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

ATTENTION: Commission Licensees

SUBJECT: Waste Form Technical Position, Revision 1

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 wastes have lower concentrations and may be segregated without stabilization. Class A wastes may also be stabilized and disposed of with stabilized Class B and C 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 (a) promote slumping, collapse, or other failure of the cap or cover over a near-surface disposal unit and thereby lead to water infiltration, or (b) impart a substantial increase in surface area of the waste form that could lead to an increase in leach rate. 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 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 or engineered structure).

This technical position on waste form was initially developed in 1983 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 has been used as an acceptable approach for demonstrating compliance with the 10 CFR Part 61 waste stability criteria. This position includes guidance on (1) the processing of wastes into an acceptable, stable waste form, (2) the design of acceptable high integrity containers, (3) the packaging of filter cartridges, and (4) minimization of radiation effects on organic ion-exchange resins. The regulation, 10 CFR 20.311 (d)(1), requires waste generators and processors to prepare wastes that meet the waste characteristics requirements of Part 61 (including the requirements for structural stability). The recommendations and guidance provided in this technical position are an acceptable method to demonstrate waste stability. One way of demonstrating conformance with the general recommendations contained in this technical position is to reference an approved Topical Report, because such reports are reviewed and approved in accordance with the acceptance criteria contained in this technical position. However, additional actions (e.g., plant-specific process control procedures) by waste generators will be needed to demonstrate that a stabilized plant-specific waste stream satisfies Part 61 waste form requirements.

Since the initial issuance of the Technical Position, it has been the intent of the NRC staff to provide additional guidance on waste form as it became necessary to address other pertinent waste form issues. One such issue involves the use of cement to stabilize low-level wastes. Field experience and laboratory testing of cement-solidified low-level radioactive waste has indicated that some unique chemical and physical interactions can occur between the cement constituents and the chemicals and compounds that can exist in the waste materials. Therefore, an appendix (Appendix "A") dealing with the qualification testing, performance confirmation and reporting of mishaps involving cement-stabilized waste forms has been included in this revision to the Technical Position.

To provide more comprehensive guidance on cement stabilization of low-level radioactive waste, Appendix A addressed several areas of concern that were not considered in the May 1983, Revision 0, version of this Technical Position. Thus, information and guidance on cement waste form specimen preparation, statistical sampling and analysis, waste characterization, process control program (PCP) specimen preparation and examination, surveillance specimens and reporting of mishaps are provided in Appendix A. The guidance provided in Appendix A is the culmination of an extended period of study and information gathering and exchange between the NRC staff and representatives of various organizations, including government laboratories, the Advisory Committee on Nuclear Waste (ACNW), cement processing vendors, other waste form vendors, nuclear utilities, and state regulatory agencies. Especially useful in the development of the guidance in Appendix A was the information exchanged in a Workshop on Cement Stabilization of Low-Level Radioactive Waste held in June 1989. The Workshop proceedings have been published as an NRC report, NUREG/CP-0103, which is available from the following sources:

Superintendent of Documents
U.S. Government Printing Office
P.O. Box 37082
Washington, DC 20013-7082

and

National Technical Information Service
Springfield, VA 22161

The waste form technical position is attached to this letter. Questions on the technical position paper may be referred to Dr. M. Tokar (301-492-0590), or to Ms. M. T. Adams (301-492-0505) of my staff. The information collections contained in the technical position have been approved under OMB number 3150-0014.

Michael Tokar
for

Paul H. Lohaus, Chief
Low-Level Waste Management Branch
Division of Low-Level Waste Management
and Decommissioning, NMSS

U. S. NUCLEAR REGULATORY COMMISSION

Availability of Revised Staff Technical Position

on Waste Form

AGENCY: Nuclear Regulatory Commission

ACTION: Notice of Availability

SUMMARY: The Nuclear Regulatory Commission (NRC) is announcing the availability of a revised Staff Technical Position entitled "Technical Position on Waste Form (Revision 1)."

The Position provides guidance on acceptable methods for demonstrating compliance with the waste form structural stability requirements of 10 CFR Part 61 and for supporting the waste generator and processor certification requirements of 10 CFR 20.311.

The Technical Position on Waste Form was initially developed in 1983 to provide guidance to low-level radioactive waste generators on waste form test methods and results acceptable to the NRC staff for implementing the 10 CFR Part 61 waste form requirements. Since the initial issuance of the technical position, field experience and laboratory testing of cement-solidified low-level waste have indicated that some unique chemical and physical interactions can occur between the cement and the waste constituents, interactions that can affect the waste form stability. Therefore, an appendix (Appendix "A") dealing with cement-stabilized waste forms has been included in this revision to the Technical Position.

To provide more comprehensive guidance on cement stabilization of low-level radioactive waste, Appendix A addresses several areas of concern that were not considered in the May 1983, Revision 0, version of this Technical Position. Information and guidance on cement waste form specimen preparation, statistical sampling and analysis, waste characterization, process control program (PCP) specimen preparation and examination, surveillance specimens and reporting of mishaps are provided in Appendix A.

The guidance provided in the revised Technical Position is the culmination of an extended period of study and information gathering and exchange between the NRC staff and representatives of various organizations including government laboratories, the Advisory Committee on

Nuclear Waste (ACNW), cement processing vendors, other waste form vendors, nuclear utilities, and state regulatory agencies. Especially useful in the development of the guidance in Appendix A was the information exchanged in a Workshop on Cement Stabilization of Low-Level Radioactive Waste held in June 1989.

The Workshop proceedings have been published as an NRC report, NUREG/CP-0103, which is available from the following sources:

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Springfield, VA 22161

Copies of the revised Technical Position are being distributed (under seperate cover) to licensees. Copies are also being distributed (seperately) by State Programs to the Agreement States, Non-Agreement States, State Liaison Officers, and others who are on the NRC's Compact Distribution List.

ADDRESSES: Copies of the Staff Technical Position may be obtained by writing to M. T. Adams at Mail Stop 5E-2 OWFN, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

FOR FURTHER INFORMATION CONTACT: M. T Adams, Division of Low-Level Waste Management and Decommissioning, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, Telephone (301) 492-0505.

Dated at Rockville, Maryland, this 18th day of January, 1989.

For the Nuclear Regulatory Commission

Paul H. Lohaus

Paul H. Lohaus, Chief

Low-Level Waste Management Branch

Division of Low-Level Waste Management
and Decommissioning, NMSS

United States Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Washington, D.C. 20555

TECHNICAL POSITION
ON
WASTE FORM
(Revision 1)

Prepared by: Low-Level Waste Management Branch
Division of Low-Level Waste Management
and Decommissioning

January 1991

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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 wastes have lower concentrations and may be segregated without stabilization. Class A wastes may also be stabilized and disposed of with stabilized Class B and C 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 (a) promote slumping, collapse, or other failure of the cap or cover over a near-surface disposal trench and thereby lead to water infiltration, or (b) impart a substantial increase in surface area of the waste form that could lead to an increase in leach rate. Stability is also a factor in limiting exposure to an inadvertent intruder since it provides greater assurance that the waste form will remain in a recognizable and nondispersable state. Structural stability of a waste form can be provided by the waste form itself (as with 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 or engineered structure).

This technical position on waste form was initially developed in 1983 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 has been used as an acceptable approach for demonstrating compliance with the 10 CFR Part 61 waste stability criteria. This position includes guidance on (1) the processing of wastes into an acceptable, stable waste form, (2) the design of acceptable high integrity containers, (3) the packaging of filter cartridges, and (4) minimization of radiation effects on organic ion-exchange resins. The regulation, 10 CFR 20.311, requires waste generators and processors to certify that their waste forms meet the requirements of Part 61 (including the requirements for structural stability). The recommendations and guidance provided in this technical position are an acceptable method upon which to base such certification by waste generators. One way of demonstrating conformance with the general recommendations contained in this technical position is to reference an approved Topical Report, because such reports are reviewed and approved in accordance with the acceptance criteria contained in this technical position. Additional actions (e.g., plant-specific process control procedures) by waste generators, however, to demonstrate that a stabilized plant-specific waste stream satisfies Part 61 waste form requirements, will be needed.

Since the initial issuance of the Technical Position, it has been the intent of the NRC staff to provide additional guidance on waste form as it became necessary to address other pertinent waste form issues. One such issue involves the use of cement to stabilize low-level wastes. Field experience and laboratory testing of cement-solidified low-level radioactive waste has indicated that some unique chemical and physical interactions can occur between the cement constituents and the chemicals and compounds that can exist in the waste materials. Therefore, an appendix (Appendix "A") dealing with the qualification testing, performance confirmation and reporting of mishaps involving cement-stabilized waste forms has been included in this revision to the Technical Position. (Reporting of mishaps is addressed for other types of waste forms in Section C.6 of the main body of this Technical Position).

To provide more comprehensive guidance on cement stabilization of low-level radioactive waste, Appendix A addresses several areas of concern that were not considered in the May 1983, Revision 0, version of this Technical Position. Thus, information and guidance on cement waste form specimen preparation, statistical sampling and analysis, waste characterization, process control program (PCP) specimen preparation and examination, surveillance specimens and reporting of mishaps are provided in Appendix A. The guidance provided in Appendix A is the culmination of an extended period of study and information gathering and exchange between the NRC staff and representatives of various sectors of the nuclear industry, including government laboratories, cement processing vendors, other waste form vendors, nuclear utilities, state regulatory agencies, and industry representative organizations such as the Nuclear Management Resources Council (NUMARC) and the Electric Power Research Institute (EPRI). Especially useful in the development of the guidance in Appendix A was the information exchanged in a Workshop on Cement Stabilization of Low-Level Radioactive Waste (Ref. 1).

B. BACKGROUND

Historically, waste form and container properties were considered of secondary importance to good site selection; a properly operated site having good geologic and hydrologic characteristics was considered the only barrier necessary to isolate low-level radioactive wastes from the environment. As experience in operating low-level waste disposal sites was acquired, however, it became apparent that the waste form should play a significant 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 structural stability. As stated 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 (a) slumping, collapse, or other failure of the disposal unit (if an engineered structure is not used) resulting from degraded wastes which could lead to water infiltration, radionuclide migration, and costly remedial care programs and (b) radionuclide release from the waste form that might ensue due to increases in leaching that could be caused by premature disintegration of the waste form. Stability is also considered in the intruder pathways where it is assumed that wastes are recognizable after the active control period, and that, therefore, continued inadvertent intrusion would be unlikely. To the extent practical, Class B and C waste forms should maintain gross physical properties and identity over a 300 year period.

To ensure that Class B and C wastes will maintain stability, the following conditions should 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, as required by 10 CFR 61.56(b)(2), 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 medium or container.

A large portion of the waste produced in the nuclear industry, including waste from nuclear power plants, 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 form for burial. The wet wastes, regardless of their classification, are required to be either absorbed or solidified. To assure that this processing will consistently produce a product which is acceptable for disposal and will meet disposal site license conditions, nuclear power plant licensees are required to process their wastes in accordance with a plant-specific process control program (PCP). Guidance for such PCPs was provided in NRC Standard Review Plan Section 11.4, "Solid Waste Management Systems," NUREG-0800 (Ref. 2) 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). However, 10 CFR Part 61 became effective in January 1983, providing requirements regarding waste form, and superseding certain of the guidance previously provided in NUREG-0800. Licensee's PCPs provide assurance that the processing of wet radioactive wastes will result in waste forms that meet the requirements of 10 CFR Part 61 and low-level waste disposal sites licenses.

Plant-specific PCPs developed and approved without consideration of Part 61 should be revised to provide assurance that applicable Part 61 requirements will be satisfied. In many cases, licensee PCPs are based on generally applicable (generic) PCPs contained in vendor-submitted topical reports that are reviewed by the NRC for referencing in licensing actions.

The guidance in this technical position may also serve as the basis for qualifying generic PCPs for Class B and C wastes. Applicable generic test data (e.g., topical reports) may be used for generic PCP qualification, and may be used in part as the basis for a plant-specific PCP. PCPs for solidified Class A waste products that are to be 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 (HIC). The high integrity container would be used to provide the long-term stability required to meet the structural 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 PCP for dewatering wet solids in HICs or liners 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 (Ref. 4).

b. 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

The stability guidance in this technical position for processed wastes should be implemented through the qualification of the individual licensee's PCP. Generic test data may be used for qualifying generic PCPs, and incorporated as part of the individual licensee's (i.e., plant-specific) PCP. Tests to demonstrate waste form stability through a generic testing program include the following:

a. Solidified waste specimens should have compressive strengths of at least 60 psi when tested in accordance with ASTM C39 (Ref. 5). Compressive strength tests for bituminous products should be performed in accordance with ASTM D1074 (Ref. 6).

Many solidification agents (such as cement) will be easily capable of meeting the 60 psi limit for properly solidified wastes. For such cases, process control parameters should be developed to achieve maximum practical compressive strengths, not simply to achieve the minimum acceptable compressive strength; (see Section II.B of Appendix A for further guidance on cement-stabilized wastes).

b. 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 (Ref. 7). 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 60°C and the low temperature limit -40°C. Following testing the waste specimens should have the maximum practical compressive strengths; (a minimum compressive strength of 60 psi as tested using ASTM D1074 is acceptable for bituminized waste forms--for cement-stabilized wastes see Section II.C of Appendix A).

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 10E+8 Rads in a gamma irradiator or equivalent. If the maximum level of exposure is expected to exceed 10E+8 Rads, testing should be performed at the expected maximum accumulated dose. Following irradiation the irradiated specimens should have the maximum practical compressive strengths (a minimum compressive strength of 60 psi as tested using ASTM D1074 is acceptable for bituminized waste forms--for cement-stabilized wastes see Appendix A).

d. Specimens for each proposed waste stream formulation should be tested for resistance to biodegradation in accordance with both ASTM G21 and ASTM G22 (Refs. 8 & 9, respectively). No indication of culture growth should be visible. Specimens should be suitable for compression testing in accordance with ASTM C39 or ASTM D1074, as applicable. Following the biodegradation testing, specimens should have the maximum practical compressive strengths (a minimum compressive strength of 60 psi as tested using ASTM D1074 is acceptable for bituminized waste forms--see Section II.E of Appendix A for guidance on biodegradation testing of cement-stabilized wastes).

For polymeric or bitumen products, some visible culture growth from contamination, additives, or biodegradable components on the specimen surface that does 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, the test specimens should be removed from the culture and washed free of all culture and growth with water, with only light scrubbing. An organic solvent compatible with the substrate may be used to extract surface contaminants. The specimen should be air dried at room temperature and the test repeated. Specimens should have observed culture growths rated no greater than 1 in the repeated ASTM G21 test. The specimens should have no observed growth in the repeated ASTM G22 test. Compression testing should be performed in accordance with ASTM C39 or ASTM D1074, as applicable, following the repeated G21 and G22 tests. The minimum acceptable compressive strength for bituminized waste forms is 60 psi. Maximum practical compressive strengths should be established for other media.

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 (Ref. 10) is acceptable for this testing. Soils used should be representative of those at disposal facilities. 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 (5 days for cement-stabilized waste forms--see Section II.F of Appendix A for cement-stabilized wastes) in accordance with the procedure in ANS 16.1 (Ref. 11). 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 the Standard 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. For proposed nuclear power station waste streams, cobalt, cesium, and strontium should be used as tracers. The leachability index, as calculated in accordance with ANS 16.1, should be greater than 6.0.

f. Waste specimens should maintain maximum practical compressive strengths 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; (see Section II.G of Appendix A for guidance on cement-stabilized wastes).

g. 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; (for cement-solidified water, free liquids should have a minimum pH of 9--see Section II.H of Appendix A).

h. 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. Correlation testing should be performed using 90-day immersion (including post-immersion compression) tests on the most conservative waste stream(s) intended for use for the particular solidification medium; i.e, the waste stream that presents the most difficulty in consistently producing a stable product(s). For cement-solidified waste forms, the mixed bead resin waste stream is expected to be the most conservative. For bituminized wastes, the sodium sulfate waste stream should be used. The full-scale specimens should be fabricated using solidification equipment the same as or comparable to that used for processing actual low-level radioactive wastes in the field.

i. 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 representative of the compressive strength as determined by testing lab-scale specimens (i.e., that meet the criteria called out in Section C2.a. above). Full-scale specimens may be fabricated using simulated non-radioactive products; however, the specimens should be fabricated using solidification equipment that is the same as or comparable to that used in the field for actual low-level radioactive wastes.

3. Radiation Stability of Organic Ion-Exchange Resins

To ensure that organic ion exchange resins will not undergo adverse degradation effects from radiation, resins should not be generated having loadings that will produce greater than 10E+8 Rads total accumulated dose. For Cs-137 and Sr-90 a total accumulated dose of 10E+8 Rads is approximately equivalent to a 10 Ci/ft concentration in resins in the unsolidified, as-generated form. In the event that the waste generator considers it necessary to load resins higher than 10E+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 that 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 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. It should be demonstrated for high integrity containers fabricated from polymeric materials that the containers will not undergo tertiary creep, creep buckling, or ductile-to-brittle failure over the design life of the containers.

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(b) 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 E+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.

High integrity container designs using polymeric materials 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 Bartha-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 173.411 and 173.412. Conditions that may be encountered during transport or movement are to be addressed by meeting the requirements of 10 CFR 71.71. 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 designed, fabricated, and used in accordance with a quality assurance program. The quality assurance program should address the following topics concerning the high integrity container: fabrication, testing, inspection, preparation for use, filling, storage, handling, transportation, and disposal. 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.

6. Reporting of Mishaps

In all future reviews and approvals of stabilization media and high integrity containers, waste generators, vendors and processors will, as a condition of approval, be asked to commit to reporting any knowledge they may have of misuse or failure of their waste forms and containers. Such mishaps include, but are not necessarily limited to, the following:

a. The failure of high integrity containers used to ensure structural stability. Such failure may be evidenced by changed container dimensions, cracking, or injury from mishandling (e.g., dropping or impacting against another object).

b. The misuse of high integrity containers, as evidenced by a quantity of free liquid greater than one percent of container volume, or an excessive void space within the container; (such use is in violation of 10 CFR 61.56(a)).

c. The production of a solidified Class B or C waste form that has any of the following characteristics;

   1. greater than 0.5 percent volume of free liquid.

2. concentrations of radionuclides greater than the concentrations demonstrated to be stable in the waste form in qualification testing accepted by the regulatory agency.

3. greater or lessor amounts of solidification media than were used in qualification testing accepted by the regulatory agency.

4. contains chemical ingredients not present or accounted in qualification testing accepted by the regulatory agency.

5. shows instability evidenced by crumbling, cracking, spalling, voids, softening, disintegration, nonhomogeneity, or change in dimensions.

6. evidences processing phenomena that exceed the limiting processing conditions identified in applicable topical reports or process control programs, such as foaming, excessive temperature, premature or slow hardening, production of volatile material, etc.

Waste form mishaps should be reported to the NRC's Director of the Division of Low-Level Waste Management and Decommissioning and the designated State disposal site regultory authority within 30 days of knowledge of the incident. For any such waste form mishap occurrence, the affected waste form should not be shipped off-site until approval is obtained from the disposal site regulatory authority. The reason for this is that the low-level waste generators and processors are required by 10 CFR 20.311 to certify that their waste forms meet all applicable requirements of 10 CFR Part 61, and waste forms that are subject to the types of mishaps mentioned above may not possess the required long-term structural stability. When mishaps of the nature described above occur, it is expected that, before the waste form is shipped to a disposal facility, either adequate mitigation of the potential effects on the waste form or an acceptable justification concerning the lack of any potential significant effects of the affected waste form on the overall performance of the disposal facility would be provided.

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, vendor, and/or processor 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.

E. REFERENCES

1. "Proceedings of the Workshop on Cement Stabilization of Low-Level Radioactive Waste," NUREG/CP-0103, October 1989.

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Appendix A

Cement Stabilization

I. INTRODUCTION

This Appendix to the Technical Position on Waste Form provides guidance to waste generators and processors who intend to use cementitious materials such as Portland and pozzolonic-type cements to solidify and stabilize low-level radioactive wastes in accordance with the requirements of 10 CFR Part 61 (Ref. A1(a)). This guidance is applicable for cementious waste forms destined for disposal in shallow-land disposal sites and engineered structures where the regulatory authorities require stable waste forms. It is expected that the guidance described herein would be used by NRC staff in any Topical Report evaluation of the acceptability of cement waste forms for disposal at near-surface disposal facilities. Waste generators using cement solidification systems and media not approved generically through the Topical Report review process may use this guidance to conduct testing to demonstrate that waste forms satisfy the requirements of Part 61. NRC regulation 10 CFR 20.311 (Ref. A1(b)) requires waste generators to certify that their waste forms meet the requirements of Part 61 (including the requirements for structural stability). Waste generators whose cement waste formulations meet the provisions of this Technical Position will be able to certify that the formulations meet the requirements of Part 61. The disposal site regulatory authorities, however, have the ultimate reponsibility for accepting or rejecting the waste.

Portland and pozzolonic cements have been observed to exhibit unique chemical and physical interactive behavior when used with certain materials and chemicals encountered in some low-level radioactive waste streams. Therefore, this Appendix specifically addresses cement waste form qualification only and is not intended to be applied generically to all stabilization agents (although many of the provisions discussed are, in principle, applicable to other media). This Appendix thus complements, and does not replace, the main body of the Technical Position on Waste Form.

Included in this Appendix are descriptions of methods that may be used in cement waste form qualification testing. Associated acceptance criteria that may be used by NRC staff or others to evaluate the acceptability of the test results are also provided. Included in this waste form testing guidance are descriptions of acceptable procedures for sample preparation and statistical treatment of data. In addition, this Appendix provides guidance on waste stream characterization, process control program (PCP) recipe qualification and specimen examination, surveillance specimen preparation and testing, and procedures for reporting of cement waste form preparation mishaps. This guidance on cement waste forms is intended to provide the best available information on an acceptable approach for demonstrating that a cement-solidified low-level radioactive waste form will possess the long-term (300-year) structural stability that is required by Part 61 for Class B and Class C wastes.

Linkage between the waste form qualification test recommendations in this Technical Position and the requirements of Part 61 is provided in 10 CFR 61.56(b)(1), where it is stated that "a structurally stable waste form will generally maintain its physical dimensions and form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture and microbial activity, and internal factors such as radiation effects and chemical changes." The discussion provided in Section II of this Appendix addresses the details of the test procedures and acceptance criteria recommended for cement-stabilized wastes. Further information on test specimen preparation and analysis of data is provided in Section III and Section IV, respectively.

II. WASTE FORM QUALIFICATION TESTING

A. General

As indicated in Section C.2 of the main body of this Technical Position, generic test data may be used "for qualifying process control programs." That is, a low-level radioactive waste generator/processor may perform qualification testing, as described in the following subsections of this Appendix, to qualify recipes for a range of waste compositions (concentrations and loadings) for a given type of waste stream. It is incumbent upon the party providing 10 CFR 20.311 certification, however, to show that the composition(s) of the waste form specimens used in the qualification testing adequately covers the range of waste compositions that will be encountered in the field. An acceptable approach to qualification testing is to perform the tests not only at the maximum waste loading but also at lower loadings (at least one), with appropriate variations in water/cement ratios and proportions of additives. It should not be necessary to perform all the qualification tests for all of the waste loadings, but adequate justifications should be provided for any omissions.

Each individual waste stream should be qualified with test data obtained for that specific waste stream. In cases where two or more waste streams are combined, it should be demonstrated that the specimen compositions used in the qualification testing adequately cover the range of compositions that are intended to be stabilized in the field. This may be accomplished by performing the full series of qualification tests on the "worst-case" composition only, along with one or more tests on alternate compositions, sufficient to show that the selected "worst-case" was chosen correctly.

B. Compression

It is stated in 10 CFR 61.56(b)(1) that "a structurally stable waste form will generally maintain its physical dimensions and form under expected disposal conditions such as weight of overburden and compaction equipment...." Assuming a cover material density of 120 lbs./cu.ft., a minimum compressive strength criterion of 50 psi was established in section C.2.b. of the 1983 Revision 0 portion of this Technical Position. To reflect the increase in burial depth (from 45 to 55 feet) at Hanford, Washington, the minimum compressive strength criterion for generic waste forms was later increased from 50 to 60 psi.

However, as further noted in the above-cited section C.2.a., for solidification agents that are easily capable of meeting the 50 (now 60) psi minimum compressive strength, the waste forms should achieve "maximum practical compressive strengths," not just the "minimum acceptable compressive strength." This provision was included in the Rev. 0, 1983 Technical Position in recognition of the fact that mere resistance to deformation under burial loads is, in itself, inadequate evidence that the waste form microconstituents are bonded together sufficiently well to ensure that the waste form will not over time fall apart due to internal stresses that are chemically, physically, or irradiation induced.

Portland cement mortars, which are comprised of mixtures of cement, lime, silica sand and water, are readily capable of achieving compressive strengths of 5000 to 6000 psi; that is approximately two orders of magnitude greater than the minimum compressive strength required to resist deformation under load in current low-level waste burial trenches. Therefore, to provide greater assurance that there will be sufficient cementitious material present in the waste form to not only withstand the burial loads, but also to maintain general "dimensions and form" (i.e., to not disintegrate) over time, it is recommended that cement-stabilized waste forms possess compressive strengths that are representative of the values that are reasonably achievable with current cement solidification processes. Taking into consideration the fact that low-level radioactive waste material constituents are not in most cases capable of providing the physical and chemical functions of silica sand in a cement mortar, a mean compressive strength equal to or greater than 500 psi is recommended for waste form specimens cured for a minimum of 28 days (see Section III.B of Appendix A). This value of compressive strength is recommended as a practical strength value that is representative of the quality of cementitious material that should be used in the waste form to provide assurance that it will maintain integrity and thus possess the long term structural capability required by Part 61.

Compressive strengths of cement-stabilized waste forms should be determined in accordance with procedures described in ASTM Standard C39: Compressive Strength of Cylindrical Concrete Specimens (Ref. A2). It is recommended that the compressive strength test specimens be right circular cylinders, 2 to 3 inches in diameter, with a length-to-diameter (L/D) ratio of approximately two. Because hydrated cement solids are brittle ceramic materials that fail in tension or shear rather than compression, and at regions of localized stress concentration or microstructural flaw, there tends to be considerable scatter in the strength test data even if all processing variables are kept relatively constant. Therefore, sufficient specimens should be tested to determine the mean compressive strength and standard deviation. Because of the many variables involved, a decision regarding the specific number of specimens to be tested is left to the judgement of the waste processor/qualifier; in no case, however, should the number of as-cured (pre-environmental test) compressive strength test specimens be less than ten. This approach should continue until there are sufficient data available to permit judgements to be made regarding what is reasonably achievable, from a statistical standpoint, in compressive strength testing of low-level waste test specimens. No precision criterion, in the form of an acceptable variance or standard deviation, is recommended at this time.

[For the purposes of verification of Process Control Program (PCP) parameters (see discussion in Section VI of Appendix A), compressive strength tests and/or penetrometer hardness tests should be performed after the qualification test specimens have been allowed to cure for approximately 24 hours. The results of these tests should be retained and made available for comparison with the results of similar tests that should be performed on PCP specimens fabricated from actual radioactive wastes in the field; (see Appendix A, Section VI.C for details).]

C. Thermal Cycling

Though thermal effects are not called out specifically as an item of concern in 10 CFR 61.56(b)(1), as other factors are, cement-stabilized low-level radioactive waste forms should be demonstrated to be resistant to thermal degradation. There are three basic reasons for this: (1) Section 61.56(b)(1) of Part 61 lists "internal factors" as a condition that must be considered in assuring that a waste form will retain structural stability, and temperature and thermal effects are internal factors; (2) thermal cycling of the waste form will occur, particularly during the storage and transport phase of the waste form's performance "life;" and (3), experience has shown that the thermal cycling test has served well in distinguishing between "strong" and "weak" solidified waste forms. The thermal cycling test imposes a stress (due to differential thermal expansion) between the various microconstituents of the waste form and between different regions of the waste form. By cycling between the maximum and minimum temperatures called for in the test, any cracks initiated in the test specimen may propagate and eventually measurably weaken the waste form. The extent of any degradation that might occur will be a function of various factors such as the amount of cementitious material in the waste form, the bond strength between the materials present, and the morphology of the microconstituents in the waste form microstructure. Thus, the thermal cycling test, by subjecting the waste form specimens to a short-term cyclic thermal stress, challenges the structural capability of the specimens and thus serves as a very useful vehicle for screening out unfavorable "weak" formulations.

The heating and cooling chambers used in determining the thermal cycling resistance of cement-stabilized waste forms should, as stated in Section C.2.b. of the main body of this Technical Position, conform to the description given in ASTM Standard Test Method B553 (Ref. A3). However, because that test method addresses thermal cycling of electroplated plastics, not cement-solidified waste materials, some modifications to the test procedure are necessary. Test specimens suitable for performing compressive strength tests in accordance with ASTM C39 should be used. The specimens should be tested "bare;" i.e., not in a container. Specimens should be placed in the test chamber, and a series of 30 thermal cycles should be carried out in accordance with Section 5.4.1 through 5.4.4 of ASTM B553, with the additional proviso that the specimens should be allowed to come to thermal equilibrium at the high (60 degrees C) and low (-40 degrees C) temperature limits. Thermal equilibrium should be confirmed by measurements of the center temperature of at least one specimen (per test group). A minimum of three specimens for each waste formulation should be subjected to the thermal cycling tests.

Following exposure to 30 thermal cycles the specimens should be examined visually and should be free of any evidence of significant cracking, spalling, or bulk disintegration; i.e., visible evidence of significant degradation would be indicative of failure of the test. Because it is not possible to provide an a priori assessment of the significance of visible defects, taking into consideration the wide range of possible defect configurations, no definition of "significant degradation" is provided here. The organization performing the tests should (1) assess whether visible defects are significant, and (2) obtain and retain photographic evidence of any defects that are judged to be insignificant for future reference. If there are no significant visible defects, the test specimens should be subjected to compression strength testing in accordance with ASTM C39 and should have mean compressive strengths that are equal to or greater than 500 psi.

D. Irradiation

In accordance with the requirements of 10 CFR 61.56(b)(1), and as indicated in Section C.2.c. of the main body of this Technical Position, irradiation testing of solidified waste forms should be conducted on specimens exposed to a minimum dose of 10E+8 rads. The 10E+8 rads radiation dose is approximately equivalent to the dose that would be acquired by a waste form over a 300-year period, if the waste form were loaded to a Cesium-137 or Strontium-90 concentration of 10 Ci/cu.ft. This is the recommended (Ref. A3) maximum activity level for organic resins based on evidence that while a measurable amount of damage to the resin will occur at 10E+8 rads, the amount of damage will have negligible effect on power plant or disposal site safety. However, cementitious materials are not affected by gamma radiation to relatively high cumulative doses (e.g., greater than 10E+9 rads--Ref. A4) considerably in excess of 10E+8 rads. Therefore, for cement-stabilized waste forms, irradiation qualification testing need not be conducted unless (1) the waste forms contain ion exchange resins or other organic media or (2) the expected cumulative dose on waste forms containing other materials is greater than 10E+9 rads. Testing should be performed on specimens exposed to (1) 10E+8 rads or the expected maximum dose greater than 10E+8 rads for waste forms that contain ion exchange resins or other organic media or (2) the expected maximum dose greater than 10E+9 rads for other waste forms. In cases where irradiation testing is warranted, a minimum of three specimens should be tested for each waste formulation being qualified.

Following the irradiation exposure the specimens should be examined visually and should be free of any evidence of significant cracking, spalling, or bulk disintegration; i.e., visible evidence of significant degradation would be indicative of failure of the irradiation test. If there are no significant visible defects (see Section II.C for discussion of "significant degradation"), the test specimens should be subjected to compressive strength testing in accordance with ASTM C39 and should have mean compressive strengths that are equal to or greater than 500 psi.

E. Biodegradation

As indicated in 10 CFR 61.56(b)(1), a structurally stable waste form is one that will be relatively unaffected by "microbial activity." Generic (not specific to type of waste form) recommendations for biodegradation testing provided in Section C.2.e. of the main body of this Technical Position indicate that ASTM Standard Practice G21 (Ref. A5) and G22 (Ref. A6) are suitable methods of test for determining susceptibility to fungi and bacteria, respectively. Experience in biodegradation testing of cement-stabilized waste forms has shown (Refs. A7-A9), however, that they generally do not support fungal or bacterial growth. The principal reason for this appears to be that the fungi and microbes used in the G21 and G22 tests require a source of carbon for growth, and in the absence of any carbonaceous materials in the waste stream, there is no internal food source available for culture growth. Consequently, for cement-stabilized waste forms, biodegradation qualification testing need not be conducted unless the waste forms contain carbonaceous materials (e.g., ion exchange resins or oils).

For cement-stabilized waste forms containing carbonaceous materials, there should be no evidence of culture growth during the G21 and G22 tests. The test specimens (at least three for each organic waste stream formulation being qualified) should also be free of any evidence of significant cracking, spalling or bulk disintegration; i.e., visible evidence of significant degradation would be indicative of failure of the test. If there are no significant visable defects following the test exposures (see Section II.C of this Appendix for discussion of "significant degradation"), the test specimens should be subjected to compression strength testing in accordance with ASTM C39 and should be shown to have mean compressive strengths equal to or greater than 500 psi.

F. Leach Testing

Resistance to leaching of radionuclides is not specifically mentioned in Part 61, nor is radionuclide containment called out as a specific requirement for low-level waste packages. Minimization of contact of waste by water is a fundamental concern of Part 61, however, as evidenced by the statement in Section 61.7 that "...a cornerstone of the system is stability...so that . . access of water to the waste can be minimized (emphasis added). Migration of radionuclides is thus minimized..." In addition, there are several statements in Section 61.51 that address minimization of contact of water with waste. These statements are in recognition of the fact that contact of waste with water is the first step in a potentially major pathway for radionuclide release and migration off-site. Thus, "leaching," or release of radionuclides from a waste form through contact with water is a first step in subsequent migration of the radionuclides from the waste through the groundwater and off the site. Therefore, leaching is a phenomenon that is of fundamental interest in waste disposal.

The leach testing procedure specified in Section C.2.e. of the main body of this Technical Position is ANSI/ANS 16.1: Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure (Ref. A10). In the ANS/ANSI 16.1 test, a test specimen is completely immersed in a measured volume of water, which is changed on a prescribed schedule. Upon removal, the leachant is analyzed for the radionuclides (or elements) of interest. The data obtained by this procedure are expressed as a material parameter of the leachability of each leached species. This parameter is called the "Leachability Index" (L), which is the arithmetic mean of the L values obtained for each leaching interval (where the L value is the logarithm of the inverse of the effective diffusivity). The leachability index, as calculated in accordance with ANSI/ANS 16.1, should be greater than 6.0.

The period of time specified for the leach test in the above-cited Section C.2.e. of this Technical Position is a minimum of 90 days, and the test period called out in the Standard corresponds to 90 days. This time period was selected as a means of determining whether there might be a change in leach mechanism with time; (as explained in the Standard, early leach rates observed with solidified waste forms are most often explained by diffusion--other mechanisms, such as erosion, dissolution, or corrosion, would generally be discernible only after longer leaching times). However, any leaching that involves other mechanisms such as erosion, dissolution, corrosion or other chemical or physical phenomena would most likely be readily observed visually and through mechanical testing. Such observations would be made as part of the immersion test, which is a 90-day test. These facts, coupled with comparisons of 5-day and 90-day data (Ref. A11) on cement waste forms that showed that the percentage differences between 5-day and 90-day leach indices were relatively small for most specimens, indicate that a 5-day leach testing period is sufficient for cement-solidified wastes.

The leachant specified in ANSI/ANS 16.1 is deionized water. It is stated in the above-cited Section C.2.e. of this Technical Position that additional testing using other leachants should also be performed to confirm the solidification agents leach resistance in other leachant media. Synthesized sea water leachant is listed as a preferred alternate leachant. The basis for this is, that while leachability indices are generally lower (i.e., leach rates are higher) for tests conducted in demineralized water than in sea water (Ref. A11), this is not true in all cases for all waste streams. For reasons of economy, however, it is desirable to limit the bulk of the testing to one leachant. If it can be shown that the chosen leachant is the most aggressive one, testing with one leachant is appropriate. Since it is not possible to initially predict (Ref. A9) which leachant (deionized water or synthesized seas water) would be most aggressive, sufficient preliminary testing should be conducted to identify the most aggressive leachant for each waste form formulation being qualified, and that leachant should be used for the balance of the testing (if only one is used). An acceptable method of identifying the most aggressive leachant is to perform 24 hour (or longer) leaching measurements on both leachants and to use the leachant that resulted in the lowest leach indices (i.e., highest leach rate) for the remaining days of testing.

G. Immersion Testing

No "Standard Method of Test" for immersion testing has been adopted for low-level radioactive waste, but as indicated in Section C.2.f. of the main body of this Technical Position, immersion testing may be performed in conjunction with the leach testing (which is to be performed in accordance with ANSI/ANS 16.1). However, in contrast with the period of time (5 days) necessary for leach testing of cement-stabilized wastes, immersion testing should be performed for a minimum period of 90 days. The immersion testing should be performed in either deionized water or synthesized sea water. The immersion liquid should be selected on the basis of short-term (24-hour or longer) leach tests that identify the most aggressive immersion medium (see discussion of leach testing).

The test specimens (at least three for each waste stream formulation being qualified) should be cured for a minimum cure time of 28 days (see Section III, "Specimen Preparation," of Appendix A for details) prior to being immersed. Following immersion, the specimens should be examined visually and should be free of any evidence of significant cracking, spalling, or bulk disintegration. If there are no significant visible defects (see Section II.C of this Appendix for discussion of "significant degradation"), the specimens should be subjected to compressive strength testing in accordance with ASTM C39 and should have post-immersion mean compressive strengths that are equal to or greater than 500 psi and not less than 75 percent of the pre-immersion test (i.e., as-cured) mean compressive strength. If the post-immersion mean compressive strength is less than 75 percent of the as-cured specimens' pre-immersion mean compressive strength, (but not less than 500 psi) the immersion testing interval should be extended (using additional specimens) to a minimum of 180 days. For these cases, sufficient compressive strength testing should be conducted (for example, after 120, 150, and 180 days of immersion) to establish that the compressive strengths level off and do not continue to decline with time.

For certain waste streams (viz., bead resins, chelates, filter sludges, and floor drain wastes) that have been found to exhibit complex relationships of cure time and immersion resistance (Ref. A12), additional immersion testing should be performed on specimens that have been cured (in sealed containers) for a minimum of 180 days. The immersion period should be for a minimum of 7 days, followed by a drying period of 7 days in ambient air at a minimum temperature of 20 degrees Celsius. After the specimens are dried, they should meet the post-immersion test visual and compressive strength criteria specified above.

H. Free Standing Liquids

It is stated in 10 CFR 61.56(b)(2) that "...liquid wastes, or wastes containing liquid, must be converted into a form that contains as little free standing or noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed...0.5% of the volume of the waste for waste processed to a stable form." Correspondingly, waste test specimens should have less than 0.5 percent by volume of the waste specimen volume as free liquids as measured using the method described in Appendix 2 of ANSI/ANS 55.1 (Ref. A13). Inasmuch as cement is an alkaline material, evidence of acidic free liquids is indicative of improper waste form preparation or curing. Therefore, any free liquid from cement-stabilized waste forms should have a minimum pH of 9.

I. Full-scale Testing

It is expected that the testing performed in accordance with the guidance provided in Sections A through H above will be carried out on small, laboratory scale specimens. As indicated in Section C.2.h. of the main body of this Technical Position, therefore, it is necessary to correlate the characteristics of full-size products with those of laboratory size specimens. The full-scale specimens should be fabricated using solidification equipment that is the same as or comparable to that used in processing real low-level waste forms in the field. The correlation of full-scale product characteristics should be accomplished by performing (1) compressive strength tests on as-cured material (cured for a minimum of 28 days), and (2) 90-day immersion tests that include post-immersion compressive strength tests (See Section II.G above) for the most conservative waste stream(s) being qualified.

Test specimens obtained from the full-scale waste forms by coring or sectioning 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 that meet the criteria called out in Section II.B above.

III. QUALIFICATION TEST SPECIMEN PREPARATION

A. Mixing

Experience in preparation of lab-scale and full-scale cement-solidified waste forms (Ref. A9) has shown that the method employed in mixing the ingredients can have a dramatic influence on the reactivity of the materials, the structure of the solidified waste form, and the resultant properties and characteristics of the waste form. Important parameters include type of equipment and mixing time because they will determine the amount of energy imparted to the ingredients used in the solidification recipe. This is especially important in cases where properties and characteristics of small, lab-scale specimens are used to predict the behavior of large, full-scale products. In preparing laboratory-sized qualification test specimens, it should be shown by analysis and/or testing that the type of equipment used, the mixing time, the speed of the mixer, etc. will, in combination, impart the same degree of mixing to the laboratory specimens as the full-scale mixing equipment and procedure will impart to full-scale waste forms and that the degree of mixing is sufficient to ensure production of homogeneous waste forms.

B. Curing

The curing conditions for small, laboratory-scale qualification test specimens, should, to the extent practical, be the same as the conditions obtained with full-scale products. Inasmuch as cement constituents exhibit a significant exothermic heat of hydration, while possessing low thermal conductivity, the interior temperature of large, full-scale cement waste forms may be elevated significantly (approaching even the boiling point of water). To ensure that the laboratory specimens endure curing conditions that are reasonably similar to those of full-size products, the waste form centerline temperature profile as a function of time should be obtained for the largest full-sized waste form to be qualified for each waste stream. That profile should be duplicated, to the extent practical, in the laboratory specimens. An acceptable method is to cure the specimens in a suitable oven for a period of time equivalent to the peak heat of hydration period. For the purposes of this Technical Position that period of time is taken to be that required for the centerline temperature of a full-scale waste form to decrease to a near-ambient (30 degrees Celsius or lower) temperature level.

Care should be taken to ensure that the waste loadings and cement concentrations in the full-scale waste forms provide sufficient margin to preclude reaching the boiling point of the pre-solidification mix. This is necessary to ensure that the waste form formulations will not be subject to uncontrolled variations due to water losses caused by evaporation during set. Uncontrolled porosities due to vapor bubble formation and rapid set due to elevated temperatures will also be avoided by limiting the maximum temperatures in the cement-solidified waste forms.

The compressive strength of hydrated cement and concrete solids increases asymptotically as the mixtures cure. Normally, the strength at 28 days approaches seventy-five percent or more of the "peak" value, though when pozzolonic cements are used the time required to reach peak strength may be extended. Sufficient test specimens should be prepared to determine the compressive strength increase with time to ensure that the specimens have attained sufficient (i.e., greater than 75% of the projected peak) strength prior to subjecting the remaining specimens to the qualification testing called out in Sections II.C through II.G. of this Appendix.

C. Storage

Test specimens that will be subjected to the qualification testing described in Section II of this Appendix should be kept in sealed containers during curing and storage. This is intended to simulate the environment that would be obtained in a typical full-scale waste form liner and will prevent loss of water that might affect the performance of the waste form specimens during subsequent testing.

IV. STATISTICAL SAMPLING AND ANALYSIS

As noted in the discussion of compressive strength testing (see Section II.B above), there tends to be considerable scatter in the compressive strength data obtained on brittle ceramic materials such as cement. Therefore, sufficient specimens should be tested in the as-cured condition to provide enough data to establish a mean and standard deviation, though for reasons discussed in Appendix A Section II.B, the number of as-cured specimens to be tested is left to the judgement of the waste formulation qualifier. For statistical purposes, however, the number of as-cured (pre-environmental test) compressive strength specimens should be ten or greater for a given formulation. Further discussion of the rationale for this provision is provided in Section II.B of this Appendix. For the minimum quantities of test specimens recommended in the respective subsections of this Appendix, the specimens tested should have a post-test mean compressive strength that is equal to or greater than 500 psi. Note that for the immersion tests, a slightly different acceptance criterion is identified, in subsection II.G of this Appendix. Variations in individual specimen compression strength need not be considered.

Other than the determinations of compressive strength, the only other parameter of interest in qualification testing of low-level waste forms that lends itself to statistical treatment is the leachability index. ANSI/ANS 16.1 (Ref. A10) uses the confidence range and correlation coefficient as measures of discrepancies in the measurements of leachability. The Standard requires that the confidence range and correlation coefficient be reported with the Leachability Index. As is the case of the ASTM C39 Compressive Strength standard, however, no precision criterion has been established yet for the ANSI/ANS 16.1 leach test.

V. WASTE CHARACTERIZATION

The importance of waste characterization was extensively discussed at the May/June Workshop on Cement Stabilization of Low-Level Radioactive Waste that was held in Gaithersburg, MD. The Proceedings (Ref. A9) of the Workshop, particularly the efforts of Working Group 4, record the discussions and provide useful information on the routine characterization of typical waste streams. Waste characterization would typically be expected to include as a minimum the identification of major constituents in the waste (including primary ions and salts or other solids), density, pH, temperature, radioactive isotopes, and a check for the presence of secondary ingredients that could significantly affect the hydration of the cement.

Some waste streams, such as pressurized water reactor (PWR) primary coolant system borated water, are relatively well-characterized and free of secondary ingredients. There are other waste streams, however, such as ion exchange resins, filter sludges and floor drain liquids, that may contain chemicals that can significantly retard or accelerate the hydration of cement or in other ways adversely affect cement waste form performance (Ref. A9). It is impractical for a waste processor to perform qualification testing on every possible combination and concentration of secondary constituents in a given type of waste stream. Nor is it considered practical or necessary for a waste generator to perform a complete quantitative chemical analysis on every batch of waste that is produced. It is, however, incumbent on radwaste system managers and processors to be cognizant of the types of chemicals that may produce problems in using cement in the solidification and stabilization of low-level radioactive waste. The introduction of such chemicals into waste treatment systems that utilize cement stabilization media should be avoided or specifically compensated for in the formula used for stabilizing that waste stream. If the waste processor is a vendor or is otherwise not the generator of the waste, it is incumbent on all parties to be in adequate communication with each other with regard to the types and quantities of chemical ingredients in the waste and the capability of the waste formulation to provide long-term structural stability to the waste form. As a part of process control, mixing of different wastes in holding tanks and transfer of liquid wastes without adequate flushing of lines should be generally avoided, because such mixing might introduce ingredients into the waste that were not present in the qualification test program that was conducted for the waste stream in question.

To assist waste generators and processors in developing a sense of greater awareness of low-level radioactive waste stream ingredients that may adversely affect the setting and stability of cement-solidified waste forms, a list of such chemicals is provided in Table I. This list is not intended to be all-inclusive. Moreover, some of the constituents listed may be considered hazardous materials, as defined by Environmental Protection Agency (EPA) criteria, and which thus, if mixed with radioactive material, could be classified as a "mixed waste." Any questions about low-level radioactive wastes that might be classified as mixed wastes should be directed to the EPA.

Low-level radioactive waste generators and processors who intend to stabilize Class B and Class C waste with cement should either (a) prevent the contamination of, (b) limit to the extent practical, or (c) pre-treat as appropriate, waste streams that may contain the chemicals and constituents in Table I. It is the responsibility of the waste generator and processor to ensure that the cement formulation used for a given waste stream is qualified for the waste stream chemical constituents and concentrations in question.

VI. PCP SPECIMEN PREPARATION AND EXAMINATION

A. General

The purpose of a Process Control Program (PCP) is to describe the envelope within which processing and packaging of low-level radioactive wastes will be accomplished to provide reasonable assurance of compliance with low-level waste requirements. All commercial nuclear power plants have plant specific PCPs. The guidance provided in this section of this Appendix is not, however, intended to address facility-specific PCPs, which, in addition to containing a general description of the methods for controlling the processing and packaging of radioactive waste, may also contain a description of the system and operating procedures, instructions on manifest preparation, and a discussion of administrative controls. Rather, this guidance addresses only the recipe portion of cement stabilization of low-level waste; that is, the guidance addresses the nature of the information that should be provided in a generic PCP concerning the type and quantity of ingredients used in the cement waste form formulation, the order of addition, and the method, process, and time required for mixing the ingredients in the preparation of verification and surveillance specimens as well as the full-scale waste forms. Also provided is guidance on the preparation of PCP "verification" and surveillance specimens and the type of examinations and testing that should be performed on those specimens.

This information on verification specimens is intended to provide assurance that the formulations used in the qualification testing program correspond to those actually used in the field. The surveillance specimen program, described in Section VII of this Appendix, is intended to provide verification that the waste forms are remaining stable with time.

For each low-level radioactive waste formulation, the generic PCP should address the boundary conditions (i.e., bounding process parameters) for processing the waste to provide reasonable assurance that the final waste form will meet 10 CFR Part 61 stability requirements. The process parameters will be influenced by (a) the characteristics of the waste prior to processing, (b) the qualities of the solidification medium, as influenced by additives, and (c) the physical/chemical process of preparing the waste into a final waste form. Variables that influence the process and have an effect on the product, and that should be, therefore, be identified and restricted within acceptable bounds for each waste form include the following:

1. Type of waste (e.g., bead resin, including type--anion/cation/mixed/manufacturer/weak acid/strong acid, percent depleted, powdered resins, boric acid, sludges);

2. Waste characteristics having influence on the final waste form (e.g., pH, oil content, chelating agents, water content, maximum concentration of secondary ingredients);

3. Additives (e.g., type of cement, water, lime, silica fume, fly ash, furnace slag,) and the order of addition;

4. Physical process parameters (e.g., maximum temperature, mixing equipment required, mixing and curing times).

The generic PCP should indicate how representative samples of the feed waste are to be obtained for preparing PCP verification and surveillance specimens. The PCP should identify typical and maximum batch sizes and the number of PCP specimens to be taken for each batch. The PCP should describe where adjustments could be made to the feed waste material, in the event that certain feed material parameters that may be encountered in the field fall outside of the acceptable range for processing. These adjustments should not be undertaken if the resultant waste stream feed material and stabilized waste form were to be chemically or physically different from that qualified in laboratory testing.

If, during the course of full-scale waste form preparation at a nuclear power plant, it should become necessary to effect an ad hoc, impromptu change in the approved recipe or procedure to avoid an incomplete or otherwise unsatisfactory solidification condition, the change should be reviewed and approved by the facility licensee pursuant to the provisions of 10 CFR 50.59. This process should be followed in all such cases where ad hoc changes are necessary whether or not a generic PCP has received approval as part of a Topical Report review process. Inasmuch as the affected waste form would lack assurance of long-term structural stability (because it was produced under conditions that were outside of the envelope of the conditions used in the qualification tests), it is anticipated that the resultant waste form would not be accepted for disposal at a disposal site without the expressed approval of the disposal site regulatory authorities. It is also anticipated that, prior to accepting the waste, the regulatory authority would require either (1) adequate mitigation of any potential adverse effects on the long-term structural stability of the waste form or (2) an acceptable justification concerning the lack of any potential significant effect of the affected waste form on the overall performance of the facility. Alternatively, the disposal site regulatory authority could accept the affected waste for disposal with the provision that the required structural stability would be provided at the disposal facility by means of an engineered structure.

After the generic PCP has been reviewed and approved by the NRC, the PCP parameters and procedures should be followed as described in the Topical Report (or other documentation) so that the 10 CFR 20.311 certification can be made without the need for additional justification that the cement-solidified waste meets the requirements of 10 CFR Part 61. Once a generic PCP has been approved by the NRC any subsequent changes to the generic PCP should be reviewed and approved by the NRC. Any incomplete or otherwise unsatisfactory solidification condition known to waste generators and processors is requested to be reported to the NRC (Director, Division of Low-Level Waste Management and Decommissioning) within 30 days after such an occurrence is known (see Section VIII). The actions taken to produce an acceptable waste form after the initial unsatisfactory solidification condition was identified should be described.

B. Preparation of PCP Specimens

Prior to plant-specific solidification of full-scale waste forms, representative samples of the feed waste should be obtained in sufficient quantity to prepare the desired number of PCP specimens. The feed waste material should be solidified using the recipe that has been qualified in laboratory testing for the given waste stream. Mixing of the waste materials with the cement and additives should be accomplished in a manner that duplicates, to the extent practical, the mixing conditions that are obtained with full-scale mixing. The specimens should be cured under conditions similar to those used in the laboratory qualification test program. PCP specimens should be prepared for each batch of waste that is required to meet the 10 CFR Part 61 structural stability criteria. For the purposes of the guidance provided in this Technical Position, a "batch" is herein defined as any quantity of waste stream feed material that is from a single source (e.g., a holding tank), that is processed as a single batch (even though it maybe subdivided in more than one unit waste form; e.g., liner), and that, therefore, possesses unvaried, single operation, batch characteristics.

C. PCP Specimen Examinations and Testing

1. Short-term (24-hour PCP Verification) Specimens -

Prior to solidifying full-scale waste forms, plant-specific PCP verification specimens should be prepared, in accordance with procedures described above, for examination and compressive strength testing. The specimens should be free of significant visible defects, such as cracking, spalling or disintegration and should exhibit less than 0.5% by volume of the specimen as free liquid. As a measure of process control, the specimens should, within a 24-hour period after preparation, be subjected to an ASTM C39 compressive strength test; (penetrometer measurements may be substituted, as described below). The compressive strength values should be within two standard deviations of the mean compressive strength values obtained at 24 hours for test specimens prepared and tested as part of the associated laboratory generic qualification test program for the waste formulation. Alternatively, penetrometer tests can be used in lieu of C39 compressive strength measurements if acceptable correlation data demonstrating the relationship between the compressive strength values and penetrometer values have been obtained for the waste stream formulation in question. If penetrometer tests are used, the mean penetrometer hardness values obtained on the verification specimens should be within two standard deviations of the mean obtained on the qualification test specimens for that formulation. If the compressive strength or penetrometer measurements do not meet the above criteria, a second set of PCP specimens should be prepared and retested. The second set of PCP specimens should be fabricated using either the same formula or an adjusted one that falls within the compositional envelope of the qualification tests conducted for that waste stream.

2. Long-term Surveillance Specimens -

The guidance herein addressing long-term surveillance specimens is directly applicable to waste generators and to vendors processing wastes at licensed facilities who intend to certify, in accordance with the provisions of 10 CFR 20.311, that the cement-solidified waste meets the structural stability requirements of 10 CFR Part 61. Sufficient PCP specimens should be prepared to permit the retention, examination and testing of surveillance specimens. The surveillance specimens should be stored in sealed containers at normal room temperatures. The examination and testing of surveillance specimens is described in Section VII of this Appendix.

VII. SURVEILLANCE SPECIMENS

The purpose of the surveillance specimens is to provide confirmation that the waste forms prepared for certain waste streams, (in particular bead resins, chelates, filter sludges, and floor drain wastes) are performing as expected. At periods of time equal to 6 months and 12 months after preparation, the surveillance specimens should be examined visually and should be free of evidence of significant cracking, spalling or bulk disintegration (see Section II.C of Appendix A for discussion of "significant degradation"). At least one specimen should be subjected to an ASTM C39 compressive strength (or penetrometer) test at the 6 and 12 month periods. The mean compression strength (or penetrometer) value(s) obtained should be not more than two standard deviations below the mean of the as-cured strength or penetrometer values obtained with the qualification test specimens cured for an equivalent period of time.

At 12 months after preparation, one or more PCP surveillance specimens should be subjected to an immersion test. The duration of the immersion test should be a minimum of 14 days. Upon removal from the immersion liquid, which should be either deionized water or synthesized sea water (see Section II.F of this Appendix) the specimens should be allowed to dry in ambient air for a minimum of 48 hours. The specimens should then be examined visually and should be free of significant surface or bulk defects such as cracking, spalling, or bulk disintegration. Following the immersion test, the specimen(s) should be subjected to an ASTM C39 compressive strength (or penetrometer) test. The test results should meet the criteria discussed above.

If the PCP surveillance specimens tested either by the vendor of an NRC-approved Topical Report or by a utility or other licensee, should fail any of the above tests, the wastes previously solidified may not meet the stability requirements of 10 CFR Part 61. Therefore, the NRC (Director, Division of Waste Management and Decommissioning) and licensee (if other than the waste processor that shipped the suspect waste to the disposal facility) should be notified in writing within 30 days. In turn, the licensee should notify the disposal facility operator and regulatory authority if the 10 CFR 20.311 certification as to waste stability was invalidated by this finding. The licensee's report should satisfy the information needs of the regulatory authority and should describe the waste stream solidified, the waste formulation used, the number of full-scale waste forms that had been produced, date of shipment, manifest numbers, and the results of the tests. The report should also contain a discussion of the significance of the test results and proposed changes, if any, that might have to be made to the waste formulation to ensure that, for the waste stream in question, future waste forms would be stable.

For all waste processors (including utility licensees and vendors of NRC-approved Topical Reports), it is recommended that a summary report that addresses the results of PCP surveillance specimen preparations and examinations should be prepared annually by the waste processor and submitted to the NRC (Director, Division of Waste Management and Decommissioning). The report should document the results of all visual examinations and immersion, compression, and/or penetometer tests performed on the cement-stabilized waste form surveillance specimens during the calendar year. The annual report should be submitted within 90 days of the end of each calendar year. A commitment to provide this information will be made a condition of approval for all future license applications, topical report submittals or other regulatory actions that deal with cement waste forms, where the waste generators and/or processors desire NRC endorsement of their 10 CFR 20.311 certifications.

VIII. REPORTING OF MISHAPS

Known cement waste form processing mishaps, including but not restricted to, cement waste forms that have not solidified completely, waste forms that have swelled and/or disintegrated, waste forms that were not prepared in accordance with an approved PCP, and waste form preparations that resulted in unusual exothermic reactions, should be reported by the cognizant waste processor to the NRC (Director of the Division of Waste Management and Decommissioning) within 30 days of the time that the vendor becomes aware of the incident. Licensees should also report such mishaps to the disposal site regulatory authority since such an event may indicate the waste form will or does not satisfy the stability requirements of 10 CFR Part 61. If the mishap becomes known to the waste generator and/or processor before the waste forms are shipped off-site, the affected waste form(s) should not be shipped until approval is obtained from the disposal site regulatory authority. A commitment to report and deal with waste form mishaps as discussed above will be made a condition of approval for all future license applications, topical report submittals, or other regulatory actions that deal with cement waste forms, where the waste generators and/or processors desire NRC endorsement of their 10 CFR 20.311 certifications.

IX. IMPLEMENTATION

This Appendix to the Technical Position on Waste Form reflects the current NRC staff position on an acceptable means for meeting the 10 CFR Part 61 structural stability requirements for cement waste forms. Therefore, except in those cases in which the waste generator, vendor, and/or processor proposes an acceptable alternative method for complying with the stability requirements of 10 CFR Part 61, the guidance described herein will be used by the NRC staff in all future evaluations of the acceptability of cement waste forms for disposal at near-surface disposal facilities.

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X. REFERENCES

A1(a). Part 61 - Licensing Requirements for Land Disposal of Radioactive Waste, Code of Federal Regulations, Title 10: Energy.

A1(b). "Method for Obtaining Approval of Proposed Disposal Procedures," Subsection 311 of Part 20 (20.302), Code of Federal Regulations, Title 10: Energy.

A2. American Society for Testing and Materials Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, ASTM C39, October 1984.

A3. D.R. MacKenzie, M. Lin, and R.E. Barletta, "Permissible Radionuclide Loading for Organic Ion Exchange Resins for Nuclear Power Plants," Brookhaven National Laboratory Draft Report, BNL-NUREG-30668, January 1982.

A4. P. Soo and L. W. Milian, "Sulfate-Attack Resistance and Gamma-Irradiation Resistance of Some Portland Cement Based Mortars," Brookhaven National Laboratory Report, NUREG/CR-5279, March 1989.

A5. American Society for Testing and Materials Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi, ASTM G21, 1985.

A6. American Society for Testing and Materials Standard Practice for Determining Resistance of Plastics to Bacteria, ASTM G22, 1985.

A7. P.L. Piciulo, C.E. Shea, and R.E. Barletta, "Biodegradation Testing of Solidified Low-Level Waste Streams," Brookhaven National Laboratory Report, NUREG/CR-4200 (BNL-NUREG-51868), May 1985.

A8. B.S. Bowerman, et al., "An Evaluation of the Stability Tests Recommended in the Branch Technical Position on Waste Forms and Container Materials," Brookhaven National Laboratory Report, NUREG/CR-3289 (BNL-NUREG-51784), March 1985.

A9. Proceedings of the Workshop on Cement Stabilization of Low-Level Radioactive Waste, U.S. Regulatory Commission Report, NUREG/CP-0103, October 1989.

A10. American National Standards Institute/American Nuclear Society American National Standard for Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure, ANSI/ANS 16.1-1986, April 14, 1986.

A11. W. Chang, L. Skoski, R. Eng, and P.T. Tuite, "A Technical Basis for Meeting the Waste Form Stability Requirements of 10 CFR 61," Nuclear Management and Resources Council, Inc. Report, NUMARC/NESP-002, April 1988.

A12. P. L. Piciulo, J. W. Adams, J. H. Clinton, and B. Siskind, "The Effect of Cure Conditions on the Stability of Cement waste Forms after Immersion in Water," Brookhaven National Laboratory Report, WM-3171-4, August 1987.

A13. American National Standards Institute/American Nuclear Society American National Standard for Solid Radioactive Waste Processing System for Light Water Cooled Reactor Plants, Appendix 2, March 1979.

LIST OF WASTE CONSTITUENTS THAT MAY CAUSE PROBLEMS WITH CEMENT SOLIDIFICATION

POTENTIAL PROBLEM CONSTITUENTS WHICH MAY BE EXPECTED IN THE WASTE STREAM

Inorganic Constituents

- Borates [1]
- Phosphates [1]
- Lead salts [2]
- Zinc salts
- Ammonia and ammonium salts
- Ferric salts
- "Oxidizing agents" [1] (often proprietary)
  - Permanganates [1]
  - Chromates [2]
- Nitrates [1]
- Sulfates [1]

Organic Constituents - Aqueous Solutions

- Organic acids [1]
  - Formic acid (and formates)
- "Chelates" [1],[3]
  - Oxalic acid (and oxalates)
  - Citric acid (and citrates)
  - Picolinic acid (and picolinates)
  - EDTA (and its salts)
  - NTA (and its salts)
- "Decon solutions"[1]
  - Soaps and detergents [1]

Organic Constituents - Oily Wastes

- Benzene [1],[2]
- Toluene [1],[2]
- Hexane [1]
- Miscellaneous hydrocarbons
- Vegetable oil additives

POTENTIAL PROBLEM CONSTITUENTS THAT MAY BE AVOIDED BY HOUSEKEEPING OR PRETREATMENT [4]

Generic Problem Constituents [5]

- Oil [1] and grease
- "Aromatic oils" [1]
- "Organic solvents" [1],[2]
  - Dry-cleaning solvents [1],[2]
- "Industrial cleaners" [1],[2]
  - Paint thinners [1],[2]
- "Decon solutions" [1]
  - Soaps and detergents [1]

Specific Problem Constituents - Organic

- Acetone [1],[2]
- Methyl ethyl ketone [2]
- Trichloroethane [2]
- Trichlorotrifluoroethane [2]
- Xylene [2]
- Dichlorobenzene [2]

Specific Problem Constituents - Inorganic

- Sodium hypochlorite [1]

NOTES:

[1] These constituents have been specifically identified by vendors as having the potential to cause problems with cement solidification of low-level wastes.

[2] The presence of these constituents may result in the generation of mixed wastes. The Environmental Protection Agency should be contacted for more information.

[3] All of these chelating agents could also be identified as "organic acids."

[4] Good housekeeping and pretreatment could also be effective in preventing problems with cement solidification for many of the constituents listed in the top li48.

[5] These specific constituents also fall into several of the "generic" problem constituents "categories" listed at the left.

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

MAY 11 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.

Leo B. Higginbotham

Leo B. Higginbotham, Chief
Low-Level Waste Licensing Branch
Division of Waste Management

May 1983
Rev. 0

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 $\mu Ci/cm^3$ (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 $\mu Ci/cm^3$. 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.

ATTENTION: Commission Licensees

SUBJECT: ISSUANCE OF FINAL BRANCH TECHNICAL POSITION ON CONCENTRATION AVERAGING AND ENCAPSULATION, REVISION IN PART TO WASTE CLASSIFICATION TECHNICAL POSITION

The regulation, "Licensing Requirements for Land Disposal of Radioactive Waste," 10 CFR Part 61, establishes a waste classification system based on the concentration of specific radionuclides contained in the waste. The regulation also states, at 10 CFR 61.55(a)(8), that, "the concentration of a radionuclide [in waste] may be averaged over the volume of the waste, or weight of the waste if the units [on the values tabulated in the concentration tables] are expressed as nanocuries per gram" [text added for clarity]. The enclosed Technical Position defines a subset of concentration averaging and encapsulation practices that the NRC staff would find acceptable in determining the concentrations of the 10 CFR 61.55 tabulated radionuclides in low-level waste.

On June 26, 1992, Commission licensees were sent copies of a proposed "Concentration Averaging and Encapsulation Technical Position, Revision in Part," on which comments were solicited. A notice of availability of the proposed Technical Position was also published in the Federal Register on June 30, 1992 (57 FR 29105). In response, nineteen comment letters were received suggesting the need for further expansions of, and several modifications to, the Technical Position. Consideration of these comments resulted in modifications and an expansion of the Technical Position. A notice of availability of the modified Technical Position was again published in the Federal Register on September 22, 1993 (58 FR 4933) and, because of the significant interest expressed by the original commenters, was again issued for comment in proposed form. Thirteen comment letters were received, suggesting further clarifications and resurfacing position justification issues raised on the initial proposal. Many of the suggested clarifications have been included in the final technical position (Enclosure 1), and further discussion and technical basis information have been attached to respond to the "position justification" and other comments. Enclosure 2 provides additional explanation of the technical bases for the concentration averaging and encapsulation positions involving the classification of certain "discrete" waste types.

The final technical position has been supported by the Conference of Radiation Control Program Directors' E-5 Committee on Low-Level Radioactive Waste Management. Through continued coordination with the E-5 Committee, the goal has been to develop a <u>subset</u> of concentration averaging and encapsulation positions that would be generally accepted by the States that will be licensing many of the future low-level radioactive waste disposal sites. Because the guidance can not address all unique waste types or waste packaging methods, an "Alternative provisions" paragraph is included that defines the bases and procedures through which other classification averaging or encapsulation positions may be judged acceptable.

Questions on the final position may be referred to William Lahs, U.S. Nuclear Regulatory Commission, Mail Stop 7F-27, Two White Flint North, Washington, DC 20555, telepnone (301) 415-6756. The information collections contained in the Technical Position have been approved under the Office of Management and Budget number 3150-0014.

M.R. Knapp

Malcolm R. Knapp, Director
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosures: As stated

BRANCH TECHNICAL POSITION ON CONCENTRATION AVERAGING AND ENCAPSULATION

CONTENTS

CONTENTS, Cont:

TECHNICAL POSITION ON CONCENTRATION AVERAGING AND ENCAPSULATION

A. INTRODUCTION

The U.S. Nuclear Regulatory Commission requires that a proposed low-level radioactive waste disposal site undergo a performance assessment that demonstrates compliance with the performance objectives stated in 10 CFR 61.41. In addition, to provide protection, for individuals, from inadvertent intrusion (i.e., 10 CFR 61.42), radioactive waste proposed for near-surface disposal must be classified to ensure its suitability for such disposal. The regulation, "Licensing Requirements for Land Disposal of Radioactive Waste," 10 CFR Part 61, establishes a waste classification system based on the concentration of specific radionuclides contained in the waste. The regulation also states, in 10 CFR 61.55(a)(8), that, "The concentration of a radionuclide [in waste] may be averaged over the volume of the waste, or weight of the waste if the units [on the values tabulated in the concentration tables] are expressed as nanocuries per gram" [text added for clarity].

A technical position on radioactive waste classification was initially developed in May 1983. This initial position included a section, "Concentration Volumes and Masses," that provided guidance to waste generators on the interpretation of 10 CFR 61.55(a)(8) as it applies to a variety of different types and forms of low-level waste. This position expands on, further defines, and replaces that guidance which was provided in Section C.3 of this original 1983 Technical Position. The other sections of this 1983 Technical Position remain in effect, with the exception of the corrections noted in the footnote below.[1] The recommendations and guidance provided in this Section C.3 revision represent acceptable methods by which specific waste streams or mixtures of these waste streams may be classified against the tabulated concentration values defined in Tables 1 and 2 of 10 CFR 61.55. The guidance is not intended to address all unique waste types or waste packaging methods. Other provisions for the classification of these specific wastes or waste mixtures may be deemed acceptable, as discussed under the "Alternative

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[1] The following corrections should be made to the May 1983, Technical Position: (1) p. 1, first para., fourth line -- delete the words, "or processor"; and (2) p. 6, fourth line and p. 12, second para., fifth line -- replace "biannual" with "biennial."

provisions" paragraph of this revision. Furthermore, if necessary, it is intended that the provisions in this paragraph be used to preclude reclassification of waste material that was packaged and classified before the issuance of this expanded guidance, if the waste were classified in accordance with accepted practices at the time of packaging.

B. DISCUSSION

Each shipment of radioactive waste to a licensed operator of a land disposal facility must be accompanied by a shipment manifest. In the manifest, the shipper/consignor-licensee must classify and clearly identify waste as Classes A, B, or C, in accordance with 10 CFR 61.55. Determination of the classification of waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides in the waste, with respect to the values given in Table 1 of 10 CFR 61.55. Second, consideration must be given to the concentration of short-lived radionuclides in the waste, with respect to the values given in Table 2 of 10 CFR 61.55.

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 10 CFR 61.55, in concentrations exceeding the applicable limits established for the individual radionuclides.

C. REGULATORY POSITION

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3. Volumes and Masses for Determination of Concentration[2]

Paragraph 61.55(a)(8) states that, for the purposes of waste classification, the concentration of a radionuclide may be averaged over the volume of the waste, or the weight of the waste, for those concentration units, in

[2] It should be noted that waste acceptance requirements for disposal facilities licensed by Agreement States (e.g., requirements for encapsulated wastes or activated metals) may differ from this guidance. Waste generators should consult with disposal site operators or appropriate regulatory authorities before classifying these wastes.

10 CFR 61.55, Table 1 that are expressed as nanocuries per gram. This requirement needs interpretation because of the 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 (i.e., volume distributed); (2) whether the "as-generated" waste has been processed and, if so, what is the mass/volume of the processed waste; (3) whether the waste includes mixtures of various waste types (i.e., a waste stream with a particular set of physical characteristics); (4) whether the waste includes mixtures of the same waste type, but at differing radioactivity concentration levels; and (5) whether the volume of the waste container, if used to represent the volume of the waste, is significantly larger than the volume of the waste itself, and the differential volume consists largely of void space.

With regard to the above considerations, many waste types may be considered to be homogeneous, for purposes of waste classification. A homogeneous waste type is one in which the radionuclide concentrations are likely to approach uniformity in the context of the intruder scenarios used to establish the values included in Tables 1 and 2 of 10 CFR 61.55 (i.e., intruder interactions with the waste are assumed to take place 100 years or more after disposal site closure). Such waste types would include, for example, spent ion-exchange resins, filter media, solidified liquid, evaporator bottom concentrates, or contaminated soil. Contaminated trash waste, which is composed of a variety of miscellaneous materials, may be considered homogeneous for purposes of waste classification, when placed in containers. To the extent that contaminated trash and contaminated soil are packaged in a disposal container to achieve ≥90 percent fill, the volumetric-averaged concentration of radionuclides in these waste types can be based on the fill-volume of the container. Alternatively, the volume of the waste can be calculated from the weight of the container contents, divided by the density of the contents. A representative density, based on a representative distribution of materials as they occur in waste, may be used.

For certain waste types (i.e., spent ion-exchange resins and filter media), care needs to be taken to differentiate between the volume of the waste form and the volume of the waste container. Although free volume should be reduced to the extent practicable, these wastes may be contained within a disposable demineralizer, liner, or high integrity container (HIC) with some waste-free volume. In such cases, the volume or weight used for waste classification should be the displaced or bulk volume (interstitial space may be included) or dewatered weight of the resins or filter media, rather than the gross internal volume of the container or the weight of the resins before dewatering.

The following paragraphs provide guidance on a subset of acceptable classification or encapsulation practices. Other provisions for classification or encapsulation of specific waste may also be deemed acceptable, as discussed in the "Alternative provisions" paragraph at the end of this section.

3.1 Mixing of homogeneous waste types or streams

Mixing of similar homogeneous waste types (e.g., spent ion-exchange resins or contaminated soils) is permissible as described below. Note, however, that a designed collection of homogeneous waste types from a number of sources within a licensee's facility, for purposes of operational efficiency or occupational dose reduction, is not considered "mixing," for purposes of this position. Under the guidance in this position, the classification of a mixture, using the sum of fractions rule specified in 10 CFR 61.55, should be based on either: (a) the highest nuclide concentrations in any of the individual waste types contributing to the mixture; or (b) the volumetric- or weight-averaged nuclide concentrations of the mixture, provided that the concentrations of the individual waste type contributors to the mixture are within a factor of 10 of the average concentration of the resulting mixture.

Mixing of dissimilar homogeneous waste streams may also be permissible, but should receive appropriate regulatory approval under the "Alternative provisions" paragraph of this position.

In any of the above cases, in accordance with Section III of Appendix F to 10 CFR Part 20, the licensee classifying the waste must have in place a quality control program to ensure compliance with the waste classification provisions of 10 CFR 61.55. As part of this quality control program, if the classification of a mixture is based on the volumetric- or weight-averaged nuclide concentration of the mixture (e.g., as allowed under (b) above), the licensee responsible for classification of the waste should prepare, retain with manifest documentation, and have available for inspection, a record documenting the licensee's waste classification analysis. It is generally expected that this record or analysis, in and of itself, should be sufficient to show that the mixing was undertaken under the provisions of this position.

3.2 Solidified and absorbed liquids

Classification of evaporator concentrates, filter backwashes, liquids, or ion-exchange resins solidified in a manner to achieve homogeneity or meet the stability criteria of 10 CFR 61.56 should be based on solidified nuclide activity divided by the volume or weight of the solidified mass. Because absorbed liquid wastes do not appreciably bind nuclides, classification of absorbed liquids should be based on the absorbed activity divided by the volume or mass of the liquids before absorption.

3.3 Mixing of activated materials or metals, or components incorporating radioactivity in their design

For neutron-activated materials or metals, or components incorporating radioactivity in their design, the waste classification volume or weight should be taken to be the total weight or displaced volume of the material, metal, or component (i.e., major void volumes subtracted from the envelope volume).

Mixtures of activated materials, metals, or components in a disposal container or liner are permissible. In determining the classification of such a mixture, it is always permissible to conservatively base the mixture classification on the highest classification associated with any piece, section, or component within a disposal container or liner. It is also permissible, under the following constraints, to average the concentrations of the radionuclides listed in 10 CFR 61.55, Table 1 and Table 2, over contents of the disposal container or liner. Because of the potential non-homogeneity of the waste. the classification of the combined waste may be affected by whether the waste contains the primary gamma-emitting nuclides (Co-60, Nb-94, or Cs-137/Ba-137m). For the purpose of applying the guidance under these paragraphs, a component may be considered to be that portion of an original component that is placed in the disposal container being classified. Although components may be comprised of multiple sections or pieces to effectuate packaging, the component (not the pieces or sections thereof) is the discrete item to which this guidance applies.

In determining the classification of the container/liner, one or more of the following paragraphs may apply, as indicated in the logic diagram (Figure 1) on pages 10 and 11.

3.3.1 Averaging involving primary gamma-emitters

For the purpose of classifying a mixture of items or components containing the primary gamma-emitters (i.e., Co-60, Nb-94, or Cs-137/Ba-137m) for which these nuclides dictate the classification of the waste, their individual nuclide concentrations may be based on the volumetric-averaged concentration of the combined materials, provided that the concentrations within the individual items or components of the mixture in the disposal container or liner are within a factor of 1.5 of the respective averaged concentration value for each nuclide. Averaging is always allowed for a primary gamma-emitting nuclide if its activity within an item or component is less than 37 MBq (1 mCi).

3.3.2 Averaging of sections or pieces of larger components containing the primary gamma-emitters

Individual sections of pieces of larger components that may result from operational considerations (e.g., packaging for transportation) should be considered as discrete items if:

(a) the volume of the piece or section is less than one-hundredth of a cubic foot (0.01 ft^3) or 0.00028 cubic meters (0.00028 m^3) -- such a piece will typically weigh less than 10 pounds (10 lbs) or 4.54 kilograms (4.54 kg), and

(b) the specific nuclide activity in the piece or section is greater than the appropriate value shown in Table A.

3.3.3 Averaging involving radionuclides other than primary gamma-emitters

For the purpose of classifying a mixture, the concentrations of all 10 CFR 61.55 tabulated radionuclides in the disposal container or liner, other than Co-60, Nb-94, or Cs-137/Ba-137m, may be based on the volumetric- or weight-averaged concentrations of the combined materials. In this case, all the concentrations of the "classification-controlling" individual nuclides[3] within all the individual items should be within a factor of 10 of their respective averages over all items in the mixture.

TABLE A

Activity Levels in Individual Sections or Pieces of Larger Components Potentially Requiring Their Piecemeal Consideration in Classification Determinations

Nuclide	For Waste Classified as Class A or B	For Waste Classified as Class C
Co-60	>26 TBq (700 Ci)	N.A.
Nb-94	>37 MBq (1 mCi)	>37 MBq (1 mCi)
Cs-137/Ba-137m	>111 MBq (3 mCi)	>1.1 TBq (30 Ci)

3.3.4 Averaging involving sections or pieces of larger components containing other than primary gamma-emitters

Individual sections or pieces of larger components, in a disposal container, that may result from operational considerations (e.g., packaging for transportation) should be considered as discrete items, if the nuclide activity in the piece or section exceeds the appropriate value indicated in Table B.

3.3.5 Mixtures containing multiple radionuclides

For activated materials, metals, or components containing combinations of tabulated nuclides, the sum-of-the-fractions rule described in 10 CFR 61.55(a)(7) would apply. This rule involves the summing of the fractions of the appropriate 10 CFR 61.55 Table 1 or 2 concentration values, as described in 10 CFR 61.55(a)(7). The sum of the fractions rule could involve summing the fraction of the appropriate 10 CFR 61.55 Table 1 or

3 A "classification-controlling" nuclide is one that 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 applicable class-dependent concentration of that nuclide in Table 2, Column 2 or 3. Note that a nuclide may be significant for reporting purposes under Section 4 in the May 1983 Technical Position and yet not be a "classification-controlling" nuclide.

Table 2 concentration values associated with the primary gamma-emitting nuclides and the fractions of tabulated concentrations associated with the other nuclides. The respective fractions contributing to the sum can be calculated by using the "highest concentration" existing in any item within the mixture or, if applicable, the concentration determined by using the "averaging" methods described previously.

TABLE B

Activity Levels in Individual Sections or Pieces of Larger Components Requiring Their Piecemeal Consideration in Classification Determinations

Nuclide*	For Waste Classified as Class A or B	For Waste Classified as Class C
H-3	>0.3 TBq (8 Ci)	N.A.
C-14	>0.04 TBq (1 Ci)	>0.4 TBq (10 Ci)
Ni-59	>0.15 TBq (4 Ci)	>1.5 TBq (40 Ci)
Ni-63	>0.26 TBq (7 Ci)	>55 TBq (1500 Ci)
Alpha emitting TRU with half-life greater than 5 years (excl. Pu-241 and Cm-242)	>111 MBq (3 mCi)	>1110 MBq (30 mCi)

* Other nuclides listed in the tables in 10 CFR 61.55 are not expected to be of importance in determining waste classification.

Independent of the method chosen, in accordance with Section III of Appendix F to 10 CFR Part 20, the licensee classifying the mixture of items must have in place a quality control program to ensure compliance with the waste classification provisions of 10 CFR 61.55. As part of this quality control program, if the classification of the mixture of items is based on the volumetric- or weighted-averaged nuclide concentrations of any of the items in the disposal container/liner, as allowed above, the licensee responsible for classification of the waste should prepare, retain with manifest documentation, and have available for inspection, a record documenting the licensee's waste classification analysis. It is generally expected that this record or analysis, in and of itself, should be sufficient to show that the averaging of concentrations over some or all the contents in the disposal container/ liner was undertaken under the provisions of this position.

3.3.6 Illustrative examples

Example 1: Three equally sized control rod blades are contained in a liner. The blades (0.6 ft^3 or 0.017 m^3) contain, respectively, concentrations of Nb-94 that are 0.9, 0.7, and 0.5 of the 10 CFR 61.55, Table 1, value for Nb-94, of 0.2 curies per cubic meter. The blades also contain Ni-59 in concentrations of 44, 22, and 11 curies per cubic meter. These concentrations are 0.2, 0.1, and 0.05 of the 10 CFR 61.55, Table 1, value for Ni-59, of 220 curies per cubic meter. The Nb-94 concentrations in the three blades are all within a factor of 1.5 of the average concentration within three blades (i.e., 0.14 curies per cubic meter). Likewise, the Ni-59 concentrations in the three blades are all within a factor of 10 of the average concentration within the three blades (i.e., 26 curies per cubic meter). The sum of the fractions for the blades in the liner would be calculated by summing 0.7 (the averaged Nb-94 fraction for the blades) and 0.12 (the fraction for the Ni-59 activity averaged over all three blades). The sum, 0.82, would qualify the liner as containing Class C waste.

Example 2: The cruciform section of a boiling-water reactor control rod blade (0.6 ft^3 (0.169 m^3) and 200 lbs. (90.8 kg)) contains a Nb-94 concentration of 0.16 curies per cubic meter, a Ni-59 concentration of 22 curies per cubic meter, and a Ni-63 concentration of 5000 curies per cubic meter. The blade, as a whole, would be classified as Class C waste (i.e., Nb-94 fraction (0.8) + Ni-59 fraction (0.1) = 0.9, using the sum of the 10 CFR 61.55, Table 1, fractions; the Ni-63 concentration is less than the respective Table 2, Column 3 value). The blade, however, is sectioned into four equal pieces to facilitate shipment. The "hottest" piece contains 80 percent of the blade's activity. This piece would contain a concentration of Nb-94 above the 10 CFR 61.55, Table 1, value. However, if pieces of the blade contained in the same disposal container are less than Class C limits on the average, the container could be classified as Class C waste, because, although the "hottest piece contains more than 1 mCi of Nb-94, the volume of each piece exceeds 0.01 cubic feet (0.00028 m^3)-see paragraph 3.3.2(a). Note in this example, the blade could represent a control rod after the velocity limiter or other segments had been removed.

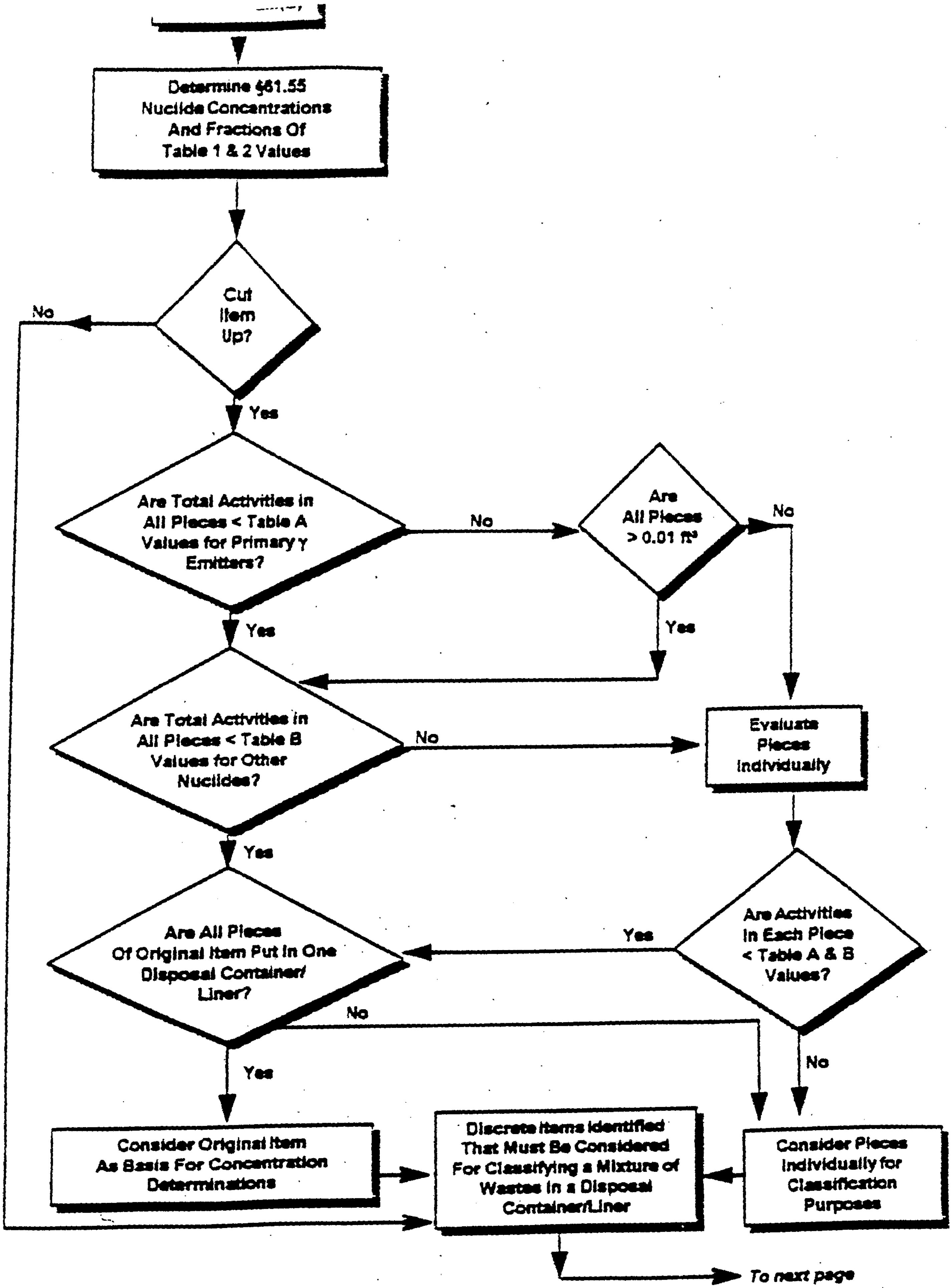
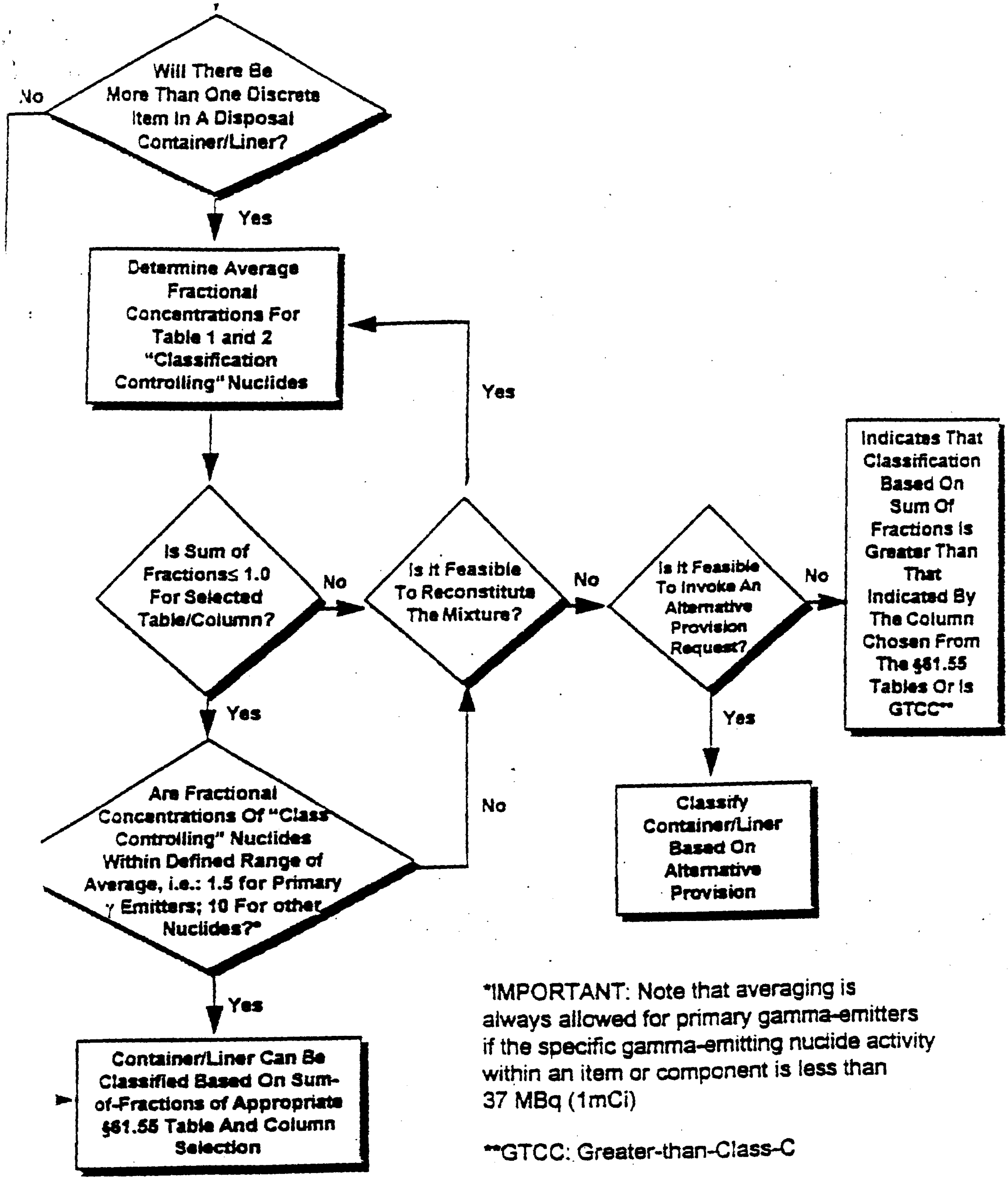


FIGURE 1. LOGIC DIAGRAM FOR CLASSIFYING WASTE COMPRISING ACTIVATED METAL OR COMPONENTS CONTAINING RADIOACTIVITY IN THEIR DESIGN.



*IMPORTANT: Note that averaging is always allowed for primary gamma-emitters if the specific gamma-emitting nuclide activity within an item or component is less than 37 MBq (1mCi)

**GTCC: Greater-than-Class-C

FIGURE 1. (Continued)

Example 3: A liner contains four local power range monitor (LPRM) strings. Note: In actual cases, liners could contain more than this number. Each string has a volume of 0.1 ft^3 (0.0028 m^3) and weighs 50 lbs (22.7 kg). The activity of the principal "classification-controlling" nuclides in each string are shown below (rounded), along with the nuclides concentration expressed as a fraction (frac) of the appropriate 10 CFR 61.55, Table 1 or Table 2, Column 3, concentration values.

	LPRM #1		LPRM #2		LPRM #3		LPRM #4		AVE.
Nuclide	Ci	frac	Ci	frac	Ci	frac	Ci	frac	
Nb-94	0.0004	0.71	0.0003	0.53	0.00035	0.62	0.0005	0.89	0.69
Ni-59	0.12	0.20	0.09	0.15	0.1	0.17	0.13	0.22	0.19
C-14	0.02	0.09	0.015	0.07	0.017	0.08	0.02	0.09	0.08
TABLE 1 TOTAL		1.00		0.75		0.87		1.2	0.96
Ni-63	18.0	0.92	13.5	0.69	15.75	0.81	22.0	1.12	0.89
TABLE 2 TOTAL		0.92		0.69		0.81		1.12	0.89

The strings need to be cut into three pieces for packaging, and this sectioning leads to essentially all of the activity being contained in a piece that has a volume of 0.017 ft^3 (0.00048 m^3) and weighs 8.5 lbs (3.9 kg).

It would be permissible to average the Nb-94 concentration over all four strings since no string contains more than 37 MBq (1 mCi) of Nb-94. Furthermore, all the concentrations of the individual strings are within a factor of 1.5 of the average concentration (i.e., 0.69 x 0.2 Ci/m^3 = 0.14 Ci/m^3). Likewise the concentrations of the other tabulated nuclides are within a factor of 10 of their average concentrations. If the strings were shipped as a whole, the waste would be classified as Class C, since the sum-of-the-Table 1 fractions is 0.96 and the Ni-63 concentration is less than (i.e., 0.89 times) the Class C limit of 7000 Ci/m^3. Although the cutting operation could increase concentrations in the "hottest" piece by about a factor of 6, this sectioning would not affect the classification of the waste since (1) the volume of the "hottest" piece is greater than

0.01 ft^3 (0.00028 m^3); (2) the largest Nb-94 activity in any piece, 0.5 mCi, is less than the 1 mCi value in Table A; (3) the activities of the other nuclides in the "hottest" piece are less than Table B values; and (4) all pieces of the sectioned string are placed in the same disposal container.

3.4 Contaminated materials

Contaminated materials typically involve components or metals on which radioactivity resides near the surface in a fixed or removable condition. Classification of individual items may be determined by representative swipes or radiation survey measurements from which the total activity of radionuclides may be estimated through the use of scaling factors. In these cases, the volume or weight of the contaminated item should be the total weight or displaced volume of the item (i.e., major void volumes subtracted from envelope volume).

Mixtures of contaminated materials in a disposal container are permissible. In these situations, the total activity of contained radionuclides may also be determined by representative swipes or radiation survey measurements of the container's contents. The volume or weight of the mixture should be the total weight or displaced volume of all the material contributing to the mixture.

In determining the classification of a mixture of contaminated materials, it is always permissible to conservatively base the mixture classification on the highest classification associated with any piece, section, or component within a disposal container. It is also permissible, under the following constraints, to average concentrations of the radionuclides listed in 10 CFR 61.55, Table 1 and Table 2, over contents of the disposal container. Again, because of the potential non-homogeneity of the waste, the classification of the combined waste may be affected by whether the contaminated waste contains the primary gamma-emitting nuclides (e.g., typically, Co-60 and Cs-137/Ba-137m). For the purpose of applying the guidance under these paragraphs, a component may be considered to be that portion of an original component that is placed in the disposal container being classified. Although components may be comprised of multiple sections or pieces to effectuate packaging, the component (not the pieces or sections thereof) is the discrete item to which this guidance applies.

In determining the classification of the container, one or more of the following paragraphs may apply.

3.4.1 Averaging involving primary gamma-emitters

For the purpose of classifying a mixture containing the primary gamma-emitters (typically Co-60 and/or Cs-137/Ba-137 contamination), for which these nuclides dictate the classification of the waste, their individual nuclide concentrations may be based on the volumetric-averaged concentration of the combined contaminated materials, provided that the concentrations associated with the individual items of the mixture in the disposal container are within a factor of 1.5 of the respective averaged concentration value for each nuclide. Averaging is always allowed for a primary gamma-emitting nuclide if its activity on a contaminated item is less than 37 MBq (1 mCi).

3.4.2 Averaging of sections or pieces of larger components containing the primary gamma-emitters

Individual sections of pieces of larger components that may result from operational considerations (e.g., packaging for transportation) should be considered as discrete items if:

(a) the volume of the piece or section is less than one-hundredth of a cubic foot (0.01 ft^3) or 0.00028 cubic meters (0.00028 m^3) -- such a piece will typically weigh less than 10 pounds (10 lbs) or 4.54 kilograms (4.54 kg), and

(b) the specific nuclide activity contaminating the material or component would be greater than the respective values shown in Table A.

3.4.3 Averaging involving radionuclides other than primary gamma-emitters

For the purpose of classifying a mixture, the concentrations of all the 10 CFR 61.55 tabulated radionuclides in the disposal container, other than the primary gamma-emitters, may be based on the volumetric- or weight-averaged concentrations of the combined materials. In this case, all the concentrations of the "classification-controlling" individual nuclides within all the contaminated items should be within a factor of 10 of their respective averages over all items in the mixture.

3.4.4 Averaging involving sections or pieces of larger contaminated items or components containing other than primary gamma-emitters

Individual sections or pieces of larger contaminated items or components in a disposal container that may result from operational considerations (e.g., packaging for transportation) should be considered as discrete items if the specific radionuclide activity on the contaminated piece or section exceeds the appropriate value in Table 8.

3.4.5 Mixtures containing multiple radionuclides

For contaminated components or metal containing combinations of tabulated nuclides, the sum-of-the-fractions rule described in 10 CFR 61.55(a)(7) would apply. This rule involves the summing of the fractions of the appropriate 10 CFR 61.55, Table 1 or 2 concentration values, as described in §§61.55(a)(7). The sum of-the-fractions rule could involve summing the fractions of the appropriate §61.55 Table 1 or Table 2 concentration values associated with the primary gamma-emitting nuclides and the fractions of tabulated concentrations associated with the other nuclides. The respective fractions contributing to the sum can be calculated using the "highest concentration" existing in any item within the mixture or, if applicable, the concentration determined using the "averaging" methods previously described.

Independent of the method chosen, in accordance with Section III of Appendix F to 10 CFR Part 20, the licensee classifying the mixture of contaminated materials must have in place a quality control program to ensure compliance with the waste classification provisions of 10 CFR 61.55. As part of this quality control program, if the classification of the mixture of contaminated materials is based on the volumetric- or weighted-averaged nuclide concentrations of the disposal container contents, as allowed above, the licensee responsible for classification of the waste should prepare, retain with manifest documentation, and have available for inspection, a record documenting the licensee's waste classification analyses. It is generally expected that this record or analyses, in and of itself, should be sufficient to show that the averaging of concentrations over all the contaminated material in a disposal container was undertaken under the provisions of this position.

3.5 Mixing of cartridge filters

The classification of cartridge filters should be based on the nuclide activity contained on the filter divided by the displaced volume (interstitial space within the filters may be included) or weight of the filter. Because of the typical distribution of activity within cartridge filters, the envelope volume would generally be expected to be an appropriate volume for determining filter classifications.

Mixing of multiple cartridge filters in a disposal container or liner is permissible. In determining the classification of the multiple filters, it is always permissible to conservatively base the classification on the highest classification associated with any single filter. It is also permissible, under the following constraints, to average the concentrations of radionuclides listed in 10 CFR 61.55, Table 1 and Table 2. Because of the potential non-homogeneity of the filters, the classification of the combined filters may be affected by whether the waste contains the primary gamma-emitting nuclides (typically, Co-60 or Cs-137/Ba-137m). However, the classification of many higher class cartridge filters could be controlled by C-14 or transuranic concentrations. In determining the classification of a container of filters, one or more of the following paragraphs may apply.

3.5.1 Averaging involving primary gamma-emitters

For the purpose of classifying multiple cartridge filters containing the primary gamma-emitters (i.e., if these nuclides dictate the classification of the waste), their individual nuclide concentrations may be based on the volumetric-averaged concentration of combined filters, provided that the concentrations within the individual filters of the mixture in the disposal container or liner are within a factor of 1.5 of the respective averaged concentration values of each nuclide. This factor of 1.5 does not apply if the classification of the combined filters, as a result of other nuclides, is higher than the class derived from the primary gamma-emitter concentrations.

3.5.2 Averaging involving radionuclides other than primary gamma-emitters

For the purpose of classifying multiple cartridge filters, the concentrations of all the 10 CFR 61.55 tabulated radionuclides in the disposal container or liner, other than the primary gamma-emitters, may be based on the volumetric- or weight-averaged concentrations of the combined materials. In this case, all the concentrations of the "classification-controlling" individual nuclides within all the individual filters should be within a factor of 10 of their respective averages over all filters in the mixture.

3.5.3 Mixtures containing multiple radionuclides

For cartridge filters containing combinations of tabulated nuclides, the sum-of-the-fractions rule described in 10 CFR 61.55(a)(7) would apply. For cartridge filters, this rule could involve summing the fractions of the appropriate 10 CFR 61.55, Table 1 or Table 2 concentration values associated with the primary gamma-emitting nuclides and the fractions of tabulated concentrations associated with the other nuclides. The respective fractions contributing to the sum can be calculated by using the "highest concentration" associated with any filter or, if applicable, the concentration determined by using the "averaging" methods described previously.

Independent of whether the "highest concentration" or "averaging" method is used to classify multiple filters in a disposal container/liner, in accordance with Section III of Appendix F to 10 CFR Part 20, the licensee classifying the mixture of filters must have in place a quality control program to ensure compliance with the waste classification provisions of 10 CFR 61.55. As part of this quality control program, if the classification of the mixture of filters is based on the volumetric- or weight-averaged nuclide concentrations of the disposal container/liner contents, as allowed above, the licensee responsible for classification of the waste should prepare, retain with manifest documentation, and have available for inspection, a record documenting the licensee's waste classification analyses. It is generally expected that this record or analysis, in and of itself, should be sufficient to show that the averaging of concentrations over all the contents in the disposal container/liner was undertaken under the provisions of this position.

3.5.4 Illustrative example

Example: A liner contains four cartridge filters. Note: In actual cases, more than this number could be contained in a liner. The filter volumes, weights, and principal "classification-controlling" nuclide activities are shown below (rounded), along with the nuclide's concentration expressed as a fraction (frac) of appropriate Table 1 concentration value. A Cs-137 concentration is also presented.

	Fuel Pool				Reactor Coolant			
	Filter #1		Filter #2		Filter #1		Filter #2	
Volume (m^3)	0.024		0.024		0.0127		0.0127	
(ft^3)	0.85		0.85		0.45		0.45	
Weight (kg)	9.08		9.08		4.09		4.09	
(lbs)	20		20		9		9	
Nuclide	Ci	frac	Ci	frac	Ci	frac	Ci	frac
C-14	0.01	0.052	0.009	0.047	0.005	0.05	0.002	0.02
Pu-241	0.008	0.25	0.007	0.22	0.01	0.71	0.004	0.28
Transuranic	0.0004	0.44	0.0003	0.33	0.0005	1.24	0.0002	0.49
10 CFR 61.55 Table 1 Total		0.74		0.60		2.00		0.79
Cs-137 =	$\frac{\text{concentration}}{1.5 \times 10^{-2}\ Ci/m^3}$		$\frac{\text{concentration}}{1 \times 10^{-3}\ Ci/m^3}$		$\frac{\text{concentration}}{1 \times 10^{-4}\ Ci/m^3}$		$\frac{\text{concentration}}{4 \times 10^{-2}\ Ci/m^3}$	

The Cs-137/Ba-137m activity in all the filters is sufficiently small such that the classification of the filters will not be determined by this gamma-emitting nuclide. Similarly, other nuclides to which 10 CFR 61.55, Table 2 values may apply have not been listed since their values will not affect cartridge filter classification. Thus, the four filters listed could be placed in a single disposal container/liner, since all the listed nuclide concentrations are within an order of magnitude of the averaged concentrations. The sum-of-the-fractions for the three nuclides would be: C-14, (0.04) + Pu-241, (0.32) + Transuranic (TRU), (0.53) = 0.89, indicating that the multiple filters could be classified as Class C waste.

3.6 Waste in high-integrity containers (HICs)

In the case of cartridge filters or other discrete item waste stabilized by emplacement within HICs, the volume or weight used to determine waste classification should be calculated over the displaced volume (interstitial space within the filters may be included - envelope volume may be appropriate) or weight of the cartridge filter or discrete item itself, rather than the gross volume or weight of the container. Similarly, the volume and mass considered for purposes of waste classification of dewatered ion-exchange resins, filter backwashes, and filter media placed into HICs should be the volume and mass of the contained waste. In both these cases, disposal in a HIC is not considered to alter the as-buried concentrations of radioactivity.

3.7 Encapsulation of solid material

For routine wastes such as filters, filter cartridges, or sealed sources centered in an encapsulated mass, classification may be based on the overall volume of the final solidified mass, provided that: (1) the volume and attributes of the encapsulated waste comply with the constraints established in Appendix C of this technical position; (2) the solidified mass meets the waste form structural stability criteria of 10 CFR 61.56 for Class B and Class C waste; and (3) the disposal unit containing the encapsulated mass is segregated from disposal units containing Class A wastes, that do not meet the structural stability requirements in 10 CFR 61.56(b). Under the above provisions, additional protection is provided through the shielding, lack of dispersibility, or identifiability of the encapsulated mass and, for Class C encapsulated waste, by the land disposal facility operational requirements in 10 CFR 61.52(a)(2). This additional protection has been considered in the classification position developed in Appendix C and has been balanced against the hypothetical radiological impact caused by potential interactions between assumed intruders and the encapsulated mass.

3.8 Mixing of dissimilar waste streams (different waste types)

Classifications may also be required for situations involving a mixture of miscellaneous waste materials -- e.g., situations in which contaminated valves, piping, or similar components are placed in containers mixed with other trash; or miscellaneous trash or components are mixed with other radioactive materials such as resins or filters. In such cases, because of potential differences in waste interactions with the disposal environment, waste classification involving averaging the total activity over the total volume or mass of the waste in the container would be accepted, if the classification of the mixture is not lower than the highest waste classification of any individual components of the mixture. This provision does not apply to small concentrated microcurie sources (<3.7 MBq (100 μCi)) of waste such as check sources or gauges that may be mixed with contaminated trash waste streams. The activity of such check sources or gauges may be averaged over the trash volume. Other classification practices may be determined to be acceptable under the "Alternative provisions" paragraph that follows.

3.9 Alternative provisions

Under 10 CFR 61.58, the Commission, on request, may authorize other provisions for the classification and characteristics of waste on a specific basis if, after evaluation of the specific characteristics of the waste, disposal site and method of disposal, it finds reasonable assurance of compliance with the performance objectives in Subpart C of 10 CFR Part 61.

Alternatives to the determination of radionuclide concentrations for waste classification purposes, other than those defined in this technical position, may be considered acceptable. For example, the physical form of certain discrete wastes (e.g., activated metals) may be such that intruder exposure scenarios, other than those used to establish the values in Tables 1 and 2 of 10 CFR 61.55, may be appropriate. A case in point could be the disposal of a large intact activated component filled with a structurally stable medium (e.g., cement), or enclosed in a massive robust container capable of meeting structural stability requirements. A request that demonstrates, with reasonable assurance, that the performance objectives in Subpart C of 10 CFR Part 61 are met, may be used to justify that the waste is acceptable for near-surface disposal. Alternatives would require the approval of, or otherwise be authorized by, the NRC or Agreement State regulatory agency. In some cases (e.g., if the approaches in this technical position had been incorporated as disposal facility license conditions), the disposal facility may need to apply for a license amendment from the NRC or Agreement State regulatory agency, to incorporate the alternative provision into its license.

Table C provides a summary of the primary aspects of the aforementioned guidance.

Table C

Volumes and Masses for Determination of Concentration

Waste Type	Allowable Classification Volume or Mass
Contaminated trash or soil	Reasonable fill volume of container/mass of waste (<10% void)*
Absorbed liquids	Volume/mass of liquid before absorption
Solidified liquids	Volume/mass of solidified mass
Solidified ion-exchange resins	Volume/mass of solidified mass**
Dewatered ion-exchange resins in HICs or liners	Displaced (bulk) volume (interstitial space may be included)/dewatered mass of ion-exchange resins
Filter cartridges in HICs or liners	Displaced volume (interstitial volume may be included) or envelope volume/mass of filters*
Activated components, components containing radioactivity in their design, or contaminated materials	Full density volume/(major void volumes subtracted from envelope volume)/ mass of components*
Encapsulated filter cartridges or sealed sources	Volume/mass of solidified mass when encapsulated in accordance with the guidance provided in Appendix C in this expansion of the technical position

* Mixtures of waste streams subject to additional guidance defined in text.

** If homogeneity maintained in solidified mass.

* * * * * *

APPENDIX C

POSITION ON ENCAPSULATION OF SEALED SOURCES AND OTHER SOLID LOW-LEVEL RADIOACTIVE WASTES

Encapsulation can mitigate dispersion of waste and can also provide additional shielding to limit external radiation fields. If provided to meet the stability criteria of 10 CFR 61.56(b) and coupled with the technical requirements for land disposal facilities in subpart D of 10 CFR Part 61 (specifically, 10 CFR 61.52), encapsulation will limit the impacts from both: (1) the direct exposure, inhalation, and ingestion pathways associated with potential intruder-waste interactions; and (2) the potential exposure pathways, to individual members of the public, involving groundwater and agricultural products.

The amount of credit allowed for encapsulation, though, needs to be limited so that extreme measures cannot be taken solely for the purposes of dilution. To be consistent with the U.S. Nuclear Regulatory Commission's policy on volume reduction and to limit extremely large "point sources" of radioactivity in the disposal site, generally acceptable values for minimum and maximum encapsulated waste volumes and masses, nuclide activities, and radiation levels are established.

These generally acceptable bounding conditions are as follows:

(1) A <u>minimum</u> solidified volume or mass for encapsulation should be that which can reasonably be expected to increase the difficulty of an inadvertent intruder moving the waste by hand, following the loss of institutional control over the disposal site. This minimum size or weight should preclude any significant movement without the assistance of mechanical equipment.

(2) A <u>maximum</u> solidified volume or mass for encapsulation of a single discrete source (from which concentrations are determined) should be 0.2 m^3 or 500 Kg (typical 55-gallon drum). Larger volumes and masses may be used for encapsulation of single sources but, in general, unless a specific rationale is provided, no credit beyond the volume or mass indicated should be considered when determining waste concentrations. Encapsulation of multiple sources (e.g., filters) in larger volumes may be considered acceptable under the Alternative provisions paragraph.

Note: The bounding volumes and weights in (1) and (2) will ensure that the potential radiological impacts from encapsulated, single discrete source disposals are within the envelope of impacts that would be calculated if the radioactivity were homogeneously distributed throughout the encapsulating media.

(3) A maximum amount of gamma-emitting radioactivity (e.g., Cs-137/Ba-137m, Nb-94) or radioactive material generally acceptable for encapsulation is that which, if credit is taken for a 500-year decay period, would result in a dose rate of less than 0.2 µSv/hr (0.02 mrem/hr) on the surface of the encapsulating media (refer to footnote 1, following page). The

calculation to determine compliance with this criterion may consider the minimum attenuation factor provided by the shielding properties of the encapsulating media but, in general, this factor should not exceed an attenuation factor that would be provided by 15 inches of concrete encapsulating material (refer to footnote 2). Furthermore, the maximum Cs-137/Ba-137m gamma-emitting generally acceptable for encapsulation in a single disposal container is 1.1 TBq (30 Ci) (refer to footnote 3 below).

(4) A maximum amount of any radionuclide that should be encapsulated in a single disposal container intended for disposal at a commercial low-level waste disposal facility is that which, when averaged over the waste and the encapsulating media, does not exceed the maximum concentration limits for Class C waste, as defined in Tables 1 and 2 of 10 CFR 61.55 (refer to footnote 4, below).

(5) In all cases when a discrete source of radioactive solid waste is encapsulated, written procedures should be established to ensure that the radiation source(s) is reasonably centered within the encapsulating medium.

Footnotes

1. Presuming the inadvertent intruder has contact with the encapsulated waste as generally defined in the intruder-agricultural scenario (reference NUREG-0945), this dose rate would result in an annual exposure of less than one-tenth of that which would be received if the radioactivity were homogenized over a soil volume equivalent to the encapsulating medium. This factor of 10 takes into consideration the possibility that the intruder may be exposed to both: (1) other encapsulated waste that may be excavated from the disposal trenches without mixing with uncontaminated cover material, and (2) other homogenized waste.

2. The 15 inches of concrete shielding is that necessary to ensure that an encapsulated 1.1 TBq (30 Ci) source of Cs-137/Ba-137m could satisfy the 0.2μSv/hr (0.02 mrem/hr) dose criteria. Additional shielding thicknesses from the encapsulating or disposal unit materials could be expected to be in existence after 500 years, but because of uncertainties about shielding orientations and effectiveness after this time period, no greater credit is considered generally appropriate. Furthermore, absent any shielding, intruder doses would still be expected to be similar to doses that would be received from homogeneous waste at concentrations permitted in 10 CFR 61.55.

3. The 1.1 TBq (30 Ci) for Cs-137/Ba-137m results from the application of the dose rate and shielding criteria in bounding condition 3.

4. Reasserting the applicability of Tables 1 and 2 of 10 CFR 61.55 emphasizes that, for alpha- or beta-emitting radionuclides, encapsulation under bounding conditions 1 through 3 does <u>not</u> provide an exemption to the classification tables in the regulations. As a result, the largest activity of a transuranic nuclide, other than Pu-241 and Cm-242, that is

generally acceptable for encapsulation in 0.2 m^3 is about 1.1 GBq (30 mCi), presuming the density of the encapsulating mass is 1.3 g/cm^3. For determining mass-based concentrations, it is generally acceptable to take credit for the actual density of the material, if the density is less than 2.5 g/cm^3.

ANALYSIS OF AND RESPONSE TO COMMENTS ON "CONCENTRATION AVERAGING AND ENCAPSULATION TECHNICAL POSITION" Revision Issued on September 16, 1993

On September 22, 1993, the Nuclear Regulatory Commission noticed in the Federal Register the availability of a proposed revision to the staff technical position on concentration averaging and encapsulation for low-level waste intended for licensed land disposal facility (58 FR 49333). The revision represented a modification and expansion of an earlier proposal that was noticed in the Federal Register on June 22, 1992 (57 FR 29105) and was developed after considering the comments received on this initial proposal. Comments on the revision were again solicited and, in response, 13 comment letters were received. These responses included four from nuclear utilities and one from their association, the Edison Electric Institute (EEI), one from a citizens group, one from a disposal facility operator, two from State health association, one from a firm in the waste classification field, and two from the U.S. Department of Energy (one stating that their comments would not be developed before the requested date). These letters raised a number of issues ranging from general policy concerns to specific comments on how the position cold be structured to facilitate its use.

1. COMMENT: A general policy comment raised by the utility commenters, the EEI, the trade association, and the Department of Energy, was that the limitation on averaging, defined in the position, are not justified within the contest of the regulations in 10 CFR Part 61. This opinion was also expressed by commenters on the initial June 22, 1992 proposal. These commenters stated that the averaging positions are arbitrary, do not have a health and safety basis, would increase costs and occupational exposures, would require changes in current practices, and would result in higher waste classifications. The commenters believed that the concentration values tabulated in the regulations, through which waste classifications are determined in the regulations, through which waste classification are determined, were derived in a manner that conservatively considered waste concentrations over a disposal trench. As a result, these commenters believed that classification based on averaging of waste activity over the contents of a waste package should be allowed. Further, the DOE stated their belief that, although the Part 61 performance objectives call in a general way for protection of the inadvertent intruder, the intruder was never the driving force behind the Part 61 rule. The DOE comments suggested that, in the Part 61 Environmental Impact Statement (EIS), the NRC determined that it would be ludicrous to assume that an inadvertent intruder would construct houses among excavated, structurally stable wastes. As a result, an "intruder-discovery" scenario was postulated.

The comments from the citizens group stated an opposite view in that it found the position unacceptable because the position would allow greater-than-Class C (GTCC) waste to be classified as Class C waste. The comments from the Department of Health also expressed concern that GTCC waste could be disposed of in a near-surface low-level waste facility, and suggested that there not be a movement of waste from one class to another. The comments from the Department of Environmental Conservation expressed support for the explanation on waste classification, but pointed out that its State regulations are more restrictive than the guidance with regard to absorbed liquids.

RESPONSE: A response to these general policy comments was attempted in the "Analysis Of and Response To Comments" that was appended to the September 16, 1993 reissued position. The staff does not take issue with the scenarios in the EIS, as described by DOE. The assessment of radiological impacts in the EIS, as described by DOE. The assessment of radiological impacts in the EIS did indeed consider a broad range of scenarios, and the development of the technical position followed a similar approach in defining the concentration averaging and encapsulation positions for "discrete" wastes that were not addressed in detail in the EIS. The staff believes that discussions in the final EIS, for example in Section 5.3.5, suggest that the NRC recognized the need for further classification guidance and/or site inventory constraints, when specific disposal sites and the composition of specific waste streams were being considered.

Notwithstanding this basis, the staff also emphasized two other major points in the September reissuance of the technical position: (1) the technical position reflects a subset of practices that are generally considered acceptable under the envelope of safety defined in the EIS, and (2) the practices defined in the position were intended to represent a subset of those likely to be generally accepted by the Agreement States. To accomplish this latter purpose, the staff has developed the technical position in cooperation with the E-5 Committee on Radioactive Waste Management of the Conference of Radiation Control Program Directors (CRCPD). Although the objective is to facilitate consistent practices on a national basis, the staff recognized that variances could occur. On this point, it should be noted that the EIS indicates that within the context of the classification provisions stated in the regulations, Agreement States have imposed waste acceptance criteria on their sites that vary from the positions assumed in the EIS. And, as the Department of Environmental Conservation commenter indicated, some minor differences between the guidance presented in the technical position and State regulation and guidance could occur.

On a more technical basis, the material in the Appendix is provided to further describe the rationale used to develop the criteria in the technical position. In all cases, the approach taken was based on demonstrating compliance with the intruder dose criterion that was used to generate the tabulated concentration values in the regulations. Thus, in response to the comments from the citizens group and the Department of Health, the staff believes that the averaging practices specified in the position always result in a waste classification that is at least as high, if not higher, than that indicated by the concentration tables in the regulations, based on the average concentrations over a disposal container (or waste Package).

2. COMMENT: Several commenters stated their belief that the position was unjustifiable complex in considering the averaging of the primary gamma-emitters (i.e., Co-60, Nb-94, and Cs-137) vis-a-vis the other nuclides tabulated in the regulations. The inclusion of activity ranges, minimum activity, and size criteria were cited as typical examples of these complexities. These commenters believed that the complexities were especially unwarranted, given the fact that the position carries on authority with the Agreement States. The citizens group commenter suggested a simpler approach through which the waste classification of a mixture of components would not be

lower than the highest waste classification of any individual component of the mixture.

RESPONSE: For those desiring to take advantage of certain acceptable concentration averaging positions (typically, those involving discrete activated materials or metals, or contaminated items), the technical position could be considered complex. Much of the current complexity, when compared to the originally proposed June 26, 1992 position, is associated with the classification of pieces of larger components. The staff decided to address these cases based on the recommendations received from some of these commenters on the initial version of the technical position. The need to differentiate between primary gamma-emitters and the other nuclides, listed in the tables in §61.55, results from the fact that the averaging positions in the technical position address "discrete" wastes within the envelope of safety defined in the EIS for wastes that were assumed to be indistinguishable from soil at the time the intruder was presumed to interact with the waste. The foundation for the practices defined in the technical position in based on ensuring compliance with the performance objectives in the regulations (most specifically §61.42). The appendix material has been provided to indicate the rationale and assumptions behind the exposure scenarios used to achieve this demonstration of compliance.

As discussed in response to the first comment, the staff recognizes that the Agreement States and Compacts are not required to accept NRC's concentration averaging positions as expressed through guidance documents (including those positions that define the breakpoint between what constitutes waste for which the States are responsible for disposal (i.e., Class C or less) and that waste for which disposal responsibility rests with the Federal government (i.e., GTCC waste)); however, the staff believes that approaching nationwide conformity sufficient to carry out the directives contained in the Low-Level Radioactive Waste Policy Amendment Act of 1985 (P>L> 99-240), is best achieved by defining a subset of acceptable concentration averaging and encapsulation practices in cooperation with State regulatory authorities through the CRCPD.

CLARIFICATIONS INCORPORATED AS A RESULT OF COMMENTERS' SUGGESTIONS

As a result of commenters' suggestions, the following clarification and editorial changes have been made to the final technical position: (1) a numbered index system has been included to assist the reader in keeping track of the specific waste type for which averaging guidance is being provided; (2) consistent terminology is used in referring to "discrete" items and "primary gamma-emitters"; (3) it has been clarified that the record of analyses which documents the licensee's use of concentration averaging and encapsulation practices defined in this technical position, should generally be sufficient, in and of itself, to show that the averaging of concentrations was not undertaken solely to lower the classification of any specific waste in a disposal container; (4) a statement has been added to the introduction to the technical position indicating that it is intended that the "Alternative provisions" paragraph in the position could be used, if necessary, to preclude the need to reclassify waste material packaged and classified prior to the issuance of this position, if the waste was classified in accordance with accepted practices at the time of packaging, provided that disposal of such waste can be conducted safely and in accordance with 10 CFR 61; (5) a statement has been added to indicate that, because of the typical distribution of activity within cartridge filters, (including the fact that higher classifications are determined over the weight of the waste), the filter's envelope volume can be used to calculate volumetric concentrations; and (6) it has been further clarified in Appendix C that the specified maximum solidified volume or mass for encapsulation is principally directed at radioactive material in a single discrete source. Averaging of the summed activity of a number of discrete sources solidified in a larger volume or mass than that associated with a 55 gallon drum may be determined to be acceptable under the provisions described in the "Alternative provisions" paragraph.

<u>COMMENTS NOT ADDRESSED IN THE TECHNICAL POSITION</u>

3. <u>COMMENT</u>: Several commenters raised issues that were judged to be outside the scope of the technical position or made suggestions that were not incorporated into the technical position. The citizen group commenter, for instance, suggested that NRC should reconsider the waste classification scheme in 10 CFR Part 20. Along similar lines, the DOE commented that the classification limits for some nuclides important to classifying metals (e.g., Ni-59 and Ni-63) were calculated using older ingestion dose calculational methods that are very conservative compared to current methods.

<u>RESPONSE</u>: The technical position has been developed to be consistent with existing regulations (i.e., the staff's intent was to define concentration averaging and encapsulation practices that are consistent with the underlying rationale expressed in the EIS supporting the Part 61 rulemaking). In response to a recent petition for rulemaking (59 <u>FR</u> 17052, April 11, 1994), the NRC provided the rationale for deciding that the change to the public dose limits did not require reconsideration of the waste classification scheme.

4. <u>COMMENT</u>: On matters more specifically directed at the details of the position, two commenters suggested that further clarification was needed on what constitutes a "homogeneous" waste type. One commenter suggested that the term, which refers to the distribution of activity over a waste type, be replaced by the phrase, "volume distributed". The other commenter suggested that a specific listing of waste types be provided that could be considered "homogeneous".

<u>RESPONSE</u>: The terminology, "homogeneous for purposes of waste classification", is defined in the introductory discussion in paragraph C.3. Within the context of this definition, the staff believes that either term of reference could have been used. In most cases, specification of a "waste type" (e.g., activated metal) should be sufficient to establish whether a waste can be considered "homogeneous" for purposes of waste classification, and the technical position provides several examples of homogeneous waste types. Some waste types, however, such as cartridge filters, could conceivably be considered either "discrete" or "homogeneous" depending on specific cartridge filter characteristics expected within the disposal environment at the time interaction with the intruder is presumed. Treatment as a homogeneous waste type would generally be expected.

5. COMMENT: The citizens group commenter observed that a statement in the revised position indicated that the position had been expanded to address current practices and questioned whether the practices included in the position were being judged to be acceptable simply because they were currently accepted.

RESPONSE: As discussed previously, and in the analysis of and response to comments on the June 22, 1992 proposal, the acceptability of a concentration averaging or encapsulation practice has been judged on the basis that the practice does not compromise the §61.42 performance objective for protection of individuals from inadvertent intrusion. The staff believes that appropriately conservative hypothetical exposure scenarios have been used in making this determination.

6. COMMENT: A few commenters believed the position should define acceptable concentration averaging positions for large activated metal pieces.

RESPONSE: Because the specifics pertaining to volumes, activities, and activity distributions can be important to the acceptability of a specific averaging practice, the staff believes that these cases should be considered through the "Alternative provisions" paragraph of the position.

7. COMMENT: A number of commenters stated that the position would force all cartridge filters in a container to be individually characterized and classified, leading to unnecessary occupational exposures an costs.

RESPONSE: The staff believes that the position does not dictate such an approach. Under the "General Criteria" in paragraph C.1 in the unrevised part of the Technical Position on Waste Classification, dated May 11, 1983, a number of acceptable methods were described for determining concentrations for classification purposes. The staff believes that knowledge regarding the activity on individual filters can be used to estimate concentrations of nuclides for classification purposes and that such methods are already used to comply with the "manifesting" provisions of the regulations.

BASES FOR CONCENTRATION AVERAGING AND ENCAPSULATION GUIDANCE FOR CLASSIFICATION OF DISCRETE (HETEROGENEOUS) WASTES REFLECTED IN REVISED BRANCH TECHNICAL POSITION

Background

In the environmental impact statement (EIS) supporting the promulgation of 10 CFR Part 61, the concentration values that appear in Tables 1 and 2 of §61.55 were based on potential exposures to inadvertent intruders. The intruder dose calculations included a scenario which presumed that the intruder took up residence on a closed disposal site and exhumed waste from its disposed location. This exhumed waste was assumed to be indistinguishable from soil and, as a result, the intruder was conservatively assumed to be unaware of his/her interaction with previously disposed radioactive waste.

The scenario, however, did recognize that, as the intruder exhumed the waste, the contaminated soils containing varying types and concentrations of radioactive contamination were likely to be thoroughly "homogenized". Furthermore, the homogenized waste would be mixed with clean interstitial and cover material. In effect, the "as disposed" concentration of radioactive material was assumed to be typically reduced by a factor of 8. In addition, in considering the postulated exhuming of Class C waste, it was recognized that this waste would not only be difficult to contact, even after 500 years, but in the postulated exhumation process, would also likely be mixed with lower activity waste streams. These considerations resulted in the application of a factor of 10 reduction to the projected intruder doses from Class C wastes.

Technical Position Bases For Concentration Averaging of Discrete (Heterogeneous) Waste

A major intent of the revised Technical Position on Concentration Averaging and Encapsulation is to define positions for the disposal of discrete wastes or mixtures of such wastes that fall within the "envelope of safety" defined in the EIS. The primary consideration in this effort was to ensure that potential exposures to the "contaminated soil" waste exhumed in the EIS scenario would be equivalent to potential exposures from the postulated exhuming of discrete wastes. Four specific discrete waste forms were addressed: (1) encapsulated sealed sources, (2) neutron-activated materials or metals, or components incorporating radioactive material into their designs, (3) contaminated materials, and (4) cartridge filters. These waste forms were further subdivided to consider the specific nuclides identified in the 10 CFR 61.55 tables: (1) the primary gamma-emitters (Co-60, Nb-94, and Cs-137/Ba-137m), and (2) other nuclides. This latter subdivision was considered because "hot spots" of gamma activity may be more significant to potential intruder doses than "hot spots" associated with the other nuclides.

Disposal of gamma-emitting sealed sources

The implicit dose criterion for the primary gamma-emitting nuclides, from

Enclosure 2

which the Table 1 and 2 concentration values of §61.55 are derived, is 500 mrem/year. This is the projected dose that an intruder would be calculated to receive if waste were exhumed and dispersed according to the EIS intruder-agricultural scenario. For example, assuming the nuclide of interest is Cs-137, the EIS methodology would presume that waste initially containing Cs-137 at the Class C upper bound concentration of 4600 Ci/m^3 could be exhumed and dispersed five hundred years after LLW site closure. Considering the scenario concentration reduction factors and radioactive decay, the intruder is presumed to be exposed to an infinite half-plane source of Cs-137 at a concentration of about 540 pCi/cm^3 or 340 pCi/g; that is,

4600 Ci/m^3 x 10^6 $pCi/cm^3/Ci/m^3$ x (9.4×10^{-6} decay factor) x (0.125 interstitial and cover mixing factor) x (10^{-1} intrusion likelihood and mixing factor with lower activity waste) = 540 pCi/cm^3 or 340 pCi/g @ 1.6g/cm^3.

An intruder exposed to this infinite half-plane source would receive a dose of about 500 mrem in a year presuming a scenario-equivalent unshielded exposure of about 2360 hours/year.

The encapsulation policy is based on two principal considerations: (1) At 500 years, the sealed (point) source (unencapsulated) should not reasonably result in a dose of 500 mrem/year, even if scenarios other than intruder-agricultural (e.g., handling) are considered, and (2) If the source is exhumed in its encapsulated state, the intruder should not receive an exposure greater than 500 mrem/year, recognizing that the intruder could be exposed to other exhumed waste or other sealed sources.

Application of the first consideration required the definition of an appropriate exposure scenario. The scenario chosen presumes that intruder interaction with the source can be reasonably bounded by evaluating exposure at one meter for a period of 2360 hours/year. This scenario, although more conservative than the pathways evaluated in the intruder-agricultural scenario, is considered a reasonable surrogate to conservatively address the potential for a wide range of potential "handling" scenarios. Application of these scenario assumptions, with the 500 mrem/yr dose criterion, results in the determination that a Cs-137 source of about 650 μCi could potentially be available to the intruder, 500 years after disposal. This is equivalent to a 65 Ci source at time of disposal.

To conservatively address the second consideration, a criterion of 50 mrem/year or 0.02 mrem/hr for 2360 hours was conservatively assigned to the surface of the encapsulated sealed source. This factor of 10 reduction in the dose criterion, and the point of measurement, were incorporated into the analysis to account for the fact that the intruder could be exposed through other than the intruder-agricultural scenario, and to additional exhumed waste containing the same radionuclide. In this case, however, it was considered reasonable to take credit for the shielding (but not the structural integrity) of the encapsulating material (approximately 15 inches that would be available from encapsulations in a 55 gallon drum). For shielding purposes, this is the largest amount of shielding that is presumed to be effective, 500 years after disposal. Under these constraints, the second criterion would allow the activity of an encapsulated Cs-137 source to be about 300 μCi at 500 years or 30 Ci at the time of disposal.

Since both the above considerations led to approximately the same source activity constraint, and no practical reason could be put forward to justify selection of the somewhat higher criterion, the technical position includes a 30 Ci bound on the activity of a Cs-137 sealed source, that can be encapsulated and disposed of as Class C waste in a near-surface disposal facility. If applied to a point source of Nb-94, the activity constraint both at disposal and at 500 years would be about 40 μCi.

<u>Disposal of alpha/beta emitting sealed sources</u>

When considering potential exposures from the postulated exhumation of alpha or beta emitting nuclides, the controlling scenarios would typically involve either ingestion or inhalation of these nuclides by the intruder. These scenarios, in turn, involve consideration of nuclide concentrations over large soil areas since the intruder must either breathe resuspended material or ingest material from contaminated foodstuffs. Both of these pathways have little dependency on localized hotspots as long as the average concentration over a large area is unaffected. Thus, if these pathways were the only consideration, encapsulation of alpha or beta-emitting sealed sources could be allowed over any reasonable disposed volume or, to a more limited degree, mass, that allowed compliance with the tabulated §61.55 concentration values. However, §61.41 also requires protection of the general population, and in the EIS, assumptions were made on the total sealed source activity disposed of at a disposal site. Furthermore, the inventory of alpha or beta-emitting sealed sources was also constrained by those source activities, that when averaged over the weight or volume of the encapsulated source in a 55 gallon drum, would lead to concentrations acceptable under the §61.55 concentration criteria. The revised Technical Position continues to reflect this limitation.

<u>Disposal of primary gamma-emitters in activated materials or metals, or components incorporating radioactivity into their design</u>

The guidance on these items evolves from the "sealed source" position. The possibility of exhumation at 500 years of sealed sources with activities typically ranging from 40 to 300 μCi was discussed above. If the same gamma-emitting activity were exhumed in the form of discrete activated materials or metals, or components incorporating radioactivity in their design, it would be highly unlikely that the hypothetical intruder would receive a dose greater than that calculated from the sealed sources because of the typical distribution of the activity over larger volumes and in materials that may exhibit a degree of self-shielding. Although these "dose reduction" aspects can not be generically quantified, when coupled with the conservative nature of the intruder-sealed source scenarios and dose constraints, it was considered reasonable to always allow 1 mCi of gamma emitting nuclide in any exhumed piece of discrete waste as long as the activity of the nuclide when averaged over the waste volume in the disposal container containing the discrete waste, complies with the appropriate §61.55 concentration value.

The rationale in the preceding paragraph is also used to construct Table A in the Position which applies to situations in which larger components require sectioning as a result of operational considerations. The Table defines gamma-emitting activity levels in individual sections or pieces of larger components that, if not large enough to be treated as other than a sealed source (a piece with a volume less than 0.01 ft^3), should be individually considered when determining waste classifications. Essentially, the tabulated values assure that, either 100 years after disposal of Class A and B waste or 500 years after disposal of Class C waste, an intruder would not interact with more than 1 mCi of gamma-emitting activity in activated material or metal or in a component containing this radioactivity in its design.

Finally, since sealed sources, activated materials or metals, or components containing radioactivity in their design may be disposed of in the same disposal container with other waste of similar type containing the same gamma-emitting nuclide, acceptable concentration averaging guidance is included for these situations. One can always classify the disposal container based on the highest classification of any specific waste of a particular type contained in the container. However, if averaging is employed, the concentration of the the primary gamma-emitting nuclides in all discrete items in the disposal container is always considered acceptable if the concentrations in all the discrete items in the container are within a factor of 1.5 of the average concentration of the nuclide over all waste in the container. This factor of 1.5 precludes "hot spots" in gamma-emitting waste from significantly affecting projected intruder doses irrespective of whether the intruder is exposed through the intruder-agricultural scenario or through direct interactions with discrete waste (e.g.,handling scenarios). For example, in 5.6m^3 of containerized waste, 2.24m^3 could contain 0.3 Ci/m^3 of Nb-94 if the remaining waste contained Nb-94 at a concentration of 0.133 Ci/m^3. If the higher activity piece(s) were all exhumed and assumed to be at the surface of the disposal facility, the dose rate at 1 meter from the center of these piece(s) would be about 6 mrem/hr (e.g., assuming a circular piece with a radius of 3.34m and a thickness of 0.0635m (e.g., a piece of steel plate)). Considering an appropriate discovery or construction scenarios as described in the Environmental Impact Statement supporting 10 CFR Part 61, a projected dose to an intruder would not be expected to exceed 500 mrem/year.

Disposal of alpha/beta emitters (nuclides other than primary gamma-emitters) in activated materials or metals, or components incorporating radioactivity in their design

The guidance on activity, other than the primary gamma-emitters, in these items also reflects the "sealed source" position described above. In this case, the Position defines a "mixing" constraint that is within the context of the general waste classification rationale expressed in the documentation that supported the Part 61 regulation. In defining this constraint, it was noted that the §61.55 concentration values that delineate the boundaries between different waste classes (i.e.,A, B, C, and GTCC) typically differ by more than one order of magnitude. Also, as noted previously, the potential dose to an intruder from alpha/beta activity, or the small quantities of gamma activity associated with nuclides other than Co-60, Nb-94, and Cs-137/Ba-137m, is essentially independent of localized "hot spots". As a result, the guidance in the Position allows concentration averaging of the alpha/beta emitting activity in individual items if all the concentrations in the individual items within a disposal container are within a factor of 10 of the average concentration over all items in the container.

The rationale in the preceding paragraph is used to construct Table B in the Position which applies to situations in which larger components require sectioning as a result of operational considerations. Since any potential intruder dose is essentially independent of alpha/beta (or non-primary gamma-emitter) "hot spots", the numerical values in the table reflect the maximum activity that would be allowed if the activity was contained in a sealed source, and a minimum volume criterion is not necessary.

Other Discrete Waste Types

The guidance in the Position for other discrete waste types (i.e., contaminated materials and cartridge filters) follows the rationale discussed above.

Alternative Provisions

Since the Position is not intended to provide guidance on all conceivable concentration averaging methods, the "Alternative provisions" paragraph is a critical feature in the Position. This paragraph indicates that other concentration averaging positions can be considered acceptable if it can be demonstrated with reasonable assurance that their application will not compromise any of the performance objectives in Subpart C of 10 CFR Part 61.

POLICY ISSUE
(Notation Vote)

April 7, 2010 SECY-10-0043

FOR: The Commissioners

FROM: R. W. Borchardt
Executive Director for Operations

SUBJECT: BLENDING OF LOW-LEVEL RADIOACTIVE WASTE

PURPOSE:

To provide the Commission with the results of the staff's analysis of issues associated with the blending of low-level radioactive waste (LLRW), as directed in Chairman Jaczko's October 8, 2009, memorandum to the staff. The closure of the Barnwell waste disposal facility to most U.S. generators of Class B and C LLRW has caused industry to examine methods for reducing the amount of these wastes, including the blending of some types of Class B and C waste with similar Class A wastes to produce a Class A mixture that can be disposed of at a currently licensed facility. This paper identifies policy, safety, and regulatory issues associated with LLRW blending, provides options for a U. S. Nuclear Regulatory Commission (NRC) blending position, and makes a recommendation for a future blending policy. This paper does not address any new commitments.

SUMMARY:

In this paper, the staff examines the blending or mixing of LLRW with higher concentrations of radionuclides with LLRW with lower concentrations of radionuclides to form a final homogeneous mixture. While recognizing that some mixing of waste is unavoidable, and may even be necessary and appropriate for efficiency or dose reduction purposes, NRC has historically discouraged mixing LLRW to lower the classification of waste in other circumstances.

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With the closure of the Barnwell LLRW disposal facility on June 30, 2008, to most U.S. generators of Class B and C wastes, licensees and industry are exploring blending higher concentration wastes with lower concentration wastes to produce a final mixture of Class A waste. Such mixing could promote the goal of disposal of waste, rather than its storage onsite, since Class A waste can be disposed of at a currently operating disposal facility. The agency's previous policies and positions on blending of LLRW are evaluated in this paper in light of these new circumstances, and options for new agency positions on blending are provided for Commission consideration. The assumption that blending is *a priori* undesirable is examined in light of risk-informed, performance-based regulation that focuses on the safety hazard of blending and the blended materials. Other alternatives for a blending position are also considered, including several that would impose additional constraints. The Enclosure is a detailed analysis of blending of LLRW. Section 4.0 of the Enclosure addresses the specific topics contained in the Chairman's October 9, 2009, memorandum.

The staff believes that the current LLRW blending guidance would be improved if it were risk-informed and performance-based, consistent with NRC's overall policy for regulation. This change could be accomplished in part through revisions to two guidance documents, the Branch Technical Position on Concentration Averaging and Encapsulation[1] (CA BTP) and the Commission's Policy Statement on Low-Level Waste Volume Reduction (Policy Statement).[2] In addition, the staff would clarify that large quantities of blended waste are considered a unique waste stream and included in NRC's ongoing rulemaking on this topic. These changes would ensure continued safety by requiring that disposal of large-scale blended waste is subjected to a site-specific intruder analysis as part of the overall performance assessment of a disposal facility. The changes would also improve NRC openness and effectiveness by clarifying the agency's LLRW blending policy and its bases.

<u>BACKGROUND</u>:

On June 30, 2008, the Barnwell disposal facility closed to most LLRW generators in the U.S. Now, only generators in the Atlantic Compact — the States of South Carolina, Connecticut, and New Jersey — can dispose of their LLRW at that facility. Although the Energy*Solutions* disposal facility in Clive, Utah remains available for Class A waste disposal by the generators that lost access to Barnwell, these generators have no disposal option for their Class B and C waste.

Licensees and industry are considering the blending of certain types of LLRW to help mitigate the impact of Barnwell's closure. One type of waste being considered for blending is ion exchange resins from nuclear power plants, which can be blended into a relatively uniform mixture. These resins account for about half of the volume of Class B and C waste generated each year. Resins are also the focus of a waste processor's expanded LLRW blending at its facility in the State of Tennessee. The waste processor has received approval for testing from its Agreement State regulator, and is continuing to develop a process for large-scale blending. Because disposal options were available for all classes of LLRW in the recent past, the agency's positions on blending were not challenged and required no further clarification.

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[1] Final Branch Technical Position on Concentration Averaging and Encapsulation, January 17, 1995.

[2] Policy Statement on Low-Level Waste Volume Reduction, 46 FR 51100, October 16, 1981.

However, the proposal to perform large-scale off-site blending has generated significant interest in the subject of blending and NRC's position on this practice. Objectives of this paper include the identification of specific safety, policy, and regulatory considerations that underlie the positions in the staff blending guidance to better inform potential revisions, as well as to identify and address concerns raised by stakeholders on blending.

Blending, as the staff uses the term in this paper, is the mixing of LLRW with different concentrations of radionuclides, which results in a relatively homogeneous mixture that may be appropriate for disposal in a licensed facility. The concentration of the resulting mixture is the total radioactivity in the mixture divided by its volume or weight. The types of waste may include those that are physically and chemically similar (such as ion-exchange resins from nuclear power plant systems), but could also include different waste types that can be made into a relatively homogeneous final mixture, such as soil and ash. Blending, as used in this paper, does not include placement of discrete wastes of varying concentrations into a disposal container, or the averaging of concentrations of radioactivity of a discrete component over its volume. Blending, as discussed in this paper, is confined to waste types that have physical properties that result in a homogeneous final waste form (the degree of homogeneity of the final waste form would be considered as part of the staff's analysis of this issue).

In the past, NRC has discouraged the blending or dilution of radioactive waste, without distinguishing between the two practices. Among the reasons given are not increasing "the burden on society" by increasing waste volume, and therefore the number of waste shipments for disposal. However, mixing or blending of waste with Class B or C concentrations with Class A would not increase the volume of waste.

This paper does not use the term "blending" in the sense of dilution (i.e., the intentional mixing of waste with clean or uncontaminated material to lower its waste classification or to release it into the general environment). The release of waste to the general environment could cause members of the public to be exposed to a hazard, however small. The use of dilution to facilitate disposal at a lower waste class would increase waste volumes, which has historically been considered undesirable. The staff notes that the terms "blending" and "dilution" are frequently used synonymously. The staff differentiates these terms as defined above.

The terms "mixing," "blending," and "dilution" are neither defined nor used in the Commission's regulations that relate to reducing a potential waste classification, or to disposal requirements for waste. Blending, including blending that lowers the waste classification, is neither prohibited nor explicitly addressed in NRC regulations.

NRC staff's guidance on LLRW blending is contained in the CA BTP. The CA BTP provides guidance to licensees on blending of LLRW, and on methods of radionuclide concentration averaging, such as encapsulation of sealed sources and the mixing of components with different waste concentrations in containers. With respect to the blending of wastes into a homogeneous final waste form, the staff in the CA BTP recommends restrictions on blending by applying a "factor of 10" provision, whereby the concentrations of batches of LLRW to be mixed should be within a factor of 10 of the average concentration of the final mixture. This limits the amount of blending that should be performed. Applying a risk-informed, performance-based approach would define the uniformity of concentration in the waste after mixing, rather than the CA BTP's approach of placing concentration limits on the wastes before they are mixed. By placing limits on the amount of mixing, however, the "factor of 10 rule" furthers the position that mixing should not be used solely to reduce waste classification. The staff in the CA BTP recommends exceptions to the “factor of 10 rule” when operational efficiency or worker dose reductions can be demonstrated. The staff’s positions are based on a combination of: (1) practical considerations in the operation of a facility, whereby wastes are routinely combined or mixed for operational efficiency; (2) NRC’s general policy that discourages mixing for the purposes of reducing the waste class; and (3) safety considerations mainly associated with protection of an individual who inadvertently intrudes into a disposal facility 100 years or more after its closure. The CA BTP attempts to balance these objectives.

Part 61 of 10 CFR establishes the procedures, criteria, and terms and conditions for the issuance of licenses for the disposal of LLRW. Four performance objectives, including protection of an inadvertent intruder into the waste disposal site, define the overall level of safety to be achieved by disposal.[3] Intruder protection is provided in part by the waste classification concentration limits in 10 CFR § 61.55, which are designed to ensure that an inadvertent intruder is not exposed to unsafe levels of radiation. Any blended LLRW must be classified in accordance with the waste classification tables in 10 CFR § 61.55. If batches of waste were not blended into a relatively homogeneous[4] final mixture, hot spots above the concentration limits for a particular waste class might expose an inadvertent intruder to unsafe levels of radiation. Concentrations of radionuclides that are used to determine the waste classification may be averaged over the volume or weight of the waste, in accordance with 10 CFR § 61.55(a)(8), and the staff has published guidance that defines acceptable approaches for such averaging. This guidance would have to be revised to address large-scale blending of waste. Blended waste, like any waste, must not affect a disposal facility’s ability to meet any of the performance objectives in 10 CFR § Part 61.

<u>DISCUSSION</u>:

This section identifies a number of different options for addressing blending in NRC’s LLRW regulatory framework. The options are designed to address the policy, technical (safety), and regulatory issues discussed in the Enclosure. The policy issues the staff evaluated include (a) NRC’s past statements on blending to reduce waste class; (b) facilitation of waste disposal through blending; (c) the impact on the LLRW management program in the U.S.; (d) impacts of blending on disposal capacity; (e) impacts on volume reduction; (f) unintended consequences of changing the Commission’s blending position; and (g) blending of greater-than-Class C LLRW. The safety issues evaluated include (a) protection of an offsite member of the public (10 CFR § 61.41); (b) protection of an inadvertent intruder into a disposal facility after the institutional control period ends (10 CFR § 61.42); (c) waste characterization and homogeneity; and (d) stability of the waste form. Regulatory issues include (a) the method for issuing an NRC position on blending; (b) National Environmental Policy Act (NEPA) compliance; and (c) the applicability of NRC’s guidance to waste processors.

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[3] The others are protection of the general population from releases of radioactivity; protection of individuals during the operation of the facility (as opposed to after the facility is closed) and stability of the disposal site.

[4] Because hot spots are a concern primarily with respect to protection of an individual who may inadvertently intruder into the waste after the end of the institutional control of the site, the CA BTP defines a “homogeneous waste type” as one in which the radionuclide concentrations are likely to approach uniformity in the context of intruder scenarios.

<u>Options</u>

The staff has identified four options for regulatory actions that NRC could undertake regarding blending of different types and classes of LLRW. These range from maintaining the status quo, to constraining all blending, to a risk-informed, performance-based approach. Each option also includes a discussion of how the staff believes that option can be effectively implemented (i.e., whether by rulemaking or guidance). In developing these options, the staff's goal was to provide the Commission with a broad range of options for a policy on blending, and to identify an appropriate means to implement that policy.

<u>Option 1</u>: Maintain current NRC positions on blending of homogeneous waste streams (status quo).

Under this option, the Commission would not change its existing positions on the use of blending as discussed in the CA BTP. This guidance recommends constraints on blending through the use of the "factor of 10" provision, which limits mixing of homogeneous waste streams to batches of waste that are within a factor of 10 of the average concentration after mixing. But the current staff position also acknowledges that blending is appropriate without the constraints of the CA BTP if it results in operational efficiencies or worker dose reductions.

NRC staff responses to three letters from industry representatives in late 2009 provide additional clarification on blending, and these clarifications are also part of the status quo.[5] These letters include the following clarifications: (a) blending is neither prohibited nor explicitly addressed in NRC regulations; (b) while the staff has stated that wastes should not be mixed *solely* to lower the waste classification, NRC guidance acknowledges that blending, including some blending that may lower the waste classification, may be appropriate under certain circumstances; (c) waste classification is related to the safety of the disposed waste, and NRC regulations do not require waste to be classified prior to its shipment for disposal, including when it is shipped to waste processors; and (d) NRC's blending guidance applies to all NRC licensees, including waste processors.

This option would be implemented by updating the CA BTP and issuing a Regulatory Issue Summary that documents staff positions in recent letters to industry. For the CA BTP, the staff would simply clarify terms, and better describe the bases for its positions. Among the advantages of this option are that licensees and Agreement States are familiar with the current averaging provisions in the CA BTP and use them extensively, and issuing guidance uses fewer resources to update the agency policy than the other options. Among the disadvantages are that this option could lead to inconsistent treatment of LLRW that could vary according to where the waste is generated, processed, and/or disposed, because guidance lacks the potential compatibility requirements of a rule. Nearly all waste processors and disposal facilities are regulated by Agreement States that are not required to follow NRC guidance. Waste blended and classified in accordance with the requirements of the State in which the generator or processor is located may not be accepted for disposal at a site in another State that has adopted different waste classification and blending criteria. Another disadvantage is that the

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[5] August 27, 2009, letter from Larry Camper to Thomas Magette, EnergySolutions. (ML092170561); October 30, 2009, letter from Larry Camper to Joseph DiCamillo, Studsvik, Inc.. (ML092930251); October 30, 2009, letter from Larry Camper to Scott Kirk, Waste Control Specialists. (ML092920426).

existing positions are not risk-informed and performance-based. Finally, there is a potential safety concern for an inadvertent intruder involving disposal of large-scale blended waste that would need to be evaluated on a case-by-case basis. While the need to protect an inadvertent intruder is specified in 10 CFR Part 61, there is some confusion concerning the requirement to conduct an analysis to ensure protection of an inadvertent intruder that may not be clarified if the status quo is maintained. The safety of an inadvertent intruder is typically ensured by the waste classification system and the disposal requirements imposed for each class of waste, and not necessarily or typically by a site-specific analysis.

Option 2: Revise blending positions to be risk-informed and performance-based.

Under this option, the agency's position on blending of waste streams would become risk-informed, performance-based, rather than, for example, relying on the "factor of 10" provision in the current guidance. The principal consideration would be whether a final blended waste form could be safely disposed of. Among the changes and clarifications that would be made to the existing blending positions are the following: (a) clarify that a site-specific intruder analysis must be performed to determine whether an intruder could be protected, or the conditions necessary for such protection; (b) develop criteria defining acceptable homogeneity and sampling considerations; and (c) eliminate the "factor of 10 rule" for mixing of wastes that can be blended into a homogeneous mixture, because the concentration of final mixture will be relatively uniform in the context of a site-specific intruder scenario.

This option would be consistent with the Commission's policy on risk-informed, performance-based regulation. In 1997, the Commission addressed risk-informed performance-based regulation as one of the 20 direction setting issues in its overall Strategic Assessment of the agency's programs at that time, deciding that NRC ". . . will have a regulatory focus on those licensee activities that pose the greatest risk to the public." In the last decade, increased use of risk-informed performance-based regulation has been a continuing agency policy and is one of the safety strategies in the NRC Strategic Plan[6] that guides work in all NRC programs.

This option would be implemented through a combination of rulemaking and issuance of guidance. The requirement for a site-specific intruder analysis, which is a risk-informed, performance-based approach to addressing blending, would be mandated in the rulemaking for unique waste streams, which the Commission directed the staff to start in its March 18, 2009, staff requirements memorandum for SECY-08-0147. The rulemaking would explicitly require a site-specific analysis for an inadvertent intruder. Under this approach, disposal of large amounts of blended waste would have to be evaluated for intruder protection on a site-specific basis. As part of the NEPA analysis for this rulemaking, disposal of blended ion exchange resins from a central processing facility would be compared to direct disposal of the resins, onsite storage of certain wastes when disposal is not possible and further volume reduction of the Class B and C concentration resins. The regulatory basis document for this rulemaking is scheduled to be completed in September 2010, and the staff would begin work on the proposed rule at that time. The staff does not believe that the addition of blended waste to the regulatory basis will require significant resources or time to complete. Nevertheless, if the Commission decision on this paper occurs late in Fiscal Year (FY) 2010 or in FY 2011, the regulatory basis document or proposed rulemaking schedules may have to be revised somewhat to

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[6] "Strategic Plan, Fiscal Years 2009-2013. NUREG-1614, Volume 4. February 2008.

accommodate the addition of blended waste to the rulemaking. The staff will take steps to mitigate any impacts in the meantime. There would be no impact on the schedule for the unique waste streams rulemaking if the Commission chooses any of the other options.

Two documents would be updated as part of this option — the Volume Reduction Policy Statement and the CA BTP. The Policy Statement, published in 1981, encourages licensees to take steps to reduce the amount of waste generated and to reduce its volume once generated. That position was issued when disposal space was scarce since two of the three operating LLRW disposal sites had threatened to close at that time, and one had recently reduced the annual amount authorized for disposal by half. Further, volume reduction techniques were not yet in widespread use and NRC's Policy Statement was meant to encourage the use of such techniques. Although the Policy Statement does not address blending directly, some stakeholders have argued that blending is contrary to the policy and to the goal of achieving reduced waste volumes. Notwithstanding NRC's policy, volume reduction is widely practiced today, in large part because disposal costs have risen significantly in the last 30 years and it is economical to reduce disposal volumes. The staff believes that the Policy Statement could be updated to recognize the progress that has been achieved, and to acknowledge that other factors may be used by licensees in determining how best to manage their LLRW. Specifically, the Policy Statement could be revised to acknowledge that volume reduction continues to be important, but that risk-informed, performance-based approaches to managing waste are also appropriate in managing LLRW safely and that volume reduction should be evaluated in this light. For the CA BTP, risk-informed, performance-based blending guidance would be specified and existing guidance that is not consistent with such approaches, such as the "factor of 10 rule," would be removed.

The staff would also issue interim guidance to Agreement States on how to evaluate proposed disposal of large quantities of blended waste until the rulemaking is completed. The guidance would recommend a case-by-case evaluation of blended waste for each site that plans to accept this type of waste for disposal. Factors such as intruder protection, the need for mitigative measures, and homogeneity would need to be evaluated by the appropriate regulator. The staff's preliminary independent analysis indicates that current practices at existing disposal facilities may safely accommodate an increase in the amount of disposed waste at or just below the Class A limits.

Among the advantages of this option are: (a) use of risk-informed, performance-based criteria, which would be consistent with NRC's overall policy of risk-informed regulation; and (b) use of fewer staff resources than options 3 and 4 by piggybacking onto a rulemaking that is already underway. Among the disadvantages are that existing licensee and applicable Agreement State regulations and guidance may have to be changed, and some stakeholders may perceive this new blending policy as a reduction in protection of public health and safety.

<u>Option 3</u>: Revise agency blending policy to further constrain blending.

Under this option, the Commission would develop a policy and promulgate a rule that would require that the in-process concentrations of waste determine waste classification, rather than the waste being classified when it is ready for disposal, the current requirement. The rulemaking would initially propose that radioactive material that has been blended as a result of stabilization, mixing, or treatment, or for any other reason, would be subject to the disposal regulations it would have been subject to prior to blending. This rule would require classification at points prior to the preparation of waste for disposal. A Regulatory Issue Summary would be published soon after the Commission decision to inform licensees that a revised blending policy was under development. Among the advantages of this option are (a) it would eliminate some stakeholder concerns over blending to reduce waste classification; (b) it would eliminate any ambiguity about blending for purposes of lowering the waste classification — any blending under this option could not lower the waste classification; (c) it would provide for more measures to isolate and contain waste than the current requirements in 10 CFR Part 61, since the classification of some wastes under this approach would be higher than current practice (a corresponding "con" is that measures unnecessary for adequate protection of public health and the environment would be required in some cases). Among the disadvantages are: (a) it may result in larger occupational exposures because of the need to sample and characterize waste more frequently; (b) it would not be risk-informed and performance-based, since classification of waste would be based on the as-generated waste, not of the concentrations of waste at the time of disposal; and (c) it would require more LLRW storage by creating more Class B and C waste.

Option 4: Prohibit large-scale blending at off-site processor.

NRC could prohibit large-scale blending that lowers the waste classification at a waste processor[7] because it is tantamount to intentional mixing to lower the waste classification. This option would be implemented through a rulemaking. A Regulatory Issue Summary would also be issued after a Commission decision, but before the rulemaking was completed, to notify licensees of the planned change. An important part of the rulemaking would be differentiating between the routine blending that currently occurs at waste processors, and large-scale blending to lower the waste classification, such as has been proposed for ion-exchange resins from nuclear power plants. Among the advantages of this option are: (a) it would address concerns raised by stakeholders opposed to blending in general and potentially increase public confidence that their health and safety are being protected; and (b) it would continue to allow for individual waste generators to blend waste as part of normal operations. Among the disadvantages are that (a) it is not a risk-informed, performance-based position; (b) there is no clear health and safety basis for discouraging this type of blending; and (c) generators could still produce resin waste similar to blended waste by removing resins from service before Class B concentrations are reached, which would increase LLRW volumes by requiring more resin to accomplish the same task.

STAKEHOLDER INPUT

The staff solicited stakeholder input in developing this paper. On November 30, 2009, the staff issued a *Federal Register* notice requesting public comments on LLRW blending. Fourteen organizations and individuals provided comments. In December 2009, the staff met individually with three companies that had written to NRC expressing their views on LLRW blending. The meetings were open to the public, and opportunities for public comment were provided. On January 14, 2010, the staff held an all day public meeting in Rockville, Maryland, to provide the public with an opportunity to comment on LLRW blending. Stakeholders commenting at the meeting included representatives from States and Compacts, advocacy groups, the waste processing industry, waste generators, and DOE. The staff reviewed and considered all of the comments received in developing this paper.

[7] Included in the scope of this prohibition would be waste processors that are designated as LLRW generators through waste attribution. See Section 3.1.3 of the Enclosure for a discussion of attribution.

Stakeholders hold a wide variety of views on blending, and there was significant controversy about the appropriate policy for blending in the public meetings. Appendix B of the Enclosure lists the organizations that commented on the November 30, 2009, *Federal Register* Notice soliciting public comments, the Adams accession number for the letters received in response to the notice, the presentations given in the four public meetings, as well as a transcript of the January 14, 2010, public meeting. Most of the issues addressed in this paper were identified and discussed in the public meetings. They include the potential safety impacts of large-scale blending, the impact of blending on LLRW volume reduction, how NRC's blending position should be documented (i.e., whether in guidance or rulemaking), and the potential unintended consequences of a new NRC blending position. The staff intends to prepare and implement a communication plan after the Commission decides on an option to help ensure that NRC's position, its bases, and the process for policy development are understood.

<u>AGREEMENT STATE VIEWS</u>

In preparing this paper, the staff consulted with Agreement States that are significantly involved in the regulation of waste processing and disposal facilities. The staff reviewed the contents of the paper with the Agreement States of Washington, South Carolina, Texas, Utah, Tennessee, and Pennsylvania. States were generally satisfied with the issues addressed and the options presented for Commission consideration. One State official was concerned that joining the site-specific intruder assessment requirement for blending with the unique waste streams rulemaking would delay that effort. Another noted that assuring homogeneity is more important for large-scale blended waste than for smaller amounts from individual generators, because it will be closer to the limits for Class A waste. Some States, but not all, argued for flexibility in implementing any new regulations on blending. Texas in particular has a regulation that addresses waste dilution and believes that any NRC regulation on blending should allow their existing regulation to remain in place. A related issue for this State is its concern about ensuring that out-of-State generators that might dispose of waste in the State disposal facility comply with their dilution regulation. The staff will have further discussions with Texas on this issue.

Two of the above States also commented formally on blending in response to the staff's *Federal Register* Notice of November 30, 2009. Utah, among other comments, is opposed to blending if the intent is to alter the waste classification for the purposes of disposal site access. For allowable blending, the State believes that requirements should be contained in performance-based regulations addressing sampling and radiological characterization standards. The Pennsylvania Department of Environmental Protection also provided comments in a January 28, 2010, submittal. The Department would not oppose intentional blending of LLRW if it results in a change of classification of waste to a lower classification and only for access to a LLRW disposal facility and not for release to the environment. The Department also recommended that NRC clearly define blending (and to prohibit dilution). The State also believes that the original generator of blended waste should be maintained in records, and that an evaluation of the potential benefits and risks associated with blending be conducted.

In the January 14, 2010, public meeting, a representative from the Tennessee Department of Environment and Conservation had no technical opinion on blending. The representative noted that if large-scale blending was determined to be commercially viable, their responsibility is to license a blending operation if protection of public health and safety and the environment are demonstrated.

The Utah and Pennsylvania comments can be found in ADAMS under the accession numbers identified in Appendix B of the Enclosure. The Tennessee comments are contained in the transcript for the January 14, 2010, meeting, which is also listed in Appendix B.

RECOMMENDATIONS:

The staff believes that the current blending positions would be improved if they were risk-informed and performance based, and were specified in regulation and further clarified in guidance. The staff recommends the Commission approve:

Option 2 — to adopt a risk-informed, performance-based LLRW blending policy.

RESOURCES:

Option 1 - (Status Quo) would require 0.6 Full Time Equivalent (FTE) and $50,000 to complete, with 0.40 FTE and $25,000 in FY 2011.

Option 2 - (Risk-Informed, Performance-Based) will require 1.0 FTE and $50K for tasks unique to blending. Blended waste is also considered a unique waste stream under this option. The unique waste streams rulemaking has already been approved by the Commission in the Staff Requirements Memorandum for SECY-08-0147. The total resources, both for tasks unique to blending and for the unique waste streams rulemaking, would be 7.3 FTE and $1,550K, with 4.2 FTE and $775K for FY 2011.

Option 3 - (Further constrain blending) will require 3.5 FTE and $250,000 to complete with 0.2 FTE in FY 2011.

Option 4 - (Prohibit large scale blending) will require 3.3 FTE and $250,000 to complete with 0.2 FTE in FY 2011.

FY 2011 resources are available in the rulemaking product line within the Decomm/LLRW business line for the preferred Option #2. If the Commission determines one of the other options should be implemented (numbers 1, 3 or 4), the staff will need to redirect resources from the Oversight product line to the rulemaking product line. Resources for FY 2012 and beyond will be addressed through the Planning, Budgeting, and Performance Management process.

COORDINATION:

The Office of the General Counsel has no legal objection concerning this paper. The Office of the Chief Financial Officer has reviewed this paper for resource implications and has no objections.

/RA by Martin Virgilio for/

R. W. Borchardt
Executive Director
for Operations

Enclosure:
Analysis of Blending of Homogeneous
Low-Level Radioactive Waste

ANALYSIS OF BLENDING OF LOW-LEVEL RADIOACTIVE WASTE

1. Introduction

In this paper, the U. S. Nuclear Regulatory Commission (NRC) staff examines blending or mixing low-level radioactive waste (LLRW) that has higher radionuclide concentrations with LLRW that has lower radionuclide concentrations, particularly blending that lowers the classification of waste. Such mixing may be done for a variety of reasons: 1) to consolidate wastes from a number of different sources within a plant for reasons of operational efficiency; 2) to reduce radiation exposures to workers; and 3) to lower the classification of some of the waste by averaging its concentration over a larger volume. While recognizing that some mixing is unavoidable and even desirable for efficiency or dose reduction, NRC has historically discouraged mixing to lower the waste classification. The maxim “dilution is not the solution to pollution” appears to have been a factor in developing agency positions that discourage and constrain, but do not prohibit, the mixing of wastes. Dilution can increase the amount of waste by mixing clean and contaminated materials together, and may enable the mixture to be released to the general environment where members of the public will be exposed to the hazard, however small. The term “blending” as used in this paper, however, involves the mixing of higher and lower concentrations of contaminated materials, not clean materials, and disposal in a licensed disposal site, not release to the general environment. Thus, the undesirable characteristics of dilution are not present in this kind of blending, while safety and efficiency may be improved by selection of appropriate criteria to be applied to such blending. Although NRC’s LLRW regulations neither prohibit nor explicitly address blending, staff guidance recommends constraints on the use of blending, while recognizing that it is appropriate in some circumstances. The constraints do not always have a clear safety basis.

With the June 30, 2008, closure of the Barnwell LLRW disposal facility to most U. S. generators of Class B and C wastes, licensees and industry are exploring the blending of LLRW that would otherwise be Class B and C into a homogeneous Class A mixture that could be disposed of as Class A waste. Such blending would eliminate the need for indefinite onsite storage of at least some of these wastes, while furthering the goal of permanent disposal. Not all LLRW can be blended into a homogeneous mixture suitable for disposal as Class A waste: irradiated reactor components, reactor pressure vessels, and other types of solid waste are not amenable to blending. Other reactor waste streams, particularly ion exchange resins, which account for about half of the volume of Class B and C waste generated each year, can be blended into a homogeneous mixture with a relatively uniform concentration of radioactivity, and some of these Class B and C resins could be blended with resins that have radioactivity concentrations well below the Class A limits to produce a final Class A mixture.

Some stakeholders, however, have raised concerns with such large-scale blending and have asked NRC to clarify its position on blending and what is acceptable under the regulations and guidance, especially with respect to blending that results in a change in the classification of the waste under 10 CFR § 61.55. Noting that policy issues were associated with blending of

LLRW, Chairman Jaczko, in an October 8, 2009, memorandum to the NRC staff, requested a vote paper that discusses the following topics:

- Issues related to intentional changes in waste classification due to blending, including safety, security, and policy considerations
- Protection of the public, the intruder, and the environment
- Mathematical concentration averaging and homogeneous physical mixing
- Practical considerations in operating a waste treatment facility, disposal facility, or other facilities, including the appropriate point at which waste should be classified
- Recommendations for revisions, if necessary, to existing regulations, requirements, guidance, or oversight related to blending of LLRW

The agency's previous policies and positions on blending of LLRW are evaluated in this paper to respond to this request and to other issues raised by stakeholders. Options for new agency positions on blending are provided for Commission consideration. The position that blending is *a priori* undesirable is examined in light of risk-informed, performance-based regulation that focuses on the safety hazard of the blended materials. This paper insofar as possible addresses the blending issue generically and without consideration of the specific business models or licensing actions for waste processing and disposal. However, in a few cases, references to specific facilities are necessary.

This paper is organized into the following sections:

- Background on waste blending, including definitions, how and why it is performed, and NRC regulations and guidance on the use of blending in general and for LLRW in particular
- Analysis of policy, safety and environmental, and regulatory issues
- Analysis of issues in the Chairman's tasking memo
- Stakeholder views
- Agreement State views
- International guidance and practice
- Options for NRC policy on blending
- Conclusions and recommendations

2. Background

This section first defines the term "blending" for the purposes of this paper, since the blending considered is narrow in scope. It then describes NRC regulations, guidance, and other positions applicable to blended LLRW. Industry initiatives that propose to expand the use of blending of LLRW and that have caused this re-examination of the NRC's guidance are then identified and described.

2.1 Definition of "Blending"

Blending, as the staff uses the term in this paper, is the mixing of LLRW having different concentrations of radionuclides to form a relatively homogeneous mixture that may be appropriate for disposal in a licensed facility. The concentration of each radionuclide in the resulting mixture is the radioactivity of each radionuclide in the mixture divided by the mixture's volume or weight. The types of waste that are blended may include those that are physically and chemically similar (such as ion-exchange resins from nuclear power plant systems), but could also include different waste types that can be made into a relatively homogeneous final mixture, such as soil, ash, and shredded trash. Blending, as used here, does not include the placement of discrete wastes of varying concentrations into a disposal container, or the averaging of concentrations of radioactivity of a discrete component over its volume. It also does not cover encapsulation of certain wastes in a non-radioactive matrix, as described in the Branch Technical Position on Concentration Averaging and Encapsulation (CA BTP) (NRC, 1995, Section 3.7). Such encapsulation may be used to meet the stability requirements for Class B and C LLRW. Blending, as discussed in this paper, is confined to waste types that have physical properties that enable mixing into a relatively homogeneous final waste form. The term “blending” as used in this paper, involves the mixing of higher and lower concentrations of contaminated materials, not clean materials, and disposal in a licensed disposal site, not release to the general environment. Blending is not “dilution,” as the staff defines the term for this paper, which is the mixing of clean and contaminated materials.

2.2 Regulations and Guidance on Waste Blending

2.2.1 Regulations addressing waste classification, protection of an inadvertent intruder, and blending

Blending of LLRW that lowers waste concentrations from Class B or C levels to Class A is the primary focus of this paper. This section therefore addresses the requirements for waste classification, protection of an individual who inadvertently intrudes into a waste facility (the primary reason for classifying waste), and blending.

The terms “mixing,” “blending,” and “dilution,” are not used in the regulations in 10 CFR that relate to reducing the potential waste class or disposal requirements for wastes. Thus blending, including blending that lowers the waste class, is neither prohibited nor explicitly addressed in NRC regulations.

The waste classification system is an important component in the regulations that provides for protection of an inadvertent intruder into a waste disposal facility. Protection of an inadvertent intruder is one of the four performance objectives for a LLRW disposal facility in 10 CFR Part 61, “Licensing Requirements for Land Disposal of Radioactive Waste.” Specific requirements were included in 10 CFR Part 61 that would prevent an intruder from receiving an unsafe exposure to radioactivity.[1] Among these requirements are the waste classification system contained in 10 CFR 61.55. Under this system, three classes of waste are defined for near-surface disposal, based on the radioactivity concentration of certain critical radionuclides. Greater controls are required as the waste classes increase in hazard. Class A waste poses the least hazard, and requires the fewest controls, while Class C is the most hazardous and requires, for example, either deeper disposal or an engineered barrier that will prevent human intrusion for 500 years, among other measures. A fourth class, greater than Class C (GTCC), is also defined, but wastes in this category are generally not suitable for near surface disposal because of the hazard they present. The allowable concentration of radioactivity in a waste class is directly related to the radiation exposure that an inadvertent intruder would receive

[1] As the Advisory Committee for Nuclear Waste and Materials (ACNW&M) noted in its April 30, 2008, letter to the Commission (ACNW&M, 2008), Resource Conservation and Recovery Act regulations for hazardous waste disposal facilities do not postulate an inadvertent intruder into the sites. Thus, the intruder protection provision in NRC regulations is conservative. Intruder protection is not always examined in managing risks associated with disposal of other waste types.

using the assumptions in the technical basis for 10 CFR Part 61. Appendix A to this paper contains a more complete explanation of the bases for the waste classification system in 10 CFR Part 61. As noted later in this paper, the technical basis for 10 CFR Part 61 contained in the draft environmental impact statement (DEIS) for 10 CFR Part 61 (NRC, 1981) and the final environmental impact statement (EIS) (NRC, 1982), considered the waste streams that were being generated at the time the rulemaking was being developed. These waste streams did not include large-scale blending of ion-exchange resins, an issue that is addressed in more detail in Section 3.2 of this paper.

In addition to 10 CFR Part 61, NRC also has provisions in its regulations that address waste classification in 10 CFR Part 20 Appendix G. These requirements, among other things, address the disposal of waste after its generation and processing. Such processing could include blending. Part 20 of 10 CFR, Appendix G describes the requirements for transferring LLRW for disposal and completing manifests for shipments of waste. The primary objective of this regulation is to ensure that the properties of waste that is being sent for disposal are identified and characterized for the disposal facility operator. The disposal facility operator needs to know this information in order to be able to determine that the site will perform safely when that waste is disposed. Some of the most important pieces of information are the radionuclides and their amounts, so that the inventory of disposed waste at the site is known and can be used in performance assessments to determine if the site can safely isolate these wastes.

In addition to the inventory, the manifest provisions in Appendix G of Part 20 also require that the classification of the waste (i.e., Class A, B, or C) be identified *when the waste is being shipped for disposal.* Waste is not required to be classified when it is shipped from a generator to a processor for subsequent disposal. NRC's land disposal regulations in 10 CFR Part 61 define the disposal requirements, including the classification of waste in 10 CFR § 61.55. Like Appendix G of Part 20, the 10 CFR Part 61 regulations do not require that waste being shipped for processing for subsequent disposal be classified. The reason for this is that waste is classified for the purposes of ensuring its safe disposal, primarily to protect an inadvertent intruder into a waste disposal site. Waste is not required to be classified at intermediate points between its generation and disposal, such as processing and storage, because the characteristics of the waste at these intermediate points do not directly affect its safe disposal. Once waste is ready for disposal, it must be classified.

Class A waste has the lowest radionuclide concentrations and requires fewer controls during disposal than Class B or C. Similarly, the disposal requirements for Class B waste are somewhat less demanding than those for Class C waste. Notwithstanding this requirement to classify waste at the time of disposal, it is not uncommon for generators and processors to classify waste before that point. Licensees may "classify" waste while it is being processed to ensure that it falls within the desired final waste class. For example, a licensee may want to avoid concentrating waste to greater than Class C concentrations, for which there is no disposal option, and could avoid that by knowing its "classification" and concentration while it is undergoing processing. In addition, the concentration and implied classification may change from the time a waste is generated until it is shipped for disposal, as a part of the routine handling and processing that occurs. It is not possible to avoid changes in the concentration, and in some cases, changing the classification of waste. Such changes are not significant in terms of protecting an intruder into a waste disposal site, since it is the characteristics of the waste at the time of disposal that affect an inadvertent intruder.

Although blending of LLRW is not addressed in the regulations, and blending that "lowers the waste classification" is, from an NRC regulatory perspective, not possible since waste is not required by NRC regulations to be classified until it is ready for disposal, NRC guidance has discouraged blending that reduces the concentrations of radionuclides in waste from Class B and C levels to Class A levels, as discussed in the next section.

2.2.2 NRC Guidance on Blending of LLRW

For blending of LLRW, the staff has developed guidance that describes how licensees may meet the concentration averaging provision in 10 CFR § 61.55(a)(8).[2] The CA BTP addresses three broad types of averaging, including blending, as summarized below:

- Blending — includes the mixing of homogeneous[3] wastes (i.e., the actual practice of blending different batches or types of waste), and the constraints that should be applied to such mixing. The CA BTP limitations on blending do not apply to a "designed collection of homogeneous waste types from a number of sources within a licensee's facility, for purposes of operational efficiency or occupational dose reduction." No further guidance on the use of these exceptions is provided. Any constraints or conditions needed in these instances must be addressed on a case-specific basis.

  If the exceptions for occupational efficiency or worker dose reduction are not used, the CA BTP states that homogeneous waste types can be mixed if either a) the classification of the mixture is based on the highest nuclide concentrations in any of the individual waste types of the mixture, or b) the average nuclide concentrations of individual waste type contributors are within a factor of 10 of their average concentrations in the final mixture (the so-called "factor of 10 rule"). In addition, other alternative mixing schemes can be authorized if specific regulatory approval is obtained under 10 CFR 61.58.[4] This provision enables the Commission to approve on its own initiative or in response to a specific request, alternative classification or characteristics of LLRW for disposal in a Part 61 facility. It is rarely used by NRC or Agreement States. For homogeneous wastes, the CA BTP does not explain why LLRW that is capable of being mixed into a homogeneous final waste form (such as soil, resins, and ash) is subject to the factor of 10 constraint on the radionuclide concentrations in the waste before mixing. A performance-based approach would define the required uniformity of radionuclide concentrations in the waste after mixing, rather than using the CA BTP's approach of placing concentration limits on wastes before they are mixed.

- Concentration averaging — is concerned with either: a) the mathematical averaging of waste concentrations, based on the size, geometry, and type of radioactive emission, or b) the combining of radioactive components in a single container and how their radioactivity may be averaged over the volume of the container. An example of the former type of

[2] 10 CFR 61.55(a)(8) states that "the concentration of a radionuclide [in waste] may be averaged over the volume of the waste, or the weight of the waste if the units [for the values tabulated in the concentration tables in 10 CFR 61.55] are expressed as nanocuries per gram."

[3] The CA BTP defines a "homogeneous waste type" as one in which the radionuclide concentrations are likely to approach uniformity in the context of intruder scenarios used to establish the concentrations for the waste classification system. Although the definition of "homogeneous waste type" is based on the waste characteristics after mixing, the CA BTP addresses this waste type before mixing by imposing the "factor of 10" rule.

[4] 10 CFR 61.58, Alternative requirements for waste classification and characteristics states "The Commission may, upon request or on its own initiative, authorize other provisions for the classification and characteristics of waste on a specific basis, if, after evaluation of the specific characteristics of the waste, disposal site, and method of disposal, it finds reasonable assurance of compliance with the performance objectives in subpart C of this part [61]."

averaging is irradiated hardware from a nuclear power reactor, which often has different radioactivity concentrations from one portion of a component to another. The CA BTP describes how and when these concentrations may be averaged to determine the waste classification of the component, based on the projected dose to an inadvertent intruder into a disposal facility.

- Encapsulation — is the surrounding of a radioactive source or component with a non-radioactive material, and using the entire volume or mass for the purposes of determining the waste concentration and class. Unlike blending, which often involves the mixing of relatively homogeneous, flowable materials of different radionuclide concentrations and may result in a final uniform mixture, encapsulation involves a radioactive core surrounded by a non-radioactive matrix. The CA BTP describes the constraints on the use of the non-radioactive matrix for concentration averaging, based on safety analyses of the radiation exposure to an inadvertent intruder into a disposal facility.

These three main sections of the CA BTP address and differentiate between mathematical concentration averaging and homogeneous physical mixing. Mathematical averaging, in the context of waste classification, is the summation of radionuclide activity measurements for a discrete package, component or volume of LLRW divided by the volume or weight of the entire package or component when the radioactivity concentrations of the components themselves cannot be altered by mixing. The mathematical average concentrations are used to determine the waste classification in accordance with concentrations defined in 10 CFR 61.55. For example, a container of waste destined for a LLRW disposal site may be filled with pieces of hardware that vary in radioactivity concentration, and the CA BTP identifies considerations and defines approaches for acceptable averaging.

In the case of wastes of varying concentrations that can be physically mixed into a homogeneous mixture, in theory, no mathematical averaging would be required, since the final mixture would have a single concentration of each radionuclide. In practice, mixtures will not be entirely uniform and some specification of the degree of homogeneity (i.e., the range of acceptable radionuclide concentrations) needs to be in place. Because releases of radioactivity from a hot spot would be mixed in the environment before reaching an off-site member of the public, hot spots are of most concern with respect to protection of a potential inadvertent intruder. Thus, the primary purpose of homogeneity requirements would be to ensure that any hot spots do not expose an inadvertent intruder to an unacceptable dose. A sampling program also needs to be in place to ensure that the homogeneity requirements are met.

Because mathematical averaging could be applied to the final blended mixture, it seems appropriate for any homogeneity requirements to be consistent with the mathematical averaging guidance. For example, it may not be risk-informed or performance-based to require smaller variations of radionuclide concentrations in a container of blended waste than NRC would allow in a container of waste to which the CA BTP mathematical averaging guidance is applied. Risk-informed requirements for blended waste would require homogeneity in the context of an intruder scenario. That is, radionuclide concentrations would not be required to be homogeneous on a physical scale smaller than the amount of waste the intruder would mix by intrusion. Alternately, homogeneity requirements stricter than mathematical averaging requirements may be justified in terms of “as low as is reasonably achievable” (ALARA) requirements, because the NRC staff expects that blended waste can be mixed to relatively homogeneous concentrations whereas discrete components to which mathematical averaging typically is applied cannot.

As noted earlier, the CA BTP positions are based on a combination of 1) practical considerations in the operation of a facility, whereby wastes are routinely combined or mixed for operational efficiency reasons, 2) NRC's general policy that discourages mixing for the

purposes of reducing the waste class, and 3) safety considerations. These three objectives are not fully compatible, but the CA BTP attempts to provide positions that balance them. For example, blended homogeneous wastes are constrained by the "factor of 10 rule" mentioned earlier, unless operational efficiency or worker dose reductions occur (in which case, the CA BTP limitations on blending are not applicable, and case-specific constraints must be developed). The CA BTP addresses waste class reduction in only two places. In a section addressing mixing of "dissimilar waste streams," one of eight different sections in the CA BTP, it states that it is acceptable to mix these streams if the classification of the mixture is not lower than the highest waste classification of any individual components in the mixture. In addition, an appendix to the CA BTP entitled, "Analysis of and Response to Comments on Concentration Averaging and Encapsulation Technical Position," contains statements that discourage waste class reduction. It states: ". . . it has been clarified [in the final version of the CA BTP] that the record of analyses which documents the licensee's use of concentration averaging and encapsulation practices defined in this technical position, should generally be sufficient, in and of itself, to show that *the averaging of concentrations was not undertaken solely to lower the classification of any specific waste in a disposal container*" [emphasis added].[5] The CA BTP is not entirely consistent in its positions on waste class reduction, since some waste blended according to the "factor of 10 rule" could undergo waste class reduction. Further, the above statement regarding waste class reduction appears only in a comment resolution appendix, not the guidance itself.

In response to letters from stakeholders, NRC staff addressed specific questions and comments on NRC's blending position in three letters published in late 2009 (NRC, 2009a, b, c). Among the comments NRC staff received was the statement that NRC policy prohibits the blending or dilution of radioactive material for the purpose of changing its waste classification. The staff noted in its responses that this statement was not correct. Nothing in NRC's regulations prohibits blending, and while staff guidance discourages blending in some circumstances, it also recognizes that there may be circumstances where blending that results in a lower waste classification is appropriate. These letters explain the guidance on selected issues and correct certain misinterpretations.

2.2.3 NRC Guidance on Blending in Other Waste Programs

Notwithstanding that blending is not addressed in the regulations and that waste classification is not required until waste is ready to be disposed of, NRC has recommended constraints, in addition to those in the CA BTP, on the blending or dilution of waste, without distinguishing between the two practices. SECY-04-0035 (NRC, 2004a, Attachment 2, p 5) summarizes a 1987 memorandum from the NRC Executive Director for Operations to one of the NRC Commissioners which provides an example of the agency's position on intentional dilution.[6] The

[5] The staff presented this more conservative position on blending in the CA BTP in a recent letter to Alaron, a waste processor (NRC 2006b). The CA BTP is arguably ambiguous on whether blending may be done solely to reduce waste class.

[6] Although the memorandum uses the term "dilution," it addresses "blending" of wastes, as defined in this paper (i.e., the mixing of wastes with higher and lower radionuclide concentrations and disposal of the mixture in a licensed facility.)

memorandum responded to a question raised by the Commissioner regarding whether an approach contemplated in an Advance Notice of Proposed Rulemaking (ANPR) would allow blending of high-level waste so that it could be classified as low-level waste. The memorandum makes clear that the ANPR neither allows nor specifically prohibits dilution of radioactive wastes but also contains the following statement:

> "The staff's view with regard to dilution has been, and continues to be, that dilution, solely for the purpose of altering the classification of the waste, is unacceptable."

The memorandum goes on to state that "while dilution might reduce the risk to an individual potentially affected by the wastes, in many cases dilution would increase the overall burden to society by making the wastes more difficult to manage (e.g., by increasing the number of shipments required for transportation of wastes to a disposal facility). Nevertheless, some dilution of wastes may result from waste processing . . . which is beneficial for the long-term safety of a waste disposal system. For this reason, the staff has handled the issue of dilution, and will continue to do so, on a case-by-case basis."

NRC staff prepared a comprehensive analysis of the intentional mixing of contaminated soil in the decommissioning of nuclear facilities in SECY-04-0035 (NRC, 2004a). In evaluating options for addressing intentional mixing associated with the decommissioning of sites, the Commission chose an option (NRC, 2004b) that allowed for certain limited mixing of contaminated soil onsite, as well as the mixing of soil for offsite disposal to meet the waste acceptance criteria (WAC) for a waste disposal facility. The staff guidance that was developed to implement the Commission decision (NRC, 2006a) also states that mixing of soil for offsite disposal is permissible ". . .as long as the classification of the waste, as determined by the requirements of 10 CFR 61.55 [the waste classification tables in Part 61], is not altered." The analysis of the blending issue in this Commission paper (SECY-04-0035) did not address in detail the lowering of waste class through mixing, since all or nearly all contaminated soils associated with decommissioning are Class A waste. Although the decommissioning guidance constrains waste class reduction from intentional mixing of soil in decommissioning of nuclear facilities, this paper addresses a much broader range of waste types and classifications where waste class reduction already is allowed, and may have certain benefits if expanded, namely reducing the amounts of LLRW in storage. Little, if any, soil from decommissioning would be Class B or C waste.

NRC similarly discourages blending that lowers the waste class in its program to review U. S. Department of Energy waste determinations for residual high-level waste. NUREG-1854, "NRC Staff Guidance for Activities Related to U. S. Department of Energy Waste Determinations," (NRC, 2007a) states that "Extreme measures [should not be taken and] may include . . . deliberate blending of lower concentration waste streams with high activity waste streams *solely* to achieve waste classification objectives*, although blending may be needed for waste management purposes"* [emphasis added].

2.2.4 NRC Policy Statement on Low-Level Waste Volume Reduction

Another document related to blending is NRC's Policy Statement (PS) on Low-Level Waste Volume Reduction (NRC, 1981b). The PS encourages licensees to take steps to reduce the amount of waste generated and to reduce its volume once generated. That position was issued when disposal space was scarce since two of the three operating LLRW disposal sites had threatened to close at that time, and one had recently reduced the annual amount authorized for disposal by half. Further, volume reduction techniques were not yet in widespread use and NRC's PS was meant to encourage the use of such techniques. NRC issued the PS was in response to a General Accounting Office (now U.S. Government Accountability Office (GAO))

report that recommended that NRC take this step to help preserve disposal facility space (GAO, 1980). This PS is discussed in more detail in Section 3.1.5 of this paper.

Although the PS does not address blending directly, some stakeholders have argued that blending is contrary to the policy and to the goal of achieving reduced waste volumes. Large-scale blending of ion-exchange resins could be performed in lieu of waste processing that would achieve further volume reduction. In addition, one stakeholder commented that the goal of the Volume Reduction Policy Statement — to extend the operational lifetime of existing commercial disposal sites — is best served by prohibiting large-scale blending of LLRW.

2.3 Practical considerations

NRC waste guidance, while discouraging blending that lowers waste classification in some situations, also recognizes that such blending may be appropriate in others. Practical considerations require this flexibility. Licensees mix different contaminated waste materials, such as clothing, paper, and floor sweepings, for operational efficiency and because there is no reason to keep them separate, as they are generally all bulk Class A materials that can be handled similarly. Such blending is a routine part of operating a facility, processing waste, or decommissioning a facility and is often incidental to the purpose of the facility — to produce electricity, to dismantle and dispose of buildings no longer used, or to process a variety of waste streams by sorting, compacting, incinerating, packaging, and stabilizing. One example that often involves blending of higher and lower activity waste is the mixing of ion exchange resins generated in various locations in a nuclear power plant. It is more efficient to combine these wastes into one or several tanks in such a facility, rather than keep them separate after they are removed from service. Blending may also be performed to keep radiation exposures to workers as low as reasonably achievable, since the doses from a mixture of two or more streams of LLRW with different radiation levels may result in a combined mixture that has lower radiation levels. Third, waste disposal may also be facilitated by blending. For example, two batches of waste blended together may meet the waste acceptance criteria for a specific disposal facility, although the higher concentration batch by itself would not.

The Chairman's October 9, 2009, tasking memo directed that this paper address the appropriate point at which waste should be classified. As noted in Section 2.2.1, NRC regulations do not require that waste be classified until it is ready for disposal, since waste classification per 10 CFR § 61.55 is designed to protect an inadvertent intruder into a disposal site, and the "classification" at points prior to final disposal are not relevant to this objective. During handling and processing, waste concentrations may increase or decrease (and the implied "classification" may also change as a result). For example, compaction and evaporation will increase concentrations of waste. A nuclear power plant may consolidate resins in a central tank in the facility, so that some of the resins are increased in concentration, while others are reduced. A generator may want to know the concentration and the implied classification prior to undertaking these operations so that a higher waste class is not inadvertently produced.

Even though NRC regulations do not require classification of waste until it is ready for shipment to a disposal facility, NRC guidance addresses waste "classification" at points prior to shipment for disposal. NRC guidance goes beyond the regulations by implying that waste will be classified at intermediate points during collection or processing. In fact, such intermediate classification is unnecessary and thus any recommended constraint on blending through

guidance is unenforceable. These recommended constraints appear to have been designed to address the maxim, “dilution is not the solution to pollution,” even if that reason is not explicitly stated in the guidance. At the extremes, using clean material to reduce large quantities of B, C or GTCC waste to a lower class would be undesirable and discouraged. In any case, NRC guidance that discourages waste class reduction before waste is required to be classified has not been a significant issue until the recent proposals to blend resins for their disposal as Class A waste.

On balance, the staff does not believe that new requirements to classify waste prior to shipment are needed. Licensees may continue to classify waste on their own in order to manage it effectively. Of course, if the Commission wishes to restrict mixing of waste classes, classification of waste at intermediate points during collection or processing would be required. Absent such a decision, the staff does not believe that requirements to classify waste prior to shipment are needed.

2.4 Initiatives to Expand LLRW Blending

On June 30, 2008, the Barnwell disposal facility closed to most LLRW generators in the U. S. Now, only generators in the Atlantic Compact — the States of South Carolina, Connecticut, and New Jersey — are able to dispose of their waste at that facility. Although the EnergySolutions’ disposal facility in Clive, Utah, remains available for Class A waste disposal by the generators that lost access to Barnwell, these generators have no disposal option for Class B and C waste. Thus, 90 of the 104 operating reactors have to store these wastes. In addition, 18,694 of the 22,357 materials licensees are located in the 36 States[7] that lost access to Barnwell. While many of these materials licensees do not produce LLRW at all,[8] and many of those that do generate LLRW generate Class A only, some of these licensees generate Class B and C waste, particularly sealed sources.

Licensees and industry representatives are considering mixing certain LLRW to help to mitigate the impact of Barnwell’s closure. A waste processor in Tennessee is exploring the blending of ion exchange resins from nuclear power plants, which can be blended into a relatively uniform mixture. These resins, which are the focus of this company’s proposed expansion of LLRW blending, account for about half of the volume of Class B and C waste generated each year in the U.S.[9] This blending would enable some materials that would otherwise have been disposed of as Class B or C waste to be mixed with Class A waste to create a Class A mixture. A recent article by the Electric Power Research Institute (EPRI) on their LLRW classification studies (Tran, 2008) reports that Class B and C resins account for approximately 12,000 ft^3 of LLRW disposed annually, whereas Class A resins account for about 75,000 ft^3 disposed annually.[10] The article states that if resin blending was practiced, the volume of Class A resin would increase by approximately 8,000 ft^3/yr to a total of 83,000 ft^3/yr. This would leave about 4,000

[7] The 197 licensees in the District of Columbia, Guam, Virgin Islands, and Puerto Rico also do not have access.
[8] Licensees use decay-in-storage or recycle sealed sources, or both, in lieu of LLRW generation.
[9] Based on 12,000 ft^3/yr of Class B and C resins, as reported in “EPRI Takes on Low-Level Waste Disposal Issues,” *Radwaste Solutions,* May/June 2008, Vol. 15, No. 3, pp 14-21. Irradiated hardware accounts for much of the rest of Class B/C waste. Resin data covers 2003-2007. (Tran, 2008).
[10] The Barnwell disposal facility was accepting out-of-compact waste at the time these data were collected.

ft^3 of Class B/C resin to be stored (see Table 1 below). Table 2 contains the total LLRW disposed of in a year, by volume, activity, and waste class.

Waste Class	Resin Volume, ft^3/yr (unblended)	Blended Resin, ft^3/yr
A	75,000	83,000
B/C	12,000	4,000
Total:	87,000	87,000

Table 1. Disposal of blended (projected) and unblended ion-exchange resin volumes by waste class[11]

Waste Class	Volume, ft^3	Activity, Curies
A	2,640,741	8,543
B	9,152	36,057
C	14,532	1,283,321

Table 2. Total LLRW disposed in one year[12]

2.5 Revisions to Concentration Averaging CA BTP in the LLRW Strategic Assessment

In SECY-07-0180, “Strategic Assessment of Low-Level Waste Regulatory Program,” (NRC 2007b), the staff identified revisions to the Concentration Averaging CA BTP as one of seven high priority tasks. As described in that paper, the staff would “[u]pdate the CA BTP guidance by, for example, revisiting the ‘factor of 10 rule,’ allowing some blending of waste to lower the waste class, and providing needed clarification of complex sections in the CA BTP, as well as articulating the bases/rationales for the positions in these sections.” The staff noted that “. . . there is general agreement that many statements in the CA BTP are difficult to interpret and that the underlying rationales for many, if not most, are not self-evident.” The potential revisions identified in this paper are one part of the overall revisions contemplated for the CA BTP in the Strategic Assessment. This paper focuses on the blending of homogeneous waste streams, such as ion exchange resins, into a reasonably homogeneous waste form. The CA BTP also addresses mathematically averaging the concentration of radionuclides in irradiated hardware and components placed in a package, as well as encapsulation of sealed sources. The staff intends to revise and update these other areas of the CA BTP, such as encapsulation of sealed sources and mathematical averaging of irradiated hardware, after it receives direction from the Commission on blending of LLRW. No policy issues have been identified for Commission consideration at this time in these other areas of the CA BTP. Any proposed revisions to the technical positions in the CA BTP will be made available for stakeholder review and comment. If in the course of considering these other revisions any policy issues are identified, the staff will inform the Commission.

2.6 Recent Interest in Clarification of NRC Position on Blending

The staff believes that because disposal options were available for all classes of LLRW in the recent past, the agency’s positions on blending were not challenged or identified as requiring

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11 Based on an analysis by EPRI (Tran, 2008).

12 Waste volumes reported are from July 1, 2007, to June 30, 2008. Data obtained from the U. S. Department of Energy Manifest Information Management System (MIMS), http://mims.apps.em.doe.gov/.

clarification. With the closure of Barnwell, industry and licensees have begun to explore mixing of homogeneous waste streams to facilitate waste disposal, and previous staff positions that may not be based solely on risk and protection of the inadvertent intruder have come under scrutiny. In the next section, the staff identifies specific safety, policy, and regulatory issues associated with blending.

3.0 Discussion

This section identifies and discusses policy, technical (safety, security, and environment) and regulatory issues associated with blending of homogeneous wastes.

3.1 Policy Issues

How and whether NRC decides to revise its position that discourages blending of LLRW raises several policy issues, each of which is addressed in this section.

3.1.1 Past Agency Positions on Reducing Waste Class

NRC has previously taken positions that discourage and constrain the mixing of waste to reduce its waste classification. These positions are not confined to mixing with clean materials, but also include mixing of contaminated materials together, as examined in this paper. Recently revised guidance for decommissioning in NUREG-1757 (NRC 2006a) that implements the Commission decision on intentional mixing of soil in decommissioning states that mixing is permissible provided it is approved by NRC and does not alter the 10 CFR § 61.55 waste classification.

Although the CA BTP already allows for waste class reduction, which is inherently part of the mathematical averaging of waste concentrations that is currently permitted by 10 CFR § 61.55, the CA BTP does not explicitly acknowledge that such waste class reductions occur. In fact, as noted earlier, an Appendix to the CA BTP states that "the record of analyses which documents the licensee's use of concentration averaging and encapsulation practices defined in this technical position, should generally be sufficient in and of itself, to show that the averaging of concentrations *was not undertaken solely to lower the classification* [emphasis added] of any specific waste in a disposal container." This statement appears to be an artifact of earlier drafts of the CA BTP, since the statement does not appear in the CA BTP itself, and is contrary to positions in the CA BTP that in effect allow for waste class reduction. Since mathematical averaging is usually undertaken to lower the classification of discrete portions of waste, consistent with the intent of 10 CFR § 61.55(a)(8), this statement would be deleted in a future revision to the CA BTP. Nevertheless, whatever increased blending might be permitted in the future (e.g., by eliminating the "factor of 10" provision), needs to be considered in light of past NRC statements that while not prohibiting waste class reduction, at least discourage it.[13]

3.1.2 Facilitation of Disposal of Waste

[13] In a related matter, the NEI/EPRI "Guidelines for Operating an Interim On-site Low-Level Radioactive Waste Storage Facility" (NEI, 2008) notes that power reactor licensees could convert Class B and C waste to GTCC waste through volume reduction. Staff understands there are no imminent industry plans for doing so, however. Staff has not developed a position on conversion of B and C waste to GTCC but will discuss the issue with NEI and DOE. If it appears that it would be used in practice, staff would notify the Commission with a possible request for policy guidance.

A second policy issue is that increased blending would facilitate the disposal of some LLRW, rather than its indefinite, onsite storage. Some waste, such as ion exchange resins from nuclear power plants, if not blended prior to disposal would be at Class B or C concentrations, and therefore would have no disposal option if generated in one of the 36 States that lost access to the Barnwell disposal facility on June 30, 2008. Intentional blending of this waste to concentrations below the Class A limits would enable it to be disposed of at the facility that accepts Class A waste. Although LLRW can be managed safely and securely both in storage and through disposal, permanent disposal is the preferred approach.[14] Permanent disposal also eliminates the need for monitoring of the waste in storage and the associated exposures to radiation by workers in performing this monitoring.

It should be noted that reactor licensees currently remove some ion exchange resins from service before Class B and C concentrations are reached. This practice enables the continued disposal of resins as Class A, but with an increase in volume of waste. Although this practice could be viewed as contrary to the Commission's PS of Volume Reduction (NRC, 1981b), it cannot not be prohibited since a PS is not enforceable. In addition, as the staff notes in Section 3.1.5 on Volume Reduction, factors other than volume reduction affect licensees' decisions on how best to manage LLRW. Blending of higher concentration waste with lower concentrations, as discussed in this paper, would enable current practices for resin removal to continue, without an increase in waste volumes.

Large-scale blending has the potential to facilitate disposal of some ion-exchange resins in an available Class A disposal facility. At least one commenter believes that such blending would, in the long-term, exacerbate challenges to disposal of all Class B and C LLRW, as discussed below.

3.1.3 Impact on Existing LLRW Management Program

Several stakeholders have indicated that a significant reduction in Class B and C waste disposal volumes caused by expanded blending could have adverse impacts on some existing and planned waste facility operations. Forecasts of waste streams for disposal are used for determination of disposal fees, for example, and a significant reduction in Class B and C waste will potentially affect the economic viability of a planned facility, according to some commenters. These same commenters stated that reducing the Class B/C waste stream amounts through blending could make disposal of the remaining Class B/C waste more difficult. At a minimum, disposal costs would increase for this waste, since the amount of B/C waste would be smaller. In the worst case, there would be no new disposal facility for Class B/C waste because a new facility would not be economically viable after a reduction in the potential Class B/C waste stream volume. The staff notes that these arguments rely on speculation about the future. Currently, there is a new facility under development and expected to be in operation in approximately a year. The operator of the facility is authorized to accept waste from two States within its LLRW Compact. Although the operator is pursuing approval of out-of-compact waste (including large quantities of class B and C waste), whether that occurs is speculative at this time. The staff did not independently analyze the economics of the facility and the potential effect of smaller Class B/C waste stream volumes, since NRC's responsibilities as a regulatory agency are limited to ensuring protection of the public health and safety and the environment

[14] For example, Staff Requirements Memorandum for SECY-93-323, "Withdrawal of Proposed Rulemaking to Establish Procedures and Criteria for On-Site Storage of Low-Level Radioactive Waste After January 1, 1996," February 1, 1994, states, "the Commission continues to favor disposal of low-level radioactive waste over storage . . ."

and promoting the common defense and security.

Waste blending is not the only initiative being explored in an effort to establish new disposal options, or the only initiative that could potentially affect the existing LLRW disposal situation in the U.S. A recent report, “Sealed Source Disposal and National Security — Problem Statement and Solution Set” (DSFG, 2009), explores potential solutions for disposal, including use of U. S. Department of Energy (DOE) disposal facilities. The Radiation Source and Protection and Security Task Force Report (RSSPTF, 2006), mandated by the Energy Policy Act of 2005, also recommends exploration of new options for disposal of LLRW.

Another potential issue raised by State officials is the effect of increased mixing on “attribution” of waste. Attribution is the identification of the waste generator. Current practice in waste processing in some cases results in wastes being “attributed” to a waste processor (i.e., the processor is considered to be the waste generator), when, for example, distinct batches attributable to individual generators cannot easily be separated during processing. Depending upon the circumstances, blending could result in the attribution of more waste to processors, and the loss of identity of the original waste generator. Attribution is important to some LLRW Compacts that regulate the import and export of waste from the Compact borders, and require generator identification for fee determinations and exercise of their other authorities to regulate LLRW. A waste processor located within a Compact that has a regional disposal facility could conceivably accept out-of-compact waste that would then become eligible, through attribution to the processor, for disposal within the Compact. With regard to the current blending proposal by industry, the staff understands that even after the blending of wastes, the wastes will be attributed to the original generators.

NRC regulations in 10 CFR Part 20, Appendix G, address manifesting of LLRW for shipment. Waste attribution is addressed in these regulations and the Statement of Considerations for the final rule (NRC, 1995b). Agreement States are currently provided flexibility in making attribution determinations. Some States and compacts believe that NRC should establish a national attribution policy that ensures that the identity of the original generator (not the waste processor) is maintained through disposal.

3.1.4 Disposal Capacity

One stakeholder also commented that blended ion exchange resins would quickly use up existing capacity at the Class A facility that is currently operating. The stakeholder made assumptions about the amount of waste that would be blended, and compared the resulting volumes and associated number of shipments with the volumes and shipments of the same waste having been processed and volume reduced at the stakeholder’s facility. The disposal facility operator, however, provided its own estimates for remaining capacity, which were significantly different from the first stakeholder’s estimates and ranged up to many years of remaining capacity, depending upon the assumptions. The staff did not independently analyze these estimates. Capacity is affected by assumptions about future business obtained, licensing of additional disposal cells, future waste generation rates, and other factors and any conclusions about future disposal capacity by the staff would be speculative. As noted in Section 3.1.3, several initiatives are currently underway to explore expanding disposal capacity, and could result in increased capacity. Other initiatives may be started as well. For example, on February 8, 2010, a private company announced plans for a new Class A disposal facility in Utah.

3.1.5 Volume Reduction

As noted earlier, some stakeholders have argued that blending is contrary to NRC's 1981 PS on Low-Level Waste Volume Reduction. They argue that Class B/C waste that would otherwise be volume reduced through waste processing would not be volume reduced if blended with Class A waste. Among other things, they argue that the remaining disposal capacity in the U.S. would be adversely impacted. Disposal capacity is discussed in the previous section.

For this paper, the staff examined whether and how much waste volumes might be affected through increased blending of LLRW. Blending, as defined in Section 2.1, is the mixing of waste streams with higher and lower radionuclide concentrations. Thus, certain wastes such as ion exchange resins from nuclear power plants that would otherwise be Class B or C waste may be blended to Class A waste. Such blending would not result in any increase in waste volumes, since the volume of the mixture would be the sum of the volume of the parts that were mixed. However, blending waste that has Class B or C radionuclide concentrations with lower activity waste to create Class A waste could be performed instead of using some available volume reduction techniques that may otherwise have been applied to the higher activity waste. Class B and C waste may undergo volume reduction as part of the required stabilization process for these two waste classes, if a generator chooses to use an available processing option. Class A waste, because of its lower hazard, is not required to be stabilized. One commenter noted that if resins with Class B or C concentrations from U.S. nuclear plants were not mixed and were instead stabilized and volume reduced, a fivefold volume reduction could result (Studsvik, 2009). Using annual resin volumes reported by EPRI (Tran, 2008),[15] the volume increase caused by not stabilizing resins with Class B and C concentrations would be 9600 ft^3/year (274 m^3/yr), or approximately 0.36 percent of the total LLRW volume disposed of each year. If all B/C resins were to be volume reduced (contrary to current practice, by which only some of the resins are volume reduced), the 12,000 ft^3 of B/C resins would be reduced to approximately 2400 ft^3.

Notwithstanding NRC's volume reduction policy, volume reduction is widely practiced today, in large part because disposal costs have risen significantly in the last 30 years and it is economical to reduce disposal volumes. Pressurized water nuclear power plants, for example, have reduced the annual volume of LLRW disposed each year by a factor of 25 from 1980 to 2000.[16] In addition, the Volume Reduction PS is appropriately guidance, not a requirement. Licensees consider other factors, such as cost and worker exposures, in determining the optimum approach for waste management.

Given the reasons stated above, the staff believes that the PS could be updated to acknowledge that other factors in determining how waste is to be managed are appropriately considered by licensees, and to put volume reduction in context. These other factors would include cost, worker exposures, and reducing the amount of waste that would need to be stored. A revision would also acknowledge that NRC's regulatory program is risk-informed and performance-based and that NRC would consider volume reduction in that context.

3.1.6 Unintended Consequences

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[15] EPRI states that 12,000 ft^3 (340 m^3) of Class B and C resins are generated each year (Tran, 2008).
[16] Source: INPO-01-003 and 96-02, "WANO Performance Indicators for U. S. Nuclear Utility Industry".

In the public comment process, one stakeholder, representing a number of different materials licensees, cautioned NRC that unintended consequences may result if a new position is taken that further restricts blending of waste. The stakeholder noted that there are materials facilities that are blending now and that could be adversely affected by a new position. Similarly, the stakeholder noted that when new facilities for molybdenum-99 are developed in the U.S., they will produce Class B/C resins that could potentially be blended. Another commenter noted that waste processor operations and numerous other licensed operations could be significantly impacted by a rigid rule that prohibits blending.

3.1.7 Greater-Than-Class C (GTCC) Waste

Several stakeholders were concerned that a new blending position would enable GTCC LLRW to be blended to a lower waste class. A specific concern is that disposal of GTCC waste is a federal responsibility, while disposal of Class A, B, and C LLRW is the responsibility of the States.

DOE is the Federal agency that is developing disposal capacity for GTCC waste. On July 23 and 31, 2007, DOE published a Notice of Intent to prepare an EIS for the disposal of GTCC LLRW (DOE, 2007a, b). In it, DOE provides an estimated inventory of GTCC for disposal through the year 2035, divided into three categories: activated metals, sealed sources, and other types of GTCC, such as equipment, debris, trash, and decontamination and decommissioning waste. The majority of GTCC wastes falls in the first two categories, activated metals and sealed sources. Waste capable of being blended would only be included in the "other" category, and would be a subset of all of the wastes in that category. The estimated total amount of waste in this category is 0.007 percent of the total curies of GTCC waste, and 2.9 percent of the volume. The total volume of this waste (i.e., not activated metals or sealed sources) through 2035 is about 10 percent of the *annual* Class B/C LLRW volume. One of the options provided in this paper would not allow for reducing the waste class of GTCC waste, or any other class of waste. In the other options, no distinction is made between GTCC and other types of waste, in part because the amount of GTCC waste that can be blended is small in comparison to both the total amount of all classes of LLRW and to other types of GTCC.

3.2 Technical (Safety, Security, and Environmental) Issues

Technical issues are those that have a potential effect on the protection of public health and safety, security, and/or environmental protection, and that are associated with the existing CA BTP positions or potential revisions to those positions. National Environmental Policy Act (NEPA) reviews are addressed in the Regulatory Issues section (3.3). Blended waste would be subject to existing security requirements and no unique issues have been identified. Although LLRW can be safely and securely stored, blending waste for disposal would reduce the amount of LLRW in storage and thereby eliminate any safety or security risk from storage of this waste.

3.2.1 Protection of an Offsite Member of the Public

Large-scale waste blending is expected to increase the amount of radioactivity disposed of at Class A disposal facilities, but not the total volume or activity of LLRW, by increasing the volume and radioactivity of waste disposed as Class A waste. Given this expected increase, the licensee and applicable regulator must address whether the performance objectives of 10 CFR Part 61 would continue to be met. The first performance objective of 10 CFR Part 61, protection of the general population from releases of radioactivity, has historically been and would continue to be demonstrated with a site-specific performance assessment. Thus any impacts of the expected increase in the amount of radioactivity disposed of at a Class A facility to an off-site member of the public would be addressed in a site-specific analysis.

3.2.2 Intruder Protection

The second performance objective in 10 CFR 61 is protection of individuals from inadvertent intrusion. Unlike the performance objective for protection of the general population from releases of radioactivity, discussed in the previous section, protection of an inadvertent intruder is not necessarily typically demonstrated with a site-specific analysis. Instead, the safety of an inadvertent intruder is typically ensured by the waste classification system and the disposal requirements imposed for each class of waste. Some waste streams different from those analyzed in the technical basis for 10 CFR Part 61 would need to be considered in the technical analyses required under § 61.13, including a site-specific evaluation for intruder protection.

The connection between the waste classification system and protection of an inadvertent intruder originated in the development of the waste classification tables in 10 CFR 61.55(a). In the DEIS for Part 61, when it was initially developed, analyses were done for several “generic” waste sites with different characteristics to evaluate the impacts of waste disposal on an off-site member of the public and an inadvertent intruder. The case that most limited the radionuclide concentrations in waste, rather than the total amount of radioactivity that could be disposed, was protection of an inadvertent intruder. Thus the concentration-based waste classification tables in 10 CFR 61.55 were ultimately designed to protect an inadvertent intruder.

Consistent with the development of the waste classification system, the technical analysis requirements in 10 CFR 61.13(b) specify that analyses of the protection of individuals from inadvertent intrusion must include a demonstration that there is reasonable assurance the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided. Unlike the requirements of 10 CFR 61.13(a) and § 61.41, which address protection of the general population from releases of radioactivity, no specific dose limit is set in the performance objective or technical requirements for protection of an inadvertent intruder. Whereas the safety of the off-site member of the public is addressed in a site-specific performance assessment demonstrating specific dose limits will be met, the safety of the inadvertent intruder is typically expected to be ensured by the waste classification system and the disposal requirements imposed for each class of waste. Thus, any inconsistency between waste disposal practices and the assumptions underlying the development of the waste classification tables in 10 CFR 61.55(a) are of greater concern regarding protection of an inadvertent intruder than they are with respect to protection of the general population from releases of radioactivity. Protection of the general population is ensured through a site-specific assessment and does not rely directly on the waste classification system.

Blended waste was not considered during the original development of the NRC waste classification system. Furthermore, there are some important differences between blended wastes and the waste streams addressed in the Part 61 DEIS analyses. One major consideration is that, in the original analysis supporting the waste classification system, NRC assumed that not all of the waste encountered by an inadvertent intruder would be present at the classification limits. That is, the staff assumed that any waste at the concentration limits would be mixed with a significant amount of waste with radionuclide concentrations far below the class limits. Thus, a waste stream that is blended so that a significant fraction of the waste that an inadvertent intruder could encounter is near or at the Class A limit is different from what NRC considered in the original analysis.

One commenter raised the concern that because a waste stream consisting primarily of waste at or just below the Class A limit was not evaluated in the Part 61 DEIS analysis supporting the waste classification system, it would be inappropriate to assume that the current waste classification system is protective of an intruder encountering a significant volume of waste blended to the Class A limit. The commenter submitted an analysis estimating the dose to an inadvertent intruder who encountered waste blended to the Class A limit, unmixed with lower concentration waste. The commenter assumed the intruder encountered the waste in an "intruder-agriculture" scenario as described in NRC staff's "Update of Part 61 Impacts Analysis Methodology," NUREG/CR-4370 (NRC, 1986). Specifically, the commenter assumed that 100 years after site closure, institutional controls have ceased to be effective and a residence is constructed on the waste site. To construct the house, 600 m^3 (21,200 ft^3) of material, including 200 m^3 (7060 ft^3) of waste and 400 m^3 (14,100 ft^3) of a clean cover, is assumed to be excavated and spread within 25 m (82 ft) of the house. The analysis assumes that all 200 m^3 (7060 ft^3) of waste exhumed is at the Class A limit (on a sum-of-fractions basis) and is dominated by Cesium-137 (Cs-137). Actual blending proposals may involve quantities of waste at the Class A limit less than the 200 m^3 (7060 ft^3) used in this conservative analysis. The analysis also implicitly assumes that at 100 years after waste site closure, the blended waste is unrecognizable and presumed to be soil. The commenter's analysis indicates that, based on these assumptions, which are not consistent with the more protective disposal methods used to dispose of waste near the Class A limits at the operating LLRW sites, an intruder living in the house and consuming food from an on-site garden would receive a dose significantly greater than 5 mSv/yr (500 mrem/yr).

Independent analyses performed by NRC staff, also based on the "intruder-agriculture" scenario described above and in NUREG/CR-4370, indicate that, in the unlikely case that a house is constructed on a disposal site such that all of the waste exhumed (200 m^3 [7060 $ft^{3]}$) is at the Class A limit, an intruder living in the house around which the waste is spread could receive an elevated dose. In this hypothetical case, which is not representative of the manner in which waste at the upper limit of Class A concentrations is actually disposed at the operating LLRW sites, the disposal would not meet the 10 CFR § 61.42 performance objective for protection of individuals from inadvertent intrusion. However, because the requirement to conduct a site-specific inadvertent intruder analysis is not specifically identified in 10 CFR Part 61 and may not be well understood, there is a concern that applicants or licensees could misinterpret the regulations to only require compliance with the concentration limits in the waste classification tables for ensuring protection of the intruder, as required by 10 CFR § 61.42. As a result, there is a concern that disposal of a significant amount of waste at the Class A disposal limit under the minimal disposal requirements for Class A waste imposed by 10 CFR 61 could cause an unacceptable dose to an inadvertent intruder.

Currently, LLRW disposal facility licensees meet additional requirements, beyond the minimum disposal requirements of 10 CFR 61, (e.g., requirements addressing waste stabilization, disposal depth, or engineered barriers) that ensure that an inadvertent intruder is protected from waste at or just below the Class A limits. For example, an operating facility in Utah plans to dispose of waste near the Class A limit at more than 5 m (16 ft) depth, which would significantly limit the amount of waste an intruder would be expected to encounter, because 5 m (16 ft) is deeper than typical residential construction depths. This facility also plans to dispose of waste near the Class A limit in containers, rather than as bulk waste, which would help to maintain a recognizable waste form, thereby limiting the expected intruder exposure. A new facility in Texas disposes of all commercial LLRW, including Class A waste, as containerized, rather than bulk waste. The facility is required by Texas regulation (30 TAC §336.730(b)(3)) to dispose of all containerized waste more than 5 m (16 ft) below the top surface of the cover or with intruder barriers that are designed to protect against an inadvertent intrusion for at least 500 years. As previously discussed, disposal at greater than 5 m (16 ft) is expected to significantly reduce exposure of an inadvertent intruder. Similarly, an intruder barrier lasting 500 years would protect an intruder by allowing radioactive decay of short-lived radionuclides, which are expected to dominate the ion-exchange resins that represent the majority of Class B/C waste amenable to blending. The staff's preliminary independent analysis indicates that current practice at these, and possibly other, disposal facilities may safely accommodate an increase in the amount of disposed waste at or just below the Class A limits. Site-specific intruder analyses could be used to confirm protection of individuals from inadvertent intrusion at these sites.

Blended wastes are not unique in their potential to have radionuclide concentrations at or just below the Class A disposal limits. For example, it is possible that resins in an operating nuclear power plant could be removed when they get close to the Class A limits for waste disposal rather than remaining in service longer and reaching Class B or C concentrations. Such resins could be similar to blended wastes in that both would be different from the DEIS assumptions for waste streams, and both could be near the Class A limits. However, the specific concern with proposals for large-scale blending is that significant fractions of waste in one area in a disposal facility, corresponding to a large shipment of blended waste, could have radionuclides at or just below the Class A disposal limits. This configuration would pose a greater risk to an inadvertent intruder than smaller batches of waste with the same radionuclide concentrations because the intruder would be more likely to exhume a significant volume of waste near the Class A limit unmixed with lower concentration waste. While other waste streams, such as ion exchange resins kept in service until they reach concentrations near the Class A limit, could have similar radionuclide concentrations, they are less likely to pose the same risk to an inadvertent intruder because they are expected to be disposed in smaller quantities in physical proximity to other, lower-concentration wastes, and to be mixed with those wastes if exhumed by an intruder.

In addition to the potential for blended wastes, there have been other changes in waste streams and disposal practices in the last 30 years as well. For example, as previously discussed, LLRW disposal facility licensees currently meet disposal requirements that are more stringent than the minimal disposal requirements assumed in the Part 61 DEIS or NRC staff's "Update of Part 61 Impacts Analysis Methodology" (NUREG/CRR-4370). In addition, the original analysis in the DEIS that supported the development of the waste classification tables in 10 CFR 61.55(a) used ICRP 2 dose methodology, while a new analysis would use a more modern dose methodology. A requirement for a site-specific intruder analysis would ensure that the inadvertent intruder continues to be protected, independent of inconsistencies with the assumptions underlying the waste classification tables in 10 CFR § 61.55(a).

3.2.3 Waste Characterization and Homogeneity

Blended waste would need to be sufficiently uniform in concentration after blending so that any "hot spots" or inhomogeneities would not affect protection of an inadvertent intruder. Some averaging of radionuclide concentrations is permitted in accordance with 10 CFR 61.55(a)(8), which states that the concentration of radionuclides may be averaged over the volume or weight of the waste. The CA BTP, which was developed to provide guidance on the implementation of

10 CFR 61.55(a)(8), states that the classification of a mixture should be based on either (a) the highest nuclide concentrations in any of the individual waste types contributing to the mixture, or (b) the volumetric or weight-averaged nuclide concentrations of the mixture, provided that the concentrations of the individual waste type contributors to the mixture are within a factor of 10 of the average concentration of the resulting mixture. While the "highest nuclide concentrations" provision is clearly conservative and relatively easy to apply (and thus requires no further explanation or rationalization), it is not often used.

The rationale for the "factor of 10" provision, which is often used by industry, is not given in the CA BTP. However, it appears to accomplish two goals. First, because the difference in allowable concentrations of long-lived radionuclides (as given in Table I of 10 CFR 61.55(a)) for Class A and Class C waste is also a factor of 10, the guidance in the CA BTP on mixing of homogeneous wastes, in effect, places a limit on the extent to which Class C waste can be blended with Class A material. While this accomplishes the goal of placing limits on mixing, it has no direct relationship to protection of public health and safety. Second, the factor of 10 in effect provides limits on the heterogeneity of the final waste form. The CA BTP does not specifically identify criteria for the homogeneity of the final form, except to define a "homogeneous waste type" as one in which the radionuclide concentrations are likely to approach uniformity in the context of intruder scenarios used to establish the concentrations for the waste classification system. The factor of 10 criterion provides assurance that the concentration variation in the final waste form will be within certain limits. In this respect, it is notable that the staff's Technical Position on Radioactive Waste Classification (NRC, 1983) states that a factor of 10 is "…a reasonable target for determining measured or inferred [radionuclide] concentrations…" in the waste, given physical limitations in the waste and resultant ". . . difficulties in obtaining and measuring representative samples at reasonable costs and acceptable occupational exposures."

By limiting heterogeneity, the "factor of 10" criterion helps to provide for protection of an inadvertent intruder into a disposal site for materials that cannot be blended or mixed into a final homogenous mass. Solid materials of varying concentrations are frequently "mixed" or packaged in a container for disposal. For wastes that can be mixed or blended into a relatively homogeneous mixture, the "factor of 10 rule" could be replaced with a performance-based criterion for final homogeneity of the waste form. In fact, a "factor of 10 rule" might be appropriate, as a performance-based approach, if applied to the final mixture rather than being applied to component wastes before they are mixed. Such an approach would enable mixtures with radionuclide concentrations that vary by more than a factor of 10 to be mixed, would be consistent with performance-based regulation, and would still provide for protection of an inadvertent intruder into a disposal facility.

Several stakeholders commented on this issue during the public meetings. The concerns are that it would be difficult to mix the waste so that it would be homogeneous enough that all of the waste was actually below the Class A limits, and it would take far more radiological characterization than is currently typically performed to show that the waste really meets all the applicable radionuclide limits. This raises a potential concern for an inadvertent intruder, who may hit "hotspots" of waste that is insufficiently blended and disposed of as Class A waste without the additional protections required of Class B and C waste. Some commenters expressed concern that, because of the need for more thorough waste characterization, there may be an increase in cumulative worker dose. An opposing argument was posited suggesting that there would be no significant increase in worker dose because a blending facility would be specially designed for blending and characterization activities and would be able to achieve worker doses lower than doses to workers characterizing waste in plants, where the same protections may not be in place. In either case, the 10 CFR Part 20 provisions for worker protection and keeping radiation exposures as low as is reasonably achievable would apply and would ensure safety.

With respect to ensuring appropriate homogeneity, as discussed in Section 2.2.2, it may be appropriate to ensure that requirements for homogeneity are consistent with allowances for

mathematical averaging, as permitted by 10 CFR 61.55(a)(8). For example, it may not be risk-informed to require that blended wastes have variations of no more than 2 or 3 in final radionuclide concentrations if mathematically averaged wastes could have radionuclide concentrations varying by a factor of 10. To impose homogeneity requirements stricter than variations allowed by mathematical averaging would be essentially equivalent to prohibiting mathematical averaging from being applied to the final blended wastes. As discussed in Section 2.2.2, it may be appropriate to prohibit mathematical averaging from being applied to blended waste based on the need to keep doses as low as reasonably achievable, because it is expected that blended wastes could be blended to a greater homogeneity whereas discrete wastes to which mathematical averaging typically is applied cannot.

In either case, risk-informed requirements for homogeneity would require that wastes be reasonably homogeneous in the context of an intruder scenario, in which a certain amount of mixing is assumed to occur. For example, if the minimum amount of mixing that could reasonably be assumed to occur during intrusion would occur if an intruder contacts waste by drilling a well and spreading drill cuttings on the land, there is no need to impose requirements that waste be homogenous on a smaller scale than the drill cutting volume, because an intruder will not encounter a “hotspot” smaller than the drill cutting volume.

Irrespective of whether NRC allows mathematical averaging to be applied to physically blended waste, the effect of mathematical averaging on waste classification will naturally be limited in a waste stream in which the radionuclide concentrations in the bulk of the waste are near the limits for a waste class. For example, in a waste stream predominantly near the Class A limits, very few sub-sections of waste could be present measurably above the Class A limits before the average radionuclide concentrations would be greater than the Class A limits on a sum-of-fractions basis. Compared to a lower-concentration waste stream in which more variation could be tolerated before the average concentration exceeded the limits, more thorough characterization of blended waste may be necessary to have reasonable assurance that smaller sub-sections of the waste did not elevate the average concentration above the Class A limits. Thus, it appears that it would be more challenging for licensees to determine that wastes close to the concentration limits for Class A waste are compliant with those limits than it is to show that typical Class A waste, which is further below the Class A limits, meets the requirements. Additional guidance may be appropriate.

3.2.4 Stability

For a 10 CFR Part 61 disposal facility, “stability,” or the ability of the site and the waste to retain its physical form and to not erode, is one of the four performance objectives (10 CFR 61.44). A stable waste form provides additional protection to an intruder, because stabilized, non-dispersible waste forms are more likely to be recognized by an inadvertent intruder, thus limiting intruder contact with the waste and thereby limiting radiation exposures. In addition, a stable waste form may also contribute to the overall stability of the waste disposal site. A problem encountered in early radioactive waste disposal facilities was slumping, or the "bathtub effect" whereby buried unstable wastes collapsed, causing voids and hollows in the disposal facility cover that collected rainwater and increased infiltration of water into the disposal trenches. 10 CFR Part 61 addresses this potential problem by requiring that Class B and C waste be stabilized. Class A is not required to be stabilized (nor is it prohibited from being stabilized) because of its lower concentration. Stabilization can be beneficial in limiting contact of the waste with water that might be present and that could increase the dissolution of radionuclides.

Blending could reduce the amount of stabilized waste disposed at a LLRW facility that accepts A, B, and C waste because some waste that would otherwise be stabilized Class B or C waste could be disposed of as unstabilized Class A waste. A disposal facility licensee would need to verify that the performance of the facility receiving less stabilized waste continued to meet the 10 CFR Part 61 performance objectives, particularly the 10 CFR 61.41 objective that limits offsite releases of radioactivity, since stability may contribute to immobilization of the waste. Such verification is routinely performed to ensure that a disposal facility can safely isolate the actual types and amounts of waste received. In addition, Agreement State regulatory agencies typically require existing disposal sites to provide engineered barriers, even for Class A waste, that will help provide stability not required by 10 CFR Part 61 for Class A waste.

3.3 Regulatory Issues

3.3.1 Method of Issuing NRC Position on Blending

If NRC were to revise its position on blending, the new position could be promulgated in a rulemaking, guidance, or a combination of the two. Revisions to the guidance can be accomplished more quickly and with fewer resources than a rulemaking. A rule, however, is enforceable and could, with the appropriate compatibility designation for Agreement States (such as Category B), provide for a uniform approach to blending in the U.S. Most U.S. licensees, including waste processors that are likely to perform blending, as well as disposal facility operators, are located in Agreement States. A compatibility category of B means that the States will have to adopt essentially the same provisions as NRC because of significant direct trans-boundary implications. Currently, the existing provisions in 10 CFR Part 61 relating to waste classification, including concentration averaging, are compatibility category B. Such a designation would help to ensure consistency between processors and disposal facilities. A final determination on compatibility for any new requirements would be made as part of the rulemaking process.

One State already has a regulation that is different from existing NRC guidance on blending and concentration averaging. The staff understands that this State provision is based on a hazardous waste provision in the State's regulations. The regulation states the following:

> "No person shall reduce the concentration of radioactive constituents by dilution to meet exemption levels . . . or change the waste's classification or disposal requirements. Radioactive material that has been diluted as a result of stabilization, mixing, or treatment, including, but not limited to, Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions (LDR) treatment, or for any other reason, *shall be subject to the disposal regulations it would have been subject to prior to dilution*." [emphasis added].

The blending provisions contained in a rulemaking would vary depending upon the option chosen by the Commission (see Section 8.0 for a discussion of the options). With respect to guidance, three different types were discussed in meetings with stakeholders, and have been considered by the staff. Several stakeholders recommended that NRC issue a Regulatory Issue Summary (RIS) that describes and references NRC blending positions. The RIS would include references to the CA BTP and to the three letters sent by NRC staff to industry stakeholders in late 2009 to clarify positions in the CA BTP. A RIS may be used, among other things, to announce staff technical or policy positions not previously communicated to industry or not broadly understood. A RIS does not have to be noticed for public comment.

The Commission's 1981 Volume Reduction PS could also be revised to address issues that have arisen in public meetings on blending. Section 2.2.4 of this paper describes the origin of this PS. Since the PS was issued, nuclear power plant licensees have significantly reduced the amount of LLRW generated and disposed of. From 1980 to 2000, pressurized water reactor licensees in the U.S. reduced the volume of LLRW by a factor of 25.[17] In addition to the PS's endorsement of volume reduction, the cost of disposal has been an incentive to reduce volumes. Given the success in volume reduction by industry, the staff believes that the PS could be updated to recognize the progress that has been achieved, and to acknowledge that other factors may be used by licensees in determining how best to manage their LLRW. Although volume reduction has never been the sole consideration of licensees in managing waste, comments by stakeholders on the blending issue did not always recognize that other factors affect licensee's decisionmaking. This point could be documented in a revision to the PS. Specifically, the PS could be revised to acknowledge that volume reduction continues to be important, but that risk-informed, performance-based approaches to managing waste are also appropriate in managing LLRW safely and that volume reduction should be evaluated in this light. The PS could also acknowledge that licensees may consider cost and operational efficiency in their decisionmaking on waste management. Dated material would also be removed, such as references to an increase in the applications to implement waste processing systems.

A third guidance document that addresses blending is the CA BTP. Section 2.2.2 describes the scope of the document, and its guidance on LLRW blending. Although this guidance has been used successfully by licensees for many years, the staff plans to update it to, at a minimum, clarify terms, and better describe the bases for its positions. In addition, the staff may have to make other changes to the CA BTP to conform to whatever option the Commission chooses for a blending position. For example, a risk-informed, performance-based blending policy would eliminate the constraints on blending in the CA BTP, such as the "factor of 10 rule."

3.3.2 National Environmental Policy Act

In public meetings and formal written comments, several stakeholders recommended that NRC undertake a NEPA analysis to evaluate the impacts of large-scale blending at a LLRW processing facility. Specifically, one commenter argued that the radiation exposure impacts of large-scale blending in comparison with other alternatives needed to be evaluated, and the approach with the lowest dose to the public should be chosen.

In developing the disposal regulations in 10 CFR Part 61, NRC prepared an EIS. As noted in the final EIS (NRC, 1982), NRC had a two-fold purpose in preparing the final EIS. The first

[17] Source: INPO-01-003 and 96-02, "WANO Performance Indicators for U.S. Nuclear Utility Industry.

purpose was to fulfill NRC's responsibility under the NEPA Act of 1969 (i.e., to prepare an EIS for a major Federal action). Second, NRC prepared the final EIS to document the decision processes applied in the development of Part 61. NRC analyzed alternative courses of action and requirements were selected with consideration of costs, environmental impacts, and health and safety effects to current and future generations. These alternatives were based on LLRW practices at the time, some of which have changed since then. The final EIS noted that it was a generic EIS in that it did not analyze all of the issues involved in the disposal of LLRW. Rather, the final EIS provided the decision analysis for requirements in Part 61 that were developed at that time.

A NEPA evaluation would be required if NRC were to promulgate a rulemaking on blending. Either an EIS or environmental assessment (EA) would be developed, depending upon the scope of the rulemaking. An EIS would be required if there were a major NRC action significantly affecting the quality of the human environment. Issuance of a PS or other guidance document would not constitute a major Federal action and no NEPA reviews would be needed. In this paper, three of the options are rulemakings and would require a NEPA analysis. Changes in practice resulting from specific licensing actions in Agreement States do not require that NRC perform a NEPA analysis.

3.3.3 Applicability to Waste Processors

As a result of industry's consideration of large-scale, offsite blending, several stakeholders raised questions about the applicability of the staff guidance in the CA BTP to waste processors. Waste processors are not specifically discussed in the CA BTP, which is addressed to "all NRC licensees." The text of the CA BTP also uses the term "licensees," which would include waste processors. In its three letters to industry in late 2009 the staff affirmed that that the CA BTP applies to waste processors, in addition to licensees that generate waste, such as nuclear power plant operators. The CA BTP also contains positions that are useful to and needed by processors in averaging and blending of LLRW.

Large-scale blending of waste that has Class B or C concentrations of radionculides with lower activity waste to result in Class A waste at a waste processor could be viewed as tantamount to blending for the purpose of lowering the waste classification, if not solely for this reason, then at least primarily. NRC guidance for other programs has discouraged blending for the sole purpose of reducing the waste classification. While the staff has clarified in its recent letters that the current guidance for LLRW blending in the CA BTP applies to waste processors, this paper contains an option that would prohibit large-scale blending at waste processing facilities if the Commission wishes to revise the current blending position.

4.0 Analysis of Issues in Chairman's Tasking Memo

Chairman Jaczko, in an October 8, 2009, memorandum to the NRC staff, requested a vote paper that discusses five different topical areas. These are identified below, along with the sections of this paper that address each.

4.1 Issues related to intentional changes in waste classification due to blending, including safety, security, and policy considerations.

Policy and safety and security issues are addressed in Sections 3.1 and 3.2 respectively.

4.2 Protection of the public, the intruder, and the environment.

These issues are addressed in Section 3.2 and in the options presented in Section 8.0.

4.3 Mathematical concentration averaging and homogeneous physical mixing.

This topic is addressed in Section 2.2.2.

4.4 Practical considerations in operating a waste treatment facility, disposal facility, or other facilities, including the appropriate point at which waste should be classified.

This topic is addressed in Section 2.2.1, "Regulations addressing waste classification, protection of an inadvertent intruder, and blending," Section 2.2.2, "NRC Guidance on blending of LLRW," and Section 2.3, "Practical considerations." The staff believes that waste should continue to be classified when it is ready for disposal, consistent with purpose of waste classification, which is to help to provide for the safety of an inadvertent intruder at a disposal facility. The staff has also provided an option, however, (Option 3) that requires classification to be based on the concentration before any dilution or blending.

4.5 Recommendations for revisions, if necessary, to existing regulations, requirements, guidance, or oversight related to blending of LLRW.

These topics are addressed in Section 9, "Conclusions and Recommendations," and Section 8.0, "Options." With respect to oversight, the staff has recommended that until a rulemaking or revisions to guidance are completed that the applicable regulators authorize disposal of blended waste from large-scale waste processing using case-specific approvals for individual sites. NRC staff is publishing interim guidance on how site specific intruder performance assessments may be done. The staff believes that existing licensing and inspection programs of NRC and Agreement State regulators will be adequate to oversee any blending operations. In addition, NRC staff will continue to implement the Integrated Materials Performance Evaluation Program to review Regional and Agreement State programs.

5.0 Stakeholder Views

The staff solicited stakeholder input in developing this paper. On November 30, 2009, the staff issued a *Federal Register* notice requesting public comments on LLRW blending. Fourteen organizations and individuals provided comments. In December 2009, the staff met individually with three companies that had written to NRC expressing their views on LLRW blending. The meetings were open to the public, and opportunities for public comment were provided. On January 14, 2010, the staff held an all day public meeting in Rockville, Maryland, to provide the public with an opportunity to comment on LLRW blending. Stakeholders commenting at the meeting included representatives from States and compacts, advocacy groups, the waste processing industry, waste generators, and DOE. The staff reviewed and considered all of the comments received in developing this paper.

Stakeholders hold a wide variety of views on blending, and there was significant controversy about the appropriate policy for blending in the public meetings. Appendix B lists the organizations that commented on the November 30, 2009, *Federal Register* Notice soliciting public comments, the accession number for the letters received in response to the notice, the presentations given in the four public meetings, as well as a transcript of the January 14, 2010, public meeting. Most of the issues addressed in this paper were identified and discussed in the public meetings. They include the potential safety impacts of large-scale blending, the impact of blending on LLRW volume reduction, how NRC's blending position should be documented (i.e., whether in guidance or rulemaking), and the potential unintended consequences of a new NRC blending position. In a related matter, bills were recently introduced into the Senate and House of the Tennessee General Assembly that would require waste processors to classify waste after processing as the highest classification that any of the radioactive materials would have had if such radioactive materials had been classified prior to processing (Tennessee, 2010).

The staff intends to prepare and implement a communication plan after the Commission decides on an option to help ensure that NRC's position, its bases, and the process for policy development are understood.

6.0 Agreement State Views

In preparing this paper, the staff consulted with Agreement States that are significantly involved in the regulation of waste processing and disposal facilities. The staff reviewed the contents of the paper with the Agreement States of Washington, South Carolina, Texas, Utah, Tennessee, and Pennsylvania. States were generally satisfied with the issues addressed and the options presented for Commission consideration. One State official was concerned that joining the need for a site-specific intruder assessment with the unique waste streams rulemaking would delay that effort. Another noted that assuring homogeneity is more important for large-scale blended waste than for smaller amounts from individual generators, because it will be closer to the limits for Class A waste. Some States, but not all, argued for flexibility in implementing any new regulations on blending. Texas in particular has a regulation that addresses waste dilution and believes that any NRC regulation on blending should allow their existing regulation to remain in place. A related issue for this State is its concern about ensuring that out-of-State generators that might dispose of waste in the State disposal facility comply with their dilution regulation. The staff will have further discussions with Texas on this issue.

Two of the above States also commented formally on blending in response to the staff's *Federal Register* Notice of November 30, 2009. Utah (Finerfrock, 2010), among other comments, is opposed to blending if the intent is to alter the waste classification for the purposes of disposal site access. For allowable blending, the State believes that requirements should be contained in performance-based regulations addressing sampling and radiological characterization standards. The Pennsylvania Department of Environmental Protection (Janati, 2010) also provided comments in a January 28, 2010, submittal. The Department would not oppose intentional blending of LLRW if it results in a change of classification of waste to a lower classification and only for access to a LLRW disposal facility and not for release to the environment. The Department also recommended that NRC clearly define blending (and to prohibit dilution). The State also believes that the original generator of blended waste should be maintained in records, and that an evaluation of the potential benefits and risks associated with blending be conducted.

In the January 14, 2010, public meeting, a representative from the Tennessee Department of Environment and Conservation had no technical opinion on blending. The representative noted that if large-scale blending was determined to be commercially viable, their responsibility is to license a blending operation if protection of public health and safety and the environment are demonstrated.

The Utah and Pennsylvania comments can be found in ADAMS under the accession numbers identified in Appendix B of the Enclosure. The Tennessee comments are contained in the transcript for the January 14, 2010, meeting, which is also listed in Appendix B.

7.0 International Guidance and Practice

The International Atomic Energy Agency (IAEA) has issued statements in its publications that address dilution of waste. IAEA does not explicitly address the blending of already contaminated materials into a homogeneous form for disposal in a licensed facility, the topic of this paper.

- An IAEA Safety Series publication (IAEA, 1995) states that **"**[s]afe radioactive waste management includes keeping the releases from the various waste management steps to the minimum practicable. The preferred approach to radioactive waste management is concentration and containment of radionuclides rather than dilution and dispersion in the environment." This provision recognizes that dilution is appropriate at times (i.e., there is no prohibition on it). It also addresses release to the general environment, rather than disposal of blended (or even diluted) materials in a licensed facility, and does not address whether both clean and contaminated materials are covered.

- The IAEA Safety Standard addressing exemption and clearance of radioactive materials (IAEA, 2004) states:

  "Deliberate dilution of material, as opposed to the dilution that takes place in normal operations when radioactivity is not a consideration, to meet the values of activity concentration given in Section 4 [the release limits], should not be permitted without the prior approval of the regulatory body." This provision applies to the release of materials to the general environment, not disposal in a licensed facility, and appears to allow the mixing of clean material with contaminated materials. The document does not define the term, "dilution" but the context suggests clean materials are not excluded.

- IAEA's Safety Guide No. GS-G-3.3, "The Management System for the Processing, Handling, and Storage of Radioactive Waste" (IAEA, 2008), states that "[l]imits may need to be established on the distribution of activity within a container to control surface dose rates and to prevent criticalities. Where required, these limits should be derived from the safety and EA of the disposal facility. They should reflect the need to reduce the dilution and dispersion elements of radioactive waste management, which is justifiable on environmental and economic grounds. The waste form should not be artificially manipulated by dilution, or by insertion of concentrated sources into a non-radioactive matrix, for the express purpose of compliance with activity limits alone." The guide appears to use the term "dilution" to refer to mixing of uncontaminated materials and "dispersion" to a practice that increases the volume of the contaminated materials. Thus, it is not directly applicable to blending as defined in this paper. Its acknowledgement of safety, environment, and economics as factors in decisionmaking is conceptually similar to NRC's current guidance that recommends constraints on blending, while at the same time stating that "operational efficiencies" may justify it.

A review of statements made by some Member States in their National Reports prepared under the terms of the "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management" (IAEA, 1997) indicates that a few of the Member States with mature nuclear programs have expressed national policies consistent with the IAEA guidance noted above. For example, the German National Report to the 2nd Review Meeting of the Joint Convention (FRG, 2005, p 80) states, “Deliberate mixing or dilution of the materials in order to achieve clearance is not permitted.” Likewise, the French National Report (ASN, 2005, p 101) states “Introduction of this restrictive criterion [regarding total quantities and concentrations of radionuclides] is meant to avoid the risk of dilution of radioactive material in order to fall below the exemption threshold.” In both of these cases, the dilution restriction focuses on preventing the dilution of waste for the purpose of achieving exemption or clearance levels of radionuclides. The staff was unable to identify any Member States’ National Report that addresses the subject of blending of radioactive waste materials as described in this report (i.e., the mixing of wastes with higher and lower radionuclide concentrations).

8.0 <u>Options for Blending Policy</u>

This section discusses options concerning regulatory actions that NRC could undertake regarding blending of different types and classes of LLRW. They range from maintaining the status quo, to constraining all blending to eliminate any reductions in waste classification, to a risk-informed, performance-based approach. Each option also includes a discussion of how it can be effectively implemented, in the staff’s view (i.e., whether by rulemaking or guidance). In developing these options, the staff’s goal was to provide the Commission with a broad range of options for a policy on blending, and to identify an appropriate means to implement the policy.

The staff considered whether an option to specifically address blending and the conditions under which it may be performed in a rulemaking should be presented, as several stakeholders had suggested. Option 1 is to maintain the status quo of using only guidance for addressing blending. Option 3 (Further Constrain Blending) is a rulemaking that in effect prohibits blending, or at least any benefits to a licensee from blending. Option 4 is a rulemaking that would prohibit large-scale offsite blending. Option 2 (risk-inform, performance-based blending) would be implemented through a combination of rulemaking and guidance. Only one aspect of blending would be addressed in the rule itself, the need for a site-specific intruder analysis for blended waste. Other blending issues, such as homogeneity of the blended waste, would be addressed in the guidance. An advantage of Option 2 is that the “unique waste streams” rulemaking is already underway and it addresses the need for a site-specific intruder performance assessment. If some additional blending criteria not included in the ongoing unique waste streams rulemaking, such as homogeneity, were determined to be best addressed in a rulemaking, rather than guidance they could be addressed in the rulemaking to risk-inform the waste classification system in 10 CFR 61.55. That rulemaking was initiated by the Commission in the Staff Requirements Memorandum for SECY-08-0147 (NRC, 2008b).

In evaluating the options, the primary criterion used by the staff was whether the option ensures safety, security, and protection of the environment. In addition, the Organizational Excellence objectives of openness and effectiveness in the NRC Strategic Plan (NRC, 2008a) were also considered. Openness means that NRC appropriately informs and involves stakeholders in the regulatory process. Effectiveness means that NRC actions are high quality, efficient, timely, and realistic, to enable the safe and beneficial use of radioactive materials. Among the strategies for achieving these objectives that are relevant to LLRW blending are the use of risk-informed, performance-based regulatory approaches, giving consideration to the burden on Agreement State programs, and ensuring that NRC guidance is up-to-date.

Option 1: Maintain current NRC positions on blending of homogeneous waste streams (status quo).

Under this option, the Commission would not change its existing positions on the use of blending as discussed in the CA BTP. This policy places constraints on blending through the use of the "factor of 10 rule," which limits mixing of homogeneous waste streams to batches of waste that are within a factor of 10 of the average concentration after mixing. But the staff position also acknowledges that blending is appropriate without the constraints of the CA BTP if it results in operational efficiencies or worker dose reductions. Figure 8.1 is a logic diagram for the current CA BTP provisions relating to the blending of homogeneous waste types that can be mixed into a uniform final mixture.

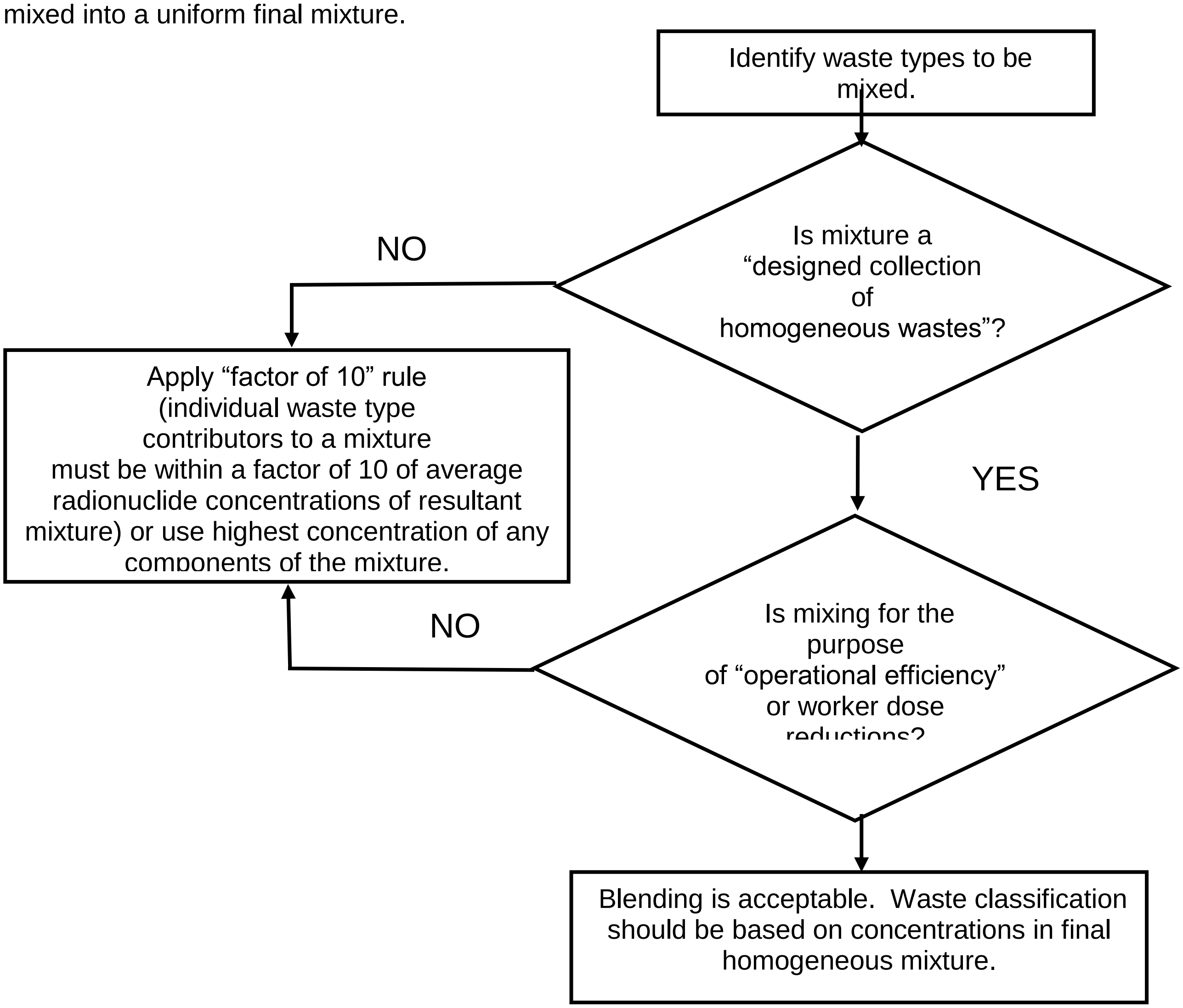

Figure 8.1 Logic diagram for current NRC blending position.

NRC staff's three letters to industry in late 2009 provide additional clarification on blending, and these clarifications are also part of the status quo. These letters include the following clarifications:

- Blending is not prohibited nor explicitly addressed in NRC regulations.

- While the staff has stated that wastes should not be mixed *solely* to lower the waste classification, NRC guidance acknowledges that blending, including some blending that may lower the waste classification, may be appropriate under certain circumstances.

- Waste classification is related to the safety of the disposed waste, and NRC regulations do not require waste to be classified prior to its shipment for disposal.

- NRC's blending positions apply to all NRC licensees, including waste processors.

This option would be implemented by clarifying the CA BTP and issuing a RIS that documents staff positions in recent letters to industry. For the CA BTP, the staff would simply clarify terms, and better describe the bases for its positions.

Pros:

- Maintains status quo in regulatory framework. Licensees and Agreement States are familiar with the current averaging provisions in the CA BTP and use them extensively.

- Guidance will take significantly fewer resources to develop than a rulemaking.

- Guidance can be developed more quickly than a rulemaking (approximately a year less time).

- Guidance provides more flexibility for Agreement States (stakeholders disagree on whether this is a pro or con, however).

Cons:

- This option could lead to inconsistent treatment of LLRW that could vary according to where the waste is generated, processed and/or disposed. Waste blended and classified in accordance with the requirements of the State in which the generator is located may not be accepted for disposal at a site in another State that has adopted different waste classification and blending criteria.

- Guidance is not binding and cannot be used to enforce a Commission policy.

- Guidance would not trigger a NEPA review, an action some stakeholders believe is necessary.

- The existing positions are not risk-informed and performance-based.

- The rationales for positions are based on a combination of practicality, ALARA, policy, and safety. These sometimes conflicting goals create a position difficult to understand that results in diverse outcomes, ranging from no guidance being specified on blending criteria in the CA BTP (i.e., case-specific constraints would be needed) to non-performance based constraints, such as the "factor of 10 rule."

- There is a potential safety concern for an inadvertent intruder when disposing of large-scale blended waste, which should be evaluated on a case-by-case basis. The need to conduct an inadvertent intruder analysis is not specifically identified in Part 61 and may not be well understood if the status quo is maintained.

- While some stakeholders believe that the current guidance is clear and appropriate, others believe it is not and have misinterpreted the guidance.

This position could enable large-scale blending at a processor, provided a specific proposal was found to be acceptable and approved by the appropriate regulators after a review including

consideration of protection of members of the public and an inadvertent intruder at a disposal facility. The staff notes that, under the current NRC regulatory framework, protection of an intruder may be assumed to be ensured by the waste classification system and disposal requirements imposed on each class of waste, rather than being demonstrated with a site-specific analysis.

Option 2: Revise blending positions to be risk-informed and performance-based.

Under this option, the agency's position on blending of waste streams would be based solely on the protection of public health and safety, security, and the protection of the environment, and factors such as the "factor of 10 rule" would not be a consideration for blending. The principal performance measure would be whether a final blended waste form could be safely disposed of. The following changes and clarifications would be made to the existing blending positions.

- Clarify that a site-specific intruder analysis would need to be performed to determine whether an intruder could be protected, or the conditions necessary for such protection. The intruder protection performance objective is in 10 CFR 61.42.

- Clarify that blended wastes need to be evaluated in site-specific performance assessments for ensuring protection of an offsite member of the public (10 CFR 61.41).

- Develop criteria defining acceptable homogeneity and sampling considerations.

- Clarify that the position applies to all licensees, including waste processors.

- Clarify that homogeneous wastes may be mixed with one another when the resulting mixture is homogeneous in the context of a site-specific intruder scenario.

- Eliminate the "factor of 10 rule" for mixing of wastes that can be blended into a homogeneous mixture, since the concentration of final mixture will be relatively uniform. The factor of 10 rule could be retained for wastes that could not be blended into a uniform mixture.

Figure 8.2 is a logic diagram for this risk-informed, performance-based approach.

This option would be consistent with the Commission's policy on risk-informed, performance-based regulation. In 1997, the Commission addressed risk-informed performance based regulation as one of the 20 direction setting issues in its overall Strategic Assessment of the agency's programs at that time, deciding that NRC ". . . will have a regulatory focus on those licensee activities that pose the greatest risk to the public." In the last decade, risk-informed performance-based regulation has been a continuing agency policy and is one of the safety strategies in the NRC Strategic Plan (NRC, 2008a) that guides work in all NRC programs.

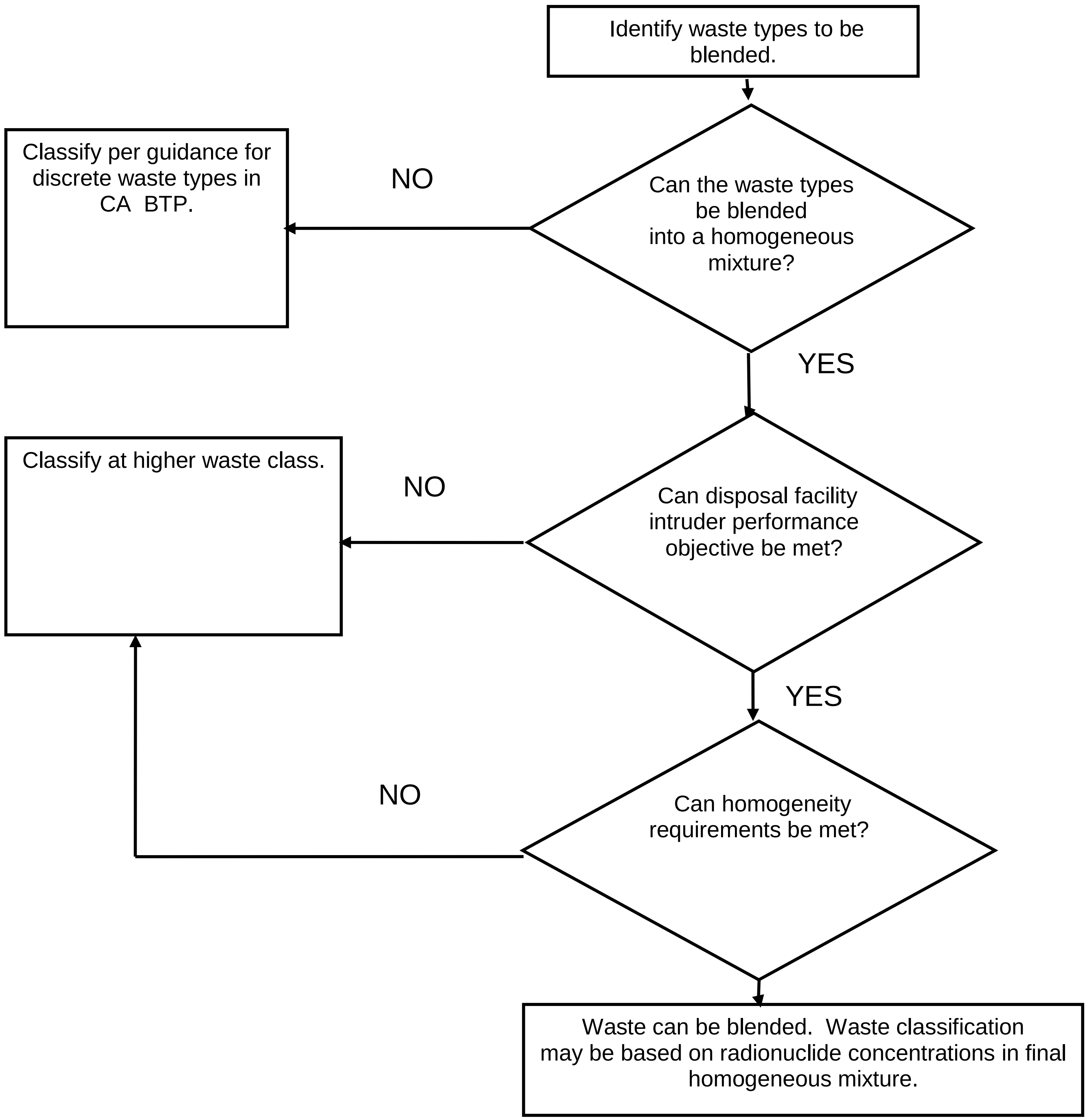

Figure 8.2 Logic diagram for risk-informed, performance-based approach to blending.

This option would be implemented through a combination of rulemaking and guidance. The requirement for site-specific intruder analysis, which is a risk-informed, performance-based approach to addressing blending, is being clarified in the rulemaking for large quantities of

depleted uranium, as directed by the Commission in the March 18, 2009, staff requirements memorandum for SECY-08-0147 (NRC, 2008b). The rulemaking would explicitly require a site-specific analysis for an inadvertent intruder. Disposal of large amounts of blended waste would have to be evaluated for intruder protection on a site-specific basis. As part of the NEPA analysis for this rulemaking, disposal of blended ion exchange resins from a central processing facility would be compared to direct disposal of the resins, onsite storage of certain wastes when disposal is not possible, and further volume reduction of the class B/C concentration resins. The regulatory basis document for this rulemaking is scheduled to be completed in September 2010 and the staff would begin work on the proposed rule at that time. The staff does not believe that the addition of blended waste to the technical basis will require significant resources or time to complete. Nevertheless, if the Commission decision on this paper occurs late in FY 2010 or in FY 2011, the regulatory basis document or proposed rulemaking schedules may have to be revised somewhat to accommodate the addition of blended waste to the rulemaking. The staff will take steps to mitigate any impacts in the meantime. There would be no impact on the schedule for the unique waste streams rulemaking if the Commission chooses any of the other options.

Two documents would be updated as part of this option — the Volume Reduction PS and the CA BTP. As noted in Section 3.3.1, since the PS was issued, there have been significant reductions in waste volume. Given this success, the staff believes that the PS could be updated to recognize the progress that has been achieved, and to acknowledge that other factors may be used by licensees in determining how best to manage their LLRW. Specifically, the PS could be revised to acknowledge that volume reduction continues to be important, but that risk-informed, performance-based approaches to managing waste are also appropriate in managing LLRW safely and that volume reduction should be evaluated in this light. The second guidance document that addresses blending is the CA BTP. It would be revised to incorporate risk-informed, performance-based approaches. For example, a risk-informed, performance-based blending policy would eliminate certain constraints in the guidance, such as the “factor of 10 rule.”

The staff would also issue interim guidance to Agreement States on how to evaluate disposal of large-scale blended waste until the rulemaking is completed. Blended waste would need to be evaluated on a case-by-case basis for the specific sites. Factors such as intruder protection, the need for mitigative measures, and homogeneity would need to be evaluated by the appropriate regulator. This interim guidance could be used until the Commission made a final decision on the depleted uranium rulemaking, including consideration of the NEPA analysis of alternatives to large-scale blended wastes. The staff's preliminary independent analysis indicates that current practice at LLRW disposal facilities may safely accommodate an increase in the amount of disposed waste at or just below the Class A limits.

Pros:

- Risk-informed, performance-based criteria would be consistent with NRC’s overall policy of risk-informed regulation.

- Disposal of some wastes that would otherwise be Class B or C would be possible, reducing the need for indefinite storage of these wastes.

- Bases for positions would be clearer. Currently, the bases are a combination of safety considerations, practicality, and constraining the use of mixing or blending.

- By piggybacking onto a rulemaking already underway, fewer resources would be needed than for options 3 and 4.

- A rule requiring a site-specific performance assessment for an inadvertent intruder would be enforceable.

Cons:

- Existing licensee and Agreement State legislation and regulations may have to be changed,

- Some stakeholders may perceive this position as a reduction in protection of public health and safety.

Option 3: Revise agency blending policy to further constrain blending.

Under this option, the Commission would develop a policy and promulgate a rule that would require that the as-generated concentrations of waste or material determine waste classification, similar to the State rule discussed in Section 3.3.1. To ensure national uniformity, the staff believes that a “B” compatibility category (i.e., Agreement State regulations would have to be essentially identical to NRC regulations) would be beneficial. The final compatibility category would be determined during the rulemaking process. The rulemaking would specify that radioactive material that has been blended as a result of stabilization, mixing, or treatment, or for any other reason, would be subject to the disposal regulations it would have been subject to prior to blending. This rule, either implicitly or explicitly, would require classification at points prior to waste being ready for disposal. A RIS would be published soon after the Commission decision to inform licensees that a revised blending policy was under development. The existing guidance on blending in the CA BTP would be removed, as would other guidance on averaging (such as guidance on encapsulation of sealed sources).

Pros:

- Would eliminate some stakeholder concerns over blending to reduce waste classification.

- Would eliminate any ambiguity about blending for purposes of lowering the waste classification — waste could not be made a lower classification through blending.

- Would require more measures to isolate and contain waste than current requirements (a corresponding “con” is that measures unnecessary for adequate protection of public health and the environment would be required).

Cons:

- Would incur more radiation exposures to workers, because of the need to sample and characterize waste more frequently.

- Licensees and Agreement States that currently follow the CA BTP may have to modify their programs if a compatibility category B rulemaking were promulgated. If the guidance were revised, it is expected that at least some Agreement States would follow the new guidance.

- Would not be risk-informed and performance-based, since classification of waste would be based on the as-generated waste, not the disposed of waste. The hazard of the as-generated waste is not related to disposal safety.

- Would require more storage of LLRW by creating more Class B and C and Greater-Than-Class C waste. Would affect not only nuclear power plant licensees, but also some materials licensees, including those with sealed sources.

- Would encourage increased waste generation. For example, ion exchange resins would be changed out more often, before they reached Class B concentrations, so that they could be disposed of as Class A.

- Would be more costly for licensees to implement, since many specific items of waste (e.g., ion exchange columns) often do not have their concentrations measured at the time the waste is generated.

<u>Option 4</u>: Prohibit large scale blending at off-site processor.

NRC could prohibit large-scale blending that lowers the waste classification at a waste processor[18] because it is tantamount to intentional mixing to lower the waste classification. This option would be implemented through revisions to either 10 CFR Part 61, or 10 CFR Part 20, Appendix G, which currently addresses some waste processing activities. A RIS would also be issued after a Commission decision and before the rulemaking was completed, to notify licensees of the planned change. An important part of the rulemaking would be differentiating between the routine blending that currently occurs at waste processors, and large-scale blending to lower the waste classification, such as has been proposed for ion-exchange resins from nuclear power plants. The compatibility designation would be determined as part of the rulemaking process. The staff believes that a “B” designation would help to ensure national uniformity.

Pros

- Would address stakeholder concerns opposing blending in general and potentially increase public confidence.

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[18] Included in the scope of this prohibition would be waste processors that are designated as LLRW generators through waste attribution. See Section 3.1.3 for a discussion of attribution.

- Would continue to allow for individual waste generators to blend waste as part of normal operations.

Cons

- Not risk-informed, performance-based.

- Not clear there is a safety basis for prohibiting this type of blending.

- Generators could still produce resin waste similar to blended waste by removing resins from service before Class B concentrations are reached, which would increase LLRW volumes.

- Would not address the possibility of larger-scale blending occurring at a generator's site.

9.0 Conclusions and Recommendations

The staff has examined the issue of blending of LLRW and the existing positions contained in staff guidance. The staff recommends that the agency position on blending of LLRW, as defined in this paper, be risk-informed and performance-based, consistent with NRC's overall policy for regulating, and as described in Option 2. These changes would improve NRC openness and effectiveness through clarification of the existing NRC blending position and its bases, and continue to ensure safety by clarifying that large-scale blended waste requires a site-specific intruder analysis. Until Option 2 was fully implemented, the staff would continue to use the current guidance in the CA BTP to respond to stakeholder requests. The CA BTP was subjected to public review and comment in the early 1990s and has been widely used since it was published in 1995. The staff plans to update the CA BTP later this year, as cited in its LLRW Strategic Assessment, but will delay that effort until it receives direction from the Commission on this paper. The staff would also clarify in interim guidance to Agreement States the need for a site-specific intruder analysis for disposal of blended wastes. Because of the significant stakeholder interest in this topic, the staff will prepare a communication plan to address implementation of the Commission's decision.

Appendix A -- Bases for 10 CFR Part 61 Waste Classification System

The classification system for near surface disposal of commercial (non-DOE) LLRW is in 10 CFR 61.55. The determination of the classification of LLRW involves consideration of the half-lives of the radionuclides present in the waste, among other factors. Thus, §61.55(a) contains separate tables for certain short-lived and long-lived radionuclides that provide a means for classifying LLRW as Class A, B, or C according to the concentrations of certain radionuclides in the waste. Part 61's classification system is intended to limit exposures of ionizing radiation to inadvertent intruders, in keeping with the performance objective in 10 CFR 61.42, which states that "design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site or contacting the waste at any time after active institutional controls over the disposal site are removed."

The potential impacts of human intrusion are addressed in detail in the EIS (NRC, 1981) for Part 61. Two concentration-limited scenarios, involving (1) excavation into the waste or construction of a house or building upon the disposal facility, and (2) persons living on the disposal facility, were considered, along with an "activity-limited" scenario involving the potential use of contaminated water from a well drilled onsite. The analyzed intruder scenarios contain a common assumption that the soil and waste mixture in which construction or agriculture takes place is more or less indistinguishable from ordinary (non-radioactive) dirt. In other words, the waste has decomposed to the point that the intruder does not realize they are contacting radioactive material. As stated in the DEIS (p.4-34), "this assumption is necessary since without it, the scenarios could not happen" (i.e., an intruder that recognized waste would not continue with an excavation or take up residence on the site).

Per 10 CFR § 61.7(b)(4), institutional control of access to the LLRW site is required for up to 100 years. Thus, the resultant radionuclide concentrations listed in the tables in §61.55(a) are established on the basis of calculations that showed that Class A and Class B waste could be disposed without special provisions for intrusion protection, because these classes of waste contain types and quantities of radioisotopes that will decay during the 100 year institutional control period (required by 10 CFR 61.59(b)) and do not present an unacceptable hazard to the intruder after the end of that period. Class C waste, however, will not decay to acceptable levels within 100 years, and either has to be buried at greater depth than the other classes so that subsequent surface activities by an intruder will not disturb the waste or, where site conditions prevent deeper disposal, requires the use of intruder barriers with an effective life of 500 years.

Although a numerical limit of 500 mrem whole body dose was proposed in the preliminary draft of Part 61 that was published in the *Federal Register* (45 FR 13104), the final rule's performance objective (10 CFR 61.42) for the intruder does not specify a numerical intruder dose limit. After receiving public comments on the draft rule, the 500 mrem dose limit was deleted, but it remains as the basis for the LLRW classification system, as indicated in the Statements of Consideration for Part 61 (NRC 1982).

The radionuclide concentrations in the waste classification tables imply that either the waste is uniform in concentration, or that the basis for classifying a waste batch uses the highest concentration within the batch. At the same time, Part 61 recognizes, in 10 CFR 61.55(a)(8) that it may be appropriate and safe to average wastes in certain circumstances. Although Part 61 itself places no constraints on blending, 61.55(a)(8) would apply to the resulting blended waste whose concentration for the purposes of waste classification would have to be an average of whatever variation occurred in the mixture.

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NRC, SECY-04-0035, "Results of the License Termination Rule Analysis of the Use of Intentional Mixing of Contaminated Soil," March 1, 2004, Attachment 2, page 5, (ML040060667).

NRC, Staff Requirements Memorandum (SRM), SECY-04-0035, "Staff Requirements - SECY-04-0035 - Results of the License Termination Rule Analysis of the Use of Intentional Mixing of Contaminated Soil," May 11, 2004. (ML041320165).

NRC, NUREG-1757, "Consolidated Decommissioning Guidance," Volume 1, Rev. 2, pages 15-35, September 2006, (ML063000243).

NRC, October 16, 2006, letter from John Kinneman, NRC, to Joseph Harverson, Alaron, (ML062900166).

NRC, "NRC Staff Guidance for Activities Related to U. S. Department of Energy Waste Determinations," NUREG-1854, August 2007, ML072360184.

NRC, SECY-07-0180, "Strategic Assessment of Low-Level Waste Regulatory Program," October 17, 2007, (ML071350291).

NRC, "Strategic Plan: Fiscal Years 2008 – 2013 (NUREG-1614, Volume 4)," February 2008.

NRC, SECY-08-0147, "Response to Commission Order CLI-05-20 Regarding Depleted Uranium," October 7, 2008, (ML081820814).

NRC, SRM, SECY-08-0147, "Response to Commission Order CLI-05-20 Regarding Depleted Uranium, March 18, 2009, (ML090770988).

NRC, August 27, 2009, letter from Larry Camper to Thomas Magette, EnergySolutions, (ML092170561).

NRC, October 30, 2009, letter from Larry Camper to Joseph DiCamillo, Studsvik, Inc., (ML092930251).

NRC, October 30, 2009, letter from Larry Camper to Scott Kirk, Waste Control Specialists, (ML092920426).

Radiation Source Protection and Security Task Force Report, August 2006.

Studsvik, "Comments on Blending of Low-Level Radioactive Waste," (NRC-2009-0520), ML093620111.

Tennessee General Assembly, Senate Bill 2735, House Bill 2826, March 2010.

Tran, P. and James, D., "EPRI Takes on Low-Level Waste Disposal Issues, Radwaste Solutions," EPRI, May/June 2008, pp 14-21, June 2008.

Appendix B – Public Comments

An important part of the development of this paper was public input on the issues associated with blending of low-level radioactive waste. The U. S. Nuclear Regulatory Commission (NRC) posted a request for formal written comments and notification of a public meeting in the *Federal Register* on November 30, 2009. Additionally, three public meetings with industry stakeholders were held at NRC Headquarters. This appendix contains information to locate the comments within ADAMS (**A**gencywide **D**ocuments **A**ccess and **M**anagement **S**ystem) which can be accessed via www.nrc.gov.

Federal Register Notice/Vol. 74, No. 228/11-30-2010 (NRC – 2009 – 0520): Notice of Public Meeting and Request for Comment on Blending of Low-Level Radioactive Waste

Below is information regarding the formal written comments received from the *Federal Register* request for public comment:

Commenter	Date	ADAMS Number
Unknown Individual	12/12/2009	ML093500087
J. Scott Kirk on behalf of Waste Control Specialists, LLC	01/08/2010	ML100131012
Richard W. Borgmeier	01/25/2010	ML100350962
Dane Finerfrock on behalf of Utah Dept of Environmental Quality, Division of Radiation Control	01/28/2010	ML100341243
Bruce Thompson on behalf of South Carolina Electric & Gas	01/28/2010	ML100341244
Rich Janati on behalf of the State of PA, Department of Environmental Protection	01/28/2010	ML100341250
Michael H. Mobley on behalf of Southeast Compact Commission	01/29/2010	ML100341251
Mike Garner on behalf of Northwest Interstate Compact	01/29/2010	ML100341252
J. Scott Kirk on behalf of Waste Control Specialists, LLC	01/29/2010	ML100341257
Joseph DiCamillo on behalf of Studsvik, Inc.	01/29/2010	ML100341258
Thomas E. Magette on behalf of EnergySolutions	01/29/2010	ML100341190
John LePere on behalf of WMG, Inc.,	01/29/2010	ML100341245
Christopher Thomas on behalf of HEAL Utah	02/01/2010	ML100341246
Leonard R. Smith on behalf of the Council on Radionuclides and Radiopharmaceuticals, Inc.	02/26/2010	ML100700591

Appendix B – Public Comments (cont.)

Public Meeting and Request for Comment on Blending of Low-Level Radioactive Waste

DATE: January 14, 2010

PLACE: The Legacy Hotel & Meeting Centre
The Georgetown Room
1775 Rockville Pike
Rockville, MD 20852

Below is information regarding the meeting presentations and summary which can be found in ADAMS. Additionally, the transcript of the meeting is available. The transcript was reviewed by the NRC and all comments were evaluated for applicability.

Presentation Title	Presenter	ADAMS Number
Public Meeting on Blending of Low-Level Radioactive Waste	Larry Camper (NRC), Director - DWMEP	ML100120008
Safety, Security, and Environmental Protection	Christianne Ridge (NRC), Senior Project Manager – DWMEP/ERB	ML100120009
Practical Considerations	Brooke Traynham, Project Manager (NRC) – DWMEP/LLWB	ML100120010
Regulatory Infrastructure	Patrice M. Bubar (NRC), Deputy Director – DWMEP/EPAD	ML100120011
Regulatory Considerations	Maurice Heath (NRC), Project Manager – DWMEP/LLWB	ML100120015
Meeting Summary	**Author**	**ADAMS Number**
Summary of Public Meeting And Request For Comment On Blending Of Low-Level Radioactive Waste	Brooke Traynham, Project Manager (NRC) – DWMEP/LLWB	ML100320730
Official Meeting Transcript	**Author**	**ADAMS Number**
Public Meeting on Blending of Low-Level Radioactive Waste	Neal R. Gross - Court Reporters and Transcribers	ML100220019

Appendix B – Public Comments (cont.)

Public Meetings and Request for Comment on Blending of Low-Level Radioactive Waste

DATE: December 14 -15, 2009

PLACE: U.S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

Below is information regarding the presentations and summaries from the meetings which can be found in ADAMS.

Presentation Title	Presenter	ADAMS Number
Blending of Low-Level Radioactive Waste	Larry Camper (NRC), Director - DWMEP	ML093620117
Changing NRC Policy on Waste Dilution to Alter Waste Classification: Why Now?	J. Scott Kirk, VP Waste Control Specialists, LLC	ML093620115
Comments on Blending of Low-Level Radioactive Waste	Lewis Johnson, President – Studsvik Brad Mason, Chief Engineer - Studsvik	ML093620111
Blending of Low-Level Radioactive Waste	Thomas Magette – Senior VP, EnergySolutions	ML093620105
Meeting Summary	**Author**	**ADAMS Number**
Summary of Public Meeting Between the U.S. Nuclear Regulatory Commission and Waste Control Specialists on Low-Level Waste Blending	Maurice Heath (NRC), Project Manager – DWMEP/LLWB	ML093650064
Summary of Public Meeting Between the U.S. Nuclear Regulatory Commission and EnergySolutions On Low-Level Waste Blending	Maurice Heath (NRC), Project Manager – DWMEP/LLWB	ML100040113
Summary of Public Meeting Between the U.S. Nuclear Regulatory Commission and Studsvik on Low-Level Waste Blending	Maurice Heath (NRC), Project Manager – DWMEP/LLWB	ML093650201

Utah Radiation Control Board
Position Statement on Down-Blending Radioactive Waste

The Utah Radiation Control Board (Board) recognizes that down-blended radioactive waste does not pose any unique health and safety issues to the public that are not observed in other classes of low-level radioactive waste. The Board also is aware that down blending may appear to some as a process to circumvent Utah law, which prohibits any entity in Utah from accepting Class B or Class C low-level radioactive waste for commercial storage, treatment or disposal, Utah Code Ann. 19-3-103.7. However, in order to maintain public confidence in the regulatory process and to protect against unforeseen hazards, the Board issues the following position statements regarding down-blended radioactive waste:

1. The Board is opposed to waste blending when the intent is to alter the waste classification for the purposes of disposal site access.

2. Dilution of radioactive wastes with uncontaminated materials should be explicitly prohibited.

3. Current guidance documents dealing with concentration averaging and mixing should be updated to address the current understanding of the possible down-blending issues. Important matters dealing with waste blending, such as prohibition of certain practices, currently in guidance should be put into regulation.

Consumers Energy
Palisades Nuclear Plant

PROCESS CONTROL PROGRAM (PCP)

Approved

Radiological Services Mgr	Date
Technical Review	Date
Plant Review Committee	Date
Periodic Review	Date
Plant General Manager	Date

Table of Contents

PALISADES PROCESS CONTROL PROGRAM (PCP)

INTRODUCTION

The Process Control Program contains methodology used to meet the requirements of 10CFR61 for land disposal of radioactive waste. Palisades only available burial ground is located near Barnwell, SC. South Carolina has Agreement State status from the Nuclear Regulatory Commission (NRC) and radioactive waste has to meet SC license conditions as well as the NRC requirements.

1.0 RVR-200 THEORY OF OPERATION

Palisades uses the VECTRA Radwaste Volume Reduction System (RVR-200) to reduce the volume of radioactive liquid concentrates to the minimum amount practicable for storage and burial purposes. The end product will meet South Carolina burial requirements.

The Blender/Dryer (B/D) steam jacket is heated by a steam boiler. The plant evaporator concentrates are introduced to the B/D via a waste slurry supply line through the waste supply valves. When the liquid level in the B/D reaches a predetermined level (approximately 3" from the top of the B/D) the waste supply valve is closed by the operator or will automatically close when a high level is achieved. The agitator/scraper then mixes the heated waste liquids under a vacuum of approximately 24-30" Hg Steam vapors are produced by the heating of the steam jacket surrounding the Blender/Dryer. These steam vapors are then drawn through a demister filter to a condensing heat exchanger (HX-1). This condenser is cooled by the chilled water system and its 50 ton chiller skid.

After the level in the Blender/Dryer boils down to a low level or the boil off rate significantly decreases as determined by the system operator, the waste supply valve is opened to refill the B/D. The process of boiling off the liquid in the form of steam vapor is repeated. This sequence of operations continues until the appropriate amount of concentrates have been transferred to the B/D for a batch cycle.

Once the last transfer has been achieved, the dry out phase begins. The dry out phase is the time it takes from the last transfer to the time when all of the free standing liquid has been removed. The dryness of the material is verified by monitoring several system parameters, as well as a visual observation of the product. Upon verification of the removal of free standing liquid, the material is ready for binder addition.

Between 50 and 70 pounds of binder (20-30% of the dried material by weight) will be used to bind the waste solids. This binding agent, which is added at the beginning of the process in solid form, is melted using steam heat from the steam generator in the binder addition tank. The binder takes approximately 2-4 hours to melt completely.

The binding agent is introduced to the B/D through a chemical addition valve (CA-1) and allowed to throughly blend with the dry waste product for approximately 20 minutes. This changes the waste product to a near liquid form to allow for free passage through the discharge valve (DV-1). Using the binder will result in a free standing billet with a compressive strength of up to 250 psi. The material is now ready for discharge into a container.

1.1 PACKAGING

The binder and waste product mixture is discharged from the unit through a six inch pneumatically operated ball valve (DV-1) into a burial container. The burial container is kept at a slight negative pressure and vented through a HEPA system. A sonic level indicator, as well as a remote visual display, allows for the operator to monitor the filling of the container. The sonic level indicator can be programmed for automatic closure of the dump valve at a predetermined level to prevent overfilling.

1.2 ALARA CONSIDERATIONS

Construction of the RVR-200 employs several concepts to permit operation without significant exposure to operating personnel. Some of these will greatly reduce the accumulated dose received by those personnel working on or around the area in which the RVR-200 is located.

- A remotely operated control panel allows for the control of major pumps and valves associated with the operation of the RVR without being near the unit during the process.
- Lead blankets can be used to shield the operator from the processing Blender/Dryer.
- All filling and dumping operations are viewed remotely at the control panel, using a CCTV monitor, which permits the operator to be shielded from direct exposure.

- A 1" steel process shield or shipping cask can be used to contain the HIC while it is being filled. A cart is used to move it out from under the RVR.
- A HEPA system is installed to filter out potential of airborne contaminants.

The major portion of radiation exposure is received by personnel during maintenance and radwaste handling. This exposure may be reduced by performing preventive maintenance on the unit after processing and removing of the waste from the system. The units are also skid mounted, permitting them to be removed from the area for maintenance or work away from the unit and reduce exposure to the personnel.

1.3 SYSTEM PARAMETERS

There are no critical chemistry parameters for the system to work as designed for acceptable waste form. However other requirements need to be addressed. Waste below 2 pH and above 12 pH is characteristically classified hazardous waste which would make the package mixed waste which must be avoided as no burial site is presently available. Palisades also wants to operate in a pH range to keep iodine in solution and in the waste matrix rather than offgassed which would be counter to good ALARA practices. The required parameters are contained in Chemistry Operating Procedure COP-17, "Radwaste System Chemistry."

Waste form Absence of Liquid will be controlled by System Operating Procedure SOP-18D, "Operating the VECTRA RVR-200 System," and visual observation of material. The visual inspection and quality control requirements will be documented on form HP 6.18-3 as required by procedure Health Physics Procedure HP 6.18, "Low-Level Radwaste Packaging."

The system produces a dry powder which meets the "free liquid" determination of Barnwell License 097. This does not meet the Barnwell License 097, condition 45 unless using wax as a binder to make the waste undispersable. The binder addition is documented in the VECTRA procedure process sheets. A letter from the South Carolina DHEC is attached to document their approval of the wax as a binder.

South Carolina
DHEC
Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201

July 30, 1992

William B. House
Corporate Director of Licensing
Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, SC 29210

Dear Mr. House:

Enclosed is information on the Pacific Nuclear Systems, Inc. RVR waste forms. The system produces a dry powder which is processed using wax as a binding matrix. The waste forms meet the intent of License 097, Condition 45 to render the powder non-dispersible. The system has been approved by the Department for processing Class A unstable waste only. Waste processed using this system may be disposed of in Type A unstable waste trenches.

If you have any additional questions concerning these waste forms, please contact our office.

Very truly yours,

Virgil R. Autry, Director
Division of Radioactive Materials
Licensing and Compliance
Bureau of Radiological Health

HJP/em
wbh72992/0792

cc: R. L. Williams, Pacific Nuclear Systems, Inc.

Meeting the above referenced procedure requirements will demonstrate that the system product is acceptable for burial at the Barnwell SC Burial Facility.

2.0 RVR-200 EQUIPMENT DESCRIPTION

2.1 ELECTRIC STEAM GENERATOR

The RVR-200 is provided with a Chromalox Electric Steam Boiler to supply the steam necessary to pressurize the Blender/Dryer, Binder addition tank and dump valve steam jackets to approximately 10-15 psig. The Blender/Dryer steam jacket is equipped with two steam reliefs to insure that the steam system meets ASME requirements for safety devices on automatically fired boilers. The Steam Boiler, referred by VECTRA as a Steam Generator (S/G), is a model CES-180A with an internal volume of 30.5 gallons. Several heating elements inside the boiler work together in a ramping arrangement. As the requirement for heat increases the heating elements pick up to supply the demand. As the requirement for heat decreases the heating elements drop out. A pressure switch manually set by the operator, is used to control the heat load. As the water level in the Steam Generator decreases due to evaporation a mercury level switch sends a signal to start the S/G makeup pump and increase level. When the level is high the mercury switch shuts the pump down. Normally the pump will cycle curing operation between the high and low level. A makeup tank is provided to supply NPSH to the pump. Periodically the Steam Generator should be blown down to remove sediment and suspended solids.

2.2 BLENDER/DRYER

The Blender/Dryer (B/D) is constructed of type 304 S/S with an internal volume of approximately 15 cu ft. The B/D will hold approximately 112 gallons of liquid waste. The B/D is equipped with four (4) two inch flanged ports to allow for the addition of optional choppers. The mixing blades are also constructed of type 304 S/S and are arranged in a double helix opposing pitch design. This design limits the axial thrust exerted on the unit because of the inherent push/pull design of the blades. Blades are supported by 1" connecting rods to a solid 4" diameter shaft that penetrates both ends of the B/D. The mixing blades are arranged in a ribbon configuration with a clearance of approximately 3/16" between the blades and the inner wall of the vessel. The shaft is driven by a 15 hp motor through a parallel gear reducer. The reducer drives the agitator/scraper assembly at a rate of 20 rpm.

A pressure switch, sensing pressure inside the Blender/Dryer, is connected to the bottom of the demister/filter housing and set at 15 psig. Should pressure inside the B/D exceed the setpoint of the pressure switch, the pressure switch will automatically trip the S/G breakers and shut down the steam being supplied to the B/D steam jacket. A manual reset in the control circuit is incorporated such that the steam generator must be re-started from the control panel if it shuts down due to high pressure. A corresponding fault light will be illuminated to alert the operator of the malfunction.

The B/D steam jacket is insulated with 2" of fiberglass insulation. This allows for a uniform heat transfer surface area and protects personnel from contacting the hot steam jacket.

Underneath the B/D, located in the center, is the discharge or dump valve. It is a 6", pneumatically operated ball valve. The dump valve is operated from the control panel. Several interlocks are used to prevent inadvertently opening the dump valve. All interlocks must be met in order to open the valve. The interlocks are listed in Section 4.0.

A fill plate and hose assembly are connected below the dump valve. The fill plate has a light, camera, and sonic probe. The light and camera are used to monitor the HIC fill evolution. The sonic probe is used to monitor the HIC level. A pneumatic lift is installed to lift the fill plate from the HIC after it is filled to allow changeout.

The B/D top cover jacket houses a viewing port equipped with wiper assemblies to permit the operator to view the level of waste slurry both locally and remotely via a CCTV camera. Also mounted on the top of the B/D is the binder addition valve, demister/filter assembly and inlet waste valves.

The Demister/Filter assembly is used to limit the amount of solid carry-over from the B/D to the condensate skid. The demister filter is a 10 inch diameter 5 micron filter. Top and bottom flush connections are installed to flush the demister screen thus, limiting the building up of solids. Hot water from the steam generator blowdown line may be used to flush binder and solids out of the filter down to the Blender/Dryer from the Demister/filter assembly.

2.3 CONDENSATE SYSTEM

The condensate system provides a heat transfer medium for the exhausted water vapors that are drawn from the Blender/Dryer. This heat transfer occurs across a primary heat exchanger, which is supplied with chilled water from a 50 ton chiller unit. The primary heat exchanger (HX-1) is a single pass, opposing flow style heat exchanger that condenses the water vapors as they are drawn across by vacuum created at the base of HX-1.

This vacuum is accomplished by use of a jet pump. The jet pump is an eductor which utilizes a motive pump (P-1) to provide motive water flow. The water to be pumped flows in through the suction. High pressure water is supplied to the driving nozzle, which is shaped like a convergent nozzle. The middle of the pump is the throat, or mixing section, which widens into the diffuser. The overall design is a convergent-divergent nozzle. This nozzle converts pressure into velocity, then converts the velocity back into pressure.

The high-pressure water enters the driving nozzle where its pressure is converted into velocity, so that it exits the nozzle at high velocity and low pressure. This low pressure area pulls the fluid to be pumped toward it where it is entrained by the high velocity driving flow. The two flows mix in the pump throat and the divergent diffuser nozzle converts the fluid velocity back to a pressure head. The pressure changes can be graphed vs position.

The motive pump is a 20 hp centrifugal pump that takes a suction on the condensate tank (T-1) and discharges through a secondary heat exchanger (HX-2), then through the jet pump (P-3) back to the condensate tank. HX-2 provides sub-cooling of the condensate prior to entering the adductor.

The condensate tank has a capacity of 157 gallons. It is approximately 30" in diameter and 54" high. The tank is equipped with four float switches, in which two alarms share a common shaft. Corresponding alarm lights are located on the control panel to alert the operator of high or low levels in the tank.

The condensate return valve, a 3/4" pneumatically operated ball valve, is located on the discharge side of the motive pump and can be operated from the control panel or automatically by the high level switch. This valve is used to pump down the Condensate Tank and return condensate to the plant. The valve is air operated to open and is spring loaded to shut.

The RVR-200 Ventilation System takes a suction on the condensate tank to remove air and non-condensible gases through a HEPA filter and moisture separator. The moisture separator has a sight glass and drain for level control.

2.4 CHILLED WATER SYSTEM

The Chilled Water system utilizes a 50 ton TRANE™ CHILLER, with its associated chilled water pump, to remove heat from the condensate system. A 7-1/2 hp pump circulates the chilled water at a rate of 120 GPM @ 50 psig to the two heat exchangers (HX-1 & HX-2).

Control for the chiller utilizes a microcomputer (UCM) that governs unit operation in response to chilled water temperature leaving the evaporator. The UCM controls the starting and stopping of the compressors to achieve the chilled water setpoint, which is programmed in the UCM. The UCM provides a diagnostic and operating code display that can be read on the from panel of the unit. A remote fault light is located on the RVR-200 control panel to indicate a problem with the chiller. Should a fault occur with the chiller, the unit will shut down and must be manually reset at the UCM. The operational display will "flash" the current diagnostic code of the problem and hold the code in memory for future reference.

A flow switch is installed on the chilled water supply line to indicate a loss of chilled water flow, which is interfaced with the TRANE™ units UCM and provides a fault indication to the unit.

2.5 CONTROL PANEL

The RVR-200 control panel is arranged to facilitate easy operation and control. The front panel doors have the necessary control knobs and push buttons to start and stop all pumps/motors and associated valves. The use of the TV monitor permits the operator to view the process remotely and monitor container filling operations by use of CCTV cameras. The logic controls provide alarm indications and protective functions to alert the operator of any potential problems.

2.6 **MCC PANEL**

Inside the Motor Control Center panel doors and mounted in the enclosure are the power supply breakers and logic control circuits. Relays and contactors for the pumps and motors are also housed in this panel and are arranged for easy access for troubleshooting or repair.

3.0 **DEWATERING SOLIDS IN HIGH INTEGRITY CONTAINERS (HIC)**

3.1 Solids such as bead resin, filter cartridges, and powdered resin (Powdex) may be dewatered and shipped in HICs per approved procedures and the HIC certificate of compliance.

3.2 High integrity containers are approved by the individual burial ground agreement states as meeting 10CFR61 waste form stability requirements.

3.3 Free water determination shall be verified by the successful completion and documentation of an approved dewatering procedure.

4.0 **10 CFR 61 REQUIREMENTS**

4.1 10 CFR 61 classification requirements will be met using a shipping computer software program using the scaling factor methodology of AIF/NESP-027, "Methodologies for Classification of Low-Level Radioactive Waste From Nuclear Power Plants," 1983.

The scaling factors will be updated by an ongoing analysis program of actual waste streams. The program will initiate with semiannual samples of available waste streams and may be modified to longer intervals if the data base warrants. Waste streams should include, if available; bead resin, evaporator concentrates, reactor coolant, clean waste, filter crud, and compacted trash.

4.2 10 CFR 61 waste form stability requirements can be met by generic testing of the waste stream product but usually High Integrity Containers (HIC) approved by the State of South Carolina will be used. The generic waste streams will be evaporator concentrates (boric acid), bead resin, and chemical regenerative wastes. Barnwell, South Carolina is only disposal site used for direct radwaste shipments from this license.

4.3 Documentation of the waste stream analysis, waste form stability, and computer software scaling factor security shall be maintained by the Radiological Services Department.

4.4 No radioactive waste shall be shipped for disposal in cardboard or fiberboard packages.

4.5 Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the liquid.

4.6 Solid waste containing liquid shall contain as little free standing noncorrosive liquid as is reasonably achievable but in no case shall the free standing liquid exceed 1% of the volume. The required parameters of Chemistry Operating Procedure COP-17, "Radwaste System Chemistry," will ensure there is no corrosive liquid potential in final waste product. Shipment procedures address free liquid determination.

4.7 Not withstanding the requirements of 4.5 and 4.6 any processed liquid waste (bead resin or filters etc) shall not contain noncorrosive free standing liquid exceed 0.5% of the waste volume. See 4.6 above.

4.8 Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressure and temperature. Hazardous chemicals are very closely controlled by this site. The few that are required are used as lab chemicals are diluted many times in the 20,000 gallon liquid waste system tanks and then ran through an evaporator system prior to solidification or resin bed clean up and are not a potential concern.

4.9 Waste must not contain or be capable of generating, quantities of toxic gasses, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. See Step 4.8 above.

4.10 The plant only uses a minimal amount of hazardous material which has the potential to enter a waste stream. The site has minimal biological, pathogenic, or infectious waste. The disposal site requirements for incineration will be met if these waste streams are generated for disposal.

4.11 Waste must not be pyrophoric. Pyrophoric material contained in waste shall be treated, prepared, and package to be non pyrophoric. See Step 4.8 above. In addition waste packages are sealed and would not support combustion.

5.0 **<u>RADWASTE SYSTEM</u>**

5.1 A radwaste system flow diagram is included in Appendix A, A-2.

6.0 TECHNICAL SPECIFICATION REQUIREMENTS

The PCP is implemented per the requirements of the Administrative Controls section of the Plant CTS-Technical Specification Chapter 6, Section 6.5.15. {ITS-Improved Technical Specification Chapter 5, Section 5.5.15} Procedural requirements included in Appendix B have been relocated from the Technical Specifications in accordance with NRC Generic Letter 89-01, dated January 31, 1989.

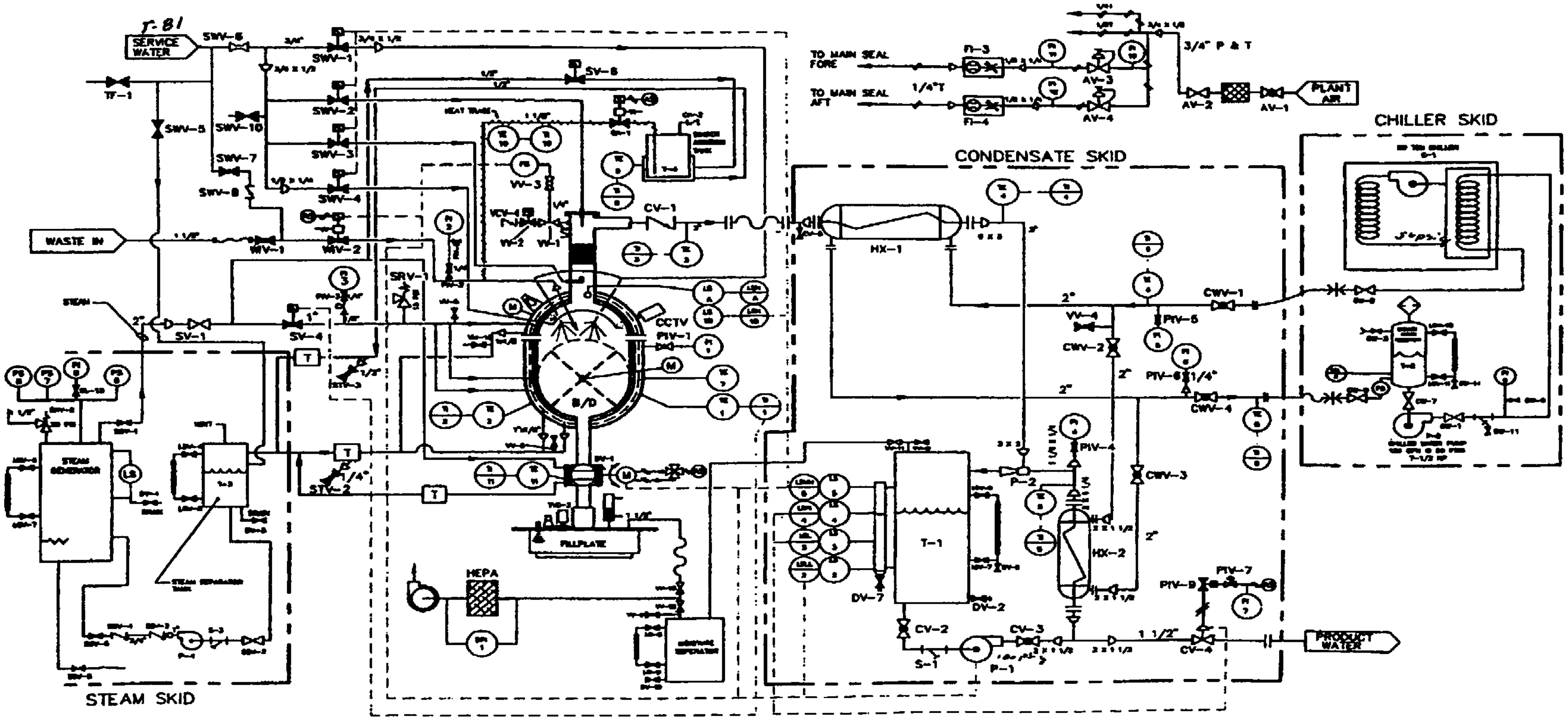
APPENDIX A

Consumers Energy
Palisades Nuclear Plant

PROCESS CONTROL PROGRAM (PCP)

System Diagrams

APPENDIX A



Rev 8
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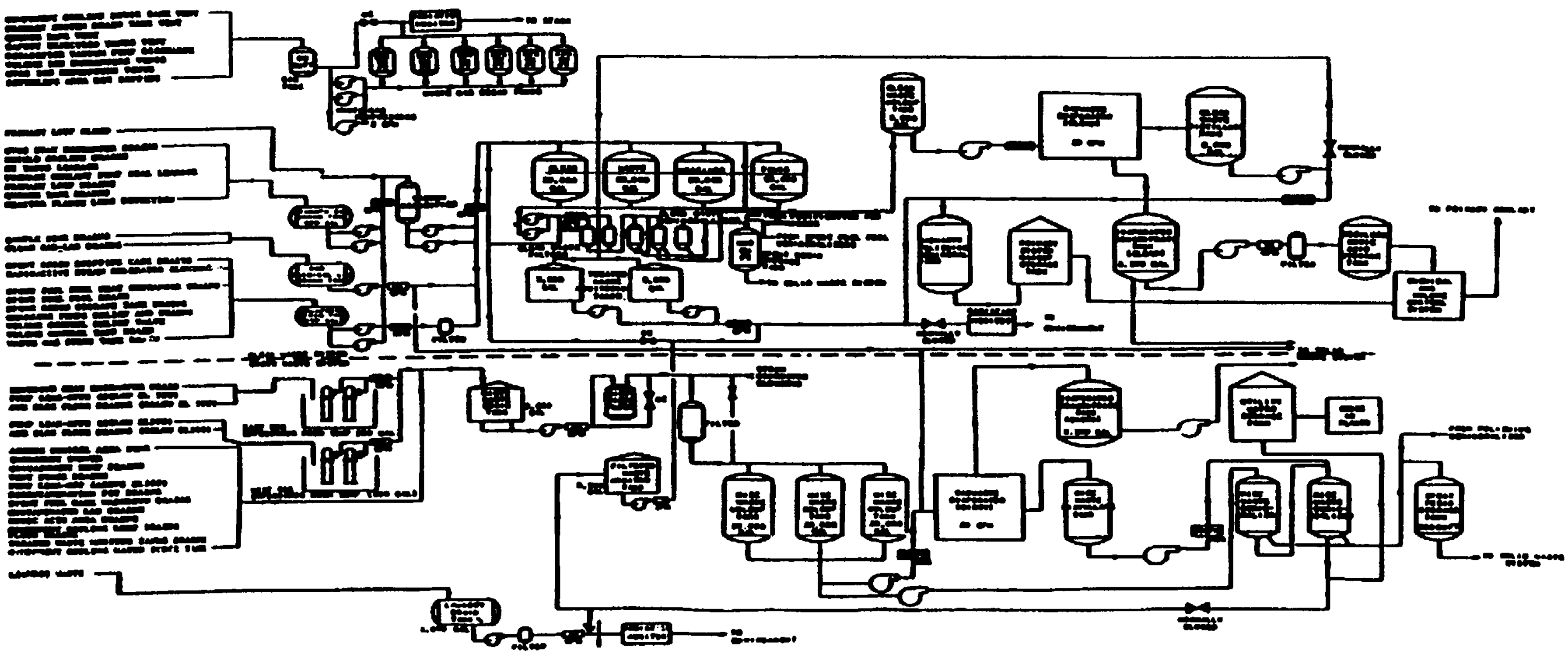
APPENDIX A

A-2 RADWASTE SYSTEM FLOW DIAGRAM



ATTACHMENT 71124.08

INSPECTION AREA: Radioactive Solid Waste Processing and Radioactive Material Handling, Storage, and Transportation

CORNERSTONE: Public Radiation Safety 80%
Occupational Radiation Safety 20%

EFFECTIVE DATE: January 1, 2010

INSPECTION BASES: The regulatory requirements in Criterion 60, "Control of Releases of Radioactive Materials to the Environment," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," and the requirements of 10 CFR Parts 20, 61, and 71 and U.S. Department of Transportation regulations in 49 CFR Parts 170 through 189, ensure adequate protection for members of the public from the processing, handling, storage, and transportation of radioactive materials. This inspection area verifies aspects of the Public Radiation Safety Cornerstone for which there are no performance indicators for unplanned public exposure during transportation of radioactive material.

LEVEL OF EFFORT: Inspect Biennially

71124.08-01 INSPECTION OBJECTIVES

01.01 To verify the effectiveness of the licensee's programs for processing, handling, storage, and transportation of radioactive material.

71124.08-02 INSPECTION REQUIREMENTS

02.01 Inspection Planning. Whenever possible, coordinate the inspection schedule with the licensee to coincide with risk-significant activities so that licensee performance can be directly observed.

a. Review the solid radioactive waste system description in the final safety analysis report (FSAR), the Process Control Program (PCP), and the recent radiological effluent release report for information on the types, amounts, and processing of radioactive waste disposed.

b. Review the scope of any quality assurance (QA) audit in this area since the last inspection to gain insights into the licensee's performance and inform the "smart sampling" inspection planning.

02.02 Radioactive Material Storage.

a. Select one to three areas where containers of radioactive waste are stored, and verify that the containers are labeled in accordance with 10 CFR 20.1904, "Labeling Containers," or controlled in accordance with 10 CFR 20.1905, "Exemptions to Labeling Requirements," as appropriate. Do not duplicate inspection effort performed under Inspection Procedure 71124.01.

b. Verify that the radioactive materials storage areas are controlled and posted in accordance with the requirements of 10 CFR Part 20, "Standards for Protection against Radiation." For materials stored or used in the controlled or unrestricted areas, verify that they are secured against unauthorized removal and controlled in accordance with 10 CFR 20.1801, "Security of Stored Material," and 20 CFR 1802, "Control of Material Not in Storage," as appropriate.

c. Verify that the licensee has established a process for monitoring the impact of long-term storage (e.g., buildup of any gases produced by waste decomposition, chemical reactions, container deformation , loss of container integrity, or re-release of free-flowing water) sufficient to identify potential unmonitored, unplanned releases or nonconformance with waste disposal requirements.

d. Select 5 to 10 containers of stored radioactive materials, and verify that there are no signs of swelling, leakage, and deformation.

Note: The inspector should exercise caution in that some of these containers may exhibit elevated dose rates and some containers may not be accessible. Container conditions can be verified by review of licensee programs or by direct observation, consistent with as low as reasonably achievable (ALARA) principles.

02.03 Radioactive Waste System Walkdown.

a. Select one to three liquid or solid radioactive waste processing systems. Walk down accessible portions of systems to verify and assess that the current system configuration and operation agree with the descriptions in the FSAR, offsite dose calculation manual, and PCP.

b. Select radioactive waste processing equipment that is not operational and/or is abandoned in place, and verify that the licensee has established administrative and/or physical controls (i.e., drainage and isolation of the system from other systems) to ensure that the equipment will not contribute to an unmonitored release path and/or affect operating systems or be a source of unnecessary personnel exposure. Verify that the licensee has reviewed the safety significance of systems and equipment abandoned in place in accordance with 10 CFR 50.59, "Changes, Tests, and Experiments."

c. Review the adequacy of any changes made to the radioactive waste processing systems since the last inspection. Verify that changes from what is described in the FSAR were reviewed and documented in accordance with 10 CFR 50.59, as appropriate. Review the impact, if any, on radiation doses to members of the public.

d. Select one to three processes for transferring radioactive waste resin and/or sludge discharges into shipping/disposal containers. Verify (for the selected processes) that the waste stream mixing, sampling procedures, and methodology for waste concentration averaging are consistent with the PCP, and provide representative samples of the waste product for the purposes of waste classification as described in 10 CFR 61.55, "Waste Classification."

e. For those systems that provide tank recirculation, verify that the tank recirculation procedure provides sufficient mixing (generally a minimum of three volumes is provided).

f. Verify that the licensee's PCP correctly describes the current methods and procedures for dewatering and waste stabilization (e.g., removal of freestanding liquid).

02.04 Waste Characterization and Classification.

a. Select two to three radioactive waste streams (e.g., dry active waste, ion exchange resins, mechanical filters, sludges, and activated materials), and verify that the licensee's radiochemical sample analysis results (i.e., "10 CFR Part 61" analysis) are sufficient to support radioactive waste characterization as required by 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste." Verify that the licensee's use of scaling factors and calculations to account for difficult-to-measure radionuclides is technically sound and based on current 10 CFR Part 61 analysis.

b. For the waste streams selected above, verify that changes to plant operational parameters are taken into account to (1) maintain the validity of the waste stream composition data between the annual or biennial sample analysis update, and (2) verify that waste shipments continue to meet the requirements of 10 CFR Part 61. For example, the shipping staff may monitor reactor coolant radiochemistry to ensure the stability of the waste stream analyses. Changes in reactor coolant chemistry (e.g., fuel integrity or corrosion film morphology) can result in changes to the waste stream compositions.

c. Verify that the licensee has established and maintains an adequate QA program to ensure compliance with the waste classification and characterization requirements of 10 CFR 61.55 and 10 CFR 61.56, "Waste Characteristics."

02.05 Shipment Preparation.

a. Observe shipment packaging, surveying, labeling, marking, placarding, vehicle checks, emergency instructions, disposal manifest, shipping papers provided to the driver, and licensee verification of shipment readiness. Verify that the requirements of any applicable transport cask certificate of compliance (CoC) have been met. Verify that the receiving licensee is authorized to receive the shipment packages. If applicable, verify that the licensee's procedures for cask loading and closure procedures are consistent with the vendor's current approved procedures.

b. Observe radiation workers during the conduct of radioactive waste processing and radioactive material shipment preparation and receipt activities. Determine if the shippers are knowledgeable of the shipping regulations and whether shipping personnel demonstrate adequate skills to accomplish the package preparation requirements for public transport with respect to the licensee's response to NRC Bulletin 79-19, "Packaging of Low-Level Radioactive Waste for Transport and Burial," dated August 10, 1979, and 49 CFR Part 172, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communication, Emergency Response Information, Training Requirements, and Security Plans," Subpart H, "Training." If direct observation is limited, review the technical instructions presented to workers during routine training. Verify that the licensee's training program provides training to personnel responsible for the conduct of radioactive waste processing and radioactive material shipment preparation activities.

02.06 Shipping Records. Select three to five nonexcepted package shipment (LSA I, II, III; SCO I, II; Type A or Type B) records. As a minimum, verify that the shipping documents indicate the proper shipper name; emergency response information and a 24-hour contact telephone number; accurate curie content and volume of material; and appropriate waste classification, transport index, and UN number. Verify that the shipment placarding is consistent with the information in the shipping documentation.

02.07 Identification and Resolution of Problems.

a. Verify that problems associated with radioactive waste processing, handling, storage, and transportation, are being identified by the licensee at an appropriate threshold, are properly characterized, and are properly addressed for resolution in the licensee corrective action program. See Inspection Procedure 71152, "Identification and Resolution of Problems," for additional guidance. (optional) In addition to the above, verify the appropriateness of the corrective actions for a selected sample of problems documented by the licensee that involve radioactive waste processing, handling, storage, and transportation.

b. Review results of selected audits performed since the last inspection of this program and evaluate the adequacy of the licensee's corrective actions for issues identified during those audits.

71124.08-03 INSPECTION GUIDANCE

03.01 Inspection Planning.

a. No guidance provided.

b. No guidance provided.

c. No guidance provided.

03.02 Radioactive Material Storage.

a. No guidance provided.

b. No guidance provided.

c. See Information Notice 90-50, "Minimization of Methane Gas in Plant Systems and Radwaste Shipping Containers," dated August 8, 1990.

d. No guidance provided.

03.03 Radioactive Waste System Walkdown.

a. No guidance provided.

c. No guidance provided.

d. See NRC, "Revised Staff Technical Position on Waste Form (SP-91-13)," dated January 30, 1991, and NRC, "Final Waste Classification and Waste Form Technical Position Papers," dated May 11, 1983.

e. See NRC, "Issuance of Final Branch Technical Position on Concentration Averaging and Encapsulation," dated January 17, 1995.

f. No guidance provided.

03.04 Waste Characterization and Classification.

a. Guidance on meeting the requirements of 10 CFR 61.55 and 10 CFR 61.56, as well as Appendix G, "Control of Exposure From External Sources in Restricted Areas," to 10 CFR Part 20 is provided in the Branch Technical Position, "Waste Form Technical Position"; IE Information Notice 86-20, "Low-Level Radioactive Waste

Scaling Factors, 10 CFR Part 61," dated March 28, 1986; Technical Position on Concentration Averaging; and NUREG-1608, "Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects," issued July 1998.

b. No guidance provided.

c. No guidance provided.

03.05 Shipment Preparation.

a. Guidance on shipping preparation is provided in NUREG-1660, "U.S.-Specific Schedules for Transport of Specified Types of Radioactive Material Consignments," issued January 1990.

b. No guidance provided.

03.06 Shipping Records. Guidance on the content of shipping records is provided in NUREG-1660. The inspector should focus on those waste stream products that represent the most risk-significant waste shipments.

03.07 Identification and Resolution of Problems. No guidance provided.

71124.08-04 RESOURCE ESTIMATE

For planning purposes, it is estimated to take 34 hours, on average (with a range of 30 to 38 hours), to perform the requirements of this attachment.

71124.08-05 COMPLETION STATUS

Inspection of the minimum sample size will constitute completion of this procedure in the RPS. The minimum sample size for this attachment is one (1), defined as the sum of all the inspection requirements. Therefore, all the inspection requirements of the procedure should be completed. If some of the requirements cannot be performed because of a lack of samples, the procedure should be closed with comment.

END

Revision History for
IP 71124.08

Commitment Tracking Number	Issue Date	Description of Change	Training Needed	Training Completion Date	Comment Resolution Accession Number
N/A	12/02/09 CN 09-030	Conducted four year search for commitments and found none. This new procedure is being issued as a result of the 2009 ROP IP Realignment. It supersedes inspection requirements in IP 71121 and 71122.	YES	09/09/2009	ML092810433

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
WASHINGTON, D.C. 20555

August 10, 1979

IE Bulletin No. 79-19

PACKAGING OF LOW-LEVEL RADIOACTIVE WASTE FOR TRANSPORT AND BURIAL

Description of Circumstances:

Low-level radioactive waste is that waste which can be transferred and shipped to one of three waste burial facilities which are located in and licensed by the Agreement States of Nevada, South Carolina, and Washington. On July 10, 1979, the Governors of the three states notified NRC Chairman Hendrie of the serious and repeated disregard for rules governing the shipments of low-level radioactive wastes to these burial facilities.

Examples of violations of Agreement State, DOT and NRC rules follow:

Improperly packaged uranium fines igniting packaged liquid scintillation vials in combustible waste are believed to have caused a fire and destruction of a truck at the Beatty, Nevada burial facility on May 14, 1979.

On July 2, 1979, three of twelve steel containers shipped to the Beatty burial facility were found to be leaking radioactive material. The material was described on the bill of lading as being a solid inorganic salt (evaporator .concentrates solidified with urea formaldehyde) from a reactor facility. The Governor of the State of Nevada ordered the drums to be shipped out of the state and the burial facility was temporarily closed.

On July 30, the first shipment into the reopened Beatty facility contained free liquid in "solid" material. The radioactive contents were sand filters used at an insitu leaching process at a uranium mill.

Forty-three shipments with sixty-three deficiencies were observed during the package inspection program between April 10 and July 5, 1979, by the Agreement State of South Carolina, at the Barnwell, S.C. burial facility. The shipments were from reactor, medical, industrial and military facilities.

On June 28, 1979, the Federal Highway Administration issued a Notice of Violation to a reactor facility proposing a $10,000 fine for truck contamination resulting from improper closures on 55-gallon drums of LSA material and for improper loading of the drums on the vehicle.

These are a few examples of shipments of radioactive material to burial facilities which did not fully meet NRC, DOT and Agreement State requirements which were developed to protect the health and safety of the public. The Governors of the three States with licensed burial facilities haVe indicated that if the situation is not rectified, they may have to initiate actions which would deny use of the three burial sites by violators.

Sources of Information:

The DOT regulatory requirements can be found in 49 CFR Parts 170-179. The NRC regulatory requirements can be found in 10 CFR Parts 19 to 71. The NRC regulatory requirements for Agreement State licensees in non-agreement states are in 10 CFR Part 150. Copies of the regulations may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402.

Information about licensing requirements for NRC packages can be obtained from the NRC Transportation Branch (301-427-4122). Information about DOT packaging and transport requirements can be obtained by calling the DOT Office of Hazardous Materials (202-426-2311).

Action to Be Taken By Licensees:

To assure the safe transfer, packaging, and transport of low-level radioactive waste, each licensee is expected to:

1. Maintain a current set of DOT and NRC regulations concerning the transfer, packaging and transport of low-level radioactive waste material.

2. Maintain a current set of requirements (license) placed on the waste burial firm by the Agreement State of Nevada, South Carolina, or Washington before packaging low-level radioactive waste material for transfer and shipment to the Agreement State licensee. If a waste collection contractor is used, obtain the appropriate requirements from the contractor.

3. Designate, in writing, people in your organization who are responsible for the safe transfer, packaging and transport of low-level radioactive material.

4. Provide management-approved, detailed instructions and operating procedures to all personnel involved in the transfer, packaging and transport of low-level radioactive material. Special attention should be given to controls on the chemical and physical form of the low-level radioactive material and on the containment integrity of the packaging.

5. Provide training and periodic retraining in the DOT and NRC regulatory requirements, the waste burial license requirements, and in your instructions and operating procedures for all personnel involved in the transfer, packaging and transport of radioactive material. Maintain a record of training dates, attendees, and subject material for future inspections by NRC personnel.

6. Provide training and periodic retraining to those employees who operate the processes which generate waste to assure that the volume of low-level radioactive waste is minimized and that such waste is processed into acceptable chemical and physical form for transfer and shipment to a low-level radioactive waste burial facility.

7. Establish and implement a management-controlled audit function of all transfer, packaging and transport activities to provide assurance that personnel, instructions and procedures, and process and transport equipment are functioning to ensure safety and compliance with regulatory requirements.

8. Perform, within 60 days of the date of this bulletin, a management-controlled audit of your activities associated with the transfer, packaging and trans port of low-level radioactive waste. Maintain a record of all audits for future inspections by NRC or DOT inspectors. (Note: If you have an established audit function and have performed such an audit of all activities in Items 1-6 within the past six months, this audit requirement is satisfied.)

9. Report, in writing within 45 days, your plan of action and schedule with regard to the above items. In addition, provide responses to the three questions below. Reports should be submitted to the Director of the appropriate NRC Regional Office and a copy should be forwarded to the NRC Office of Inspection and Enforcement, Division of Fuel Facility and Materials Safety Inspection, Washington, D.C. 20555.

Provide answers for 1978 and for the first six months of 1979 to the following questions:

1. How many low-level radioactive waste shipments did you make? What was the volume of low-level radioactive waste shipped? (Power reactor licensees who report this information in accordance with Technical Specifications do not need to respond to this question.)

2. What was the quantity (curies) of low-level radioactive waste shipped? What were the major isotopes in the low-level radioactive waste? (Power reactor licensees who report this information in accordance with Technical Specifications do not need to respond to this question.)

3. Did you generate liquid low-level radioactive waste? If the answer is ‘yes,’ what process was used to solidify the liquid waste?

Licensees who do not generate low-level radioactive waste should so indicate in their responses and do not need to take other actions specified in the above items.

Approved by GAO, B180225 (R0072); clearance expires 7-31-80. Approval was given under a blanket clearance specifically for identified generic problems.

SECTION XII

RADIOLOGICAL CONTROLS

A. RADIOACTIVE WASTES

1.0 Design Bases

1.1 Objectives

The radioactive waste handling systems have been designed to meet the following objectives:

1. Collect and process all radioactive waste generated in the Station without limiting normal Station operation.
2. Process radioactive wastes for disposal and, where necessary, convert them into liquid-free solid forms for proper disposal.
3. Release radioactive material to the environment in a controlled manner so that all releases are within the standards set forth in 10CFR20 and the Technical Specifications.
4. Retain radioactive wastes if they accidentally leak from the systems so that they can be recovered and reprocessed.

1.2 Types of Radioactive Wastes

1.2.1 Gaseous Waste

Gaseous radioactive wastes include airborne particulates as well as gases vented from process equipment. Sources of gaseous waste activity are the offgas system effluent, steam-packing exhauster system effluent and building ventilation exhausts.

Flows and associated activities for the major sources of gaseous activity are given in Table XII-1 for the normal operating condition. These values are based on experience gained during 12 yr of Station operation.

Station gaseous discharge limits and atmospheric dispersion rates (see Technical Specifications) limit exposures in the uncontrolled environment to values within the standards given in 10CFR20.

1.2.2 Liquid Wastes

Liquid radioactive wastes include all liquids collected in equipment drains and floor drains in areas of the Station which are potentially contaminated with radioactive materials. In addition, laundry wastes, laboratory wastes, and decontamination area wastes are handled by the liquid waste system.

Flows and associated activities for the major sources of liquid wastes are given in Table XII-2. These values are derived from 12 yr of Station operation.

Liquid wastes are handled in one of the four handling processes described in Section XII-2.2. Waste which is discharged to the environment in the cooling water effluent is dispersed in that effluent so that activities in the uncontrolled environment are within the standards listed in 10CFR20 and the Technical Specifications. Liquid waste which is too radioactive for disposal in the cooling water effluent will be concentrated, mixed in a solidification media and handled as solid waste.

1.2.3 Solid Wastes

Solid wastes include filter sludge, spent resin, concentrated liquid waste mixed with a solidification media, radioactive tools and equipment, and miscellaneous trash from laboratory, maintenance and cleanup operations. The solid waste handling system is capable of collecting, processing and temporarily storing these various wastes.

Annual accumulation and average activities of these wastes are given in Table XII-3. These values are based on experience gained during 12 yr of Station operation.

Solid waste is stored in the waste handling facility for decay and for accumulation of enough waste for shipment to an authorized burial site. Radiation levels of shipped containers are maintained within the standards set forth by the Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT).

2.0 System Design and Evaluation

2.1 Gaseous Waste System

The gaseous waste system is composed of seven major parts.

1. Offgas system

2. Steam-packing exhauster system

3. Turbine building ventilation system

4. Reactor building ventilation system

5. Waste building ventilation system

6. Stack

7. Offgas building ventilation system

2.1.1 Offgas System

For a description of the OFG system, see Section XI-B.3.

2.1.2 Steam-Packing Exhauster System

A greater volume of gases is handled by this system than by the OFG system. This larger volume of gases results from the addition of room air to the steam leaking from the turbine gland seals. This system is described in detail in Section XI-B.1.

2.1.3 Building Ventilation Systems

These systems are described in other sections of the report.

1. Turbine building - Section III-A.2.2

2. Reactor building - Section VI-E.2.0

3. Waste building - Section III-C.2.2

Particulate airborne activity exhausted by each of these systems can be monitored by a constant air monitor (see Section XII-B.2.2).

In areas where significant quantities of airborne particulates can be generated, such as the radiochemical laboratory hoods, decontamination area exhausts and some equipment exhausts, filters are installed in the exhaust duct to remove these particulates. Because the many tanks and equipment in the waste building can be a source of airborne particulate activity, this entire building exhaust is filtered before discharge to the stack.

2.1.4 Stack

The stack is described in Section III-G.

The stack monitoring system (see Section VIII-C.3.0) is provided to continuously measure the gaseous activity discharged from the stack. This system also incorporates a composite collection of particulate and halogen activity. These filter samples will be removed periodically and the particulate and halogen activity determined in the Station laboratory.

The design features of the stack assure that diffusion of the emitted plume will not be significantly influenced by the eddy currents around the Station structures.

2.2 Liquid Waste System

2.2.1 Liquid Waste Handling Processes

The liquid waste system is designed to handle four types of liquid waste: high-conductivity waste, low-conductivity waste, chemical waste and miscellaneous waste. Figure XII-1 is a schematic flow diagram for the liquid waste system and shows the processes for handling all four types of liquid waste. The process for handling each type of waste is described below.

1. <u>High-Conductivity Waste</u>

   High-conductivity liquid wastes are collected in the floor drain sumps located within the drywell, the reactor building, the turbine building and the waste disposal building. The wastes in these floor drain sumps are pumped into the floor drain collector or utility collector tank (during power operation and/or when drywell is inerted, the drywell discharge is routed to the waste collector system) which are located in the waste disposal building. After sufficient waste is collected in the floor drain collector, the waste is pumped to one of two floor drain sample tanks and is available for processing. Waste collected in the utility collector tank may be processed directly from this tank. Waste from either the floor drain collector or utility collector may be processed via the floor drain filter or a combination of the floor drain filter and waste demineralizer for processing through the low conductivity system.

   The normal process is to route the liquid through the waste concentrator and to recycle it through the plant. Under certain conditions the liquid waste can be pumped into the circulating water discharge tunnel at a flow rate which will assure that concentrations in the effluent will not exceed Station limits.

2. <u>Low-Conductivity Waste</u>

   Low-conductivity liquid wastes which usually come from piping and equipment drains are collected in equipment drain sumps or equipment drain tanks located in the drywell, the reactor building, the turbine building and the waste disposal building. These liquids are pumped to the waste collector tank which is located in the waste disposal building. Other (less frequent) sources of low conductivity waste are waste effluents from the fuel pool cooling system, the reactor cleanup system, the containment suppression chamber, ECs, and the backwash water from the condensate demineralizers (CND). This waste is also pumped to the waste collector tank in the waste disposal building.

A waste surge tank, located in the turbine building, is provided to collect the water from Station system surges and provide interim storage for liquids which are off-standard and which must be recycled through the liquid waste disposal system.

The liquid wastes in either the waste collector tank or the waste surge tank are pumped through a high-efficiency precoat type filter (a separate filter from the one used for high-conductivity waste) and a mixed-bed waste demineralizer to either one of two waste sample tanks. The floor drain filter can be used as a spare waste collector filter. While one of the two waste sample tanks is being filled, the other can be sampled and after sample analysis, the liquid is normally pumped to the condensate storage tank (CST) in the turbine building. Under certain conditions this liquid can be pumped into the discharge tunnel after careful analysis to assure that concentrations in the effluent will not exceed Station limits.

In addition to being able to pump fuel pool water and reactor cleanup system water to the waste collector tank, these liquids can also be discharged through filters into the condenser hotwell. From the hotwell the water is processed through the CNDs and pumped to the CST.

3. <u>Chemical Waste</u>

Chemical waste originates at the demineralizer regeneration area, laboratory sinks, and equipment decontamination drains. Since this waste is not only high-conductivity waste but also may contain acids and other chemicals, it is collected in the waste neutralizer tank or utility collector tank in the waste disposal building.

The wastes are then neutralized and either pumped directly to the waste concentrator or pumped through the floor drain system precoat filter into one of the floor drain sample tanks and then to the waste concentrator, where these are concentrated and then collected in the concentrated waste tank. This concentrated waste is then mixed with a solidification media and handled as solid waste.

4. <u>Miscellaneous Liquid Waste</u>

Liquid waste from laundry operations, personnel decontamination or any other radioactive liquid waste which might contain detergents is collected in the waste neutralizer tank, floor drain collector tank, or utility collector tank in the waste disposal building.

The waste is then routed to the waste concentrator for processing.

2.2.2 Sampling and Monitoring Liquid Wastes

Sampling lines are provided from each collection tank and each sample tank to evaluate filter and demineralizer performance. These sample lines run to a sample station adjacent to the waste disposal facility control room. In addition, local sample points have been provided where deemed necessary throughout the waste facility. Samples are analyzed in the Station laboratory.

A composite sample of the circulating water discharge stream is taken at a point downstream of the waste effluent discharge. An aliquot of this composite sample is periodically analyzed in the Station laboratory.

Data from samples taken of the tank to be discharged are recorded along with discharge water volume data so that a continuous record is maintained of released activity.

The liquid waste discharged is also monitored by a shielded scintillation detector mounted on a vertical section of the liquid waste discharge pipe which leads to the circulating water discharge tunnel. (See Section VIII-C.3.0.) The activity detected is recorded and annunciated at abnormally high concentrations, but the activity is still below discharge limits.

2.2.3 Liquid Waste Equipment Arrangement

Equipment is arranged and shielded to permit operation, inspections and maintenance with minimum personnel radiation exposure. (Shielding is designed to meet the requirements of Table XII-6.) Sumps, tanks, pumps, instruments and valves are arranged in accessible areas or shielded rooms which are accessible if the equipment is isolated.

Process equipment is designed for long life, ease of decontamination and minimum maintenance.

Major equipment and their respective capacities are listed in Table XII-4. The liquid waste disposal system is adequately designed to maintain absolute control over all liquid wastes within the Station during all modes of normal operation. Sufficient reserve tank holdup capacity is provided for the expected short-term high usage conditions.

2.2.4 Liquid Radioactive Waste System Control

The liquid waste processing systems are manually initiated and the process controlled from the radioactive waste control panels located in the waste disposal building. Instrumentation and alarms are provided for the control of the process and for detection and signaling of abnormal conditions.

In some cases, hose connections and chemical transfer hoses are used to transfer water, water/resin slurry, or water/flocculent slurry.

The interconnection of systems or vendor-supplied processing equipment is evaluated and approved prior to use for changes to plant operation and procedures. Administrative procedures are currently used to provide control for use, testing and inspection of chemical transfer hoses. A possible failure of chemical transfer hoses is bounded by the tank rupture failure.

Activity discharged to the environment is kept to a practical minimum by the treatment and recycle of much of the waste within the Station, by filtration of much of the waste before discharge, and by the concentration of radiological waste and conversion of the resulting concentrate into solid waste.

Protection against accidental discharge is accomplished by procedural control, by providing double waste discharge line valves, blanked off lines and locked valves, waste discharge line valve leakoff indication and suitable monitors and alarms of abnormal conditions.

To prevent spread of radioactivity within the Station or to outside areas, the significant concentrations of radioactive materials have double-barrier protection. This feature is provided by enclosure within the buildings, containment in concrete pipe tunnels, containment in double-wall piping, and containment in steel sump liners. Consequently, in the event of leaks, spills and overflows from equipment, containment of the liquid radioactive waste is assured.

If a tank is accidentally ruptured, its contents will be contained within the restricted area of the waste disposal building. In some cases, a retention curb is built around a local area or equipment cubicle to contain minor amounts of leakage within the area. The dispersed liquid can be readily recovered and processed as required through the floor drain system. Sumps and drains are provided for the collection and return of wastes to the system.

2.3 Solid Waste System

2.3.1 Solid Waste Handling Processes

The solid waste system is designed to handle four general types of solid waste: solidified concentrated liquid waste, spent resins and filter sludge, compressible solids and noncompressible solids.

1. Solidified Concentrated Liquid Waste

   Liquid waste is concentrated and mixed with solidification agents inside large containers or drums.

The drum filling and capping operation is done using remotely-operated equipment and viewing devices. The containers are then transferred to a storage area and are stored until such time as they are to be shipped for offsite disposal.

2. Spent Resins and Filter Sludge

Filter sludges are normally stored in tanks in the buildings where the filters are located. After accumulation, these sludges are transferred as a liquid slurry to the waste building for processing. Spent resins from all contaminated demineralizers in the Station, when not regenerated, are stored in the spent resin storage tank in the waste disposal building.

The filter sludge can be processed and shipped in one of two ways. The normal process is by routing through the phase separator system where suspended material is settled out by gravity. This material is then solidified by using an accepted media.

Spent resins are pumped to a shipping cask in the truck bay where the cask is dewatered during the loading process. The cask is then sealed and shipped as solid waste. Filter sludge may also be processed in this manner.

3. Compressible Solid Waste

Compressible low-level solids may be packaged into 100-cu ft containers or 55-gal drums using one of two hydraulic compactors. These containers are stored until such time as they can be shipped for offsite disposal. Other methods such as offsite processing may be used.

4. Noncompressible Solid Waste

Noncompressible solid waste is packaged into 55-gal drums or 100-cu ft containers. Special containers are used for large or odd-shaped components.

5. Miscellaneous Solid Wastes

Solid materials such as spent fuel assemblies, spent control blades, poison curtains, in-core chambers and other equipment originating from the reactor primary system are stored in the spent fuel storage pool until offsite storage or disposal is necessary.

2.3.2 Solid Waste System Equipment

Equipment is arranged and shielded to permit operation, inspections and maintenance with minimum personnel radiation exposure. (Shielding is designed to meet the requirements of Table XII-6.) Highly radioactive wastes are loaded into containers with remotely-controlled equipment and using remote viewing devices.

Control of the radwaste system is from the radwaste building control panel. Instrumentation is provided both for process control and for detection of abnormal conditions.

Major equipment and their respective capacities are listed in Table XII-5.

3.0 Safety Limits

Limits for discharge of gaseous and liquid waste from the Station and the monitoring of these effluents are in accordance with Technical Specifications.

4.0 Tests and Inspections

4.1 Waste Process Systems

The waste processing systems are used on a routine basis and do not require specific testing to assure operability. The effectiveness of design is ultimately demonstrated by the effluent monitors and the environmental monitoring program.

4.2 Filters

The exhaust ventilation filters are replaced when the pressure drop across the filters exceeds the normal operating range. Test connections are available for checking the efficiency of newly installed filters. Adequate tests to determine filter efficiency are conducted in accordance with the Technical Specifications.

4.3 Effluent Monitors

The effluent monitors will be calibrated periodically to assure that they are accurately detecting effluent activity.

4.3.1 Offgas and Stack Monitors

An isotopic analysis is made of a representative sample of gaseous activity downstream of the steam jet air ejectors (SJAE) and at the stack sample point in accordance with the Environmental Technical Specifications.

These waste gas effluent monitors are calibrated at least annually by means of a known radioactive source which has been calibrated to a National Institute of Standards and Testing source. The stack monitors are instrument channel tested quarterly and the offgas monitors once per operating cycle. Each monitor is sensor tested daily.

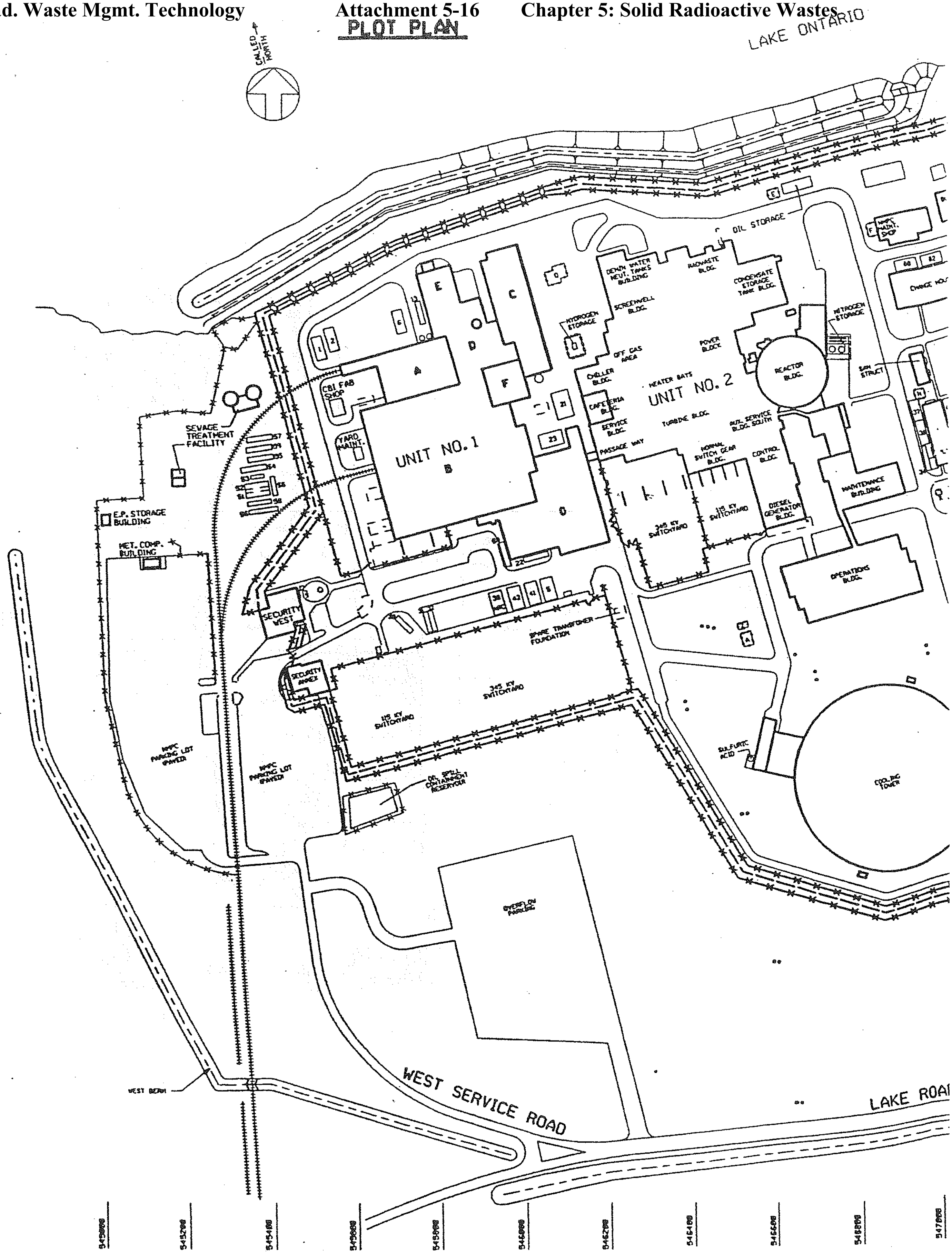
4.3.2 Liquid Waste Effluent Monitor

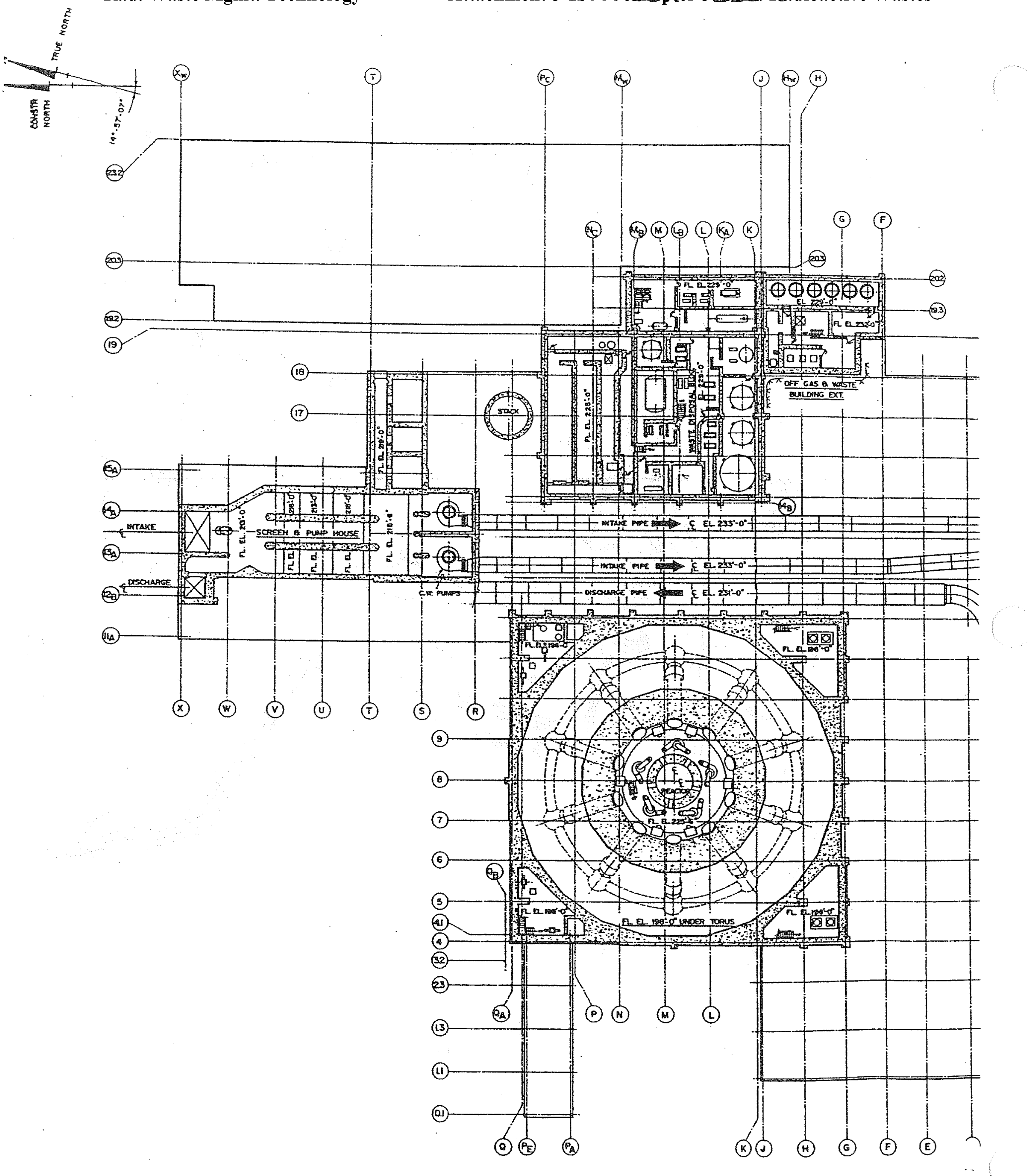
The liquid waste effluent monitor is calibrated annually* by means of a radioactive source which is certified by or traceable to the National Institute of Standards and Testing. Each monitor shall also have a quarterly instrument channel test and a source check* prior to a release.

Accounting of liquid waste discharge will be by laboratory analysis and volume measurement as described in the Technical Specifications.

* Required prior to removal of blank flange in discharge line and until blank flange is replaced.

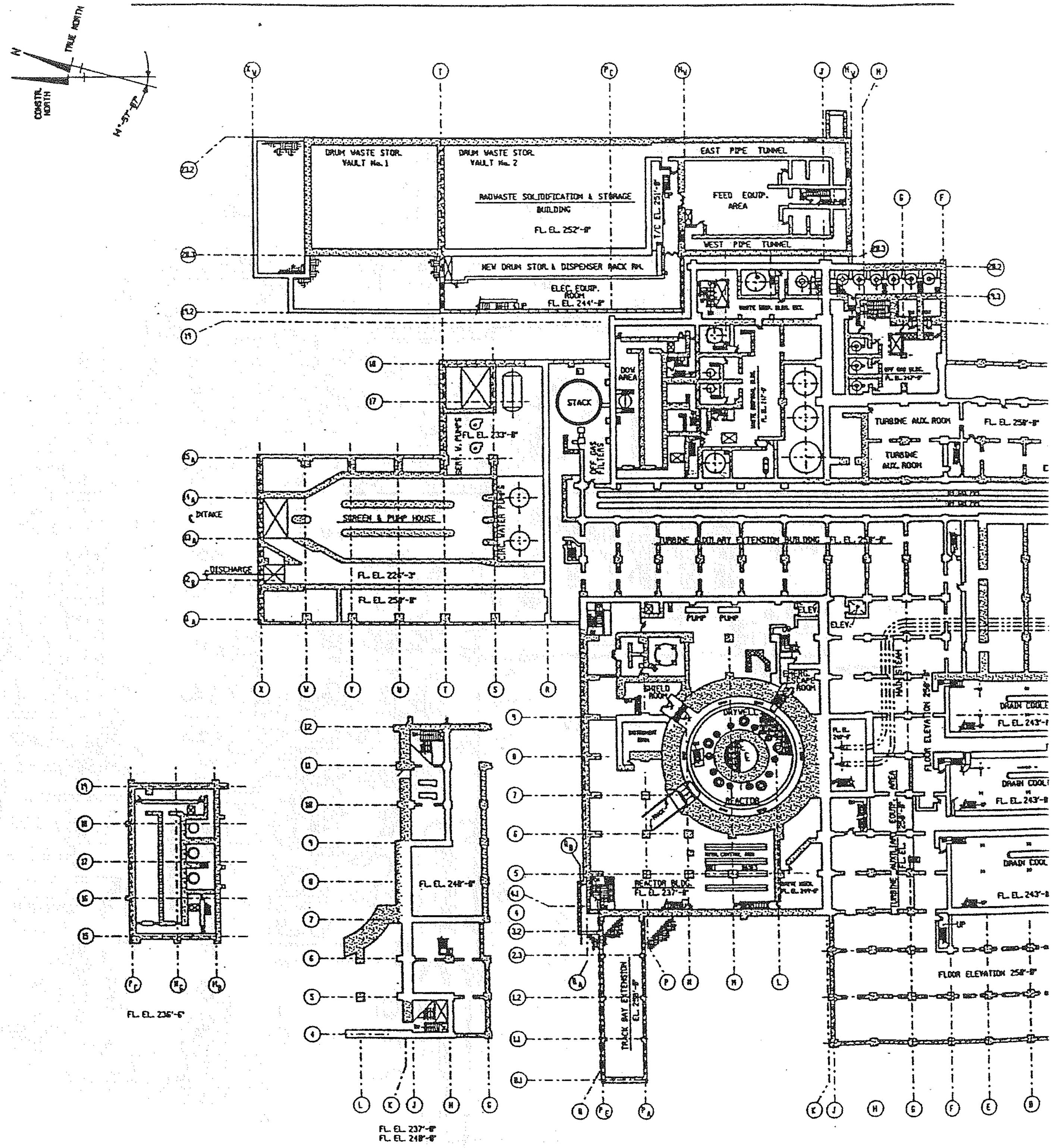
PLOT PLAN


CALLED NORTH
LAKE ONTARIO
OIL STORAGE
UNIT NO. 1
UNIT NO. 2
REACTOR BLDG.
TURBINE BLDG.
HEATER BAYS
POWER BLOCK
RADWASTE BLDG.
SCREENWELL BLDG.
HYDROGEN STORAGE
OFF GAS AREA
CHILLER BLDG.
CAFETERIA BLDG.
SERVICE BLDG.
PASSAGE WAY
NORMAL SWITCH GEAR BLDG.
CONTROL BLDG.
DIESEL GENERATOR BLDG.
MAINTENANCE BUILDING
OPERATIONS BLDG.
NITROGEN STORAGE
CONDENSATE STORAGE TANK BLDG.
345 KV SWITCHYARD
115 KV SWITCHYARD
SPARE TRANSFORMER FOUNDATION
CBI FAB SHOP
YARD MAINT.
SEWAGE TREATMENT FACILITY
E.P. STORAGE BUILDING
MET. COMP. BUILDING
SECURITY WEST
SECURITY ANNEX
OIL SPILL CONTAINMENT RESERVOIR
OVERFLOW PARKING
SULFURIC ACID
COOLING TOWER
WEST BERM
WEST SERVICE ROAD
LAKE ROAD



REACTOR BUILDING - FL. EL. 225'-6"

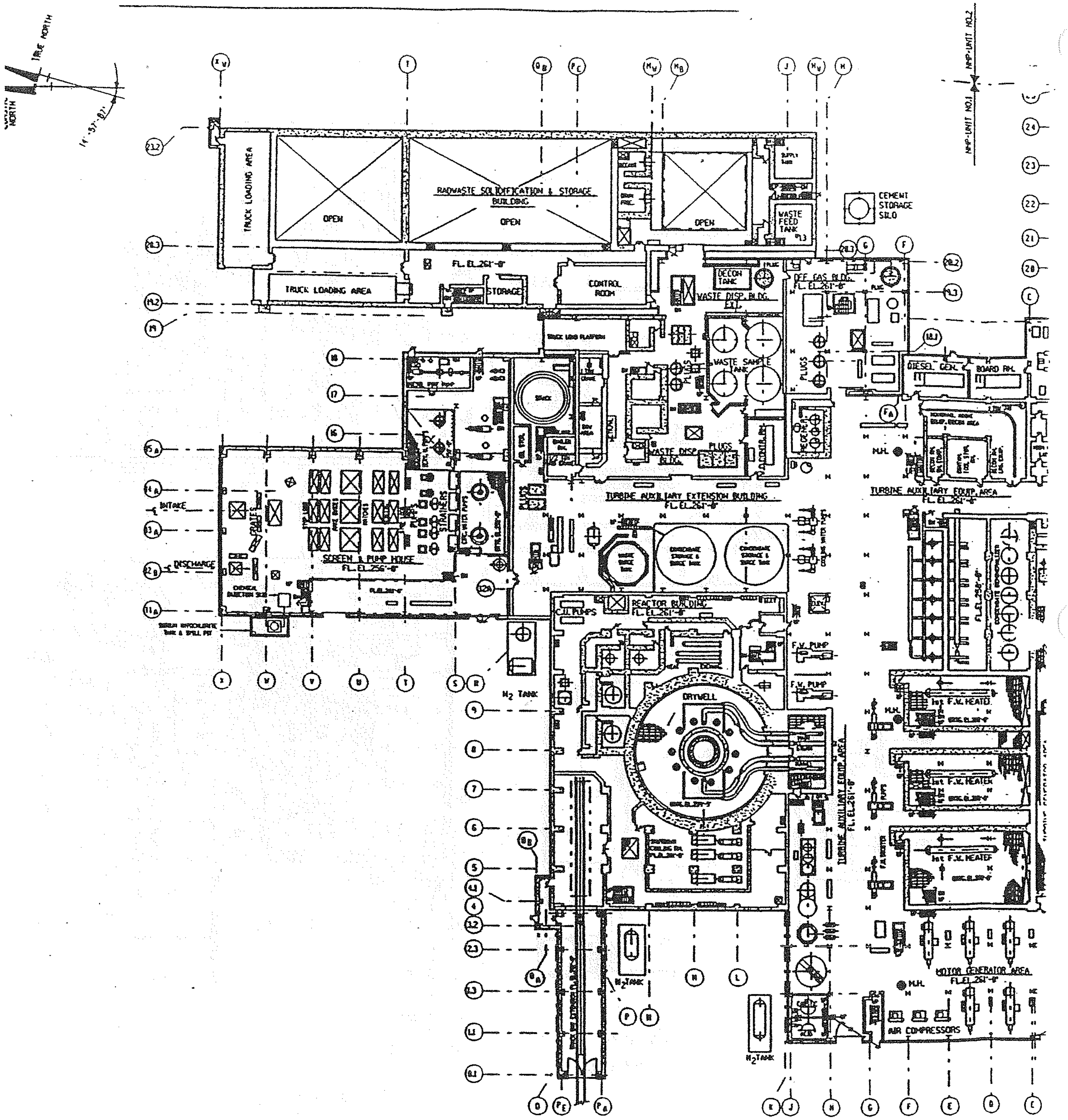
STATION FLOOR PLAN - ELEVATIONS 237'-0" AND 250'-0"



REACTOR BUILDING - FL. EL. 237'-0"

TURBINE BUILDING - FL. EL. 250'-0"

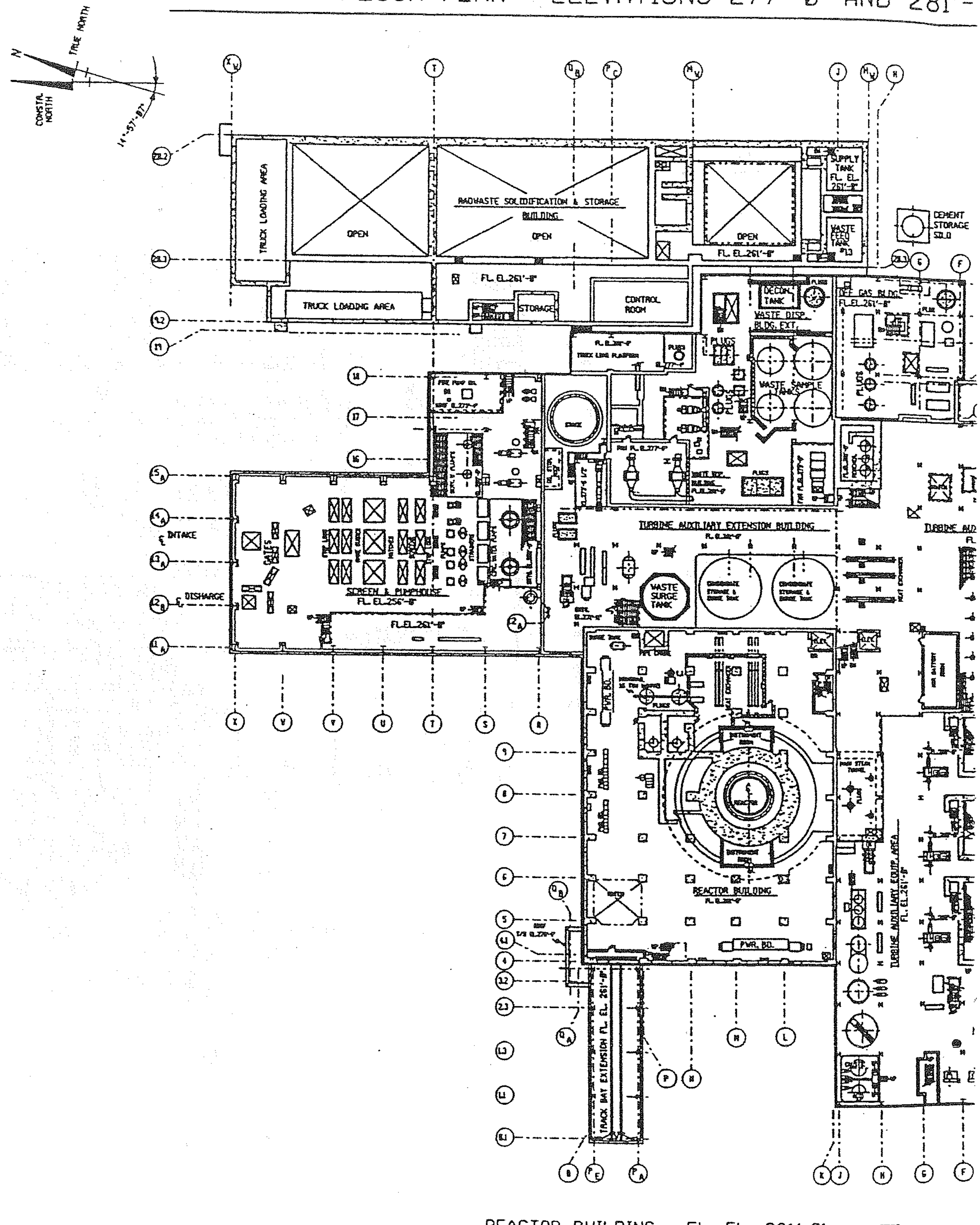
STATION FLOOR PLAN - ELEVATION 261'-0"



REACTOR BUILDING - FL. EL. 261'-0"

TURBINE BUILDING - FL. EL. 261'-0"

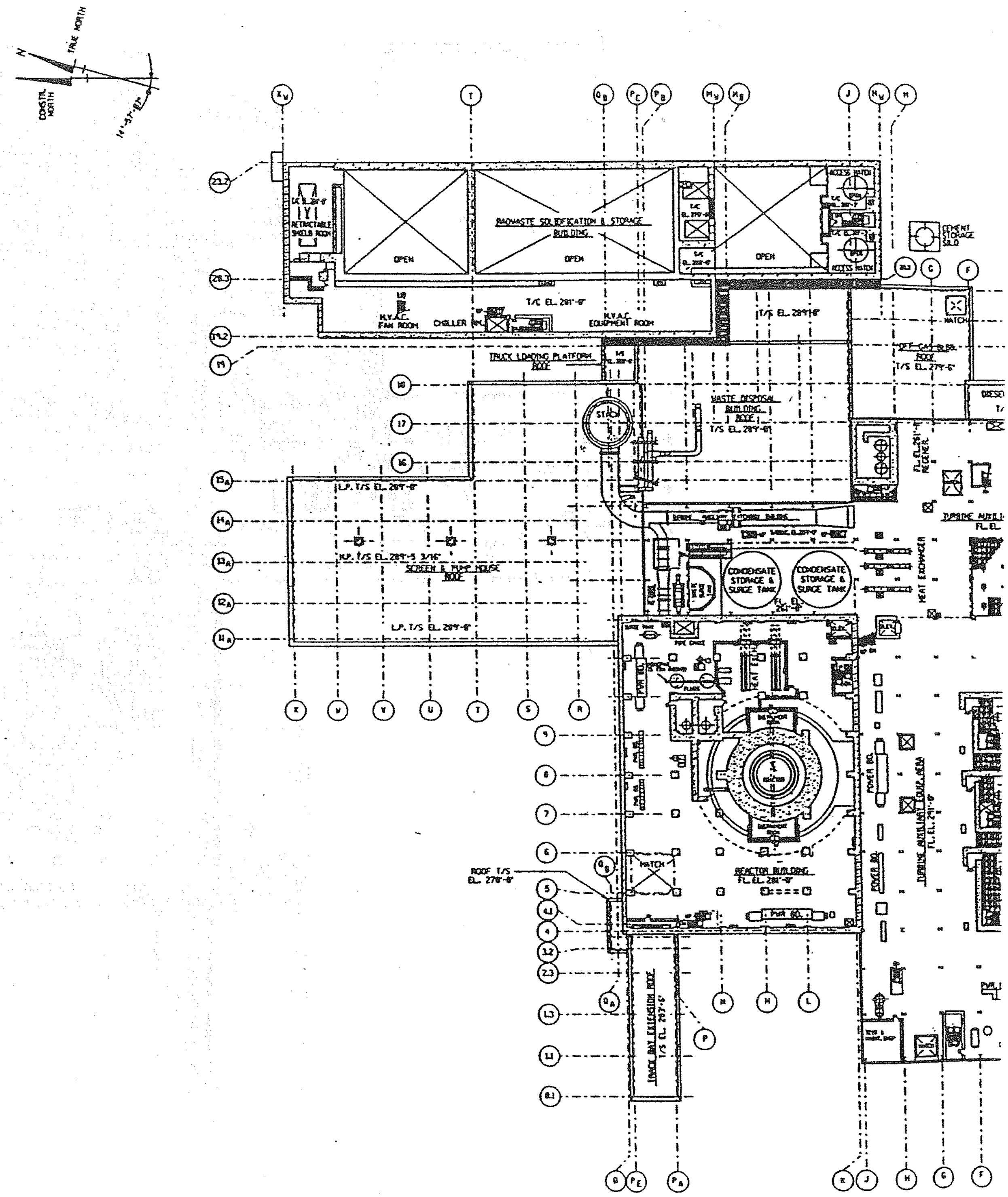
STATION FLOOR PLAN - ELEVATIONS 277'-0" AND 281'-



REACTOR BUILDING - FL. EL. 281'-0'

TURBINE BUILDING - FL. EL. 277'-0"

STATION FLOOR PLAN - ELEVATIONS 281'-0" AND 291'-0"



REACTOR BUILDING - FL. EL. 281'-0"

TURBINE BUILDING - FL. EL. 291'-0"