UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAY 1 1 1983

ATTENTION: Commission Licensees

SUBJECT: FINAL WASTE CLASSIFICATION AND WASTE FORM TECHNICAL POSITION PAPERS

By Federal Register Notice dated December 27, 1982 (47 FR 57446), NRC amended its regulations to provide specific requirements for licensing facilities for the land disposal of low-level radioactive waste. The majority of these requirements are contained in a new Part 61 to Title 10 of the Code of Federal Regulations (10 CFR Part 61) entitled "Licensing Requirements for Land Disposal of Radioactive Waste." Some additional requirements directed primarily at waste generators and handlers including certification and use of shipping manifests were concurrently published as a new § 20.311 of Part 20 ("Standards for Protection Against Radiation").

As noted in the December 27 Federal Register Notice, the effective date of 10 CFR Part 20, § 20.311 is December 27, 1983, while the effective date of 10 CFR Part 61 and all other amendments is January 26, 1983. Section 20.311 requires that any licensee who transfers radioactive waste to a land disposal facility or to a licensed waste collector or processor must classify the waste according to § 61.55 of 10 CFR Part 61. Licensed waste processors who treat or repackage radioactive waste for disposal into a land disposal facility must also classify their waste according to § 61.55. This section defines radioactive waste suitable for disposal as falling into one of three classes (Class A, Class B, or Class C), and waste is determined to fall into one of the classes by comparison to limiting concentrations of some particular listed radionuclides. Class B and C wastes are subject to waste stability requirements which are set forth in § 61.56 of the rule. In addition, § 20.311 also requires that waste generators record on shipment manifests a description of the transferred waste as well as a certification that the waste is properly classified and that the manifest is filled out correctly. Licensees must also conduct a quality control program to assure compliance with the waste classification and waste stability requirements.

NRC staff recognizes that the new requirements may result in some modifications to existing licensee waste management practices, and furthermore believes that it will be useful to licensees to begin planning for implementation of the new requirements in advance of the December 27, 1983 effective date. At this time NRC staff is preparing Regulatory Guides on both waste classification and waste form. To provide immediate guidance to licensees, however, the NRC Low-Level Waste Licensing Branch has prepared technical position papers on waste classification and waste form.

The waste classification technical position paper describes overall procedures acceptable to NRC staff which may be used by licensees to determine the presence and concentrations of the radionuclides listed in § 61.55, and thereby classifying waste for near-surface disposal. This technical position paper also provides guidance on the types of information which should be included in shipment manifests accompanying waste shipments to near-surface disposal facilities.

The technical position paper on waste form provides guidance to waste generators on test methods and results acceptable to NRC staff for implementing the 10 CFR Part 61 waste form requirements. It can be used as an acceptable approach for demonstrating compliance with the 10 CFR Part 61 waste structural stability criteria. This technical position paper includes guidance on processing waste into an acceptable stable form, designing acceptable high-integrity containers, packaging cartridge filters, and minimizing radiation effects on organic ion-exchange resins.

The guidance in the waste form technical position paper may be used by licensees as the basis for qualifying process control programs to meet the waste form stability requirements, including tests which can be used to demonstrate resistance to degradation arising from the effects of compression, moisture, microbial activity, radiation, and chemical changes. Generic test data (e.g., topical reports prepared by vendors who market solidification technology) may be used for process control program qualification where such generic data is applicable to the particular types of waste generated by a licensee.

While the NRC staff has not formally reviewed or aproved any products, NRC staff believes that solidification processes and high-integrity containers currently exist that can be qualified to meet the waste form stability requirements. Licensees and vendors should continue their efforts to have qualified products available in advance of the December 27, 1983 implementation deadline. NRC staff will continue to work with licensees and vendors to meet the waste form requirements and implementation deadline. NRC staff will also continue to coordinate their work with cognizant representatives of States which currently have licensed low-level waste disposal sites.

Draft versions of both technical position papers have previously been made available to interested members of the public. Comments received on these drafts have been considered during development of the technical position papers being published at this time. Further public comment on these technical positions is welcomed, and any such comment received will be considered during preparation of the waste classification and waste form Regulatory Guides. Comments on the technical position papers may be forwarded to myself (Address: U.S. Nuclear Regulatory Commission, Washington, DC, 20555, mailstop SS-623). Questions on the technical position papers may be referred to Mr. Paul H. Lohaus (301-427-4500), to Mr. G. W. Roles (301-427-4593), or to Mr. Timothy C. Johnson (301-427-4697) of my staff.

The waste classification and waste form technical position papers are included as attachments to this letter. The information collections contained in these technical positions have been approved under OMB number 3150-0014.

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Low-Level Waste Licensing Branch
Division of Waste Management

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LOW-LEVEL WASTE LICENSING BRANCH TECHNICAL POSITION ON RADIOACTIVE WASTE CLASSIFICATION

A. Introduction

Section 20.311 ("Transfer for Disposal and Manifests") of 10 CFR Part 20 ("Standards for Protection Against Radiation") requires that any licensee who transfers radioactive waste to a land disposal facility or to a licensed waste collector or processor must classify the waste according to Section 61.55 ("Waste Classification") of 10 CFR Part 61 ("Licensing Requirements for Land Disposal of Radioactive Waste"). Section 20.311 also requires that any licensed waste processor who treats or repackages radioactive waste for disposal into a land disposal facility also classify their waste according to Section 61.55. Section 61.55 defines radioactive waste suitable for land disposal as falling into one of three categories--i.e., Class A waste, Class B waste, and Class C waste. Wastes are determined to fall into one of the classes by comparison to limiting concentrations of particular radionuclides which are set forth in Table 1 and Table 2 of Section 61.55. Wastes determined to fall into one of the classes must be labeled as such in accordance with Section 61.57 ("Labeling"). Waste generators and waste processors must record on shipment manifests a description of the transferred waste, and must also carry out a quality control program to assure that classification of waste is carried out in a proper manner.

All three classes of waste are required to meet certain minimum requirements as set forth in paragraph 61.56(a) of Section 61.56 ("Waste Characteristics") which are intended to facilitate handling of waste at the disposal site and provide protection of public health and safety. Class B and Class C wastes, however, are required to meet more rigorous requirements on waste stability. These stability requirements are set forth in paragraph 61.56(b) of Section 61.56. Class C waste must be also identified to allow for additional disposal procedures to be carried out at the disposal site to provide protection to a potential inadvertent intruder. Finally, wastes having concentrations of particular radionuclides exceeding those allowed for Class C waste are generally considered unacceptable for near-surface disposal.

This technical position describes overall procedures acceptable to the regulatory staff which may be used by licensees to determine the presence and concentrations of radionuclides listed in Section 61.55, and thereby classifying waste for near-surface disposal. The technical position also provides guidance and clarification on the minimum types of information which should be included on shipment manifests.

B. Discussion

Each shipment of radioactive waste by a waste generator to a licensed collector, processor, or operator of a land disposal facility must ensure that a shipment manifest accompany the waste. Section 20.311 states that the manifest must include information on waste characteristics including (as a minimum) a physical description of the waste, the volume, the radionuclide identity and quantity, the total radioactivity, the principal chemical form, the solidification agent (if any), and the waste class. As a minimum, the total quantity of the radionuclides H-3, C-14, Tc-99, and I-129 must be listed. These radionuclides, as well as the other radionuclides listed in Section 61.55, are used to determine the classification status of radioactive waste. Controlled disposal of wastes containing these radionuclides is considered important in assuring that the performance objectives of Subpart C of the Part 61 regulation are met. The manifest must also identify waste containing more than 0.1 percent by weight chelating agents, as well as provide an estimate of the weight percentage of the chelating agent. Additional information may be required for shipment to a particular disposal facility depending upon facility-specific license conditions.

To classify waste for disposal and fill out shipment manifests, a licensee must make two basic determinations: (1) whether the waste is acceptable for near-surface disposal, and (2) if acceptable for near-surface disposal, whether the waste is classified as Class A, Class B, or Class C waste. Another determination is whether the waste complies with any additional waste form, package, or content requirement which may be in place at the particular disposal facility to which the waste is to be shipped.

Waste is determined to be generally unacceptable for near-surface disposal if it contains any of the radionuclides listed in Tables 1 and 2 of Section 61.55 in concentrations exceeding the limits established for the radionuclides. If determined to be acceptable for near-surface disposal, waste is determined to be Class A, Class B, or Class C based upon the lists of radionuclide concentration limits set forth in Tables 1 and 2.

C. Regulatory Position

All licensees must carry out a compliance program to assure proper classification of waste. Licensee programs to determine radionuclide concentrations and waste classes may, depending upon the particular operations at the licensee's facility, range from simple programs to more complex ones. In general, more sophisticated programs would be required for licensees generating Class B or Class C waste, for licensees generating waste for which minor process variations may cause a change in classification, or for licensees generating waste for which there is a reasonable possibility of the waste containing concentrations of radionuclides which exceed limiting concentration limits for near-surface disposal.

The regulatory staff is prepared to be flexible in the adaptation of a particular program to a particular waste generating facility. A principal consideration for the acceptability of a particular program will be whether a reasonable effort has been made to ensure a realistic representation of the distribution of radionuclides within waste, given physical limitations, and to classify waste in a consistent manner. Example "physical limitations" can include difficulties in obtaining and measuring representative samples at reasonable costs and acceptable occupational exposures. The staff considers a reasonable target for determining measured or inferred radionuclide concentrations is that the concentrations are accurate to within a factor of 10. The staff recognizes, however, that this target may be difficult to achieve for some waste types and forms.

A licensee's program should be specific to a particular facility, and should consider the different radiological and other characteristics of the different waste streams generated by the facility. There are at least four basic methods which may be potentially used either individually or in combination by licensees:

- materials accountability;
- classification by source;
- gross radioactivity measurements; or
- direct measurement of individual radionuclides.

The following discussion outlines instances and conditions whereby each basic method or combinations thereof would be acceptable to regulatory staff as a program for demonstrating compliance with the waste classification requirement. Some licensees, such as nuclear power facilities, are expected to employ a combination of methods. Appendix A to this technical position outlines an example program for nuclear power facilities which the regulatory staff would find acceptable.

1. General Criteria

a. Compliance Through Materials Accountability

One method which the regulatory staff would find acceptable to determine radionuclide concentrations and demonstrate compliance with the waste classification requirements is through a program of materials accountability. That is, a given quantity (and resulting concentration) of radioactive material may be known to be contained within a given waste or may be inferred through determining the difference between the quantity of radioactive material entering and exiting a given process. This procedure is expected to be most useful for licensees who receive and possess only a limited number of different radioisotopes in known concentrations and activities (e.g., holders of source material, special nuclear material, or specific byproduct material licenses).

An example use of this method would be at a biomedical research facility at which known amounts of a radioisotope are injected into research animals, the carcasses of which are ultimately disposed of as radioactive waste. Another example would be a research or test facility performing activation analysis experiments. In this case, the quantity of radioactive material within a given waste stream may be inferred through calculation. A third example would be a power plant in which the radionuclide content of a particular process vessel (e.g., a resin bed) is determined on the basis of measurements of influent and effluent streams.

This method may also be used to determine the absence of particular radionuclides. That is, for most licensees, the absence of particular radionuclide may be determined through a knowledge of the types of radioisotopes received and possessed, as well as the process producing the waste. For example, if a licensee receives, possesses, and uses only tritium, there is no need to measure the waste stream for other isotopes such as iodine-129 or cesium-137.

b. Classification by Source

This method is similar to the above method of materials accountability and involves determining the radionuclide content and classification of waste through knowledge and control of the source of the waste. This method is expected to be useful for occasions when the radionuclide concentrations within waste generated by a particular process are relatively constant and unaffected by minor variations in the process.

This method is also expected to be frequently useful for determining the absense of particular radionuclides from a given waste stream. For example, within a given licensed facility there may be a number of separate controlled areas within which only a limited number of radioisotopes are possessed and used (e.g., Cs-137 may be used in one area and tritium in another). As long as facility operations are conducted so that transfer of radioactive material from one controlled area to another cannot occur, waste generated from a particular area may be readily classified by source. An example of a licensee for which this method is expected to be useful is a large university which holds a broad license for byproduct material.

c. Gross Radioactivity Measurements

Measurement of gross radioactivity is an acceptable method for all classes of waste provided that:

- the gross radioactivity measurements are correlated on a consistent basis with the distribution of radionuclides within the particular waste stream analyzed, and

- the radionuclide distributions are initially determined and periodically verified by direct measurement techniques.

Licensees carrying out gross radioactivity measurements to assure compliance with the waste classification requirement must establish a program to correlate and calibrate measured radioactivity levels with radionuclide concentrations in wastes prepared for shipment. This program must at a minimum take into account waste package and detector geometry, shielding and attenuation effects, the effective gamma energies of the emitted photons, and the number of photons per decay. The accuracy of the correlation must be initially established by and periodically checked through more detailed sample analysis involving measurement of specific radionuclides. The accuracy of the correlation should also be checked whenever there is reason to believe that process changes may have significantly altered previously determined correlations.

d. Measurement of Specific Radionuclides

Another method acceptable to the regulatory staff for determining radionuclide concentrations in waste is by direct measurement. In using this method, licensees may directly measure individual radionuclides or may establish an inferential measurement program whereby concentrations of radioisotopes which cannot be readily measured (through techniques such as gamma-spectral analysis) are projected through ratioing to concentrations of radioisotopes which can be readily measured. An example would be the practice of scaling transuranic concentrations to concentrations of the isotope Ce-144. Scaling factors should be developed on a facility and waste stream specific basis, and should be initially determined and periodically confirmed through direct measurements.

2. Determination and Verification of Radionuclide Concentrations and Correlations

Radionuclide concentrations should be determined based upon the volume or weight of the final waste form. Samples may be taken for analysis either from the final waste form or from the waste prior to processing into a final waste form (e.g., from any intermediate process step). Samples taken prior to final processing should enable the results of the sample analysis to be directly translated to the final waste form.

The lower limit of detection of a measurement technique for direct measurement of a particular radionuclide should be no more than 0.01 times the concentration for that radionuclide listed in Table 1, and 0.01 times the smallest concentration for that radionuclide listed in Table 2. For this technical position, the lower limit of detection for a particular measurement may be assumed by licensees to be consistent with the definitions for lower limit of detection (LLD) provided in references 1 and 2.

The radionuclides listed in Section 61.55 may be roughly organized into two groups: (1) those that are amenable to routine quantification by direct measurement techniques (e.g., gamma spectral analysis of isotopes such as Co-60 or Cs-137), and (2) those that require more costly and time consuming analysis frequently removed from the waste generator's facility (e.g., alpha/beta analysis).

For the first group of radionuclides, measurements to identify and quantify specific radionuclides within final waste forms should be performed:

- routinely for Class B and Class C wastes; and

- routinely for wastes for which minor process variations could cause an upward change in waste classification.

In this case, "routine" measurements would involve a limited number (e.g., one or two) of samples out of a batch. If radionuclide distributions are shown to be reasonably consistent from one batch to the next, however, consideration will be given to decreasing the frequency of routine measurements.

A more detailed analysis for the second group of radionuclides should be performed:

- periodically to confirm the correlation of measurements made from gross radioactivity measurements; and

- whenever there is reason to believe that facility or process changes may have significantly altered (e.g., by a factor of 10) previously determined correlations of gross radioactivity measurements.

The staff believes that for most facilities and for most Class B and C waste types, this confirmatory analysis should be performed on at least an annual basis. Confirmatory analyses for Class A wastes should be performed on at least a biannual basis. However, these frequencies may be raised or lowered based upon consideration of particular facility, waste stream, or radionuclide characteristics. Factors which would influence this consideration include the frequency of process vessel changeout or waste shipment, the difficulty (e.g., costs, occupational exposures) in obtaining a representative sample of a particular waste stream, the variability of the radionuclide distribution within the waste stream over time, and the availability of analytical capability for particular radionuclides.

It is recognized that it is sometimes difficult to obtain a truly representative sample of some waste streams and that some judgment will be necessary to determine sampling adequacy and representative radionuclide distributions. One example could include Class A dry active waste such as miscellaneous trash. In this case, an estimate of the radionuclide distribution within the waste could be made based upon distributions determined from other waste streams associated with generation of the trash waste. Alternatively, radionuclide distributions could be potentially estimated from smear samples obtained from locations in which the waste is generated. Another example could include activated metals. In many cases, radionuclide concentrations within activated metals will be difficult to directly measure, and NRC staff will in such cases accept estimates based on consideration of activation analysis calculations for similar material types.

3. Concentration Volumes and Masses

Paragraph 61.55(a)(8) states that the concentration of a radionuclide may be averaged over the volume of the waste, or the weight of the waste if the concentration units are expressed as nanocuries per gram. This requirement needs to be interpreted in terms of the variety of different types and forms of low-level waste. Principal considerations include: (1) whether the distribution of radionuclides within the waste can be considered to be reasonably homogeneous, and (2) whether the volume of the waste container is significantly larger than the volume of the waste itself, and the differential volume consists largely of void space.

Most waste streams may be considered to be homogeneous for purposes of waste classification. Such waste streams would include, for example, spent ion-exchange resins, filter media, solidified liquids, or contaminated dirt. Contaminated trash waste streams, which are composed of a variety of miscellaneous materials, may be considered homogeneous for purposes of waste classification when placed and compacted within shipping containers. The activity of small concentrated sources within the trash, such as small check sources or gauges, may be generally averaged over the trash volume.

In many cases the volume used for waste classification purposes may be considered to correspond to the volume of the waste container. This would be the case, for example, for trash waste streams which are compacted into shipping containers. The waste classification volume of large unpackaged components such as contaminated pumps, heat exchangers, or other machinery may be taken to be the overall volume of the component.

Care needs to be taken, however, to differentiate between the volume of the waste form and the volume of the waste container if the latter is significantly larger (e.g., greater than 10%). For example, for wastes such as ion-exchange resins or filter media contained within a disposable demineralizer or liner, the volume used for waste classification should be the volume of the contained waste rather than the gross volume of the container. Waste classification volumes of cartridge filters stabilized by emplacement within high integrity containers should be determined as calculated over the volume of the cartridge filter itself rather than the gross volume of the container. Similarly, the volume and mass considered for purposes of waste classification of dewatered ion-exchange resins and filter media placed into high integrity containers should be the volume and mass of the contained waste. Classification of absorbed liquids should be based on the volume and mass of the liquids prior to absorption.

An exception to the above would be a situation in which a particular waste type is stabilized within a waste container using a solidification media. For example, assume that a cartridge filter or large sealed source is solidified with a 55-gallon drum using a binder such as cement or bitumen. In this case, the waste and binder forms a solid mass within the container and the waste classification volume may be considered to be the volume of the solidified mass. Similarly, classification of solidified liquids would be based on the volume and mass of the solidified waste mass.

4. Reporting on Manifests

Section 20.311 of 10 CFR Part 20 requires that each shipment of radioactive waste to a land disposal facility be accompanied by a manifest which describes the shipment contents. This manifest may be shipping papers used to meet regulations promulgated by the Department of Transportation or the Environmental Protection Agency, provided that the information required by Section 20.311 is included. The waste shipment receiver (e.g., the disposal facility operator) may also require specific additional information. In addition to shipper identification requirements and a certification, the manifests required by Section 20.311 must include the following information as a minimum:

- the waste class;
- a radiological description; and
- a physical and chemical description.

Waste class

Identifying the waste class of the shipped waste is required, since certain disposal requirements are imposed for each waste class and the waste disposal facility operator must be able to identify the waste in order to carry out these disposal requirements. The individual waste containers must be labeled as being Class A, Class B, or Class C, and the waste class of each container must also be indicated on the manifest. The format of the shipment labels (or markings) is at the discretion of the disposal facility operator. Unpackaged Class A waste (e.g., bulk shipments of contaminated dirt) do not need to be labeled provided that the waste class is recorded on the manifest.

The shipment manifest should also record the date for which the classification determination is valid. This can be, for example, the date of transfer of the waste package from the site of generation to the disposal site. In no case should the date chosen for decay correction be beyond the date on which the waste is transported to the disposal site.

Radiological description

The requirements in Section 20.311 include a general requirement to list radionuclide identities and quantities, a general requirement to list the total radioactivity in the waste, and a specific requirement to list four individual radionuclides: H-3, C-14, Tc-99, and I-129. These requirements need some further guidance, however, since a wide range of radionuclides over a wide range of concentrations may be contained in a particular waste package.

The regulatory staff has determined three criteria for determining specific radionuclides which should be listed in manifests:

1. any radionuclide specifically required to be listed by Section 20.311, or by license conditions at the disposal facility to which the waste is shipped;

2. any radionuclide which is listed in Section 61.55 and forms a significant part of the total activity which determines the waste class; and

3. any radionuclide which is contained in significant quantities within a waste container or shipment.

Currently, only the isotopes H-3, C-14, Tc-99, and I-129 are required in Section 20.311 to be specifically identified and their quantities listed in manifests. In the manifests, if a particular one of these four radioisotopes is known to be not present within a waste stream (e.g., through material accountability), the quantity of the radionuclide should be recorded as "not present." If the radionuclide is determined through material accountability, direct measurement, or inference through direct measurement or gross radioactivity measurement, this quantity should be reported as determined. If the radionuclide is known or suspected to be contained within the waste but is in quantities less than the lower limit of detection for the analyzed sample, the quantity of the radionuclide should be recorded as being less than the minimum detectable, with the minimum detectable amount included alongside in parentheses. The total quantities of these four nuclides may be reported on a waste shipment rather than an individual waste container basis. In the case of Tc-99, care should be taken to distinguish between this nuclide and its short-lived precursor, Tc-99m.

Other radionuclides listed in Section 61.55 should be specifically identified and the quantities reported if they are significant for purposes of classification. A radionuclide shall be determined to be "significant for purposes of classification" if it is contained in waste in concentrations greater than 0.01 times the concentration of that nuclide listed in Table 1 or 0.01 times the smallest concentration of that nuclide listed in Table 2. This criterion does not include isotopes identified in Table 2 as having half-lives less than 5 years. An isotope (other than Cm-242) having a half-life less than 5 years is considered significant for the purposes of waste classification if it is contained in the waste in concentrations greater than 7 μCi/cm³ (0.01 times the Table 2, Column 1 value).

Radionuclides not listed in Section 61.55 should also be specifically identified and the quantities reported if they are contained in significant quantities within a waste container or shipment. In general, a radionuclide shall be deemed to be "contained in significant quantity" if it is in concentrations greater than 7 μCi/cm³. In addition, the total quantity of source or special nuclear material should be reported, if the waste contains such material.

Otherwise, radionuclides should be listed in shipment manifests in compliance with Department of Transportation requirements in 49 CFR Part 172, Section 172.203.

Physical and chemical description

Items to be included in the physical and chemical description include, as a minimum, the following: a physical description of the waste; the volume; the principal chemical form; and the solidification agent used (if any). Waste containing more than 0.1% chelating agents by weight must be identified, and the weight percentage of the chelating agent estimated. Amplification of NRC's intent regarding these requirements is provided below.

A physical description of the waste is needed in order to facilitate safe handling at the disposal facility and to better predict long-term environmental impacts. The description need only be a few words but should be as specific as possible. For example, a description such as "solidified resins" or "solidified evaporator bottoms" should be used rather than the description "solidified radwaste." Similarly, the description "scintillation vials" is preferable to the description "laboratory waste."

The volume listed in the manifest should be the volume of the waste container, if any, or the volume of the waste itself if shipped unpackaged (e.g., a bulk quantity of contaminated soil).

The principal chemical form of the waste also needs to be provided as an aid to waste handling safety and to improve prediction of long-term environmental impacts. This should be the principal chemical form in which the radioactivity is contained (e.g., calcium fluoride, toluene, etc.). There is no need to list trace chemical contaminants, however.

The solidification agent need only be provided in general terms (e.g., cement, asphalt, vinyl ester styrene). The type of solidification agent used may be combined with the physical description of the waste (e.g., "resins solidified in cement").

The intent of the requirement to identify waste containing chelating agents in quantities greater than 0.1% is to identify waste containing large quantities of such agents. Large quantities of such agents may be segregated from other waste at a disposal facility and/or disposed through some special disposal method. Disposal facility operators need to have such waste identified in order for them to perform these additional disposal operations. For purposes of this requirement, chelating agents include the following: amine polycarboxylic acids (e.g., EDTA, DTPA), hydroxy-carboxylic acids, and polycarboxylic acids (e.g., citric acid, carbolic acid, and glucinic acid).

APPENDIX A

GENERAL PROGRAM FOR CLASSIFYING WASTES AT NUCLEAR POWER FACILITIES

In order to meet the requirements in 10 CFR Part 61 to classify radioactive wastes at nuclear power plants, NRC staff has prepared a general program for implementing the waste classification system. This implementation program consists of a three-tiered approach which includes:

1. periodic analysis for all nuclides listed in Table 1 of Section 61.55;

2. gamma spectroscopy of certain nuclides from which waste classification nuclides are correlated; and

3. gross radioactivity measurements which correlate activity levels of wastes from similar batches to the gamma-spectroscopy measurements.

The periodic sampling for listed nuclides would be performed on various waste streams in the plant. These periodic analyses should be the basis for establishing correlation factors between the waste classification nuclides and nuclides which can be more easily measured using gamma spectroscopy techniques. Samples should be taken nominally on an annual basis from individual waste streams such as boric acid evaporator bottoms, primary system cleanup resins, chemical regenerative evaporator bottoms, etc., which are likely to be Class B or C wastes. If unit operations or plant conditions are modified such that the radionuclide distribution for any of the individual waste streams changes by a factor of 10, a reanalysis should be performed. Plant operational changes would include changes in the failed fuel fraction or a crud burst. If operations remain consistent, consideration can be given to performing reanalysis on a less frequent basis. In addition, consideration should be given to increasing the frequency of analysis depending upon individual facility, waste stream, and radionuclide characteristics. Factors which would influence this consideration include the frequency of process vessel changeout or waste shipment, the difficulty in obtaining a representative sample of a particular waste stream, the variability of the radionuclide distribution within the waste stream, and the available analytical capacity for particular radionuclides.

The gamma spectroscopy measurements should be performed on a limited number of samples obtained from individual waste batches. This can be performed by analyzing waste samples prior to or after volume reduction and/or solidification, analyzing waste drums or liners by any of the commercial devices designed for this task, or by analyzing influent and effluent samples from the process stream. Other methods which provide reasonable analysis will also be considered. Efforts should be made to obtain reasonably representative samples for analysis. The results of the gamma spectroscopy measurements should be applied with the correlation factors to obtain concentrations for those nuclides listed in the waste classification table.

Gross radioactivity measurements may also be performed on individual waste packages from similar waste batches for which gamma-spectroscopy results are available. Gross radioactivity measurements should include corrections for attenuation and container size and configuration. The gross activity measurements should be used to scale the nuclide concentrations obtained from the gamma spectroscopy data and correlations.

For Class A wastes such as contaminated trash, gross radioactivity measurements may be performed as the basis for waste classification provided that these measurements can be correlated to the concentrations of the radionuclides listed in Section 61.55. Confirmatory reanalysis of the correlation factors should be performed on at least a biannual basis.

The NRC staff believes that the above approach presents a workable and enforceable program for implementing the waste classification system. This approach should minimize the administrative and operational burdens on plant personnel, but still provide reasonably accurate data for use in quantifying disposal site nuclide concentrations and inventories.

REFERENCES

(1) U.S. Nuclear Regulatory Commission, "Radiological Effluent Technical Specifications for PWR's," NUREG-0472 (as revised), July 1979.

(2) U.S. Nuclear Regulatory Commission, "Radiological Effluent Technical Specifications for BWR's," NUREG-0473 (as revised), July 1979.

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Technical Position on Waste Form

A. Introduction

The regulation, "Licensing Requirements for Land Disposal of Radioactive Waste," 10 CFR Part 61, establishes a waste classification system based on the radionuclide concentrations in the wastes. Class B and C waste are required to be stabilized. Class A waste have lower concentrations, and may be segregated without stabilization. Class A wastes may also be stabilized and disposed of with the Class B wastes. All Class A liquid wastes, however, require solidification or absorption to meet the free liquid requirements. Structural stability is intended to ensure that the waste does not degrade and promote slumping, collapse, or other failure of the cap or cover over the disposal trench and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder since it provides greater assurance that the waste form will be recognizable and nondispersable during its hazardous lifetime. Structural stability of a waste form can be provided by the waste form itself (as with large activated stainless steel components), by processing the waste to a stable form (e.g., solidification), or by emplacing the waste in a container or structure that provides stability (e.g., high integrity container).

This technical position on waste form has been developed to provide guidance to both fuel-cycle and non-fuel-cycle waste generators on waste form test methods and results acceptable to the NRC staff for implementing the 10 CFR Part 61 waste form requirements. It can be used as an acceptable approach for demonstrating compliance with the 10 CFR Part 61 waste stability criteria. This position includes guidance on the processing of wastes into an acceptable, stable waste form, the design of acceptable high integrity containers, the packaging of filter cartridges, and minimizing the radiation effects on organic ion-exchange resins.

It is the intent of the NRC staff to add other guidance on waste form in additional technical positions as is necessary to address other pertinent waste form issues.

B. Background

Historically, waste form and container properties were considered of secondary importance to good site selection; the combination of a properly operated site having good geologic and hydrologic characteristics were considered the only barriers necessary to isolate low-level radioactive wastes from the environment. Experience in operating low-level waste disposal sites indicated that the waste form should play a major role in the overall plan for managing these wastes.

The regulation for near-surface disposal of radioactive wastes, 10 CFR Part 61, includes requirements which must be met by a waste form to be acceptable for near-surface disposal. The regulation includes a waste classification system which divides waste into three general classes: A, B, and C.

The classification system is based on the overall disposal hazards of the wastes. Certain minimum requirements must be met by all wastes. These minimum requirements are presented in Section 61.56(a) and involve basic packaging criteria, prohibitions against the disposal of pyrophoric, explosive, toxic and infectious materials, and requirements to solidify or absorb liquids.

In addition to the minimum requirements, Class B and C wastes are required to have stability. As defined in Section 61.56(b) of the rule, stability requires that the waste form maintain its structural integrity under the expected disposal conditions. Structural stability is necessary to inhibit slumping, collapse, or other failure of the disposal trench resulting from degraded wastes which could lead to water infiltration, radionuclide migration, and costly remedial care programs. Stability is also considered in the intruder pathways where it is assumed that after the active control period wastes are recognizable and, therefore, continued inadvertent intrusion is unlikely. To the extent practical Class B and C waste forms should maintain gross physical properties and identity over a 300 year period.

In order to ensure that Class B and C waste or its container will maintain its stability, the following conditions need to be met:

a. The waste should be a solid form or in a container or structure that provides stability after disposal.

b. The waste should not contain free standing and corrosive liquids. That is, the wastes should contain only trace amounts of drainable liquid, and in no case may the volume of free liquid exceed one percent of the waste volume when wastes are disposed of in containers designed to provide stability, or 0.5 percent of the waste volume for solidified wastes.

c. The waste or container should be resistant to degradation caused by radiation effects.

d. The waste or container should be resistant to biodegradation.

e. The waste or container should remain stable under the compressive loads inherent in the disposal environment.

f. The waste or container should remain stable if exposed to moisture or water after disposal.

g. The as-generated waste should be compatible with the solidification media or container.

A large portion of the waste produced in the nuclear industry is in a form which is either liquid or in a wet solid form (e.g., resins, filter sludge, etc.) and requires processing to achieve an acceptable solid, monolithic form for burial. The liquid wastes, irregardless of its classification, are required to be either absorbed or solidified. In order to assure that the solidification process will consistently produce a product which is acceptable for disposal and will meet disposal site license conditions a process control program should be used. General requirements for process control programs are provided in the NRC Standard Review Plan 11.4, "Solid Waste Management Systems," (NUREG-0800[1]) and its accompanying Branch Technical Position ETSB 11-3, "Design Guidance for Solid Waste Management Systems Installed in Light-Water-Cooled Nuclear Power Reactor Plants," (revised in July 1981). These documents may also be used as the basis for individual solidification process control programs by other fuel-cycle and by non-fuel-cycle waste generators who would solidify wastes. The guidance in this technical position should be the basis for qualifying process control programs for Class B and C wastes. The use of applicable generic test data (e.g., topical reports) may be used for process control program qualification. Process control programs for solidified Class A waste products, which are segregated from Class B and C wastes, need only demonstrate that the product is a free standing monolith with no more than 0.5 percent of the waste volume as free liquid.

An alternative to processing some Class B and C waste streams, particularly ion exchange resins and filter sludges, is the use of a high integrity container. The high integrity container would be used to provide the long-term stability required to meet the stability requirements in 10 CFR Part 61. The design of the high integrity container should be based on its specific intended use in order to ensure that the waste contents, as well as interim storage and ultimate disposal environments, will not compromise its integrity over the long-term. As with waste solidification, a process control program for dewatering wet solids should be developed and utilized to ensure that the free liquid requirements in 10 CFR Part 61 are being met.

C. Regulatory Position

1. Solidified Class A Waste Products

a. Solidified Class A waste products which are segregated from Class B and C wastes should be free standing monoliths and have no more than 0.5 percent of the waste volume as free liquids as measured using the method described in ANS 55.1.[2]

b. Solidified Class A waste products which are not segregated from Class B and C wastes should meet the stability guidance for Class B and C wastes provided below.

2. Stability Guidance for Processed (i.e., Solidified) Class B and C Wastes

a. The stability guidance in this technical position for processed wastes should be implemented through the qualification of the individual licensee's process control program. Generic test data may be used for qualifying process control programs. Through the use of a well designed and implemented process control program, frequent requalification to demonstrate stability is expected to be unnecessary. However, process control programs should include provisions to periodically demonstrate that the solidification system is functioning properly and waste products continue to meet the 10 CFR Part 61 stability requirements. Waste specimens should be prepared based on the proposed waste streams to be solidified and based on the range of waste stream chemistries expected. The tests identified may be performed on radioactive or non-radioactive samples.

b. Solidified waste specimens should have compressive strengths of at least 50 psi when tested in accordance with ASTM C39[3]. Compressive strength tests for bituminous products should be performed in accordance with ASTM D1074[4].

Many solidification agents will be easily capable of meeting the 50 psi limit for properly solidified wastes. For these cases, process control parameters should be developed to achieve the maximum practical compressive strengths, not simply to achieve the minimum acceptable compressive strength.

c. The specimens for each proposed waste stream formulation should remain stable after being exposed in a radiation field equivalent to the maximum level of exposure expected from the proposed wastes to be solidified. Specimens for each proposed waste stream formulation should be exposed to a minimum of 10^8 Rads in a gamma irradiator or equivalent. If the maximum level of exposure is expected to exceed 10^8 Rads, testing should be performed at the expected maximum accumulated dose. The irradiated specimens should have a minimum compressive strength of 50 psi following irradiation as tested in accordance with ASTM C39 or ASTM D1074.

d. Specimens for each proposed waste stream formulation should be tested for resistance to biodegradation in accordance with both ASTM G21[5] and ASTM G22[6]. No indication of culture growth should be visible. Specimens should be suitable for compression testing in accordance with ASTM C39 or ASTM D1074. Following the biodegradation testing, specimens should have compressive strengths greater than 50 psi as tested using ASTM C39 or ASTM D1074.

For polymeric or bitumen products, some visible culture growth from contamination, additives or biodegradable components on the specimen surface which do not relate to overall substrate integrity may be present. For these cases, additional testing should be performed. If culture growth is observed upon completion of the biodegradation test for polymeric or bitumen products, remove the test specimens from the culture, wash them free of all culture and growth with water and only light scrubbing. An organic solvent compatible with the substrate may be used to extract surface contaminants. Air dry the specimen at room temperature and repeat the test. Specimens should have observed culture growths rated no greater than 1 in the repeated ASTM G21 test, and compressive strengths greater than 50 psi. The specimens should have no observed growth in the repeated ASTM G22 test, and a compressive strength greater than 50 psi. Compression testing should be performed in accordance with ASTM C39 or ASTM D1074.

If growth is observed following the extraction procedure, longer term testing of at least six months should be performed to determine biodegradation rates. The Bartha-Pramer Method[7] is acceptable for this testing. Soils used should be representative of those at burial grounds. Biodegradation extrapolated for full-size waste forms to 300 years should produce less than a 10 percent loss of the total carbon in the waste form.

e. Leach testing should be performed for a minimum of 90 days in accordance with the procedure in ANS 16.1[8]. Specimen sizes should be consistent with the samples prepared for the ASTM C39 or ASTM D1074 compressive strength tests. In addition to the demineralized water test specified in ANS 16.1, additional testing using other leachants specified in ANS 16.1 should also be performed to confirm the solidification agents leach resistance in other leachant media. It is preferred that the synthesized sea water leachant also be tested. In addition, it is preferable that radioactive tracers be utilized in performing the leach tests. The leachability index, as calculated in accordance with ANS 16.1, should be greater than 6.

f. Waste specimens should maintain a minimum compressive strength of 50 psi as tested using ASTM C39 or ASTM D1074, following immersion for a minimum period of 90 days. Immersion testing may be performed in conjunction with the leach testing.

g. Waste specimens should be resistant to thermal degradation. The heating and cooling chambers used for the thermal degradation testing should conform to the description given in ASTM B553, Section 3. Samples suitable for performing compressive strength tests in accordance with ASTM C39 or ASTM D1074 should be used. Samples should be placed in the test chamber and a series of 30 thermal cycles carried out in accordance with Section 5.4.1 through 5.4.4 of ASTM B553. The high temperature limit should be 60C and the low temperature limit -40C. Following testing the waste specimens should have compressive strengths greater than 50 psi as tested using ASTM C39 or ASTM D1074.

h. Waste specimens should have less than 0.5 percent by volume of the waste specimen as free liquids as measured using the method described in ANS 55.1. Free liquids should have a pH between 4 and 11.

i. If small, simulated laboratory size specimens are used for the above testing, test data from sections or cores of the anticipated full-scale products should be obtained to correlate the characteristics of actual size products with those of simulated laboratory size specimens. This testing may be performed on non-radioactive specimens. The full-scale specimens should be fabricated using actual or comparable solidification equipment.

j. Waste samples from full-scale specimens should be destructively analyzed to ensure that the product produced is homogeneous to the extent that all regions in the product can expect to have compressive strengths of at least 50 psi. Full-scale specimens may be fabricated using simulated non-radioactive products, but should be fabricated using actual solidification equipment.

3. Radiation Stability of Organic Ion-Exchange Resins

In order to ensure that organic ion exchange resins will not produce adverse radiation degradation effects, resins should not be generated that have loadings which will produce greater than 10^8 Rads total accumulated dose. For Cs-137 and Sr-90 a total accumulated dose of 10^8 Rads is approximately equivalent to an 10 Ci/ft^3 concentration. This position is applicable to resins in the unsolidified, as-generated form. In the event that the waste generator considers it necessary to load resins higher than 10^8 Rads, it should be demonstrated that the specific resin will not undergo radiation degradation at the proposed higher loading. The test method should adequately simulate the chemical and radiologic conditions expected. A gamma irradiator or equivalent should be utilized for these tests. There should be no adverse swelling, acid formation or gas generation which will be detrimental to the proposed final waste product.

4. High Integrity Containers

a. The maximum allowable free liquid in a high integrity container should be less than one percent of the waste volume as measured using the method described in ANS 55.1. A process control program should be developed and qualified to ensure that the free liquid requirements in 10 CFR Part 61 will be met upon delivery of the wet solid material to the disposal facility. This process control program qualification should consider the effects of transportation on the amount of drainable liquid which might be present.

b. High integrity containers should have as a design goal a minimum lifetime of 300 years. The high integrity container should be designed to maintain its structural integrity over this period.

c. The high integrity container design should consider the corrosive and chemical effects of both the waste contents and the disposal trench environment. Corrosion and chemical tests should be performed to confirm the suitability of the proposed container materials to meet the design lifetime goal.

d. The high integrity container should be designed to have sufficient mechanical strength to withstand horizontal and vertical loads on the container equivalent to the depth of proposed burial assuming a cover material density of 120 lbs/ft^3. The high integrity container should also be designed to withstand the routine loads and effects from the waste contents, waste preparation, transportation, handling and disposal site operations, such as trench compaction procedures. This mechanical design strength should be justified by conservative design analyses.

e. For polymeric material, design mechanical strengths should be conservatively extrapolated from creep test data.

f. The design should consider the thermal loads from processing, storage, transportation and burial. Proposed container materials should be tested in accordance with ASTM B553 in the manner described in Section C2(g) of this technical position. No significant changes in material design properties should result from this thermal cycling.

g. The high integrity container design should consider the radiation stability of the proposed container materials as well as the radiation degradation effects of the wastes.

Radiation degradation testing should be performed on proposed container materials using a gamma irradiator or equivalent. No significant changes in material design properties should result following exposure to a total accumulated dose of 10^8 Rads. If it is proposed to design the high integrity container to greater accumulated doses, testing should be performed to confirm the adequacy of the proposed materials. Test specimens should be prepared using the proposed fabrication techniques.

Polymeric high integrity container designs should also consider the effects of ultra-violet radiation. Testing should be performed on proposed materials to show that no significant changes in material design properties occur following expected ultra-violet radiation exposure.

h. The high integrity container design should consider the biodegradation properties of the proposed materials and any biodegradation of wastes and disposal media. Biodegradation testing should be performed on proposed container materials in accordance with ASTM G21 and ASTM G22. No indication of culture growth should be visible. The extraction procedure described in Section C2(d) of this technical position may be performed where indications of visible culture growth can be attributable to contamination, additives, or biodegradable components on the specimen surface that do not affect the overall integrity of the substrate. It is also acceptable to determine biodegradation rates using the Bathta-Pramer Method described in Section C2 (d). The rate of biodegradation should produce less than a 10 percent loss of the total carbon in the container material after 300 years. Test specimens should be prepared using the proposed material fabrication techniques.

i. The high integrity container should be capable of meeting the requirements for a Type A package as specified in 49 CFR 173.398(b). The free drop test may be performed in accordance with 10 CFR 71, Appendix A, Section 6.

j. The high integrity container and the associated lifting devices should be designed to withstand the forces applied during lifting operations. As a minimum the container should be designed to withstand a 3g vertical lifting load.

k. The high integrity container should be designed to avoid the collection or retention of water on its top surfaces in order to minimize accumulation of trench liquids which could result in corrosive or degrading chemical effects.

l. High integrity container closures should be designed to provide a positive seal for the design lifetime of the container. The closure should also be designed to allow inspections of the contents to be conducted without damaging the integrity of the container. Passive vent designs may be utilized if needed to relieve internal pressure. Passive vent systems should be designed to minimize the entry of moisture and the passage of waste materials from the container.

m. Prototype testing should be performed on high integrity container designs to demonstrate the container's ability to withstand the proposed conditions of waste preparation, handling, transportation and disposal.

n. High integrity containers should be fabricated, tested, inspected, prepared for use, filled, stored, handled, transported and disposed of in accordance with a quality assurance program. The quality assurance program should also address how wastes which are detrimental to high integrity container materials will be precluded from being placed into the container. Special emphasis should be placed on fabrication process control for those high integrity containers which utilize fabrication techniques such as polymer molding processes.

5. Filter Cartridge Wastes

For Class B and C wastes in the form of filter cartridges, the waste generator should demonstrate that the selected approach for providing stability will meet the requirements in 10 CFR Part 61. Encapsulation of the filter cartridge in a solidification binder or the use of a high integrity container are acceptable options for providing stability. When high integrity containers are used, waste generators should demonstrate that protective means are provided to preclude container damage during packaging handling and transportation.

D. Implementation

This technical position reflects the current NRC staff position on acceptable means for meeting the 10 CFR Part 61 waste stability requirements. Therefore, except in those cases in which the waste generator proposes an acceptable alternative method for complying with the stability requirements of 10 CFR Part 61, the guidance described herein will be used in the evaluation of the acceptability of waste forms for disposal at near-surface disposal facilities.

References:

1. NUREG-0800, Standard Review Plan

2. ANS 55.1, "American National Standard for Solid Radioactive Waste Processing System for Light Water Cooled Reactor Plants," American Nuclear Society, 1979

3. ASTM C39, "Compressive Strength of Cylindrical Concrete Specimens," American Society for Testing and Materials, 1979

4. ASTM D1074, "Compression Strength of Bituminous Mixtures," American Society for Testing and Materials, 1980

5. ASTM G21, "Determining Resistance of Synthetic Polymeric Materials to Fungi," American Society for Testing and Materials, 1970

6. ASTM G22, "Determining Resistance of Plastics to Bacteria," American Society for Testing and Materials, 1976

7. R. Bartha, D. Pramer, "Features of a Flask and Method for Measuring the Persistance and Biological Effects of Pesticides in Soils," Soil Science 100 (1), pp-68-70, 1965

8. ANS 16.1, "Measurement of the Leachability of Solidified Low-Level Radioactive Wastes," American Nuclear Society Draft Standard, April 1981

9. ASTM B553, "Thermal Cycling of Electroplated Plastics," American Society for Testing and Materials, 1979