered as treatment options. These candidate technologies are as follows:

- Gravity Settling
  - inclined plate separator
- Centrifugation
  - solid bowl centrifuge
- Continuous Screening
  - continuous rotary screen
- Hydrocyclone Separation
  - two-stage hydrocyclone
- Vacuum Filtration
  - rotary drum vacuum filter
- Gravity Filtration
  - self-advancing fabric filter
- Pressure Filtration
  - vertical leaf filtration

Those technologies that were eliminated between the preliminary and final listings are given in Table 7. These technologies were rejected for qualitative and quantitative technical reasons, based on direct vendor recommendations, vendor and EG&G Idaho testing of a BOSS waste sample, vendor literature, various engineering literature sources, and engineering judgement.

TABLE 7. TECHNOLOGIES NOT CHOSEN FOR FINAL CONSIDERATION.

Technology	Reason for Rejection
Clarification	Settling tests indicate that this would be time-intensive, and would require additional treatment steps, such as dewatering and polishing. Relatively large space requirements. Would require use of flocculents.
Froth Flotation	Paint chip density and size may make for inefficient operation; may require additional treatment steps. May require use of flotation aids.
Ultrafiltration (UF)	Not well developed for large-scale separations. UF membrane filters may clog frequently with fine paint chips.
Granular Media Filtration	Anticipated solids loading may be too high, and a dewatering step would be required. Useful as a polishing step.
Bag Filtration: Felt Strainer Bags	Limited capacity; limited practical particle size rating. Cannot handle high percentages of larger particles.
Cartridge Filtration	Limited capacity. Disposable cartridge adds to solid waste. Would require frequent replacement or backwashing; backwash solution needs dewatering.

Tubular membrane pressure filtration and plate and frame filter/belt press filtration were also deleted from the final listing because it was decided to include only the most promising subcategory of a given separation technology in the technology evaluation. Thus, these two subcategories were not included in the final list since vertical leaf pressure filtration appeared to be superior to them in initial assessments of pressure filtration.

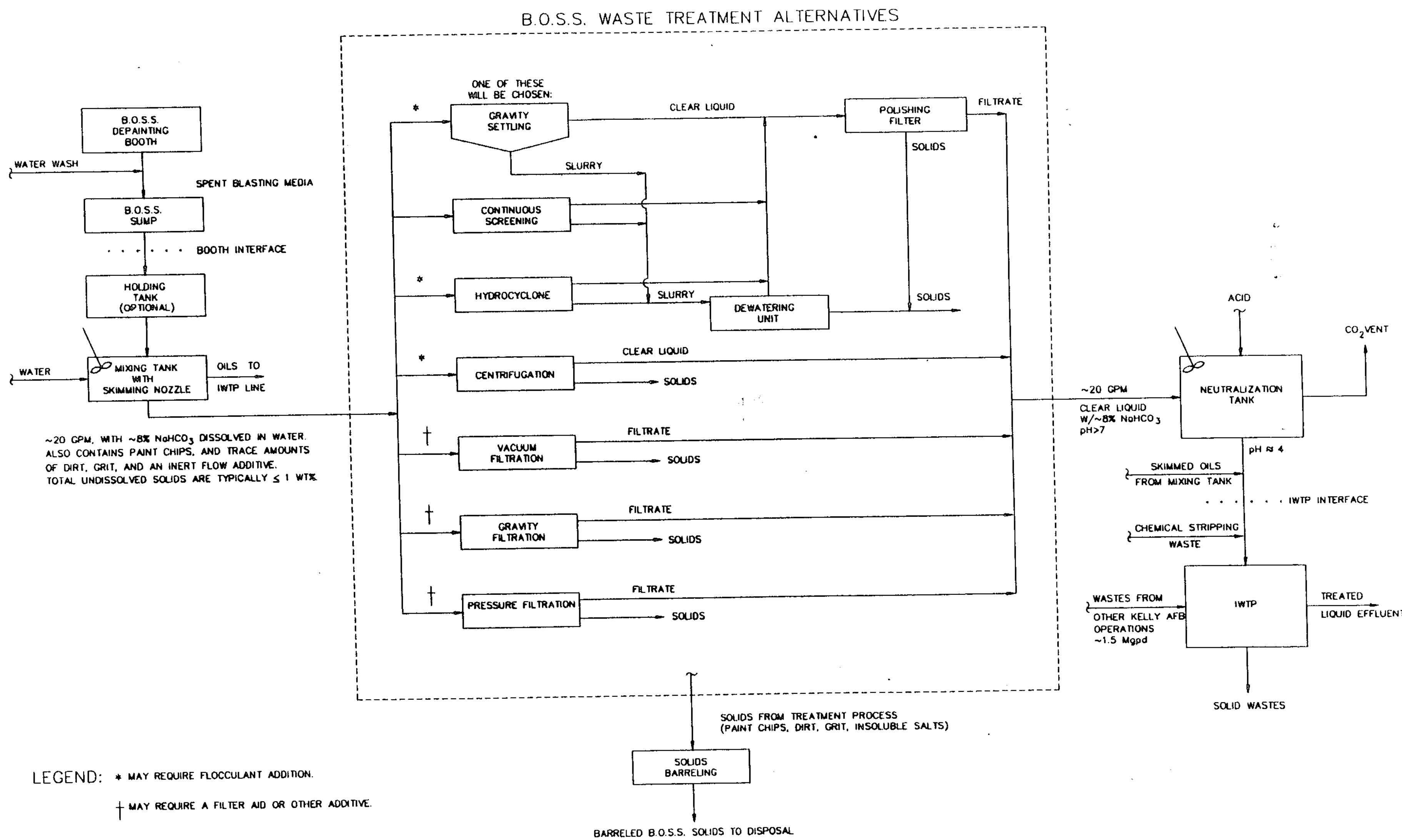
E. EXPLANATION OF TECHNOLOGIES

1. Overall BOSS Waste Treatment Scheme

A block flow diagram showing the overall BOSS waste handling and waste treatment alternatives is shown in Figure 5. The process description is given below.

Starting at the BOSS depainting booth, the spent blasting media is washed off the stripped aircraft parts, and is drained into the BOSS sump for temporary storage. It is assumed that the sump will be able to contain the BOSS waste from at least 1 day of depainting operation. The sludge in the sump is then pumped batch-wise into the holding tank, perhaps once a day. Additional water may have to be added to the sump to render the sludge pumpable. The holding tank is listed as optional since it may not be needed if the sump is of sufficient volume to contain typical and surplus amounts of the spent BOSS sludge. From the holding tank, the sludge is pumped into a dissolution mixing tank, where enough water is added to totally dissolve the sodium bicarbonate and sodium carbonate. Upon exiting the mixing tank, the flow rate of the waste stream is approximately 20 gallons per minute (gpm). The dissolution mixing tank is equipped with a skimming nozzle to facilitate the removal of oils and light hydrocarbons, which will be piped downstream to the existing IWTP line.

Leaving the dissolution mixing tank, the waste stream enters one of the BOSS waste treatment alternatives, which are shown inside the dashed box; one of these treatment alternatives will be chosen as a result of our technology evaluation. The BOSS waste is then treated, wherein the solids (paint chips, dirt, grit, etc.) are separated from the bulk of the liquid and readied for placement in barrels or drums, and the clear liquid effluent is pumped to a neutralization tank, where sufficient acid is added to neutralize all carbonate and bicarbonate ($pH \approx 4$). A gas vent has been included on the neutralization tank to allow the release of CO_2 that results from the acid-base neutralization reactions. The CO_2 produced may be suitable for recovery,



LEGEND: * MAY REQUIRE FLOCCULANT ADDITION.

† MAY REQUIRE A FILTER AID OR OTHER ADDITIVE.

Figure 5: Overall B.O.S.S. Waste Handling and Waste Treatment Alternatives Block Flow Diagram

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providing it is of satisfactory purity and quantity. Finally, the neutralized waste stream is transferred to the IWTP line, where it is combined with the skimmed oils and chemical stripping wastes, and enters the IWTP along with approximately 1.5 million gallons per day (Mgpd) of other Kelly AFB wastes.

This assessment is only for those pieces of equipment between the booth interface and the IWTP interface, as shown in Figure 5.

2. Technology Descriptions

Given below are brief technology descriptions for the technologies chosen for the final listing of the technology evaluation.

a. Gravity Settling: inclined plate separator

Also referred to as a lamella plate separator, this gravity-based sedimentation technique uses inclined plates to enhance the separation of heavier solids from lighter liquids. During operation, a layer of clear liquid forms directly beneath the inclined plate, where the pressure difference between the liquid and dense (suspension) phases causes the clear liquid layer to rise at a greater rate than would be achieved without an inclined plate. Thus, for a given amount of material separation surface area, the inclined plate separator provides improved separation rates as compared with conventional sedimentation techniques.

b. Continuous Screening: continuous rotary screen

This separation technique typically consists of a horizontally-mounted rotary drum screen with an internal screw which, under normal operation, transports the screenings (thickened solids) out to one of the drum ends. The filtrate passes through the screen, collects in a trough, and is piped outside of the unit. Rotary screens are best suited for larger solid particles, as there are practical limitations for the screen mesh size (0.6 to 1.0 millimeter).

c. Hydrocyclone Separation: two-stage hydrocyclone

Being a gravity-based separation device, the hydrocyclone consists of a cylinder fitted with a tangential feed connection and a lower conical section that has a bottom apex opening that facilitates solids discharge. Under typical operation, a pressurized slurry feed enters the tangential inlet, which induces a downward spiraling fluid motion. Centrifugal force drives the solids to the wall of the hydrocyclone, and the solids migrate toward the apex opening at the bottom. As the liquid approaches the apex, it reverses its axial direction and moves upward through the cylinder and discharges out the top. A two-stage hydrocyclone would essentially contain two hydrocyclones in series, where the first hydrocyclone is used to separate out the larger solid particles, and the secondary hydrocyclone is used to remove the finer solids; this allows for classification of solids.

d. Centrifugation: solid bowl centrifuge

A solid bowl centrifuge uses large centrifugal forces to achieve separation between liquid(s) and heavier solids. The feed enters the centrifuge through a central stationary pipe and is dispersed into a spiral conveyor contained within the centrifugal bowl. The bowl rotates, causing the solids to migrate to the bowl surface where they follow the spiraled conveyor path to a solids discharge at the conical end of the bowl, while the lighter filtrate accumulates at the opposite end of the bowl and is discharged. Generally, centrifuges operate under very high revolutions per minute (rpm), creating localized gravitational forces that can be several thousand times greater than normal gravity.

e. Vacuum Filtration: rotary drum vacuum filter

This filtration technique consists of a fabric-covered rotating drum that is partially submerged into a vat of the solid-liquid slurry. As the drum slowly rotates, a vacuum is applied to the inside of the drum, causing a filter cake to form on the outside of the fabric filter media. The filter cake is partially dried by the vacuum action and is typically dislodged from the fabric by a knife edge mechanism or by air pulses. The filtrate, upon passing to the inside of the drum, is collected and sent to a vacuum receiver, where it is separated from the air and is pumped away. Rotary drum vacuum filters are quite versatile in that there are several operational variables that can be arranged so that a particular type of slurry can be treated. Some of these variables include: speed of drum rotation, amount of vacuum, knife edge arrangement, level of slurry in vat, and the use of a filter-aid precoat.

f. Gravity Filtration: self-advancing fabric filter

This gravity-based separation technique relies heavily on the density differential between solids and liquids, and employs a continuous sheet of disposable fabric filtering media that is slowly dispensed from a roll. The slurry flows over the dispensed fabric, where the filter cake is formed while the filtrate is collected below. The fabric is automatically advanced as the solids loading on a particular section of fabric reaches a limiting value, thus providing fresh filtering media for the remaining slurry.

g. Pressure Filtration: vertical leaf filter

In a vertical leaf filtration system, the slurry to be treated is pumped under pressure into a closed vessel that contains several vertically-aligned filter leaves. A high surface area for solid-liquid separation is provided by the many leaves. As the pressurized fluid encounters the leaves, the liquid passes through the leaf material and into liquid draw-off channels that are sandwiched between each pair of leaves. The solid material forms a filter cake on the outside surface of the leaves. The filter cake can be dislodged from the leaves by a water purge, gas purge, vibration or a combination of these. The dislodged solids can then be discharged from the vessel through a hinged bottom outlet. Under certain conditions, the performance of a vertical leaf pressure filter can be improved by the use of a filter-aid precoat, such as diatomaceous earth.

F. COMPARATIVE EVALUATION OF TECHNOLOGIES

In this section, the technologies included in the final listing are rated and ranked according to the criteria and weighting factors defined above. It should be noted that the evaluation considers the application of the listed technologies to the treatment of BOSS waste only; no generic evaluation is implied. The scoring of the weighting factors was based on manufacturer's claims, recommendations from vendors, general equipment information from the literature, and engineering judgement. Table 8 contains the results of the technology evaluation, and the final technology scores are plotted in Figure 6. A breakdown of the technology evaluation is given in Appendix B. A list of vendors contacted is given in Appendix C. Vendor information and correspondence are given in Appendix D.

G. RECOMMENDED TREATMENT TECHNOLOGY

1. Discussion of Findings from Technology Evaluation

The results of the technology evaluation shown in Table 8 indicate that pressure filtration is the preferred separation technology for treating spent-stripping media from BOSS operations for the given criteria. Specifically, a vertical leaf pressure filter proved to be the most attractive treatment alternative.

The emboldened values in Table 8 are for technologies that have the highest scores of a given criterion. It is seen that pressure filtration ranks highest in four of the six criteria, where two of these highest scores are shared with other technologies. Therefore, it should be expected that vertical leaf pressure filtration should provide superior performance for treating BOSS waste. The second and third choices would be vacuum filtration and centrifugation, respectively.

TABLE 8. COMPARATIVE EVALUATION OF TECHNOLOGIES FOR BOSS WASTE TREATMENT.

TECHNOLOGY		CRITERIA (weighting factor)						Final Score
		LDRA (.25)	FWF (.20)	RCM (.20)	V&R (.15)	UR (.10)	CC (.10)	
Gravity Settling + Polishing/Dewatering Steps*	(a)	2.0 [8]	1.4 [7]	1.2 [6]	0.75 [5]	0.6 [6]	0.8 [8]	6.75
Continuous Screening + Polishing/Dewatering Steps*	(b)	1.5 [6]	1.4 [7]	1.2 [6]	0.9 [6]	0.7 [7]	0.8 [8]	6.50
Hydrocyclone Separation + Polishing/Dewatering Steps*	(c)	1.75 [7]	1.4 [7]	1.2 [6]	1.05 [7]	0.6 [6]	0.9 [9]	6.90
Centrifugation	(d)	1.75 [7]	1.6 [8]	1.4 [7]	0.9 [6]	0.8 [8]	0.5 [5]	6.95
Vacuum Filtration**	(e)	2.0 [8]	1.4 [7]	1.4 [7]	1.2 [8]	0.7 [7]	0.5 [5]	7.20
Gravity Filtration**	(f)	1.75 [7]	1.0 [5]	1.4 [7]	0.9 [6]	0.8 [8]	1.0 [10]	6.85
Pressure Filtration**	(g)	2.25 [9]	1.6 [8]	1.6 [8]	1.2 [8]	0.7 [7]	0.8 [8]	8.15

LEGEND:
(a) inclined plate separator
(b) continuous rotary screen
(c) two-stage hydrocyclone
(d) solid bowl centrifuge
(e) rotary drum vacuum filter
(f) self-advancing fabric filter
(g) vertical leaf filtration

* Polishing Step would consist of a polishing filter, such as a cartridge filter or a granular media filter with backwash. These technologies may require flocculent addition.

** These technologies may require the use of a precoat filter aid or other additive.

[ ] Numbers in square brackets represent the relative score from 1 to 10.

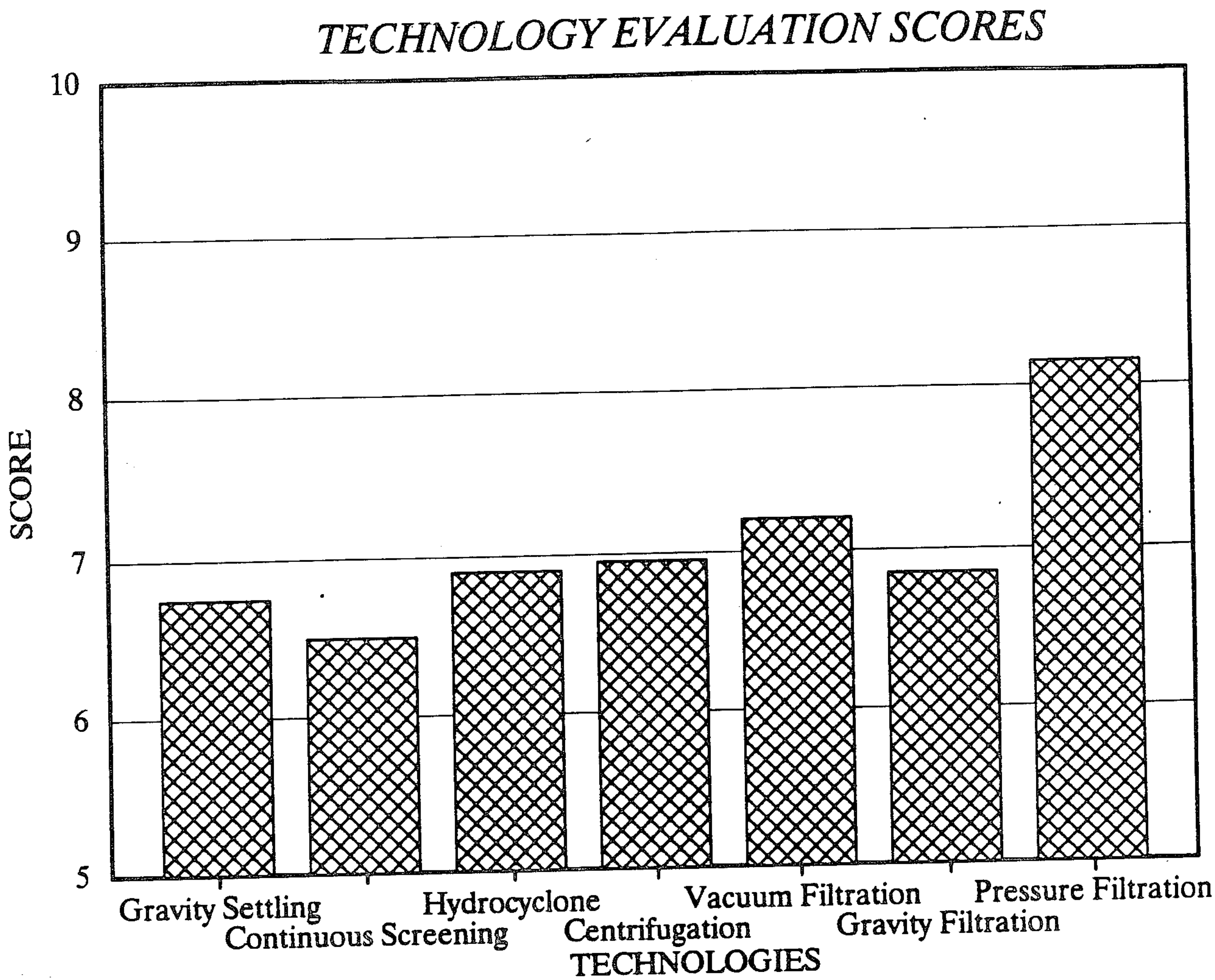

Figure 6. Final Scores from Technology Evaluation of BOSS waste treatment alternatives.

Gravity-based separation technologies such as gravity settling, hydrocyclones, and gravity filtration were generally ranked lower than the other technologies, which is due in part to their low scores for criteria dealing with reliability (RCM) and versatility (V&R). These gravity-based techniques would provide poor performance for separating solids that have densities that are near to, equal to, or less than that of the surrounding liquid media. Centrifugation ranked higher than the other gravity-based technologies in part because it uses artificially produced gravitational forces several times stronger than normal gravity; this magnified gravity tends to exploit the solid-liquid density differential to a greater extent.

2. Process Description

The following process description covers the recommended treatment process as depicted in the process flow diagram, Figure 7. The purpose of the BOSS spent media treatment system is to remove filterable solids, particularly paint chips, and to produce a liquid effluent suitable for further treatment in the Industrial Waste Treatment Plant (IWTP). The BOSS treatment system will consist of dissolution of the sodium bicarbonate in water, removal of the insoluble suspended solids by pressure filtration, and neutralization of the liquid effluent with acid. It is recommended that the spent media treatment process be a batch operation. A batch operation will minimize fluctuations in the flow rate and composition of the effluent, and thus minimize the potentially adverse impact these fluctuations could have on the IWTP operation.

The spent media from each shift will be collected in a stripping booth sump and/or in an optional spent media holding tank. If an integral sump is provided with the stripping booth that has sufficient capacity to contain all of the spent media from one shift, the spent media holding tank may not be required.

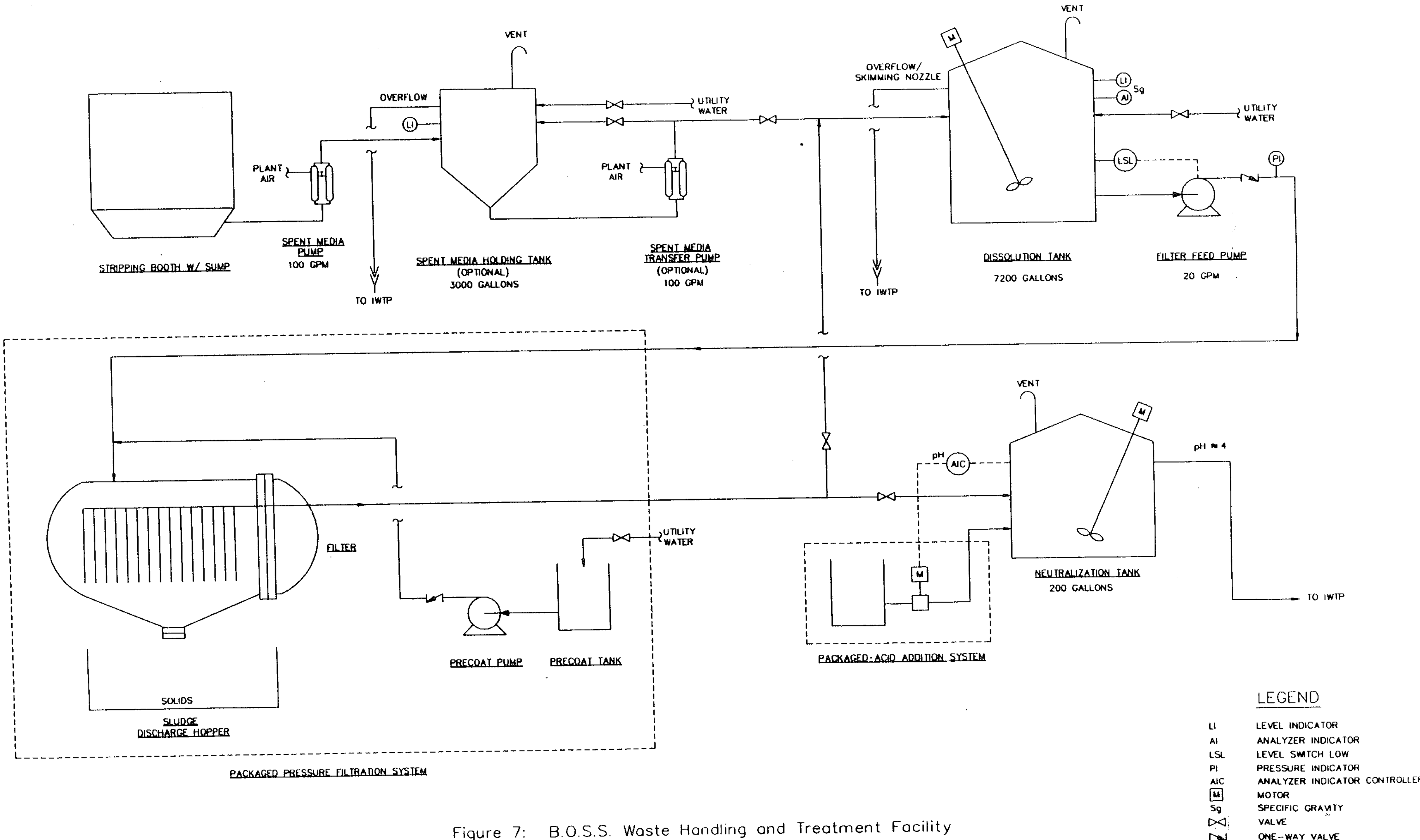

Figure 7: B.O.S.S. Waste Handling and Treatment Facility Process Flow Diagram

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Assuming that the spent media holding tank is required, the spent media sludge will be pumped from the stripping booth sump to the spent media holding tank. The spent media holding tank will be sized to hold the spent media generated from one 8-hour shift. The contents of the spent media holding tank will be circulated by a spent media transfer pump back to the holding tank to keep the contents mixed and fluid.

To initiate treatment of a batch of spent media, the contents of the spent media holding tank are transferred to the dissolution tank using the spent media transfer pump. Once the sludge is transferred, the dissolution tank is filled to the maximum operating level with utility water and the tank mixer put in service. The soluble solids consisting primarily of sodium bicarbonate and sodium carbonate are dissolved into the water. Once the soluble solids have been dissolved, the resulting solution should contain 0.3-0.6 percent (wt) suspended solids consisting primarily of paint chips.

The contents of the dissolution tank are then pumped at a rate of 20 gpm to the packaged pressure filtration system. The recommended filter is a vertical leaf-type pressure filter with capability to use a precoat material, such as diatomaceous earth. Use of a precoat material will increase run length and filtering rate, but will add approximately 20 percent to the volume of solids to be disposed. It will take approximately 6 hours to pump the contents of the dissolution tank through the filter at 20 gpm. A low level switch will shut off the filter feed pump before pump suction is lost.

The filtrate from the filter system is routed to a neutralization tank. Sulfuric acid is added to the neutralization tank to neutralize the sodium bicarbonate and sodium carbonate. The addition of sulfuric acid is controlled by a pH controller. Carbon dioxide gas is produced at an approximate rate of 3,800 standard cubic feet at 60°F and 1 atmosphere (scf)/h by the neutralization reactions and is vented from the tank to atmosphere. The effluent from the Neutralization Tank is routed by gravity overflow to the existing IWTP line. The effluent from the BOSS treatment system to the IWTP will contain dissolved sodium sulfate and is expected to contain less than 50 parts per million, weight basis (ppm (wt)) of suspended solids and to be controlled at a pH of 4(±0.5).

Once a filter run is completed as determined by the filter back pressure, the filter must be taken out of service and the filter cake removed from the filter leaves. Removal of the filter cake from the filter leaves may be enhanced by vibration of the leaves or by air pulses. The filter cake should contain a minimum of 25 percent (wt) solids and be discharged directly into drums for disposal. Once the filter cake is removed, the filter leaves must be coated with the precoat material before the filter is put back in service. This is accomplished by mixing up a slurry containing water and the precoat material and pumping it through the filter.

3. Impact of Treated BOSS Liquid Effluent on IWTP

a. Flow rate

The total flow rate of the treated liquid effluent from BOSS waste treatment is anticipated to be between 20 to 25 gpm into the IWTP (the flow rate can be higher than 20 gpm because of the acid addition in the neutralization tank). This flow would increase the total IWTP throughput by only 0.5 to 0.6 percent overall, since the IWTP typically processes about 1.5 Mgpd. This is based on liquid effluent from the BOSS treatment process being sent to the IWTP for 6 hours per day. It is anticipated that this slight increase in IWTP flow rate should not disrupt IWTP operation.

b. Constant Flow and Composition

Because the feed to the BOSS treatment is well mixed, the liquid effluent from BOSS waste treatment will be of constant flow and composition for each day of operation. The flow and composition may vary slightly between different days of operation.

c. Sodium Levels

Assuming that there is approximately 7 to 8 percent (wt) $NaHCO_3$ in the filtered effluent, there will be about 22,000 ppm Na^+ in this stream. However, this stream will be diluted by the other IWTP streams (totaling approximately 1.5 Mgpd), and will flow into the IWTP 6 hours per day.

Thus, there will be between 100 and 150 ppm Na^+ in the IWTP that comes from the BOSS liquid effluent. EG&G Idaho and Kelly AFB personnel indicated that this amount of additional sodium should not cause difficulties in the IWTP operation.

d. Total Suspended Solids (TSS)

According to the performance specification, the TSS in the treated BOSS liquid effluent will not exceed 50 ppm (before dilution in the IWTP). This low TSS level should not have an adverse impact on IWTP operation, as the Kelly AFB IWTP permit (National Pollution Discharge Elimination System (NPDES) permit no. TX0000671) states that TSS levels in the liquid discharge must be less than 40 ppm.

e. pH

The pH of the treated BOSS liquid sent to the IWTP will be 4±0.5. This acidic pH will destroy all bicarbonate and carbonate species, and in so doing, will eliminate CO_2 liberation at the IWTP from BOSS sources. Note that CO_2 formation could adversely affect IWTP operation, as it can cause bubbling and effervescence that can lead to unfavorable equipment performance. Also, an acidic pH for the BOSS filtrate is desirable since the chrome reduction facility at the IWTP operates under acidic conditions.

f. Organic Compounds and Dissolved Heavy Metals

The anticipated amounts of organic compounds and dissolved heavy metals in the treated BOSS effluent are very small, if not negligible, and should be easily treated in the IWTP. The organic compounds (for example, light oils) will be treated in the biological digesters, and the heavy metals should be precipitated in the chrome reduction/precipitation facilities.

From the above information, it can be concluded that the treated BOSS liquid effluent should not have any significant impact on the operation of the IWTP at Kelly AFB. In fact, the BOSS effluent may provide some benefit to the IWTP, such as providing acidity for selected IWTP operations.

SECTION VII
PERFORMANCE SPECIFICATION
FOR
SPENT-STRIPPING MEDIA TREATMENT SYSTEM

A. PROJECT REQUESTOR AND END USER

U.S. Air Force, Kelly Air Force Base, San Antonio, Texas.

B. NEED FOR THIS PROJECT

The Air Force intends to use sodium bicarbonate ($NaHCO_3$) as an abrasive media for stripping paint from aircraft parts. The paint chips removed in this operation may contain toxic heavy metals, including chromium and cadmium. A treatment system is required to separate the paint chips from the remainder of the spent media.

C. FUNCTION

The purpose of the treatment system covered by this specification is to treat spent sodium bicarbonate media generated in paint-stripping operations to remove filterable paint chips and to produce a liquid effluent suitable for further treatment in the IWTP at Kelly AFB. This treatment will consist of dissolution of the sodium bicarbonate in water, removal of the insoluble suspended solids by pressure filtration, and neutralization of the liquid effluent with acid.

D. OPERATIONAL REQUIREMENTS

1. Process Requirements (Refer to the process flow diagram)

a. General Treatment Process

The treatment process shall be a batch operation. A spent media pump will be provided to pump the spent media sludge (see Table 9 for characterization of spent BOSS sludge) from the stripping booth sump to a spent media holding tank. This tank shall have sufficient capacity to hold the spent media generated in one 8-hour shift's stripping operation. A spent media transfer pump shall be provided to transfer the sludge from the holding tank to a dissolution tank. The transfer pump shall also be used to circulate the sludge in the holding tank to keep the contents mixed and fluid. (Note: If an integral sump is provided with the stripping booth that has sufficient capacity to contain all of the spent media from one shift, the spent media holding tank and spent media transfer pump may not be required).

Sufficient utility water shall be added to the dissolution tank to dissolve all soluble solids. A dissolution tank mixer will be provided to dissolve the soluble solids and to keep the insoluble solids in suspension. Once the soluble solids have been dissolved, the contents of the dissolution tank shall be pumped by a filter feed pump to a packaged pressure filtration system. This operation will continue for approximately 6 hours until a low level switch shuts off the filter feed pump. An overflow/skimming nozzle shall be provided to allow for overflow conditions and to facilitate the removal of light oils.

The packaged filtration system shall include a vertical leaf filter unit, precoat tank, and precoat pump. A filter leaf vibration or air pulsation system shall be provided to facilitate removal of solids from the filter media. Solids will be discharged directly from filter unit into drums for disposal. The filtered solids will contain no free liquid.

TABLE 9. CHARACTERIZATION OF SPENT BICARBONATE SLUDGE.

Waste form: Sludge-like material consisting of water, sodium bicarbonate, sodium carbonate, paint chips, dissolved heavy metals, an inert flow additive, and trace amounts of oil and grit. The flow additive is a proprietary food-grade material. The sodium salts are only partially dissolved, and constitute the majority of the solid material.

Moisture content of sludge: Variable, but too low to totally dissolve the sodium bicarbonate and sodium carbonate.

Relative average amount of paint chips: 0.055 g paint chips per g dried sludge

Approximate heavy metal analysis of dried sludge:

Heavy Metal	ug/g
Cr	70.4
Zn	21.2
Cd	5.7
Pb	6.2
Other Metals	
Fe	36.6
Al	368.6

Approximate heavy metal analysis of decanted liquid:

Heavy Metal	ug/g
Cr	3.14
Zn	2.78
Cd	0.18
Pb	0.24
Other Metals	
Fe	1.46
Al	2.85

Liquid Specific Gravity: 1.07 (approximate)

Paint Chip Specific Gravity: 1.61 to 1.69

Particle Size Distribution of Paint Chips:

Size, microns	Wt%
>1,000	8
600-1,000	26
425-600	5
250-425	8
150-250	30
106-150	11
75-106	6
45-74	3
<45	3

The filtrate shall be routed through a neutralization tank to a tie-in to an existing industrial wastewater line. An acid addition package shall be provided to add acid on pH control to the tank to neutralize the sodium bicarbonate and sodium carbonate in the liquid effluent. Carbon dioxide will be evolved from the neutralization tank as the sodium bicarbonate and sodium carbonate react with the acid. A vent to outside air shall be provided on the neutralization tank.

The effluent from the neutralization tank will contain a maximum of 50 ppm (wt) total suspended solids and the pH will be maintained at 4(±0.5). The filter cake discharge from the packaged pressure filtration system shall contain a minimum of 25 percent (wt) solids.

b. Throughput Requirements

Spent media sludge shall be pumped from the stripping booth to the spent media holding tank and from the holding tank to the dissolution tank at a minimum rate of 100 gpm. The treatment system downstream of the dissolution tank shall be designed for a maximum flow rate of 20 gpm.

c. Equipment Performance Requirements

The equipment performance requirements are as follows:

Spent Media Pump	Flow	100 gpm min.
	Liquid density	1.04-1.07 SG
	Solids content	10%(wt) max.
	Provide low flow protection. Consider air-driven diaphragm-type pump.	
Spent Media Holding Tank	Working Volume	3,000 gallons min.
	Type	Cone bottom
	Provide vent, overflow, drain, and utility water connections.	

Spent Media Transfer Pump	Flow	100 gpm min.
	Liquid density	1.04-1.07 SG
	Solids content	10%(wt) max.
	Provide low flow protection. Consider air-driven diaphragm-type pump.	
Dissolution Tank	Working Volume	7,200 gallons min.
	Working volume will be above level switch low and below overflow/oil-skimming connection. Provide vent, overflow, and drain connections. A 3-inch minimum (min.) utility water connection shall be provided.	
Dissolution Tank Mixer	Power	80 horse power (hp) min.
Filter Feed Pump	Flow	20 gpm
	Liquid density	1.04-1.07 SG
	Solids content	0.43%(wt) ave. 0.64%(wt) max.
	Liquid is aqueous solution containing up to 8.8%(wt) $NaHCO_3$.	
Packaged Pressure Filtration System	Flow	20 gpm
	Liquid density	1.04-1.07 SG
	Solids density	1.6-1.7 SG
	Filtrate solids	50 ppm(wt) max.
	Cake solids	25%(wt) min.
	Type	Vertical leaf
	Provide capability to add precoat material, including precoat tank with	

	utility water supply and precoat pump. Provide for discharge of solids from filter directly into drums. Provide filter leaf vibration or air pulsation system to facilitate solids removal.
Neutralization Tank	Working volume 2,000 gallons min.
	Provide elevated discharge to maintain level. Provide a minimum of 3 feet of freeboard above normal liquid level to allow for foaming. Allow for venting of up to 3,800 scf/hour of carbon dioxide gas from neutralization reactions (3-inch vent minimum). Provide drain connection.
Neutralization Tank Mixer	Power 4 hp min.
Packaged Acid Addition System	System to supply a maximum of 13.5 lbs/minute of H_2SO_4 (as 100% H_2SO_4), e.g.,, if 20%(wt) H_2SO_4 is used, the maximum flow rate would be 7.1 gpm. Expected normal acid requirement is 6.7 lbs/minute H_2SO_4. Minimum turndown ratio is 10:1. System shall accept input from pH controller.

d. Utilities Requirements

Utility water connections shall be provided at the spent media holding tank, dissolution tank, and to the precoat tank included with the packaged pressure filtration system. The utility water connection to the Dissolution tank shall be capable of delivering 140 gpm (3-inch minimum line size).

An appropriate power supply shall be provided to the pumps and mixers as required. Plant air shall be provided to the sludge pumps if necessary.

e. Control Loop Strategies

As a minimum, the following control and monitoring instruments shall be provided:

- Level indicators on the spent media holding tank and the dissolution tank
- Pressure gauges on the discharge of all pumps
- Specific gravity analyzer on the dissolution tank
- Level switch low on the dissolution tank to shut off filter feed pump
- pH analyzer indicating controller on the neutralization tank (the output from this controller will adjust acid addition).

f. Testing

Before final selection of filter media and precoat material, testing shall be performed on a sample of spent media provided by the Air Force to determine filtration capacity and performance. The results of these filtration tests shall be reported to Kelly AFB personnel, and shall meet cake density and other requirements listed previously.

g. Special Maintenance Features

Clean-out connections shall be provided at all elbows and tees in the sludge piping from the stripping booth through the dissolution tank. Sludge piping shall be sized and configured to minimize solids build-up. Connections shall be provided to flush sludge piping with utility water.

SECTION VIII
CONCLUSIONS

Based on vendor testing and recommendations, spent depainting media from BOSS operations is treatable with conventional, commercially-available equipment typically used for solid-liquid separations. From the technology evaluation contained herein, the top three (of seven) treatment technologies are pressure filtration (vertical leaf filter), vacuum filtration (rotary drum vacuum filter), and centrifugation (solid bowl centrifuge), where pressure filtration is clearly the superior technology when judged by the selection criteria used here.

Vertical leaf pressure filtration excelled in four of the six technology criteria, and had an overall rating that exceeded that of the next best technology by a significant margin. Contributing to the superior score of pressure filtration are the following factors: (1) separation between solids and liquid is not density dependent, (2) reasonable capital costs, (3) versatility, and (4) positive vendor testing and recommendation.

In addition to the treatment of the BOSS waste, the transportation and handling of the wastes between the depainting booth interface, the filtration unit, and the IWTP interface can be accomplished by using standard process equipment as described in the performance specification. By using these treatment and transportation methods, the primary effluent streams exiting the proposed treatment scheme are: (1) approximately 20 to 25 gpm of clarified liquid effluent of pH≃4 that will be piped to the IWTP at Kelly AFB, and (2) a solids cake containing no free liquid that is ready to be placed in disposal containers. Secondary effluent streams would include skimmed oils and liquid overflow, which would be transferred directly to the IWTP line.

SECTION IX
RECOMMENDATIONS

We recommend that a vertical leaf pressure filter system be considered for installation at Kelly AFB for the purpose of treating the spent depainting media from BOSS operations. The technology evaluation has demonstrated that this type of pressure filter can provide excellent performance at a moderate price. The use of a precoat filter aid (e.g., diatomaceous earth) is strongly encouraged, as it was recommended as a result of vendor testing.

We also recommend that the equipment and methods presented in the process flow diagram and described in the performance specification be chosen as a basis for BOSS waste treatment and transportation. In so doing, Kelly AFB will produce a clarified acidic liquid stream (pH≃4) that can be sent to their IWTP with minimal impact; this liquid stream is acidified to destroy all carbonate and bicarbonate species so that CO_2 liberation is avoided at the IWTP. Also to be produced will be a solids cake of at least 25 percent solids by weight that can be discharged into barrels or drums and sent to disposal. It should be noted that the solids will consist mostly of paint chips, as it is recommended that all soluble salts (sodium carbonate and bicarbonate) be dissolved before filtration so that the final solid waste volume is somewhat minimized; this is one of the bases for the treatment scheme discussed herein.

Finally, vendor testing is highly recommended once final equipment selection has been made by Kelly AFB for the BOSS waste treatment. This testing should be performed on various BOSS waste samples provided by the United States Air Force, and the test results should be thoroughly reviewed before equipment purchases. If possible, testing should be done by the selected vendor(s).

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2. Metcalf & Eddy, Inc., Engineering Treatment, Disposal, and Reuse, Third ed., McGraw-Hill, Inc., New York, 1991.

3. Perry, R. H., Green, D. W., and Maloney, J. O., Perry's Chemical Engineer's Handbook, Sixth ed., McGraw-Hill Company, Inc., New York, 1984.

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APPENDIX A

CHEMICALS, EQUIPMENT, AND LABORATORY SUPPLIES USED FOR EXPERIMENTS

CHEMICALS

aqua regia
carbon tetrachloride
concentrated hydrochloric acid
hexane
5% hydrochloric acid
methylene chloride
methylene iodide
nanopure water
nitric acid
potassium hydrogen phthalate
fresh sodium bicarbonate paint-stripping media
spent sodium bicarbonate paint-stripping media
sodium hydroxide
trichloroethylene

EQUIPMENT

Mettler analytical balance, Model AE200, Range 200 g ±.3 mg
Class A chemical fume hood
ARL Inauctively Coupled Plasma (ICP), Model 3410, Serial No. 1098
Thermolyne muffle furnace, Model 47900, Range 0-1,100°C
Polaroid MP.4 with 6X magnification
Corning Ion Analyzer (pH meter), Model 255
Amary scanning electron microscope, Model 1830
Fisher Isotemp laboratory oven, 500 series
Mettler top loading balance, Model PM4600, Range 4,000 ± 0.02 g

LAB SUPPLIES

50 mL beakers
100 mL beakers
250 mL beakers
125 mL separatory funnels

Class A 10 mL volumetric flasks, Tolerance ± 0.02
Class A 250 mL volumetric flasks, Tolerance ± 0.15
Class A 1 L volumetric flask, Tolerance ± 0.30
Class A 50 mL burette, Tolerance ± 0.05
Class A 20 mL pipette, Tolerance ± 0.03
Class A 50 mL pipette, Tolerance ± 0.05

LAB SUPPLIES (concluded)

250 mL polypropylene sample bottles with caps.desiccator
Whatman 42 filter paper (2.5 micron)
Thermolyne nuova II stir plate
Tyler Portable sieve shaker, Model RX24
Tyler U.S. standard sieve 1000 micron (No. 18)
Tyler U.S. standard sieve 600 micron (No. 30)
Tyler U.S. standard sieve 425 micron (No. 40)
Tyler U.S. standard sieve 250 micron (No. 60)
Tyler U.S. standard sieve 150 micron (No. 100)
Tyler U.S. standard sieve 106 micron (No. 140)
Tyler U.S. standard sieve 75 micron (No. 200)
Tyler U.S. standard sieve 45 micron (No. 325)

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APPENDIX B

BREAKDOWN OF TECHNOLOGY EVALUATION

The following section explains how scores were determined for each of the criterion in the technology evaluation. This breakdown of scores serves to quantify the evaluation. The numbers in parentheses at the end of each bulleted sentence are relative scores (from 1 to 10) for each subcategory of a given criterion; these scores are averaged, and the average is rounded to the nearest whole number, resulting in an integer score for each criteria.

1. INCLINED PLATE SEPARATOR

LDRA:
- Development: average to well-developed (8).
- Technical Risk: moderate, due to gravity-based separation, which will not perform well for low density solids (7). Vendor tested and recommended by Parkson Corp.(8).
- Commercial Availability: good (8).

Average Score = 7.75 ==> **8**

FWF:
- Solids: would require dewatering (7).
- Liquid: would require a polishing filter (7).
- Flocculents would be in final solid waste, resulting in disposal of a greater volume of solids (6).

Average Score = 6.67 ==> **7**

RCM:
- Reliability: not reliable for feeds with solids that settle slowly or that have variable feed rates (6 to 7).
- Complexity: high, due to the auxiliary equipment needed for dewatering, polishing, and flocculent addition (6).
- Maintenance: moderate to high (6).

Average Score = 6 to 6.33 ==> **6**

V&R:
- Not a Stand-Alone treatment for our application (6).
- Not suitable for low density solids (5).
- Removal of fine solids would require flocculents (6).
- Performance highly dependent on feed characteristics (5).

Average Score = 5.5 ==> **5**

UR:
- Utilities: moderate to high due to auxiliary equipment (6)
- Chemicals: requires flocculents (6).

Average Score = 6 ==> **6**

CC: • Low to moderate capital costs, for an estimated total base equip. cost of $53K. Break down of costs: inclined plate separator, $17K (Parkson Corp); polishing filter, $18K; dewatering equip, $18K (8).

Average Score = 8 ==> [8]

2. CONTINUOUS ROTARY SCREEN

LDRA:
- Development: average to well-developed (7 to 8).
- Technical Risk: moderate to high, due to gravity-based separation, and lack of vendor testing on a sample of BOSS waste; may not produce effluent that is satisfactory for a polishing filter (6).
- Commercial Availability: fair, because screens with smaller mesh sizes (below 1.0 mm) may have to be custom made (5).

Average Score = 6 to 6.33 ==> [6]

FWF:
- Solids: may require dewatering (8).
- Liquid: would require a polishing filter (7).
- Flocculents may be in final solid waste, resulting in disposal of a greater volume of solids (7).

Average Score = 7.33 ==> [7]

RCM:
- Reliability: not reliable for feeds with fine solids that settle slowly (6 to 7).
- Complexity: high, due to the auxiliary equipment needed for dewatering, polishing, and flocculent addition (6).
- Maintenance: moderate to high (6).

Average Score = 6 to 6.33 ==> [6]

V&R:
- Not a Stand-Alone treatment for our application (6).
- Not suitable for low density and/or fine solids (5).
- Removal of light and/or fine solids may require flocculents (7).

Average Score = 6 ==> [6]

UR: • Utilities: moderate due to auxiliary equipment, which may include a dewatering unit (7).
• Chemicals: may require flocculents (7).

Average Score = 7 ==> [7]

CC: • Low to moderate capital costs, for an estimated total base equip. cost of $31K to $49K. The $31K estimate excludes dewatering equipment. Break down of costs: rotary screen, $13K (Parkson Corp); polishing filter, $18K; dewatering equip, $18K (8).

Average Score = 8 ==> [8]

3. TWO-STAGE HYDROCYCLONE

LDRA: • Development: average to well-developed (7 to 8).
• Technical Risk: moderate to high, due to gravity-based separation, and lack of vendor testing on a sample of BOSS waste (6).
• Commercial Availability: good (8).

Average Score = 7 to 7.33 ==> [7]

FWF: • Solids: would require dewatering (7).
• Liquid: may require a polishing filter (8).
• Flocculents may be in final solid waste, resulting in disposal of a greater volume of solids (7).

Average Score = 7.33 ==> [7]

RCM: • Reliability: decreases for feeds having a high percentage of low density or fine solids, e.g., less than 5 micron

(7)

• Complexity: high, due to the auxiliary equipment needed for dewatering, polishing, and flocculent addition. Also, the feeds to the hydrocyclones must be pressurized (5).
• Maintenance: moderate to high (6 to 7).

Average Score = 6 to 6.33 ==> [6]

V&R:
- May not be a Stand-Alone treatment for BOSS application (7).
- Not suitable for low density solids (5 to 6).
- Removal of light and/or fine solids may require flocculents (7).

Average Score = 6.33 to 6.67 ==> **7**

UR:
- Utilities: moderate to high due to auxiliary equipment (6)
- Chemicals: may require flocculents (7).
- Pressurized feeds will increase power requirements (6).

Average Score = 6.33 ==> **6**

CC:
- Low to moderate capital costs, for an estimated total base equip. cost of $20K to $38K. The $20K estimate excludes polishing equipment. Break down of costs: 2 hydrocyclones, $2K (Dorr-Oliver); polishing filter, $18K; dewatering equip, $18K (9).

Average Score = 9 ==> **9**

4. SOLID BOWL CENTRIFUGE

LDRA:
- Development: average to well-developed (7 to 8).
- Technical Risk: moderate to high, due to gravity-based separation (6).
  Recommendations from two vendors did not agree: testing performed by one vendor on a sample of BOSS waste resulted in a positive recommendation, suggesting that flocculents be used; a second vendor (performed no tests) indicated that centrifugation was not preferred for treatment of BOSS waste (6).
- Commercial Availability: fair to good (7 to 8).

Average Score = 6.5 to 7 ==> **7**

FWF:
- Solids: would not require dewatering (9).
- Liquid: would probably not require a polishing filter (8).
- Flocculents may be needed, and would increase the volume of final solid waste (7).

Average Score = 8 ==> **8**

RCM:
- Reliability: not reliable for feeds having a high percentage of lighter solids, i.e., those solids with a specific gravity less than or equal to that of the clarified liquid (7).
- Complexity: moderate (8).
- Maintenance: moderate to high, due to the inherent maintenance associated with high speed rotary equipment (6 to 7).

Average Score = 7 to 7.33 ==> | 7 |

V&R:
- Not well-suited for low density solids (6 to 7).
- Removal of extremely light or fine solids may require flocculents (7).
- May require prethickening of feed to enhance performance or reduce equipment costs (5).

Average Score = 6 to 6.33 ==> | 6 |

UR:
- Utilities: moderate, primarily electrical (8).
- Chemicals: may require flocculents (7 to 8).

Average Score = 7.5 to 8 ==> | 8 |

CC:
- High capital costs, for an estimated total base equip. cost of $120K (Bird Machine Company) (5).
- Cost of prethickener unit may have to be added to base cost; however, this unit may allow a smaller (cheaper) centrifuge to be used (6).

Average Score = 5.5 ==> | 5 |

5. ROTARY DRUM VACUUM FILTER

LDRA:
- Development: well-developed (8).
- Technical Risk: moderate, due to lack of vendor testing on a sample of BOSS waste (7).
- Commercial Availability: good (8).

Average Score = 7.67 ==> | 8 |

FWF:
- Solids: would not require dewatering (9).
- Liquid: would probably not require a polishing filter (8).
- Would require the use of a precoat, which would result in an increase of the overall volume of solid waste by approximately 20% (5).

Average Score = 7.33 ==> **7**

RCM:
- Reliability: moderate (7 to 8).
- Complexity: moderate to high, due to the many operational variables (7).
- Maintenance: moderate to high, due to the wear and adjustment of the fabric drum belt, and the adjustment of other operational variables (6).

Average Score = 6.67 to 7 ==> **7**

V&R:
- Overall good versatility; will treat most kinds of solids when a precoat is used (9).
- Use of precoat required (7).

Average Score = 8 ==> **8**

UR:
- Utilities: moderate, due to the need for a vacuum pump, precoat tank and accessories, and filtrate pump (7).
- Chemicals: precoat material (e.g., diatomaceous earth) (6 to 7).

Average Score = 6.5 to 7 ==> **7**

CC:
- High capital costs, for an estimated total base equip. cost of $115K (Komline-Sanderson) (5).

Average Score = 5 ==> **5**

6. SELF-ADVANCING FABRIC FILTER

LDRA:
- Development: average to well-developed (7 to 8).
- Technical Risk: moderate, due to gravity-based separation and lack of vendor testing on a sample of BOSS waste (6).
- Commercial Availability: good (8).

Average Score = 7 to 7.33 ==> **7**

FWF:
- Solids: cake would contain low to moderate percent solids. Dewatering may be necessary, but may be difficult because of the disposable fabric filter media (5 to 6).
- Solid waste would contain the disposable fabric, which would result in an increase of the overall volume of solid waste (5).
- Flocculents and filter aids may be in final solid waste, resulting in disposal of a greater volume of solids (5).

Average Score = 5 to 5.33 ==> **5**

RCM:
- Reliability: low to moderate, since reliability is dependent on the feed stream characteristics, e.g., solids loading, density of solids, upsets in flow rate, etc. (7).
- Complexity: low to moderate (8).
- Maintenance: moderate (7 to 8).

Average Score = 7.33 to 7.67 ==> **7**

V&R:
- Not suitable for low density solids or slow settling fine solids (6).
- May require a precoat and flocculent addition (6).
- Performance is likely to suffer during feed stream upsets (7).

Average Score = 6.33 ==> **6**

UR:
- Utilities: low (10).
- Chemicals: precoat material (e.g., diatomaceous earth) and possibly flocculents (6 to 7).
- Purchase of disposable fabric filter (7).

Average Score = 7.67 to 8 ==> **8**

CC:
- Low capital costs, for an estimated total base equip. cost of $10K (Serfilco) (10). Cost would increase if dewatering and flocculent addition were found to be necessary.

Average Score = 10 ==> **10**

7. VERTICAL LEAF PRESSURE FILTER

LDRA:
- Development: well-developed (8 to 9).
- Technical Risk: low, due to vendor testing and recommendation (Industrial Filter and Pump) (9).
- Commercial Availability: good to excellent, with several models to choose from (9).

Average Score = 8.67 to 9 ==> **9**

FWF:
- Solids: cake can contain moderate to high percent solids, depending on the method used to dislodge solids from the leaves (e.g., water purge, air purge, or vibration). Dewatering not necessary (9).
- Solid waste would contain the precoat, which would result in an approximate 20% increase of the overall volume of solid waste (6 to 7).

Average Score = 7.5 to 8 ==> **8**

RCM:
- Reliability: moderate to high (8 to 9).
- Complexity: low to moderate; feed must be pressurized (8)
- Maintenance: moderate, since the pressure filter may require partial disassembly to clean away the solids (7 to 8).

Average Score = 7.67 to 8.33 ==> **8**

V&R:
- Robust performance under a variety of feed conditions (9 to 10).
- May require a precoat (7).

Average Score = 8 to 8.5 ==> **8**

UR:
- Utilities: moderate to high, such as compressed air, steam, or water for solids discharge, plus typical electrical requirements (7).
- Chemicals: precoat material (e.g., diatomaceous earth) (7).

Average Score = 7 ==> **7**

CC: • Low to moderate capital costs, for an estimated total base equip. cost of $40 to $60K (Industrial Filter and Pump) (8).
Cost range covers various models.

Average Score = 8 ==> | 8 |

APPENDIX C

LIST OF VENDORS CONTACTED

List of Vendors Contacted for BOSS-related Waste Treatment Applications:

Company	Contact	Telephone
Bird Machine Company	Mark Phillips	(508) 668-0400
Dorr-Oliver, Inc.	Jim Bowersox	(203) 876-5510
Eimco Process Equipment Co.	Jim Monroe	(801) 526-2000
Hoesch Industries	John Mangina	(201) 398-9000
Industrial Filter & Pump Mfg. Company	Paul Eggerstedt	(708) 656-7800
Komline-Sanderson	Jeff Ornum	(908) 234-1000
Parkson Corporation	Brett Boyd	(305) 974-6610
Sharples Division of Alfa Laval	Richard Weeks	(415) 883-8520
Spray Booth Systems	Dave Hunt	(800) 722-1045

APPENDIX D

VENDOR INFORMATION AND CORRESPONDENCE

ALFA-LAVAL SEPARATION

TELECOPY

DATE: AUGUST 21, 1991

TO: JIM FINLEY

E,G & G IDAHO

NOVATO

FAX #: 208/526-1998

FROM: SUSAN AHMADI

THIS TELECOPY CONTAINS 4 PAGES INCLUDING THIS COVER SHEET.

ADDITIONAL COMMENTS:

PLEASE FIND ENCLOSED A COPY OF THE CLARIFICATION OF SPENT BLASTING MEDIA REPORT THAT YOU HAD REQUESTED. WE APOLOGIZE FOR THE DELAY IN SUBMITTING THIS TO YOU.

ALFA-LAVAL SEPARATION, INC.
Customer Service Division
23 Pimentel Court
Novato, California 94949

Telephone
415-883-8480

Fax
415-382-0308

Headquarters:
ALFA-LAVAL SEPARATION, INC.
955 Mearns Road
Warminster, PA 18974-3999

ALFA-LAVAL
SHARPLES

RECEIVED
JUL 26 1991

SUBJECT E, G & G IDAHO, IDAHO FALLS, ID CDL 2069

DATE July 22, 1991

TO Richard Weeks

FROM Craig R. Reed

IN RE Clarification of Spent Blasting Media

COPIES TO H. Carseberg, File

Craig R. Reed, Manager
Centrifuge Demonstration Laboratory

CRR/ehd

ALFA-LAVAL SEPARATION INC
SHARPLES DIVISION
955 MEARNS ROAD
WARMINSTER PA 18974-0556

MAIN (215) 443-4000
FAX (215) 443-4234

ALFA-LAVAL
SHARPLES

E, G & G Idaho
1955 Fremont Avenue
Idaho Falls, ID 83402
Clarification of Spent Blasting Media CDL 2069

E, G & G Idaho, a contractor for the Air Force is looking into the feasibility of using sodium bicarbonate blasting media for the removal of paints from metal parts. If this procedure proves favorable, it will greatly reduce the amount of waste solids that must be disposed of. The spent sodium bicarbonate media will be dissolved in water, leaving the paint chips and metal flakes, to be removed from the slurry and disposed of. The liquid will then be further processed. E, G & G Idaho is considering using Alfa-Laval centrifuges to remove these paint and metal chips.

The one-half gallon can of solids was tested on July 18, 1991. Per the client's instructions, one pound of solids was added to 1.5 gallons of water. This slurry was manually agitated for several minutes, to allow the sodium bicarbonate to dissolve. Eight ounce jar samples were spun in the bottle centrifuge, spinning at 2000 XG for various times. Bench testing with available flocculants, Allied Colloids Percol 787 proved most effective. Eight ounce jar samples of the slurry were treated with 787 and then spun in the bottle centrifuge, spinning at 2000 XG. Further details of the test can be found on the Evaluation Sheet.

Results from tests conducted in the Centrifuge Demonstration Laboratory indicate a Super-D-Canter with the addition of a flocculant will be capable of producing 99% recovery of the insoluble solids and a minimum 23% solids by weight cake. Two cases for capacity of 20 gpm and 100 gpm were stated by the client. These tests indicate a Sharples P3000 should be capable of handling the 20 gpm feed rate and a Sharples P5400 will be capable of handling the 100 gpm. Field testing is recommended to determine maximum cake dryness and also to see if the torque will be a limiting factor.

ALFA-LAVAL SEPARATION, INC.
SHARPLES DIVISION
955 MEARNS ROAD
WARMINSTER PA 18974-0556

MAIN (215) 443-4000
FAX (215) 443-4234

CLIENT E, G+G Idaho

DATE 7/18/91

BOTTLE CENTRIFUGE EVALUATION
(RCF X G = 2000)

SPIN TIME MINS	.5	1	3		
SLURRY AR ①					
LIQUID APPEAR ②	C/B	C/B	B		
SEDIMENT CC					
%	<1	<1	<1		
Percol 787					
SLURRY WF ①					
LIQUID APPEAR ②	B	B/A	A		
SEDIMENT CC					
%	<1	<1	<1		

① AS RECEIVED
WITH FLOCCULANT

② A CLEAR
B SL CLOUDY
C CLOUDY
D ≈FEED

Feed = .06% insolubles
Cake = 22.84% T.S.
Effluent = .006% insolubles
pH = 8.5

** TOTAL PAGE.001 **

INDUSTRIAL FILTER & PUMP MFG. CO.
5900 Ogden Avenue • Cicero, Illinois 60650-3888
FAX # 708-656-7808
PHONE # 708-656-7800

FAX MESSAGE

Date:	August 20, 1991	No. Of Pages:	1
To:	EG&G Idaho, Inc. 1335	From:	Paul Eggerstedt
Attn:	Jim Findlay	Re:	Bicarbonate stripping filtrati
FAX #	208-526-1998		application - Our Job #91-0484

Jim:

Per our discussion last week and my earlier 8/5 FAX to you, it appears as though a good filterability rate and good filtrate quality were most easily attained by means of precoat, hence a precoat filter system was recommended to you.

As you may recall, we initially thought a bed type (multi-media) filter might be applicable. However, where solids loadings exceed about 100 ppm and in the presence of fine particulates, a media filter turns out to be a poor choice. (Media filters are generally best suited to remove low levels of relatively large particles.)

Cartridge type filters might be worth considering since they can be obtained in a variety of pore sizes to yield good clarity and are relatively inexpensive. Our experiences, however, show that cartridge filters can actually create a waste problem since the solids plus cartridges must be disposed of (as hazardous waste, in your case). Although they have an attractive initial cost, they must be frequently cleaned (high labor intensity) and operating costs (replacement cartridges) can be high.

Filter presses can be used and high dry solids levels (i.e., good solids volume reduction) can be achieved. They have several drawbacks though, including labor intensity, poor performance (or even damage to the filter) during intermittent operation, and difficulty in compressing cakes which have incompressible solids (like Diatomaceous earth precoat).

A standard precoatable pressure leaf or horizontal plate type filter, we feel, is worth considering. Pressure leaf filters furnish a large filtration area in a relatively small chamber size and can be cleaned by means of vibrating the filter cake from the filter leaf ("dry cake discharge"). Where intermittent operation is envisioned, a horizontal late type filter is more suitable since the precoat will not "slough off" the media.

Approximately, in rubber lined steel construction, a 20 GPM (150 ft.^{2}) pressure leaf filter system would cost roughly \$65,000 while a similar horizontal plate filter system would be approximately \$40,000 (based upon a cycle length of 6-8 hours).

We hope the above information is helpful to you. Regards,

Paul Eggerstedt

PE:njb

INDUSTRIAL FILTER & PUMP MFG. CO.
5900 Ogden Avenue • Cicero, Illinois 60650-3888
FAX # 708-656-7806
PHONE # 708-656-7800

FAX MESSAGE

Date:	August 5, 1991	**No. Of Pages:**	1 + 9
To:	EG&G Idaho, Inc.	**From:**	Paul Eggerstedt
Attn:	Jim Findley	**Re:**	Preliminary lab filterabilit
FAX #	208-526-1998		testing - Bicarbonate stripp

Jim:

Following this cover sheet are 9 pages of results compiled from three (3) filterability tests performed recently on your spent sodium bicarbonate stripping application.

Only the test involving precoat/C-273 polypropylene cloth media yielded both a good filterability rate, as well as a clean effluent.

From a preliminary standpoint, we feel that a precoated pressure filter, sized to polish the flow stream directly, might be most advantageous.

We can discuss the above further later this week.

Regards,

Paul Eggerstedt
PE:njb

EXPERIENCE, INNO' ON, ADVANCED ANSWERS

2

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

DATA			
VOLUME	TIME	FLOW	PRESSURE
10	.62	0.4258	10
17	3.55	0.0631	20
TOTAL THRUPUT		0.4500	GAL/FT²
AVERAGE THRUPUT RATE		0.1268	GPM/FT²

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

July 22, 1991

Company:	EG&G	Lab Order #:	91078
Cust. ID:	C91025	Sample #:	S91024
Date:	July 22, 1991	Test #:	3
pH:	8.74	Salesman:	PME
		Job #:	91-0484

TEST CONDITIONS

Starting Volume......	50 ml
Media......................	24 x 110 screen
Effluent Clarity......	Cloudy
Precoat....................	1 g Hyflo Super-Cel™
Bodyfeed..................	N/A
Treatment................	Sample was concentrated.
Formed Cake Thickness................	1.625 inches
Comments................	None.

Technician: J Miller, K Halla

cc: PME, EG&G File

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

DATA			
VOLUME	TIME	FLUX	PRESSURE
1560	62.13	0.3882	70
1580	63.78	0.3200	70
1600	65.47	0.3124	70
1620	66.75	0.4125	70
1640	68.83	0.2538	70
1660	70.87	0.2588	70
1680	73.20	0.2266	70
1700	75.33	0.2479	70
1720	78.02	0.1983	70
1740	79.77	0.3017	70
1760	82.46	0.1970	70
1780	85.20	0.1920	70
1800	87.93	0.1934	70
1820	90.05	0.2491	70
1840	93.35	0.1600	70
1860	96.53	0.1660	70
1880	99.57	0.1737	70
1900	102.92	0.1576	70
1920	105.73	0.1879	70
1930	108.13	0.1100	70
TOTAL THRUPUT		50.9900	GAL/FT²
AVERAGE THRUPUT RATE		0.4718	GPM/FT²

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

DATA			
[illegible]	TIME	FLOW	PRESSURE
1040	35.83	0.7543	20
1060	36.37	0.7136	20
1080	37.10	0.7233	20
1100	37.83	0.7233	25
1120	38.42	0.8949	25
1140	39.32	0.5867	25
1160	40.15	0.6361	30
1180	41.02	0.6069	30
1200	42.15	0.4673	35
1220	42.83	0.7765	35
1240	43.73	0.5867	40
1260	44.82	0.4844	40
1280	45.85	0.5126	45
1300	47.02	0.4513	45
1320	47.80	0.6769	45
1340	48.90	0.4800	45
1360	49.87	0.5443	60
1380	51.02	0.4591	60
1400	52.02	0.5280	20
1420	52.87	0.6212	30
1440	54.23	0.3882	30
1460	55.55	0.4000	40
1480	56.70	0.4591	50
1500	57.96	0.4125	60
1520	59.07	0.4844	60
1540	60.77	0.3106	60

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

DATA			
VOLUME	TIME	FLOW	PRESSURE
520	18.47	0.6439	20
540	19.27	0.6600	20
560	20.47	0.4400	20
580	21.53	0.4981	25
600	22.67	0.4632	25
620	23.35	0.7765	30
640	24.52	0.4513	30
660	25.62	0.4800	36
680	26.58	0.5500	40
700	0.00	-0.0199	40
720	27.93	0.0189	40
740	28.47	0.9778	40
760	28.80	1.6000	40
780	29.17	1.4270	40
800	29.53	1.4667	40
820	29.95	1.2571	40
840	30.52	0.9263	40
860	31.23	0.7437	40
880	31.83	0.8600	20
900	32.20	1.4270	20
920	32.52	1.6500	20
940	32.95	1.2279	20
960	33.65	0.7543	20
980	34.05	1.3200	20
1000	34.50	1.1733	20
1020	34.93	1.2279	20

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

DATA			
VOLUME	TIME	FLOW	PRESSURE
20	.62	0.8516	5
40	1.78	0.4552	5
60	2.48	0.7543	5
80	3.13	0.8123	5
100	3.70	0.9263	5
120	4.18	1.1000	5
140	4.95	0.6857	5
160	5.48	0.9962	5
180	6.13	0.8123	5
200	6.58	1.1733	5
220	6.98	1.3200	5
240	7.37	1.3538	5
260	7.93	0.9429	5
280	8.50	0.9263	5
300	9.32	0.6439	5
320	10.68	0.3882	5
340	11.43	0.7040	5-7
360	12.07	0.8250	7
380	12.75	0.7765	10
400	13.50	0.7040	13
420	14.10	0.8800	13
440	14.92	0.6439	13
460	15.48	0.9429	15
480	16.63	0.4591	15
500	17.65	0.5176	15

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

July 17, 1991

Company:	EG&G	Lab Order #:	91078
Cust. ID:	C91025	Sample #:	891024
Date:	July 17, 1991	Test #:	2
pH:	8.74	Salesman:	PE
		Job #:	91-0484

TEST CONDITIONS

Volume	2000 ml
Media	C273
Effluent Clarity	Clear
Precoat	1 g Hyflo Super-Cel™
Bodyfeed	N/A
Treatment	Added 80 g of sludge to 1 liter of tap water
Formed Cake Thickness	.125"
Comments	None.

Technician: J Miller, K Ralls

cc: PE, EG&G file

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

DATA			
VOLUME	TIME	FLOW	PRESSURE
20	.62	0.8516	5
40	1.10	1.1000	5
60	1.92	0.6439	5
80	2.67	0.7040	5
100	3.48	0.6519	5
120	4.13	0.8123	5
140	4.96	0.6439	5
160	5.92	0.5443	5
180	6.75	0.6361	5
194	7.05	1.2320	5
TOTAL THRUPUT		5.1300	GAL/FT^2
AVERAGE THRUPUT RATE		0.7277	GPM/FT^2

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

July 17, 1991

Company:	EG&G	Lab Order #:	91078
Cust ID:	C91025	Sample #:	S91024
Date:	July 17, 1991	Test #:	1
pH:	8.74	Salesman:	PE
		Job #:	91-0484

TEST CONDITIONS

Volume	200
Media	C273
Effluent Clarity	Cloudy
Precoat	N/A
Bodyfeed	N/A
Treatment	Added 80g of sludge to 1 liter of tap water.
Formed Cake Thickness	.015825
Comments	None.

Technician: J. Miller, K Halla

cc: PME, EG&G File

INDUSTRIAL FILTER & PUMP MFG. CO.
RESEARCH & DEVELOPMENT DIVISION
PHYSICAL LABORATORY DEPARTMENT

5900 Ogden Avenue ■ Cicero, Illinois 60650-3888
PHONE # 708-656-7800 FAX # 708-656-7806

FAX MESSAGE

Date: July 18, 1991
To: EG & G Idaho Inc.
Attn: Jim Findley
FAX # (208)526-1998

Pages: 8
From: Peter Aguilar
Re: Test Reports

Dear Jim,

The following data sheets contain figures developed from tests 1 & 2.

Test 1 was terminated early due to excessive solids bleed through. Test 2 produced a clear effluent.

We are yet to run another trial using body feed, and perhaps another one without diluting the sample. The latter may be indicative of the maximum cake thickness that can be achieved.

Please feel free to call if you have any questions.

Thanks.

Sincerely,

Pete Aguilar
R&D Physical Laboratory
PA:cm
FX910718.A
cc: PE, 91-0484, LAB

EXPERIENCE. INNOVATION. ADVANCED ANSWERS

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

DATA			
VOLUME	TIME	FLUX	PRESSURE
1560	62.13	0.3882	70
1580	63.78	0.3200	70
1600	65.47	0.3124	70
1620	66.75	0.4125	70
1640	68.83	0.2538	70
1660	70.87	0.2588	70
1680	73.20	0.2266	70
1700	75.33	0.2479	70
1720	78.02	0.1963	70
1740	79.77	0.3017	70
1760	82.45	0.1970	70
1780	85.20	0.1920	70
1800	87.93	0.1934	70
1820	90.05	0.2491	70
1840	93.35	0.1600	70
1860	96.53	0.1660	70
1880	99.57	0.1737	70
1900	102.92	0.1576	70
1920	105.73	0.1879	70
1930	108.13	0.1100	70
TOTAL THRUPUT		50.9900	GAL/FT²
AVERAGE THRUPUT RATE		0.4716	GPM/FT²

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

DATA			
VOLUME	TIME	FLOW	PRESSURE
1040	35.63	0.7543	20
1060	36.37	0.7135	20
1080	37.10	0.7233	20
1100	37.83	0.7233	25
1120	38.42	0.8949	25
1140	39.32	0.5867	25
1160	40.15	0.6361	30
1180	41.02	0.6069	30
1200	42.15	0.4673	35
1220	42.83	0.7765	35
1240	43.73	0.5867	40
1260	44.82	0.4844	40
1280	45.85	0.5126	45
1300	47.02	0.4513	45
1320	47.80	0.6789	45
1340	48.90	0.4800	45
1360	49.87	0.5443	60
1380	51.02	0.4591	60
1400	52.02	0.5280	20
1420	52.87	0.6212	30
1440	54.23	0.3882	30
1460	55.55	0.4000	40
1480	56.70	0.4591	50
1500	57.98	0.4125	60
1520	59.07	0.4844	60
1540	60.77	0.3106	60

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

DATA			
VOLUME	TIME	FLOW	PRESSURE
520	18.47	0.6439	20
540	19.27	0.6600	20
560	20.47	0.4400	20
580	21.53	0.4981	25
600	22.67	0.4632	25
620	23.35	0.7765	30
640	24.52	0.4513	30
660	25.62	0.4800	36
680	26.58	0.5500	40
700	0.00	-0.0199	40
720	27.93	0.0189	40
740	28.47	0.9778	40
760	28.80	1.6000	40
780	29.17	1.4270	40
800	29.53	1.4667	40
820	29.95	1.2571	40
840	30.52	0.9263	40
860	31.23	0.7437	40
880	31.83	0.8800	20
900	32.20	1.4270	20
920	32.52	1.6500	20
940	32.95	1.2279	20
960	33.65	0.7543	20
980	34.05	1.3200	20
1000	34.50	1.1733	20
1020	34.93	1.2279	20

CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

DATA			
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80	3.13	0.8123	5
100	3.70	0.9263	5
120	4.18	1.1000	5
140	4.95	0.6857	5
160	5.48	0.9962	5
180	6.13	0.8123	5
200	6.58	1.1733	5
220	6.98	1.3200	5
240	7.37	1.3538	5
260	7.93	0.9429	5
280	8.50	0.9263	5
300	9.32	0.6439	5
320	10.68	0.3882	5
340	11.43	0.7040	5-7
360	12.07	0.8250	7
380	12.75	0.7765	10
400	13.50	0.7040	13
420	14.10	0.8600	13
440	14.92	0.6439	13
460	15.48	0.9429	15
480	16.63	0.4691	15
500	17.65	0.5176	15

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CUSTOMER SAMPLE PRESSURE FILTRATION REPORT

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July 17, 1991

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Date:	July 17, 1991	Test #:	1
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Treatment	Added 80g of sludge to 1 liter of tap water.
Formed Cake Thickness	.015625
Comments	None.

Technician: J Miller, K Halla

cc: PME, EG&G File

EXPERIENCE, INNOVATION, ADVANCED ANSWERS

SENT BY: XEROX Telecopier 7017; 8- 5-91 ; 14:13 ; 3059746182-2085261998 ;# 1

PARKSON CORPORATION
2727 N.W. 62ND STREET
FT LAUDERDALE FL 33309
FAX PHONE 305/974-6182

MESSAGE NO. 6180
DATE 8/2/91

TO: Mr. Jim Findley
EGG, Idaho

FAX PHONE # 208 526-1998 or 97

FROM: Barbara Hill

TOTAL NO. PAGES (INCL. COVER PAGE)

RE: Lab test summary

Enclosed are copies of the lab test summaries for the samples recently submitted by your company. The final copy and cover letter will be sent to you soon by our process department. Samples of effluent and filtrate were returned via UPS earlier this week. If you have any questions concerning the testing please call.

Regards,

Barbara Hill

MAG

PARKSON CORPORATION

LAMELLA® GRAVITY SETTLER

Date Tested: July 19 thru 25, 1991

Customer Sample Number: 9098-0791

**LABORATORY SETTLING TEST SUMMARY
for the
LAMELLA GRAVITY SETTLER/THICKENER (LGST)**

For: EG & G IDAHO
Scoville, ID

Application: Spent Sodium Bicarbonate blasting media-Used to strip coatings from metal parts.

FEED AS RECEIVED: Suspended Solids: 5,976 ppm; pH: 8.0

FEED PRETREATMENT: None
Temperature: ambient

FLOCCULATING AIDS:

Polyelectrolyte used: 10 ppm American Cyanamid Magnifloc 1598C.

10 seconds Flash Mixing time, one-minute Flocculation time

OUR RECOMMENDATIONS:

Based on a maximum feed rate of 100 GPM, we recommend the use of one Model 300/55 LGS/one Model 360/55 LGST. Each unit has 240 sq.ft. (LGS)/288 sq.ft. (LGST) of clarification area and 60 sq.ft. (LGS)/72 sq.ft. (LGST) of thickening area. At the maximum feed rate, the surface loading rate is .42 GPM/sq.ft.(LGS) /.35 GPM/sq.ft.(LGST). At this loading rate, the unit will produce an effluent containing less than 60 ppm suspended solids and an underflow containing at least 3-4% (LGS) / 4-5% (LGST) suspended solids, if attainable in static settling tests.

2727 N.W. 62nd Street
P.O. Box 408399
Fort Lauderdale, Florida 33340-8399
Telephone: 305 974-6610
FAX: 305 974-6182

An Axel Johnson Inc. Company

COMMENTS:

A concentrated sample was received for testing. This sample was diluted with tap water at the rate of 1.5 gallons of water per pound of sample. The soluble portion of the feed was dissolved resulting in a feed with a suspended solids concentration of 664 ppm.

The insoluble solids in this sample were thickened to approximately 5,976 ppm total suspended solids prior to the lab Lamella Gravity Settler settling tests.

Barbara Hill

REPORTED BY: Barbara J. Hill, Laboratory Manager - 7/30/91

BJH:pg
7/31/91

Material of Construction: Should be compatible with the chemical content of the sample.

Max. S.G. for Structural Design: 1.1

Type of Mixer/Flocculator:

In-line/vari-speed picket fence.
Fixed-speed propeller/variable-speed picket fence.

July 31, 1991

PARKSON CORPORATION

LABORATORY SUMMARY

DYNASAND® FILTER

CUSTOMER: EG & G IDAHO

PROJECT OR LOCATION: SCOVILLE, ID

DATE TESTED: JULY 25, 1991

SAMPLE NUMBER: 9098-0791

APPLICATION: Lamella® Gravity Settler Effluent-
Spent Sodium Bicarbonate Blasting Media

SAMPLE CHARACTERISTICS:

SUSPENDED SOLIDS: 30 ppm pH: 8.0

RECOMMENDED PRETREATMENT: None

RECOMMENDED EQUIPMENT:

DSF FEED SUSPENDED SOLIDS: less than 60 ppm

ANTICIPATED FLOW RATE: 100 GPM

NUMBER OF DSF UNITS & SIZE: One Model DSF-19

ANTICIPATED LOADING RATE: 5.3 GPM/ft^2

ANTICIPATED EFFLUENT SUSPENDED SOLIDS: 10-15 ppm

DSF MATERIALS OF CONSTRUCTION: Should be compatible with chemical content of the feed slurry.

COMMENTS: A simulated Lamella Gravity Settler effluent was filtered through 1.3-1.4 mm effective size sand with no additional pretreatment.

Barbara Hill

Barbara J. Hill, Laboratory Manager - 7/30/91

BJH:pg
7/31/91

2727 N.W. 62nd Street
P.O. Box 408399
Fort Lauderdale, Florida 33340-8399
Telephone: 305 974-6610
FAX: 305 974-6182

FAX

DATE 8-20-91 FAX NO.

ATTENTION James Finlely

FIRM/COMPANY EG&G Idaho

CITY/STATE

SENT BY

REFERENCE

SERFILCO, LTD.

1234 Depot Street 708-998-9300
Glenview, IL 60025 U.S.A. 800-323-5431
Telex: 289557 SERFC UR FAX: 708-998-8629

No. of pages (including this one). 2

Basis: Flow 20 GPM, .6 weight % solids

Volume of Solids $20\ GPM \times .006 \times \frac{.1337\ ft^3}{gal} = 0.16\ \frac{ft^3}{min} = .963\ \frac{ft^3}{HR} = 1664\ \frac{IN^3}{HR}$

DF-17 $17\ ft^2$ filtermedia $= 2448\ in^2 = 33'' \times 74''$

1 cycle = 74"

Assuming 1/4" cake

$$\frac{1664\ \frac{IN^3}{HR}}{.25\ in} = 6,656\ \frac{in^2}{HR} = 2.72\ \frac{\text{Cycle media}}{HR}$$

$$= 5.607\ \frac{\text{yards media}}{HR}$$

$$\frac{200\ \text{yards media/roll}}{5.607\ \text{yards media/HR}} = 35.67\ HR/Roll = 4.46\ \frac{8\ HR\ Shifts}{Roll}$$

DF-17 (price code 49.0012) $9,586

200 yard rolls 5 micron media (3 min) $283 ea

'91 08/20 16:26 ☎708-657-8400 001

FAX

SERFILCO, LTD.

1234 Depot Street 708-998-9300
Glenview, IL 60025-2991 U.S.A. 800-323-5431
Telex: 289557 SERFC UR

FAX numbers -
- [ ] 708-998-8929
- [ ] 708-657-8400 (Sales Dept.)
- [ ] 708-998-8629 (Purchasing Dept.)

DATE 8-20-91 FAX NO.

ATTENTION James Findley

FIRM/COMPANY EG&G Idaho

CITY/STATE/COUNTRY Idaho Falls, Idaho 83415

SENT BY Brian J. Fitzgerald

REFERENCE DF units

No. of pages (including this one). 2

50 inch media, 1/4" cake

$$\frac{6,656 \frac{in^2}{Hr}}{50"} = 133 \frac{\text{inch media}}{Hr} = 3.694 \text{ yards}/Hr.$$

$$\frac{200 \text{ yard/rolls}}{3.694 \text{ yards}/Hr} = 54.14 \frac{Hrs}{Roll} = 6.77 \frac{8 \text{ Hr. Shifts}}{Roll}.$$

200 yard Roll 50" wide (3 roll min) $413.

DF-19-5 (pc 49-0015) $9,586

Jim,

All of these calculations are estimates only. Without Test I cannot garentee a 1/4" cake on the media. However, it is a reasonable estimate. I have given you prices on two different unit just for Reference. Please give me a call tomorrow and I will explain this for you.

Brian

8/22 3:40 CALL from B.F.

RANGE OF CAKE THICKNESSES,
1/8" - 3/8"

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