DISPOSAL OF RADIOACTIVE WASTES

A REVIEW OF IAEA EFFORTS TO ASSURE SAFETY

Almost all major nuclear operations produce residues containing radioactive materials; in reactor operations, for example, the fission products, new elements (such as plutonium) produced by neutron irradiation and the unfissioned nuclear fuel are all radioactive. Some of this material can be put to further use: useful radioisotopes, for instance, can be extracted from the fission products and plutonium can be extracted for subsequent use as concentrated nuclear fuel. Theoretically, it should be possible to find some application for most of the radioactive substances that are produced in the course of atomic operations.

In practice, however, it is not possible to utilize all these substances; and not all of those which may have some practical value can be easily extracted in usable form. As a result, even after some usable materials have been extracted, the atomic energy industry is left with considerable quantities of radioactive substances.

Something has to be done to these unusable by-products - the so-called radioactive wastes. Because they are radioactive, steps must be taken to ensure that the radiations they emit do not pose any threat to human health and safety. From this arises the problem of safe disposal of radioactive wastes - a problem that has been growing in size and complexity with the development of nuclear operations.

Radiation safety is one of the main areas in which the International Atomic Energy Agency has a distinct role to perform. One of the Agency's statutory functions is to establish or adopt "standards of safety for protection of health and minimization of danger to life and property", and safe disposal of radioactive wastes is among the most important problems to which the Agency must give attention in this connection. The Agency's Preparatory Commission in its report suggested that the Agency begin studies of problems posed by the disposal of radioactive wastes at sea and on land and the discharge of radioactive effluents into streams and the atmosphere. The Commission stated: "These problems arise at present only in certain States or within limited areas but they will increase with the development and spread of nuclear power, and international co-operation will be essential to minimize contamination."

Radioactive wastes differ from all other wastes in that they cannot be rendered innocuous by chemical or biological treatment. The radioactivity, however, decreases with time, the rate of decrease being dependent on the lifetimes (usually expressed as half lives) of the radioactive materials involved. Some of the materials have half lives measured in fractions of a second, while some others have half lives of millions of years.

Whatever the method of their disposal, the possibility has to be taken into account that some of the radioactive materials may re-enter man's immediate environment or even find its way into the biological cycles. Safety in disposal depends not only on the nature and quantities of the materials but also on their behavior in different types of environment and the nature of man's contact with that environment.

Broadly speaking, the wastes can be disposed of in two ways; they can be diluted and dispersed so that the radiation to which any single individual would be subjected would be negligible, or they can be concentrated and permanently isolated from man and his immediate environment. A variation is to delay the disposal of the waste until the radioactive concentration has decayed to an acceptable level.

A variety of methods for the discharge of radioactive wastes into the ground, into water and into the air were described at an international conference in Monaco in November 1959, organized by IAEA jointly with UNESCO and with the co-operation of FAO*. Many of the experts at the conference were of the view that most of the proposed, or actually applied, methods of waste disposal were compatible with safety requirements. Some differences of opinion existed about disposal into the sea. It was generally agreed that much additional research was necessary for devising the most effective and economical methods of disposal and gaining a better knowledge of the effects of the various types of disposal operations.

Sea Disposal: Brynielsson Report

The subject of sea disposal was considered in detail by a panel of experts constituted by IAEA in October 1958. The panel, which was presided over by Mr. Harry Brynielsson, Head of the Swedish Atomic Energy Company, and which included experts from nine countries, finished its work early last year and submitted a report to the Agency's Director General+.

In that report the experts stated that the release into the sea of high-level wastes from irradiated fuel could not at present be recommended as an operational practice, because the properties of the deep sea were not fully known. Ways, however,

---

* *See IAEA Bulletin, Vol. 2, No. 1.*

\+ *See Bulletin, Vol. 2, No. 3.*

might be found of fixing such wastes into solid, non-leachable forms and then dumping these into the deep sea, but in any case there must be an adequate study of the physical, chemical and biological processes in the deep sea.

As regards wastes of low and intermediate activity, the panel was of the view that their disposal into the sea could be permitted under specified and carefully controlled conditions. All such wastes, except those incidental to the operation of nuclear ships, should be released into designated disposal sites in conformity with the conditions specified for each site. The sites should be designated by a responsible national or international authority. This authority should also be aware of the results of the monitoring of the area to verify that safe conditions were maintained, and collect records of disposal that would show the state of a particular site. All these authorizing bodies should furnish to a suitable international authority such information as would make it possible to maintain an adequate register of sea disposals. In the opinion of the panel, this register should be maintained by IAEA.

The panel also made certain recommendations about the disposal of radioactive wastes from nuclear ships. Although these wastes are likely to be of low or intermediate activity, their indiscriminate release into the sea would be hazardous because many areas of the sea to which the ships would travel are not suitable for receiving radioactive material. The ships, therefore, should have facilities for temporary storage, although low and intermediate activity wastes could be discharged into the open sea "without undue risk to man".

Follow-up Action

Several recommendations of the Brynielsson report need further elaboration or call for further investigations, and simultaneously with circulating the report to Member Governments the Agency has arranged for these studies to be made by separate panels of experts.

A panel of experts from ten countries has been examining the administrative, organizational and legal implications of the recommendations. The panel, which held its first series of meetings in January 1961, also made some comments on the basic premises of the report, on the validity of the technical data used in the report, and on items which should be studied further in connection with the implementation of the recommendations. The panel felt that a number of important scientific and technical problems had not been fully answered in the report, and that IAEA should immediately arrange for further studies on these questions.

Some of the necessary scientific studies are being carried out under research projects sponsored or supported by the Agency (described later in this article). In the meantime, the Agency has initiated work on some other lines suggested in the Brynielsson report. For example, scientists on the Agency's staff are making a preliminary examination of arrangements that would be necessary for maintaining a register of all waste disposal into the sea. Methods of monitoring the disposal of radioactive wastes into the sea are being examined by an international panel of experts. The aim of the panel is to formulate a system that would, among other things, help in determining the levels of radioactivity in marine materials, in establishing the relationship between these levels and the rate of disposal, in plotting the resulting distribution of radioactive materials in the sea and in providing specimens for radiobiological examination so as to find out the possible effects of radioactivity.

At its first series of meetings from 17 - 22 April 1961, the panel reviewed the general considerations and techniques involved in monitoring; among the subjects discussed were investigations before disposal, selection of monitoring criteria, the necessary technical and physical arrangements, actual monitoring techniques, and the interpretation of monitoring data.

Other Forms of Disposal

As regards high level wastes, it is generally agreed that they must be suitably contained so as to prevent them from finding their way into the open environment. If the containers provided effective radiation shielding and could be relied upon not to give way at any time, they could be safely stored underground or dumped into the deep sea. But all containers have a limited life, while the effective radioactive life of some of the wastes may extend to thousands of years.

Various solutions have been offered to deal with this problem. For example, the wastes could be permanently fixed in some geological strata so that they would be prevented from returning to man's immediate environment. Studies are being made on the possibility of discharging the wastes into salt formations, especially in view of the impermeability of salt, or incorporating them in glass for subsequent storage in vaults. In most cases, some preliminary treatment is essential to let the wastes "cool off" before they can be safely stored. Various problems connected with high level wastes will be discussed at a scientific symposium planned by IAEA for the near future.

A panel of experts has meanwhile been considering methods of disposal into fresh water; its work is mainly concerned with the formulation of valid criteria for assessing the possible effects on man of the discharge of radioactive wastes into fresh water environments. Since many atomic installations are and will be located far from the sea, knowledge of the fate of radioactive materials in fresh water will become very important.

Another panel of experts has gone into the techniques of disposing of low level wastes, such as are produced from the use of radioisotopes. The purpose of the panel is to prepare a manual on waste disposal

and decontamination procedures for small scale users of radioisotopes; a draft prepared by the Agency's Secretariat was considered by the experts at a series of meetings last March. In the light of comments made by the experts, the draft is now being given final shape.

Yet another panel of experts is to be convened to consider nuclear ship safety with emphasis on harbour criteria. The problem of waste disposal from nuclear ships is certain to assume increasing significance in the years to come. Certain general considerations in this regard are outlined in the Brynielsson report; some pertinent discussions also took place at the symposium at Taormina last November on nuclear ship propulsion with special reference to nuclear safety*.

Measurement of Radioactivity Levels

Allied to the problem of waste disposal is the task of determining the level of radioactivity in the biological environment. Most of the existing literature on radioactivity in the biosphere is specifically concerned either with fall-out problems or with conditions in the immediate vicinity of nuclear installations. Several Member States have, however, asked for the Agency's assistance in connection with the task of controlling any contamination of large areas by the disposal of radioactive wastes, and in this context the Agency convened a panel of experts to formulate methods for the collection and analysis of samples for the measurement of radioactivity levels over large areas of the biosphere. The recommendations of the panel, now published in the form of a booklet, place special emphasis on rapid, simple and economical methods of sampling, processing and identification in large area control work.

In making these recommendations, the experts were guided by two basic criteria: (a) the system proposed should be able to detect sudden releases of radioactive material soon enough to enable appropriate measures to be taken, and (b) it should provide for the continuous measurement of particularly hazardous radioactive substances the levels of which may be built up even by small periodic releases.

The panel pointed out that to be able to detect an accidental release checks must be made in those parts of the biosphere which would be immediately contaminated, i.e. air and surface water. Continuous measurements on foodstuffs may be necessary to estimate the future hazard to the population, while measurements on human material give a direct value of the existing contamination in a given region at any given time. It has been emphasized that in view of the extremely small amounts of radioactive substances likely to be present in the samples, precautions must be taken in siting the laboratories as well as in the processing and measuring procedures; it is recommended that laboratories carrying out work to determine trace amounts of radioactive substances should preferably not be situated in the vicinity of a radiation source or of a potential source of contamination.

* *See Bulletin, Vol. 3, No. 2.*

The relevant procedures are discussed in the booklet separately for the various types of materials in the biosphere, viz. (1) water: rivers, lakes, oceans, wells and tap water; (2) rain, snow and dry depositions; (3) air; (4) food: milk, fish and meat, and rice and vegetables; and (5) human material. The main headings under which the technical information is arranged are: radioactivity to be measured, sampling, processing, analysis, measurement, and units of reporting, calibration and standardization.

Research Projects

IAEA has taken due note of what appears to be the unanimous view of all experts that a great deal of important scientific research remains to be done. This research must cover a wide range of specific topics, such as general radiation effects, movement of radioactive materials, the properties of the deep sea and all aspects of the radioactive waste problem. While some of these subjects, such as the biological effects of radiation, are of general importance and not exclusively connected with the waste disposal problem, some others, such as the movement of radioactive materials in the biosphere or methods of treating waste products, are of specific significance in the context of disposal operations.

At present, 17 research projects are under way at well-known scientific centers in various countries under contracts awarded by the Agency. Two of the projects deal with the effects of radioactivity on the biological life in rivers and lakes; six deal with these effects on marine organisms; two projects concern the cycling of radioisotopes in the biosphere; the disposal of radioactive wastes in the lithosphere (i.e. the earth's crust) is being investigated under six research contracts; and one contract is concerned with methods of waste treatment. The countries where those investigations are being conducted are: Argentina, Austria, Australia, the Czechoslovak Socialist Republic, Japan, Italy, Norway, the United Arab Republic, and the United States of America.

A special project for research on the distribution of radioactive materials in the oceans, particularly in the biological cycles, has recently been undertaken by the Agency under an agreement with the Government of the Principality of Monaco and the Institute of Oceanography in Monaco*. The program has three major objectives. In the first place, it is aimed at acquiring knowledge about the movement of water and marine organisms and the deposition of organic and inorganic matter. Secondly, it provides for a special study of the distribution in marine organisms of radioactive materials already existing or that may be introduced into various locations. And thirdly, there will be an investigation of the effects of radioactive materials at various concentration levels on the marine ecology.

Co-operation with International Bodies

This brief account of IAEA's work in the field of waste disposal would indicate the measure of impor-

* *See Bulletin, Vol. 3, No. 2.*

tance that the Agency attaches to the problem, but the account is far from being exhaustive; it should be pointed out in this connection that several other activities of the Agency, for example fundamental studies on radiobiological problems or studies in connection with basic safety standards, have a bearing on this subject. In an attempt to secure effective international co-ordination of these activities the Agency has not only sought the advice and assistance of specialists from all parts of the world but has also assisted the work of other international bodies engaged in similar problems. In particular, it has co-operated actively with the United Nations Scientific Committee on the Effects of Atomic Radiation, and in determining basic safety standards it has been guided by the recommendations of the International Commission on Radiological Protection.

Under arrangements made by the Agency, several scientists presented statements on various aspects of the waste disposal problem at the ninth session of the United Nations Radiation Committee. The following four reports were presented: "Origin and Nature of Radioactive Wastes" by Rolf Eliassen and Byung Cho Kim, both from the USA; "Some Aspects of Future Radioactive Waste Disposal" by Alina Gotwald and Edward Kowalsko, both from Poland; "Current Procedures for the Disposal of Radioactive Waste" by H. J. Dunster (UK); and "Environmental Consequences of Radioactive Waste Disposal" by Frank L. Parker, of IAEA's Division of Isotopes. Copies of these statements, which do not necessarily reflect the Agency's official position, have been distributed by the Agency to Members of the Radiation Committee, the specialized agencies, and the International Commissions on Radiological Protection and on Radiological Units and Measurements.

The Agency has also taken steps to stimulate public interest in, and informed public discussion on, the problem of radioactive waste disposal. At a public meeting organized by the Agency during the fourth session of its General Conference in Vienna last September, the subject was discussed by three prominent scientists: Harry Brynielsson (Sweden), H.J. Dunster (UK) and Leslie Silverman (USA). The statements by these experts as well as their answers to questions from the audience were reproduced in a special number of this Bulletin published in November 1960.

Mr. J.D. Pearson, an IAEA Technical Assistance Expert, removing a consignment of radioactive sodium and potassium from the wing-tip of an aircraft at Bangkok airport. The consignments are carried on the wing-tip so that the isotopes may not present any radiation hazard to people on board the aircraft. The isotopes in this consignment were used to help Thai doctors in investigating cases of cholera