UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555

April 29, 1991

Mr. Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Bernero:

SUBJECT: INDIVIDUAL AND COLLECTIVE DOSE LIMITS AND RADIONUCLIDE RELEASE LIMITS

The Advisory Committee on Nuclear Waste has been developing comments, thoughts, and suggestions relative to individual and collective dose limits and radionuclide release limits. Since we understand that your staff is reviewing these same topics, we wanted to share our thoughts with you. In formulating these comments, we have had discussions with a number of people, including members of the NRC staff and Committee consultants. The Committee also had the benefit of the documents listed.

Basic Definitions

As a basic philosophy, individual dose limits are used to place restrictions on the risk to individual members of the public due to operations at a nuclear facility. If the limits have been properly established and compliance is observed, a regulatory agency can be confident that the associated risk to individual members of the public is acceptable. Because the determination of the dose to individual members of the public is difficult, the International Commission on Radiological Protection (ICRP) has developed the concept of the "critical group" and recommends that it be used in assessing doses resulting from environmental releases. As defined by the ICRP, a critical group is a relatively homogeneous group of people whose location and living habits are such that they receive the highest doses as a result of radionuclide releases. The group may be real (in which case their actual habits may be known or predicted) or hypothetical (in which case their habits may be assumed, based on observations of similar groups).

The dose to individuals within the critical group is assumed to be that received by a typical member of the group. The purpose of this approach is to ensure that members of the public do not receive unacceptable exposures while, at the same time, ensuring that decisions on the acceptability of a practice are not prejudiced by a very small number of individuals with unusual habits.

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If the number of people being exposed is large, the question often arises as to how to quantify the societal impact of the individual exposures. The collective dose concept was developed for expressing that impact in a quantitative manner and, as such, it is a numerical expression of the summed doses to a given population.

In many respects, placing limits on total radionuclide releases from a nuclear facility is comparable to placing a limit on its total societal impact. In other words, placing a limit on the quantity of a given radionuclide that can be released is equivalent to placing a limit on the total societal impact that the facility can exert. This was the basis used by the U.S. Environmental Protection Agency (EPA) in setting release limits for a high-level radioactive waste repository, and it relates directly to EPA's basic criterion that the number of health effects should not exceed 1,000 during the first 10,000 years.

Underlying Assumptions

Although it is generally accepted that the dose received by an individual is a reasonable expression of the associated risk, it is questionable whether the collective dose is a true measure of the societal impact of the aggregate of exposures to individual members of a population. Implicit in the concept of collective dose is the assumption that the linear hypothesis is correct, that is, that there is a linear (non-threshold) relationship between the total dose to a population group and the associated health impacts.

In many ways, application of the collective dose concept leads to a paradox. At high doses and high dose rates where the risk coefficients are best known, the concept of collective dose cannot be applied since the dose-response curve is nonlinear; at low doses and low dose rates where linearity between dose and the associated health effects is assumed to apply, the risk coefficients are far less certain. This leads to additional restrictions in the application of the collective dose concept, as follows:

- The exposed population must be well known with respect to size and possibly age, sex, and temporal distributions.
- The exposure pathways must be characterized for the population at risk.
- Individual contributions to the collective dose must consist only of doses to the whole body, or to specific organs or tissues for which stochastic risk coefficients are known.

In short, application of the collective dose concept requires detailed knowledge of the exposed population and the radiation doses to its members. The collective dose concept is valid for representing the collective risk only if both of these factors can

be described and quantified, and it should be used for risk assessments only if the associated uncertainties are sufficiently small that the calculated collective dose itself is within an acceptable range of uncertainty. In addition, it is important to note that a high individual risk to a small number of people is not necessarily the same as a low individual risk to a large number of people, even though the collective dose may be the same. For this reason, expressions of societal risk in terms of collective dose should always include detailed data not only on the number of people exposed, but also on the number of people receiving exposures within each dose range. Although collective dose can be used as a surrogate for societal risk, its interpretation requires care.

Truncation of Collective Dose Calculations

On a theoretical basis, there is no justification for excluding the application of the linear hypothesis to the evaluation and interpretation of the societal impact of low doses and low dose rates on population groups. This hypothesis, in fact, has been generally accepted by the scientific community, including organizations such as the National Council on Radiation Protection and Measurements (NCRP) and the ICRP, as a valid basis for estimating the stochastic risks associated with low doses of ionizing radiation. If one accepts this observation, calculations of collective doses should include the doses to all individuals within the population group, regardless of how small the associated doses and/or dose rates may be. At the same time, however, it is important to recognize that there may be cogent reasons for not including within collective dose calculations extremely low doses to individual members of a population group. Several approaches that have been proposed and/or applied to justify such omissions are discussed below.

Following the concept that certain risks to individual members of the population are negligible, the NCRP has recommended (under what it defines as the concept of a "Negligible Individual Risk Limit") that annual doses to individual members of the population that are less than 0.01 mSv (1 mrem) be excluded from collective dose calculations. In interpreting this recommendation, however, it is important to understand the underlying principle on which it was based. Informal discussions with representatives of the NCRP revealed that truncation in this case was considered to be acceptable from the standpoint of societal impact, because the burden on society represented by any additional cancers among people receiving exposures in this dose rate range would not necessitate any additional medical facilities. Another approach for truncation that has been informally suggested by representatives of the NCRP is that it might be permissible to discard a collective dose (calculated on the basis of extremely low dose rates to members of an exposed population) provided that the

associated collective dose would not be estimated to result in one additional cancer.

Variations in the dose rates from natural background radiation sources have been proposed as another basis on which to truncate collective dose calculations. The contribution to collective dose from natural sources is large relative to that from many artificial sources. Consequently, it is often difficult to measure in a meaningfully quantitative manner very low dose rates to individual members of the population that arise from artificial sources. Thus, although there may be no biological basis for excluding very low dose rates from collective dose calculations, there is justification for excluding them on a statistical basis because of the uncertainties in the associated calculations.

Determinations of Compliance With Standards

From the previous discussion, it follows that the establishment of limits on the concentration of individual radionuclides in various environmental media (e.g., air and water) is comparable to the establishment of dose limits for individual members of the population. Likewise, the placement of limits on total radionuclide releases from a nuclear facility is comparable to the establishment of limits on the associated permissible collective doses to the affected population. In terms of the determination of compliance with a set of standards, it is readily possible to measure the concentrations of individual radionuclides in various environmental media, and it is similarly possible to estimate the associated doses to individual members of the population. In contrast, estimates of the total releases of radionuclides from a nuclear facility would require not only knowledge of the concentrations of individual radionuclides in all environmental media, but also the determination of the rate of movement (transport) of each radionuclide (including the evaluation of site-specific pathways) within all such media from the facility to the accessible environment. Similar uncertainties would accompany estimates of the associated collective doses.

Summary

In summary, the Committee offers the following statements on the benefits of the application of various limits for determining the public health risks associated with nuclear operations.

1. Individual dose limits can be used to limit the risks to individual members of a population group.

2. Collective dose limits can be used to limit the societal impacts of doses to a large number of individuals. The accuracy of collective dose as a measure of societal risk, however, depends on the validity of the linear (non-threshold)

hypothesis in assessing the stochastic effects of ionizing radiation.

3. Collective dose calculations are representative of societal risk only if certain conditions are satisfied; namely, the exposed population is defined and characterized with respect to size, age, and sex; the distribution of doses to individual members of the population is within a limited range; the exposure pathways have been characterized for the population at risk; and individual contributions to the collective dose consist only of doses to the whole body, or to specific organs or tissues for which stochastic risk coefficients have been adopted.

4. Techniques for measuring the concentrations of individual radionuclides in various environmental media, and for estimating the associated dose rates to individual members of the population, are readily available, and compliance with such limits can be determined. In contrast, the measurements that would be required to determine the total releases of individual radionuclides from a nuclear facility and estimations of the associated collective dose to all offsite population groups would be difficult.

5. Given the general acceptance of the linear hypothesis, there is no biological basis on which to truncate calculations of collective doses. Nonetheless, regulators must recognize that estimates of dose rates from artificial radiation sources, that represent only a few percent of those from natural radiation sources, carry with them large uncertainties and relatively little aggregate risk. Such uncertainties may well serve as a basis for truncating collective dose calculations at very low dose rates without adverse impacts on estimates of the associated risks.

We trust that these comments will be helpful. We plan to review and comment on your report regarding this subject when it becomes available, consistent with the SRM dated April 18, 1991.

Sincerely,

Dade W. Moeller

Dade W. Moeller
Chairman

References:

1. International Commission on Radiological Protection, "1990 Recommendations of the International Commission on Radiological Protection," Publication 60, Annals of the ICRP (1991).
2. National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," Report No. 91 (1987).
3. National Radiological Protection Board, "Radiological Protection Objectives for the Land-based Disposal of Solid Radioactive Wastes." Consultative Document. NRPB-M279, March 1991.
4. "Possibilities and Limits of the Application of the collective Dose." A Recommendation of the Radiological Protection Commission (SSK). Bundesanzciger, No. 126a, July 1985.