UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JAN 16 1981

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

John G. Davis, Director
Office of Nuclear Material Safety and Safeguards

FROM: Robert B. Minogue, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER # 110 - RELATIVE HAZARD OF RADIOIODINE AS A FUNCTION OF RADIATION QUALITY AND AGE AT EXPOSURE

Introduction and Summary

This memorandum transmits the results of completed research on factors affecting the risks from radioiodine exposures. Although it had been suspected that short-lived radioiodines produced more biological damage than the same dose from iodine-131, definitive studies were lacking. Similarly, the immature thyroid gland was known to be more radiosensitive than that of the adult, but quantitative comparisons could not be made.

In an effort to improve consequence assessments for accidents involving release of volatile radioiodines, research was initiated to provide data on the biological effectiveness of different radioiodines and on the radiosensitivity of the thyroid gland as a function of age. This work was performed by the Laboratory for Energy-Related Health Research of the University of California at Davis under the direction of the Environmental Effects Research Branch of the Office Nuclear Regulatory Research. The final report entitled, "Relative Hazard of Radioiodine as a Function of (A) Radiation Quality and (B) Age at Exposure," NUREG/CR-1228, has been transmitted to your staff.

Methodology

For the study of the comparative effects of short-lived radioiodines, the index of biological effect chosen was the ability of the thyroid gland to enlarge in response to goitrogenic stimulation via thyroid-stimulating hormone from the anterior pituitary gland. Female Sprague-Dawley rats were injected intraperitoneally with single, graded doses of either I-132 or I-131 in sterile saline. After 4 weeks, irradiated and unirradiated control rats were randomly divided into two groups: (1) those maintained on standard laboratory chow and (2) those on the same diet but containing 0.1 percent propylthiouracil (PTU), a goitrogen. Animals were maintained on these diets for 4 weeks and then sacrificed. Thyroid glands were removed,

weighed and prepared for histopathologic examination. A three-way (radioiodine, goitrogen, dose) analysis of variance was performed on the thyroid weights and the percentage weight increase was determined as:

$$\frac{Gr - Cr}{G - C} \times 100$$ where

Gr is the mean weight of goitrogen-stimulated, irradiated thyroid glands,

G is the mean weight of goitrogen-stimulated, unirradiated thyroid glands,

Cr is the mean weight of unstimulated, irradiated thyroid glands,

C is the mean weight of unstimulated, unirradiated thyroid glands.

For the study of the differences in age-related radiosensitivity of the thyroid gland to radioiodine exposure, fetal, neonatal, weanling, and adult guinea pigs were exposed to single, graded doses of I-131. The guinea pig was chosen as the experimental model because of its lengthy gestation period (9 weeks) and because its thyroid begins to function relatively early in fetal life. At approximately 100 days of age, or 100 days after dosing in the case of adults, each animal was given a single microcurie of I-131 and sacrificed 24 hours later. The animals were weighed, and the radioactivity in the thyroids was measured. Analyses were performed on thyroidal uptakes of I-131 expressed as a percent of the injected dose per gram of thyroid.

Results

Thyroid gland weights were fairly consistent among the groups of rats which remained on control food after irradiation, but they showed a wide range of response to the goitrogen treatment. Thyroids of animals which received the highest doses demonstrated the least ability to respond to the effects of PTU. The effectiveness of the two radioiodines was compared by plotting the relative thyroid weight increase versus the radiation dose to the thyroid gland. From this plot, the 50 percent suppression of thyroid growth was determined to result from 280 rads of I-132 and 2500 rads of I-131, indicating a higher effectiveness for I-132 by a factor of nine.

Tracer uptakes of I-131 by thyroids of guinea pigs demonstrated differences in I-131 concentration and retention. At 100 days of age, or 100 days after dosing in the case of adults, uptakes of I-131 and weights of thyroid glands decreased with increasing radiation exposure. Doses to reduce the percent uptake of I-131 to half the unirradiated values were determined to be 13, 34, 14, and 19.5 kilorads for fetuses, newborns,

weanlings, and adults, respectively. This indicates that fetuses and weanlings are about one and a half times as radiosensitive as adults.

Future Work

All work on this project has been completed.

Conclusions and Recommendations

The study of the influence of radiation quality ccnfirmed the appropriateness of the factor of 10 used for the increased effectiveness of short-lived radioiodines. Since the magnitude of this difference is similar to that observed in animals for X-rays and I-131, application of X-ray results as surrogates for short-lived radioiodines is appropriate.

The study of the influence of age at exposure confirmed the greater thyroidal radiosensitivity of fetuses and weanlings compared to adults. In addition, it quantified the risk factor difference as less than an order of magnitude.

As a result of these studies, more accurate estimates of the consequences of accidental releases of radioiodines can be made. We recommend that the relative hazard factors determined by this study be used in risk assessment calculations required for reactor safety or fuel cycle facility licensing.

For further information on these studies, please contact Dr. Judith D. Foulke at 427-4358.

Robert B. Minogue, Director
Office of Nuclear Regulatory Research