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PUBLIC HEALTH ASPECTS OF ATOMIC ENERGY

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Human Studies Project

PUBLIC HEALTH ASPECTS OF ATOMIC ENERGY*

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Introduction

In preparing for this discussion, my first and most difficult problem has been to decide which aspects of the subject are most important to discuss with this group. In order to speak definitely yet briefly of the relationships of atomic energy to public health we must first define and delimit the scope of the discussion.

Our subject is stated in general terms and is very extensive. It could be interpreted to include many details concerning radioactivity from either natural or artificial sources; and any present or prospective benefits or hazards to human health that might be attributed to atomic energy. We might logically speak of the benefits and public health implications that are apparent or expected from the use of radioisotopes in medical research, diagnosis, and treatment; and just as logically we might discuss the relatively old and familiar hazards of x-rays or of radium as used in hospitals and clinics, in industry, and increasingly in offices and commercial establishments.

Undoubtedly, as the peacetime uses of atomic energy expand, state and local health officials will be more and more concerned with

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the administrative aspects of radiation protection and with the interrelationships of public health departments and other agencies that have various degrees of responsibility for the prevention of radiation hazards. Potential hazards from unusual or emergency occurrences are not being ignored but deserve much further study and discussion. There are many uncertainties as to the nature and extent of health problems that might conceivably develop in connection with accidents, fires, or natural catastrophes in which radioactive materials are involved; and as to the safeguards that can be made effective locally to obviate such emergencies. Within the scope of our subject we might even speculate on the technical and administrative problems with which state and local health departments may be faced in programs of civil defense in the event radioactive materials are ever used against us by enemies in sabotage or actual warfare.

Public health is very broad and diversified in its interests, responsibilities, and functions. It must accomplish its overall purpose of protecting and promoting human health through the combined efforts of many specialists, both within and outside of official health departments. For effective and truly preventive work, the worker in a public health department requires a variety of specific and general information. In addition to familiarity with his own and related parts of the health department program he must be aware of new developments which may create or intensify public health problems; and he must be informed concerning the efforts of non-public health agencies that are or may be directed

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toward the solution of such problems.

From this viewpoint, the implications of atomic energy activities and particularly the recent development of large scale nuclear fission operations should be of interest to everyone engaged in public health work. It seems doubtful that the majority of health departments, especially local health departments, will be affected by these activities at the moment or for some time to come. Future expansion of the operations and increasingly wide use of the products, the radioisotopes, may change this situation. Before this occurs it is important that we should obtain as much information as possible and be prepared to meet or forestall difficulties.

Much published material is now available including the semi-annual reports of the Atomic Energy Commission (AEC) which review various aspects of the production and research program of the Commission and its contractors. The July, 1949 report, entitled "Atomic Energy and the Life Sciences," was devoted largely to problems of biology and medicine and to research programs looking to the solution of such problems. In recent months published papers, reports of meetings, and articles in professional journals have appeared; and published bulletins on a variety of subjects more or less directly related to public health are available from the Oak Ridge and Washington offices of the AEC. A paper by A. E. Gorman and Abel Wolman on "Some Public Health Problems in Nuclear Fission Operations" published in the April, 1949 issue of the American Journal of Public Health includes many details which are pertinent to our discussion today.

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My purpose in this paper is to speak primarily of the unique public health problems that are incidental to the atomic energy developments of the past ten years and to the present program of the AEC and its associated projects. This will include a brief review of the nature of radioactive materials and associated health hazards, the problems of radioactive waste disposal, and the program of waste disposal research now in progress at the Oak Ridge National Laboratory.

Recognition of Health Problems in the Atomic Energy Industry

From the inception of the atomic energy projects, nuclear physicists, chemists, engineers, and management have emphasized the necessity for adequate controls and protection against radiation hazards both in and beyond the operating areas. High standards of protection against these hazards have been maintained even when it required expensive emergency measures to do so. Instruments and techniques for radiation measurements, continuous survey and monitoring services, standards of safety and personnel protection, and maximum limits of air and water contamination were developed quickly and used with large factors of safety. It has been proved that, with proper precautions, radioactive materials can be handled safely even in large quantities as attested by the fact that thousands of people have been engaged on the plutonium projects (meaning Oak Ridge National Laboratory, Argonne National Laboratory, and Hanford Works) for years without anyone being injured by radiation insofar as can be determined from millions of meter readings and from frequent medical inspections.

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The practice of health physics - a new profession - has evolved as a specialty in matters of radiation protection. On atomic energy projects the health physics divisions are responsible for the safety of operations involving radiation and radioactive materials. They conduct survey-monitoring and research programs designed to prevent any conditions of radiation exposure that might possibly cause health hazards. Although up to the present most of the work of health physicists has been on AEC projects they are now increasingly employed in hospitals and research institutions that handle radioactive materials. It seems logical that they will soon find their place on the staffs of public health departments that expect to do appreciable amounts of work and consultation in connection with specific radiological problems.

The range of health problems created or accentuated by atomic energy developments is very broad and involves practically all branches of public health. However, from the very nature of nuclear fission phenomena and operations, the protection of people from radiation hazards must be based largely upon environmental health controls which is the special field of sanitary engineering. In general, the basic principles of sanitary engineering are applicable, but additional special knowledge and techniques are needed for the sanitary engineer to work most effectively in this field. Moreover, he must join closely with health physicists and other specialists who are trained and experienced in nuclear physics and he must depend upon them for the actual solution of many technical problems with which he will be faced. The health problems associated with the production, study, and use of radioactive materials

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are unique in many respects and are relatively unfamiliar to most people, even to a great majority of those in the technical professions.

Nature of Radioactive Materials and Associated Health Hazards

The field of nuclear physics is relatively new and knowledge of the phenomena of radioactivity is far from complete. Natural radioactivity in uranium and radium was discovered in 1896 and 1898 respectively and in other materials at later dates. Altogether there are some fifty naturally occurring radioisotopes in our earth's surface, the amounts of which differ widely in different places. In recent years the amounts of radioactivity to be dealt with have been increased enormously by the manufacture of hundreds of new radioisotopes in accelerators and especially in the more efficient and prolific chain reacting piles or reactors. In these atom smashing machines the desired isotopes, new elements, and various fission products are produced. Many of these new materials are very highly radioactive although in a majority the activity is short-lived. The half-life is defined as the time required for a radioisotope to reduce to one-half its radioactivity by decay. The half-life of different radioisotopes varies from a matter of microseconds to millions of years.

A tremendous amount of research has been done and is continuing to gain knowledge of radioactivity and of the properties, behavior, and effects of the various radioisotopes. The physical and chemical properties of these materials are now fairly well understood by specialists in the atomic energy field and it is well known that undue exposure to the energy radiations of radioactive materials is damaging to living tissues.

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Unfortunately, present knowledge of the mechanism by which radiation harms living tissues is still quite inexact and the factors involved are very complex and difficult to define. Our knowledge of the effects of radiation is based largely upon medical and biological experience with x-rays and with radium and upon experimental work with animals. Available knowledge about the effects of radiation and the maximum permissible exposure of people has been summarized in a number of publications and reports by the Atomic Energy Commission and other agencies.

The health hazards from radioactive materials are due to the fact that the nuclei of their atoms which are unstable tend, sooner or later, to change to a stable form. In so doing they give off ionizing radiations - particles or rays of high energy. Each such readjustment of the nucleus of an atom is known as a disintegration. The radiation is able to penetrate solid matter to a greater or less degree and may have detrimental effects upon living tissue. Parts or all of the body may be affected either by external radiation or from internal exposure to radioactive products taken into the body. Radioactive products enter the body by inhalation, ingestion, and through the skin. They are eliminated principally by way of the feces, urine, perspiration, expectoration, and exhaled air. It is well known that people are subject continually to a low level of radiation from cosmic rays and from the natural radioactive products contained normally in the human body; and occasionally higher exposures occur as from diagnostic x-rays, shoe-fitting fluoroscopes, and various other sources. The objective of health physics is to prevent any exposure which might cause undesirable effects when added

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to the radiation to which people are ordinarily subjected.

A common unit of radioactivity is the curie (c) which is based upon the number of radioactive atoms that disintegrate in an interval of time as determined by some type of counting instrument. One curie is arbitrarily taken as thirty-seven billion disintegrations per second and approximates the amount of radioactivity of one gram of radium. A microcurie is one millionth of a curie or thirty-seven thousand disintegrations per second. The curie is a convenient measurement for monitoring purposes since it indicates the amount of radioactive material present. Other units such as the roentgen (r) and the roentgen equivalent physical (rep) indicate the amount of energy absorbed per unit of mass and in living tissue this appears to be related to the death of cells.

In setting permissible limits for external and internal exposure, standards are based upon the amounts of different kinds of radiation that an individual can withstand indefinitely without apparent injury; and then a factor of safety of ten or more is included. The National Committee on Radiation Protection of the National Bureau of Standards is responsible for setting standards of maximum permissible exposure which are observed by the AEC and other agencies in the maintenance of protective measures. The National Committee on Radiation Protection has been active for more than twenty years. Tolerance limits have been the subject of constant study and occasional revision, generally toward more conservative values. The quantities that are involved and which we must measure are extremely small. For example, the present maximum permissible limit of radioactivity

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in drinking water, and which is maintained in the Clinch River below Oak Ridge, is 10^{-7} microcuries per cubic centimeter - or in other words one ten millionth of a millionth of a curie per cc.

It is not easy to comprehend the enormous increase in the magnitude and complexity of radiation problems that has resulted from the successful operation of a production pile. In the past fifty years in the whole world only about two and one-half pounds of radium have been isolated. In an operating nuclear reactor, radiation equal to that from hundreds of tons of radium may be given off. Radioisotopes by irradiation of various materials and numerous radioactive fission products are produced within the reactors. Persons in pile buildings are adequately protected from these radiations by the concrete shields surrounding the pile; and great care is taken to prevent the escape of radioactive materials into the work areas or the outside atmosphere. To remove the enormous amount of heat that is generated, water or air is circulated through the pile and the constituents of the water or air thus exposed also may become radioactive and must be disposed of in a safe manner. After removal from the pile or reactor, the valuable radioactive materials must be separated and treated by various chemical and other processes, again with special measures to protect workers and to prevent the escape of dangerous radioactivity in waste materials.

Problems of Radioactive Waste Disposal

The rise of nuclear fission as an industry has been both spectacular and rapid. In the space of a few short years we have witnessed

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the birth of an industry so new, so large, and so unique that it is a little difficult to comprehend. Of the environmental problems presented by atomic energy developments, an outstanding one is that of waste disposal. It has become almost axiomatic that an industry, like a community, can have a healthy program only so long as it can adequately dispose of its own waste products. The production, processing, and use of radioactive materials may produce liquid, solid, or gaseous wastes. These wastes vary widely in composition and in the kinds and amounts of radioactivity in the materials they contain. Some may contain toxic chemical substances but as a rule the essential problem is to reduce the radioactivity to negligible amounts before the wastes are disposed of into the air, water, or soil.

The ideal objective would be to retain absolute control of all radioactive wastes and prevent any increase in the natural background of radioactivity. This can be accomplished only by extremely costly methods, if at all, and is practically impossible for an expanding permanent program of atomic energy development. The minimum objective, therefore, is that the radioactive isotopes released into drainage systems, the atmosphere, or soils must be incapable of sufficient concentration in air, water, food, or drugs to be harmful to man or to plant and animal life.

With regard to atmospheric contamination an air cooled pile such as the one at Oak Ridge National Laboratory causes induced activity in the air and any dust contained in the cooling air stream. Radioargon is the principal radioisotope discharged into the air. Since it is not

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selectively absorbed into the body it presents a minimum hazard and is disposed of from tall stacks which give an adequate dilution factor. The radioactive dust is removed by the use of filters. Air samples and other measurements are taken very frequently or continuously in the neighborhood of the pile to insure that its operation is maintained safely at all times.

Problems of air contamination are presented by chemical operations during solution, separation, and purification of the irradiated materials; and are also the concern of the thousands of users of the isotopes which are sent out from Oak Ridge or produced at accelerator installations. The most successful method of control is to confine the contamination as much as possible and remove the contaminants from the smallest possible volumes of air near the source. This requires especially designed hoods which contain their own filters, air washers, precipitators, and such. This air is then collected through a central filter system and passed up a stack of suitable height. Other points to observe are that hood surfaces which may be exposed to radioactive substances must be of a material that can be decontaminated readily; parts must be removable for replacement; air samples must be taken inside and outside of laboratories that use large quantities of radioactive materials, as in chemical processing; and the utmost care in techniques must be taken to avoid spilling or the careless disposal of radioactive materials into ordinary laboratory sinks.

In the case of radioactive solid wastes useful material and equipment may be decontaminated and reclaimed. Contaminated clothing is

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laundered and tested before reuse. Worthless solid materials and equipment that cannot be decontaminated are buried in carefully selected burial grounds which are permanently fenced and restricted and which are monitored regularly. Earth cover usually assures adequate shielding but concrete cover may be used if necessary. It is essential that burial areas should be selected and tested to assure that there will be no dangerous leaching of radioactive materials underground and that the areas will be under permanent control. Some have suggested that radioactive waste materials be encased in large steel drums and disposed of by dumping to the bottom of the sea many miles offshore. Special research is being conducted on incineration and other methods of concentrating solid wastes such as contaminated trash and biological specimens in order to reduce the volume which must be buried. In this as in other forms of radioactive wastes it must be remembered that radioactivity cannot be neutralized or destroyed by any known artificial process. Radioactive materials can be concentrated or diluted but the rate of disintegration cannot be speeded up or retarded and is eliminated only by processes of natural decay which for different radioisotopes may require days, months, or thousands of years.

Liquid wastes are produced in some quantity wherever radioactive materials are produced, processed, and purified or where used as in hospitals and research laboratories. Therefore the disposal of radioactive liquid wastes is a major problem throughout the atomic energy field of activities and one which must be met at all research and production areas. The magnitude of the problem varies greatly depending upon

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the location and the type of institution. Work done at hospitals, universities, industrial laboratories, and other non-AEC facilities usually involves the use of only very small quantities of radioisotopes. At the national laboratories such as the ORNL where research and development include pilot scale studies and some production much larger quantities of radioactive wastes may be expected. The greatest volumes of liquid radioactive wastes result at certain types of large production plants such as the Hanford Works at Richland, Washington.

The possibilities for disposal of liquid radioactive wastes include concentration as by evaporation or chemical treatment followed by permanent storage for the long-lived materials; storage for a period of weeks or months for the short-lived materials to allow radioactive decay; or dilution through dispersal in surface waters. In considering methods of disposal of individual radioisotopes or mixed materials, the differences in their properties must be taken into account. Physical properties include the types of radiation, the energies involved, and the half-lives or radioactive decay constants. Chemical properties influence the action of ingested radioisotopes on persons or animals - solubility and efficiency of absorption in the body, concentration in particular organs or tissues, and rate of elimination from the body. Many of the long-lived radioisotopes tend to be absorbed and concentrated on clay particles; and also in the bodies of living organisms such as algae or aquatic plants and animals. Of special interest is the solubility of particular isotopes in water and the efficiency of their removal by water purification plants. It is also of interest to learn the extent

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to which various radioactive materials may be absorbed and concentrated by slimes and organic matter in drainage systems or sewage disposal plants.

It is apparent that the disposal of radioactive wastes presents difficult problems similar to the disposal of chemical wastes but complicated by the peculiar properties and hazards of the radioisotopes that may be present. The only logical approach has been and must continue to be through an adequate program of research and practical studies. Such waste disposal studies must be developed along broad lines. In addition to physics and chemistry, they involve a basic sanitary engineering approach and various collateral fields such as meteorology, geology, and biology.

The broad public health implications of the problems of radioactive wastes have received definite attention and a considerable number of sanitary engineers have been employed or have been assigned by other agencies to work on these problems. Several programs for this purpose have been established including that of the Waste Disposal Research Section in the Oak Ridge National Laboratory, study programs on waste disposal being conducted at other AEC sites, and a number of research projects in universities. Active work in the analysis and codification of available knowledge on waste disposal is being done by a special subcommittee of the National Committee on Radiation Protection. This subcommittee is giving particular attention to the problems of research institutions, hospitals, and other off-project users of radioisotopes.

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Waste Disposal Research Program of Health Physics Division

The Waste Disposal Research Section in the Health Physics Division, ORNL, was organized July 1, 1948. Prior to that time the need for a broad program of fundamental and practical studies of radioactive wastes to consider both local and general problems and with a basic sanitary engineering approach had been emphasized and preliminary steps had been taken toward its establishment. This is a cooperative project in which the participating agencies are ORNL, the USPHS, TVA, and the Oak Ridge office of the AEC. Very recently practically all of our program has been declared an unclassified area of research so that with few exceptions we shall be permitted to publish whatever information we may obtain.

The broad purpose of the program is, through fundamental and practical studies, (1) to evaluate the hazards incidental to the release of radioactive materials into the atmosphere, ground waters, and waste drainage systems; (2) to study the factors that influence the extent and significance of such hazards; and (3) to aid in the development of effective and economical measures for their prevention and control under conditions of either peace or war.

The importance of the concentration and the retention of wastes at the source is recognized and at ORNL the Technical Division conducts research and develops methods for this purpose. The Health Physics Division is responsible for the study of those wastes that must be discarded or which escape after treatment within the plant. Certain types of studies are made directly by the Health Physics group. The program is also coordinated with special meteorological, geological, and biological studies

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that are being conducted in the Oak Ridge area. Personnel of the Section - employed by the Laboratory or on loan from cooperating agencies - now includes four senior personnel (sanitary engineers and sanitary chemists), seven junior scientific personnel, a laboratory technician, and a secretary.

The study program comprises three general areas of study: (1) survey studies; (2) process studies; and (3) corollary studies.

Survey Studies. Field sampling projects include the collection and assay of a variety of aquatic and other specimens which may indicate the dispersion and behavior of radioactive materials in the natural environment. Hydraulic and hydrologic data are analyzed to define the conditions of dilution and diffusion in surface water. Experiments on the controlled exposure of fish and algae in contaminated water are planned. Through these studies we hope to define the situation in the vicinity of Oak Ridge and, by extrapolation, elsewhere, with special reference to the travel of released materials, concentration in mud, algae, fish, and other substances, and the possible human exposures to radioactivity that may result.

Process Studies. This category includes laboratory and pilot plant studies on water, sewage, and industrial waste treatment processes which are well-established and provide a logical starting point for development of liquid wastes decontamination methods. This work is of public health significance in that it will enable us to determine the effects of radioactive materials upon sanitary engineering works and processes. As a corollary objective we will determine the effectiveness of these processes as waste treatment procedures.

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Corollary Studies. These include work to improve field instrumentation and laboratory techniques as well as cooperative efforts in conjunction with the TVA and with the geological, meteorological, and ecological study programs mentioned previously. Special projects are: the development of surface water survey instruments for the scanning of water and mud for evidence of radioactivity; and a setup for continuous water and waste monitoring by conventional instruments at White Oak Dam which is located a short distance below the ORNL area.

Conclusion

No one can foresee at present the full extent or direction of atomic energy development in the future. As is often the case with new and important discoveries, there has been a tendency to over-publicize and to exaggerate both the promise and the hazards of operations in this field. The logical objective is to deal with the health and sanitation problems as they now exist, to study and learn more of the fundamental factors involved, and to develop rational systems of controls that are as conservative and adaptable as possible. The importance of fundamental research and developmental study programs is emphasized constantly and a large part of the present efforts in connection with atomic energy projects is devoted to research.

It is sometimes difficult to judge, at a given time, how much progress actually is being made. The idea that I should like to convey is one of optimism. Given a little time, these problems will be resolved just as others have been in the past. If you will recall, chlorination

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of water was practiced for many years before we really understood the fundamental mechanism involved. In the present instance, we may be confident that understanding will proceed more rapidly, because everyone concerned is very conscious of the problems involved, and a concerted effort is being made to solve them.

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