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An Approach for Sampling Solid Heterogeneous Waste at the Hanford Site Waste Receiving and Processing and Solid Waste Projects

R. A. Sexton

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Westinghouse Hanford Company
P.O. Box 1970
Richland, Washington 99352

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AN APPROACH FOR SAMPLING SOLID HETEROGENEOUS WASTE AT THE HANFORD SITE WASTE RECEIVING AND PROCESSING AND SOLID WASTE PROJECTS

R. A. Sexton

Westinghouse Hanford Company
Richland, WA

ABSTRACT. This paper addresses the problem of obtaining meaningful data from samples of solid heterogeneous waste while maintaining sample rates as low as practical. The Waste Receiving and Processing Facility, Module 1, at the Hanford Site in south-central Washington State will process mostly heterogeneous solid wastes. The presence of hazardous materials is documented for some packages and unknown for others. Waste characterization is needed to segregate the waste, meet waste acceptance and shipping requirements, and meet facility permitting requirements. Sampling and analysis are expensive, and no amount of sampling will produce absolute certainty of waste contents. A sampling strategy is proposed that provides acceptable confidence with achievable sampling rates.

INTRODUCTION

The Hanford Site, located in south-central Washington State, has a variety of forms of radioactive and mixed waste to be treated and/or disposed. The Waste Receiving and Processing Facility Module 1 (WRAP-1) currently is being designed to examine, process, certify, and ship drums and boxes of solid wastes that have a surface dose rate of less than 200 mrem/h. These wastes, known as Contact Handled (CH), consist of both waste currently in retrievable storage and waste to be newly generated concurrently with the operation of WRAP-1. WRAP-1 will segregate the waste into three streams. Transuranic (TRU) waste, which contains greater than 100 nCi of transuranic radionuclides per gram of waste matrix, will be packaged and certified for shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico. Waste below this limit containing dangerous waste, as defined by *Washington State Administrative Code* 173-303 (1), will be held for subsequent treatment at another facility. Waste below the 100 nCi/g limit, which is free of dangerous waste, is considered low-level waste (LLW) and will be disposed of onsite.

The proper characterization of waste is driven by several needs. These needs include: the designation of the waste for subsequent treatment and/or disposal, waste acceptance requirements for disposal at WIPP or at the Hanford Site, documentation required for shipping of the waste, and the permitting requirements for operation of the facility.

The most challenging waste to be characterized is the retrievably stored waste. There are nearly 38,000 drums of retrievable waste buried in trenches.

Characterization of the waste for each drum will include several steps. These steps include examination and weighing of the drum, Non-Destructive Assay (NDA), Non-Destructive Examination (NDE) through radiography, and chemical analysis of a head-gas sample. These steps, in combination with the available waste history, will answer many, but not all, questions needed to characterize the waste. Some physical sampling and analysis of the waste will be needed to identify dangerous wastes that are not able to be identified through any of the other characterization steps.

Sampling large quantities of heterogeneous waste presents an important challenge. Taking many samples, with analysis done to meet certification requirements, becomes very expensive and increases personnel exposure to radiation. However, no amount of sampling will produce absolute certainty of the content of this waste. This paper will consider the problem of how to provide acceptable levels of confidence with achievable sampling rates.

RETRIEVABLE WASTE DESCRIPTION

The U.S. Atomic Energy in 1970 defined TRU waste as a separate waste category and required that it be stored in a retrievable form, pending decisions on permanent disposal. At that time, 10 nCi/g was selected as the lower limit for the TRU waste category. Waste with a TRU content above that limit was stored in the Hanford Site burial grounds. The limit was revised upward to the present value of 100 Ci/g in 1982. Equipment required to assay to the 100 nCi/g limit was installed in 1985. Some waste stored between 1970 and 1985 will be found to be below the TRU limit when it is retrieved and assayed. It has been estimated that 47 percent of the 37,641 drums in retrievable storage will be found to be LLW when assayed.

Waste continued to be buried in this form through 1988. This waste is from 44 different sources, both onsite and offsite. The waste comes from processing operations of several types such as cleanup operations, laboratories, and other sources. It can include metal, glass, wood, paper, cloth, liquid, powder, etc. Most of the waste is heterogenous in nature. Most drums contain multiple packages of waste within plastic bags.

The older the waste, the less information there is available on it. In particular, documentation of the dangerous components is incomplete for the older waste. Generators have been required to document the presence of hazardous constituents in the waste since 1986. Prior to that, limited information is available on the presence of hazardous materials in the retrievable waste. Consequently, just over 2 percent of the retrievable drums are currently documented as containing hazardous materials. However, it is estimated that approximately 12 percent of all drums will contain some hazardous materials. This estimate is based on the percentage of drums with mixed waste from 1986 and 1988, after generators were required to document mixed waste.

Some of the hazardous material will be detected through head gas analysis. Some will be in a form that is detectable through NDE. NDE will also identify smaller containers within the drums. These containers will contain some of the hazardous materials and will be removed from the main process enclosure and processed separately. None of these conditions contribute to the problem of detecting hazardous materials by sampling heterogenous waste. However, some hazardous material is expected in the heterogenous waste that is not detectable through means other than sampling.

SAMPLING STRATEGY

The following describes the logic that will be used to determine the amount of sampling needed for characterization in WRAP-1 and the conclusions that will be drawn from that sampling.

Define Lot

Drums of waste will be processed in lots. To be defined as a lot for sampling purposes, a group of drums must meet three requirements: (a) the drums, based on what is known about the process that produced them, contain similar waste; (b) the expected probability of finding hazardous material, through sampling, is equal; and (c) the drums are available for processing through WRAP-1, such that the lot can be dispositioned together. That is, the first drums to be processed must be stored until final conclusions are drawn for the lot. Nonconforming and hazardous items that are identifiable through other means will have been dispositioned separately and do not impact the issue addressed by this paper. Process history, waste type, other characterization data (NDE, NDA, Head Gas Analysis), and burial records may all provide information useful in defining lots.

Examples. Out of the 236 drums received from Rockwell Energy Systems Group, there is a 21-drum shipment known to contain oil, based on burial records. There are 7 shipments totaling 93 drums known to contain lead. The 21 drums in which oil is suspected would not be grouped in a lot with the remaining drums unless the oil is containerized, identified through NDE, and removed before sampling. Because lead can be detected through NDE and removed prior to sampling, the 93 drums in which lead is suspected could be included in the same lot unless the waste type for these drums is significantly different.

There are 203 drums received from Exxon and 150 from General Electric. Although these drums are from different generators, they are the result of similar processes and are similar in age. There is a low expectation of finding hazardous materials in this waste, and it is likely that all 353 drums could be grouped together as a lot.

It should be noted that in both examples, final definition of lots will be done based on additional information that will be available after retrieval.

Minimum Process Sampling and Analysis

Random samples of a lot will be taken until one of following two conclusions is drawn.

1. No hazardous material has been detected and the lot can be considered nonhazardous. The number of samples needed to draw this conclusion is a function of the variables used in the following statements. "We will be w% confident that lots with x% or less drums containing hazardous waste will be accepted, and we will be y% confident that lots with z% or more drums with hazardous waste will be rejected." These variables are negotiable with regulatory agencies, but are expected to result in the need to sample approximately 25 drums (regardless of lot size for lots larger than 100) to consider the lot nonhazardous.

2. Some hazardous material has been detected, but further analysis is needed to draw a conclusion. In this case, the number of samples will not exceed the number that would be required to draw conclusion "a" (approximately 25 drums sampled), but a smaller number of samples will be taken if a high percentage of them contain hazardous material. This reject number is also a function of the variables in the above risk statements, but it will take approximately two drums found to have hazardous material to suspend further sampling at this step. Further sampling would only be done after statistical and economic analysis has determined that additional sampling is necessary and cost effective.

Process sampling and analysis will have data quality adequate to make reliable processing decisions, but will be less expensive than the more stringent analysis needed to meet certification requirements of regulatory agencies.

The number of samples per drum will depend upon the needed data quality, the sampling method, the number of packages of waste in a drum, and the heterogeneity of the waste within a drum. Currently, WRAP-1 is being designed based on a "snip and swipe" sampling method. In this method, small portions of soft waste are removed as samples and hard items requiring sampling have a smear sample taken. These methods lend themselves to "authoritative" sampling within the drum; that is, the waste items in the drum most likely to contain hazardous material are sampled. The drum will have been selected on a random basis, but the waste items within the drum may be selected on an authoritative basis. Using the snip and swipe method, three to four samples will probably be taken from each drum sampled. This does not ensure that an unsampled packet within a drum would not contain hazardous material. Rather, the statistically based sampling approach will be based on confidence statements as described above. Remote detection methods, which would provide near real-time analysis of waste during processing, are being evaluated. If a remote detection method is used for process sampling, it is likely that the number of detections per drum sampled will increase due to the speed and ease with which these readings can be taken.

Hazardous Material Detection

Analysis will be completed for hazardous materials that could potentially be in the waste. Process history and other characterization data will be used to rule out materials that do not require analysis. Only those materials found at this step will be of further concern if additional process sampling and analysis are required.

Subdivision of Lots

The appearance of hazardous material in the lot may be able to be correlated to some factor that had not been considered in the initial definition of the lot. For example, if the drums that had hazardous material in their samples also had pumps or piping in the drums and drums without pumps or piping were free of hazardous material, this might be used as a basis for subdividing the lot. Based on NDE examination, those drums with pumps and piping could be considered a sublot and those without another sublot. Any information that is available through NDE, NDA, head-gas analysis, process history, or burial records and that also correlates with hazardous material in the known samples may be used. This is true even if the reason for the correlation is unknown. The sublots will now be handled as separate lots and any additional sampling to meet "minimal" requirements will have to be done.

Example. Suppose a 1,000-drum lot is divided into 203 suspect hazardous and 797 are expected to be nonhazardous, based on correlation with 5 drums sampled and found to be hazardous and 20 drums sampled and found to be nonhazardous. The previous sample results are applicable to the new lots, but the 797-drum lot will require 5 additional drums to be sampled (for a total of 25). The suspect hazardous lot will require additional consideration to determine if additional sampling is warranted.

Lots With Small Quantities of Hazardous Material

If a lot has some hazardous material and there is no basis for subdividing the hazardous from nonhazardous drums (there is no basis for predicting the presence of hazardous material in the drums that have not been sampled), the lot may still qualify as nonhazardous if the amount of hazardous material is small. Based on EPA SW-846 (2), the lot can qualify as nonhazardous if the confidence interval is less than the regulatory threshold.

Examples. Assume samples are taken from 25 randomly selected drums and 23 are found to have no detectable hazardous materials, but 2 have levels of 250 and 200 ppm, respectively, of a hazardous material with a regulatory threshold (RT) of 50 ppm. The sample mean would be 18; the variance (s^2) would be

3,933; the standard deviation(s) would be 62.7; the standard error would be 12.5; and the confidence interval (CI) would be 32.5. Because this is below the RT of 50 ppm, the entire lot can be declared nonhazardous based on these samples.

Assume results similar to the previous example, except that the two samples with hazardous material have results of 500 and 600 ppm, respectively. In this case, the sample mean would be 44 (still below the RT); the s^2 would be 23,400; s would be 153; the standard error would be 30.6; and CI would be 84.3. Because this is above the RT, the lot cannot be declared nonhazardous without additional sampling.

Consideration of Additional Sampling

In cases where the sample mean is below the RT, but the CI is above the RT, additional sampling may be considered. It is possible that additional sampling will lower the CI, which is a function of the number of samples, sufficiently to declare the lot nonhazardous. Before additional samples are taken, the number that would be needed to qualify the lot as nonhazardous should be estimated. If the sample mean is above the regulatory threshold, there is no reason to expect further sampling to qualify the lot, and a decision must be made whether it is economically justifiable to sample each drum.

Examples. In the previous example where the sample mean is 44, the RT is 50, and the CI is 84.3, consideration should be given to additional sampling as a means of qualifying the lot as nonhazardous. Assume that the number of samples increased until CI < RT. Also, assume that the additional samples have results similar to the initial 25 (i.e., the sample mean and s are unchanged). With the sample mean at 44, reducing CI to below 50 would require an additional 1,043 samples, based on the relationship between CI and the number of samples.

Consider a lot in which 23 of 25 samples contained no detectable hazardous material and the other two had levels of 350 and 400, respectively. The sample mean would be 30, and the CI would be 57.4, above the RT. In this case, adding samples with the same sample mean and s would reduce CI below RT after an additional 21 (for a total of 46) samples are taken. The additional samples may change the sample mean and s, which would increase or decrease the actual number of samples required to qualify this lot as nonhazardous.

Before additional samples are taken or analyzed, consideration must be given to the economic justification of the additional sampling and analysis. This will be based on three values: (a) the estimated number of nonhazardous drums in the lot, (b) the cost of the additional sampling, and (c) the added cost of treating nonhazardous waste as hazardous. The last value will depend on the treatment required for the specific waste type and hazardous contaminant under consideration.

Additional sampling has the potential operational effect of recycling drums through the process enclosure, which were previously processed. In some cases, it may be beneficial initially to take more samples than are needed and perform analysis only on as many as are required.

Extended Lots

In some cases, a lot may have been processed which is expected to be similar to additional drums that are yet to be retrieved. After a lot has been designated nonhazardous, other similar drums can be designated as an extension of the same lot. A representative number of these drums will be randomly sampled to confirm that they are indeed similar to those that have already been qualified. Process sampling and analysis will be done to confirm that an extended lot, which is considered nonhazardous, continues to qualify as nonhazardous on the same basis as the original lot.

Examples. A lot of 100 drums qualifies as nonhazardous based on 25 drums being sampled without any hazardous materials being detected. Another 900 drums are identified as candidates for the same lot had they been available for processing at the same time. These 900 drums, located as such that their retrieval will take place over a number of years, will be received at WRAP-1 in groups of 50 or less. For each new group, a number of drums will be randomly selected that would equal a rate of 25 drums over the cumulative number of drums in the extended lot. That is, in a group of 47 received immediately after the first 100 were qualified, 8 drums (25*47/147) would be sampled. In the last group of 40, out of a total of 1,000, only 1 drum (25*40/1000) would be sampled. As long as samples continued to be free of nonhazardous materials, drums would be dispositioned on an ongoing basis.

In a lot with some hazardous material that was qualified based on CI<RT, the number of samples from each new group would be selected in the same manner with CI being updated, based on ongoing results.

Combined Lots

After process sampling has occurred, there may be justification for combining lots of nonhazardous material to reduce the amount of more stringent analysis done to meet regulatory requirements. To justify this step, it would need to be shown that the combined lot consists of similar material with an equal, very low, probability of finding hazardous material in a sample.

Sampling Each Drum of a Lot

Some lots that cannot be qualified as nonhazardous through sampling may not have any basis for subdividing the lot. However, there may still be a significant number of nonhazardous drums in the lot. The only way to segregate the nonhazardous drums in this case is to sample every drum. Before this is done, the cost of the additional sampling must be compared to the cost of treating the entire lot as hazardous. An estimated number of nonhazardous drums in the lot will be based on the previous sample results. In this case, the purpose of sampling is to categorize the drum as hazardous or nonhazardous, without regard to the rest of the lot. Each drum is treated as though it was a separate lot and will be designated as hazardous or nonhazardous based on sample results from that drum. After this segregation has occurred, the hazardous and nonhazardous groups may be considered segregated lots and further stringent analysis needed may be applied to these segregated lots.

Analysis to Meet Regulatory Requirements

The data quality and the amount of documentation needed for waste certification to satisfy regulatory agencies are expected to be greater than are needed for processing decisions. The number of samples taken for certification can be minimized by considering process sampling as part of the process that produces a final lot for certification purposes. The final lot can be based on the original lot, an extended lot, a combined lot, or a segregated lot.

ESTIMATED SAMPLING REQUIREMENTS

The anticipation of success with the above sampling strategy is based on estimates that there will be a significant number of lots processed by WRAP-1 without hazardous materials in the samples, and a relatively small number of lots that will warrant drum-by-drum segregation. There are many unknowns about the waste and it is not possible to know in advance how many samples will be required, but rough estimates have been prepared based on the proposed sampling strategy.

An estimated 12 percent of retrieved drums will contain hazardous material, but of these, approximately 80 percent are expected to be detected through means other than random sampling. Therefore, only an estimated 900 will contain hazardous materials detectable only through sampling. These will not occur randomly, but often will be in clusters. Based on analysis of these clusters where hazardous waste is documented, approximately 40 percent of retrieved drums will occur in lots with no hazardous materials detectable through sampling, and an additional 20 percent in lots with only trace amounts of hazardous materials that still will require only minimum sampling. The remaining 40 percent of lots will be subject to strategies of lot subdivision, increased sampling, or designation of the entire lot as hazardous. The economic analysis involved in deciding on increased sampling is very dependent on the type of process sampling used. That is, the relative economy of remote detection, if it were used, makes increased process sampling more attractive. Based on currently planned sampling methods, these estimates result in total process sampling rates of approximately 13 percent of all drums, leaving more stringent analysis to meet regulatory requirements on about 3 percent of all drums.

REFERENCES

1. WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended, Washington Department of Ecology, Olympia, Washington.

2. U.S. Environmental Protection Agency, *Test Methods for Evaluating Solid Waste*, SW-846, Revision 1, Washington, D.C. (1990).

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