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Thermal Incineration and Homeland Security

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ABSTRACT

When a building is contaminated by chemical /biological (CB) materials or toxic industrial chemicals (TICs) as the result of a terrorist attack, significant quantities of waste are generated during building decontamination operations. These waste streams may include aqueous solutions; furniture; ceiling tiles; wall decorations; carpeting; heating, ventilation and air conditioning (HVAC) filters; and personal protective equipment from the cleanup crews. All of these waste streams may be contaminated with CB materials and TICs at varying levels as well as with residues from the decontamination process itself. The safe disposal of these materials will involve packaging, transportation, thermal treatment including incineration, and landfilling of the materials directly or of the thermal treatment residues. This paper describes the EPA/ORD program to provide guidance for permitting authorities and industry to address the thermal destruction of these contaminated materials.

INTRODUCTION

As a result of the anthrax attacks on various government and news media buildings in 2001, the EPA instituted the "Safe Buildings Program" to address issues related to building decontamination. After a building has gone through decontamination activities following a terrorist attack with chemical warfare (CW), biological warfare (BW) agents, or toxic industrial chemicals (TICs), there will be a significant amount of residual material and waste to be disposed of. Although it is likely that the materials to be disposed of will have already been decontaminated, the possibility exists for trace levels of the toxic contaminants to be present in absorbent and/or porous material such as carpet, fabric, ceiling tiles, office partitions, furniture, and personal protective equipment (PPE) and other materials used during cleanup activities. There could also be wastes from the decontamination process itself, such as scrubber slurries or activated carbon from scrubbers used to remove fumigants such as chlorine dioxide (ClO_2) from the buildings. In addition, there may be additional contaminated materials such as carbon adsorption beds and high-efficiency particulate air (HEPA) filters from the building's heating, ventilation, and air conditioning (HVAC) system. It is likely that much of this material will be disposed of in high-temperature thermal incineration facilities, such as medical/pathological waste incinerators, municipal waste combustors, and hazardous waste combustors. It is also possible that some sort of portable incineration technology might be field erected to dispose of these materials on-site in order to minimize exposure. Selection of appropriate disposal facilities requires fundamental knowledge of the behavior of the matrix-bound contaminants in various thermal environments.

It is highly unlikely that any pathogens will survive the incineration process if exposed to the nominal time-temperature history for which the incinerator has been designed. However, due to the complex fluid dynamics within incineration systems, coupled with in-bed mass transfer limitations and incomplete bed mixing, it is conceivable that some of the contaminants initially in the feed could bypass the high-temperature zones and be released as a stack emission, as a fugitive emission, or in the solid residue.

A useful approach in the past has been to rank materials according to their ease of destruction in an incinerator. This "incinerability index" (1) has been used to help develop trial burn plans under the Resource Conservation and Recovery Act (RCRA). Past work has also shown the usefulness of using fluid dynamics modeling of incineration systems to examine the potential for CW materials to bypass the high temperature zones and be emitted (2). The thermal incineration work to be done under the Safe Buildings Program will utilize similar approaches to help develop guidance on selection of the appropriate incineration technologies.

PROGRAM DETAILS

This research program is moving forward under the assumption that the disposal of all the building decontamination residues will be done in accordance with existing regulations. This would include: proper transportation to the disposal site as defined in U.S. Department of Transportation (DOT) rules; proper packaging and handling of the materials as per the Occupational Safety and Health Association (OSHA), and the operational permits of the disposal facilities as governed by RCRA and the Clean Air Act.

The primary clients for this program will be: 1) emergency response authorities who have to decide the most appropriate decontamination methods and disposal of the resulting residues; 2) state and local permitting agencies, who have to make decisions about which facilities will be allowed to dispose of the materials; and 3) the waste management industry, that needs to safely dispose of building decontamination residues without affecting the operation of its facilities and without violating any of its environmental permits. Several research projects and paper studies are being performed to address the issues related to disposal of building decontamination residues by thermal incineration. These projects are a combination of in-house experimental research (bench- and pilot-scale) and extramural efforts so that the work can be completed as expeditiously as possible. Some work has been initiated at this point in time; however, most of the work is still in the planning stages. Following is a description of the proposed work.

Bench-scale thermal treatment studies

The disposal of building materials contaminated with chemical and biological (CB) agents is complicated by matrix effects associated with the contaminant and the material it is bound on. It is important to know the relative difficulty of destroying these toxic agents when bound on different materials to assure that minimum solid phase residence times will be achieved and residual solids (such as fly ash and bottom ash) and gaseous emissions leaving the system are free of contaminants. To provide guidance on minimum solid phase residence times, a fundamental knowledge must be gained of the combustion behavior of CW and BW agents bound on common building materials, and the desorption behavior of CW agents and TICs from filter media such as activated carbon.

Bench-scale research will be conducted to examine the destruction of surrogate CB agents that are present on or within several common building materials including carpeting, furniture and drapery fabrics, ceiling tiles, and wallboard. A laboratory-scale reactor will be used to examine the effects of substrate material, time-temperature profiles, and furnace conditions on the destruction of several surrogate CB contaminants.

Table I lists some of the potential substrates and contaminants that will be tested. Contaminants will consist of various TICs (as simulants for CW agents) and simulants for spore-based pathogens like anthrax, such as *bacillus globigii* (BG). Spore-based pathogens represent the most thermally resistant classes of pathogens, and BG was found to the most thermally resistant of those simulants (3). Filter media will be characterized for physical and chemical surface properties, and adsorption/desorption isotherms will be determined experimentally for various TICs and CW agent simulants, so that modeling can be performed to assess various combinations of media/contaminants in different incinerator/thermal treatment system designs and operations. The results from these studies can be used to evaluate incineration technologies for appropriateness for disposal of contaminated building materials.

Table I. Potential Substrates and Contaminants to be Tested

Substrates	**CW agent simulants**	**BW agent simulants**	**TICs**
Carpeting	SF_6	*bacillus globigii*	Formaldehyde
Ceiling tiles	Malathion	*bacillus thuringiensis*	
Fabric	Biphenyl		
Wallboard	Monochlorobenzene		
Wood	Dimethyl methyl phosphate		
Activated carbon			

Pilot-scale incineration studies

Pilot-scale testing will be performed to provide some scale-up to the bench-scale testing, and to investigate issues related to operational difficulties that might result from burning large quantities of building decontamination residues. The pilot-scale testing will be performed in the EPA's rotary kiln incinerator simulator (RKIS), a rotary kiln equipped with a secondary combustion chamber (SCC), each with a nominal firing rate of 73 kW (250,000 Btu/hr). The RKIS, shown in Fig. 1, is capable of burning solid materials (through a manual charging mechanism) and liquid fuels (directly injected into the burner[s] or sprayed into the transition section between the kiln and SCC).

Testing will be performed on both contaminated and uncontaminated materials, to measure the destruction efficiency of the initial contaminating agent (e.g., biological or chemical) as well as possible combustion byproducts of concern. Test methods may include bioassays where applicable. Several different types of filter media will be tested in these experiments, including contaminated carbon adsorbents or HEPA filters. Emphasis will be placed on minimum time/temperature environments required to assure adequate destruction of the contaminants, so that technical guidance may be given to facilities and permitting entities regarding proper incineration of waste materials recovered from building decontamination activities.

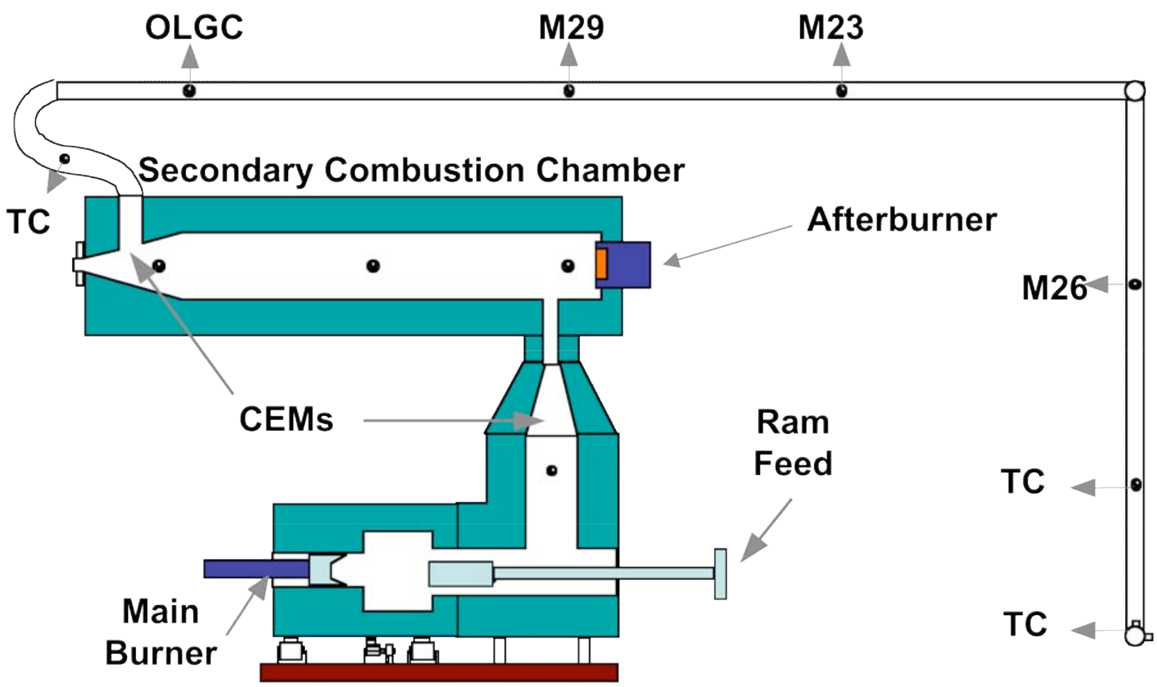

Fig. 1. Rotary Kiln Incinerator Simulator

Initial pilot-scale testing will focus on issues related to combustion of uncontaminated carpeting and impacts of the products of combustion on air permits granted under the Clean Air Act. These tests, to be done in collaboration with the American Society of Mechanical Engineers (ASME) and the Carpet and Rug Institute (CRI), will examine potential operational issues that result from the combustion of uncontaminated carpeting. The CRI is interested in the potential for using waste carpeting (with heating values approaching 8,000 Btu/lb) as auxiliary fuel in cement kilns. Most carpeting is made from nylon and has a high nitrogen (N) content and could potentially cause excess emissions of nitrogen oxides (NO_x). In addition, the effect of carpet fuel on emissions of air toxics such as mercury (Hg) and polycyclic aromatic hydrocarbons (PAHs) is not known. Tests are ongoing to examine the effect of carpet feed on NO_x, PAH, and Hg emissions. Tests are also planned to address issues related to the impact that different sized carpet pieces have on burnout times and emissions, both transient and steady-state.

Sampling and analytical methods development

Since the mobility of biological contaminants within landfills and thermal treatment devices has not been well-explored, it is critical that sampling and analytical methods be available to determine efficacy of destruction and permanence of land disposal. Preliminary sampling and analytical methods (4) for some microorganisms have been developed for potential use on medical waste incinerator stack gases and ash residues, but these methods have not been validated, and moreover, have not been tested for some of the primary biological warfare (BW) agents of concern (e.g., anthrax). This project will adapt and expand upon existing sampling and analytical methods for BW agents in combustor stacks and ash residues.

The primary goals of this project are:

- Investigate relevant sampling/analytical measurements issues such as sample collection efficiency, stability, preservation, etc

- Investigate/determine potential method detection limits
- Develop a draft procedure suitable for field testing

Guidance document development

Delays in the disposal process due to permitting are intolerable, thus the process must be streamlined. This program will prepare a guidance document that will be developed in partnership with industry, state and local government, and federal agencies. The technical approach that this project will take is to collect all of the short-term products that were developed early on in the Safe Buildings Program, and couple them with a compilation of all of the research that was done in the disposal area by EPA and others, as well as information that was generated by other federal agencies, to produce a document or series of documents that provide information to the permitters, the emergency responders, and the disposal facilities.

Data will be collected from the open literature, from state and federal regulatory agencies, and from incinerator manufacturers and operators, to develop operating guidelines for incineration of contaminated building materials and reagents and materials used during decontamination. The goal of the project is to develop technical guidance for feed processing, thermal treatment system time/temperature profiles, pollution control system designs and operating conditions, and other parameters, as well as permit implications. The project will address the following questions:

- What are the minimum and optimum times and temperature requirements needed to destroy contaminants to ensure an adequate margin of safety to the public and to disposal personnel?
- What are the minimum and optimum requirements for post-combustion treatment of incineration flue gases to ensure that containment of contaminant incineration products is adequate to protect the safety of the public and decontamination personnel?
- What are the characteristics of residues formed during the incineration process, and what are the requirements for their disposal in a safe manner?
- What are the potential harmful byproducts of the incineration processes and how can systems be designed to ensure minimal formation of these byproducts?
- What are the current capabilities of portable incineration systems, and can they be used or modified to meet the requirements developed above?
- What permit implications will there be for facilities disposing of these materials?

SUMMARY

The U.S. EPA is initiating the Safe Buildings Program to address issues related to decontamination and restoration of buildings after a terrorist attack with CB agents or TICs. Part of this program will investigate technical issues related to the disposal of wastes generated during the decontamination of buildings. The target audience for this program will be: 1) the emergency response personnel who have to make decisions about decontamination methods and disposal of the resulting residues; 2) state and local permitting agencies, who have to make the decisions about which facilities will be allowed to dispose of the materials; and 3) the waste management industry, that needs to be able to safely dispose of the building decontamination residues without affecting the operation of its facilities and without violating any of its environmental permits. The goal of this research program is to produce, in two years, technical information and guidance documents that will enable the safe and effective disposal of these materials.

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