Comments prepared for a Panel Discussion on "NUCLEAR CRITICALITY SAFETY" at the "4th International Symposium on the Packaging and Transportation of Radioactive Materials" held in Miami Beach, Florida, USA, September 22 to 27, 1974.

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I propose to comment on the Canadian regulations for the safe transport of Fissile Radioactive Materials and to discuss the choice of model to analyse criticality.

The Canadian regulations are based on the International Atomic Energy Agency regulations and take into account the regulations of the United States because of our proximity and our reciprocity agreement. Currently we are revising our regulations following issuance of the IAEA 'Regulations for the Safe Transport of Radioactive Materials' 1973 Revised Edition. We are using the IAEA regulations nearly verbatim with minor exceptions for internal reasons and to take into account our practice of issuing a single Certificate for approval of packaging design and shipment.

For Fissile materials, the following are some of the differences between the Canadian, the IAEA, and the US regulations:

1. Some of the exemptions for fissile material in the IAEA and US regulations are left out because there has been no need for their use. Should they become necessary we anticipate no problem in their implementation.

2. The examples of packaging design and calculational models appearing in the IAEA regulations have also been left out. Instead we intend to issue certificates covering both packaging design and shipment approval as they are needed.

3. The use of specification containers with the permissible contents described in the US regulations are not included. Again we intend to issue certificates. We have already done this for the 6L Specification Container.

I would like to draw your attention to the requirement for prior notification of the Competent Authority. This is required for international shipments exceeding a certain size. The requirement in the IAEA regulations is for notification 15 days in advance to the Competent Authority through or into which any shipment of Fissile III packages; type B(M); or type B(U) packages containing radioactive material exceeding either 30,000 curies or 3,000 times the lesser of the $A_1$ or $A_2$ quantity. Converted into mass of fissile material the type B(U) limit would have little practical
affect on Fissile I or II shipments of uranium enriched in U-235 as the quantities involved would have to be in the megogram range. A similar situation exists for U-233, except that the level for notification is 31.6 kilograms. However, most practical fuel shipments of plutonium would be affected as the notification level is much lower: 97 grams for Pu-239, and 2.7 grams for Pu-241. In Canada the licensing and reporting system requires that prior notification be given for each significant shipment of fissile material. Similar notification would have to be given for export or import shipments.

Now I would like to turn from the regulations to discuss the selection of conditions for analysing criticality safety. To introduce the subject I have chosen the following words from T. H. Huxley:

"Mathematics may be compared to a mill of exquisite workmanship which grinds you stuff of any degree of fineness, but nevertheless what you get out depends on what you put in - and as the grandest mill in the world will not extract wheat flour from pea pods, so pages of formula will not get a definite result out of loose data."

With validated codes and methods of calculation the "Criticality Mill" is capable of grinding out all sorts of 'stuff' but the fineness of the 'stuff' depends upon the 'seed', and the 'mill', and the 'miller'; of course. Given data on a packaging, and a code, the criticality analyst has to choose a configuration to determine an allowable number of packages that is both realistic and includes a reasonable degree of conservatism. Choosing the most pessimistic set of conditions from the available data is typical of the current practice. Occasionally the analyst may encounter resistance to his choice but the arguments are usually found to be associated with the packaging data rather than the choice of conditions. The pessimistic case then, although it may prove restrictive, may in fact be the most efficient model to use for basing criticality safety - it will prevent a critical reviewer from asking "What if..."

Tuning the mill does not end at choosing the configuration of the seed. The mill may 'choke' on dry seed or 'clog' on wet seed and yet grind fine flour from moist seed. What level of moisture is appropriate? For packages that are subcritical when dry and effectively isolated when submerged in a canal or river the analyst may feel the case has been made by considering the two extreme conditions. But what if the packages were deluged in rain? - subject to sprinklers while in storage? - or dumped into a snowbank? All of these are intermediate densities. Unfortunately, Nature presents the full range of water density to the transportation environment. This cannot be modelled with a single set of conditions beforehand so I suggest the criticality analyst should base the safe number of packages on
optimum moderation. "Optimum" in this case is defined by that moderation which will result in the least number of packages being critical. We have found that package arrays of low assay uranium (less than 5 w/o U-235) are smallest at an interspersed water density about 0.1 g/m/cm$^3$. This is close to the density of loosely packed snow, like the snow along the roadside after a snowfall. As appropriate, other conditions should be treated in the same way.

Having done the testing, tuned the mill and ground the 'stuff', the task is partially complete. Remaining is the task of putting together an application for approval by the competent authority. At this point efficient communication is essential—particularly if there are schedules to be met. And, keep in mind that the persons reviewing the application for the Competent Authority are pressured for time as much as anyone else and would welcome a well prepared, short report clearly and rigorously demonstrating compliance with all aspects of the regulations. It would almost seem that Sir Ernest Gowers had this in mind when he wrote, in the early 1950's in "The Complete Plain Words":

"Clear thinking is hard work, but loose thinking is bound to produce loose writing. And clear thinking takes time, but time that has to be given to a job to avoid making a mess of it cannot be time wasted and may in the end be time saved."

With sufficient hard work I think we could answer with "No" instead of "I hope not" to the question posed in the title of a talk earlier this week "Does the Paper Equal the Weight of the Shipping Cask Yet?"