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Project Summary

Design and Development of a Hazardous Waste Reactivity Testing Protocol

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A project was conducted to develop a test scheme (protocol) to determine the gross chemical composition of waste materials in the field. Such a test scheme is needed during remedial actions at hazardous waste disposal sites, where it is necessary to predict the potential consequences of mixing wastes from separate sources. Earlier procedures have assumed a prior knowledge of the chemical composition of the wastes. Information obtained from these tests is used to classify wastes into reactivity groups and thus predict compatibility.

The test scheme developed here includes a field test kit, a series of flow diagrams, and a manual for using the flow diagrams and test procedures. Because small-scale mixing is needed as a safeguard before large-scale mixing takes place (even when the chemical composition of two wastes indicates compatibility), a simple device is included for observing the effects of mixing two hazardous materials.

The protocol was challenged with more than 60 compounds and mixtures of compounds in the laboratory and 29 waste samples in the field. Of 755 laboratory observations, 15 were false positives and 2 were false negatives (including replicate tests). All but one of the field samples were classified into the correct reactivity group based on the bulk chemical composition listed in the suppliers' manifest. The one incorrectly identified sample was found to be incorrectly labeled by the supplier and was correctly classified according to its actual composition.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, 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

With funds allocated by the regulations to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), numerous locations have been identified as containing large quantities of hazardous wastes. Uncontrolled or abandoned hazardous waste sites may present long-term danger to the local environment and possible immediate danger to personnel involved in cleanup activities. A major effort in any cleanup is the bulk recontainerization of materials residing in leaking drums or tanks, or stored in holding ponds. This task is usually performed for shipment to intermediate storage or ultimate disposal. Many materials are incompatible with each other and, when mixed, can result in immediate catastrophic reactions or intermediate-term reactions that can cause dangerous results.

Presently, some work is underway to identify the types of materials that have compatibility problems and the potential results of their mixing. These efforts are primarily theoretical studies incorporating the chemistry of pure compounds. One study (Hatayama, H.K., et al., "A Method of Determining the Compatibility of Hazardous Wastes," EPA-600/2-80-076, U.S. Environmental Protection

Agency, Cincinnati, OH, 1980)* has classified materials into several reactivity groups, identified potential problems with mixing the different groups, and specified a logical series of procedures to avoid mixing incompatible materials. The procedures require that the user have at least a minimal knowledge of the chemical nature of the materials in question. Other work has been directed toward field tests for one or two specific reaction hazards or chemical characteristics. These efforts address only the most immediate and catastrophic effects of incompatibility. Cleanup personnel are left with no way of estimating the short-term (minutes to hours) or long-term (days to weeks) effects of mixing and recontainerizing unknown materials.

The purposes of this project were (1) to identify any field-usable procedures for classifying wastes into the reactivity groups developed by Hatayama et al., (2) to test identified procedures against representatives of their respective reactivity groups, (3) to establish a protocol for the use of the procedures, and (4) to assemble a field test kit. Tests were needed for 41 reactivity groups, which are numbered 1 through 34 and 101 through 107. These are called the reactivity group numbers, or RGN's. The tests used to classify a sample waste into the correct RGN had to be simple enough so that users with minimum training could apply them. The associated protocol had to be logical and contain a minimum of complex decisions. The test kit itself had to be as self-contained as possible and require no field laboratory. That is, it was to be transportable in a car or van and to require an absolute minimum of utilities.

The project was divided into six phases:

- Literature search to identify RGN tests
- Testing of the identified procedures against representative compounds
- Establishing the testing sequence or protocol
- Verification of the reproducibility of the protocol and test procedures
- Assembly of the field test kit
- Field verification of the complete system using actual wastes

The project was successfully concluded with the preparation of a hazardous waste reactivity test protocol and associated field kit that allowed the correct RGN classification of 29 wastes for which there was no prior chemical knowledge.

*This EPA report is no longer available from EPA or NTIS. An updated version of this report entitled "A Proposed Guide for Estimating the Incompatibility of Selected Hazardous Wastes Based on Binary Chemical Reactions" is scheduled to be published in 1984 by the American Society for Testing and Materials (ASTM) D34 Committee on Waste Disposal.

Procedures

Because identifying the RGN for a waste sample is a qualitative assessment, the literature search concentrated on qualitative analysis methods. Of particular interest were color spot tests and other wet chemical tests requiring only a few milligrams of material. Reference and text books for college-level qualitative analysis courses (both organic and inorganic) were reviewed along with literature on spot testing. Some 59 compounds were selected from the RGN lists of Hatayama et al. to provide the broadest possible coverage on the various groups. These compounds were then subjected to the identified procedures to verify that the tests gave unequivocal results and correctly identified the RGN to which the compound belonged.

The procedures were organized into a sequence or protocol. Two technicians were then assigned to subject the (unmarked) compounds and mixtures of compounds to the protocol. This procedure was carried out to ensure that the protocol would correctly classify the compounds into their respective RGN's. After successful completion of this phase, the field kit was assembled. As part of the kit, a field-mixing device was also constructed. This device was a simplification of previously developed devices in that it did not require utilities or a laboratory setting. The device itself is used in the last step of the protocol to verify that two materials will not generate immediate catastrophic results when mixed.

The final phase of the project was to take the assembled kit to the field (the EPA Combustion Research Facility at Jefferson, Arkansas) and attempt to identify and classify actual wastes. Much of the testing was conducted independently and in duplicate to assure that different operators would achieve the same results.

Results and Discussion

The literature search resulted in identification of appropriate tests for all but two of the listed RGN's — RGN 25 (nitrides) and RGN 103 (polymerizable compounds). Tests for nitrides were not sought because compounds were not commercially available; synthesis of nitrides is very dangerous, and the authors felt that working with such compounds offered too high a risk. In addition to the two RGN's for which tests were not found, no qualitative test could be located for epoxides (RGN 34).

During verification of the 35 test procedures, 755 individual observations were made, including duplicate and triplicate observations by a single technician and repeated run-throughs of the protocol by two other analysts. Of the 755 observations, only 15 were false positives and 2 were false negatives (including duplicates).

Field testing was conducted on 25 wastes. Since 4 wastes contained 2 phases, a total of 29 samples was tested. The waste descriptions in the suppliers' manifests identified 39 materials classifiable into RGN categories. The test protocol identified 33 of these and also found 15 additional RGN's that were not predicted from the manifest information. Indeed, one sample identified on the manifest as a waste solvent was classified by the protocol as RGN 106 (water and mixtures containing water). On further investigation, the sample was found to be the water layer of a two-phase system that had been mislabeled during sampling. Two of the RGN's missed by the test procedure were manifested as being at low levels. The levels were not specified. The remainder of the unidentified RGN's were organics dissolved in water, a classification not in the current RGN list. Analysis time averaged 1.3 hr per phase.

The sensitivities of the tests to their respective RGN's is important because it is not known at what levels the danger from the reactivity of a particular RGN may become significant. For example, an oil identified as having high levels of polychlorinated biphenyls (PCB's) was found to contain chlorinated aromatic organics (a correct identification); but two oils said to have low PCB levels gave negative responses to the chloride test. The difference in the PCB levels of these oils is not known, but they would require significantly different decisions about handling and disposal procedures. Also, some materials had a positive nitrogen test, but no nitrogen-containing RGN's could be identified.

Conclusions and Recommendations

Actual wastes were classified into correct RGN's, and a hazardous waste reactivity test protocol was developed that can classify wastes into the 41 reactivity groups defined by Hatayama et al. The equipment and materials needed to carry out the protocol can be packaged and transported to the field in a car or small van. The tests can be conducted in the field without utilities. The classification time per waste phase (1.3 hr) is reasonable.

Weaknesses in the field application of the kit include the need for a working surface of about 1.8 m^2 (20 ft^2) and difficulties in performing the tests under adverse weather conditions. Specifically, wind, temperature below about 5°C (40°F), or precipitation makes testing difficult. A temperature above 33°C (90°F) will also have adverse effects on test results. One potential problem area with the RGN classification system is RGN 106 (water and materials dissolved in water). The system does not classify water phases heavily laden with dissolved organics into the organic RGN's. A few cases of compounds classified into the wrong RGN by Hatayama et al. were also noted.

Recommendations arising from the results and conclusions of this project are as follows:

- Efforts should be initiated to establish the detection limits of the various RGN tests.
- A review of the original (Hatayama et al.) classification scheme should be conducted to verify the accuracy of the RGN listings.
- The predicted compatibilities of the Hatayama et al. compatibility chart should be verified in the laboratory.
- RGN 106 in Hatayama et al. should be reviewed to determine whether it is appropriately defined or should be further broken down.
- Procedures should be developed to identify organics in water phases and the RGN's to which they belong.
- The protocol should be expanded to include schemes for more accurate identification of specific compounds or classes of compounds.
- The protocol should be expanded to include procedures to identify specific generic wastes streams.
- The protocol should be challenged by an expanded variety of wastes.

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The complete report, entitled "Design and Development of a Hazardous Waste Reactivity Testing Protocol," (Order No. PB 84-158 807; Cost: $16.00, subject to change) will be available only from:
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