

## ASTM STANDARD GUIDE FOR EVALUATING DISPOSAL OPTIONS FOR REUSE OF CONCRETE FROM NUCLEAR FACILITY DECOMMISSIONING

Ann Marie Phillips  
Idaho National Engineering And Environmental Laboratory  
P.O. Box 1625, Idaho Falls, ID 83415 -3765  
Phone: (208) 526-6877 Fax: (208) 526-4313  
E-Mail: [aqg@inel.gov](mailto:aqg@inel.gov)

Richard H. Meservey, Environmental Remediation Technologies Department Manager  
Idaho National Engineering And Environmental Laboratory  
P.O. Box 1625 Idaho Falls, ID 83415-3710  
Phone: (208) 526-1834 Fax: (208) 526-6802  
E-Mail: [rhm@inel.gov](mailto:rhm@inel.gov)

### ABSTRACT

Within the nuclear industry, many contaminated facilities that require decommissioning contain huge volumes of concrete. This concrete is generally disposed of as low-level waste at a high cost. Much of the concrete is lightly contaminated and could be reused as roadbed, fill material, or aggregate for new concrete, thus saving millions of dollars. However, because of the possibility of volumetric contamination and the lack of a method to evaluate the risks and costs of reusing concrete, reuse is rarely considered. To address this problem, Argonne National Laboratory–East (ANL-E) and the Idaho National Engineering and Environmental Laboratory teamed to write a “concrete protocol” to help evaluate the ramifications of reusing concrete within the U.S. Department of Energy (DOE). This document, titled the *Protocol for Development of Authorized Release Limits for Concrete at U.S. Department of Energy Site* (1) is based on ANL-E’s previously developed scrap metal recycle protocols; on the 10-step method outlined in DOE’s draft handbook, *Controlling Release for Reuse or Recycle of Property Containing Residual Radioactive Material* (2); and on DOE Order 4500.5, *Radiation Protection of the Public and the Environment* (3).

The DOE concrete protocol was the basis for the *ASTM Standard Guide for Evaluating Disposal Options for Concrete from Nuclear Facility Decommissioning*, which was written to make the information available to a wider audience outside DOE. The resulting *ASTM Standard Guide* is a more concise version that can be used by the nuclear industry worldwide to evaluate the risks and costs of reusing concrete from nuclear facility decommissioning. The bulk of the *ASTM Standard Guide* focuses on evaluating the dose and cost for each disposal option. The user calculates these from the detailed formulas and tabulated data provided, then compares the dose and cost for each disposal option to select the best option that meets regulatory requirements. With this information, the reuse of concrete may be possible, thus reducing dose and decontamination and decommissioning costs. This paper outlines ten steps required to release concrete for reuse and discusses the disposal options covered in the *ASTM Standard Guide*.

### INTRODUCTION

The *ASTM Standard Guide for Evaluating Disposal Options for Reuse of Concrete from Nuclear Facility Decommissioning* is a decision-making tool for evaluating the risk and cost of reusing concrete from nuclear facility decommissioning. With this tool, reuse of concrete may be possible, thus saving millions of dollars (4) during decontamination and decommissioning (D&D) of nuclear facilities.

Numerous nuclear facilities containing large amounts of concrete are scheduled for D&D over the next several decades. Much of this concrete is either not contaminated or only lightly contaminated on or near the surface. However, since concrete is slightly porous, it has the potential to be contaminated volumetrically. Volumetric contamination is more difficult to measure than surface contamination, and currently there are no release guidelines for volumetrically contaminated concrete. As a result, large volumes of concrete are often disposed of as radioactive waste at a large cost.

Under certain conditions, the depth or amount of contamination may be limited such that a case can be made for concrete release for reuse outside of regulatory control. These cases are likely to be ones where the radioactive contamination is shallow and is limited to a depth that can be removed by scabbling (removal of the concrete surface), or where the depth can be estimated based on the history and condition of the concrete. If released, this concrete could be reused for purposes such as roadbed or backfill material.

Argonne National Laboratory East (ANL-E) and the Idaho National Engineering and Environmental Laboratory (INEEL) teamed to develop a protocol to facilitate reuse of concrete within the U.S. Department of Energy (DOE). The resulting document, *Protocol for Development of Authorized Release Limits for Concrete at U.S. Department of Energy Sites* (1), hereafter referred to as the “concrete protocol”, provides guidelines for reuse of concrete within DOE and outlines the steps necessary to apply for release on a case-by-case basis, as allowed by DOE. The concrete protocol is based on the ten-step process for reuse of material outlined in DOE’s draft handbook, *Controlling Release for Reuse or Recycle of Property Containing Residual Radioactive Material* (2); on DOE Order 4500.5, *Radiation Protection of the Public and the Environment* (3); and on protocols for scrap metal reuse previously developed by ANL-E. The *ASTM Standard Guide for Evaluating Disposal Options for Reuse of Concrete from Nuclear Facility Decommissioning* was developed to make the process described in the concrete protocol available across the nuclear industry. The *ASTM Standard Guide* for reuse of concrete uses the analysis methodology and data from the concrete protocol, but is an abbreviated version that does not include the DOE requirements.

The *ASTM Standard Guide* for reuse of concrete describes a ten-step process for releasing radioactively contaminated concrete from decommissioning nuclear facilities. As one of the steps, the process provides a method and supporting data to estimate the dose and cost impacts for various disposal options. Using an As Low as Reasonably Achievable (ALARA) approach, this data can be used to select the best disposal option, which should meet regulatory guidelines while reducing dose and cost. Release of any surface or volumetrically contaminated material must meet all criteria of the governing regulatory agencies.

One of the ten steps is to complete a detailed analysis of the cost and dose to non-radiation workers (the public) for each disposal option. The methodology and supporting data to perform this analysis are detailed in the appendices of the guide. These data, which establish a technical basis to apply to release the concrete, can be used in several ways:

- To show that the release meets existing release criteria
- To establish a basis to request release of the concrete on a case-by-case basis
- To develop a basis for establishing release criteria where none exists.

For any of the above situations, or even if the concrete is not released, using the process outlined here provides a clear approach for making decisions about disposal of the concrete, as well as detailed records/documentation of how the decision was made, which will be useful to future custodians and decision-makers.

## TEN STEP PROCESS

Table I. Summary of the Ten Step Process.

Step 1	Characterize Property and Prepare a Description
Step 2	Determine whether Applicable Authorized or Supplemental Guidelines Already Exist
Step 3	Define Authorized or Supplemental Guidelines Needed
Step 4	Develop Authorized or Supplemental Guidelines
Step 5	Compile and Submit Application for Approval from the Regulatory Agencies
Step 6	Document Approved Guidelines in the Public Record
Step 7	Implement Approved Guidelines
Step 8	Conduct Surveys/Measurements
Step 9	Verify that Applicable Authorized or Supplemental Guidelines have been Met
Step 10	Release Property

### Step 1: Characterize Property and Prepare a Description

In step one, radiological surveys are conducted to determine the isotopes and level of radioactive contamination on the surface of the concrete. In addition, the concrete's physical and radiological characteristics, including history, should be documented. These can be used to estimate the depth of penetration of radioactive contamination, or the depth can be measured.

### Step 2: Determine whether Applicable Authorized or Supplemental Guidelines Already Exist

The second step involves determining whether existing authorized release guidelines, such as ANSI/HPS N13.12-1999 (5), U.S. NRC Regulatory Guide 1.86 (6), or others, apply. If they do and the concrete meets them, the concrete could be released per the guidelines under direction of the governing regulatory agency. Even if the concrete meets release guidelines and can be released, it might be helpful to complete the analysis of disposition alternatives described in step four to help decide the most cost effective way to dispose of the concrete.

### Step 3: Define Authorized or Supplemental Guidelines Needed

If no applicable guidelines exist, the third step in the process is to define what type of release guidelines are needed. They may be surface or volumetric, one-time or routine release, or for restricted or unrestricted release.

### Step 4: Develop Authorized or Supplemental Guidelines

In the fourth step, the dose to the public and cost for various disposal options can be estimated and an ALARA analysis conducted to select the best option. Seven general options are described in the guide, including, for example, "Decontaminate, dispose of all low-level radioactive waste (LLW), crush, and reuse as roadbed material." For each disposal option, one or more of the following five actions may apply: decontamination, demolition/crushing, packaging/transportation, reuse, and disposal/entombment. The dose and cost of a disposal option depend on the actions that make up that option. Table I provides a list of the options and the applicable actions.

The *ASTM Standard Guide* provides the methodology and supporting data to estimate the dose and cost of each action. To evaluate a disposal option, use the applicable sections of the guide to calculate the dose and cost for each action in the disposal option, then sum the dose and cost from all of the applicable actions to find the total dose and cost for that disposal option.

The costs or radiological doses (when applicable) can be estimated by using unit-cost or unit-dose factors. The dose estimate is based on the isotopes present, the estimated or measured depth of penetration, and the disposal option. Unit-dose factors are used to estimate the radiological doses to members of the public from the reuse or disposal of concrete materials. These factors were generated with a suite of computer codes, such as RESRAD (7), RESRAD-BUILD (8), RESRAD-RECYCLE (9), TSD-DOSE (10), and RISKIND (11). The cost is based on factors associated with the disposal option, such as decontamination, transportation, and disposal. The unit-cost factors were obtained from such sources as Ayers et al. (4), Chen et al. (12), Dickerson et al. (13), and others. The cost analysis information provided does not include cost avoidance through such things as schedule acceleration and reduced surveillance.

Table II. Concrete Disposal Options and Applicable Actions.

Disposal Options	Applicable Actions
Decontaminate the concrete material, dispose of all LLW, and crush and reuse the decontaminated material	Decontamination, Demolition/Crushing, Packaging/Transportation, Reuse, and Disposal.
Crush and reuse the concrete without decontamination	Demolition/Crushing, Packaging/Transportation, and Reuse
Decontaminate the concrete, dispose of all LLW, demolish the structure, and dispose of the decontaminated material as construction debris (nonradiological landfill) or reuse as backfill	Decontamination, Demolition/Crushing, Packaging/Transportation, Reuse, and Disposal
Demolish the structure and dispose of the concrete material as construction debris or reuse as backfill (nonradiological landfill – no decontamination)	Demolition/Crushing, Packaging/Transportation, Reuse, and Disposal
Demolish the structure and dispose of all materials as LLW	Demolition/Crushing, Packaging/Transportation, and Disposal
Decontaminate the building and reuse as office space	Decontamination, Packaging/Transportation, Reuse, and Disposal
Demolish the building and entomb on-site	Demolition/Crushing, and Disposal/Entombment

After completing a detailed analysis of the estimated dose and cost for each option, the results can be compared to choose the best option. The best option is likely to be the one that meets regulatory guidelines while reducing dose and cost. The data can be used to support release of the concrete if release guidelines already exist. If release guidelines do not exist, the data can be used to establish a basis to request release of the concrete either on a case-by-case basis or to set new release guidelines.

#### **Step 5: Compile and Submit Application for Approval from the Regulatory Agencies**

Once the disposal option is selected, an application for approval to release material can be compiled and submitted.

#### **Step 6: Document Approved Guidelines in the Public Record**

In step six, the approved guidelines and release should be documented in the public record to provide the public with information about the radiation levels and expected dose.

#### **Step 7: Implement Approved Guidelines**

The seventh step of the process is to implement the approved guidelines, per the governing regulatory agency.

#### **Step 8: Conduct Surveys/Measurements**

Prior to releasing the material, radiological surveys need to be conducted to show that the concrete meets applicable release guidelines.

#### **Step 9: Verify that Applicable Authorized or Supplemental Guidelines have been Met**

In the ninth step, radiological survey results are compared to the release guidelines to verify that the release guidelines have been met, and the results of this comparison are documented.

#### **Step 10: Release Property**

After verifying that the release meets all applicable regulations and procedures, the material is released for reuse under the direction of the governing agencies.

### **APPLICABLE AREAS/LIMITATIONS**

The *ASTM Standard Guide* for reuse of concrete helps determine estimated doses to the public during disposal of concrete and to future residents of disposal areas. It does not include dose to radiation workers or others already involved in a radiation protection program. It is assumed that the dose to radiation workers is already tracked and kept within acceptable levels through a radiation control program. The cost and dose to radiation workers could be added to determine an overall cost and dose for each option.

This guide applies to surface or volumetrically contaminated, non-rubblized concrete that is still in place with a defined geometry and known history where the depth of contamination can be measured or estimated based on its history. After concrete has been rubblized, it is difficult to measure the radiation levels and not easy to remove surface contamination to reduce radiation levels. This guide does not apply to the reinforcement bar (rebar) found in concrete. Although most concrete contains rebar, it is generally removed before the concrete is dispositioned. In addition, rebar may be activated, and is covered under procedures for reuse of scrap metal.

### **ADDITIONAL SUPPORTING ASTM DOCUMENTS**

In addition to the *ASTM Standard Guide* described herein, other ASTM documents provide information about D&D of nuclear facilities. These include the *ASTM Standard Guide for Unrestricted Disposition of Bulk Materials Containing Residual Amounts of Radioactivity*, ASTM-E-1760-96 (14), which provides a general process for release of materials containing residual amounts of radioactivity. The ASTM document *Standard Guide for Radioactive Pathway Methodology for Release of Sites Following Decommissioning*, ASTM-E-1278-88 (15), provides a general process for analyzing radioactive pathways. Information about conducting radiological surveys can be found in the *Standard Guide for*

*Selection and Use of Portable Radiological Survey Instruments for Performing In Situ Radiological Assessments in Support of Decommissioning*, ASTM Standard E-1893 (16).

## CONCLUSION

Nuclear facilities typically contain large volumes of structural and shielding concrete. Most of the concrete is clean or lightly contaminated and could be reused as back-fill material or roadbed. However, because of the risk of volumetric contamination and the lack of a method to evaluate the risks and costs of reuse of concrete, reuse is rarely considered, and the concrete is usually disposed of as LLW at a high cost. With the new *ASTM Standard Guide* for reuse of concrete described in this paper, reuse of material may be possible. The guide outlines a ten-step process for releasing concrete for reuse. One of the primary steps involves evaluating the dose and cost for various disposal options and selecting the one that meets regulatory requirements while reducing dose and cost. With the data from this analysis, several things can be done. If the concrete meets regulatory requirements and release is approved, it may be released under direction of the governing regulatory agency. If no guidelines exist, the analysis could be used to apply for release on a case-by-case basis or to set new regulatory guidelines for release. However the data are used, they provide clearly documented history of the decision process used in determining the disposition of concrete from nuclear facility decommissioning.

## REFERENCES

1. Arnish, J., et al., *Protocol for Development of Authorized Release Limits for Concrete at U.S. Department of Energy Sites*, ANL/EAD/TM-92, Argonne National Laboratory, Argonne, IL (July 2000).
2. U.S. Department of Energy, *Draft Handbook for Controlling Release for Reuse or Recycle of Property Containing Residual Radioactive Material, Interim Guide — for Interim Use and Comment*, Washington, D.C. (June 1997).
3. U.S. Department of Energy, Order 5400.5, *Radiation Protection of the Public and the Environment*, as amended, Washington, D.C. (February 1990).
4. Ayers, K., et al., *Reuse of Concrete from Contaminated Structures*, Vanderbilt University, Nashville, TN (January 1999).
5. American National Standards Institute Health Physics Society, *Surface and Volume Radioactivity Standards for Clearance*, ANSI/HPS N13.12.
6. U.S. Nuclear Regulatory Commission (NRC), *Termination of Operating Licenses for Nuclear Reactors*. Regulatory Guide 1.86, Washington D.C. (1974).
7. Yu, C., et al., *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0*, ANL/EAD/LD-2, Argonne National Laboratory, Argonne, IL (September 1993).
8. Yu, C., et al., *RESRAD-BUILD: A Computer Model for Analyzing the Radiological Doses Resulting from the Remediation and Occupancy of Buildings Contaminated with Radioactive Material*, ANL/EAD/LD-3, Argonne National Laboratory, Argonne, IL (November 1994).
9. Cheng, J. -J., et al., unpublished information on RESRAD-RECYCLE, Argonne National Laboratory, Argonne, Ill. (January 1999).

10. Pflingston, M., et al., *TSD-DOSE: A Radiological Dose Assessment Model for Treatment, Storage, and Disposal Facilities*, ANL/EAD/LD-4 (Rev.1), Argonne National Laboratory, Argonne, IL (September 1998).
11. Yuan, Y. C., et al., *RISKIND — A Computer Program for Calculating Radiological Consequences and Health Risks from Transportation of Spent Nuclear Fuel*, ANL/EAD-1, Argonne National Laboratory, Argonne, IL (November 1995).
12. Chen W. -Y., et al., *Assessment of Risks and Costs Associated with Transportation of U.S. Department of Energy Radioactively Contaminated Carbon Steel*, ANL/EAD/TM-62, Argonne National Laboratory, Argonne, IL (September 1996).
13. Dickerson, K. S., et al., *Demonstration Recommendations for Accelerated Testing of Concrete Decontamination Methods*, ORNL/TM-13098, Oak Ridge National Laboratory, Oak Ridge, TN (December 1995).
14. American Society for Testing and Materials (ASTM), *Standard Guide for Unrestricted Disposition of Bulk Materials Containing Residual Amounts of Radioactivity*, ASTM-E-1760 (1996).
15. ASTM *Standard Guide for Radioactive Pathway Methodology for Release of Sites Following Decommissioning*, ASTM-E-1278 (1988).
16. ASTM, *Standard Guide for Selection and Use of Portable Radiological Survey Instruments for Performing In Situ Radiological Assessments in Support of Decommissioning*, ASTM-E-1893.