



## Technical Basis for Proposed Fissile Exemption Criteria for Transport Packages

**C. V. Parks and C. M. Hopper**  
**Oak Ridge National Laboratory, Oak Ridge, TN, USA**

The U.S. experience in applying the fissile exceptions from the 1996 Edition of ST-1 has 1) identified concerns regarding the potential for inadequate criticality safety in certain shipments of excepted quantities of fissile material (beryllium oxide containing low-concentration of high-enriched uranium), 2) identified multiple examples where fissile-excepted consignments were accumulated on a conveyance in quantities which exceeded the excepted fissile material limits (demonstrating that the ad hoc control provided by a consignment limit was insufficient), 3) demonstrated continued confusion among licensees regarding what constitutes a "lattice" or "essentially homogeneous" material as required for 672(b), and 4) identified additional special moderating material (reactor-grade graphite) that the IAEA regulations do not address, thus permitting a potential for inadequate safety margin for exempt packages.

The use of fissile-to-nonfissile mass ratios as the criteria for mass-limiting exception quantities 1) removes the uncertainty related to potential change of form and concentration under normal or accident conditions; 2) eliminates the need for a restriction on low-absorbing moderators such as Be, D<sub>2</sub>O, and graphite; and 3) removes the consignment restriction on fissile mass and puts the criteria strictly on a package basis. The non-fissile material considered in the ratio determination should ideally be insoluble-in-water and non-combustible to survive the hypothetical accident condition. However, use of solid materials (that would remain solid under normal transport conditions) in the quantities specified should provide adequate mitigation against unacceptable accumulation of fissile material in the quantities necessary to pose a risk of criticality. Mass quantities of Be, C, and D<sub>2</sub>O should be excluded from consideration as non-fissile material for the purposes of determining the ratio value. Mass ratios are often easier to determine than values related to volume or volumetric concentration, and they are judged to provide an improved assurance for subcriticality under hypothetical accident conditions (i.e., it is judged to be more probable that fissile material will remain dispersed in non-fissile mass quantities subsequent to an accident than the probability that desired volumes are maintained during accident conditions).

The exception for uranium enriched to no more than 1 wt % <sup>235</sup>U as provided in 672(b) should be modified to remove the requirement for homo-geneity and prevention of a lattice arrangement. Instead, a moderator criteria restricting the mass of Be, C, or D<sub>2</sub>O to less than some percentage of the fissile mass should be provided. Ref. 1 suggested a value of 0.1% as the percentage of fissile mass, but a more appropriate value has been recently determined using computational analysis to determine the minimum amount of special moderator needed for criticality to occur in a heterogeneous system with uranium enriched to 1 wt% U-235. Such a change is needed in this provision because conditions such as "essentially homogeneous" and "lattice arrangement" are extremely difficult to define in a concise and clear manner.