

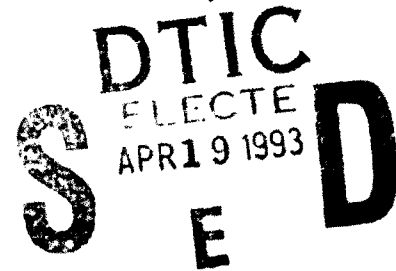
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Arthur D Little

**Survey of
Generation and
Management of
Explosive-Laden
Spent Carbon**

Final Report



Prepared for:
U.S. Army Toxic and
Hazardous Materials Agency
(USATHAMA)
Aberdeen Proving Ground,
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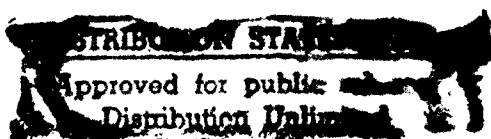


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Nine Army installations were surveyed with respect to current methods of managing activated carbon spent during the treatment of explosive-containing wastewater. The initial purpose of this survey, designed to follow-up on a previous survey conducted in 1986, was to identify the potential market of explosive-laden carbon for commercial regeneration. Additional objectives of the survey were to document spent carbon management efforts and regeneration experiences of the individual installations surveyed. The following summarizes the primary findings of this survey: • A greater than 40% decrease in spent carbon generation has occurred since 1986; • An increase in spent carbon generation (Army-wide) is unlikely within the next two years; • Experiences with regeneration of explosive-laden carbon are mixed (ranging from negative to positive) across the installations surveyed; and (continued)					
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19. ABSTRACT (continued)

- Shipping the spent carbon off-site for use as a supplemental fuel in cement kilns has become an attractive alternative for some installations.

Based on these, and other findings, it is concluded that management of explosive-laden carbon is something that must be considered on a site-by-site basis.

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1.0 Summary

In 1987, a survey of U.S. Army facilities generating energetic-contaminated carbon was conducted by Arthur D. Little, Inc. under contract to the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). This survey generated data used to conduct technical and economic assessments of spent carbon management alternatives including different configurations of: thermal regeneration, oxidative incineration, and thermal deactivation. The results of this study indicated that, at that time, off-site commercial thermal regeneration was the most cost-effective alternative for management of this carbon (1).

In 1992, Arthur D. Little was tasked to update selected findings of the 1987 study. The primary objective of this follow-up effort was to identify the potential market of explosive-laden carbon for commercial regeneration. The information to be developed could then be used by the Army for presentation to potential commercial regeneration sources.

Additional objectives of the 1992 efforts, as described in this report, included the identification of current spent carbon management approaches taken by the Army facilities and documentation of regeneration experiences.

Based on discussions relating to a prepared questionnaire submitted to eight installations in 1992, the following features of explosive-laden carbon generation and management experiences were identified:

- Since 1986, a greater than 60% decrease (from approximately 466,000 to 168,000 lb/yr) in total explosive-laden carbon generation has occurred. A factor contributing to this decrease is the halt in trinitrotoluene (TNT) production at Radford Army Ammunition Plant (AAP) resulting in the elimination of approximately 175,000 lb/yr of explosive-laden carbon. However, excluding this factor, a decrease of greater than 40% has been experienced by the other facilities: from an estimated rate of 291,000 lb/yr in 1986 to approximately 168,000 lb/yr in 1991.
- An increase in explosive-laden carbon generation is unlikely within the next two years. Of the six current explosive-laden carbon generators, four do not expect any change in generation rates. One generator anticipates significant decreases over the next two years as existing contracts expire. The final facility will no longer be generating spent carbon as of May 1992.
- Of the five active explosive-laden carbon generators, four manage the spent carbon as a KO45 hazardous waste. (Note: KO45 is the hazardous waste number assigned under the Resource Conservation and Recovery Act [RCRA] for spent carbon from the treatment of wastewater containing explosives.) The fifth generator, in agreement with state regulators, may "delist" the waste by batch by demonstrating lack of explosive reactivity.
- Experiences with regeneration of explosive-laden carbon are mixed across the installations surveyed. Expressed opinions of the efficacy of carbon regeneration based on experience range from negative (will not further consider regeneration) to positive (will actively pursue regeneration).
- There is apparently only one commercial regenerator experienced in regenerating explosive-spent carbon and willing to continue doing so.
- Two facilities ship explosive-spent carbon off-site for use as a supplemental fuel in cement kilns.

Since the time of the 1987 study, a new alternative for the management of explosive-laden carbon has surfaced. This alternative takes advantage of the heating value of the spent carbon by using the waste as a supplemental fuel for cement kilns. This approach, successfully implemented by two Army facilities, provides an attractive alternative based on implications of resource recovery, cost, and the transformation of a hazardous waste into a non-hazardous product.

It is apparent from the findings of the current survey, that the best approach to be taken for the management of explosive-laden spent carbon may be based on site-specific characteristics and requirements. This conclusion is supported by the relatively wide variance in acceptance of regeneration among the facilities as well as the pursuit of alternative approaches by some facilities.

Because of the various factors described above, it appears that management of explosive-laden carbon is something that must be considered on a site-by-site basis. This consideration should be based on site-specific requirements for carbon quality and wastewater treatment as well as the economics associated with carbon use and management of the spent carbon.

Addendum

The 1992 survey was designed specifically to follow up on the findings of the 1987 survey. Initially, only those installations surveyed in 1987 were surveyed in 1992. However, since the completion of the 1992 survey, it was brought to our attention that significant quantities of activated carbon were being used to treat pinkwater resulting from operations of the Western Area Demilitarization Facility (WADF) at Hawthorne Army Ammunition Plant (HWAAP). In order to include a discussion of this use of activated carbon in this report, HWAAP personnel responded to an abbreviated questionnaire regarding the generation of spent carbon (Appendix B).

A discussion of various aspects of spent carbon generation at HWAAP including current generation rates; projected generation rates; and options for management of the spent carbon is provided in Appendix B of this report. In addition, the impact of this additional spent carbon generation on the overall conclusions of this present study is described.

Despite the relatively significant increase in Army-wide explosive-laden spent carbon generation as a result of HWAAP WADF operations (an increase of approximately 10% in 1992), the decrease in Army-wide spent carbon generation since 1986 is greater than 40%. Similarly, planned increases in the use of carbon at HWAAP do not significantly affect the projected changes in spent carbon generation over the next two years: the HWAAP increase will likely be offset by overall, Army-wide decreases.

Alternatives for the management of the spent carbon generated at HWAAP are being investigated by installation personnel. Current investigations are centered on off-site regeneration.

Based on the information provided by HWAAP and presented in Appendix B, the conclusions of this study remain the same.

2.0 Background and Objective

As a result of the treatment of wastewater generated during munition production at Army facilities, spent activated carbon is generated. This carbon, spent with energetic materials (primarily nitrocompounds), represents a unique waste management challenge. In the past, individual attempts to regenerate the energetic-contaminated carbon have met with mixed success and documentation of these attempts is minimal. A few Army facilities have shipped their spent carbon to a commercial regenerator. However, the technical, economic, and practical implications of this action are not clear -- particularly from a broad-based Army perspective.

One of the problems experienced by the Army in attempting to identify issues relating to management of spent carbon is a lack of an adequate database reflecting current and projected carbon use in Army munition operations and current methods of management of spent carbon at these facilities.

In 1987, a survey of Army facilities generating energetic-contaminated carbon was conducted by Arthur D. Little, Inc. under contract to the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). One of the objectives of this effort was to take a "first look" at patterns of carbon use within the Army. Data identified in the survey were then used to conduct technical and economic assessments of spent carbon management alternatives. Technology alternatives considered in these assessments included thermal regeneration, oxidative incineration, and thermal deactivation. In addition, different implementation configurations of each technology alternative were considered: off-site (commercial), centralized, and on-site.

The conclusions of the 1987 Arthur D. Little study were that, based on available data, off-site commercial regeneration was the most economical of the alternatives examined (1). Several key questions were identified, however, that would need to be addressed before completely assessing the practicality (technical and economic) of any of the alternatives. These questions centered on issues including:

- Availability of commercial regenerators willing and able to routinely process explosive-laden carbon;
- Safety aspects of the explosive-laden carbon from the viewpoints of liability and transportability; and
- Identification of factors responsible for significant variations in the quality of regenerated carbon.

In 1992, Arthur D. Little was tasked to update selected findings of their 1987 study. The primary objective of this follow-up effort was to identify and define the potential market of explosive-laden carbon for commercial regeneration. The information to be developed could then be used by the Army for presentation to potential commercial regeneration sources.

To meet this objective, the scope of the follow-up effort was designed to address the following issues:

- Current explosive-laden carbon generation rates at major Army Ammunition Plants;
- Current methods of management of explosive-laden carbon; and

- Future trends in explosive-laden carbon generation.

In addition, information from the facilities was obtained addressing other aspects germane to the potential for regeneration of explosive-laden carbon. These aspects include:

- Safety and regulatory considerations associated with spent carbon management (including handling and transportation); and
- Experiences with regeneration.

3.0 Approach

This survey effort was initiated by the preparation of a questionnaire for distribution to cognizant installation personnel. This questionnaire was developed jointly through discussions between the USATHAMA and Arthur D. Little project engineers. The resulting questionnaire is illustrated in Figure 3-1.

As can be seen in Figure 3-1, the questionnaire addresses issues directly related to the objectives of this effort as well as issues that may indirectly affect the results of the survey or that may be useful to USATHAMA in the future. It is important to note that the questionnaire addresses only the generation and management of carbon spent with nitrobodyies: carbon used to remove solvents and other organics from waste streams was not part of this evaluation.

The questionnaires were distributed to specific installation points of contact by U.S. Armament, Munitions, and Chemical Command (AMCCOM) personnel. To facilitate installation responses to the questionnaire, a telephone interview with each point of contact was conducted using the questionnaire as an outline for discussion. Results of these interviews are provided in Appendix A of this report.

The findings of the interviews are discussed in the subsequent sections of this report.

Figure 3-1. Spent Carbon Generation Survey

Characterization of Activated Carbon Usage and Spent Carbon Management at Army Facilities

A. Activated Carbon Adsorption Use

A1. Type of carbon used

- Supplier: _____
- Grade: _____
- Mesh Size: _____

A2. Total number of carbon beds: _____

A3. Quantity of carbon in each bed: _____

A4. Usual frequency (i.e. lb/day) of carbon replacement: _____

A5. Purchase cost of carbon: \$ _____/lb in _____ lb lots

A6. Design Basis for carbon adsorbers :

A7. Do you anticipate any significant changes in the amount of carbon currently used? If so, how much of a change and why?

B. Treatment and/or Disposal of Explosive-Laden Spent Activated Carbon

B1. Are any chemical analyses performed to determine the content of explosives and other organics on the spent carbon? If so, what is a typical analysis?

B2. What is the explosive safety classification of the explosive-laden spent carbon?

B3. How is explosive-laden carbon disposed of or managed?

- _____ On-site open burning
- _____ On-site incineration in explosive waste incinerator
- _____ Regenerated on-site. If so, how?
- _____ Temporary on-site storage
- _____ Off-site disposal
- _____ Off-site regeneration

B4. What is the position of local, state, or regional environmental regulators with respect to management of spent carbon?

How does this position affect management of the carbon?

B5. If explosive-laden carbon is shipped off-site for disposal:

- What is the type, size, and cost of container used for shipping?
- How much carbon can be packed into each of the containers?
- Is the spent carbon dewatered before the carbon is packed? How?

C. On-Site Explosive Waste Incinerator (EWI) Characteristics

Is the facility equipped with an incinerator for disposing of explosive wastes? If so:

C1. What type of explosive waste incinerator?

C2. Has the EWI been used to incinerate explosive-laden spent carbon? If so:

- Were there any unusual circumstances or concerns involving such incineration? (i.e. air emission excursions, increased safety awareness, changes in incinerator operating parameters or burning patterns)
- Was an analysis of residues performed? Are any data available? If so, provide.
- How were residues managed?

D. Experiences with Regeneration of Explosive-Laden Spent Carbon

If explosive-laden spent carbon from facility has been regenerated either on-site or off-site:

D1. Is explosive-laden spent carbon from facility currently being regenerated?

D2. Has explosive-laden carbon from facility been regenerated in the past and is no longer? Why not?

D3. If regeneration has been performed by contract, identify firms responsible for regeneration.

D4. What are specific experiences with regeneration (on-site or off-site) with respect to:

- Quality of the regenerated carbon
- Carbon weight loss
- Degree of attrition
- Cost

E. Site-Specific Factors Affecting Actual or Potential Regeneration of Explosive-Laden Spent Carbon

E1. Has regeneration of this carbon every been considered?

E2. What are major issues regarding regeneration of this carbon? (i.e. regulatory, safety, cost, quality control)

E3. Is there any facility policy or opinion regarding explosive-laden spent carbon regeneration: on-site and off-site?

Source: Arthur D. Little, Inc.

4.0 Findings

4.1 Spent Carbon Use and Generation Rates

Of the eight installations surveyed, six are currently generating activated carbon laden with nitrobenzenes as a result of treatment of pinkwater generated during load, assemble, and pack (LAP) operations. A seventh installation (Joliet AAP) has not used activated carbon in operations since 1975 and has no specific plans to do so in the future. The eighth installation, Radford AAP, last used carbon for the treatment of wastewater generated during the production of TNT in 1986, at which time TNT production operations ceased at that installation.

Current spent carbon generation rates for each of the installations surveyed are provided in Figure 4-1. This table also illustrates the spent carbon generation rates identified in the 1987 study. These data (excluding values for Joliet AAP) are represented graphically in Figure 4-2.

As can be seen in Figures 4-1 and 4-2, spent carbon generation has decreased significantly since 1986. A comparison of the totals reflects a decrease of greater than 60% in spent carbon generation from 1986 to 1992. A factor in this decrease is the halt in TNT production operations at Radford AAP reflecting a drop from 175,000 lb/yr of spent carbon generated in 1986 to zero in 1992. Nevertheless, excluding this factor from the analysis indicates that a decrease of over 40% has occurred at the other six active installations.

Anticipated changes in spent carbon generation rates over the next two years are provided in Figure 4-3. Based on current knowledge of installation personnel, quantification of these changes could not be made; therefore, Figure 4-3 is indicative of anticipated relative changes only. Of the eight installations surveyed, six anticipate no change in spent carbon generation rates over the next two years. Two installations, Louisiana and Mississippi AAPs, project decreases in that same time period. In fact, as of May 1992, Mississippi AAP will no longer generate spent carbon. In summary, based on the survey results, it is anticipated that overall spent carbon generation will decrease over the next two years.

4.2 Current Spent Carbon Management Approaches

A summary of current methods of spent carbon management is provided in Figure 4-4.

It was apparent from the interviews that each installation has examined spent carbon management alternatives and has selected an approach suited for the specific circumstances and requirements of the site. No installation expressed significant concerns or problems associated with management or handling of the carbon.

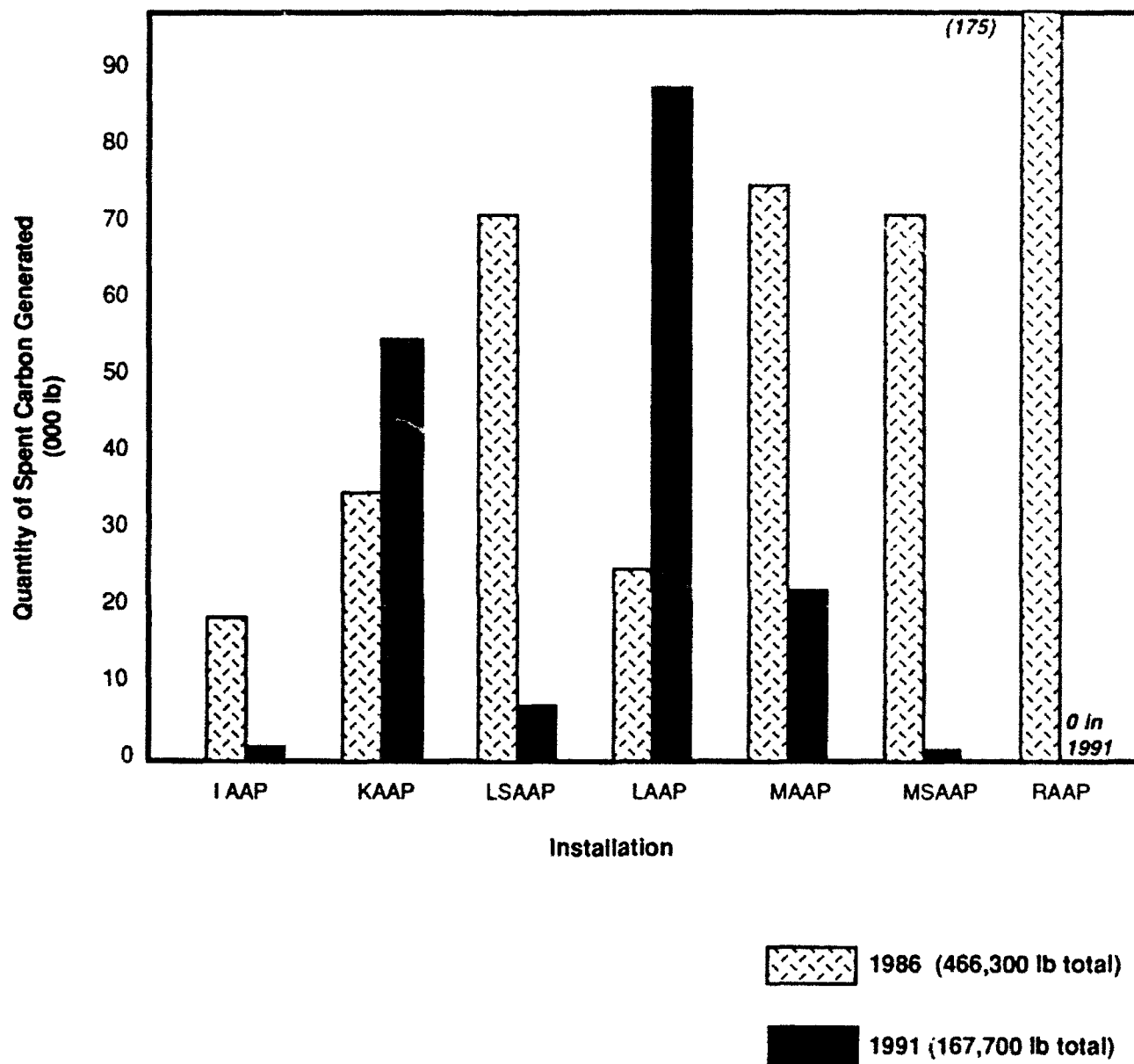
Two installations, Iowa AAP and Lone Star AAP, are currently shipping their spent carbon as a hazardous waste (listed KO45) to an off-site, commercial regenerator. Both installations are now using carbon previously regenerated by the commercial firm. In addition to the KO45 carbon, Lone Star AAP generates carbon spent with metals from its lead and chromium treatment plants. This carbon, classified as non-hazardous, is also shipped off-site for regeneration.

Figure 4-1. Spent Carbon Generation

Facility	Annual (1986) Estimated Carbon Generation (lb/yr)	Annual (1991) Estimated Carbon Generation (lb/yr)
Iowa AAP	18,700	1,200
Joliet AAP	0	0
Kansas AAP	34,400	53,000
Lone Star AAP	70,000	5,500
Louisiana AAP	23,300	86,600
Milan AAP	74,900	20,600
Mississippi AAP	70,000	800
Radford AAP	175,000	0
Totals	466,300	167,700

Source: Arthur D. Little, Inc.

Figure 4-2. Spent Carbon Generation (1986/1991)



Source: Arthur D. Little, Inc.

Figure 4-3. Spent Carbon Generation Trends

Facility	Likely Trend In Carbon Generation
Iowa AAP	No Change
Joliet AAP	No Change
Kansas AAP	No Change
Lone Star AAP	No Change
Louisiana AAP	Less (1)
Milan AAP	No Change
Mississippi AAP	Less (2)
Radford AAP	No Change

Notes

- (1) Facility anticipates significant reductions over the next two years
(2) Spent carbon will no longer be generated as of May 1992

Source: Arthur D. Little, Inc.

Figure 4-4. Spent Carbon Management

Facility	Current Method of Spent Carbon Management (1992)
Iowa AAP	Off-site regeneration
Joliet AAP	N/A
Kansas AAP	Off-site shipment to cement kiln
Lone Star AAP	Off-site regeneration
Louisiana AAP	Temporary storage/off-site disposal
Milan AAP	Off-site shipment to cement kiln
Mississippi AAP	On-site storage
Radford AAP	N/A

Note: N/A - Not Applicable

Source: Arthur D. Little, Inc.

Louisiana AAP currently stores spent carbon as a hazardous waste on-site pending off-site shipment for disposal. Bids for the regeneration of this spent carbon on a trial basis are currently being solicited.

Because of the small volume of spent carbon generated and the upcoming halt in activities at Mississippi AAP, the spent carbon is being stored on-site pending a decision on final disposition of the carbon after May 1992.

Milan and Kansas AAPs ship spent carbon to cement kilns for use as a supplemental fuel. This management practice represents a relatively new alternative for this carbon and is discussed in greater detail in Section 5.0 of this report. Milan AAP manages the spent carbon as a KO45 hazardous waste. Kansas AAP has negotiated with Kansas state regulators (with the concurrence of the Environmental Protection Agency) to allow them to "delist by batch". This "delist by batch" status allows the facility to manage the spent carbon as a non-hazardous waste based on batch reactivity tests without formally petitioning to delist.

4.3 Experiences with Regeneration

Six of the installations surveyed have investigated the potential for regeneration of spent carbon. Their experiences with regeneration are summarized in Figure 4-5 and discussed below. The only commercial regenerator used by these installations is Envirotrol located in Sewickley, Pennsylvania. Envirotrol uses countercurrently-fired rotary kilns to regenerate the carbon (1).

Iowa AAP. A single 10,000 lb shipment of spent carbon was made to Envirotrol for regeneration. Regeneration of this lot yielded 8,500 lbs of regenerated carbon that was returned to Iowa. This regenerated carbon was placed into one column for use. Initially, the effluent from that column exceeded Total Suspended Solids (TSS) limits due to excessive fines. After continued use, TSS were reduced to acceptable levels. According to installation personnel there has not been an assessment of the effect of regeneration on effectiveness of the carbon.

Kansas AAP. A sample of spent carbon was sent to Envirotrol for an evaluation of the potential for regeneration. The regeneration process resulted in the complete "shattering" of the carbon structure and the carbon was rejected by Envirotrol. Kansas personnel suspect that the cause of this failure was the virgin carbon used and feel that an alternate virgin carbon might result in more favorable regeneration. Further investigations into regeneration have not been pursued.

Lone Star AAP. Lone Star AAP has continued to ship its explosive-laden carbon to Envirotrol in Pennsylvania for regeneration since the time of the 1987 study. Although the regenerated carbon is of apparent acceptable quality, operators are less pleased with its performance. It has been noted that the paperwork and documentation required for shipment to Envirotrol and subsequent processing has increased with each batch regenerated. Much of this increased documentation is apparently due to increasingly stringent regulatory requirements imposed by Pennsylvania for waste brought into the state.

Figure 4-5. Carbon Regeneration Experiences

Facility	Source of Virgin Carbon (1)	Regenerator	Carbon Weight Loss	Degree of Attrition (2)	Quality (3)	Cost to Regenerate (\$/lb)
Iowa AAP	Calgon-VLP	Envirotrol	15% (by wt)	High	Unknown	0.75
Kansas AAP (3)	Unknown	Envirotrol	Unknown	Very High	Unknown	N/A
Lone Star AAP	Hydro Arco HD 4000	Envirotrol	Unknown	Moderate	Less Effective	0.70
Louisiana AAP	Unknown	Envirotrol	36% (by wt)	High	Unsatisfactory	0.75
Milan AAP	Carbonundum GAC 30	Envirotrol	67% (by wt)	High	Unsatisfactory	Unknown
Radford AAP	Calgon FS 400	Envirotrol	Unknown	Moderate	Effective	0.51 (4)

Notes

- (1) Source of virgin carbon subsequently regenerated, if known.
 (2) Subjective assessment of reduction in particle size or fines generated.
 (3) Effectiveness in subsequent use.
 (4) Cost in 1986.

N/A - Not Available

Source: Arthur D. Little, Inc.

Louisiana AAP. Approximately six years ago, a sample of spent carbon generated at Louisiana AAP was regenerated. The resulting regenerated carbon exhibited a loss of structural integrity when put back into use. Attrition of the carbon resulted in a carry-over of small carbon particles and fines surfacing in the effluent from the column. Louisiana AAP personnel feel that the specific carbon used at that time may have contributed to the loss of integrity on regeneration. The potential for regeneration continues to be pursued by installation personnel.

Milan AAP. Spent carbon generated at Milan AAP was shipped to Envirotrol for regeneration on a trial basis. The resulting regenerated carbon was unsatisfactory for reuse. A two-thirds weight loss of carbon was observed. In addition, the particle size was so reduced that the regenerated carbon required blending with virgin carbon to provide for physical support of the carbon. Further investigations of regeneration have not been pursued based on these negative results.

Radford AAP. Spent carbon generated during TNT production operations prior to 1987 was proven regenerable. This spent carbon was shipped to Envirotrol and the resulting regenerated carbon was determined to be as good as virgin carbon in terms of adsorptive capacity. A slightly smaller particle size was observed, but was not shown to affect efficiency. These favorable results provided incentive for Radford AAP personnel to investigate on-site regeneration as a cost-effective approach. An electrically-heated thermal regenerator has been purchased for prove-out and demonstration at Radford AAP; however, due to insufficient funds, no testing has been performed.

5.0 Discussion of Findings

Principal findings of the present survey include:

- Since 1986, a greater than 60% decrease in total explosive-laden carbon generation has occurred. A major factor contributing to this decrease is the halt in TNT production at Radford AAP resulting in the elimination of approximately 175,000 lb/yr of explosive-laden carbon. However, excluding this factor, a decrease of greater than 40% has been experienced by the LAP facilities: from an estimated rate of 291,300 lb/yr in 1986 to 167,700 lb/yr in 1991.
- An increase in explosive-laden carbon generation is unlikely within the next two years. Of the six current explosive-laden carbon generators surveyed, four do not expect any change in generation rates. One generator anticipates significant decreases over the next two years as existing LAP contracts expire. The final facility will no longer be generating spent carbon as of May 1992.
- Of the five active explosive-laden carbon generators, four manage the spent carbon as a KO45 hazardous waste. The fifth generator, in agreement with state and federal regulators, may "delist" the waste by batch by demonstrating lack of reactivity.
- Experiences with regeneration of explosive-spent carbon are mixed across the installations surveyed. Expressed opinions of the efficacy of carbon regeneration based on experience range from negative (will not further consider regeneration) to positive (will actively pursue regeneration).
- There is apparently still only one commercial regenerator experienced in regenerating explosive-spent carbon and willing to continue doing so.
- Two facilities ship explosive-spent carbon off-site for use as a supplemental fuel in cement kilns. This management approach represents a new alternative since the time of the earlier (1987) Arthur D. Little survey.

One of the primary objectives of the current survey was to determine the current and potential market for commercial regeneration of the explosive-laden carbon. In this respect, although it has been shown that there is a market, it is also evident that the market has decreased since 1986 and is likely to further decrease over the next two years. These trends may make regeneration of this carbon a less attractive venture for commercial regenerators.

Although the attractiveness of the market for commercial regeneration may be limited, the findings of the 1987 survey and study are nevertheless reinforced by the 1992 survey. In 1987, an economic assessment of spent carbon management alternatives (on-site and off-site thermal regeneration, thermal deactivation, and incineration), indicated that the most economically attractive alternative was off-site commercial regeneration. It was identified at that time that commercial regeneration was less costly due to economy of scale. Due to the observed decrease in spent carbon generation rates, this appears to still be the case.

An additional factor affecting the potential for regeneration is the willingness of the individual installations to pursue regeneration as a spent carbon management solution. Based on the 1992 survey results, two installations (currently generating over 23% of the total generated by the six active generators) have successfully and cost-effectively employed other management alternatives based on negative experiences with off-site (commercial) regeneration.

Of the installations surveyed, all but one of the active generators manage the explosive-laden carbon as a hazardous waste. However, several facilities noted that the spent carbon is not reactive and that a potential for delisting exists. As described in Section 4.2, one facility has successfully negotiated with state regulators to allow them to "delist" the carbon by batch based on a demonstrated lack of reactivity.

The off-site shipment of the explosive-laden carbon to a cement kiln for use as a supplemental fuel appears to offer an attractive solution for the management of the spent carbon. The practice allows for resource recovery by making use of the heating value of the spent carbon. In addition, any residues remaining from its use as a fuel become part of the nonhazardous cement product. There are apparently at least two cement kiln facilities permitted to accept KO45 waste providing some flexibility and potential cost competition (See Appendix C).

Based on conversations with a representative of a waste management firm experienced in the use of cement kilns for resource recovery, the process is more cost effective than disposal of the carbon by incineration (2). Based on available data, primary factors affecting the cost of using waste as a supplemental fuel include the BTU value of the waste and handling requirements. Intuitively, the lower the BTU value, the higher the cost. Fuel feed systems and other requirements associated with material handling and blending the spent carbon with fuel for the cement kiln may also increase the cost.

In one example involving the blending of KO45 waste carbon, it was required that the spent carbon be repackaged in 5 gallon plastic containers at the cement kiln. In this instance, the cost was approximately \$0.80/lb of carbon (2). Another cement kiln has been identified that can accept carbon in bulk (greater than 55-gal) quantities. In this form, the cost of using the carbon as a supplemental fuel is approximately \$0.05 to \$0.10/lb of carbon, depending on BTU values (2). Regardless of the required condition of the feed, resource recovery in this manner compares favorably with incineration of the material which has been estimated at \$1.20/lb (2).

Two criteria must be met prior to acceptance of explosive-laden carbon for use as a supplemental fuel in cement kilns: the wastes must be proven explosively non-reactive (see Appendix B) and a minimum BTU threshold (typically 5000 BTU/lb) must be met or exceeded. Based on data provided by Iowa AAP (see Appendix A), a representative BTU value for explosive-laden carbon is over 7000 BTU/lb - well above the threshold.

6.0 Conclusions

The generation of explosive-laden carbon has decreased significantly over the past five years, and is anticipated to further decrease over the next two years. Naturally, from a position of waste reduction, this is a positive occurrence. However, reductions such as those observed make assessments of management alternatives more difficult.

The economic analyses performed in the 1987 study by Arthur D. Little Inc. indicated that commercial regeneration was more cost-effective compared to on-site regeneration, thermal deactivation, or incineration. The economics of commercial versus on-site regeneration were most significantly impacted by the quantities of carbon to be processed due to economies of scale. For this reason, it is expected that reductions in spent carbon generation would result in reinforcing the cost-effectiveness of commercial regeneration over on-site regeneration.

However, commercial regeneration requires that an appropriate market exist for a regenerator's efforts. As the market decreases, commercial interest may decrease also. One of the problems identified in the 1987 study was that only one commercial regenerator was willing to routinely regenerate explosive-laden carbon; thus, mandating that the Army rely on a service with one supplier. This situation has evidently not changed.

Fortunately, there is a relatively new alternative surfacing for the management of explosive-laden carbon. Since the time of the 1987 study, explosive-spent carbon has been considered for use as a supplemental fuel for cement kilns. This approach, successfully implemented by two Army facilities, provides an attractive alternative based on implications of resource recovery, cost, and the transformation of a hazardous waste into a non-hazardous product.

It is apparent from the current survey of Army explosive-laden carbon generators, that the best approach to be taken for the management of this carbon is based on site-specific characteristics and requirements. This is emphasized by the relatively wide variance in acceptance of regeneration among the facilities. Regeneration is only feasible if the regenerated product is of use. If the regenerated product is not acceptable, it remains a waste.

Because of the various factors described above, it appears that management of explosive-laden carbon is something that must be considered on a site-by-site basis. This consideration should be based on site-specific requirements for carbon quality and wastewater treatment as well as the economics associated with carbon use and management of spent carbon.

7.0 References

- (1) Arthur D. Little, Inc., 1987, *Treatment Alternatives for Explosive-Laden Spent Carbons*, Report No. AMXTH-TE-CR-87140.
- (2) Key Environmental Services, Inc., 1992, Personal Communication with R. McAtee, President and Vendor Literature (Appendix C).

Appendix A

Carbon Generation Survey Results

Personnel Contacted

Installation	Point of Contact	Phone Number
Iowa AAP	Leon Baxter	(319) 753-7130
Joliet AAP	Bernie Kavanaugh	(815) 424-2326
Kansas AAP	Victoria O'Brien	(316) 421-7574
Lone Star AAP	Stephanie Grelle	(903) 334-1690
Louisiana AAP	Steve Flowers	(318) 459-5132
Milan AAP	Bill Blaylock	(901) 686-6739
Mississippi AAP	Wayne Gouguet	(601) 689-8761
Radford AAP	Dave Lieving	(703) 639-8746

Source: Arthur D. Little, Inc.

Activated Carbon Usage and Management Survey

Facility

Iowa AAP

Current Carbon Generation Status

Active

A Activated Carbon Usage Characteristics

A1 Type of carbon

Supplier

Calgon

Grade

Dedusted VLP

Mesh Size

6 X 16

A2 Number of carbon beds

32 of which 8 are "small"

A3 Quantity of carbon in each bed

600 lb in "standard" beds

A4 Typical frequency of carbon replacement

600 lb/180 days

A5 Purchase price of carbon

\$2.25/lb in 10,000 lots

A6 Carbon adsorber design information

800 gpm through 18,000 lb carbon (no specified time)

A7 Anticipated changes in carbon usage

None anticipated

B Management of Spent Carbon

B1 Chemical analyses of spent carbon

Analysis performed by Envirotrol (copy provided)

B2 Explosive safety classification

Hazard classification: ORM-E

B3 Management of spent carbon

Off-site regeneration

B4 Regulatory position with respect to management of spent carbon

Hazardous waste. Permitted RCRA Part B storage

B5 Off-site shipment of spent carbon

Type, size, cost of container used

55 gal steel drum, DOT 17H, \$33/drum

Quantity of carbon packed into each container

500 lb

Is spent carbon dewatered? How?

Not dewatered

C Is Facility Equipped with Explosive Waste Incinerator?

Yes

C1 Type of incinerator

Explosive waste incinerator (APE-1236)

C2 Has incinerator been used to destroy spent carbon

Yes

Observations

None out of the ordinary

Analysis of residues

None performed

Management of residues

Managed as hazardous waste

(Continuation)

Facility

Iowa AAP

D Experiences with Regeneration of Spent Carbon

D1	Is carbon currently being regenerated?	Yes
D2	If carbon was regenerated in the past and is no longer, why?	N/A
D3	Firms responsible for regeneration	Envirotrol
D4	Experiences with regeneration	One 10,000 lb shipment to Envirotrol
	Quality of regenerated carbon	Satisfactory from appearance (Note 1)
	Carbon weight loss	0.15 (85% returned)
	Degree of attrition	See Note 1
	Cost	\$0.75/lb

E Site-Specific Factors Affecting Carbon Regeneration

E1	Has regeneration ever been considered?	Yes
E2	What are major issues regarding regeneration?	Regulatory - hazardous waste classification
E3	Facility policy regarding carbon regeneration	
	On-site	None
	Off-site	None

NOTE 1.

A single 10,000 lb shipment of spent activated carbon was sent to Envirotrol for regeneration. The regenerated carbon received from Envirotrol was placed into only one column. Initially, limits on total suspended solids (TSS) in the effluent from that carbon were exceeded possibly indicating that there were a large number of fines in the regenerated carbon. The column is currently meeting TSS effluent limits. There has not been enough experience with the regenerated carbon to determine its quality.

N/A - Not Applicable

Source: Arthur D. Little, Inc.

Sample Spent Carbon Hazardous Profile

Parameter, unit	Characteristic
pH	5.19
Cyanide, mg/kg	<10.7
Sulfide, mg/kg	8.54
Oil & Grease, mg/kg	4990
Arsenic, mg/kg	2.23
Barium, mg/kg	136
Cadmium, mg/kg	<1.27
Chromium, mg/kg	12.5
Lead, mg/kg	8.17
Mercury, mg/kg	<0.13
Nickel, mg/kg	4.24
Selenium, mg/kg	<0.95
Silver, mg/kg	<1.12
Copper, mg/kg	34.3
Molybdenum, mg/kg	<12.7
Zinc, mg/kg	90.9
Flashpoint	No Flash
Reactivity, mg/kg	
Cyanide	<25
Sulfide	<25
Antimony, mg/kg	8.04
Hexavalent Chromium, mg/kg	<0.26
TOC, mg/kg	1960
EOX, mg/kg	0.789
Total solids, %	74.96
PCBs, mg/kg	<9.23
Volatile solids, %	15.52
2,3,7,8-TCDD, mg/kg	<10
DBCP, mg/kg	<51
BTU/lb	7771

Source: Iowa AAP

Activated Carbon Usage and Management Survey

Facility	Kansas AAP
Current Carbon Generation Status	Active
A Activated Carbon Usage Characteristics	
A1 Type of carbon	
Supplier	Various
Grade	N/A
Mesh Size	N/A
A2 Number of carbon beds	14
A3 Quantity of carbon in each bed	900 lb
A4 Typical frequency of carbon replacement	1075 lb/week; 53,000 lb/yr
A5 Purchase price of carbon	N/A
A6 Carbon adsorber design information	N/A
A7 Anticipated changes in carbon usage	None
B Management of Spent Carbon	
B1 Chemical analyses of spent carbon	RDX/TNT <11,000 ppm. Reactivity - negative.
B2 Explosive safety classification	None
B3 Management of spent carbon	On-site storage; off-site shipment to cement kiln (See Note 1)
B4 Regulatory position with respect to management of spent carbon	Kansas AAP has received policy letter from EPA and state that allows for "delisting by batch"
B5 Off-site shipment of spent carbon	
Type, size, cost of container used	55 gal steel drums
Quantity of carbon packed into each container	345 lb
Is spent carbon dewatered? How?	Yes, by gravity
C Is Facility Equipped with Explosive Waste Incinerator?	
	Yes
C1 Type of incinerator	Explosive Waste Incinerator (APE 1236)
C2 Has incinerator been used to destroy spent carbon	No
Observations	
Analysis of residues	
Management of residues	

(Continuation)

Facility

Kansas AAP

D Experiences with Regeneration of Spent Carbon

- | | | |
|----|--|--|
| D1 | Is carbon currently being regenerated? | No |
| D2 | If carbon was regenerated in the past and is no longer, why? | Sample sent to Envirotrol for test. Carbon "shattered" beyond usefulness. Although the use of an alternate virgin carbon might help, there is no interest in doing so. |
| D3 | Firms responsible for regeneration | Envirotrol |
| D4 | Experiences with regeneration | |
| | Quality of regenerated carbon | Carbon was "shattered" rendering it useless |
| | Carbon weight loss | |
| | Degree of attrition | |
| | Cost | |

E Site-Specific Factors Affecting Carbon Regeneration

- | | | |
|----|---|-------------------------------|
| E1 | Has regeneration ever been considered? | Yes (see above) |
| E2 | What are major issues regarding regeneration? | Quality of regenerated carbon |
| E3 | Facility policy regarding carbon regeneration | |
| | On-site | None |
| | Off-site | None |

NOTE 1.

Kansas AAP has shipped their spent carbon to a cement kiln facility in Kansas City for use as a fuel supplement. They have evidently done this for the last few years. Although the facility in Kansas City is permitted for KO45 wastes, since Kansas AAP's spent carbon is "delisted by batch", that is not an issue. The cost to Kansas AAP for this is about \$225/drum (\$0.65/lb).

N/A - Not Available

Source: Arthur D. Little, Inc.

Activated Carbon Usage and Management Survey

Facility

Lone Star AAP

Current Carbon Generation Status

Active

A Activated Carbon Usage Characteristics

- A1 Type of carbon Regenerated and Virgin
Supplier Virgin: American Norit Co.
Grade Hydro Arco HD 4000
Mesh Size 12 X 40
- A2 Number of carbon beds 7 beds for pinkwater treatment (See Note 1)
- A3 Quantity of carbon in each bed 500 lb
- A4 Typical frequency of carbon replacement 5500 lb/year (47 drums in 3 years)
- A5 Purchase price of carbon Virgin: \$1.00/lb in 1200 lb pallets. Regenerated \$0.70/lb
- A6 Carbon adsorber design information 0.125 lb TNT/lb carbon adsorptive capacity
- A7 Anticipated changes in carbon usage None

B Management of Spent Carbon

- B1 Chemical analyses of spent carbon Analysis currently being performed
- B2 Explosive safety classification None (shipped as Hazardous Waste)
- B3 Management of spent carbon Off-site regeneration
- B4 Regulatory position with respect to management of spent carbon Local - none (See Note 2)
- B5 Off-site shipment of spent carbon
Type, size, cost of container used Lined, 55-gal steel drum, \$20/ea
Quantity of carbon packed into each container 350 lb
Is spent carbon dewatered? How? Yes. Burlap placed over top of filled drum. Drum inverted.

C Is Facility Equipped with Explosive Waste Incinerator?

No

- C1 Type of incinerator
- C2 Has incinerator been used to destroy spent carbon
Observations
Analysis of residues
Management of residues

(Continuation)

Facility

Lone Star AAP

D Experiences with Regeneration of Spent Carbon

- | | | |
|----|--|---|
| D1 | Is carbon currently being regenerated? | Yes |
| D2 | If carbon was regenerated in the past and is no longer, why? | N/A |
| D3 | Firms responsible for regeneration | Envirotrol |
| D4 | Experiences with regeneration | |
| | Quality of regenerated carbon | Operators less pleased with quality. Not as effective |
| | Carbon weight loss | Unknown |
| | Degree of attrition | Unknown (suspected significant) |
| | Cost | \$0.70/lb (excluding shipping - approx. \$4,000/77 drums) |

E Site-Specific Factors Affecting Carbon Regeneration

- | | | |
|----|---|-------------|
| E1 | Has regeneration ever been considered? | Not on site |
| E2 | What are major issues regarding regeneration? | See Note 2 |
| E3 | Facility policy regarding carbon regeneration | |
| | On-site | None |
| | Off-site | See Note 2 |

NOTE 1.

In addition to the seven pinkwater treatment carbon beds, there are 2-200 lb beds in the Cr treatment plant and 1-500 lb bed in the Pb treatment plant. Carbon generated from the operation of these beds totalled 121 drums in three years. This carbon is non-hazardous and is regenerated by Envirotrol.

NOTE 2.

The installation has experienced significant paperwork hurdles in getting the latest shipment of KO45 carbon off to Envirotrol. According to Ms. Grelle (Day Zimmerman), the amount of pre-shipment efforts necessary to meet Envirotrol and Pennsylvania (location of Envirotrol's plant) requirements has increased dramatically since the last shipment was made three years ago. Ms. Grelle said that if there was a viable alternative it would be pursued to reduce the time and problems associated with the current shipment.

N/A - Not Applicable

Source: Arthur D. Little, Inc.

Activated Carbon Usage and Management Survey

Facility

Louisiana AAP

Current Carbon Generation Status

Active

A Activated Carbon Usage Characteristics

A1 Type of carbon

Supplier

Calgon

Grade

Filtrisorb 400

Mesh Size

12 X 40

A2 Number of carbon beds

18

A3 Quantity of carbon in each bed

1000 lb

A4 Typical frequency of carbon replacement

1000 lb/4 days (86,600 lb/year)

A5 Purchase price of carbon

\$0.95/lb in 7500 lb lots

A6 Carbon adsorber design information

7 of 9 treatment systems operate with 2 beds in series at 10 gpm. 2 systems operate with 2 beds in series at 20 gpm
Not this year, however as existing contracts expire, usage will decrease drastically over the next 2 years

A7 Anticipated changes in carbon usage

B Management of Spent Carbon

B1 Chemical analyses of spent carbon

None

B2 Explosive safety classification

Handled as nonexplosive & nonflammable

B3 Management of spent carbon

Temporary storage followed by off-site disposal

B4 Regulatory position with respect to management of spent carbon

Hazardous waste. Can not be landfilled

B5 Off-site shipment of spent carbon

Type, size, cost of container used

DOT 17H steel 55-gal drums, \$33/drum

Quantity of carbon packed into each container

50 gallons or 400 lb (wet)

Is spent carbon dewatered? How?

Yes. Carbon held in portable drying container and allowed to dewater by gravity for approximately 48 hours

C Is Facility Equipped with Explosive Waste Incinerator?

Yes

C1 Type of incinerator

Explosive waste incinerator (APE 1236)

C2 Has incinerator been used to destroy spent carbon

No

Observations

Analysis of residues

Management of residues

(Continuation)

Facility

Louisiana AAP

D Experiences with Regeneration of Spent Carbon

- D1 Is carbon currently being regenerated? No
- D2 If carbon was regenerated in the past and is no longer, why? Yes (See Note 1)
- D3 Firms responsible for regeneration
- D4 Experiences with regeneration (See Note 1)
- Quality of regenerated carbon Unsatisfactory
- Carbon weight loss 36% by weight
- Degree of attrition High
- Cost \$0.75/lb

E Site-Specific Factors Affecting Carbon Regeneration

- E1 Has regeneration ever been considered? Yes. Currently soliciting bids for regeneration on trial basis
- E2 What are major issues regarding regeneration? See Note 2
- E3 Facility policy regarding carbon regeneration
- On-site None
- Off-site None

NOTE 1.

Approximately six years ago, Louisiana AAP regenerated a sample of the brand of carbon in use at that time. The regenerated carbon exhibited a loss of structural integrity when put back into use. It tended to break down with a carry-over of some small carbon particles and fines surfacing in the effluent. It is believed that the particular brand of carbon used at that time may have created or contributed to the problem.

NOTE 2.

Issues relating to carbon regeneration include:

- Degree of contamination of spent carbon;
- Strength of regenerated carbon;
- Increasingly stringent regulations governing disposal;
- Cost of transportation to and from regeneration facility; and
- Effectiveness of explosives removal versus that of virgin carbon.

Source: Arthur D. Little, Inc.

Activated Carbon Usage and Management Survey

Facility

Milan AAP

Current Carbon Generation Status

Active

A Activated Carbon Usage Characteristics

A1 Type of carbon

Supplier

Carborundum Company

Grade

GAC 30

Mesh Size

8 X 30

A2 Number of carbon beds

3-40 gpm beds, 3-80 gpm beds

A3 Quantity of carbon in each bed

40 gpm beds - 2475 lb/bed; 80 gpm beds -4400 lb/bed

A4 Typical frequency of carbon replacement

20,625 lb average per year

A5 Purchase price of carbon

\$0.80/lb in 300 lb lots

A6 Carbon adsorber design information

4.61 lb nitrobodies/ft³ carbon (26 lb carbon)

A7 Anticipated changes in carbon usage

See Note 1

B Management of Spent Carbon

B1 Chemical analyses of spent carbon

Analyze for nitrobodies. Range from a few to 20 ppm NB.

B2 Explosive safety classification

None. KO45/Reactive hazardous waste

B3 Management of spent carbon

Temporary storage. Picked up by Defense Reutilization and Marketing Office (DRMO) for off-site disposition. See Note 2

B4 Regulatory position with respect to management of spent carbon

Managed as hazardous waste. DRMO handles all wastes generated at Milan AAP.

B5 Off-site shipment of spent carbon

Type, size, cost of container used

55 gal plastic-lined drums, \$26/drum

Quantity of carbon packed into each container

350 lb/drum

Is spent carbon dewatered? How?

Yes. Drained by gravity and natural evaporation. Looking at drying enhancement techniques

C Is Facility Equipped with Explosive Waste Incinerator?

No

C1 Type of incinerator

C2 Has incinerator been used to destroy spent carbon

Observations

Analysis of residues

Management of residues

(Continuation)

Facility

Milan AAP

D Experiences with Regeneration of Spent Carbon

- | | | |
|----|--|--------------------|
| D1 | Is carbon currently being regenerated? | No |
| D2 | If carbon was regenerated in the past and is no longer, why? | See Note 3 |
| D3 | Firms responsible for regeneration | Envirotrol |
| D4 | Experiences with regeneration | See Note 3 |
| | Quality of regenerated carbon | Not useful |
| | Carbon weight loss | two-thirds |
| | Degree of attrition | Extreme |
| | Cost | Not cost-effective |

E Site-Specific Factors Affecting Carbon Regeneration

- | | | |
|----|---|---|
| E1 | Has regeneration ever been considered? | Yes |
| E2 | What are major issues regarding regeneration? | Quality control |
| E3 | Facility policy regarding carbon regeneration | Not interested in regeneration based on past experience |
| | On-site | |
| | Off-site | |

NOTE 1.

Two factors will influence future carbon usage patterns. First, an upcoming National Pollutant Discharge Elimination System (NPDES) review will probably result in a reduction in nitrobenzenes allowed in treatment effluent resulting in an increase in carbon usage. Secondly, methods to reduce the generation of pinkwater will be implemented in the near term which will reduce the usage of carbon. The general feeling is that the net generation of carbon will be the same.

NOTE 2.

Last shipment of carbon was sent to a firm in Kansas City for use as a fuel supplement for a cement kiln. Installation is planning to attempt to delist the carbon.

NOTE 3.

Previous attempt to thermally regenerate (by Envirotrol) produced a regenerated carbon with significantly changed physical characteristics. The attrition rate was so high that the regenerated carbon had to be mixed with virgin carbon just to physically support it.

Source: Arthur D. Little, Inc.

Activated Carbon Usage and Management Survey

Facility

Mississippi AAP

Current Carbon Generation Status

Inactive as of May 1992

A Activated Carbon Usage Characteristics

A1 Type of carbon

Supplier

Various - competitive bid

Grade

Mesh Size

A2 Number of carbon beds

2

A3 Quantity of carbon in each bed

2000 lb

A4 Typical frequency of carbon replacement

2000 lb every two to three years (app. 800 lb/yr)

A5 Purchase price of carbon

\$1.00/lb in 50 lb lots

A6 Carbon adsorber design information

15-20 gpm. RDX limit of 1 ppm in effluent

A7 Anticipated changes in carbon usage

Will no longer be generating spent carbon as of May 1992

B Management of Spent Carbon

B1 Chemical analyses of spent carbon

Reactivity only - negative

B2 Explosive safety classification

None.

B3 Management of spent carbon

On-site storage. Incineration in explosive waste incinerator

B4 Regulatory position with respect to management of spent carbon

Regulators have indicated that if the carbon is not reactive, then it isn't hazardous. This position is taken by Miss. AAP

B5 Off-site shipment of spent carbon

Not shipped off-site

Type, size, cost of container used

Quantity of carbon packed into each container

Is spent carbon dewatered? How?

C Is Facility Equipped with Explosive Waste Incinerator?

Yes

C1 Type of incinerator

Explosive waste incinerator (APE 1236)

C2 Has incinerator been used to destroy spent carbon

Yes

Observations

Unknown. Perhaps some fugitive emissions resulting

Analysis of residues

Subjected to reactivity test - negative

Management of residues

Landfilled on-site as non hazardous

(Continuation)

Facility

Mississippi AAP

D Experiences with Regeneration of Spent Carbon

D1 Is carbon currently being regenerated? **No**

D2 If carbon was regenerated in the past and is no longer, why?

D3 Firms responsible for regeneration

D4 Experiences with regeneration

Quality of regenerated carbon

Carbon weight loss

Degree of attrition

Cost

E Site-Specific Factors Affecting Carbon Regeneration

E1 Has regeneration ever been considered? **No. Quantity generated not sufficient to be feasible**

E2 What are major issues regarding regeneration?

E3 Facility policy regarding carbon regeneration

On-site

Off-site

Source: Arthur D. Little, Inc.

Activated Carbon Usage and Management Survey

Facility	Radford AAP
Current Carbon Generation Status	Currently inactive -- responses below reflect earlier periods of generation
A Activated Carbon Usage Characteristics	
A1 Type of carbon	Virgin and Regenerated
Supplier	Calgon Envirotrol
Grade	Filtrisorb 400 EI-40
Mesh Size	12 X 40 12 X 40
A2 Number of carbon beds	2
A3 Quantity of carbon in each bed	24,000 lb/bed
A4 Typical frequency of carbon replacement	600 lb/day (maximum)
A5 Purchase price of carbon	\$0.93/lb in 200 lb lots (virgin, 1986); \$0.50/lb regenerated
A6 Carbon adsorber design information	37500 lb/hr wastewater with 2 lb/hr contaminants (nitrobenzenes)
A7 Anticipated changes in carbon usage	No plans in place to resume TNT production
B Management of Spent Carbon	
B1 Chemical analyses of spent carbon	16 -17% nitrobenzenes on a dry weight basis (MNT, TNT, TNB)
B2 Explosive safety classification	Flammable, 1.4 Moderate Burning Hazard
B3 Management of spent carbon	Last carbon generated shipped to Envirotrol for regeneration
B4 Regulatory position with respect to management of spent carbon	Regulators encourage regeneration
B5 Off-site shipment of spent carbon	
Type, size, cost of container used	Delex HDPE drum; 59.4 gal; \$21/drum
Quantity of carbon packed into each container	400 lb
Is spent carbon dewatered? How?	Yes. Drained in bin; conveyed and drained by screw to drums (20% moisture in filled drums)
C Is Facility Equipped with Explosive Waste Incinerator?	Yes
C1 Type of incinerator	Rotary kiln. Waste propellant incinerator.
C2 Has incinerator been used to destroy spent carbon	Yes
Observations	Temperature not high enough; system not amenable to changes required to successfully burn carbon.
Analysis of residues	
Management of residues	

(Continuation)

Facility

Radford AAP

D Experiences with Regeneration of Spent Carbon

- | | | |
|----|--|--|
| D1 | Is carbon currently being regenerated? | No (no carbon being generated) |
| D2 | If carbon was regenerated in the past and is no longer, why? | When carbon was generated, method of management of spent carbon was regeneration |
| D3 | Firms responsible for regeneration | Envirotrol |
| D4 | Experiences with regeneration | |
| | Quality of regenerated carbon | Good as or equal to virgin carbon in terms of efficiency |
| | Carbon weight loss | Unknown |
| | Degree of attrition | Slightly small particle size - did not affect efficiency |
| | Cost | \$0.51/lb (1986) |

E Site-Specific Factors Affecting Carbon Regeneration

- | | | |
|----|---|---|
| E1 | Has regeneration ever been considered? | On-site - yes |
| E2 | What are major issues regarding regeneration? | Regulatory issues resolved for on-site regeneration |
| E3 | Facility policy regarding carbon regeneration | |
| | On-site | See Note 1 |
| | Off-site | Favorable - policy is cost driven |

NOTE 1.

Equipment purchased to demonstrate carbon regeneration. No funds have been provided by the Army to install and operate the equipment.

Source: Arthur D. Little, Inc.

Appendix B

Activated Carbon Use at Hawthorne Army Ammunition Plant (HWAAP)

B.0 Background

Since late 1991, the industrial waste water treatment plant located in the Western Area Demilitarization Facility (WADF) at Hawthorne Army Ammunition Plant (HWAAP) has been operated to treat pinkwater generated during demilitarization operations.

To supplement a survey of other Army facilities generated spent carbon completed early in 1992, a questionnaire was sent by USATHAMA to HWAAP personnel requesting information be provided with respect to carbon usage, spent carbon generation, and spent carbon management. The findings of the completed questionnaire are provided in Figure B-1 and are discussed below.

B.1 Carbon Use and Spent Carbon Generation Rates at HWAAP

Currently, the pinkwater treatment system at HWAAP employs two activated carbon columns; each containing 5000 lb of carbon to remove explosives (primarily nitrocompounds). Approximately 10,000 lb of spent carbon are generated every six months. According to installation personnel, there are plans to introduce two additional columns into the system thereby doubling the amount of spent carbon to be generated (to 20,000 lb per six months).

Current spent carbon generation rates at HWAAP are presented in Figure B-2 together with spent carbon generation rates at other Army facilities using activated carbon for pinkwater treatment. These data are presented graphically in Figure B-3. This figure also provides spent carbon generation rates in 1986 to illustrate the change in Army-wide spent carbon generation since that time.

Anticipated changes in spent carbon generation rates over the next two years for these Army facilities are presented in Figure B-4. With the exception of HWAAP, the Army facilities anticipate either no change or a decrease in generation of this carbon. It is expected that despite the planned increase in spent carbon generation at HWAAP, the amount of the increase will be offset by the anticipated decrease at Louisiana AAP.

B.2 Spent Carbon Management Approaches at HWAAP

Spent activated carbon is currently stored on-site at HWAAP pending off-site shipment for regeneration. As this will be the first shipment of spent carbon at HWAAP, there is no experience with respect to regenerated carbon quality and performance.

According to installation personnel, in addition to off-site regeneration, a test of on-site regeneration is being considered. The installation plans to use an existing facility (Hot Gas Decontamination Unit) for carbon regeneration by stripping the explosives from the carbon through flashing. No further details regarding these plans were provided by the installation.

B.3 Conclusions

Despite the increase in Army-wide generation of explosive-laden carbon as a result of HWAAP WADF operations (an increase of approximately 10% in 1992), the decrease in Army-wide spent carbon generation since 1986 is greater than 40%. Similarly, planned increases in the use of carbon at HWAAP do not significantly affect the projected changes in Army-wide spent carbon generation over the next two years: the HWAAP increase is likely to be offset by a higher anticipated Army-wide decrease.

Figure B-1. Activated Carbon Usage and Management at Hawthorne AAP

Facility - Hawthorne AAP

Installation Point-of-Contact: Louis Dellamonica, DSN 830-7354

Current Carbon Generation Status Active

Activated Carbon Usage Characteristics

Type of carbon

Supplier	Envirotrol - EI40
Grade	Not available
Mesh Size	Not available

Number of carbon beds	2
Quantity of carbon in each bed	5000 lb
Typical frequency of carbon replacement	10,000 lb/6 months
Purchase price of carbon	\$0.99/lb

Anticipated changes in carbon usage Plan to operate two add'l columns thus double carbon use

Management of Spent Carbon

Chemical analyses of spent carbon None

Management of spent carbon Temporary on-site storage/Off-site regeneration (planned)

Off-site shipment of spent carbon

Type, size, cost of container used	55 gal steel drum, DOT 17H, \$50/drum
Quantity of carbon packed into each container	300 lb (dry)
Is spent carbon dewatered? How?	Not currently. Will be dewatered in the future

Experiences with Regeneration of Spent Carbon

Is carbon currently being regenerated? No

Site-Specific Factors Affecting Carbon Regeneration

Has regeneration ever been considered?	Yes
What are major issues regarding regeneration?	Regulatory - impact on RCRA and Air Quality Permits

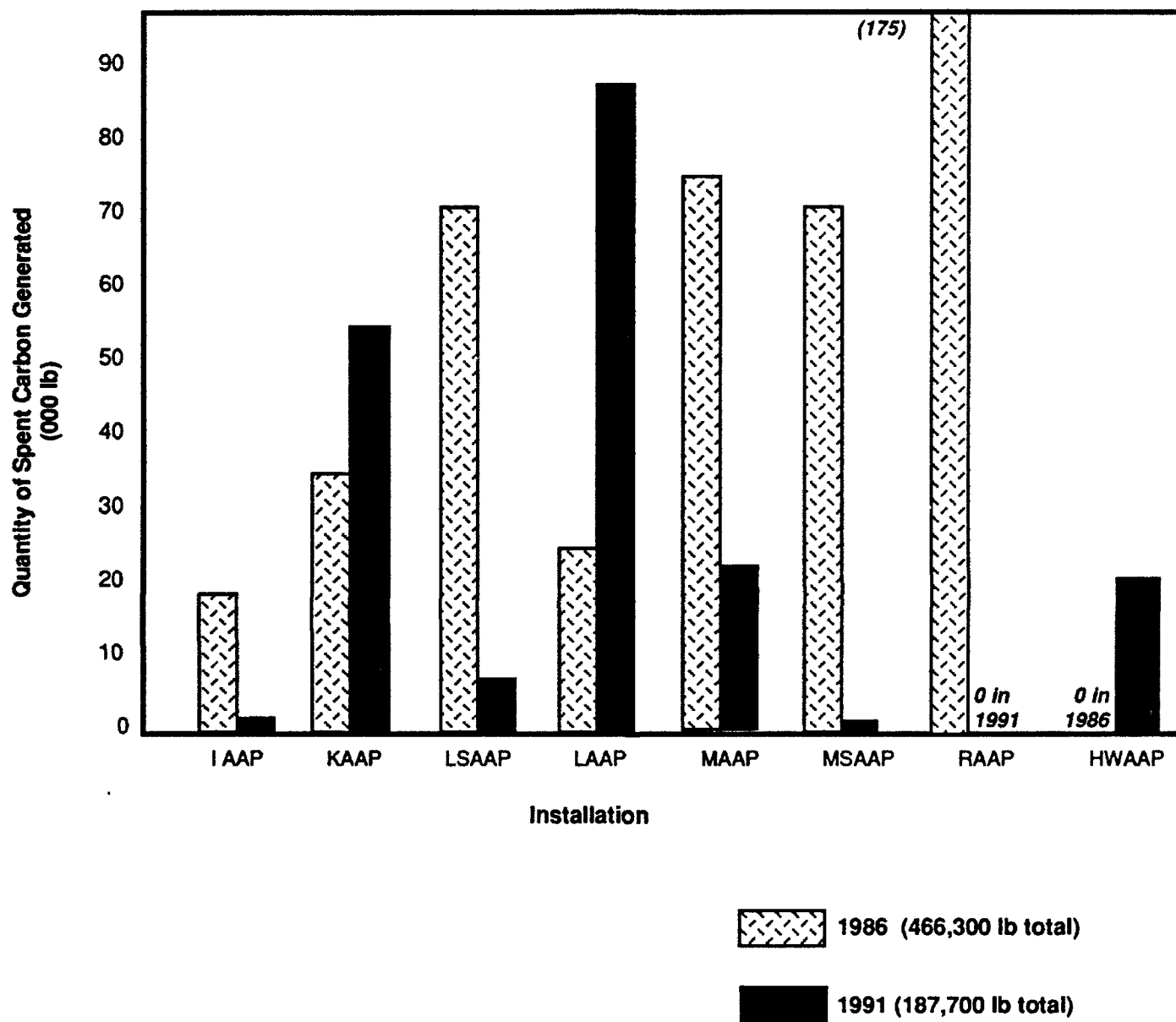
Source: Arthur D. Little, Inc.

Figure B-2. Spent Carbon Generation

Facility	Annual (1986) Estimated Carbon Generation (lb/yr)	Annual (1991) Estimated Carbon Generation (lb/yr)
Iowa AAP	18,700	1,200
Joliet AAP	0	0
Kansas AAP	34,400	53,000
Lone Star AAP	70,000	5,500
Louisiana AAP	23,300	86,600
Milan AAP	74,900	20,600
Mississippi AAP	70,000	800
Radford AAP	175,000	0
Hawthorne AAP	0	20,000
Totals	466,300	187,700

Source: Arthur D. Little, Inc.

Figure B-3. Spent Carbon Generation (1986/1991)



Source: Arthur D. Little, Inc.

Figure B-4. Spent Carbon Generation Trends

Facility	Likely Trend in Carbon Generation
Iowa AAP	No Change
Joliet AAP	No Change
Kansas AAP	No Change
Lone Star AAP	No Change
Louisiana AAP	Less (1)
Milan AAP	No Change
Mississippi AAP	Less (2)
Radford AAP	No Change
Hawthorne AAP	Increase (3)

Notes

- (1) Facility anticipates significant reductions over the next two years.
- (2) Spent carbon will no longer be generated as of May 1992.
- (3) Facility anticipates an increase of 20,000 lb per year.

Source: Arthur D. Little, Inc.

Alternatives for the management of the spent carbon generated at HWAAP are being investigated by installation personnel. Current investigations are centered on off-site commercial regeneration and the potential for on-site thermal regeneration in the existing Hot Gas Decontamination Unit.

Prior to the investigation into spent carbon use and generation at HWAAP, the conclusion reached as a result of a survey of other Army facilities generating explosive-laden spent carbon was that the best approach to be taken for the management of this carbon is based on site-specific characteristics and requirements. This conclusion was based on dramatically decreasing rates in carbon usage, varied experiences with use of regenerated carbon, and the fact that the facilities were independently pursuing management options to meet their needs. The new information obtained from HWAAP does not alter this conclusion.

Appendix C

Vendor Literature

KEY

Environmental Services

Site Assessment • Compliance Reports • Remediation • Hazardous Waste Treatment
• Storage • Disposal

March 09, 1992

To: Arthur Delittle Co., Inc.
Attn: Janet Mahannah
2113 Emmerton Park Road, Suite 101
Edgewood, Maryland 21040

Subject: K045, Activated Carbon

Dear Janet;

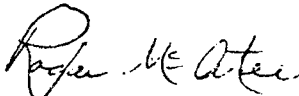
I was very glad to discuss the K045 project with you, and it was pleasant that you have concern about the highest, and best use of the Carbon. Fuel blending is the best method to utilize the K045 Activated Carbon, and fuel blending does constitute recycling.

Important factors as follows:

1. The price of fuel blending varies depending on how the Carbon is shipped, which facility etc. Milan Tennessee was packaged in 55 gallon drums, and went to Ash Grove Cement after the Carbon was repackaged in 5 gallon plastic containers. The price at Riedel was \$300.00 to \$325.00 per 55 gallon drum depending on B.T.U. Value. Minimum B.T.U. Value is 5000 per pound, and low B.T.U. is the highest price. Riedel letter attached.
2. Bulk loads cannot go to Ash Grove, but can go to Continental Cement. The price again varies with B.T.U. Value, but the price is \$110.00 to \$140.00 per ton in bulk. (End dump, or roll-off)
3. If B.T.U. Value is less than 5000 the Carbon needs to be landfilled, or incinerated. Landfill can be accomplished at Chem Waste, Emelle, Alabama for about \$200.00 per ton, and incineration as indicated on Riedel letter, \$1.20 per pound.
4. All facilities listed are permitted for K045, but none can take K045 if it is reactive. We test the Carbon, attached Bureau of Mines letter, for reactivity prior to receiving an accepted profile,

and we make all of our contracts subject to Carbon not being reactive. Also unlike incineration the Cement Kilns have no ash to be landfilled, as it becomes part of the product.

Sincerely;

A handwritten signature in cursive script, appearing to read "Roger McAtee".

Roger McAtee/President

Environmental Engineering and Waste Management

RIEDEL INDUSTRIAL WASTE MANAGEMENT, INC.

A Subsidiary of Riedel Environmental Technologies, Inc.

*"Imagining A Cleaner World"*

March 21, 1991

Key Environmental Services, Inc.
Mr. Roger McAtee
209 East Lewis, Suite A
Pocatello, ID 83201,

Dear Mr. McAtee:

Thank you for the opportunity to quote on your K045 waste. This quote is based on the analysis you provided and is subject to verification before acceptance at Riedel Solvent Recovery Corporation. All material must be Shock Tested before shipping.

The price for disposal is as follows:

<5,000	BTU	\$ 1.20 per pound
5,000-7,999	BTU	\$325.00 per drum
>8,000	BTU	\$300.00 per drum

If you have any questions regarding this proposal, please contact me at (816)474-1391.

Sincerely,

Richie S. McGinnis
Hazardous Materials Coordinator

RSM/dd

Riedel Industrial Waste Management, Inc.
22 North Euclid
St. Louis, MO 63108
(314) 361-3838
FAX (314) 361-4545

Laaser & Schreiber, Inc.
22 North Euclid
St. Louis, MO 63108
(314) 361-3838
FAX (314) 361-4545

Solvent Recovery Corp.
801 Mulberry
Kansas City, MO 64101
(816) 474-1391
FAX (816) 474-1275

Resource Recovery, Inc.
P.O. Box 902
Hannibal, MO 63401
(314) 248-0730

Riedel Energy, Inc.
P.O. Box 314
R.R. 1, HWY 154
Perry, MO 63462
(314) 565-3232

MEMORANDUM OF AGREEMENT
BETWEEN
THE UNITED STATES OF AMERICA
AND
KEY ENVIRONMENTAL SERVICES, INC.

This Memorandum of Agreement, made and entered into this 1st day of July, 1991, between the United States of America, acting through the Department of the Interior, Bureau of Mines (hereinafter referred to as the Bureau) and Key Environmental Services, Inc. (hereinafter referred to as the Cooperator):

W I T N E S S E I H

WHEREAS, the Cooperator represents that it evaluates explosive contaminated waste and needs certain data relative to the safety of this waste which it is not able to generate, and

WHEREAS, the Bureau represents that it has the capability to generate the data in question, and the interest in compilation of data for this waste, and

WHEREAS, the parties wish to cooperate in the establishment of such data,

NOW, THEREFORE, the parties wish to cooperate as follows:

1. Cooperation. The Bureau and Cooperator agree to cooperate on a research project to determine the explosion hazards of waste evaluated by the Cooperator.

2. Description of the Work. The Bureau will evaluate the explosive reactivity of one sample provided by the Cooperator by means of the Bureau of Mines Gap and Internal Ignition Tests. The Bureau is represented in many governmental, international, and standardization bodies concerned with explosives, such as the U.N. Group of Experts on Explosives, the O.E.C.D. International Group on Unstable Substances, the Federal Interagency Committee on Explosives, the National Fire Protection Association Committee on Explosives, and the American Society for Testing Materials Committee on Hazard Potential of Chemicals. Among the research undertaken for the U.N. Group of Experts on Explosives was the development of tests designed to determine whether a substance has explosive properties. These tests are currently under consideration for international standardization, and are called the Gap Test and the Internal Ignition Test. The Bureau has conducted these tests on low density materials and developed criteria for interpretation of the test results. These tests are suitable to determine the properties described in 40 CFR 261.23(a)(6) and (7) which defines a solid waste as having the characteristic of reactivity if it has, among others, any of the following properties:

- (a)(6) Capable of detonation or explosive reaction if subjected to a strong initiating source, or if heated under confinement.

- (a)(7) Readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.

The Gap Test is an arrangement for determining the response of a substance to a maximum plausible shock stimulus under confinement. The sample is contained in a length of steel tubing and subjected to the shock stimulus from the detonation of a 0.4 lb. pentolite booster in contact with one end of the sample. The occurrence of detonation or other explosive reaction is evidenced by fragmentation of the tubing, the rate of propagation of the pressure wave in the sample in excess of 1500 m/s (using an electrical probe) and the perforation of a steel plate at the opposite end of the sample.

The Internal Ignition Test is an arrangement for determining the response of a sample to heating by internal ignition under confinement. The sample is placed in a steel pipe capped at both ends; an ignitor capsule containing 20 grams of black powder is inserted in the center of the sample and ignited. The response of the sample is observed according to various degrees (failure to ignite; partial burning; cap blown off; pipe bulged, split, or laid open; pipe fragmented; and pipe and caps fragmented). The last two are indicative of an explosive reaction.

It is considered necessary to perform both tests since there are materials which are sensitive to ignition under confinement but not to shock, such as ammonium perchlorate and cellulose nitrate, while there are others which are sensitive to shock, but not to ignition under confinement, such as various ammonium nitrate mixtures.

3. Bureau's Contribution: The Bureau will conduct, using its manpower, equipment, and supplies, Bureau of Mines Gap and Internal Ignition tests on the sample provided by the Cooperator and, on completion, evaluate the explosive reactivity of the sample and submit a formal report to the Cooperator.

4. Cooperator's Contribution: The Cooperator shall provide one sample to the Bureau for testing and shall provide material safety data sheets and information about the health hazards of the sample. The Cooperator shall pay the sum of \$1,400.00 (ONE THOUSAND FOUR HUNDRED DOLLARS) to the Bureau to cover direct and indirect costs. These funds will be deposited in a trust fund in the United States Treasury for use of, and to be drawn upon by, the Bureau for any costs and expenses incurred in connection with the work under this agreement.

Detailed cost accounting of the expenditures from the funds provided and for materials furnished hereunder will not be provided to the Cooperator. Any statement the Bureau desires to provide regarding the status of funds or materials shall be deemed prima facie correct.

5. Title to Property: All equipment, instruments, materials, and supplies purchased by the Bureau, whether from funds advanced by the Cooperator or not, during the term of this agreement shall be and remain at all times the property of the Bureau. At the completion or termination of testing, the Cooperator shall arrange for shipment of any unused sample(s) at its own expense from the Bureau.

6. Ownership of Data and Records: All original notebooks, data sheets, record charts, graphs, films, video tapes or other records maintained by the Bureau, which are kept during, or arise out of, the work done pursuant to this agreement, shall be the property of the Bureau. Copies of such material may be released by the Bureau.

The Freedom of Information Act (FOIA) and its amendments have resulted in an increasing number of requests from outside the government for copies of information and data submitted to Federal agencies. If information and data provided by the Cooperator to the Bureau under this Agreement contain information that the Cooperator believes should be withheld from such requestors, under the FOIA, on the grounds that it is "trade secrets and commercial or confidential" [(b)(4) of the FOIA], the Cooperator should identify all such information so that if the information and data are ever the subject of an FOIA request, the decision by the responsible Federal official to disclose or withhold can be made promptly. If the Cooperator considers parts of the information and data withholdable under the FOIA, put the following notice on the title page:

Some parts of this document, as identified on individual pages, are considered by the submitter to be privileged or confidential trade secrets or commercial or financial information not subject to mandatory disclosure under the Freedom of Information Act. Material considered privileged or confidential on such grounds is contained on pages (specify page numbers).

Mark each individual item considered privileged or confidential under the FOIA with the following notice:

This data or information is considered confidential or privileged, and not subject to mandatory disclosure under the Freedom of Information Act.

All information and data which are not so designated may be subject to automatic public disclosure if it is requested under the FOIA. It must be emphasized that under the FOIA no information is automatically exempt from public disclosure. However, no disclosures under FOIA will be made without a careful and exacting evaluation by the Bureau giving due regard to the need for safeguarding material considered by the submitter to be privileged or confidential. The Bureau's policy is to withhold whenever possible material that is genuinely privileged or confidential.

7. Publication. It is understood that a major purpose of the work performed by the Bureau is to obtain information that may be made available by the Bureau to industry and the public through publications or otherwise. The Cooperator shall not announce, publish or otherwise disclose information or conclusions resulting from the work performed or observed by the Bureau or by the Cooperator under this agreement, until after review, for technical accuracy, by the Bureau. Such review will not be unreasonably delayed. Any announcement or publication of work under this agreement by either party shall recognize and give credit in the text and on the title page to the cooperation of the other party, unless requested otherwise.

8. Officials Not to Benefit: No Member of or Delegate to Congress shall be admitted to any share or part of this agreement or to any benefit that may arise therefrom.

9. Liability. The Cooperator agrees to be responsible for its own acts and the results thereof, and will assume all risk and liability to itself, its agents or employees, for any injury to persons or property resulting in any manner from the conduct of its own operations and the operations of its agents or employees under this agreement, and for any loss, cost or damages or expenses resulting at any time from any and all causes due to any act or acts, negligence, or the failure to exercise proper caution, of or by itself, or its agents or its employees while occupying or visiting the premises under and pursuant to this agreement. Furthermore, the United States Government agrees to be responsible as to and under this agreement to the extent of, and by the authority set forth in the Federal Tort Claims Act as amended [28 U.S.C 2671-80 (1976)] and will have no other liability.

10. Termination: This agreement shall expire on June 15, 1992, but may be extended for additional periods by written agreement between the parties hereto, provided, however, that it may be terminated at any time by either party giving written notice of termination to the other party at least thirty (30) days prior to the date fixed in such notice.

Where the operation of this agreement extends beyond the current fiscal year, this agreement is expressly conditioned and contingent upon the Congress making appropriation for necessary expenditure hereunder after such current year shall have expired. In case such appropriation as may be necessary to carry out this agreement is not made, the Cooperator hereby releases the Bureau from all liability for failure to perform due to failure of Congress to make such appropriation.