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USE OF FISSION PRODUCT NUCLEAR DATA IN LIFE SCIENCES

Oral Presentation by

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I will be repeating somewhat what has already been said by others, but I believe it may be important to reformulate our thinking in a way that develops from my own background in radiation protection.

I can identify seven general applications for fission product nuclear data and data on the fission process in uranium and transuranic elements:

1. Toxicity to exposed individuals from externally located isotopes, i.e., isotopes in the environment or in the fuel cycle.

2. Toxicity caused by deposition of radioactive materials in living systems.

3. Medical application of injected radioisotopes for diagnostic or therapeutic means.

4. Use of sealed sources for implantation in living tissue. (Brachy therapy)

5. Use of sealed sources at a distance from the patient for therapeutic purposes. (Teletherapy)

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6. Environmental pathways for uncontrolled release of materials into biosphere.

7. And, finally, isotopic applications in medicine, biology, agriculture, and industry including gamma ray and neutron radiography.

1. <u>External Exposure</u>. Exposure of human beings to ionizing radiation sources may occur either accidentally by loss of process control or accidental release into uncontrolled environments, or it may occur under controlled conditions with pre-established exposure limits. Typically, the former may occur with effluents from large production and processing facilities for nuclear fuels.

Almost without exception these exposures occur as the result of releases of mixed fission products and activation products of complex age and history. For this reason exposure control and dose estimation are made on the basis of total ionization measurements, and nuclear data are needed only for prediction, regional modeling for future events, and for shielding calculations. Rarely is exposure to beta rays a significant hazard under these conditions, and only gamma ray data fission yield and half-life are essential.

The same generalizations may also be made for exposure under controlled conditions, but here beta dose is often important for exposure of extremities, and beta ray spectrum is useful for dose prediction models.

In any of these cases half-life data for short-lived nuclides is generally not significant. By short, I would indicate that nuclides with half-lives measured to be several hours or less are of little importance.

An unusual but important case in the external exposure category is that of criticality accidents. Since dosimetry must usually be reconstructed, it is essential to know the prompt neutron spectra--both thermal and fast, the prompt gamma spectrum, and the ratio of each.

Data are generally adequate for all of these applications, and accuracy in the 25-40% range is adequate.

2. Internal Emitters. This subject would appear to be a far more significant area for human exposure to both fission products and transuranic elements.

The dosimetry relating to estimating hazards from ingested radioactive materials is extremely complex and troublesome. The material is rarely, if ever, uniformly distributed throughout the body of the exposed person; in fact, it is rarely uniformly distributed in even the individual organ of interest, such as bone and bone marrow for Sr-90 and Cs-137 or lung and lymph nodes for plutonium isotopes.

The data that must be known to derive a dose estimate for an organ are the concentration, of course, the number of disintegrations per unit time, and the average energy deposited in the volume of interest per disintegration. All but the first are derived from nuclear data, but other considerations are equally important.

The concept of "effective half-life" has been derived as a useful tool to assist in this dosimetric problem. It is calculated as a resultant half-life taking into account both radioactive decay and excretion from the body. It may also be quite different for different tissues of the body, and even for different regions of the same tissue.

Given these generalizations, it is clear that we need to know the physical parameters of the decay process, but it is also clear that we rarely need to know them with high precision. From the scientific view we are satisfied with the present state of knowledge of FPND, and from the radiation protection point of view the data are more than adequate.

The data which which are presently limiting our capabilities to deal with deposited radionuclides are generally chemical data, i.e., solubilities, chemical form, etc., particularly for plutonium and other transuranics.

3. Medical Application. When radioisotopes are used by injection for diagnostic or therapeutic purposes, we generally need the same data mentioned before for internally deposited nuclides, since either protection of the patient or calculation of the therapeutic radiation dose to the organ of interest is the objective.

For the special case that the isotope is being used for visualization of an organ by means of scintillation cameras, we need to know the gamma energies and the disintegration rates with reasonable precision. Again, biological processes are such that the precision with which we know them is generally more limiting than the present precision of physical measurements.

4. Sealed Sources for Brachy Therapy. A number of radionuclides are in use to supplant radium, usually for economic reasons, but also occasionally because they are medically superior. For examples, isotopes of iridium, gold, and tantalum are in present use.

Obviously, we need to know with some precision the nuclear properties of these materials, particularly the gamma and beta energies as well as the decay rate. Since the sources are usually encapsulated, empirical data are usually derived by ionization chamber measurements to estimate dose.

A new and unusual brachytherapy source is now coming into use, spontaneously fissioning Cf-252. Data are still being completed on estimation of the dose from these sources, and because of the unique difficulties associated with neutron dosimetry, it is important to have as complete data as possible on neutron spectra.

5. Sealed Sources Used in Teletherapy. Only two nuclides have had wide usage; these are Co-60 and Cs-137. For dosimetry of this class of sources we need to know and do know the gamma ray energies. For design of sources we need to know specific decay rates. Half-life is not important since only radionuclides measured in years are useful.

6. Environmental Pathways. We are rarely, if ever, interested in dose delivered to plants or even animals from environmental sources. We need to know ultimately the dose to man as the result of ingestion of foods prepared from plant and animal sources. We therefore generally need only to know how to identify and measure radionuclides incorporated in food chain members.

7. Isotopic Applications. Dr. Kuhn has addressed himself to this problem, but I believe I would like to interject the note that there are usually very convenient ways to bypass the need for precise physical knowledge about a radionuclide being used as an isotopic label. Use of decay standards is routine and eliminates the need for accurate half-life data. The energies associated with the decay need only be known in general.

An exception, of course, is the need for very accurate gamma ray energy data for gamma ray spectrometry of mixed trace radionuclides, either fission products or activation products. (Whole body activation analysis)

Summary. Nuclear data within the charter of this panel appears to be more than adequate for the user applications I have covered.