Criticality Safety Limits and Regulation of SNM in LLW –
a Case Study of the Envirocare Order

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ABSTRACT

The U.S. Nuclear Regulatory Commission issued an Order to Envirocare of Utah, Inc. exempting it from licensing requirements in 10 CFR Part 70, subject to certain conditions, for possession of special nuclear material (SNM) in excess of the mass limits in 10 CFR Part 150. This Order established concentration-based limits for SNM that provide the same level of protection as the current mass limits specified in 10 CFR 150.11. Under these concentration limits and conditions, Envirocare can possess an unlimited quantity of SNM. This presentation discusses the regulatory background of the disposal of SNM low-level waste (LLW), the basis of the Envirocare Order, and possible changes to NRC regulations.

INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) regulates the commercial uses of nuclear material. This paper discusses NRC's regulation of special nuclear material (SNM) and low-level waste (LLW) disposal. It provides a regulatory background and current regulatory framework of SNM and LLW. Unlike other radioactive material, SNM posses a unique concern in that a criticality, a chain reaction where large numbers of neutrons are produced, can result under certain conditions. These conditions and means to prevent criticality are discussed in detail below. This paper also discusses an Order issued to Envirocare of Utah, Inc. (Envirocare) exempting Envirocare from certain NRC regulations relative to the possession and disposal of SNM at its Clive, Utah disposal facility. The safety basis and associated conditions of the Order are discussed. In addition, this paper discusses possible regulatory changes relative to SNM and LLW disposal.

REGULATORY BACKGROUND OF SNM AND LLW DISPOSAL

The Commission's authority to regulate SNM is contained in Chapter 6 (§§ 51 - 58) of the Atomic Energy Act (AEA) of 1954, as amended. The AEA requires persons who possess SNM to have a general or specific license issued by the Commission. Pursuant to Section 274(b) of the AEA, NRC can enter into agreements with States (called Agreement States) where the State assumes the regulatory authority to regulate byproduct, source and SNM. Because of criticality concerns, the quantity of SNM that an Agreement State can regulate is limited. This is codified in 10 CFR Part 150, "Exemptions and Continued Regulatory Authority in Agreement States and in Offshore Waters under Section 274." This section of the regulations provides certain exemptions to persons in Agreement States from certain NRC licensing requirements and defines activities in Agreement States over which the regulatory authority of the NRC continues. As it relates to SNM, 10 CFR 150.10 exempts persons in Agreement States from NRC licensing for SNM in quantities not sufficient to form a critical mass. Quantities not sufficient to form a critical mass are defined in 10 CFR 150.11 as enriched uranium not exceeding 350 grams, uranium-233 not exceeding 200 grams, plutonium not exceeding 200 grams, or mixtures where the sum of the fractions is less than unity. In both Agreement States and non-Agreement States, an NRC license is required, pursuant to 10 CFR Part 70, "Domestic licensing of special nuclear material," for persons who possess quantities of SNM in excess of the 10 CFR 150.11 limits. As it pertains to disposal of SNM at LLW disposal facilities, the concept of quantities not sufficient to form a critical mass has been applied to above ground possession. Once the SNM was disposed (i.e., placed into a disposal trench), this quantity of SNM was not considered to apply to the 10 CFR 150.11 limits.

The disposal of LLW is regulated in 10 CFR Part 61,"Licensing requirements for land disposal of radioactive waste." LLW, which contains SNM, is currently disposed of at three facilities (Barnwell, South Carolina; Hanford, Washington; and Clive, Utah). All of these facilities are licensed by Agreement States under 10 CFR Part 61 equivalent regulations. The Barnwell and Hanford facilities were licensed by the NRC under 10 CFR Part 70 to receive, possess, store, and dispose of kilogram quantities of SNM. In 1997, these facilities requested that the SNM possession limits be reduced to the 10 CFR 150.11 limits and that the NRC licenses be transferred to the respective Agreement States. The State of Washington and the State of South Carolina retained criticality safety measures from the NRC Part 70 licenses. The State of Utah Envirocare license did not address criticality safety beyond the 10 CFR 150.11 mass limits. In July 1999, Envirocare requested that the State of Utah amend its license to incorporate the criticality safety conditions in the NRC Order to Envirocare, dated May 24, 1999 [1].

ENVIROCARE ORDER

In May 1997, the State of Utah determined that Envirocare had exceeded the SNM possession limits in its State of Utah license. Consequently, NRC Region IV conducted an inspection of the facility in June 1997. As a result of that inspection, NRC issued a Confirmatory Order on June 25, 1997, that required Envirocare, in part, to reduce its possession of SNM and to submit a compliance plan (CP) to NRC for approval. As part of the approved CP, trucks containing SNM waste could proceed to the disposal cell (assuming the conditions stated in the Confirmatory Order apply) without counting the SNM waste as part of Envirocare's possession inventory. This waste was considered "in-transit," under the exemption of 10 CFR 70.12, because the carrier was still present.

Before the Confirmatory Order and CP, rail shipments were transported directly to a rail siding adjacent to the site. Rail cars were staged on the siding until the waste could be moved onto the site within licensed limits. Subsequent to the Confirmatory Order and CP, it became operationally advantageous for Envirocare to receive SNM waste via truck shipments. Thus, the Confirmatory Order and CP may have led to a practice of transferring of SNM waste from rail cars to trucks in Salt Lake City. Some trucks and SNM waste were staged at a nearby industrial facility and did not go directly to the disposal site because of the SNM possession limit. NRC concluded that this process resulted in a change in the mode of transportation of waste to the site (i.e., more truck shipments), leading to a slightly higher probability of a transportation accident. Moreover, the increased waste handling increased the possibility of container rupture and resultant spillage in a metropolitan area. In addition, SNM waste was being staged while in transit at nearby unlicensed industrial facility. Although that practice conformed to applicable NRC and DOT regulations, it was regarded as less safe and a direct result of conditions in the CP.

To resolve this issue, NRC explored ways in which rail cars could be allowed to proceed directly to the site. If the SNM waste was shipped in accordance with 10 CFR Part 71,"Packaging and transportation of radioactive material," and applicable DOT regulations, these conditions were sufficiently protective while the waste was on the rail cars, regardless of being located inside or outside the site boundary. NRC further evaluated whether concentration limits could be established to prevent an inadvertent criticality. Considering that concentration limits could be established, an acceptable rationale, therefore, existed for allowing above-ground storage of similar material in a comparable or more dispersed configuration. This rationale supported NRC taking action to alleviate the regulatory constraint that appeared to have led to the less than optimal practice, described above, for transporting SNM waste to Envirocare.

NRC decided that the appropriate means for resolving this issue was through the issuance of an Order to Envirocare. To support this Order, a Safety Evaluation Report [2] and Environmental Assessment [3] were prepared. The Environmental Assessment was published in the Federal Register (99 FR 12241) [4]. The Order became effective when the conditions of the Order were incorporated into Envirocare's State of Utah license.

Based on its analysis of the operations and waste forms at the Envirocare site, NRC concluded that waste processing and disposal operations could be conducted with acceptably low risk of nuclear criticality subject to certain conditions (Attachment 1). Conceptually, the conditions are SNM isotope concentration limits (Condition 1); bulk chemical limits (Condition 2); unusual moderator limits (Condition 3); soluble uranium limits (Condition 4); mixed waste processing limits (Condition 5); waste characterization and certification requirements (Condition 6); and waste receipt sampling condition (Condition 7). The basic approach is the specification of four sets of technical criticality safety limits (Conditions 1 through 4), then the provision in condition 6 for a certification and waste characterization assuring that these limits will not be exceeded. The waste sampling plan of condition 7 provides for detection of erroneous shipment of waste not complying with the concentration limits. Condition 5 limits mixed waste-processing activities to those currently used by Envirocare. The technical bases for conditions 1 through 4 are summarized below.

Concentration Limits for Subcriticality

For a criticality to occur, special conditions involving a number of factors must occur. Important factors that affect the criticality safety of a LLW disposal site are: (1) the isotope, (2) enrichment, (3) mass, (4) concentration, and (5) presence of neutron moderating and absorbing materials. Each of these is discussed below.

(1) Isotope: The SNM isotopes present in LLW are dependent on the waste stream. The vast majority of SNM waste is generated from the production of nuclear fuel for nuclear power plants and from LLW generated by nuclear power plants. Of the SNM isotopes, uranium-235 is the most common. Large quantities of plutonium and uranium-233 (the other SNM isotopes) are not present in the commercial waste. However, these materials are present in Department of Energy (DOE) facility waste, and some DOE waste is being shipped to commercial LLW disposal facilities. The criticality characteristics vary among the SNM isotopes.

(2) Enrichment: Enrichment is a ratio of the weight of uranium-235 to the weight of the total uranium and is commonly expressed as a percent. Natural uranium, found in most soils, has an average enrichment of 0.71 percent. In order to be used as nuclear fuel, natural uranium must be enriched in uranium-235. Most nuclear fuel is enriched to less than 6 percent; however, some nuclear fuel for special reactors such as those in naval vessels is enriched to much higher values. At enrichments less than about 0.96 percent, criticality is not possible regardless of the mass or concentration. As enrichment increases, criticality becomes a greater concern.

(3) Mass: The mass of SNM in individual waste packages or in accumulations of waste packages will effect the criticality characteristics of the system. In general, the criticality concern increases with the mass of SNM present. There is a minimum mass required to achieve criticality. This minimum critical mass varies depending on the isotope.

(4) Concentration: Similar to mass, the concentration of the SNM in the waste will effect the criticality characteristics of the system. In general, the criticality concern increases with the concentration of the SNM. There is a minimum concentration required to achieve criticality. This minimum critical concentration varies depending on the isotope.

(5) Presence of neutron moderator and absorbers: Neutrons that are produced during a fission have a relatively high energy and are termed "fast" neutrons. Moderators are materials that reduce the energy or slow neutrons. This is important because uranium-235 is much more likely to be fissioned by slow neutrons than by fast neutrons. Therefore, the presence of moderator materials can increase the criticality concern. Elements such as hydrogen and carbon are particularly good moderators. Because water is abundant and is a very efficient moderator, assuming water is present is a common approach in evaluating the criticality significance of situations. However, there are certain materials such as beryllium,

graphite, and deuterium that are more efficient moderators than water. These materials are commonly termed "unusual" moderators.

Absorbers are materials that absorb or capture neutrons. Because capturing neutrons prevents those neutrons from possibly causing a fission, the presence of absorber materials will decrease the criticality concern. Most materials act both as a moderator and an absorber to varying degrees. In analyzing the criticality hazard of waste at LLW disposal facilities, it is conservative to assume that moderators will be present in optimal amounts. The presence of absorber materials is not limited by regulations. These materials, such as iron, calcium, etc., are present in LLW and in the waste containers. However, the amount and distribution of absorbers cannot be assured, so they are typically omitted in analyzing criticality hazards. For example, although a steel drum acts as an absorber, the drum will corrode within tens of years and can no longer be depended on to contain the waste and act as an absorber.

In establishing the uranium-235 concentration limits, NRC used criticality calculations in two studies prepared by Oak Ridge National Laboratories (ORNL), NUREG/CR-6505 Volumes 1 and 2 [5 and 6]. In order to allow Envirocare greater flexibility, NRC established a concentration limits for 100 percent and 10 percent enriched uranium. In addition to these studies, ORNL performed similar criticality calculations for uranium-233, plutonium-239, and mixtures of plutonium that will be documented in a NUREG/CR on emplacement criticality guidance [7].

In the ORNL studies, silicon dioxide (SiO_2) was used to represent the waste matrix. The SNM concentrations presented in the ORNL studies are assumed to be uniformly distributed and are expressed in grams of SNM isotope per gram of SiO_2. It is also assumed that unusual moderators are not present. The studies provide the neutron multiplication factor (k) for infinite media systems (k-infinity) over a range of SNM concentrations. (A k-value greater than one would represent a critical condition.) The studies also provide dimensions and areal densities for infinite slabs and linear densities for cylinders, and diameter and minimum SNM mass for finite spheres corresponding to a k-effective of 0.95 over a range of concentrations. NRC conservatively used the infinite media results in developing the concentration limits.

In establishing operational concentration limits and considering that concentration will be the primary criticality control, NRC reduced the subcritical limit to account for operational uncertainties. Part of the concern in establishing the operational concentration limit was based on how accurately generators could determine the concentration of the SNM in the waste. Typically, uranium-235 and other fissile isotopes are measured using gamma spectroscopy methods to measure the activity of the isotope and/or daughter products. The uncertainties associated with this method are based on a number of factors including count time, type of detector, container geometry, density of the waste, distribution of SNM within the container, etc. NRC considers that a reasonable measurement uncertainty value (one-sigma) would be in the range of 15 percent. A 30 percent (two-sigma) was used in calculating the operational limit to increase the confidence level that the concentration of the waste based on measurement would not exceed the subcritical value. Other radiochemistry techniques may be used to quantify the concentration of these radionuclides. These techniques typically have lower measurement uncertainty levels, but introduce sampling uncertainty. The measurement uncertainty levels are included in condition 1 and represent 15 percent of the maximum concentration value. A concentration value was used for the measurement uncertainty rather than a percentage value to allow greater flexibility for generators with waste having very low SNM concentrations.

Table 1 shows the conversion from activity of the SNM per gram of waste (as presented in the NUREG/CR-6505 reports) to grams of SNM per gram of waste (as presented in the Order). The maximum concentrations in the second column are given in picoCuries per gram of waste. The fourth column of Table 1 converts these concentrations to a mass ratio, that is, mass of SNM per mass of waste, by dividing by the specific activity.

CONVSERSION OF MAXIMUM CONCENTRATION TO MASS RATIO
TABLE 1

Radionuclide	Maximum Concentration (pCi/g waste)	Specific Activity of Nuclide (Ci/g nuclide)	Max. Concentration As Mass Ratio (g nuclide/g waste)
<10% U-235	1900	2.16e-06	8.80e-04
>10% U-235	1190	2.16e-06	5.51e-04
U-233	7.5e-08	9.70e-03	7.28e-06
Pu-239	1.0e-08	6.20e-02	1.61e-07
Pu-240	1.0e-08	2.30e-01	4.35e-08
Pu-241	3.5e-07	1.00e+02	3.50e-09

Unlike the above isotopes, criticality concentration limits for the other plutonium isotopes in an infinite matrix of SiO_2 have not been determined. Some of the common plutonium isotopes such as plutonium-238, plutonium-240, plutonium-242 and plutonium-244 are fissionable but not fissile. Non-fissile fissionable materials require high-energy neutrons to maintain a fission chain reaction; while, fissile material (U-233, U-235, Pu-236, Pu-239, Pu-241, and Pu-243) can be fissioned by neutrons of any energy. To evaluate the criticality significance of these other plutonium isotopes, NRC compared the minimum critical masses (typically optimally moderated spheres) of these isotopes with the minimum critical mass of plutonium-239 and compared the mass-based radiological concentration limits of these isotopes with the subcritical concentration for plutonium-239. Table 2 below illustrates this point. Because the minimum critical masses for the other plutonium isotopes are significantly higher than plutonium-239 and the concentration limit of the other plutonium isotopes (based on radiological safety considerations) are significantly less than the subcritical concentration of plutonium-239, NRC concluded that the concentration limits for the other plutonium isotopes will not contribute significantly to criticality.

RATION OF CONCENTRATION LIMITS AND SUBCRITICAL LIMITS
TABLE 2

Nuclide	Minimum Critical Mass (**Mc**) (grams)	Mc(nuclide)/ Mc(Pu-239)	Concentration Limit (**CL**) (g isotope/g waste)	CL(isotope)/ Subcritical Concentration (Pu239)
Pu-236	*	NA	9.40e-13	3.4e-09
Pu-238	4.00e+03	9.3	5.88e-10	2.1e-06
Pu-239	4.50e+02	1.0	1.61e-07	5.8e-04
Pu-240	1.90e+04	42.2	4.35e-08	1.6e-04
Pu-242	5.60e+04	124.0	2.56e-06	9.2e-03
Pu-243	*	NA	1.90e-16	6.8e-13
Pu-244	*	NA	2.80e-05	1.0e-01

* - Data not provided in literature
NA - Not applicable

Bulk Chemical Limits

As discussed above, SiO_2 was assumed to conservatively represent the waste matrix. Evaluations by ORNL for a range of compounds also confirmed that silicon dioxide is likely to be the most reactive feasible waste matrix. Other likely soil or waste constituents, such as iron, aluminum, and calcium act as neutron absorbers. Similarly the hydrogen in water acts as a neutron absorber more effectively than silicon for low concentrations of SNM in a waste matrix. Disposal of pure bulk chemical compounds containing some enriched uranium would raise the question of whether there are chemical compounds more reactive than pure SiO_2. ORNL performed additional studies replacing the Si in the SiO_2 matrix with other common elements and determined that beryllium, bismuth, carbon, helium, oxygen, fluorine, and magnesium produced more reactive systems. Of these elements, pure helium and oxygen are gases and would not be expected to be present in significant quantities in the waste. Beryllium and pure carbon (i.e., graphite) are unusual moderators and are limited in condition 2. Although magnesium, fluorine, carbon, and other oxide forms are present in earth materials and in fuel cycle waste, these chemicals are typically not present in bulk quantities or in "pure" form. The presence of bismuth is not anticipated to be significant in waste. To limit the presence of these chemicals from occurring in bulk quantities in pure form, Condition 2 was included to preclude this for waste shipped to Envirocare. As part of its mixed waste processing, Envirocare adds magnesium oxide. For the general case, 20 percent magnesium oxide was assumed, and the uranium-235 concentration values presented in the ORNL studies were reduced to reflect this magnitude of magnesium oxide.

Unusual Moderator Limits

The concentration values reported in NUREG/CR-6505 Volumes 1 and 2 are based on the assumption that unusual moderators are not present. Unusually effective neutron moderating materials, such as beryllium, graphite, or heavy water, could provide a more reactive matrix. Previous evaluations have shown that the presence of large amounts of beryllium can permit criticality to occur at lower concentrations of SNM in soil. Therefore, limiting unusual moderators was required to assure the effectiveness of the SNM concentration limits in maintaining criticality safety. Because prohibiting unusual moderators could result in problems demonstrating compliance, NRC decided to set a finite maximum limit on unusual moderators. In discussions with Envirocare, a limit of one percent of the SNM mass was selected as a bounding value. ORNL performed additional calculations that included varying amounts of beryllium, graphite, and heavy water within the silicon dioxide waste matrix. As discussed above, this magnitude of unusual moderators was used to calculate the general case concentration limits.

During the development of the exemption, Envirocare requested a concentration limit for uranium-235 without regard for the beryllium or magnesium oxide content. ORNL performed additional criticality analyses varying the beryllium and magnesium oxide content to calculate a subcritical limit for uranium-235 above 10 percent enrichment. A subcritical limit for this case of 160 pCi/g was obtained. Envirocare also requested a limit for beryllium and magnesium oxide that would result in a uranium-235 concentration limit of 680 pCi/g for 10 percent enrichment or greater. ORNL performed additional criticality analyses and determined that the associated sum of beryllium and magnesium should be less than 49 percent. These additional concentration limits are included in Condition 1.

Soluble Uranium Compounds

NRC examined mechanisms that could increase the concentration of the SNM in the waste. One of these mechanisms is that highly soluble uranium could be readily leached with water and concentrate. Highly soluble forms of uranium include, but are not limited to: uranium sulfate, uranyl acetate, uranyl chloride, uranyl formate, uranyl fluoride, uranyl nitrate, uranyl potassium carbonate, and uranyl sulfate. NRC considered that leaching or washing of soluble uranium from waste in containers could occur and collect in a corner of the container.

The maximum calculated amount of uranium-235 that could be permissible at the maximum concentration (1300 pCi U-235/g) for a large intermodal container (70 yd^3) assuming the density of the waste was 1.6 g/cm^3 was calculated to be 51.6 kg. This value was compared with the minimum critical mass for uranium-235 (760 g). In order to insure criticality safety, the mass of soluble uranium should be a fraction of the minimum critical mass. Consistent with 10 CFR Part 150, NRC selected a mass limit of 350 g of soluble uranium-235 or 200 g of soluble uranium-233 as being acceptable to insure subcriticality. For mixtures of uranium-233 and uranium-235, the sum of the fractions rule would apply. It was further recognized that the mass of uranium will be limited by the consignment mass limits in 10 CFR Part 71.

POSSIBLE REGULATORY CHANGES

As discussed above, the regulation of SNM LLW disposal changed in 1997 when Chem-nuclear Systems Inc. and U.S. Ecology Inc. requested that the SNM possession limits in their NRC Part 70 license be reduced and that the licenses be transferred to the States. Now, SNM waste is only disposed of at LLW disposal facilities licensed by Agreement States. These actions caused NRC to reevaluate its involvement with SNM and LLW. Several issues were raised to the Commission in SECY-98-010 [8], including possible changes to 10 CFR 150.

In SRM-SECY-98-010 and SRM-SECY-98-226 [9], the Commission requested the staff to evaluate the impacts of the Envirocare Order and to consider modifying 10 CFR 150.10 to include a concentration-based exemption limit in addition to the current mass-based exemption limit.

CONCLUSION

NRC examined a basis for establishing a concentration-based criticality safety limit for SNM in LLW. This concept was incorporated into an Order to Envirocare that allows Envirocare exceed the SNM mass limits in 10 CFR 150, subject to the conditions of the Order. NRC is continuing to work with the State of Utah and Envirocare to evaluate the usefulness of this concept. In the long term, NRC is considering modifying 10 CFR 150 to incorporate a concentration-based limit in addition to the current mass-based limit.

REFERENCES

[1] USNRC, Order to Envirocare of Utah, Inc., U.S. Nuclear Regulatory Commission, Washington, DC, May 1999 .

[2} USNRC, "Safety Evaluation Report Regarding the Proposed Exemption from Requirements of 10 CFR Part 70," U.S. Nuclear Regulatory Commission, Washington, DC, May 1999.

[3] USNRC, "Environmental Assessment and Finding of No Significant Impact for Exemption from certain NRC Licensing Requirements for Special Nuclear Material for Envirocare of Utah, Inc," U.S. Nuclear Regulatory Commission, Washington, DC, May 1999.

[4] USNRC, "Environmental Assessment and Finding of No Significant Impact for Exemption from certain NRC Licensing Requirments for Special Nuclear Material for Envirocare of Utah, Inc.," Federal Register, Vol.64, No. 93, Friday May 14, 1999, pp 26463-26465.

[5] Toran, L.E., et al., "The Potential for Criticality Following Disposal of Uranium at Low-Level Waste Facilities," NUREG-6505, Volume 1, U.S. Nuclear Regulatory Commission, Washington, DC, June 1997.

[6] Toran, L.E., et al., "The Potential for Criticality Following Disposal of Uranium at Low-Level Waste Facilities," NUREG-6505, Volume 2, U.S. Nuclear Regulatory Commission, Washington, DC, August 1998.

[7] Elam, K.R., et al., "Emplacement Guidance for Criticality Safety in Low-Level Waste Disposal," NUREG-6626, U.S. Nuclear Regulatory Commission, Washington, DC, Draft.

[8] USNRC, "Petition for Envirocare of Utah to Possess Special Nuclear Material in Excess of Current Regulatory Limits," SECY-98-010, U.S. Nuclear Regulatory Commission, Washington, DC, January 1998.

[9] USNRC, "Staff Requirements - SECY-99-226 – Issuance of a Section 274f Atomic Energy Act Order to Exempt Envirocare of Utah, Inc. from the Licensing Requirements for Special Nuclear Material in Diffuse Waste That will be Regulated by the State of Utah" SRM- SECY-99-0226, U.S. Nuclear Regulatory Commission, Washington, DC, October 1998.

CONDITIONS IN THE ORDER TO ENVIROCARE
DATED MAY 7, 1999

1. Concentrations of SNM in individual waste containers must not exceed the following values at time of receipt:

Radionuclide	Maximum Concentration (pCi/g)	Measurement Uncertainty (pCi/g)
U-235[a]	1,900	285
U-235[b]	1,190	179
U-235[c]	160	24
U-235[d]	680	102
U-233	75,000	11,250
Pu-236	500	75
Pu -238	10,000	1,500
Pu-239	10,000	1,500
Pu-240	10,000	1,500
Pu-241	350,000	50,000
Pu-242	10,000	1,500
Pu-243	500	75
Pu-244	500	75

a - for uranium below 10 percent enrichment and a maximum of 20 percent MgO of the weight of the waste
b - for uranium at or above 10 percent enrichment and a maximum of 20 percent MgO of the weight of the waste
c - for uranium at any enrichment with unlimited MgO or beryllium
d - for uranium at any enrichment with sum of MgO and beryllium not exceeding 49 percent of the weight of the waste

The measurement uncertainty values in column 3 above represent the maximum one-sigma uncertainty associated with the measurement of the concentration of the particular radionuclide.

The SNM must be homogeneously distributed throughout the waste. If the SNM is not homogeneously distributed, then the limiting concentrations must not be exceeded on average in any contiguous mass of 145 kilograms.

2. Except as allowed by notes a, b, c, and d in Condition 1, waste must not contain Apure forms@ of chemicals containing carbon, fluorine, magnesium, or bismuth in bulk quantities (e.g., a pallet of drums, a B-25 box). By Apure forms,@ it is meant that mixtures of the above elements such as magnesium oxide, magnesium carbonate, magnesium fluoride, bismuth oxide, etc. do not contain other elements. These chemicals would be added to the waste stream during processing, such as at fuel facilities or treatment such as at mixed waste treatment facilities. The presence of the above materials will be determined by the generator, based on process knowledge or testing.

3. Except as allowed by notes c and d in Condition 1, waste accepted must not contain total quantities of beryllium, hydrogenous material enriched in deuterium, or graphite above one percent of the total weight of the waste. The presence of the above materials will be determined by the generator, based on process knowledge, physical observations, or testing.

4. Waste packages must not contain highly water soluble forms of uranium greater than 350 grams of uranium-235 or 200 grams of uranium-233. The sum of the fractions rule will apply for mixtures of uranium-233 and uranium-235. Highly soluble forms of uranium include, but are not limited to: uranium sulfate, uranyl acetate, uranyl chloride, uranyl formate, uranyl fluoride, uranyl nitrate, uranyl potassium carbonate, and uranyl sulfate. The presence of the above materials will be determined by the generator, based on process knowledge or testing.

5. Mixed waste processing of waste containing SNM will be limited to stabilization (mixing waste with reagents), micro-encapsulation, and macro-encapsulation using low-density polyethylene.

6. Envirocare shall require generators to provide the following information for each waste stream:

   Pre-shipment

   1. Waste Description. The description must detail how the waste was generated, list the physical forms in the waste, and identify uranium chemical composition.
   2. Waste Characterization Summary. The data must include a general description of how the waste was characterized (including the volumetric extent of the waste,

and the number, location, type, and results of any analytical testing), the range of SNM concentrations, and the analytical results with error values used to develop the concentration ranges.

3. Uniformity Description. A description of the process by which the waste was generated showing that the spatial distribution of SNM must be uniform, or other information supporting spatial distribution.
4. Manifest Concentration. The generator must describe the methods to be used to determine the concentrations on the manifests. These methods could include direct measurement and the use of scaling factors. The generator must describe the uncertainty associated with sampling and testing used to obtain the manifest concentrations.

Envirocare shall review the above information and, if adequate, approve in writing this pre-shipment waste characterization and assurance plan before permitting the shipment of a waste stream. This will include statements that Envirocare has a written copy of all the information required above, that the characterization information is adequate and consistent with the waste description, and that the information is sufficient to demonstrate compliance with conditions 1 through 4. Where generator process knowledge is used to demonstrate compliance with Conditions 1, 2, 3, or 4, Envirocare shall review this information and determine when testing is required to provide additional information in assuring compliance with the conditions. Envirocare shall retain this information as required by the State of Utah to permit independent review.

At receipt

Envirocare shall require generators of SNM waste to provide a written certification with each waste manifest that states that the SNM concentrations reported on the manifest do not exceed the limits in Condition 1, that the measurement uncertainty does not exceed the uncertainty value in Condition 1, and that the waste meets conditions 2 through 4.

7. Sampling and radiological testing of waste containing SNM must be performed in accordance with the Utah Division of Radiation Control license Condition 58.

8. Envirocare shall notify the NRC, Region IV office within 24 hours if any of the above conditions are violated. A written notification of the event must be provided within 7 days.

9. Envirocare shall obtain NRC approval prior to changing any activities associated with the above conditions.