Hot Gas Decontamination of Explosives-Contaminated Equipment

K. R. Keehan, T. S. O'Rourke, W. E. Sisk, and E. B. Hangeland
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland

ABSTRACT

Explosives manufacturing, handling, and demilitarization operations at U.S. Army industrial facilities have resulted in contaminated process equipment, scrap metal, and sewer systems. Because of the residual contamination, these items can not be reused or disposed. The U.S Army Toxic and Hazardous Materials Agency has studied technologies to effectively treat these explosive-contaminated materials. The most promising of these technologies was hot gas decontamination. A recent field demonstration at Hawthorne Army Ammunition Plant demonstrated the ability of the hot gas decontamination system to effectively remove explosives such that the test items are not characteristically hazardous and are appropriate for disposal as scrap. Based upon the success of this demonstration, the Hawthorne Army Ammunition Plant intends to implement this technology in current demilitarization operations. Full-scale operation will begin following completion of several system changes. The results of the field demonstration and the proposed system changes are described.

INTRODUCTION

Each year the Department of Defense must dispose of thousands of tons of energetic material and munitions which are obsolete or unserviceable. The processing of this material is usually accomplished by one of two methods, either reclaiming the energetic material from its casing or through the use of open burning/open detonation. Both of these methods result in contaminated scrap metal or process equipment that cannot be disposed due to the presence of residual energetic materials. These residual explosives, even in trace quantities, poses both a safety and environmental hazard. Because of these problems, the Department of Defense has found itself holding an ever growing stock of contaminated equipment and scrap which it cannot process through normal property disposal channels.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **AUG 1992**	2. REPORT TYPE	3. DATES COVERED **00-00-1992 to 00-00-1992**

4. TITLE AND SUBTITLE **Hot Gas Decontamination of Explosives--Contaminated Equipment**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Toxic and Hazardous Materials Agency, ,Aberdeen Proving Ground,MD,21010-5401**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADA260985, Volume II. Minutes of the Twenty-Fifth Explosives Safety Seminar Held in Anaheim, CA on 18-20 August 1992.

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**7**	

A number of methods have been employed in an attempt to eliminate this problem, however, none has proven totally satisfactory and effective. The two most common techniques for decontaminating these items has been the use of steam cleaning and fire. Steam cleaning, in most cases, is an effective means of achieving surface decontamination, however, hard to reach areas on complex structures such as demilitarization process equipment are not thoroughly decontaminated. The use of fire typically centers on the use of a flash furnace or burning. In either case, a number of drawbacks can be found in the use of thermal treatments. Both flashing and burning are subject to regulatory requirements since the procedures create air emissions and the public perceives this technology as an incineration technology. The flashing furnace relies on thermal initiation to decontaminate any residual explosives. This procedure results in a surface decontamination and cannot adequately treat the complex surfaces of machinery and process equipment. Incineration is another technology which is capable of complete decontamination, however, it is uneconomical, and destroys the physical structure and inherent value of the contaminated material. Also, the contaminated material must be small enough to fit into the incinerator.

IDENTIFICATION AND EVALUATION OF NOVEL DECONTAMINATION CONCEPTS

In 1982, the U.S Army Toxic And Hazardous Materials Agency (USATHAMA) sponsored a project to offset these problems and develop an effective decontamination procedure suitable for both process equipment and scrap materials. The goal of this project was to identify and evaluate safe decontamination technologies which produce little or no waste while completely decontaminating the energetic materials. The targeted explosives compounds were trinitrotoluene (TNT), hexahydro-1,3,5-trinitro-s-triazine (RDX), octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), di- and tri- nitrobenzene compounds, smokeless powder, and ammonium picrate (Yellow-D). Research efforts were centered on identifying and evaluating technologies that could be applied to a number of structural materials such as metal, concrete, and painted surfaces. Battelle Columbus Laboratories performed an analyses of existing explosives decontamination techniques. Battelle representatives gathered information from government and private sector energetics manufacturers, and visited and analyzed government facilities and equipment contaminated with explosives.

In July of 1983, Battelle completed the analyses of technologies[1]. These technologies were centered on the four main concepts of thermal decomposition, abrasive removal, extraction, and chemical treatment. Each technology was judged based upon the following characteristics; destruction efficiency, mass transfer, safety, damage to exiting structures, applicability to complex surfaces, penetration, operating and capital costs, and waste residue and disposal. A number of combined methodologies were also considered and evaluated. A total of fifty-six technologies and combined technologies were evaluated. Of these technologies, only six were found to be suitable for further investigation into their potential effectiveness as explosive decontamination scenarios. The six methods selected were hot gas, combined hot gas and chemical pretreatment, vapor circulation, free radical induced decomposition, base initiated decomposition, and sulfur based reduction.

Within the realm of thermal decomposition, the use of hot gases received the highest overall ranking and the most favorable results in all the evaluated categories. The hot gas concept is built upon exposing contaminated items to hot gases in order to volatilize and decompose the contaminant. The resulting stream of hot gases, vaporized explosives, and break down products are then destroyed in an afterburner unit. Burning was regarded fairly well in most categories, but received the lowest possible ratings for safety and structural damage. The only thermal concept recommended for further development was the hot gas process.

LABORATORY TESTING

Having identified six technologies suitable for additional investigation, the program entered a second phase of development which provided more technical data. The laboratory testing was designed to determine each technology's range of applications and efficiency of decontamination[2]. These tests were conducted with coupons that had been spiked with known quantities of 2,4-Dinitrotoluene (DNT), 2,6-DNT, TNT, RDX, HMX, and TETRYL. Coupons composed of steel, concrete, and painted concrete were subjected to the treatment scheme under investigation. After appropriate treatment times the coupons were analytically examined for residual explosives and adverse effects on the coupon material. These tests revealed a number of cases where residual explosive levels were below detection limits. Each technology was found to have its own unique advantages and disadvantages. The widest applicability and greatest degree of decontamination was found with the use of the hot gas system.

A detailed analysis also showed that the hot gas method entailed some potential problems. During laboratory testing it was noted that explosive crystals formed on the outer (uncontaminated) surface of concrete coupons. This formation indicated that the hot gas system caused explosives to migrate through concrete rather than destroying the energetic material. The concrete coupons were also found to be dried out because of the high operating temperature of the hot gas technique. This drying caused a noticeable loss of strength within individual concrete coupons. These problem areas led to further evaluation of chemical pretreatment combined with the hot gas system.

In exploring chemical pretreatment, it was found that the use of caustic chemicals created a situation in which not only lower operating temperatures were used but also quicker destruction times were achieved with the hot gas system. At the same time the quicker destruction and lower temperatures reduced the chances of explosive migration. These findings contributed to the conclusion that the hot gas system, complimented by chemical pretreatment, was clearly the most promising technology to pursue outside of the laboratory and for wide spread application.

HOT GAS DECONTAMINATION OF CONTAMINATED BUILDINGS

After considering a number of potential pilot test sites a projectile washout facility at Cornhusker Army Ammunition Plant (CAAP) was selected for a field demonstration test in 1987[3]. The demonstration was conducted for USATHAMA by Arthur D. Little, Incorporated. The objectives were to determine the full scale effectiveness of the hot gas system (both with and without pretreatment), provide full scale design criteria, and data for regulatory permitting. The CAAP facility measured approximately twenty-five feet long by twenty-five feet wide and eleven feet high. The demonstration area was divided by constructing a wall and false ceiling to provide two distinct areas in order to pretreat one area with caustics (a solution of sodium hydroxide and dimethylformamide). The TNT concentration in the building was too low to properly challenge the hot gas methodology so contaminated concrete blocks (from a sump) were placed in the test areas.

Hot gases were pumped into the building through duct work from a 3 million btu/hour propane fired burner. The resulting gas stream was than collected and exited the building through a propane fired afterburner. The gas streams entering and exiting the building, and exiting the afterburner were carefully monitored and analyzed. Additionally, thermocouples were employed to monitor and record the temperature profiles of building materials, and inside the building. Concrete samples were mechanically tested both before and after the hot gas treatment.

The evaluated data from the CAAP test indicated that the hot gas system was both safe and feasible. Although the pretreatment with caustics was effective in increasing surface explosives removal, the effects of the hot gas stream alone provided the bulk of interior explosives removal and decontamination. The mechanical testing of concrete samples revealed an average compressive strength loss of five percent while tensile strength losses averaged between twenty and thirty percent. These effects imply that the age and style of concrete construction should be considered when designing individual hot gas system applications.

DEMONSTRATION ON EXPLOSIVES CONTAMINATED EQUIPMENT

In 1989, a pilot-scale test was conducted by Roy F. Weston Inc., to expand the understanding of the hot gas system and its applications to explosives contaminated equipment[4]. The demonstration was conducted at the Hawthorne Army Ammunition Plant (HWAAP), Hawthorne, Nevada. The HWAAP tests were designed to examine the ability of the hot gas system to decontaminate process equipment and known structural materials such as vitrified clay, copper, and aluminum. The list of evaluated contaminants was also expanded to include nitroglycerine, nitrocellulose, and ammonium picrate. An existing flashing chamber at HWAAP was modified to utilize the same burner and afterburner from the CAAP test. A process diagram is provided in figure 1. This modified chamber was than used to treat materials selected from the large stock of contaminated equipment and munitions items held at the HWAAP. Vitrified clay materials were taken from the highly contaminated piping system at the West Virginia Ordinance Works.

Prior to treatment all materials were sampled to determine the extent and quantity of contamination and instrumented with thermocouples to monitor temperature profiles. The items were then placed on a large cart and placed in the flashing chamber. Following treatment the items were subjected to surface wipes and solvent rinses to sample for residual explosives contamination. The tests revealed that treatment at 500 degrees fahrenheit for twelve hours successfully decontaminated the surfaces and interior of intricate process equipment of all tested materials. Based on the results of this field demonstration, the hot gas decontamination technology is ready for full-scale implementation. Several modifications were identified which make this process economical.

TECHNOLOGY TRANSFER

The Hawthorne Army Ammunition Plant is currently implementing several of the design modifications identified in the previous field demonstration to the hot gas decontamination system at HWAAP. These changes should improve the performance and economics of the decontamination system. The air preheater and afterburner are being modified to operate on diesel fuel (DF2) instead of propane. A recirculation system is being designed to permit the use of the afterburner exhaust gases to preheat the air entering the air preheater. The retrofited flashing chamber has been insulated to prevent the thermal energy loss through the concrete walls. These modifications are nearly completed and the State of Nevada has issued an operating and air quality permit for the operation of this system. Another set of tests are scheduled in the near future to identify the benefits of these new modifications and determine the full scale operating parameters.

REFERENCES

1. Benecke, H. P., Zemeju, E. R., Nixon, J. R., Garrett, B.C., Carlton, P. J., Gaughan, P. J., Graham, S. M., Hallowell, J. B., Vanek, D. G., Vutatakis, D. G., and E. J. Mezey, "Development of Novel Decontamination and Inerting Techniques for Explosives-Contaminated Facilities, Phase I - Identification and Evaluation of Novel Decontamination Concepts", U.S. Army Toxic and Hazardous Materials Agency, Report No. DRXTH-TE-CR-83211, Aberdeen Proving Ground, Maryland, July 1983.

2. Hopper, D. R., Benecke, H. P., Mezey, E. J., and S. C. Lugibihi, "Development of Novel Decontamination and Inerting Techniques for Explosives-Contaminated Facilities, Laboratory Evaluation of Concepts, Phase II - Laboratory Evaluation of Novel Explosives Decontamination Concepts, U.S. Army Toxic and Hazardous Materials Agency, Report No. DRXTH-TE-CR-85009, Aberdeen Proving Ground, Maryland, July 1985.

3. Woodland, L.R., Balasco, J. W., Adams, K. J., Beltis, K. J., Kleinschmidt, D. E., Randel, M. A., Rosetti, M., and K. E. Thrun, "Pilot Plant Testing of Caustic Spray/Hot Gas Building Decontamination Process", U.S. Army Toxic and Hazardous Materials Agency, Report No. AMXTH-TE-CR-87112, Aberdeen Proving Ground, Maryland, August 1987.

4. Mazelon, M., Johnson, N., Cosmos, M. and P. Marks, "Task Order, Pilot Test of Hot Gas Decontamination of Explosives-Contaminated Equipment at Hawthorne Army Ammunition Plant (HWAAP) Hawthorne, Nevada, U.S. Army Toxic and Hazardous Materials Agency, Report No. CETHA-TE-CR-90036, Aberdeen Proving Ground, Maryland, July 1990.

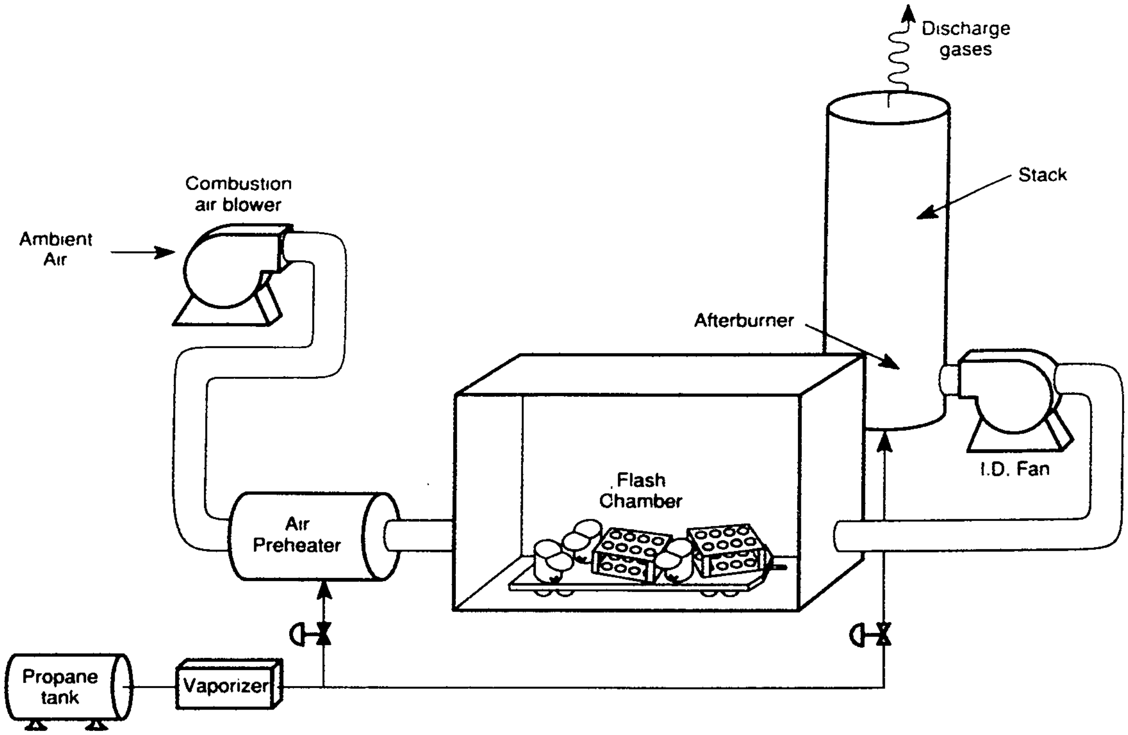

Figure 1
Hot Gas Decontamination Process Schematic