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Project Summary

Experimental Investigation of Critical Fundamental Issues in Hazardous Waste Incineration

J. C. Kramlich, E. M. Poncelet, R. E. Charles, W. R. Seeker, G. S. Samuelsen, and J. A. Cole

The results of a laboratory-scale program investigating various fundamental issues in hazardous waste incineration are presented. The key experiment for each study was the measurement of waste destruction behavior in a subscale turbulent spray flame. Nozzle performance of subscale nozzles was directly measured in terms of droplet size by laser diffraction. Because some wastes can be highly viscous or contain solids, atomization quality can be a limiting factor, even for correctly operating nozzles. Even in the absence of secondary atomization, an influence of compound concentration in the feed stream has been noted in field data. In field tests, a large number of compounds that are apparently unrelated to the original waste compounds are observed.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Incineration is an attractive alternative for the disposal of organic hazardous wastes. As opposed to landfilling or deep well injection, it effects a permanent solution. However, incineration is attractive only if the waste is destroyed to an acceptable efficiency and if harmful emissions of hazardous byproducts are avoided. The Federal government has recognized that the public welfare requires government regulation of waste disposal through the Resources Conservation and Recovery Act (RCRA). Through RCRA, Congress has charged the Environmental Protection Agency (EPA) with the development of regulations and the enforcement of these regulations. The EPA has identified over 300 compounds as hazardous and has established licensing and operating regulations for devices destroying these compounds. These regulations recognize the fact that thermal destruction devices cannot operate to 100% efficiency. Therefore, some emission level must be defined as a minimum standard for safety. Currently, 99.99% destruction and removal efficiency (DRE) of the principal organic hazardous constituents (POHCs) is the standard.

Field testing of full-scale waste destruction facilities and testing of subscale flames have shown that well designed systems have little trouble meeting the performance standard. Indeed, the evidence suggests that a substantial perturbation of design or operational parameters is necessary for substantial emissions to occur. These perturbations have been termed "failure modes" because the perturbations have caused some fundamental rate limiting step to fail to completely destroy the waste. Thus, the key questions with respect to DRE are:

What mechanisms permit the small amounts of waste to escape during high efficiency operation?

What mechanisms are responsible for waste release during a failure mode?

Objectives

The objectives of this study were to define and address experimentally a series of issues fundamental to hazardous waste incineration. These issues were selected because they represent practical problems or approaches to practical problems that can be addressed through fundamental research. These issues include:

- *Effect of Waste Atomization on DRE*: Combustion efficiency can be degraded in industrial flames by poor fuel atomization (i.e., large droplets). The key problem is defining the mechanism by which DRE is influenced by waste atomization.

- *Effect of Secondary Atomization on DRE*: This addresses the question, can fragmentation of waste droplets by internal boiling improve DRE?

- *Effect of Waste Concentration on DRE*: Field data indicate a correlation between waste concentration and DRE. Identification of the mechanism responsible for this behavior would be an important step toward defining the fundamental release mechanism.

- *PIC Formation*: Considerable work has been done identifying products of incomplete combustion (PICs) in idealized plug flow experiments. Here, the appearance of PICs in turbulent spray flames is addressed.

In addition to providing specific information on these issues, one goal of this work was to provide insight into the critical, rate-limiting processes that govern waste release from practical devices.

Conclusions

Principal conclusions of this study are:

1. *Waste Atomization*: For degraded atomizers, the principal cause of poor waste destruction efficiency is the increase in the fraction of very large droplets. The extreme delay in evaporation associated with these large droplets can allow unreacted material to reach the wall or penetrate through the flame zone. Design to avoid this behavior is more difficult for hazardous waste incineration than for conventional combustors because:

- A large amount of empirical experience has been obtained on liquid fuel combustion.

- The atomization properties of waste streams (viscosity, surface tension, presence of solids) can vary considerably.

The results suggest a design methodology in which atomization quality is directly measured in cold flow. The size and trajectory of the largest droplets are compared to the combustion chamber geometry to determine the initial suitability of the design

2. *Secondary Atomization*: Some materials may have sufficiently poor atomization properties to prevent acceptable spray fineness at any conditions. The use of a volatile waste dopant was shown to inc in-flame droplet fragmentation an Improve DRE. This suggests that of volatile dopants, or the blendin different waste streams can be u to avoid poor DRE due to penetra of large droplets through the flam

3. *Compound Concentration*: Field data show a remarkable correla between compound concentratio the feed and DRE. Testing in turbulent flame reactor also sho this correlation. However, the pa for the subscale flame indicated secondary atomization wa potential cause of the behavio higher concentrations. This does explain the subscale variation of with waste concentration at waste concentrations, nor do fully explain the field data mechanism involving mixing lir equilibrium chemistry was prop for the field data.

4. *PIC Formation*: The yield of organic compounds was meas from the turbulent flame reactor results indicated that:

- PIC concentrations were compa with waste emissions.

- Incomplete combustion of the au fuel rather than true PICs from doped waste dominated the app PIC emissions.

Thus, PICs can arise from any c hazardous or nonhazardous consti of the waste stream or the auxiliary The implication is that conditions promote high combustion efficienc favor reduced PIC emission.

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J. *Kramlich, E. Poncelet, R. Charles, W. Seeker, G. Samuelsen, and J. Cole are with Energy and Environmental Research Corporation, Irvine, CA 92718-2798.*
***W. Steven Lanier** is the EPA Project Officer (see below).*
The complete report, entitled "Experimental Investigation of Critical Fundamental Issues in Hazardous Waste Incineration," (Order No. PB 90-108 507/AS; Cost: $23.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

Air and Energy Engineering Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

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