PROCEEDINGS SERIES

RAPID METHODS FOR MEASURING RADIOACTIVITY IN THE ENVIRONMENT

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FOREWORD

Over the years considerable progress has been made in improving techniques and methods of analysing environmental radioactive contamination, but until recently little attention was paid to the time factor involved in the various procedures. However, rapid methods of environmental monitoring and analysis would be of vital importance in the event of an accident leading to uncontrolled release of radioactivity to the environment. The matter is naturally of international as well as national importance, since a release of highly radioactive waste into the air or into a river in one country could present serious problems to a neighbouring one.

Without rapid determination of doses and radioactivity levels, no adequate decision can be made on the measures to be taken to protect the general public in emergency situations. Such rapid measurements are also important for the normal operation of nuclear plants and installations to ensure adequate monitoring of radioactive effluents. Rapid and simple methods are also needed to handle large numbers of samples at reasonable cost under normal conditions and to save the time of highly trained experts and technicians.

The International Symposium on Rapid Methods for Measurement of Radioactivity in the Environment was held at Neuherberg near Munich, Federal Republic of Germany, from 5 to 9 July 1971. It was organized by the Government of the Federal Republic of Germany in co-operation with the Gesellschaft für Strahlen- und Umweltforschung mbH München, and with the co-sponsorship of the International Atomic Energy Agency.

The Symposium was attended by about 200 participants representing nearly 30 countries and six international organizations. Apart from 12 invited papers, 43 papers were presented orally and, because of the unexpectedly large number of papers submitted, 21 were read by title only. All these papers, together with the discussions, are published in this volume.

Among the topics covered in the Symposium were chemical and physical laboratory methods; field methods; normal and emergency surveillance; and data evaluation. The meeting concluded with a panel on future developments, the record of which will be of great interest to all those working on improvements in the techniques.

EDITORIAL NOTE

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Invited Paper

HEALTH PHYSICS AND THE ENVIRONMENT*

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Abstract

HEALTH PHYSICS AND THE ENVIRONMENT.

Health physics is the science and profession for the protection of man and his environment from the harmful effects of all forms of electromagnetic radiation while at the same time maximizing its beneficial applications. In the early period (1942-49), there were no recommended national or international levels for the disposal of radioactive waste to the environment, and the health physicist was forced to set his own standards. Although these standards were considered by some at the time as conservative by a factor of 1000, they were larger by factors of 200 to 7000 than those commonly used today. Some early methods for disposal of radioactive waste at Oak Ridge National Laboratory and the more recently developed methods for disposal in hydrofractured formations and in bedded salt are discussed. Environmental sampling techniques used by the early health physicists are reviewed, and the role of the health physicist in determining the critical radionuclides, the critical radionuclides, the critical environmental pathways and the critical segment of the population is emphasized. The health physicist is cautioned not to neglect the principal source of population exposure to man-made radiation, namely, medical diagnostic exposure. Some early objections to radiation ecology research are recalled, and several interesting findings of the Oak Ridge National Laboratory Radiation Ecology Program are indicated. It is emphasized that the health physicist has a major responsibility in identifying the critical segment of a population which receives the highest environmental radiation exposure, and if this is done properly, a bonus reward in terms of improved public relations can be expected by the nuclear energy industry. It is concluded that the present radiation protection standards are reasonable and satisfactory, but they do not contain an unnecessarily large margin of safety. It is urged that the population dose limits should include exposure from medical diagnosis and must continue to maintain a large reserve which, it is hoped, will never be used.

INTRODUCTION

In speaking on the subject assigned to me for this lecture — health physics and the environment — I am sure it will not be necessary for me to give a detailed description of the science and profession of health physics. One may state simply that health physics research is the study of the effects of electromagnetic radiation on matter with particular emphasis on understanding its effects on man and his environment, and applied health physics is directed towards numerous activities designed to reduce radiation exposure of man to the lowest practicable level. Usually, health physicists limit their research and applied activities to problems of ionizing radiation. However, a few health physicists are becoming increasingly involved with non-ionizing radiation — microwave, r.f., laser (coherent), u.v. and thermal problems. All of us are concerned not only with protecting man and his environment from direct and indirect forms of radiation damage but with enhancing the beneficial uses of this great source of energy or maximizing the ratio of its benefits to its risks. The environment with which we are concerned and

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attempting to protect includes all outside conditions and forces having an effect on the existence and development of man. We hear many discussions today about the pollution of our environment by many substances and by various forms of energy, and we are told this pollution threatens the very survival of many forms of life, including man. Thus, it is of extreme importance, and perhaps there is some urgency that major efforts be made to reduce these energy pollutants which may be classified [1] broadly as:

(1) chemical — oxides of sulphur, oxides of nitrogen, hydrocarbons, particulates, insecticides, herbicides, detergents, food additives, cosmetics, tobacco, drugs, etc.
(2) mechanical — vibrating buildings, sound, ultrasound and infrasound.
(3) biological — an imbalance of the ecosystem comprised of plants, animals, insects, bacteria, fungi, viruses, etc.
(4) radiation — heat, light, u.v., X-rays, gamma rays, alpha and beta particles, neutrons, high energy radiation, etc.

It should be emphasized throughout these discussions that all forms of energy are valuable human resources which are essential to a better way of life. Also, we should keep in mind that they are not inexhaustible, and they become pollutants of our environment only when man allows too much of them at the wrong place and at the wrong time, or when they are wasted or are no longer under proper control and when they are dumped into our environment with insufficient long-range planning and sometimes with wanton disregard of their ultimate fate or the consequences of their uncontrolled release. I will limit this discussion of health physics and the environment to a brief summary of activities of the health physicist in minimizing and assessing the risks to man from environmental sources of ionizing radiation, and will not mention further sources of non-ionizing radiation such as microwave ovens which in some cases may be introducing serious radiation hazards into our homes. I will further limit this discussion primarily to sources of ionizing radiation associated with the operation of nuclear reactors and their related facilities. However, with this restriction, we will not lose sight of the fact that in many of the advanced countries (and especially in the United States of America), medical diagnostic X-ray exposure accounts for most of the population dose to man-made sources of ionizing radiation (about 95% in the United States of America), and it is here that the health physicist could and should be most effective in reducing unnecessary population exposure. During the past few years, I have indicated in publications [2] and hearings of the US Congress [3] over 100 ways in which this medical diagnostic exposure could be reduced to less than 10% of its present value while at the same time greatly increasing the quantity and quality of medical information provided by the X-ray radiogram. Unfortunately, I have been engaged in a losing endeavour because present estimates are that the genetically significant dose, GSD, in the United States of America from medical exposure in 1970 had risen from the 1964 value [4] of 55 mrem/yr to 95 mrem/yr [5] and the significant organ doses are more than twice these values. I certainly agree it is of the greatest importance to have international symposia such as these directed toward further reducing radiation exposure of populations from nuclear reactor operations, and we must continue to put forth a tremendous effort in order to maintain this new industry as the safest of all modern industries. However, I believe, at least in the

TABLE I. CHANGES IN RADIATION PROTECTION STANDARDS FOR THE RADIATION WORKER

Recommended rate[a]	Comments
0.2 R/day (or 1 R/week)[b]	Recommended as a tolerance exposure by ICRP [7] in 1934 and continued in world-wide use until 1950
0.1 R/day (or 0.5 R/week)[b]	Recommended as a tolerance exposure by NCRP [6] on 17 Mar.1934, and continued in use in the United States of America until 1949
15 rem/yr (0.3 rem/week)	Recommended as a maximum permissible dose by NCRP [8] on 7 Mar.1949, and ICRP [9] in July 1950, and continued in use until 1956
5 rem/yr (0.1 rem/week)	Recommended as a maximum permissible dose by ICRP [10], April 1956, and NCRP [11] on 8 Jan.1957

[a] The values are in addition to medical and background exposure.
[b] Based on a five-day work week.

United States of America, health physicists must not ignore the major population exposure problem, namely, medical diagnostic exposure which is contributing over 200 times as much GSD as the entire nuclear energy industry. In this case, I am including under the nuclear energy industry not only the occupational and non-occupational (environmental) dose from nuclear power plants, but also that from uranium mining, fuel processing and reprocessing, radioactive waste disposal and exposures in the various laboratories that are doing research on reactors and associated facilities.

EARLY HEALTH PHYSICS RULES FOR DISPOSAL OF RADIOACTIVE WASTE IN THE ENVIRONMENT

When health physics had its beginning at the University of Chicago in 1942 and 1943, and when plans were being made for the first nuclear reactors at Oak Ridge, Tennessee, and Hanford, Washington, there were no rules or recommendations that could be referred to as guides in establishing safe and reasonable levels for radiation exposure of the public or for the discharge of radionuclides into the environment. At Oak Ridge National Laboratory (then Clinton Laboratories), H.M. Parker and I were the first to face this problem when ORNL began the discharge of low levels of radioactive waste into the environment (the Oak Ridge Graphite Reactor began operation on 4 Nov. 1943). The only guide we had was the occupational tolerance dose rate of 0.1 R/d which, as indicated in Table I, had been recommended by the National Council on Radiation Protection, NCRP, in 1934 [6]. The radioactive liquid waste containing high concentrations of radioactivity and the solutions comprising the dissolved fuel elements were retained in underground storage tanks. Intermediate and low levels of liquid, radioactive wastes were discharged into open settling ponds which emptied into White Oak Lake. White Oak Lake is an impoundment of five to seven million cubic feet of water located in the Oak Ridge reservation at a distance of about one mile from Oak Ridge National Laboratory. The outflow of White Oak Lake runs into and mixes with the waters of the Clinch River about one-fourth of a mile below the overflow at White Oak Lake dam. It is at this point that the contaminated waters mix with and are diluted by those of the public domain. Lacking any suitable guidance from NCRP or the International Commission on Radiological Protection (ICRP), Parker and I chose as our radiation protection standard a dose limit of 0.1 R/d to an imaginary microscopic organism suspended in the waters of White Oak Lake. We determined this dose theoretically and experimentally by dissolving various radionuclides in large tanks of water and making measurements of the dose received by a small dosimeter. We established this same standard, also, for airborne radioactive contamination which might result under expected meteorological conditions following the escape of radioactive gases or particulates from tall laboratory stacks. These stacks were used for venting, dispersing and diluting chemical off-gases and cooling air from the reactor and associated laboratory facilities, the "hot cells" and chemical, physical and metallurgical operations after the air had been passed through appropriate filter and precipitator systems. When some of the engineers, public health officials and "behind-the-desk supervisors" heard of the dose limit we had set which was based on an exposure rate of 0.1 R/d for exposure 24 h/d, we were severely criticized and ridiculed for such ultraconservatism. Although this early limit for environmental exposure is high in comparison with present standards, in retrospect it probably was not so reckless when we consider the waste water from White Oak Lake had an average dilution of greater than 600 just below the point of mixing in the Clinch River where it enters the public domain. Since ORNL is about 10 miles from the nearest populated area (the village of Oak Ridge), the dose rate from ORNL gaseous effluents never reaches 10% of this level. On the other hand, this 0.1 R/d level was over 200 times the 170 mrem/yr population dose limit permitted in the United States today for such an operation and over 70 times the 500 mrem/yr value recommended by ICRP as an upper limit of dose to any individual in the population-at-large. Furthermore, at that time we had very scanty information regarding the body uptake of radionuclides from inhalation of air or ingestion of water contaminated with radionuclides, or from ingestion of food contaminated as a result of cycling of radionuclides in the environment. We believed in 1943 that ^{239}Pu and ^{90}Sr probably presented serious risks from internal exposure, but the data available to assess this risk and to set permissible organ burdens or maximum permissible concentrations in air and water were almost entirely lacking. This early experience where we set health physics tolerance levels at what many persons thought were too low by a factor of 1000 only to find out some 30 years later that they were too high by a factor of 200[1], has had a very sobering influence on some of us, and guided and supported our claim that there may still be pathways and forms of radiation damage to man which are not adequately understood, and so all human exposure to ionizing radiation should be maintained as low as practicable, and no radiation exposure which can be avoided easily should be tolerated.

[1] The USAEC is considering setting the dose limit of 5 mrem/yr to individuals living in the neighbourhood of a nuclear power plant as a consequence of nuclear plant operations. The spread between this 5 mrem/yr and the level suggested by some critics in the early period (1943-45) is 7×10^6.