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SAFETY CONSIDERATIONS IN THE USE OF PORTS AND APPROACHES BY NUCLEAR MERCHANT SHIPS

PUBLISHED ON BEHALF OF THE INTERNATIONAL ATOMIC ENERGY AGENCY AND THE INTER-GOVERNMENTAL MARITIME CONSULTATIVE ORGANIZATION

INTERNATIONAL ATOMIC ENERGY AGENCY
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SAFETY CONSIDERATIONS IN THE USE OF PORTS AND APPROACHES BY NUCLEAR MERCHANT SHIPS
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ABSTRACT. Report, published on behalf of the IAEA and the Inter-Governmental Maritime Consultative Organization, of a panel of experts convened by the IAEA. The report is the outcome of the last two meetings held in Vienna on 9-13 May 1966 and 18-22 March 1968, at which representatives of four international organizations were also present. The purpose of this publication is to provide guidance to Governments and Port Authorities on the various procedures and precautionary measures that may be employed when nuclear merchant ships use ports and approaches.


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THIS REPORT IS ALSO PUBLISHED IN FRENCH
FOREWORD

In 1961, when the Agency convened the first meeting on the Safety Considerations in the Use of Ports and Approaches by Nuclear Merchant Ships, the only nuclear ship on the high seas was the USSR icebreaker "Lenin"; since then the United States N.S. "Savannah" has been commissioned and has visited many ports. The "Otto Hahn" of the Federal Republic of Germany has now been launched and several other countries have plans for nuclear ships.

The purpose of this publication is to provide guidance to Governments and Port Authorities on the various procedures and precautionary measures that may be employed when nuclear merchant ships use ports and approaches. The problem is basically that of siting a nuclear reactor in a populated area, with the extra factor of mobility. Added to this is the fact that the safety standards of the nuclear ship may be those of a country other than that of the port of entry. Thus the problem must be solved in international agreements.

The guide is the outcome of the last two meetings held at the Agency's headquarters on 9-13 May 1966 and on 18-22 March 1968, with experts from seven countries. Also present at the meetings were representatives of the World Health Organization (WHO), the International Association of Ports and Harbors (IAPH), the Inter-Governmental Maritime Consultative Organization (IMCO) and EURATOM.
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1. **PURPOSE AND SCOPE**

1.1. The purpose of this guide is to set forth considerations pertinent to matters of use of ports and harbours by nuclear merchant ships, to indicate the factors which are important to a port safety evaluation and to provide guidance as to various procedures and precautionary measures that may be employed.

1.2. Such guidance as is set forth herein is in no sense to be regarded as mandatory and nothing in this guide is intended to define, interpret or modify international law or conventions applicable to the operations of nuclear merchant ships. It is recognized that individual countries will wish, at the present time, to judge each situation involving the use of their ports and approaches on their individual merits in accordance with their own procedures and safety standards. Nothing in this guide is intended to be construed as limiting or detracting from the exercise of such governmental rights.

1.3. This guide is primarily concerned with matters of safety to be considered when a nuclear ship operates to a port in the course of normal commercial operation. Repair work on the reactor plant and nuclear fuelling are not considered since these operations require separate safety considerations.

1.4. The manner in which the safety evaluation of the ship's reactor is carried out and the safety criteria used have been excluded from consideration in this guide.²

1.5. No recommendations have been made regarding reference doses to individuals or populations which might be adopted for port safety evaluation, or for planning for possible emergencies.³

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¹ Throughout this document the word port implies a port or harbour.

² In both these areas references are supplied in the bibliography which it is hoped will provide guidance for those concerned with these matters.

³ In both these areas too references are supplied in the bibliography.
2. INTRODUCTION

2.1. Nuclear merchant ships are being designed and built to achieve a high degree of safety. If a ship is designed, constructed and operated in accordance with the best current practices for nuclear ships and within the framework of the 1960 Safety Convention, it can be reasonably assumed that:

(a) the main nuclear hazard to be considered in port would arise from the occurrence of a highly unlikely accident of sufficient severity to cause an appreciable release from the ship of gaseous or volatile radioactive materials, of which the iodine isotopes and noble gases are of particular significance;

(b) ship design and care in navigation may ordinarily be expected to eliminate the possibility of a serious nuclear hazard due to collision and grounding;

(c) normal operations in ports and at the berth will not give rise to levels of radioactivity in and about the ship in excess of those specified for routine operation.

2.2. Despite this there still remains some small probability that accidents might be experienced which could lead to off-ship releases of radioactive materials. Whilst a ship is far out at sea the consequences of such accidents are not likely to be hazardous to more than a relatively limited number of people. However, the situation could be very different should an abnormal release of radioactive materials occur whilst close to land, and particularly within a densely populated port area. Consequently, if a nuclear merchant ship is expected to use a particular port, those responsible for the port and its surroundings should assess the risk such use might entail and establish suitable precautionary measures.

2.3. In general, there are three main problems involved in making a technical appraisal of the suitability of a port for use by a nuclear merchant ship:

(a) the establishment of the reference doses to individuals or populations to be used for evaluating accidents involving the release of radioactive materials;

(b) the assessment of the potential releases of radioactive materials from a nuclear merchant ship and their consequences;

(c) the possible limitation of such consequences by careful selection of a berth and by emergency planning.
3. GENERAL FACTORS IN THE SELECTION OF BERTHS

3.1. In most ports there are several locations or berths where a ship may be moored. A list of advantages and disadvantages relating to these berths can be drawn up to make the selection easier. These factors from a safety viewpoint might be grouped as follows:

(a) factors influencing the relative probability of an accident occurring due to external causes, such as shipping channels, shipping frequencies and speeds, location of airports and flight paths, tidal and meteorological conditions affecting navigation, collision statistics and any unusual dock operations;

(b) factors influencing the dispersal capability of the environment, such as frequencies and times of prevailing and extreme meteorological, tidal and water flow (flushing) conditions; these might be of particular interest in some geographical and climatological areas with great seasonal variations (monsoons; river currents, tides);

(c) factors having a bearing on the potential consequences of an accident, such as surrounding land use, ease of fire fighting, towing, radiation monitoring and other services and depth of water to facilitate ship movement.

3.2. On the basis of such considerations some locations can be tentatively selected. Estimates can then be made of the radiological consequences should some unforeseen event result in an accidental release of radioactive materials at these locations. A comparison of the estimates made for the various berths can provide further guidance as to the relative advantage of one berth versus the other. When examined together with the probability of the postulated event, an indication of the relative risk of experiencing an unacceptable situation can be obtained.

4. RADIOLOGICAL CONSIDERATIONS

4.1. The safety evaluation of the nuclear merchant ship is to be set forth in a "Safety Assessment" as required by the International Convention for the Safety of Life at Sea, 1960, and provided in advance to the Governments of the countries which the merchant
ship intends to visit. The Safety Assessment should include sufficient detailed information to permit evaluation of the safety aspects of the reactor design and the manner of its intended operation.

4.2. It is clearly beyond the scope of this document to deal with the question of the detailed contents of a Safety Assessment. Nonetheless, it can be said that such documentation can reasonably be expected to include an evaluation of the safety aspects of nuclear plant design wherein various accident possibilities are analysed. Commonly what is done is to postulate failure of some component or control system and then to examine the consequences of these events. This analysis is done to assess the effectiveness of
(a) features engineered into the power plant to terminate the accident before the release of radioactive materials from the reactor;
(b) features which would minimize consequences should the postulated accident sequence involve off-ship releases.

4.3. These analyses cover a spectrum of events, varying both in probability of occurrence and severity of consequences. Obviously, the Government of registry will have evaluated the ship from the viewpoint of the probability of events identified as potentially serious and satisfied itself on the adequacy of the design and the intended manner of operation. In considering port entry, the Receiving Government also should satisfy itself that:
(a) the general safety aspects of the ship and its operations represent a reasonable basis for consideration for port entry;
(b) the consequences of an accident, taking into account the probability of a given release of radioactive materials, are acceptable when examined against the conditions and environment peculiar to the specific port and berth(s);
(c) suitable precautionary measures are organized and implemented. Considerations of (b) and (c) above form the basic objectives of a Port Evaluation.

4.4. For the Port Evaluation those various accidents examined in the Safety Assessment, which are postulated to result in off-ship release of radioactive materials, either as airborne or liquid effluents, are evaluated, using the particular berth under study, as the reference point. (In so doing, the evaluator should bear in mind the relative probability of the accidents postulated
to cause the releases.) Commonly what is done is to choose one such event as a "reference accident" for purposes of determining a release of radioactive material ("source term").

4.5. From this starting point, the dispersion of the airborne release postulated may be described by well-known atmospheric diffusion models. Diffusion models will have been used in the Safety Assessment, but values of the meteorological parameters may need adjustment to reflect local conditions. In performing this exercise, the following guidance may be helpful.

(a) Such calculations show that the dominant hazard at short distances is from direct radiation and inhalation, while at larger distances the dominant hazard arises from contamination of agricultural products, especially milk. Since the short-range hazard is of immediate concern, the number of people staying in the immediate vicinity of the berth, the distance to the residential area and the population distribution in this area are primary factors to consider.

(b) If calculations are made of the consequences resulting from a release of radioactive materials, assuming (a) that the ship remains at the berth throughout the release and (b) that the ship is moved according to the assessed mobility, the relative merit of mobility will be indicated.

(c) The radiological consequences calculated should not be treated as being any more precise than the assumptions used in the calculational model.

(d) Radiation doses so calculated are commonly compared with "reference doses" selected by national authorities for the purpose of evaluating such highly unlikely situations. (There is no international standard. A number of countries have published reference doses; the use of such doses for evaluation purposes does not necessarily imply acceptance by the authorities of emergency exposure of the public to such values.)

(e) In determining whether the exposure is acceptable, not only the doses to the individuals, but also the integrated dose to the population should be taken into consideration.

(f) Having estimated the doses to individuals within the port area and adjacent residential areas the authorities may want to establish protective measures such as evacuation, monitoring, alarm and ship removal and the designation of a place for remote anchoring. Evacuation may be practicable for
persons in the port area but one should not consider evacuation of large numbers of people in a residential area as a practical safety measure.

(g) The long-term contamination effects of the release of radioactive materials are not usually of primary concern in evaluation of a port, but attention should be given to possible adverse effects on consumptive products, food factories in the affected area, foodstuff warehouses and the use of land for agricultural purposes.

4.6. The release of radioactive materials to the harbour water will generally not constitute an immediate hazard to people, provided these materials remain in the water. Special consideration would be necessary for ports located in fresh water from which domestic water supplies may be drawn. Other than this, the main effect on people from such a release might arise from consumption of seafood from the area, but danger from such a possibility can be prevented by imposing restrictions after monitoring of the actual radioactivity levels. The necessary time for carrying out these functions will be available.

While the hydrospheric conditions of a harbour and adjacent waters are not generally limiting with respect to port suitability, such conditions should be examined to ascertain if there are ways for the released radioactive materials to reach the human body. Such examination could lead to suitable precautions being taken.

5. PRACTICES CONCERNED WITH USE OF PORTS BY NUCLEAR MERCHANT SHIPS

In consideration of the matter of the operation of nuclear merchant ships in ports the following practices are set forth for guidance:

5.1. Ship design and manning

The Receiving Government should ensure that

(a) nuclear ships entering its ports have been designed and constructed in accordance with the provisions of the International Convention for the Safety of Life at Sea, 1960, Chapter VIII, and the applicable codes or regulations of the
Government of registry with due regard to the Recommendations Applicable to Nuclear Ships outlined in Annex C to the 1960 Convention;

(b) the Safety Assessment required by the Final Act of the 1960 Safety Conference has been prepared and approved by the Government of registry, and made available sufficiently in advance of the planned visit of the nuclear ship, so that the Receiving Government may make or cause to have made an independent appraisal of the safety of the ship;

(c) the visiting ship has an appropriate and valid Nuclear Passenger Ship Safety Certificate or Nuclear Cargo Ship Safety Certificate as appropriate issued in accordance with the provisions of the 1960 Safety Convention, in addition to other usual statutory documents such as the International Load Line Certificate;

(d) the Master, officers and members of the crew of the nuclear ship possess the requisite qualifications and have undergone proper training appropriate to their responsibilities and duties in accordance with arrangements approved by the Government of registry.

5.2. Ship operation

The Receiving Government should ensure that:

(a) the conventional navigation and safety equipment is in good order and readily available for use;

(b) the emergency propulsion plant, if provided, is in a state of readiness;

(c) the nuclear plant and its associated systems are in good working order and comply with the information given to the Receiving Government;

(d) the levels of radioactivity in and about the ship are not in excess of those specified for normal operations;

(e) records of periodic tests of vital safety systems and conditions of the reactor and the ship are available for inspection by a person duly authorized to carry out such an inspection by the Government of the port to be visited; such inspection might entail the issue of an Entry Certificate irrespective of the fact that the ship is in possession of the relevant statutory documents; the Entry Certificate would be evidence to the Port Authority and others concerned that the visited Government is satisfied with the general safety of the ship.
5.3. Arrangements prior to entry into port waters

With respect to arrangements prior to entry the following practices pertain:

(a) Prior notification of the ship's intention to call at the port is given.
(b) As a condition of entry into port waters the ship is inspected and granted such Entry Certificate as may be required by the Receiving Government.
(c) Daylight arrival is preferred unless advanced methods of shipping control have been developed at the port. It is recognized that delay by weather, tides or other causes might make it impracticable to avoid night arrival, in which case it might be safer for the vessel to proceed to the berth during darkness rather than to anchor in a busy approach outside port limits.
(d) For each port a remote ship anchorage is designated. The remote ship anchorage is to serve as
   (i) a location to which the nuclear ship could be directed if conditions in the approaches to the berth preclude the ship's entry into port;
   (ii) a location to which the nuclear ship could be taken if necessary as an expedient and emergency measure should the ship experience an accident in the port involving potential for sustained off-ship release of radioactive materials; in the latter case the ship would be expected to remain at the remote anchorage until the release ceases or until further action is possible.
(e) In the case of ports approached by long inland water passages, additional remote anchorages may need to be designated for use in these circumstances.
(f) In designating a remote anchorage, the following considerations should be taken into account:
   (i) since the vessel may still continue to release radioactive materials over a prolonged period of time following an accident - perhaps weeks - the remote anchorage should be isolated from large groups of population;
   (ii) the remote anchorage should be located away from the normal navigation routes so as not to affect the ships navigating nearby.
(g) In ports where adequate surveillance and communication facilities are provided so as to be able to inform the nuclear
vessel of the presence of poor visibility, adverse weather conditions and obstruction in port waters, a point is determined past which the nuclear ship should not proceed but is diverted to the remote anchorage. If the ship has passed this point when the adverse port conditions arise, then the vessel is permitted to proceed at the Master's discretion, assisted by advice from the Port Authority. In ports where no such adequate facilities are provided, the ship proceeds at the Master's discretion at all times.

5.4. Conditions whilst in transit to and from berth

5.4.1. The handling of the ship is not affected by the type of power system and therefore pilotage requirements for nuclear ships are considered to be no different from those of conventional ships of similar size and draught. Equally no privilege of right of way or special speed limit appears necessary because a ship is nuclear powered.

5.4.2. In port waters a tug or tugs of adequate power accompany the vessel. The location at which the tug or tugs should be provided on the inward journey and should leave the ship on the outward journey is a matter for individual consideration by Port Authorities. In most cases the presence of tugs ensures that in any emergency it will be possible to remove the vessel to the remote anchorage or other safe location depending on the nature of the emergency.

5.4.3. Nuclear ships are required to display the same signals as conventional ships but have not been required to display in addition a "nuclear ship" signal.

5.5. Conditions at the berth

5.5.1. In considering berthing arrangements attention should be given to the following points:
(a) the provision of electric power and/or special lighting arrangements that the ship or the security forces may require;
(b) any possible requirement by the ship for a supply of water for in-ship fire fighting, whether the ship will require a
fixed connection from the shore supply to the ship fire mains, and how this supply may be achieved;
(c) the communication facilities between the ship and shore organization; such facilities might include ship-to-shore telephone connection to the public telephone service, connection to the port network, use of a direct line and use of radio-telephone facilities;
(d) the security arrangements at the berth; ports that operate an internal security organization will be able to increase security over the ship and surrounding area; in the case of ports that rely upon the public security forces special liaison might be established so that adequate supervision may be exercised over access to the vessel;
(e) the need and availability of health physics equipment.

5.5.2. With respect to berthing arrangements the following suggestions are made:

(a) Fire precautions: Appropriate arrangements should be made by the Port Authority for adequate fire cover while the vessel is at the berth, having in mind the potential complications that may arise if the nuclear ship is involved in a fire. Due regard should be paid to the necessity for fire-fighting forces to be properly informed of any problems on board the vessel.

(b) Security:
(i) Security arrangements in excess of those required for a similar conventional ship should be considered, depending on local circumstances.
(ii) The ship should be required to station security personnel at each gangway during the period that she is at berth, to prevent unauthorized access.
(iii) The security forces should exercise special surveillance, especially during the period outside working hours and the hours of darkness.

(c) Access: Consideration should be given to the problem of access to the ship in the port area so that emergency action is not impeded.
(d) Manning of the ship while at the berth:
   (i) A senior officer-in-charge should be available.
   (ii) A sufficient complement of crew should be on board to
        man the ship and take her outside port limits at short notice
        if necessary.
   (iii) A continuous fire patrol should be maintained on board
        the ship.

(e) Pilot availability: Arrangements should be made for any neces-
    sary pilots to be available on short call for the period that the
    ship is at her berth.

(f) Facilities at adjacent berths:
   (i) No handling of explosives should be permitted within
       the vicinity of the nuclear ship.
   (ii) Careful consideration should be given to the handling
       of large quantities of hazardous materials at adjacent berths.

5.6. Mobility of ship

5.6.1. The emphasis on the merits of mobility is determined
by the result of the safety evaluation of the ship and the vulnerability
of the port and the adjacent area. Mobility of the ship is provided
either by emergency means aboard the ship, and/or by tugs available
at the port.

5.6.2. In the evaluation of the reliability of the mobility
arrangements attention should be given to the following:
   (a) If tugs are employed, the means for providing tugs of sufficient
       number and power within the required time will need evalua-
       tion. Consideration should be given to adequate protection of
       tugboat personnel.
   (b) Characteristics of the port which might impair mobility should
       be evaluated to determine their effect. Such factors include
       passage through bridges or locks, sufficiency of water depth to
       ensure floatation and ship movement at all times, prevalence of
       adverse tidal and weather conditions, and the degree of port con-
       gestion which will impair ship movement. If mobility is
       seriously impaired, other factors may compensate for these
       disadvantages.
While it is expected that the ship will have sufficient stand-by staff while it is in port, to assist with moving the ship, the receiving country should make sure that this is done.

5.7. Radioactivity control in port

5.7.1. Reactor containment: The integrity of the containment systems should not be violated without reference to the Port Authority.

5.7.2. Radioactive waste: Discharge of solid, liquid or airborne radioactive materials should be permitted only after prior consultation with the appropriate authority. If permitted, the discharge of radioactive materials should be within the limits fixed in agreement with the authority. Any deviation in excess of these limits should be properly notified to the authorities. Records of radioactive materials discharged from the ship whilst in port should be made available.

5.7.3. Monitoring for radiation:
(a) Consideration should be given to the need for environmental monitoring before, during and after the visit of the ship. Such data might be useful for record purposes.
(b) Consideration should be given to the monitoring of the ship’s hold at the start of any loading or discharging operations to provide assurance to dock workers.

5.8. Administrative arrangements for emergencies

Towards defining a set of administrative arrangements that should be established as precautionary measures for dealing with emergency conditions the following guidance is provided:

5.8.1. The potential problems can be considered to be divided among the control and operation of the ship, the area under the control of a Port Authority (or similar body) and the area outside this boundary which will be the responsibility of other appropriate civil authorities.

5.8.2. The effects of a nuclear accident can extend into the port area and even beyond. The Master of a nuclear ship can be assumed competent to deal with situations arising in the ship as a
result of accident conditions involving the release of radioactive material, and the safety of the reactor installation remains the responsibility of the Master.

5.8.3. Executive responsibility for action concerned with the safety of the port needs to be clearly defined. It may, for example, be invested in a senior member of the Port Authority, advised as necessary by competent experts.

5.8.4. Before the arrival of the ship, provisions should be made for full consultation with all appropriate competent bodies so that their responsibilities for public safety may be clearly defined. These may include police, health officials and those concerned with agriculture and food. Such bodies would be responsible for the control and possible evacuation of the public, the medical treatment of people who may be contaminated and the control of contaminated foodstuffs or milk.

5.8.5. Environmental hazard can extend beyond the confines of the ship. Arrangements should therefore be available to warn civic authorities and government bodies. If it appears that radioactive materials may be more widespread the civic authorities and government bodies should be advised to take appropriate action.

5.8.6. It can be expected that in many cases assistance will be required from experts in the fields of environmental monitoring, meteorology, health physics and engineering to assist in the assessment of the probable course of events and the nature and extent of any consequent hazard.

5.8.7. The Master should be responsible for advising the designated authority immediately of the occurrence of any abnormal reactor conditions constituting potential hazard to public health and safety, and his assessment of the situation. Such guidance will enable appropriate action to be taken (for example, the removal of the vessel to the chosen remote anchorage).

5.8.8. Detailed plans and emergency actions should be prepared in advance of the arrival of the ship and should be available to the Master. In such plans particular attention should be paid to the adequacy and reliability of communications at all times when the emergency plan may be required to operate.
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LIST OF PARTICIPANTS

CONSULTANTS
G.D. Bell (Chairman) United Kingdom Atomic Energy Authority
A. Burban Commissariat à l'énergie atomique, France
E.G. Case\(^1\) United States Atomic Energy Commission
J.J. DiNunno\(^2\) United States Atomic Energy Commission
H. Jensen Atomic Energy Commission, Denmark

REPRESENTATIVES
E.C. Anderson\(^1\) World Health Organization
J. Bunge EURATOM
F. Luykx EURATOM
G. Meilland\(^2\) World Health Organization
V. Nadeinski\(^1\) Inter-Governmental Maritime Consultative Organization
H.G. Parker\(^1\) World Health Organization
Y. Sasamura\(^2\) Inter-Governmental Maritime Consultative Organization
W.T. Worts International Association of Ports and Harbors

\(^1\) Attended first meeting only.
\(^2\) Attended second meeting only.
OBSERVERS

A. Calori\textsuperscript{2} \hspace{1cm} Comitato Nazionale per l'Energia Nucleare, Italy

R. P. Denise\textsuperscript{1} \hspace{1cm} First Atomic Ship Transport Inc., United States of America

R. E. Knowles \hspace{1cm} Board of Trade, United Kingdom

H. Nakato\textsuperscript{1} \hspace{1cm} Japan Nuclear Ship Development Agency

H. Schmerenbeck \hspace{1cm} Gesellschaft für Kernenergieverwertung in Schiffbau und Schifffahrt, Federal Republic of Germany

J. M. Will\textsuperscript{1} \hspace{1cm} First Atomic Ship Transport Inc., United States of America

SCIENTIFIC SECRETARIES

J. Beránek \textsuperscript{1} \hspace{1cm} International Atomic Energy Agency

A. Massera \textsuperscript{2} \hspace{1cm} International Atomic Energy Agency

J. D. McCullen\textsuperscript{1} \hspace{1cm} International Atomic Energy Agency

\textsuperscript{1} Attended first meeting only.

\textsuperscript{2} Attended second meeting only.
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