



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

JAN 29 1981

112

MEMORANDUM FOR: Ray G. Smith, Acting Director  
Office of Standards Development

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

SUBJECT: RESEARCH INFORMATION LETTER # 112 - HEALTH  
STATUS AND BODY RADIOACTIVITY OF FORMER THORIUM  
WORKERS

Summary

The health effects of industrial exposure to thorium are being investigated by studying the former employees of a thorium-processing plant. In a study cohort of 3039 men, there were 511 known deaths versus 486.8 deaths expected on the basis of age- and year-specific mortality rates for U.S. white males. In general, differences between the observed and expected numbers of deaths from specific causes showed little association with measures of thorium exposure (job type and length of employment). However, there was a statistically significant excess of deaths from pancreatic cancer among men employed a year or more (6 observed vs 1.3 expected) but not for shorter-term workers (3 observed vs 2.7 expected). Data on a small sample of the cohort indicated a higher proportion of cigarette smokers relative to U.S. males, and this could explain at least part of the excess mortality from lung cancer and respiratory diseases. A puzzling excess of deaths from motor vehicle accidents was found (38 observed vs 23.2 expected). Medical examinations and measurements of residual body radioactivity are being made on a subpopulation of 592 men most exposed to thorium. By thoron-breath measurements, thorium deposition was detected in 131 of 194 men who have been examined, and measurable amounts of bismuth-212 (range 0.2 to 3 nCi) were found in 55 of the men by gamma-ray measurements in vivo.

Introduction

This memorandum transmits an interim report<sup>1</sup> for the project entitled, "Health Effects of Industrial Exposure to Thorium," begun in FY 1976 as a joint effort of the Department of Energy and the Nuclear Regulatory Commission. The study is being conducted by the Center for Human Radiobiology of the Argonne National Laboratory, under the direction of the Environmental Effects Research Branch, endorsed by your office in RR-RES-77-3.

<sup>1</sup>Health Status and Body Radioactivity of Former Thorium Workers,  
NUREG/CR-1420, January 1980

The interim report provides a summary of the progress to date in the study of the health of former workers at an industrial plant where thorium and rare-earth chemicals were produced from the 1930's to 1973. The objectives of the study are as follows:

- (1) to assess possible health effects of employment in the thorium milling industry by comparing mortality experience and morbidity characteristics of former thorium workers with those of suitable control populations,
- (2) to examine mortality and morbidity outcomes by estimated exposure levels to thorium and daughters for possible dose-related effects, and
- (3) to determine the body distribution of inhaled thorium and rare-earths in humans by in vivo radioactivity measurements of the workers and by analysis of autopsy samples.

### Methodology

With the cooperation of the Kerr-McGee Chemical Corporation, employment lists of the former Lindsay Light Company were compiled from various records. A total of 4582 former employees were identified, but due to incomplete information, the study population was limited to 3222 men and 714 women who worked at the West Chicago site.

Information on working conditions and exposure to radioactivity was obtained from a report on an industrial hygiene survey made in 1952 by the U.S. Atomic Energy Commission and from later AEC compliance inspections from 1956 to 1973. Kerr-McGee also provided complete records of the personnel dosimeter readings and data sheets on survey meter readings and measurements of airborne and surface radioactivity. In addition, many of the filter samples taken for measurement of airborne radioactivity have been obtained and are being analyzed.

### Mortality Study

Based on name, social security number, and date of birth, searches of Social Security Administration records were made to identify deceased workers. Copies of death certificates were obtained from state vital statistics offices and the cause of death coded.

Person-years of follow-up were enumerated from the year of first employment at the West Chicago plant, or from 1940 for those who had started work earlier, to the year of death or of last search by the Social Security Administration. Standardized mortality ratios (SMR's) were calculated by dividing the observed number of deaths by the expected number of deaths calculated by the method of Monson for each cause of death category.

### Morbidity Study

Initially the subgroup for the morbidity study included only the 592 men who worked at the West Chicago plant for at least one year in occupations involving the highest probable exposure to thorium. A number of methods were used to trace members of this group, and a questionnaire on medical history and respiratory symptoms was sent to them. The same questionnaire will be sent to a random sample of the remaining 2630 men in order to obtain information on shorter-term workers and on men in other occupational groups.

### Medical Examinations and Radioactivity Measurements

Medical examinations and measurements of radioactivity are planned for those still alive among the 592 men identified above. The general medical protocol includes a complete physical examination, blood and urine analyses, electrocardiogram, visual and auditory examinations, chest X-ray, and pulmonary function tests. A detailed medical history will be obtained to amplify the questionnaire reply.

The in vivo radioactivity measurements consist of external whole-body counting and collection of thoron in exhaled breath. Autopsy samples will be radiochemically analyzed to relate organ content to the external measurements.

### Results and Discussion

#### Mortality Analyses

Based on the analysis of all 511 deaths among male workers, only two statistically significant results were found for U.S. white males. The observed number of deaths from diseases of the circulatory system was significantly lower than the expected number. The observed number of deaths from motor vehicle accidents was significantly higher than the expected number.

Because a major addition to the plant was built in 1954 and licensing requirements were imposed in 1956, the study population was divided into two cohorts based on year of first employment (1940-54 and 1955-69). The SMR for overall mortality was statistically significant for the later (1955-69) group but not for the earlier group. Additionally, the later group showed statistically significant SMR's for lung cancer and cancer of the pancreas.

Mortality from selected causes was analyzed by duration of employment: 0-1 month, 2-11 months, 12-35 months, and greater than 36 months. The shortest term workers showed high SMR's for cancers of the rectum and lung, diseases of the respiratory system, and external causes. The second group showed no notably high mortality ratios except for pneumonia. The mortality ratio was high for lymphosarcoma in the 12-35 month group and for leukemia in the greater than 36 months group; SMR's were high for cancer of the pancreas in both of these groups.

Mortality from selected causes was also analyzed by job classification: group 1 - laborer, operator; group 2 - maintenance; group 3 - service, technical, office, other. Group 1 showed excess number of deaths from all cancers combined, lung cancer, skin cancer, and motor vehicle accidents. Four of five deaths due to leukemia occurred in group 1, but the SMR was not statistically significant. The other two groups showed high SMR's for cancers of the pancreas but not for lung cancer. The SMR for diseases of the respiratory system was high in group 3.

#### Radioactivity Measurements

The results of the whole-body counting showed statistically significant amounts of bismuth-212 in 55 of the 195 people. The largest amount was estimated to be about 3.2 nCi of bismuth-212, which corresponds to 29 mg of thorium, assuming radioactive equilibrium and no losses.

In contrast to the above, many more workers (131) showed detectable amounts of thoron in their exhaled breath.

#### Future Work

The results of the mortality study underscore the importance of the information to be obtained from the morbidity study. Questionnaires have been returned by 300 of the 366 men who were located while still living. Physical examinations and radioactivity measurements have been performed on 199 of those people, and eventually all remaining members of the sub-group will be examined.

#### Conclusions and Recommendations

The observed higher mortality ratios involving cancer of the lung or pancreas in a few of the male thorium-workers suggest possible effects due to thorium or other chemicals. Attribution is not straightforward because at least part of the lung cancer excess mortality could have been related to cigarette smoking. The findings were not consistent with a strong relationship between length of employment and mortality from respiratory disease. The results to date offer no evidence that present standards for occupational exposure to thorium require modification. Any large excesses of deaths due to exposure to thorium would have been detected by the mortality analyses. The morbidity analysis to be performed will provide a better understanding of the small increase in cancer incidence among the workers being studied. Additionally, the breath, bioassay and whole body radioactivity measurements will provide much valuable information on thorium metabolism.

For further information on this research program, please contact Dr. Judith Foulke, Environmental Effects Research Branch (427-4358).

*Robert B. Minogue*

Robert B. Minogue, Director  
Office of Nuclear Regulatory Research

Ray G. Smith

JAN 29 1981

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RECORD NOTE: A meeting was held with the cognizant individual and it was decided that a RIL was appropriate at this time.

*Robert B. Minogue*  
 Robert B. Minogue, Director  
 Office of Nuclear Regulatory Research

\*See previous yellow for concurrence.

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