



International Atomic Energy Agency*

INFORMATION CIRCULAR

INFCIRC/205/Add. 1/Rev. 1
August 1978

GENERAL Distr.

Original: ENGLISH

CONVENTION ON THE PREVENTION OF MARINE POLLUTION BY DUMPING OF WASTES AND OTHER MATTER

The Definition Required by Annex I, paragraph 6 to the Convention, and the Recommendations Required by Annex II, section D

1. The Provisional Definition and Recommendations Concerning Radioactive Wastes and Other Radioactive Matter Referred to in Annexes I and II to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter[1] had been the object of a review and revision process carried out by the International Atomic Energy Agency during 1975-1978, with the help of several consultants' meetings and advisory groups and taking into account the comments expressed by the Contracting Parties to the Convention at their First and Second Consultative Meetings, held in London in September 1976 and September 1977 respectively. As a result of this work, the Revised Definition and Recommendations were submitted to the Board of Governors by the Director General in June 1978.

2. On 9 June 1978 the Board of Governors authorized the Director General:

- (a) To transmit the Revised Definition and Recommendations Concerning Radioactive Wastes and Other Radioactive Matter Referred to in Annexes I and II to the Convention, to the Inter-Governmental Maritime Consultative Organization (IMCO) which performs secretariat duties in relation to the Convention; and
- (b) To request IMCO:
 - (i) To provide the Third Consultative Meeting of the Contracting Parties to the Convention, to be held in London in October 1978, with the said Definition and Recommendations for the purpose of implementing the Convention; and
 - (ii) To inform the Meeting that such Definition and Recommendations, which should not be construed as encouraging in any way the dumping at sea of radioactive wastes and other radioactive matter, will be subject to review and revision by the Agency, as and when appropriate, in the light of technological developments and increased scientific knowledge.

3. The texts of the Revised Definition and Recommendations and of the Annex thereto for the purposes of the Convention are reproduced herein for the information of all Members.

[1] The texts of the Convention and of the Provisional Definition and Recommendations have been reproduced in documents INFCIRC/205 and INFCIRC/205/Add. 1 respectively.

CONVENTION ON THE PREVENTION OF MARINE POLLUTION
BY DUMPING OF WASTES AND OTHER MATTER

The IAEA Revised Definition and Recommendations of 1978
Concerning Radioactive Wastes and Other Radioactive
Matter Referred to in Annexes I and II
to the Convention

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^{*/} The lines in the margin and underlining in the text of this Document, except for the headings, indicate changes from the text of the IAEA Provisional Definition and Recommendations set forth in the previous Document (INFCIRC/205/Add.1).

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DEFINITION AND RECOMMENDATIONS

The Definition and Recommendations set forth in this Document should not be interpreted as precluding the adoption of more restrictive requirements by any Party to the Convention or appropriate national authorities, pursuant to Articles IV.3 and VI.3 of the Convention. Nothing in this Document shall be construed as encouraging the dumping at sea of radioactive waste or other radioactive matter.

A. DEFINITION

A.1. Definition of High-Level Radioactive Wastes or Other High-Level Radioactive Matter Unsuitable for Dumping at Sea[1]

A.1.1. For the purposes of Annex I to the Convention, high-level radioactive wastes or other high-level radioactive matter unsuitable for dumping at sea means any waste or other matter with an activity per unit gross mass (in tonnes) exceeding:

- (a) 1 Ci/t for α -emitters but limited to 10^{-1} Ci/t for ^{226}Ra and supported ^{210}Po ;
- (b) 10^2 Ci/t for β/γ -emitters with half-lives of at least 0.5 years (excluding tritium) and β/γ -emitters of unknown half-lives; and
- (c) 10^6 Ci/t for tritium and β/γ -emitters with half-lives of less than 0.5 years.

The above activity concentrations shall be averaged over a gross mass not exceeding 1000 tonnes.

A.1.2. The Definition must not be taken to imply that material falling outside the Definition is thereby deemed to be suitable for dumping.

A.1.3. Materials of activity concentrations less than those in the above Definition shall not be dumped except in accordance with the provisions of the Convention, in particular Annexes II and III thereto, and the Recommendations set out in this Document, in particular Section B.1.2.

[1] The Definition is based on:

- (1) An assumed upper limit to the mass dumping rate of 100 000 t per year at a single dumping site; and
- (2) Calculated upper limits to activity release rates from all sources (other than natural sources) of
 - (a) 10^5 Ci/yr for α -emitters (but limited to 10^4 Ci/yr for ^{226}Ra and supported ^{210}Po);
 - (b) 10^7 Ci/yr for β/γ -emitters with half-lives of at least 0.5 years (excluding tritium) and β/γ -emitters of unknown half-lives; and
 - (c) 10^{11} Ci/yr for tritium and β/γ -emitters with half-lives of less than 0.5 years

at a single dumping site and also in the case of α -emitters when released to an ocean basin of not less than 10^{17} m³.

B. THE RECOMMENDED BASIS FOR ISSUING SPECIAL PERMITS FOR RADIO-ACTIVE MATERIALS LISTED IN ANNEX II TO THE CONVENTION

B.1. Environmental Evaluation of Specific Dumping Applications

B.1.1. The appropriate national authorities shall not grant a special permit for dumping of radioactive waste unless a detailed environmental and ecological assessment gives a reasonable assurance that such dumping can be accomplished in accordance with the objectives and provisions of the Convention and the Recommendations set out in this Document.

B.1.2. When granting a special permit, the appropriate national authorities shall, to the extent practicable, ensure that the proposed dumping operation complies with the radiation protection requirements set forth in the IAEA Basic Safety Standards for Radiation Protection [2]. These requirements are based upon the System of dose limitation of the International Commission on Radiological Protection (ICRP) which requires that:

- (1) The operations should be justified by assessing their net benefits, taking into consideration the radiation consequences and the possibilities of alternative procedures;
- (2) The radiation protection aspects of the operation should be optimized, keeping the resulting collective doses (including their occupational and public components) as low as is reasonably achievable, economic and social factors being taken into account; and
- (3) The doses to individual members of the public should not reach the appropriate dose limits, now or in the future. In estimating the doses, account must be taken of other practices which might expose the same critical population groups.

In particular, the upper limits to activity release rates from all sources (other than natural sources) when released into an ocean basin with a volume of not less than 10^{17} m³ shall not exceed:

- (a) 10^5 Ci/year for α -emitters but only 10^4 Ci/year for ^{226}Ra and supported ^{210}Po ;
- (b) 10^8 Ci/year for β/γ -emitters with half-lives of at least 0.5 years (excluding tritium and β/γ -emitters of unknown half-lives);
- (c) 10^{12} Ci/year for tritium and β/γ -emitters with half-lives of less than 0.5 years.

No special permit should be issued which would cause these limits to be approached.

B.1.3. It is essential that a general policy of continued isolation and containment of radioactive waste after descent to the sea-bed should be pursued through the use of suitable packaging to minimize to the extent reasonably achievable the radioactivity which might ultimately be released, thereby preventing unnecessary contamination of the marine environment.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY Safety Series No. 9: "Basic Safety Standards for Radiation Protection", 1967 Edition, Vienna, 1967, STI/PUB/147. (This publication is under joint revision by the IAEA, the World Health Organization and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development.)

*B.1.4. The environmental assessment shall include, in addition to the factors specified in Annex III to the Convention, consideration of:

- (1) The justification for the proposed dumping operation when weighed against land-based alternatives, including the respective population dose commitments;
- (2) The total alpha, beta and gamma activities and the activity of any individual nuclide of special significance for the assessment;
- (3) Those factors likely to affect significantly the movement of radioactive materials from the dumping site to the human environment, including the nature of the sea-bed and the physical processes of mixing and transport in the sea at the dumping site;
- (4) Dose commitments to individual members of the public and to the population via critical and other appropriate pathways;
- (5) The risk to marine ecosystems resulting from the release of radioactivity from dumped packages;
- (6) The degree to which it is practical to attempt to reduce dose commitments, either for normal dumping or in case of accidents, by techniques such as having the radioactive material in a relatively insoluble form or within a relatively insoluble matrix, by designing the containment to retain for a period of time radioactive material when it is on the sea-bed, or by selecting an area with characteristics that will facilitate the retention of the radioactive material in the vicinity of the dumping site;
- (7) Operational methods to be used, including arrangements for dealing with accidents and emergencies and methods of verifying their correct execution.

**B.1.5. The IAEA is of the opinion that it is necessary that the reports to be submitted, pursuant to Article VI.4 of the Convention, to the Inter-Governmental Maritime Consultative Organization (IMCO) include this environmental assessment in relation to an individual application for a special permit for dumping.

B.2. Monitoring and Assessment

B.2.1. In the context of dumping carried out in accordance with the Convention, the following requirements shall be met:

- (1) Determination by measurement or estimation of the nature and quantities of radioactive waste or other radioactive material to be dumped; and
- (2) Monitoring, to the extent feasible and meaningful, of the condition of the seas with respect to dumped radioactive wastes in the vicinity of the dumping site, taking into full account the relevant guidance as provided for in the IAEA Safety Series No. 5 [3] and the ICRP Publication 7 [4].

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Series No. 5, "Radioactive Waste Disposal into the Sea", Vienna, 1961, STI/PUB/14.

[4] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, "Principles of Environmental Monitoring related to the Handling of Radioactive Materials", A Report by Committee 4, ICRP Publication 7, 1965.

* Formerly B.1.2 in the previous Document.

** Formerly B.1.3, ibidem.

B.3. Environmental Evaluation of Total Dumping

B.3.1. In addition to the environmental assessment in relation to an individual application for a special permit for dumping, the appropriate national authorities shall take the following factors into account in determining whether each proposed dumping operation is acceptable:

- (1) Periodic reviews of the total dumping which has been carried out under permits issued by them;
- (2) Dumping which has been reported pursuant to the Convention as having been carried out by other States; and
- (3) Prospective dumping which may reasonably be expected.

This evaluation will be facilitated through the establishment of regional agreements and other appropriate forms of international co-operation.

C. THE RECOMMENDED DETAILED BASIS FOR OPERATIONAL CONTROL OF DUMPING OF WASTE

C.1. General Requirements Governing Operational Control of Dumping of Waste

C.1.1. The dumping of liquid or unpackaged radioactive waste into surface and shallow waters should not be authorized until such time as the IAEA formulates appropriate recommendations governing such dumping. The direct dumping of unpackaged liquid radioactive waste into the deep sea shall be prohibited since such waste would not be sufficiently dense or immiscible with sea-water to descend to and remain on the sea-bed. The dumping of packaged liquid radioactive waste into the deep sea is specifically excluded pursuant to Section C.3.2.2. Solid radioactive wastes where the radioactivity is intrinsically contained in a relatively insoluble matrix and which can be shown not to disperse before reaching the sea-bed, do not require packaging and can be dumped in the deep sea under the same requirements as for packaged solid waste.

C.1.2. In order to make an assessment for the Definition of material which is unsuitable for dumping, a model was developed based on a calculated upper limit to radioactivity-release rates from all sources. For operational control these calculated values were expressed as activity per unit-gross mass in tonnes based upon an assumed dumping rate of 100 000 tonnes per year at any site. This assumed rate of dumping should not be interpreted as implying that such a rate will be reached or as encouraging such a rate. It would be prudent for the appropriate national authorities to authorize dumping at the lowest rate which is reasonably practicable, having regard to the development of applications of nuclear energy.

C.1.3. The dumping operation must be subject to strict control. A number of factors have to be taken into consideration. They concern, in particular, the conditioning and packaging of the waste in order to ensure safe transport and handling, and minimization of the risk of accidental recovery of containers after disposal. This is covered by operational measures dealing with the choice of a suitable dumping site, the design and construction of waste containers, the choice of an appropriate ship able to dispose of the waste at the given dumping site, provisions for radiation protection of the crew, and an adequate supervision of the dumping operations by competent escorting officers. All these operational requirements shall, therefore, be included in the special permits issued by the appropriate national authorities in accordance with the Convention.

C.2. Requirements for Selection of a Dumping Site

C.2.1. In addition to the factors specified in Annex III to the Convention, the following requirements shall be met by the appropriate national authorities in the selection of a site for the dumping of packaged waste:

- (1) The chance of recovering the waste by processes such as trawling shall be minimized;
- (2) Dumping shall be restricted to those areas of the oceans between latitudes 50°N and 50°S. The area shall have an average water depth greater than 4000 metres. Recognizing that variations in sea-bed topography do exist, this restriction should not be interpreted to exclude those sites within which there are localized areas with water depths of 3600 metres;
- (3) Sites should be located clear of continental margins and open sea islands, and not in marginal or inland seas. Nor should they be situated in known areas of natural phenomena, for example volcanic activity, that would make the site unsuitable for dumping;
- (4) The area must be free from known undersea cables currently in use;
- (5) Areas shall be avoided that have potential sea-bed resources which may be exploited either directly by mining or by the harvest of marine products, or indirectly (e.g. spawning) as feeding grounds for marine organisms important to man;
- (6) The number of dumping sites shall be strictly limited; and
- (7) The area must be suitable for the convenient conduct of the dumping operation and so far as possible shall be chosen to avoid the risk of collision with other traffic during manoeuvring and undue navigational difficulties. The area chosen should preferably be one covered by electronic navigational aids.

C.2.2. The dumping site shall be defined by precise co-ordinates. In order to ensure a reasonable operational flexibility, it should have an area as small as practicable, but no larger than 10⁴ square kilometres.

C.3. Special Requirements for Packages for Dumping

C.3.1. General

C.3.1.1. In addition to the provisions of Article IV of the Convention, the following requirements for conditioning, handling, transport and immersion shall be met.

C.3.2. Conditioning of Waste

C.3.2.1. Waste in the package shall be either solid, solidified or absorbed in a solid substrate.

C.3.2.2. Waste in liquid form shall be excluded, because its rise to the surface cannot be precluded. Small quantities of liquids such as tritiated water may, however, be absorbed in a material of good absorption capacity. Containers of such absorbed liquids shall be mounted within a second enclosure of an appropriate design.

C.3.3. Handling and Transport

C.3.3.1. The relevant provisions of the IAEA Transport Regulations [5] shall be complied with, together with any applicable national and international transport regulations for dangerous goods. In particular, the packages shall be designed to ensure adequate containment of the waste during handling and transport until the end of the dumping operations.

C.3.4. Immersion

C.3.4.1. The packages shall be designed to ensure that the contents are retained within them during descent to the sea-bed. To achieve this, the following requirements shall be met:

- (1) The package shall have an overall specific gravity of not less than 1.2 to ensure sinking to the sea-bed to a depth greater than 4000 metres;
- (2) The design shall be such that any inner container will remain on the sea-bed;
- (3) The container shall be made sufficiently strong or pliable to remain intact and retain its contents under the pressure encountered during descent to the sea-bed, or be equipped with a pressure equalization system which relieves the stress on the container; and
- (4) Buoyant material shall be excluded unless it is treated or packaged so as either to preclude the return of such material to surface waters or to ensure that, on its return, it will not constitute a radiation hazard nor interfere materially with fishing, navigation or other legitimate uses of the sea.

C.4. Approval of the Ship and its Equipment

C.4.1. Certain special requirements are necessary for ships engaged in the dumping of packaged radioactive wastes. These requirements are set out below:

- (1) The ship shall be capable of safely carrying the approved [6] consignment to the designated dumping site;
- (2) The ship shall be provided with the appropriate navigational and communication equipment suitable for use in the particular dumping area which shall be operable during the dumping operations;
- (3) An adequate supply of dunnage and equipment shall be provided to ensure that the containers can be suitably stowed;
- (4) The ship shall be provided with suitable handling gear, including gear to recover any debris which does not sink, which shall be functional during dumping operations;
- (5) Provisions for decontaminating the holds and bilges shall be available; and

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Series No. 6, "Regulations for the Safe Transport of Radioactive Materials - 1973 Revised Edition", Vienna, 1973, STI/PUB/323; and INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Series No. 37, "Advisory Material for the Application of the IAEA Transport Regulations", Vienna, 1973, STI/PUB/324.

[6] Throughout Sections C.4, C.5 and C.6 the term 'approved' means approved by the appropriate national authorities within the meaning of the Convention.

- (6) The ship shall be available for inspection by the appropriate national authorities before an approved dumping operation is carried out and thereafter as necessary.

C.5. Escorting Officers

C.5.1. General

C.5.1.1. The dumping operation shall be supervised by approved escorting officers representing the national authorities granting the dumping permits. Their duties and responsibilities, powers and qualifications are separately specified in Sections C.5.2.1, C.5.3.1 and C.5.4.1 below.

C.5.2. Duties and Responsibilities

C.5.2.1. The escorting officer shall have the following duties and responsibilities:

- (1) He must ensure that the holder of the special permit complies with the requirements and conditions specified therein;
- (2) In the execution of his duties he shall pay special attention to the following items:
 - (a) He must ensure that he is provided with a certified copy of the special permit with respect to each dumping operation. He must ensure that he is provided in advance with sufficient information about all containers and their contents to enable him to act appropriately in an emergency;
 - (b) Before loading, he must be satisfied that all containers are:
 - (i) of an approved type and on visual inspection appear sound and not to be leaking;
 - (ii) correctly identified and marked with the gross weight to show a specific gravity not less than 1.2; and
 - (iii) within the radiation and contamination limits laid down by the appropriate national authorities;
 - (c) The escorting officer must ensure that the master of the ship is provided with a loading sheet showing weights and volumes to be dumped;
 - (d) In conjunction with the master, the escorting officer shall ensure that the cargo is safely stowed. The consignment must be stowed and segregated to ensure that the levels of radiation measured at living quarters and regularly occupied working spaces do not expose the crew to doses exceeding those specified by the appropriate national authorities;
 - (e) He is responsible for the radiological safety and the individual dosimetry of all personnel engaged in the operation. For this purpose, he shall ensure that there is an adequate supply of personal dosimeters, protective clothing, monitoring and decontaminating equipment. He shall ensure that the crew is monitored and provided with protective clothing whenever necessary;
 - (f) The daily rate of dumping and the dumping hours must be approved by the escorting officer. Before dumping commences, the escorting officer must obtain from the master an assurance that the ship is at the approved

dumping site and make arrangements for hourly fixes of the ship's position during dumping. He must also witness the dumping of all containers to satisfy himself that the drums and their contents sink;

- (g) He must ensure that monitoring for radioactive contamination occurring on the ship is carried out and arrange for decontamination of the affected areas as necessary. Subject to his ultimate responsibility for the safety of the ship, the master must comply with any directions given by the escorting officer in this connection; and
- (h) When the dumping operation is completed and after completion of any necessary decontamination, the escorting officer must provide the master with a Clearance Certificate of an approved type. He must also prepare, for the appropriate national authorities, a Certificate of Disposal confirming that the recorded cargo has been dumped at the designated site, with details of how the ship's position was fixed. This shall be accompanied by a certified copy of the ship's log for the duration of the voyage, including details of hourly fixes of the ship's position during the dumping period.

C.5.3. Powers

C.5.3.1. Without prejudice to the master's overall responsibility for the safety and control of the ship and the crew:

- (1) The escorting officer must be empowered to refuse the loading or dumping of any container which, in his opinion, does not conform with the standards of packaging or have the documentation required by the special permit;
- (2) He must be empowered to stop the dumping operation at any time if, in his judgement, the requirements for the operation cannot be met or the safety of the operation cannot be guaranteed;
- (3) He must be empowered to prescribe, through the ship's officers or port officials, any protective measures which in his opinion are necessary for the radiological safety of the personnel engaged in the operation; and
- (4) Subject to the requirements of the appropriate national authorities, he must be empowered to require that the ship or any part of it may not be used for other cargoes except in accordance with the terms of a Contamination Clearance Certificate.

C.5.4. Qualification

C.5.4.1. To fulfil these responsibilities and to exercise these powers, the escorting officer:

- (1) must be adequately trained in the basic principles of radiation protection and must know how to use monitoring equipment and interpret the readings;
- (2) must be fully conversant with the design and construction of all approved types of container and, if possible, should have practical experience of the problems involved in handling them;
- (3) should have supervisory and organizing experience.

C.6. Record Keeping

C.6.1. Approved records of the nature and quantities of all matters permitted to be dumped, and the location, time and method of dumping shall be kept and reported to IMCO and to other parties as appropriate, in accordance with Article VI.1(c) and 4 of the Convention.

C.7. International Co-operation and Observation

C.7.1. Dumping should preferably be carried out within the framework of regional co-operation agreements as provided for by Article VIII of the Convention.

C.7.2. International co-operation in the selection of dumping sites should be encouraged.

C.7.3. In order to further the objectives and provisions of the Convention, the IAEA is of the opinion that the Parties to the Convention, IMCO, and the appropriate national authorities should provide for international or multilateral observation of loading and disposal at sea of radioactive waste or other radioactive matter to satisfy themselves that these operations are carried out in accordance with the Convention and with the Definition and Recommendations set out in this Document.

ANNEX

I. INTRODUCTION

1.1. The London Dumping Convention of 1972

1.1.1. The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter[1] was adopted by an Intergovernmental Conference which met in London from 30 October to 13 November 1972, at the invitation of the Government of the United Kingdom of Great Britain and Northern Ireland. The Convention was opened for signature by any State at London, Mexico City, Moscow and Washington from 29 December 1972 until 31 December 1973 and thereafter for accession by any State. After the entry into force of the Convention on 30 August 1975, a meeting of the Contracting Parties to decide on organizational matters, held in London from 17 to 19 December 1975, designated the Inter-Governmental Maritime Consultative Organization (IMCO) as the Organization responsible for Secretariat duties in relation to the Convention. The Convention provides for control of "any deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea" and any deliberate disposal of such vessels, aircraft, etc. themselves. The prevention of marine pollution emanating from the normal operations of vessels, aircraft, etc. or directly arising from the exploration and exploitation of sea-bed mineral resources is excluded from the scope of the Convention (Article III. 1).

1.1.2. With respect to radioactive materials, the Convention entrusts the IAEA with specific responsibilities in the following provisions pursuant to Article IV:

(1) In Annex I on materials prohibited from dumping, item 6 states:

"High-level radioactive wastes or other high-level radioactive matter, defined on public health, biological or other grounds, by the competent international body in this field, at present the International Atomic Energy Agency, as unsuitable for dumping at sea";

(2) In Annex II on materials requiring special care in dumping procedures, item D states:

"Radioactive wastes or other radioactive matter not included in Annex I. In the issue of permits for the dumping of this matter, the Contracting Parties should take full account of the recommendations of the competent international body in this field, at present the International Atomic Energy Agency".

1.1.3. Article IV. 1 of the Convention makes a distinction between materials that may be dumped after the issue of a general permit and those that may be dumped only after the issue of a special permit. Annex II puts "radioactive wastes or other radioactive matter" into the class requiring special permits without, however, defining such radioactive wastes or matter.

1.1.4. Article IV. 3 of the Convention provides that no provision thereof is to be interpreted as preventing a Contracting Party from prohibiting, in so far as that Party is concerned, the dumping of wastes or other matter not listed in Annex I. Further, the content of the Annexes to the Convention will be kept under review by consultative meetings of the Contracting Parties, which will be convened not less frequently than once every two years, or by special meetings which may be convened at any time on the

[1] Reproduced in IAEA Document INFCIRC/205.

request of two thirds of the Parties, pursuant to Article XIV. 3(a), 4(a) and 4(b) of the Convention. Amendments to the Annexes, which will be based on scientific and technical considerations, are subject to a simplified procedure as compared with amendments to the basic provisions of the Convention (Article XV. 2).

1. 1. 5. Further, Article IV. 2 of the Convention provides that all the factors specified in Annex III thereto should be given careful consideration prior to the issue of any permit, including prior studies of the characteristics of the dumping sites as set forth in Sections B and C of that Annex.

1. 2. Purpose of this Annex

1. 2. 1. This Annex provides background material pertinent to the specific responsibilities entrusted to the IAEA under the Convention, namely to define "high-level radioactive wastes or other high-level radioactive matter . . . unsuitable for dumping at sea" and to ensure that any dumping of radioactive matter into the sea involves no unacceptable degree of hazard to man and his environment. It provides information on the way the IAEA arrived at the revised Definition and outlines the thinking behind the Recommendations which are set out rather formally and without elaboration in the Definition and Recommendations.

II. BACKGROUND INFORMATION

2. 1. Radiation Protection Principles to be applied to Waste Management

2. 1. 1. The rapid development and increasing use of nuclear energy for peaceful purposes and the expanding application of radioisotopes in various fields of science, medicine and technology are unavoidably associated with the production of growing amounts of radioactive wastes. The basic principle to be applied in the management of radioactive wastes is to protect man and other sensitive elements of the biosphere from undue exposure to ionizing radiation emanating from these wastes.

2. 1. 2. In selecting an appropriate waste management system it should be verified that natural resources are protected and that any reduction of amenities is acceptably low. Man is dependent upon the land and the sea, and both must be protected.

2. 1. 3. A balance has to be achieved between the need to find suitable storage or disposal methods, the radiation protection of workers and members of the public, and the overall cost involved. The justification for dumping radioactive wastes must be viewed in this light.

2. 1. 4. The most recent applicable recommendations by the International Commission on Radiological Protection (ICRP) should be used as a guide in this area.

2. 2. Sources of Radioactivity in the Sea

2. 2. 1. Radioactive wastes may enter the sea through one of the following major routes, by:

- (1) Direct dumping of the wastes into the seas and oceans;
- (2) Discharge to river systems;
- (3) Discharge to tidal estuaries;
- (4) Discharge to coastal waters;
- (5) Discharge from nuclear-powered ships; and
- (6) Deposition from the atmosphere.

2.2.2. Some solid wastes have been dumped in packaged form in the depths of the sea. This form of disposal has been limited to materials with low radioactivity content. For example, during the 1967-1977 period a total of about 51 600 tonnes of packaged solid radioactive waste, containing about 5900 curies of α -emitters, about 190 000 curies of β/γ -emitters and, additionally, about 183 000 curies of tritium has been dumped in the north-east Atlantic Ocean. The annual amounts dumped during that period, expressed as fractions of the limiting release rates implied in the Definition, never exceeded

1% for α -emitters

1% for β/γ -emitters with half-lives of at least 0.5 years (excluding tritium)

10^{-4} % for tritium

and only twice approached 10% of the assumed upper limit to the mass dumping rate.

2.2.3. Unlike many of the stresses presently confronting man, radiation and radioactivity have always been a part of man's environment. Studies by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) show that the present doses to humans of naturally occurring radiation lie generally in the range of 100 mrem/yr to 300 mrem/yr with doses in a few areas exceeding 1000 mrem/yr. The main contributions to this exposure are radioactive materials in the earth's crust, cosmic radiation and natural radioactivity in the human body (mainly ^{40}K).

2.2.4. The marine environment contains a wide range of natural radionuclides, mainly ^{40}K , ^{87}Rb , members of the uranium and thorium series, and ^{14}C and ^3H . The total activity in all of the sea (mainly ^{40}K) amounts to rather more than 300 Ci/km³ or nearly 500 000 MCi in total. Radium alone accounts for more than 1000 MCi. The doses to marine organisms are usually of the order of 10 mrad/yr to 100 mrad/yr.

2.2.5. Though the total naturally occurring radioactive content of the sea is very large, this does not provide a sure basis for determining what quantities of radioactivity may be added in local areas without leading to unacceptable additional exposures to man or the marine environment. Though such additions may be relatively small in quantity, the hazards associated with localized releases of wastes must be assessed and considerable care exercised, as contemplated by the Convention, in disposing of any radioactive wastes into the marine environment.

2.2.6. Man has been dealing with radioactive materials in artificially concentrated or artificially produced forms for nearly three quarters of a century and has been generating electrical power from nuclear fission for over a decade. Man has also released radioactive material as the result of several series of nuclear explosions.

2.2.7. These operations have all resulted in some radionuclides being released into the environment, including the sea. Apart from short-lived radionuclides close to the scene of nuclear explosions, the quantities released to the sea so far amount to some hundreds of megacuries from explosions and a few megacuries from nuclear operations. To date, civilian nuclear power programmes have accounted for only a small fraction of these latter releases. These quantities amount to less than one thousandth (10^{-3}) of the natural activity in the sea. This fraction gives an indication of the relative magnitudes, but no such simple comparison of activities can indicate the relative biological importance of the different radionuclides. They have very widely ranging toxicities, and their significance in a given environment depends not only on this fact but also on their distribution and on the uses made of that environment.

2.3. Basis of the Definition (High-Level Radioactive Wastes or Other High-Level Radioactive Matter Unsuitable for Dumping at Sea)

2.3.1. The Definition[2] identifies material, the radioactive content of which is at such a level that the Parties to the Convention would wish to prevent any participating State from issuing a special permit even after a detailed appraisal of the safety of the proposed operation, and even for the sector of the marine environment furthest removed from man, i. e. the deep sea with depth greater than 4000 metres. The Definition also covers those wastes which have relatively high concentrations of radioactivity and have been generally recognized by the appropriate national authorities as being unsuitable for dumping, for example the "first cycle wastes" from nuclear reprocessing, irradiated fuel and irradiated fuel cladding. The Definition must not be so permissive that regular and repeated operations somewhat below the defined levels would endanger man or his environment, even though each individual operation had been conducted with appropriate care. The Definition has, therefore, been based on the concept of the limiting capacity of the deep oceans to receive radioactive waste, which capacity is based on the annual input of radioactivity which will result in individual dose commitments via the critical pathways equal to the dose limits for individual members of the public recommended by the ICRP.*

2.3.2. The limiting capacity of the oceans to receive radioactive waste has been extensively reviewed by a series of Consultants' Meetings and Advisory Group Meetings convened by the IAEA during 1976-1978.

2.3.2.1. The IAEA convened two Consultants' Meetings to review the Oceanographic Basis of the Provisional Definition and Recommendations: one at the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA, in December 1976, and the other at the Fisheries Laboratory, Lowestoft, United Kingdom, in February 1977. A Working Paper prepared by the two Consultants' Meetings was used as a basis for discussions at an Advisory Group Meeting, which was held at IAEA Headquarters, Vienna, in March 1977, to review the oceanographic basis. The meeting was attended by 25 experts from 12 countries and 4 international organizations.

2.3.2.2. In keeping with the recommendations of the Advisory Group on the Oceanographic Basis, the IAEA convened in June 1977 a Consultants' Meeting to review the radiological basis, at IMCO Headquarters, London. The consultants considered the conclusions and recommendations of the Advisory Group on the Oceanographic Basis as the primary guidelines and also took into account the comments expressed at the First Consultative Meeting of the Contracting Parties to the London Dumping Convention[3], which was held at IMCO Headquarters, London, from 20 to 24 September 1976.

2.3.2.3. The conclusions of these meetings, which were laid down in two reports[4], [5], were further reviewed by an Advisory Group Meeting, held in Vienna in March 1978. This meeting was attended by 42 experts from 24 countries and 3 international organizations.

[2] The IAEA Provisional Definition and Recommendations have been reproduced in document INFCIRC/205/Add.1.

[3] See Report of the First Consultative Meeting, IMCO, LDC/I/16, paragraph 49.

[4] Report of the Advisory Group Meeting to Review the Oceanographic Basis of the Provisional Definition and Recommendations for the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. Technical document IAEA-210 (1978).

[5] Report of the Consultants' Meeting to Review the Radiological Basis of the Provisional Definition and Recommendations for the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. Technical document IAEA-211 (1978).

* Following sentence in the previous Document has been deleted.

A summary of the conclusions concerning the oceanographic basis, the radiological assessment, and the implications for the Definition and Recommendations required by the London Dumping Convention is given below.

2.3.3. The present knowledge of oceanic processes is insufficient for the construction of a single comprehensive model to describe the movement of radionuclides released on the ocean bottom through the marine environment. Limiting calculations have thus been made separately for the long- and short-term transports of radionuclides in the ocean. These calculations have been made assuming a continuous release of radionuclides from the deep ocean over periods as long as 40 000 years which is commensurate with the half-life of ^{239}Pu .

2.3.3.1. The physical processes which could transport material in the short term from the deep sea to where interactions would occur with man's food chain on the time scale of months to years are not well understood. On the basis of two calculations which have been made for different possible mechanisms, it is recommended however that, for the continuous release of 1 Ci/yr from a single deep-sea dumping site, the water concentration at the place of interaction with man's food chain be taken to be 10^{-6} Ci/m³ and that site specific calculations only be used if they result in larger concentrations.

2.3.3.2. For those radionuclides whose half-lives are longer than the mixing time of a finite ocean basin, for example ^{239}Pu , the well-mixed average concentration, including decay, provides a more reliable estimate of the water concentration than that given above for short-term processes. For these long-lived radionuclides, this finite basin concentration is greater than that specified above for the short-term processes and determines both the permissible release rate from a single site and from all sites in an ocean basin.

2.3.3.3. At intermediate time scales, especially for those radionuclides with half-lives similar to such time scales, oceanographic modelling of the transport of radionuclides is perhaps the most difficult. For these time scales it has been considered reasonable, however, for releases from a single site to use the concentrations given above for short-term processes since it is unlikely intermediate time scale processes could lead to larger concentrations.

2.3.3.4. For the estimation of the total permissible release rate in a finite ocean basin from all sites a model by Shepherd (1976)[6] has been recommended for all time scales. This model gives the correct long-term finite basin well-mixed average concentration and is taken to have some validity at intermediate and short time scales. The isolation of man and his food chain from bottom water cannot be guaranteed due to biological pathways short circuiting the physical transport of radioactivity. Bottom water concentrations must therefore be limited to levels which will be acceptable in surface waters. For the hazard assessment the water concentration used in all cases is the bottom water concentration calculated from the Shepherd model using a vertical diffusion coefficient of 1 cm²/yr.

2.3.3.5. In general, the long-term large-scale processes lead to a release rate limit from all sites in a basin, whereas short-term small-scale processes lead to a limit which applies to a single-site only. The single-site release rate is more restrictive for short-lived radionuclides and in this case partitioning of wastes between sites can increase the overall limit for the basin as a whole. For long-lived radionuclides, the long-term basin release rate is more restrictive and partitioning of wastes between sites does not affect the limit for the basin as a whole. Indeed, in this case, it is clear that the input of radionuclides into the basin from all sources, including those from other than the dumping of radioactive wastes, must be included in any assessment of the release rate limit.

[6] Shepherd, J.G. (1976), "A simple model for the dispersion of radioactive wastes dumped on the deep sea bed", Ministry of Agriculture, Food and Fisheries, UK, Fisheries Research Technical Report, No. 29.

2.3.3.6. Partition of radionuclides between water and sediment will result in reduced concentrations in a particular medium. In the hazard assessment no allowance was made for the removal of radionuclides to one pathway when considering the other.

2.3.3.7. Since estimates made of the transfer through the water column from a dump site were principally based on knowledge of processes in the large-scale anticyclonic oceanic gyres, they are not applicable to marginal seas or to the poleward side of the major oceanic gyres where deep convection or regions of low stability may result in more intense exchanges.

2.3.3.8. Keeping in mind both our present level of understanding of oceanic processes and the attempt at generality in the oceanographic basis, it is concluded that, for the continuous release of radionuclides in the deep ocean, the initial concentration at the source is unlikely to be important in determining the hazard to man; for long-lived radionuclides, calculated release rates must be interpreted as those arising from all sources in an ocean basin, whether these sources arise from dumping operations or other activities; and, finally, that future knowledge could result in estimates of release rates being revised either upward or downward.

2.3.4. In the radiological assessment, release rate limits were derived for individual nuclides using the oceanographic basis as described in 2.3.3 and postulating a number of representative pathways by which man might become exposed to radiation after release of radionuclides on the sea bed, resulting from dumping operations.

2.3.4.1. Pathways leading to exposure of man were selected to include some which are known to exist and some which may become important in the future. While the selected pathways are generalized representations they are thought to provide reasonable estimates of the maximum rates of transfer of radioactivity to man by a variety of mechanisms. It was intended that the parameters selected for the pathways should be sufficiently general to cover population groups which could become critical in various areas in the world. It is not necessarily the case that unforeseen pathways will involve significant changes; it is probable that they will be covered in the essentials of one of the selected pathways. The assessment evaluated each pathway independently; however, where it appeared likely that members of one critical group could also become members of another critical group the calculated limits have been reduced accordingly. Twelve pathways were selected, five of which involve the consumption of sea food. The latter pathways are not intended to represent particular species but examples of general fishery resource pathways. The consumption rates used in this assessment are not actual rates but reflect assumed maximum rates. In four pathways the exposure of beach dwellers was considered. Since critical groups of this type are likely to be exposed to all four pathways, a combined limit was calculated. Three additional pathways covering miscellaneous practices such as bathing, the use of desalinated sea-water as drinking water and the use of sea salt for domestic needs were considered and combined.

2.3.4.2. The release rate limits derived for the various pathways were based on the ICRP dose limits for individual members of the public. The philosophy underlying the procedure and the use of critical groups is presented in ICRP publications. It should be stressed that ICRP dose limits provide a lower boundary of an unacceptable range of values. Values above the ICRP limits are specifically to be avoided while values up to the limit are not automatically permitted. The ICRP limits should be considered as constraints for optimization procedures, which usually would result in radiation doses much lower than the dose limits. On the other hand, the dose limits are not thresholds above which undesirable effects begin to appear, but represent dose values corresponding to individual risks approaching unacceptable levels.

2.3.4.3. The maximum permissible annual intakes (MPAI) corresponding to the dose limits were taken from the IAEA Basic Safety Standards for Radiation Protection[7]. Pathways that included the ingestion of radionuclides which were transported through sea-water were based on MPAIs for soluble forms of the particular radionuclide. In the case of inhalation, the most restrictive MPAIs have been used. The concentration factors used for each radionuclide in this assessment were obtained from a number of publications. Where factors were not available for certain elements or the potential pathways could not be specifically identified, for example, deep ocean living cephalopods, comparable values based on similar chemical elements or species with similar behaviour were assumed.

2.3.4.4. In the selection of radionuclides for the assessment, consideration was given to those that were expected to occur in wastes likely to be dumped at sea, including fission products, activation products and actinides with half-lives of more than a few days. The selection included some radionuclides which would not normally arise in wastes from the nuclear fuel cycle but which might arise from other sources.

2.3.4.5. It should be noted that since the objective of the radiological assessment was to derive release rate limits, and since these by definition are related directly to the ICRP dose limits, assessment of collective doses or collective dose commitments was not done. This assessment would be appropriate for the optimization procedures recommended by ICRP[8] and is a requirement when granting a special permit for dumping of radioactive waste (see B. 1.2 of the Recommendations).

2.3.4.6. The permissible damage to the marine ecosystems due to dumping operations was considered and it was concluded that the radiation doses arising as a result of releases within the limits of the Definition are not expected to lead to significant adverse effects to populations as a whole.

2.3.5. Release rate limits were derived for individual radionuclides. For the sake of administrative convenience and analytical simplicity the radionuclides were grouped into three categories according to the basic properties of decay type and half-life. The groupings and the appropriate release rate limits are:

Group	Release Rate Limits (Ci/year)	
	Single-site	Finite Ocean Volume (10^{17} m^3)
α -emitters, but limited to 10^4 Ci/yr for ^{226}Ra and supported ^{210}Po	10^5	10^5
β/γ -emitters with half-lives of at least 0.5 years (excluding tritium) and β/γ -emitters of unknown half-lives	10^7	10^8
Tritium, and β/γ -emitters with half-lives less than 0.5 years	10^{11}	10^{12}

[7] INTERNATIONAL ATOMIC ENERGY AGENCY Safety Series No. 9: "Basic Safety Standards for Radiation Protection", 1967 Edition, Vienna, 1967, STI/PUB/147. (This publication is under joint revision by the IAEA, the World Health Organization and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development.)

[8] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Publication 26: Recommendations of the International Commission on Radiological Protection, Pergamon Press 1977.

The release rate limits represent the limit of the most restrictive radionuclide in the particular group with two exceptions. It was concluded, however, that these exceptions could be included in their natural place in the grouping, either because the calculations are considered quite conservative because of unrealistic assumptions or because the relative amounts compared to other radionuclides of importance are known to be small. [5]

2.3.6. In the Provisional Definition and Recommendations two explicit safety factors of 10^2 were applied to the calculated release rate limits to allow for:

- (a) The possible presence of more than one dumping site; and
- (b) The fact that certain areas of the ocean may have characteristics less favourable than those assumed in the assessment.

2.3.6.1. In the present assessment explicit account has been taken of the possibility of multiple-sites by preparing estimates both for single-sites and for a finite ocean volume. [4] The oceanographic basis has also been constructed to take account of possible extreme events in ocean areas so that the model is insensitive to detailed parameter values in any particular ocean area. It is therefore not appropriate to apply safety factors for the same reasons to the present assessment.

2.3.6.2. A review of the way in which the assessment was made reveals that where specific data were not available conservative assumptions were used in the calculations and this could result in a substantial safety factor[5]. Its numerical value depends on the particular radionuclide and set of circumstances and can neither be determined precisely nor be guaranteed. Certain important considerations, such as exposure of the critical group from more than one pathway or radionuclide and the possible existence of unforeseen pathways from the deep ocean to man, were taken into account. There was an attempt at all stages to make the results of the assessment as general as possible. Therefore, the release rates given above were adopted without modification as being the best possible estimates which can be made for them at the present time.

2.3.7. To meet the objectives of the Convention it is necessary to express the Definition in terms of a concentration (radioactivity per unit mass). The revised definition has therefore been based on the release rate limits for a single-site and an assumed upper limit on mass dumping rate at a single-site of 100 000 tonnes/year. This leads directly to the concentration limits given below:

- (a) 1 Ci/t for α -emitters but limited to 10^{-1} Ci/t for ^{226}Ra and supported ^{210}Po ;
- (b) 10^2 Ci/t for β/γ -emitters with half-lives of at least 0.5 years (excluding tritium) and mixtures of β/γ -emitters of unknown half-lives;
- (c) 10^6 Ci/t for tritium and β/γ -emitters with half-lives less than 0.5 years.

2.3.8. The assumption of 100 000 tonnes/year is arbitrary and the radiological hazards would not be materially altered if the concentration figures were to be revised upward (or downward) provided the release rate limits are observed.

2.3.9. The necessity to limit releases to finite ocean basins (i. e. effectively to limit the number of sites per ocean basin) has been met by an addition to paragraph B.1.2 of the Recommendations which imposes the release rate limits for a finite ocean volume of 10^{17} m^3 . The Definition and Recommendations have therefore been constructed so that the single-site release rate limits are incorporated via the combination of initial concentration of radioactivity and the mass dumping rate. The finite ocean volume release rate limits are incorporated as part of the Recommendations.

*2.3.10. In practice, it is expected that areas selected for dumping will be specially chosen as having favourable characteristics. This fact, together with the way in which the assessment was made, ensures that man and his environment should be protected if wastes of higher total activity than this are prohibited from dumping. Moreover, other wastes shall only be disposed of at sea in accordance with special permits issued by the appropriate national authorities after ensuring that the proposed dumping operations comply with the radiation protection requirements as in paragraph B.1.2 and after proper assessment of the possible environmental impact.

**2.3.11. The use of these concentration limits would cause the annual limits stated above to be approached only if the rate of dumping at any one site approached 100 000 tonnes per year and if all this material had an activity concentration close to the concentration limits. The assumed annual dumping rate at each site will be reviewed by IMCO and by the IAEA. The appropriateness of the Definition in the light of actual dumping rates will be kept under review by the IAEA.

2.3.12. For operational purposes it is necessary to average the limiting values over a substantial mass of waste. It is recommended that the limiting concentration in the Definition be taken to be the average over a mass not exceeding 1000 tonnes. Expressing the Definition as an activity per unit gross mass averaged over a small fraction of the assumed annual dumping rate should result in keeping the total activity dumped annually below the calculated annual release rate limits.

2.3.13. The Definition must not be taken to imply that material in which the concentration of radioactivity is below that specified in the Definition is thereby deemed to be suitable for dumping. No radioactive material may be dumped except in accordance with the provisions of the Convention, in particular Annexes II and III thereto, and with the Recommendations set out in this Document.

2.3.14. It should be noted that no material is totally devoid of radioactivity. However, it is clearly not the intention of the Convention that every material should be treated as a potential radioactive pollutant and the competent authorities of the Contracting Parties will wish to define some "de minimis" level of specific activity below which a material will not be regarded as "radioactive" for the purposes of the Convention. No such numbers are suggested at this time and some flexibility of interpretation is therefore left to the appropriate national authorities. Although not derived for the purpose of dumping, some guidance may be found in the levels set forth for exemption of radioactive materials from regulatory control in various international and national standards and regulations; such levels are generally within an order of magnitude of 10^{-3} Ci/t.

2.4. Environmental Evaluation of Specific Dumping Applications

2.4.1. The appropriate national authorities may grant a special permit for dumping of radioactive waste only after a detailed environmental and ecological assessment gives a reasonable assurance that such dumping can be accomplished in accordance with the objectives and provisions of the Convention.

2.4.2. At the levels of radioactive materials which may be dumped under the terms of the Definition, the present state of knowledge, cautiously interpreted, should provide a satisfactory basis for environmental assessments. There is a substantial body of relevant scientific literature, including publications of the IAEA (e. g. the Safety Series, the Technical Reports Series and the Symposium Proceedings), ICRP and UNSCEAR. In carrying out these environmental assessments it should not be necessary for the appropriate national authorities to require that detailed field and experimental studies be

* Paragraph 2.3.6 in the previous Document.

** Paragraph 2.3.10, ibidem. Paragraphs 2.3.8 and 2.3.9 in the previous Document were no longer appropriate and have been deleted.

undertaken in every case. Dumping sites provide an opportunity for studying the interactions of radionuclides with deep sea sediments and organisms. The IAEA recommends that these studies be carried out where appropriate and practical to obtain knowledge for future practices and needs.

2.5. Monitoring and Assessment

2.5.1. Article VI.1(c) and (d) of the Convention requires that the appropriate national authorities:

- (1) Keep records of the nature and quantities of all matter permitted to be dumped and the location, time and method of dumping; and
- (2) Monitor individually, or in collaboration with other parties and competent international organizations, the condition of the seas for the purposes of the Convention.

2.5.2. As detailed in the relevant guidance provided by the IAEA publications (particularly IAEA Safety Series No. 5)[9] and ICRP Publication 7[10], the general objectives of environmental monitoring programmes are as follows:

- (1) The assessment of actual or potential exposure of man and other sensitive elements of the biosphere, or estimation of upper limits of such exposure; these assessments or estimations may be needed in relation to regulatory functions;
- (2) Scientific investigations;
- (3) Improved public understanding;
- (4) Conservation of ocean resources.

In the context of dumping carried out in accordance with the Convention and the Recommendations set out in the Document, it is unlikely that exposure assessment objectives could be entirely fulfilled by direct environmental monitoring. The use of other less direct methods (e. g. modelling calculations) could provide more precise estimates. However, environmental monitoring combined with research can provide information testing the validity of present assumptions and help to provide a sound scientific basis for the conservation of ocean resources and for future monitoring operations and an improved technical basis for evaluating future practices. These studies should be carried out.

2.6. Environmental Evaluation of Total Dumping

2.6.1. In addition to evaluating individual applications for permits for dumping, the appropriate national authorities should make periodic reviews of the total dumping which has been carried out under permits issued by them. They should also consider the dumping which has been carried out by other States. Further, they should consider prospective dumping which may reasonably be expected. It is desirable that a comparable international review also be carried out. Such reviews, after considering the past and

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Series No. 5: "Radioactive Waste Disposal into the Sea", Vienna, 1961, STI/PUB/14.

[10] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION: "Principles of Environmental Monitoring related to the Handling of Radioactive Materials", a Report by Committee 4, ICRP Publication 7, 1965.

prospective quantities dumped, their locations, the significant operating experience as reported by escorting officers and the findings of pertinent oceanographic and ecological research, could lead the IAEA to update the Recommendations set out in the Document.

2.6.2. In addition to these reviews the Contracting Parties to the Convention are required by Article VI.4 to report in detail to IMCO the special permits issued and the nature and quantities of all matter permitted to be dumped, together with the location, time and method of dumping. National records are expected to contain all the information necessary for such reporting as well as for the establishment of an international register. The environmental assessment is considered a necessary part of this information.

2.7. General Principles Governing Operational Control of Dumping of Waste

2.7.1. Provisions to be considered in establishing criteria for the issue of permits for dumping are set out in Annex III to the Convention. The general principles for control of dumping of radioactive waste are provided for in the IAEA's Safety Series No. 5[8]. At present, dumping almost always takes place in the deep sea in packages with the waste either solid, solidified or absorbed in a solid substrate. The dumping of radioactive waste into surface and shallow waters from vessels, aircraft, platforms, etc. may also be envisaged under the Convention; this could involve higher exposure to man than dumping into the deep sea. However, such dumping is expected to be rare in practice and, pending the development of data concerning the nature, extent and potential effects of such operations, the IAEA has not yet formulated any specific recommendations for the operational conduct of such disposal. In the opinion of the IAEA, solid or packaged radioactive wastes should not be dumped into shallow waters because of the risk of accidental recovery of the material. The Recommendations are, therefore, limited to deep sea dumping.*

2.7.2. In addition to the movement of the radioactivity through ecosystems, other factors have to be taken into consideration in assessing the acceptability of a proposed dumping operation. They concern, in particular, the conditioning of the waste in order to ensure safe transport and handling and the risk of an accidental recovery of packaged waste after dumping. This is covered by operational measures dealing with the design and construction of waste containers, the required forms of solid wastes (see paragraph 2.9.4.4), the choice of a suitable dumping site, the choice of an appropriate ship able to dispose of the waste in the given dumping site, provisions for radiation protection of the crew and an adequate supervision of the dumping operations by competent escorting officers. All these operational measures should, therefore, be included in the special permits issued by the appropriate national authorities in accordance with the Convention.

2.8. Factors Affecting the Choice of a Dumping Site

2.8.1. In the selection of marine areas to be utilized as dumping sites for packaged wastes, consideration must be given primarily to the factors affecting the safety of man and his environment and secondly to economic considerations.

2.8.2. In general, the first step in an evaluation will involve the selection from a number of possible sites of those apparently most suited for safe disposal of packaged or solid wastes. Among the factors which must be considered in such a site selection are:

- (1) The probability of accidental recovery of packaged or solid waste by man. A site would not be suitable for packaged or solid waste disposal unless it were highly improbable that accidental recovery would occur; the selection of shallow waters for dumping is therefore considered to be unacceptable;

* Following sentence in the previous Document has been deleted.

- (2) The possible utilization of the sea-bed site by man directly in the harvest of marine products, or indirectly in the use made of the area by organisms which are harvested by man for food in adjacent areas;
- (3) The nature of bottom sediments with respect to the uptake of the activity from the water and impact damage to packages;
- (4) Transport by deep-sea currents from the dumping site with particular concern for the shoreward-directed flow;
- (5) Rate of turbulent diffusion in the waters in the vicinity of the dumping site;
- (6) Rate of exchange of waters of the particular marine sub-division containing the dumping site with other sub-divisions of the marine environment.

2.8.3. It is evident that dumping sites must be selected in areas not used for bottom trawling or other types of bottom fishing and which are unsuited for future utilization. Areas crossed by sub-marine cables in current use are likewise undesirable. In general, dumping sites located in the deep sea should be in areas where there is a low rate of exchange of the deep waters with the surface layers and with the waters of any adjacent continental shelf. Thus, sub-marine canyons located on the edge of the continental shelf are generally less suited for dumping sites than the deep waters in the true ocean basins, since the deep waters of the canyons more readily exchange with the waters of the continental shelf. As regions of deep convection exist to the poleward side of the major oceanic gyres, these requirements are best satisfied by the selection of sites in water having depths of 4000 m or more situated between latitudes 50°N and 50°S. Sites should be located clear of continental margins and open sea islands and not in marginal or inland seas. Nor should they be situated in known areas of natural phenomena, for example volcanic activity; that would make such a site unsuitable for dumping.

2.8.4. The importance of the sea and sea bed for resource development in the future can hardly be seen in accurate perspective today. They are likely however to be used on an increasing scale to obtain the mineral and food resources needed by mankind. Before selecting a dumping site studies should therefore be carried out to assess possible future resource development in the area concerned. The conduct of such studies could well be co-ordinated by an appropriate international organization. It would also seem desirable to agree internationally to approved dumping sites. Concern about the future exploitation of the sea would also make it prudent to keep the total number of dumping sites as limited as practicable.

2.9. Special Requirements for Packages for Dumping

2.9.1. General

2.9.1.1. It is essential that packages of radioactive matter permitted to be dumped under the provisions of the Convention meet certain minimal requirements to ensure that the packages may be handled and transported safely and that upon immersion the waste materials reach the sea bed without being released.

2.9.1.2. When dealing with radioactive waste of the levels that may be permitted to be dumped the protection of man and the marine environment does not depend upon the long-term integrity of the packaging. However, packages so designed that their contents are retained during descent to the sea bed will generally remain intact for a period of time after they have reached the bottom. The packages will, however, eventually release some or all of their radioactive contents. When considering whether to issue a special permit for a specific site the appropriate national authorities should ensure that the concentration of radioactivity in the vicinity of the package does not present any unacceptable risk to man or the marine ecosystem.

2.9.1.3. To meet essential packaging requirements the considerations set forth in paragraphs 2.9.2 to 2.9.8.2 below apply.

2.9.2. Conditioning

2.9.2.1. The radioactive waste within the packages should be in a form which, even in the case of containers which may be damaged or corroded, will as far as possible prevent a release and subsequent spreading of the radioactive material; this is particularly important to ensure safe handling and transport. Therefore, it is essential that the radioactive waste permitted to be dumped be in a form either solid, solidified or absorbed on a solid. The waste may be incorporated into a solid packaged matrix such as cement, concrete or bitumen, forming a single block (monolithic design of the package) or packaged separately and assembled in a concrete vessel or a metal drum (multistage design of the overall package). Liquid wastes should be excluded. However, small quantities of liquids such as tritiated water may be absorbed on a material of good absorption capacity and then dumped as packages containing solid substrate.

2.9.3. Transport

2.9.3.1. The transport of radioactive waste should be in accordance with the IAEA Transport Regulations[11] and any other applicable international and national transport regulations, in particular when the radioactive waste has other hazardous characteristics such as explosiveness, inflammability, pyrophoricity, chemical toxicity and corrosiveness. The IAEA Transport Regulations include provisions for special arrangements when the package design or shipment conditions do not comply in all respects with the standard requirements. This system of special arrangements is the one most likely to be used for dealing with the transport of waste for dumping.

2.9.4. Packaging Materials

2.9.4.1. It can be expected that packages containing radioactive waste will be made of dense material and that they will be made strong enough for safe handling. For the purpose of dumping it may be desirable to have the additional quality of some resistance to attack by sea-water.

2.9.4.2. Steel drums are frequently used for forming concrete containers and both the concrete and the steel can be regarded as protective. It is desirable that concrete used in packaging be of good quality and of low porosity if it is intended to resist breakage on impact with the sea bed and to withstand the destructive action of sea-water. It should not be regarded merely as weighting material. When concrete alone is used the thickness of the concrete between the waste and the outer surface should be sufficient to prevent rupture of the package on impact if this is required. Other suitable material can be used to provide the needed weight.

2.9.4.3. Baled radioactive waste which is not provided with a containment system should not be dumped.

2.9.4.4. Some forms of waste material are such that radioactivity is intrinsically well contained within the waste form itself (e. g. a metal matrix in which induced activity is fixed). When it can be shown that wastes in such forms will reach the ocean bed intact without dispersion of their radionuclide contents they should be considered to conform to the requirements for the dumping of packaged solid radioactive waste.

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety Series No. 6: "Regulations for the Safe Transport of Radioactive Materials - 1973 Revised Edition", Vienna, 1973, STI/PUB/323; and INTERNATIONAL ATOMIC ENERGY AGENCY Safety Series No. 37: "Advisory Material for the Application of the IAEA Transport Regulations", Vienna, 1973, STI/PUB/324.

2.9.5. Specific Gravity

2.9.5.1. All packaged solid radioactive waste disposed of into the sea must be sufficiently dense to sink immediately. This condition should not be difficult to meet since the specific gravity of sea-water at sea level does not exceed about 1.03. However, precautions must be taken to see that the contents of a broken package will not rise to the surface. It is expected that light materials, such as cloth and paper, would be incorporated into concrete within the outer protective containment system, and the overall specific gravity of all packages disposed of in deep waters would not be less than 1.2. Packages and their contents should be sufficiently dense to ensure that they are not readily moved along the sea bed by currents. Should inner containers be incorporated into the principal container the design must be such that they will remain on the sea bed.

2.9.6. Voids

2.9.6.1. If a package containing voids or compressible materials is dumped in deep water it will collapse due to the hydrostatic pressure unless there is provision for equalizing the pressure between interior and exterior, or the container is made sufficiently strong or pliable to retain its contents under the pressure encountered during descent to the sea bed.

2.9.7. Strength against Impact

2.9.7.1. Packaged wastes will suffer impact at the surface of the sea and again when they hit the bottom. Designers should take this into account.

2.9.8. Contents

2.9.8.1. Material in the package should comply with the relevant criteria and conditions set forth in the Annexes to the Convention.

2.9.8.2. The package should exclude buoyant material unless it is treated or packaged so as either to preclude the return of such material to surface waters or to ensure that, on its return, it will not constitute a radiation hazard nor interfere materially with fishing, navigation or other legitimate uses of the sea. Among the materials which might thus be disposed of polyethylene is one of the few which are permanently buoyant and which thus present a special risk of return to the surface, especially when used in the form of closed bottles. The presence of polyethylene in containers for dumping would be acceptable only in the following cases:

- (a) When thin polyethylene sheeting is used to protect the inside surface of the containers against corrosion;
- (b) When the material is processed, for example by shredding, granulating, or cutting into small fragments; and
- (c) Where it can be guaranteed that the specific gravity of an inner polyethylene container and its contents is not less than 1.2, provided the contents have been solidified by an acceptable method (e. g. with cement).

2.10. International Co-operation and Observation

2.10.1. The IAEA welcomes the undertaking provided for by Article VIII of the Convention with respect to the conclusion of regional agreements for the prevention of pollution, especially by dumping. This seems particularly necessary in considering environmental monitoring and the need for the appropriate national authorities to be aware of the sites used and the quantities disposed of in the dumping carried out by other States, as discussed in paragraph 2.6.1 above.

2.10.2. International co-operation in the selection of dumping sites and international observation of dumping operations have been suggested. International or multilateral observation is considered desirable to establish to the satisfaction of all parties concerned that dumping involving radioactive materials is carried out in accordance with the requirements of the Convention and the Definition and Recommendations of the IAEA. For instance, such observation is provided for under the Multilateral Consultation and Surveillance Mechanism for Sea Dumping of Radioactive Waste, established within the framework of the Organisation for Economic Co-operation and Development on 22 July 1977.