NUREG/CR-7239, "Review of Fissile Material Exemptions and General Licenses in 10 CFR Part 71," and Proposed Revisions to Harmonize with IAEA SSR-6 Fissile Material Requirements

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ABSTRACT

Title 10 of the United States (US) Code of Federal Regulations (CFR), Part 71, Packaging and Transportation of Radioactive Material, includes requirements for the transport of fissile material in packages. These regulations provide requirements for packaging that is certified by the US Nuclear Regulatory Commission (NRC) to transport fissile material. The regulations also include provisions that allow for shipment in packages that are not required to be certified by the NRC. These provisions include criteria for exemptions from classification as fissile material (§71.15) and permit general licenses for limited quantities of fissile material and plutonium-beryllium special form sources (§71.22 and §71.23, respectively). This paper will discuss recommendations that NRC has made on the use of the fissile material exemptions and general license provisions in a recently published NUREG/CR, and changes to these provisions proposed for an upcoming rulemaking action.

NUREG/CR-7239, "Review of Fissile Material Exemptions and General Licenses in 10 CFR Part 71," was recently developed by Oak Ridge National Laboratory (ORNL) for the NRC. This document provides technical recommendations to fissile material licensees on how to apply the fissile material exemption and general license regulations. This paper will outline this NUREG/CR, including: 1) the technical basis, intent, and anticipated usage of each of the fissile material exemption and general license provisions; 2) the recent regulatory history of the Part 71 fissile material exemptions and general licenses; and 3) example problems which illustrate how the provisions might be applied and justified.

In 2012, IAEA made several significant changes to the fissile material requirements in SSR-6, including the fissile exception provisions and provisions similar to the U.S. fissile material general licenses. In 2016, the NRC began a rulemaking effort to consider these changes (among others), and to decide how to best harmonize the domestic U.S. regulations. This paper will review the 2012 changes made to SSR-6, discuss the NRC staff consideration of those changes, and detail the proposed revisions to 10 CFR Part 71 that NRC is considering for the fissile material exemptions and general licenses.

1. INTRODUCTION

Title 10 of the United States (US) Code of Federal Regulations (CFR), Part 71, "Packaging and Transportation of Radioactive Material[1]," includes requirements for the transport of fissile material in packages. The objective of the fissile material exemptions in 10 CFR 71.15 and fissile material general licenses in 10 CFR 71.22 and 71.23 is to facilitate the safe transport of low-risk (e.g., small quantities or low concentrations) fissile material by exempting shipments of these materials from the criticality safety packaging requirements for fissile material transportation, and to allow the shipments to take place without specific U.S. Nuclear Regulatory Commission (NRC) approval. The lower amount of regulatory oversight is acceptable for these shipments, because the exemptions are established so as to ensure safety under all credible transportation conditions.

The International Atomic Energy Agency (IAEA) promulgates regulations similar to those in 10 CFR Part 71 for transportation of radioactive materials in "Specific Safety Requirements No. SSR – 6" (SSR-6, 2012 and 2018 edition)[2, 3]. SSR-6 contains exceptions from the fissile material transportation requirements, similar to the exemptions in 10 CFR Part 71, for small quantities and concentrations of fissile material which may be shipped without the approval of a transportation Competent Authority. The NRC periodically reviews the regulations in IAEA SSR-6, and makes changes to 10 CFR Part 71 to harmonize with the IAEA regulations to the extent practical.

The provisions in 10 CFR Part 71 were revised by the NRC in 2004 as part of a broad rulemaking effort that included extensive revision to the exemptions and general licenses for fissile material. In 2018, the NRC issued NUREG/CR-7239, "Review of Fissile Material Exemptions and General Licenses in 10 CFR Part 71,"[4] to provide explanatory information on the background, intent, and anticipated use of the provisions in an effort to assist fissile material licensees in their interpretation and application of the fissile material exemptions and general licenses. The next section outlines this NUREG/CR, including: 1) the technical basis, intent, and anticipated usage of each of the fissile material exemption and general license provisions; 2) the recent regulatory history of the Part 71 fissile material exemptions and general licenses; and 3) example problems which illustrate how the provisions can be applied and justified.

The provisions in IAEA SSR-6 were revised in both 2012 and 2018. In 2016, the NRC staff initiated a rulemaking to harmonize 10 CFR Part 71 with the revised regulations in SSR-6. Several of the changes made to SSR-6 involved fissile exceptions and provisions similar to the fissile material general licenses in 10 CFR Part 71. Section 3 details the SSR-6 provisions the NRC is considering in its rulemaking effort, and the changes to 10 CFR Part 71 the NRC is proposing to make. Section 4 details several clarification changes the NRC is proposing to make to the fissile material general licenses that are unrelated to SSR-6 harmonization.

2. NUREG/CR-7239, "REVIEW OF FISSILE MATERIAL EXEMPTIONS AND GENERAL LICENSES IN 10 CFR PART 71"

Parameters that must be considered to ensure criticality safety in a fissile material system are: the mass, concentration, or isotopic distribution of the fissile material; and the system geometry, degree of neutron moderation, and neutron reflection of the package from surrounding materials. These parameters were carefully considered in developing the requirements for the exemptions from the classification of fissile material and the requirements for general licenses for fissile material, as described in NUREG/CR-7239 and summarized in the following subsections.

2.1 10 CFR 71.15: Exemption From Classification as Fissile Material

Fissile material that meets one of the six exemption criteria in 10 CFR 71.15 can be transported in packages that do not meet the fissile material transportation requirements of 10 CFR 71.55 and 10 CFR 71.59. The exemptions consider that the material may be released from any packaging during transport, may reconfigure into a worst-case geometric arrangement, may combine with material from other transport vehicles, and may be subject to the fire and water immersion conditions assumed as part of the criticality safety assessment for package designs approved to transport fissile material. The following sections describe each of the six fissile exemption criteria in 10 CFR 71.15.

2.1.1 10 CFR 71.15(a): Individual package containing 2 grams or less fissile material

Individual packages containing small quantities of fissile materials, such as environmental samples shipped frequently for testing purposes, contain such a low quantity of fissile materials that the risk of accumulating the number and type of packages needed to present a potential criticality hazard is negligible. The provision in 10 CFR 71.15(a) limits a single package in a consignment to a "*de minimis*" value of 2 total grams of ^{233}U, ^{235}U, ^{239}Pu, and ^{241}Pu. This exemption does not limit the accumulation of packages because the NRC judged it impractical in commerce to accumulate a sufficient number of individual packages to result in significant criticality safety concerns. Under normal conditions of transport, a cubic array of 84,853, 1-liter packages containing only ^{235}U, at near-optimal moderation, would be required for criticality to be possible[5].

2.1.2 10 CFR 71.15(b): Individual or bulk packaging containing 15 grams or less of fissile material

This exemption is for 15 grams or less of fissile material, provided the package has at least 200 grams of solid nonfissile material for every gram of fissile material. Lead, beryllium, graphite, and hydrogenous material enriched in deuterium may be present in the package but must not be included in determining the required mass of solid nonfissile material. This fissile material exemption allows larger per-package limits than the 2 gram limit in 10 CFR 71.15(a), provided a sufficient amount of nonfissile packaging or other material is present. Single package subcriticality is assured by the small fissile material mass limit, and package accumulation does not result in criticality safety concerns due to the dilution effect of the required nonfissile mass. The exclusion of effective neutron reflectors (e.g., lead and beryllium) from the required nonfissile mass further reduces the probability of inadvertent criticality from package accumulation.

2.1.3 10 CFR 71.15(c): Low concentrations of solid fissile material commingled with solid nonfissile material

This exemption provision is for low concentrations of solid fissile material commingled with solid nonfissile material, provided that: (1) there is at least 2000 grams of solid nonfissile material for every gram of fissile material, and (2) there is no more than 180 grams of fissile material distributed within 360 kg of contiguous nonfissile material. Similar to 10 CFR 71.15(b), lead, beryllium, graphite, and hydrogenous material enriched in deuterium may be present in the package but must not be included in determining the required mass of solid nonfissile material. This fissile material exemption allows transportation of large volumes of waste or other material containing low concentrations of solid fissile material, commingled with a large amount of solid nonfissile material. The quantity of fissile material in this provision is not limited, but must be commingled such that no more than 180 grams is distributed within 360 kg (360,000 grams) of solid nonfissile material, resulting in a package matrix that is practically acting as a homogeneous mixture of fissile material.

2.1.4 10 CFR 71.15(d): Uranium enriched in ^{235}U to a maximum of 1 percent by weight

This exemption is for uranium enriched in ^{235}U to a maximum of 1 percent by weight, with total plutonium and ^{233}U content of up to 1 percent of the mass of ^{235}U, provided that the mass of any beryllium, graphite, and hydrogenous material enriched in deuterium constitutes less than 5 percent of the uranium mass. Also, the fissile material should be distributed homogeneously and not form a lattice arrangement within the package. Systems containing homogeneous mixtures of uranium enriched to less than 1 percent will not be critical, irrespective of the mass or size of the system, provided other fissile materials are not present. 10 CFR 71.15(d) also limits the quantity of some less common moderating materials (beryllium, graphite, hydrogenous material enriched in deuterium) because the

presence of these materials has the potential to reduce the minimum critical enrichment, increasing the potential for criticality with uranium of lower enrichment.

2.1.5 10 CFR 71.15(e): Liquid solutions of uranyl nitrate enriched in ^{235}U to a maximum of 2 percent

This exemption is for uranyl nitrate solutions enriched in ^{235}U to a maximum of 2 percent by mass, with a total plutonium and ^{233}U content not exceeding 0.002 percent of the mass of uranium, and with a minimum nitrogen to uranium atomic ratio (N/U) of 2. The material must be contained in at least a U.S. Department of Transportation (DOT) Type A package, to ensure that the liquid is not released during normal conditions of transport. This requirement also ensures that the solution material will not convert to oxide form, combine with fissile material from other packages, mix with water, or form into an unfavorable geometry during normal conditions of transport. The total mass of ^{235}U in the consignment is not controlled for criticality safety purposes; however, the mass of uranium in the solution must be known if there is plutonium or ^{233}U present, since the mass of other fissile nuclides is limited to 0.002 percent of the mass of uranium. Additionally, the ratio of atomic nitrogen to uranium (N/U) ratio is limited to 2 or more. This limit ensures that a minimum level of neutron absorption by the nitrogen is present in the fissile material package.

2.1.6 10 CFR 71.15(f): Packages containing, individually, a plutonium mass of not more than 1000 grams

This exemption is for packages containing up to 1000 grams of plutonium, of which not more than 20 percent by mass may consist of ^{239}Pu, ^{241}Pu, or any combination of these radionuclides. This fissile exemption does not constrain the total mass of fissile material in a consignment nor does it constrain the mass of commingled nonfissile material or moderating materials. It is intended primarily for shipment of the nonfissile isotopes of plutonium, such as ^{238}Pu in heat sources. The presence of the nonfissile plutonium isotopes provides significant parasitic neutron absorption, and eliminates the potential for criticality.

2.2 General Licenses in 10 CFR 71.22 and 10 CFR 71.23

The general license criteria in 10 CFR 71.22 (fissile material) and 71.23 (Pu-Be special form material) are intended to allow NRC licensees to ship small quantities of fissile material in packages that have been assigned a Criticality Safety Index (CSI) to ensure accumulation control for packages on a conveyance. These general license criteria require that the licensee have an NRC-approved quality assurance program under Subpart H of 10 CFR Part 71, that the fissile material is present in a Type A package and that the package contains no more than a Type A quantity of radioactive material (see Section 4.1 for proposed changes to these restrictions). The Type A package requirement ensures that the package maintains sufficient structural integrity under normal conditions of transport to preclude fissile material dispersing from the package.

The CSI equation for each general license is derived to assure that at least two conveyances, shipped under non-exclusive use, would have to experience accident conditions before there was a potential for criticality. The CSI for the fissile material general license in 10 CFR 71.22 is calculated using the equation:

$$CSI = 10\left[\frac{Grams\ of\ ^{235}U}{X} + \frac{Grams\ of\ ^{233}U}{Y} + \frac{Grams\ of\ Pu}{Z}\right] \quad (1)$$

Where the denominators *X*, *Y*, and *Z* are determined one of two ways:

- Table 71-1 of 10 CFR 71.22 must be used if any of the following conditions exist: ^{233}U is present in the package, plutonium mass exceeds 1 percent of the mass of ^{235}U, the uranium is of unknown enrichment or greater than 24 weight percent enrichment, or substances having a moderating effectiveness (i.e., an average hydrogen density) greater than H_2O (e.g., certain hydrocarbon oils or plastics) are present in any form, except as polyethylene used for packing or wrapping; or
- Table 71-2 of 10 CFR 71.22 may be used if the package contains only ^{235}U with known enrichment (the terms for ^{233}U and plutonium are assumed to be 0 in the equation).

The general license mass limits in Table 71-1 of 10 CFR 71.22 used to calculate the CSI for single and multiple packages are based on the upper subcritical mass allowed for materials of interest (e.g., 600, 430, and 370 grams, respectively for fully enriched ^{235}U, ^{233}U, and ^{239}Pu). The CSI for an individual package must be less than or equal to 10. Table 71-1 includes a second set of reduced mass values based on upper subcritical mass values for fissile material present with moderators having a hydrogen density higher than water (e.g., 240 g for ^{239}Pu). For uranium of known enrichment up to 24 weight percent, the value of *X* in Equation 1 is given as a function of enrichment in Table 71-2, from 0.92 to 24 weight percent, based on 10 percent of the safe subcritical mass value for each enrichment.

The CSI for the general license for Pu-Be special form sources, limited to 1,000 grams total plutonium, of which no more than 240 grams may be ^{239}Pu and/or ^{241}Pu, in 10 CFR 71.23 is calculated using the equation:

$$CSI = 10\left[\frac{Grams\ of\ ^{239}Pu + Grams\ of\ ^{241}Pu}{24}\right] \quad (2)$$

In recognition of the increased confidence in these special form sealed sources, the CSI for an individual package may be greater than 10. Any plutonium over 240 grams must be non-fissile isotopes of plutonium.

NUREG/CR-7239 provides additional detail on the intent and technical basis of each of the fissile material exemption and general license provisions. Additionally, many of the calculations that support the limits in the fissile material exemption and general license provisions were performed, or referenced in, NUREG/CR-5342, “Assessment and Recommendations for Fissile-Material Packaging Exemptions and General Licenses Within 10 CFR Part 71[6].”

2.3 History of Part 71 Fissile Exemptions and General Licenses

The fissile exemption and general license criteria have existed in some form in 10 CFR Part 71 for several decades. The following paragraphs include a summary of the major rulemaking actions that are discussed in NUREG/CR-7239.

In 1997, the NRC initiated an emergency rulemaking of 10 CFR Part 71 to address concerns regarding the potential for inadequate criticality safety in certain exempted quantities of fissile material (specifically beryllium oxide containing a low concentration of high-enriched uranium) under the regulations in effect at the time. The NRC issued an emergency final rule on February 10, 1997[7], to revise the regulations on fissile material exemptions and the general licenses to limit the consignment mass and restrict the presence of beryllium, deuterium, and graphite.

Based on the public comments on the emergency final rule, the NRC staff contracted with Oak Ridge National Laboratory (ORNL) to review the fissile material exemptions and general

license provisions, study the regulatory and technical bases associated with these regulations, and perform criticality model calculations for different mixtures of fissile materials and moderators. The ORNL study, published as NUREG/CR-5342, confirmed that the emergency final rule was needed to provide safe transportation of packages with low-absorption moderators shipped under the general license and fissile material exemptions, but concluded that the regulations may be excessive for shipments where water moderation is the only concern. NUREG/CR-5342 made a series of recommendations on how to revise the fissile material exemptions and general licenses, which were largely incorporated in a rulemaking that was final in 2004[8], resulting in the format of the exemptions and general licenses described in Sections 2.1 and 2.2 above.

Subsequent to the 2004 rulemaking, analyses performed by the U.S. Department of Energy (DOE) indicated that large arrays (i.e., multiple conveyances) of heterogeneous uranium with enrichment of one percent by weight of ^{235}U, exempted under 10 CFR 71.15(d), could exceed a k_{eff} of 0.95 when optimally moderated by water. The NRC decided that additional restrictions on low-enriched fissile material shipped under the fissile material exemption at 10 CFR 71.15(d) are warranted to provide similar safety equivalence provided by certified packages per the criteria of 10 CFR 71.55 and 10 CFR 71.59. The revised provision excludes from the exemption's scope situations where fissile "lumps" or lattices of fissile material are present within the package, by ensuring "that the fissile material is distributed homogeneously and does not form a lattice arrangement within the package."

2.4 NUREG/CR-7239 Example Problems

NUREG/CR-7239 provides hypothetical examples for the fissile exemption provisions in 10 CFR 71.15 and general license provisions 10 CFR 71.22 and 71.23. Each example problem was chosen based upon transportation scenarios that could illustrate how the provisions might be applied and justified. The following are two examples from Section 5 of NUREG/CR-7239.

2.4.1 Uranium-Contaminated Process Equipment

Legacy equipment in a nuclear facility may contain fissile material in small quantities. For example, a converter from a gaseous diffusion plant may contain fissile material even following significant efforts to decontaminate the equipment non-destructively. Assume a converter from a gaseous diffusion plant processes uranium hexafluoride gas with uranium enrichment of 1.75 weight percent ^{235}U. It is known that fissile material is present mainly as internal surface contamination. The interior portions cannot be visually inspected, and the equipment is known to contain less than 95 grams of ^{235}U, a value that contains at least two times the uncertainty of the measurement. The site would like to ship this large item intact using fissile material exemption 10 CFR 71.15(c) because it contains significantly more fissile material than allowed by 10 CFR 71.15(a) and 71.15(b), and the 2,000:1 ratio of nonfissile material to fissile material is clearly met based on the quantity of ^{235}U present and the large mass of the converter casing (nonfissile material). Based on operating experience, the consignor must assume that the fissile material present could redistribute during transportation operations, which is not consistent with the intent of 10 CFR 71.15(c) with respect to the fissile material being uniformly distributed within the nonfissile material, in this case the converter casing. Therefore, the converter cannot be shipped using the 10 CFR 71.15(c) fissile material exemption.

The size of the uranium-contaminated process equipment makes shipping options difficult. As discussed above, the fissile exemption regulations are not applicable to this situation. The general license requirements are an option; however, these requirements require a Quality Assurance (QA) program approved by the NRC under Subpart H of 10 CFR Part 71

and the use of a Type A package that meets the DOT requirements in 49 CFR 173.417(a). If a Type A package can be designed or is available to ship the converter, the general license requirements can be used for the equipment. The uranium enrichment for this problem, 1.75 weight percent ^{235}U, is well within the enrichment data shown in Table 71-2, "Mass Limits for General License Packages Containing Uranium-235 of Known Enrichment per 71.22(e)." The CSI based on the ^{235}U present, 95 grams, and the mass limit for a ^{235}U enrichment of 1.75 weight percent, 246 grams for 2 weight percent enrichment material (interpolation is not permitted and the next-highest enrichment value must be used), is 3.9 (CSI = 10 × [95 ÷ 246]). Based on this CSI result, and assuming the converter can be shipped in a Type A package, single or multiple converters can be shipped with a CSI of less than 50, which qualifies the package to be shipped on a nonexclusive use conveyance.

2.4.2 Uranium-Graphite Waste

A fissile material operation generates wastes that contain a mixture of uranium, graphite, and other nonfissile solids after dissolution and precipitation operations. The enrichment of the uranium in the waste material is 20 weight percent ^{235}U. The solids are transferred to a 5 gallon drum (18.9 Liters (L)) and placed in a Type A package after the operations are completed. The solids have an average uranium concentration of about 7.5 grams U/L. At 20 weight percent ^{235}U, the concentration of ^{235}U is about 1.5 grams ^{235}U/L. The quantity of ^{235}U in the 5 gallon drum is about 28.4 grams (1.5 grams ^{235}U/L × 18.9 L). Approximately 300 grams of graphite (bulk density of 0.0159 g/cm^3) is present in the 5 gallon drum.

The contents will be contained within a Type A package, and no more than a Type A quantity of additional radioactive material is present in the container. Again, approximately 300 grams of graphite is present inside the package and mixed with the fissile material, which is within the 500 gram limitation. Furthermore, the licensee that will ship the package has an NRC-approved QA program that meets the requirements in 10 CFR Part 71 Subpart H.

The CSI can be calculated by using the quantity of ^{235}U present in the 5 gallon drum, 28.4 grams, and the enrichment of the uranium, 20 weight percent ^{235}U. This mass quantity has already factored in two times the measurement uncertainties in the sampled data. The CSI equation, with the mass of ^{235}U and the mass limit referenced from Table 71-2 for uranium of known enrichment, is as follows:

$$CSI = 10\left[\frac{Grams\ of\ ^{235}U}{X}\right] \tag{3}$$

$$CSI = 10\left[\frac{28.4\ g}{63\ g}\right] = 4.507 \tag{4}$$

The final CSI is 4.6, rounded up to the next decimal place. The calculated CSI for the single package is less than the limit of 10. The package can be shipped on a nonexclusive use conveyance which has a total CSI limit of 50. The consignor can ship multiple Type A packages if desired based on the calculated CSI.

If a general license is not desired for shipping the drum of uranium graphite waste, the fissile exemption criteria in 10 CFR 71.15(c) can be used for this example if nonfissile diluent is added to the package to ensure a nonfissile-to-fissile mass ratio is greater than 2,000-to-1. This regulation allows graphite to be present in the package along with the fissile material and diluent material but the graphite cannot be used to determine the required mass of solid nonfissile material in the package. Because there is less than 30 grams of ^{235}U present in the

package, the package will contain less than 180 grams of fissile material distributed within the nonfissile matrix.

3. NRC CONSIDERATION OF IAEA PROVISIONS

In 2012, the IAEA updated its fissile exception provisions in SSR-6 paragraph 417. Additionally, the IAEA updated its provisions for fissile material packages that do not require criticality analysis, where accumulation control is provided using a CSI label (analogous to 10 CFR Part 71 fissile material general license provisions), in paragraphs 674 and 675. The NRC considered the differences between the fissile material exemptions and general licenses in 10 CFR Part 71, and similar provisions in IAEA SSR-6, as part of its effort to harmonize its regulations with the IAEA's radioactive material transportation requirements. The NRC divided the changes in SSR-6 related to the transportation of fissile material into four sub issues, discussed in each of the following four subsections.

3.1 Issue No.1a: New Fissile Exceptions in IAEA SSR-6, Paragraph 417

The IAEA revised the fissile exceptions in SSR-6 paragraph 417 to include three new provisions, each with package or mass accumulation controls from paragraph 570:

- 417(c) – uranium with enrichment up to 5.0 weight percent ^{235}U, up to 3.5 grams ^{235}U per package, with up to 45 grams ^{235}U per consignment,
- 417(d) – up to 2.0 grams fissile nuclides (^{233}U, ^{235}U, ^{239}Pu, or ^{241}Pu) per package, with up to 15 grams fissile nuclides per consignment, and
- 417(e) – up to 45 grams fissile nuclides, packaged or unpackaged, shipped exclusive use.

The NRC is proposing to incorporate IAEA SSR-6 paragraph 417(c), without the associated consignment limit of IAEA SSR-6 paragraph 570(c), as an additional fissile exemption under 10 CFR 71.15. The amount of fissile material allowed by this new provision correlates to the existing exemption in 10 CFR 71.15(a) when the lower enrichment (maximum of 5 weight percent ^{235}U) is considered. So, in terms of reactivity, the staff determined that the consignment limit of IAEA SSR-6 paragraph 570(c) is not necessary. Consignment limits do not prevent the accumulation of packages on a transport conveyance, as there is no limit to the number of consignments that may be present on a single conveyance. Additionally, Ref. 5 discusses a series of calculations performed to determine the number of 10-liter containers containing 2.0 grams of fissile material required to achieve criticality under optimal conditions (i.e., pure ^{235}U or fully enriched uranium), optimum moderation, optimum geometry (spherical units/cubic array), and full water reflected array. No packaging material is credited in these calculations. A cubic array of 84,853 1-liter packages was required at near-optimal moderation (hydrogen-to-uranium ratio of approximately 1200) for criticality to be possible. The size of the array in the calculation model was roughly 4.4 meters (14.4 feet) on a side. The results of these calculations demonstrate that it would be impractical or uneconomical to accumulate a large number of such packages, especially considering that under realistic conditions (e.g., neutron absorption by package material and nonfissile uranium isotopes) a critical array would be much larger.

Paragraph 417(d) of IAEA SSR-6 is similar to the existing exemption in 10 CFR 71.15(a), but with a consignment limit of 15 grams (as specified in paragraph 570(d)). This means that the only change under consideration related to this exemption would be adding a consignment limit to the exemption in 10 CFR 71.15(a). Although theoretically possible, the NRC staff does not consider the accumulation of such packages in sufficient numbers to cause criticality concerns to be credible, as discussed in the preceding paragraph.

Therefore the NRC staff is proposing not to adopt the consignment limit of IAEA SSR-6 paragraph 570(d).

The NRC staff considers the provision in paragraph 417(e) of IAEA SSR-6 to be conservative (45 grams represents about one eighth of the consensus minimum subcritical mass value for ^{239}Pu moderated by water). Also, the NRC staff has determined that a mass value higher than that contained in IAEA SSR-6 paragraph 417(e) is justified, given the conservatism inherent in the exclusive use restriction of the SSR-6 provision, and in basing the mass limit on ^{239}Pu (which would have to be shipped in a Type B package which meets the containment criteria in 10 CFR Part 71 after being subjected to hypothetical accident conditions). The NRC is proposing a limit of 140 grams of fissile material. This limit is based on one fifth of a consensus minimum critical mass of ^{235}U under optimum conditions. This mass represents a conservative limit for fissile material, since five times this amount would remain subcritical under any conditions. Additionally, the limit provides safety equivalent to packages approved under 10 CFR Part 71 and could provide more flexibility for shipping individual contaminated items or small quantities of fissile material. The NRC staff considers ^{235}U for this limit rather than ^{239}Pu, as any amount of ^{239}Pu over 0.435 grams is considered Type B, which would have to be packaged to meet 10 CFR Part 71 containment criteria under both normal and hypothetical accident conditions of transport. The NRC is not proposing to adopt the "packaged or unpackaged" language in the fissile exception provision of IAEA SSR-6 paragraph 417(e). The 140-gram limit, as with other fissile exemption provisions in 10 CFR 71.15, only relieves the consignor from having to ship in a "Fissile" certified package, evaluated per the requirements of 10 CFR 71.55 and 71.59. This material is still subject to all other radioactive materials transportation requirements in 10 CFR Part 71 and in 49 CFR Part 173 and should be packaged accordingly.

3.2 Issue 1b: Competent Authority-Approved Fissile Exception, SSR-6 Paragraph 417(f)

The IAEA added a fissile exception provision in SSR-6 paragraph 417(f), for "a fissile material that meets the requirements of paragraphs 570(b), 606, and 802." This exception was added to SSR-6 in part to recognize that some competent authorities would like to approve exceptions for fissile material that are different from those in paragraph 417. The NRC is proposing not to adopt the provision in IAEA SSR-6 paragraph 417(f) for the following reasons: (1) the NRC staff estimates that such a provision would rarely be used by U.S. fissile material licensees; (2) the existing fissile material exemptions and general licenses in 10 CFR 71.15, 71.22, and 71.23, as well as the new exemptions proposed under Issue 1a discussed in Section 3.1, already provide a great deal of flexibility in shipping small quantities or low concentrations of fissile material; and (3) the allowance to request a specific exemption under 10 CFR 71.12 is adequate to address the rare case where exemption from a requirement might be justified.

3.3 Issue 1c: CSI-Controlled Fissile Material Packages, SSR-6 Paragraph 674

In 2012, the IAEA added provisions in SSR-6 paragraph 674 for CSI-controlled packages of fissile material, analogous to the fissile material general license requirements in 10 CFR 71.22 and 71.23. The NRC is not proposing to adopt the changes in IAEA SSR-6 paragraph 674, because the existing mass limits and other requirements in 10 CFR 71.22 and 71.23 are appropriate for providing criticality safety equivalent to packages approved under the criticality safety requirements of 10 CFR 71.55 and 71.59. The calculations from NUREG/CR-5342 which form the basis of the mass limits in 10 CFR 71.22 and 71.23 demonstrate that the existing mass limits will maintain packages shipped under these provisions subcritical under all conditions. Adopting the provisions of IAEA SSR-6 would result in more restrictive mass limits for 10 CFR Part 71 fissile material general licenses.

3.4 Issue 1d: Plutonium Shipments in Nonfissile Packages, SSR-6 Paragraph 675

Paragraph 675 of SSR-6 is a provision for shipping plutonium in a nonfissile package, with accumulation control provided by the calculation of a CSI. Plutonium is limited to 1000 grams per package, no more than 20 percent of which may be the fissile isotopes of plutonium (^{239}Pu and ^{241}Pu). This same criterion for plutonium was previously a provision in IAEA SSR-6 paragraph 417, with no accumulation control. The regulation in 10 CFR 71.15(f) currently includes the provision without accumulation control. The NRC is proposing to not adopt the changes in IAEA SSR-6 paragraph 675, since the NRC staff has determined that the fissile exemption in 10 CFR 71.15(f) is safe without accumulation control, and that there is no safety benefit to limiting accumulation through the use of a CSI.

4. PROPOSED CHANGES TO THE FISSILE MATERIAL GENERAL LICENSES IN 10 CFR 71.22 AND 71.23

In addition to the changes proposed for 10 CFR Part 71 discussed in the previous section, the NRC is proposing to make several clarification changes to the fissile material general licenses that are unrelated to SSR-6 harmonization. These changes are discussed in the following sections.

4.1 Type A Package Requirements in Fissile Material General License

The general licenses in 10 CFR 71.22 and 71.23 are currently limited to Type A quantities of material transported in a Type A package (see 10 CFR 71.22(a) and (c)(1) and 10 CFR 71.23(a) and (c)(1)). This restriction to a Type A package is not consistent with the mass limits for some fissile nuclides. For example, the limit of 37 grams of ^{239}Pu in Table 71-1 corresponds to a mass that is more than 85 times the A_2 quantity. The general license cannot be used for ^{239}Pu in excess of 0.435 gram. Similarly, the mass limit of 240 grams ^{239}Pu, ^{241}Pu, or any combination of these nuclides in 10 CFR 71.23, is more than 21 times the A_1 value (for special form material) for ^{241}Pu of 11 grams. Because of these inconsistencies, the NRC staff has determined that the limitation to a Type A quantity in a Type A package is not consistent with the intent of the general license, and that shipment in a Type B package can be allowed.

Shipping material that meets the mass limits of the general licenses in 10 CFR 71.22 and 71.23 in a Type B package would not invalidate the criticality safety conclusions associated with these mass limits. In fact, the material would then be less likely to present a criticality hazard, as Type B packages generally have more mass, which would increase neutron absorption, and limit releases under hypothetical accident conditions, which would prevent material from multiple packages from redistributing together under optimum moderation conditions. The NRC is proposing to remove the restriction on Type B quantities of material in Type B packages for the two general license provisions, in order to correct the inconsistences between the mass limits and package restrictions.

4.2 ^{233}U Restriction in 10 CFR 71.22 – General License: Fissile Material

Table 71-2 of the general license in 10 CFR 71.22 cannot be used if “Uranium-233 is present in the package,” according to 10 CFR 71.22(e)(5)(i). The intent of this provision was to limit ^{233}U to levels below the detection limit of existing methods. As has been pointed out by several stakeholders, it is now possible to detect ^{233}U at a much lower level than previous equipment was capable of detecting, to the point that it prevents the use of this general license for some material with very low levels of ^{233}U.

In order to limit ^{233}U to an amount that will not affect the criticality safety of quantities of enriched uranium under this general license, the NRC is proposing to modify 10 CFR 71.22 to indicate that ^{233}U must be less than one percent of the mass of ^{235}U, similar to the provision limiting plutonium in 10 CFR 71.22(e)(5)(ii). This is also consistent with the way that ^{233}U is limited in the fissile exemption in 10 CFR 71.15(d), for uranium enriched in ^{235}U up to one percent by weight. ^{233}U present at one percent of the mass of ^{235}U will not invalidate the conclusions of the calculations in Ref. 6 to support the mass limits in Table 71-2, which are based on optimally moderated ^{235}U systems.

5. SUMMARY

This paper outlined a reference NUREG/CR document, developed by ORNL for the NRC, which provides technical recommendations to fissile material licensees on how to apply the fissile material exemption and general license regulations in 10 CFR Part 71. This paper also discussed the NRC staff consideration of recent changes to IAEA SSR-6, and detailed the proposed revisions to 10 CFR Part 71 that NRC is considering for the fissile material exemptions and general licenses. Section 2 summarized discussions from NUREG/CR-7239, including: 1) the technical basis and intent of each 10 CFR Part 71 exemption and general license provision; 2) the recent regulatory history of the 10 CFR Part 71 fissile material exemptions and general licenses; and 3) example problems which illustrate how the provisions can be applied and justified. Section 3 summarized the SSR-6 provisions the NRC is considering in its current rulemaking effort, and the changes to 10 CFR Part 71 the NRC is proposing to make. Finally, Section 4 summarized several clarification changes the NRC is proposing to make to the fissile material general licenses in 10 CFR Part 71 that are unrelated to SSR-6 harmonization.

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