RADIOACTIVE WASTE DISPOSAL INTO THE SEA

Safe disposal of the increasing amounts of radioactive waste produced in atomic operations is a problem of the first magnitude. According to a recent, necessarily tentative, estimate, there will be about 60 tons of fission products a year when the current plans for atomic development in various parts of the world will materialize. When nuclear fission eventually becomes a major source for meeting the world's energy needs, the output will probably amount to at least 1 000 tons a year. In addition, there will be considerable amounts of secondary and very low activity wastes, and some resulting from the use of radioisotopes.

These, of course, are estimates of future dimensions, and it will be some time before the problem reaches these proportions. But that does not diminish the urgency of the problem. The subtle and persistent nature of the hazards involved makes it particularly desirable that safe practices be evolved and initiated from the beginning. If one were to wait for harm to be manifested, the consequences could affect large numbers of people over long periods of time with little hope of any corrective measures undoing the harm. Advantage, therefore, should be taken of the fact that at the present time radioactive waste disposal is a relatively small problem and various methods may be explored in order to find a long-term solution that will be both effective and economical.

While high-level wastes* must be concentrated and contained to prevent them from finding their way into man's environment, the less dangerous wastes can be diluted and suitably dispersed. Because of its enormous capacity, the sea appears attractive as an environment for the latter type of disposal. But obviously this cannot be done indiscriminately or indefinitely; there is a limit to the capacity of the sea to disperse and dilute radioactive materials since man should continue to have unrestricted opportunities for the harvest of marine products. Besides, there are various ways in which the radioactivity of the wastes released into the sea can reach man. So far as external exposure is concerned, we may receive this radiation from the sea water itself as well as from contaminated beaches and fishing gear. We may also absorb the radiation sources internally - mainly through marine food products.

Concern over Possible Danger

Methods of disposal must, therefore, be so devised as to reduce the possibility of danger as far as possible; in any case, the risk must not be such as is unacceptable either to the individual or to the population at large. Concern over potentially unsafe practices has often been expressed in recent years. At the United Nations Conference on the Law of the Sea in 1958, a new article was proposed for inclusion in the International Law Commission's report, asking all States to "take measures to prevent pollution of the seas from dumping of radioactive wastes". In addition, one of the Articles Concerning the Law of the Sea, for submission by the Commission to the U.N. General Assembly, was so amended as to recommend that IAEA "should pursue whatever studies and take whatever action necessary to assist States in controlling the discharge or release of radioactive materials to the sea, promulgating standards, and in drawing up internationally acceptable regulations to prevent pollution of the sea by radioactive materials in amounts which would adversely affect man and his marine resources".

A similar programme of work had also been recommended by the Agency's Preparatory Commission. Accordingly, in October 1958, the Agency's Director General set up an ad hoc Panel of Experts to advise him on Radioactive Waste Disposal in the Sea. This international panel, presided over by Mr. Harry Brynielsson, Head of the Swedish Atomic Energy Company, was composed of the following experts: Dr. Bo Aler (Sweden), Prof. Francis Behounek (Czechoslovakia), Mr. Pierre Cohen (France), Dr. Anil Kumar Ganguly (India), Mr. H. Howells (United Kingdom), Dr. Colin Ashley Mawson (Canada), Prof. Donald William Pritchard (United States of America), Prof. Nobuhusa Saito (Japan), Mr. J.B. Schijf (Netherlands) and Ing. V. Vesely (Czechoslovakia). Representatives of the United Nations, the Food and Agriculture Organization, the World Health Organization and Unesco also took part in the work of the Panel.

The Panel conducted its studies at a series of meetings at the IAEA headquarters in Vienna and its conclusions are contained in a report recently submitted to the Director General, who has transmitted it to the Agency's Member States. The conclusions reached by the Panel and the recommendations made are summarized below.

Assessment of Safety

The experts have pointed out that the first principle must be the safeguarding of man against the damaging effects of radiation. In assessing the safety of proposed disposal operations the most recent

* *High level wastes are defined as those with an activity of hundreds or thousands of curies per gallon, whereas those with an activity in the range of one microcurie per gallon are defined as low level wastes. These are evidently separated by a wide range of wastes of intermediate activity.*

The curie is the unit of the activity (rate of radioactive disintegration) of a radioactive substance. One curie is approximately equal to the activity of one gramme of radium. A microcurie is one-millionth of a curie.

Experts discussing radioactive waste disposal into the sea. The Chairman of the Panel, Dr. Harry Brynielsson, is seated at the head of the table

recommendations of the International Commission on Radiological Protection should be used as a guide.

Disposal operations can be conveniently divided into two types: (a) those affecting a particular nation, and (b) those which may affect a number of countries. In operations of the first type, the radiation exposure will be limited to a small fraction of the whole national population and consequently will not contribute significantly to the genetic dose of the whole population. Control of such operations will therefore be exercised in accordance with the exposure of the individual.

For the second type of operations, however, the controlling factor must be in terms of the genetic dose which could be received by the various national populations involved. The International Commission on Radiological Protection has recommended that the genetic exposure of the whole population, except from the natural background and medical sources, should be limited to less than 5 rem over a period of 30 years. The apportionment of the total genetic dose to the various radiation sources will depend on circumstances prevailing in a particular country. In the case of waste disposals which may have international implications, one-twenty-fifth of the genetic dose should, however, be allocated to possible exposure from marine sources.

The report states that at present the release into the sea of high level wastes from irradiated fuel cannot be recommended as an operational practice, because enough is not known about the properties of the deep sea. Ways, however, may be found of fixing such wastes into solid, non-leachable forms and dumping them into the deep sea. But before such a programme is undertaken, adequate research must be carried out to obtain basic data on the physical, chemical and biological processes in the deep sea.

Disposal Sites

Wastes of low and intermediate activity may, however, be safely disposed of into the sea under controlled and specified 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. In evaluating a disposal site, a number of factors will have to be considered. Once a level is set for permissible radiation exposure of man from sea disposals, it is necessary to find the numerical relation between the rate of discharge and the resulting exposure. All the significant routes by which the radioactivity could reach man must be considered; in particular, a proper study should be made of the ways in which the population concerned makes use of its marine environment.

Ordinarily, calculations of permissible rates of sea disposal can be of value only as a broad guide. They can, however, be made more dependable by certain experimental studies, such as the release of simulating substances or actual wastes on a limited scale. In addition, a system of monitoring should be established in order to check the significant routes through which exposure is possible. Occasional checks of other possibilities may be made to ensure that nothing has been overlooked or misinterpreted. It is also desirable to standardize the monitoring techniques so as to permit intercomparison of data between the nations concerned.

All sea disposal sites, says the report, should be designated by a responsible national or international authority which should set out conditions of use for each specific site. It should also provide for any necessary monitoring of the area to verify that safe conditions are maintained and collect records of disposal that would show the state of the disposal site. Further, all such authorities should furnish to a suitable international authority information necessary to maintain an adequate register of sea disposals. In the opinion of the Panel, this register should be maintained by the International Atomic Energy Agency which should receive (a) notice of the licensing requirements of all sea disposal areas, (b) annual reports on the state of such sites, and (c) the monitoring programme and all relevant scientific findings.

Wastes from Ships

As regards the disposal of radioactive wastes from nuclear ships, the Panel has pointed out that these wastes will depend upon the design of the reactor and the ancillary equipment used. Judging by the current plans for nuclear ship propulsion, it can, however, be assumed that the wastes will be of low or intermediate activity for the present.

Nuclear ships will traverse regions of the sea which are unsuitable as safe receivers of radioactive wastes. These ships should, therefore, be provided with facilities for temporary storage. Both low and intermediate level wastes produced in the course of normal operations of a nuclear ship may be discharged into the open sea without undue risk to man. Harbours, estuaries and other inshore areas appear unsuitable for the discharge of wastes of intermediate activity, but many harbours could receive the low level liquid effluent without any unacceptable hazard. The continental shelf and coastal area can safely receive the low level liquid wastes but cannot be recommended as suitable for the release of wastes of intermediate activity.

The Panel has recommended that the disposals from a nuclear ship should be entered in a record maintained on the ship and available for inspection by port authorities. An abstract of the record could be transmitted to the Intergovernmental Maritime Consultative Organization which, jointly with IAEA, should work out an effective registration and compilation of disposals from nuclear ships.

All disposals from ships in harbours and national waters should be in conformity with conditions laid down by the local authority. Disposals in international waters should conform to conditions specified in the licensing of the vessel or by the appropriate international authority.

Finally, the Panel has recommended that IAEA, in collaboration with other international organizations concerned, should review all these problems at appropriate intervals.

FABRICATION OF FUEL ELEMENTS

The prospects of economic nuclear power depend to a large extent on the lowering of fuel costs by achieving the maximum yield of acceptable fuel elements during the fabrication process and by a more effective utilization of the fuel in the reactor system. In fact, the efficiency of a reactor during operation is in a significant measure a function of fuel technology and is dependent upon the form and arrangement in which the fuel elements are placed in the reactor system.

The primary consideration, of course, is a self-sustaining, controlled fission chain reaction, and the fabricated elements must contain right amounts of fuel and placed in a geometry within the reactor that would facilitate such a reaction. Usually these elements are in the form of rods, plates or other structures of fissile material "clad" or closely sheathed in metal containers. The metal cladding or can protects the fuel element from damage by other substances in the reactor system: it prevents the fuel from coming in contact with water or other moderator materials with which it reacts vigorously whenever a fuel element failure occurs. Such a failure in most cases requires the reactor to be shut down to remove the defective fuel element. The canning also serves to contain the fission products and facilitates the handling of irradiated fuel during chemical reprocessing.

These requirements demand complex techniques of fabrication and cladding, and considerable research has been going on in a number of countries with the object of improving these techniques. Many of them were discussed in detail at an international symposium held by IAEA in Vienna last May. The symposium, which was in session from 10 May to 13 May 1960, was attended by nearly 200 experts from 23 countries. Representatives of the OEEC and the Euratom also took part in the meeting.

In his opening speech at the symposium, the IAEA Director General, Mr. Sterling Cole, stressed the importance and complexity of development of fuel element fabrication techniques and especially the role of cladding materials in lowering fuel costs. He explained that for the efficient and economic operation of a power reactor the fabricated and clad fuel elements must be able to stand up to high temperatures and also contain the fission products within themselves. Furthermore, the capture of neutrons by the cladding materials must be sufficiently low not to affect the conversion of fertile into fissile material. (By neutron irradiation, fertile material, such as uranium 238 or thorium, is converted into plutonium or uranium 233 which are fissile materials.)

Cladding Materials

The special emphasis at the symposium was on cladding materials and the first two sessions were devoted to a discussion of the characteristics of materials that can be used for canning. A number of papers were presented and discussed on different aspects of the principal cladding materials, such as aluminium, zirconium, zirconium alloys and graphite. The views expressed were supported by practical experience, and several suggestions were made for improvements in the use of these materials.

At the next two sessions, some of the technical problems of fuel fabrication were taken up, and the papers presented contained accounts of fuel fabrication facilities and methods employed in several countries. This was followed by a session on quality control and inspection; the topics discussed included tightness control, production control and the applications of microradiography for inspection. Problems raised by corrosion and radiation damage of cladding materials were considered at the following session, and