TRANSPORTATION OF RADIOACTIVE MATERIAL - PROGRESS AND POTENTIAL

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ATOMIC ENERGY CONTROL BOARD

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SUMMARY

The bases for the IAEA Regulations for the Safe Transport of Radioactive Materials and the organization and regulations of the Canadian modal regulatory authorities are introduced. Regulatory progress in the transportation of radioactive materials is examined as well as its effect on the Canadian nuclear program. Potential improvements in the transportation of radioactive materials are also described.
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PROGRESS AND POTENTIAL

1) INTRODUCTION

The purpose of this paper is to describe the current progress and the future potential in the transportation of radioactive materials and to relate such progress and potential to the Canadian nuclear program. Since transportation is a regulated activity, this paper will be presented from the regulatory point of view. This paper is also intended to update the earlier paper on this subject presented at the CNA Conference '67.

Transportation involves the movement of radioactive materials within and between the nations of the world. Thus, there is a strong incentive for health and safety standards which are internationally uniform. Such standards have been provided by the International Atomic Energy Agency in the form of Safety Series No. 6, "Regulations for the Safe Transport of Radioactive Materials, 1967 Edition" which I will refer to hereafter as the "IAEA Regulations". These regulations were developed during the period 1959 to 1967 and Canada participated actively in their development. These regulations cover the packaging, preparation for shipment, and shipment of all types of radioactive materials.

The IAEA Regulations, which have been recommended for use by all IAEA Member States and by international transport organizations such as International Air Transport Association (IATA) and Inter-Governmental Maritime Consultative Organization (IMCO), are advantageous in a number of ways. The primary advantage is that these regulations provide international and intermodal uniformity, i.e., they are the same for each country and for each mode of transport. Prior to the IAEA Regulations, different national regulations and different modal regulations seriously impeded the transportation and utilization of radioactive materials. Another advantage of the IAEA Regulations is that they are based on a broad scope of experience derived from the many nuclear nations of the world.

I do not propose to discuss the details of the IAEA Regulations in this paper. However, I do think that it would be useful to outline some of the general bases for these regulations in point form below:

1.1) The hazard potential of each radionuclide is classified according to its radiotoxicity, form, and activity.
1.2) The acceptable radiation exposure of personnel and sensitive cargo such as undeveloped photographic film is defined.

1.3) The transport environment is defined in terms of packaging performance tests for both normal and accident conditions of transport. The latter condition includes severe impact followed by fire exposure.

1.4) Packaging performance is specified in terms of retention of shielding and containment capability under normal and accident conditions of transport. Packaging performance standards are also specified in terms of criticality safety and decay heat dissipation for cases where such factors are appropriate.

1.5) Overall safety is the sum of design safety and operational safety. Design safety is provided by the packaging. Operational safety is provided by the shipper and by the carrier. The relative amounts of design safety and operational safety may be varied provided that the required level of overall safety is maintained.

1.6) The primary responsibility for safety in the transportation of radioactive materials is assigned to the shipper (proper packaging and preparation for shipment) and the secondary responsibility is assigned to the carrier (safe handling during carriage).

1.7) The following types of packagings are defined and their use authorized in terms of type and activity of radioactive material.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7.1</td>
<td>Exempt</td>
</tr>
<tr>
<td>1.7.2</td>
<td>Low specific activity</td>
</tr>
<tr>
<td>1.7.3</td>
<td>Type A (withstands normal conditions of transport only)</td>
</tr>
<tr>
<td>1.7.4</td>
<td>Type B (withstands normal and accident conditions of transport)</td>
</tr>
<tr>
<td>1.7.5</td>
<td>Large radioactive source (same as Type B but with additional containment and decay heat dissipation requirements)</td>
</tr>
<tr>
<td>1.7.6</td>
<td>Fissile</td>
</tr>
</tbody>
</table>
1.8) Since it is impossible for the regulations to anticipate every type of radioactive shipment, a "special arrangements" provision is included. This provision permits departure from the detailed regulatory requirements provided that it can be shown to the satisfaction of the regulatory authority that the overall level of safety is not reduced.

Prior to the publication in 1949 of the first Board of Transport Commissioners (BTC) regulations for rail transport, the packaging and shipment of materials were not covered by detailed regulations. The development of BTC regulations paralleled those of the United States Interstate Commerce Commission up to the point of the publication of BTC Circular 286 in 1960. This Circular, in requiring impact and fire resistance for packaging for large quantities of radioactive material, was a fore-runner of the IAEA Regulations. The promulgation of the Atomic Energy Control Board Shipping Containers Order in 1963 and the development of regulations for air and marine transport completed the Canadian regulations prior to the adoption of the IAEA Regulations.

At the present time in Canada, there is a different safety regulatory authority for each mode of transport. The relation between these regulatory authorities and their advisory bodies is shown in Appendix 1. The principal modal regulatory authorities are shown in heavy outline.

Rail, air, and marine transport are federal jurisdictions. Intra-provincial road transport is a provincial jurisdiction although no province has yet published detailed regulations for radioactive materials transport. Extra-provincial road transport is a federal jurisdiction although the Canadian Transport Commission is not yet active in this area. The National Harbours Board and the St. Lawrence Seaway are autonomous regulatory authorities. The full names and the regulations of each authority are defined in Appendix 2.

The advisory bodies are the Working Group on IAEA Regulations, the Technical Committee on Dangerous Goods, and the Atomic Energy Control Board. The Working Group is the primary channel of communication between the Canadian regulatory bodies and the IAEA. Its membership includes the regulatory organizations, Atomic Energy of Canada Limited, Canadian Nuclear Association, and Ontario Hydro. The Technical Committee on Dangerous Goods advises the marine authorities on all hazardous material shipments. The Atomic Energy Control Board, in addition to acting as an advisor to other regulatory authorities on the transport of radioactive materials, serves temporarily as the regulatory authority for road transport.
Having introduced the IAEA Regulations and their bases and the Canadian regulatory authorities and their regulations, let us now examine the progress which has been made in the regulatory aspects of transportation and relate this to the Canadian nuclear program.

The IAEA Regulations were adopted for full application by all modes of transport in Canada effective 1 January 1969 - some 17 months ago. Shippers were advised more than two years in advance of this deadline that their existing packaging and shipment authorizations would expire on 31 December 1966 and that in order to obtain new authorizations, they must demonstrate that their packagings and shipments were in compliance with the IAEA Regulations. The same deadline for full adoption of IAEA Regulations was applied in the United States of America. Earlier deadlines had been invoked in the European countries although they continued to accept, with some restrictions, Canadian shipments which did not comply with the IAEA Regulations.

The Canadian adoption of the IAEA Regulations provided an opportunity to streamline some of the administrative procedures associated with the approval of packagings and shipments by the regulatory authorities. In 1964, the Atomic Energy Control Board was requested by the federal Technical Committee for Uniform Regulations for the Transportation of Radioactive Material (predecessor of the current Working Group on IAEA Regulations) to provide technical assistance to the Canadian regulatory authorities on the safe transport of radioactive materials. In 1966, the Board was requested by the same Committee to receive all applications for packaging and shipment approvals, to evaluate these applications, and to submit appropriate recommendations to the relevant regulatory authorities along with a single approval certificate for endorsement by those authorities. To assist approval applicants, the Board has prepared "A Guide to the Preparation of Applications for Radioactive Materials Packaging and Shipment Approvals".

The experience of shippers under the new regulations has been that packaging designs existing prior to 1 January 1969 may have had to be modified, particularly from an impact- and fire-resistance point of view, in order to comply with the new regulations. The cost of these modifications and the resultant additional package weight have, in most cases, not been very great. Many new packagings have been designed - many showing considerable skill and ingenuity on the part of designers to achieve functional, low cost, and safe packagings. Many existing packagings which are not in full compliance with the regulations continue to be used on a "special arrangements" basis - with either exclusive-use vehicles or radiation-surveyor
escorts being used to provide the necessary additional operational control. The additional cost of packaging and shipment is more than compensated by the increased safety, service life, and acceptance by other national regulatory authorities of Canadian-approved packagings and shipments.

A summary of packaging and shipment approvals issued from 1 January 1969 to date is shown in Appendix 3. Approvals have been granted for a total of 212 individual packaging-modes. Note that a packaging approval certificate will include several modes - the actual number of certificates issued is 81. Road transport is the most popular mode - accounting for 50% of the modal approvals. This reflects the popularity of road transport for domestic shipment. The other modes in decreasing order of popularity are rail (24%), marine (21.2%) and air (5.3%). Marine and air shipments combined (45.2%), being the export modes, indicate the magnitude of approvals issued for foreign shipments. The most popular packaging type is the large radioactive source, accounting for 41%. This includes most radioisotope shipments in excess of 5000 curies and also irradiated fuels shipments. Fissile packaging approvals account for 18.8% of the total with Fissile Class II being the most popular and Fissile Class III a close second. Over 20% of packaging approvals were issued of the special arrangements variety. This fraction reflects the increased use of this approach during the transition period following adoption of the IAEA Regulations. The use of special arrangements is expected to decrease to a lower level in the future.

The experience of Canadian shippers with the new regulations and the effect of the new regulations may be more evident by considering some of the materials transported for use in the Canadian nuclear power program.

Natural uranium in all its forms - ore concentrate, fuel material, and fabricated fuel is classified as a low specific activity material and as such require no special packaging. The steel drums which are normally used for ore concentrates and fuel materials provide adequate safety. Styrofoam shells, with overpack depending upon the type of shipment, are used for natural uranium fuel bundles.

Enriched uranium is used in reactor fuels, e.g., N RX, NRU, and WR-1, and in reactivity devices. Although enriched uranium presents a minimal radiation safety hazard, it requires special handling from the point of view of criticality safety. The IAEA Regulations provide three types of fissile materials packaging termed Class I, II, and III with the different classes reflecting the different degree of design safety and operational safety utilized.
Tritiated heavy water is being shipped in significant quantities for new reactors and for upgrading and purification. Sample quantities of low-tritium heavy water may be exempted from packaging and shipment requirements. Heavy water with tritium concentrations up to 5 curies per liter is classified as a low specific activity material and may be shipped in specification steel drums with a total activity-per-shipment limitation. Tritiated heavy water with concentration exceeding 5 curies per liter or with total activity exceeding the per-shipment limit must be shipped either as a large radioactive source in packaging capable of withstanding the impact and fire resistance requirements or by special arrangements. At least two types of individual drum containers have been approved as large radioactive source packagings as well as a bulk container capable of carrying twelve drums which has been approved for special arrangements shipment. A large shipment of tritiated heavy water to the KANUPP reactor in Pakistan has recently been completed and future shipments are anticipated to the Gentilly, Pickering, and RAPP reactors. A revision of present IAEA regulations is being considered which will increase the 5 curie per liter low specific activity threshold and the total activity permitted per shipment. These proposed changes, if adopted, will facilitate the shipment of tritiated heavy water considerably.

Irradiated natural and enriched uranium fuels present a challenge in safe packaging and shipment. A large part of the IAEA Regulations is devoted to irradiated fuel and bulk radioisotope shipment (treated collectively as "large radioactive sources") and the regulatory requirements are quite detailed particularly with regard to containment and decay heat dissipation. An AECL design is used by both AECL and Ontario Hydro for interproject transfers of up to two irradiated fuel bundles. The NPD twenty-five bundle flask, although not meeting all IAEA regulatory requirements, continues to be used for NPD-to-Chalk River transfers of NPD fuels under special arrangements. At the present time all other shipments of Canadian irradiated fuels are handled by American, British, and French organizations in packagings designed in those countries to the IAEA Regulations. This is a good example of the value of internationally-uniform regulations facilitating the shipment of Canadian irradiated fuel. There is currently some activity on the part of Canadian companies to get into the irradiated fuels shipping business, the volume of which is expected to increase sharply in the future.

Most radioactive wastes and contaminated and/or activated components can be shipped as low specific activity materials. Higher activity wastes and unusual types of materials are usually shipped by special arrangements.
It would be appropriate here to refer briefly to the shipment of larger activities of radioisotopes as by AECL, Commercial Products because these shipments are a very important Canadian nuclear industry export. As mentioned earlier, the packagings used for these shipments were modified by the addition of a fire shield in the form of a thick-walled wooden box. More recent designs utilize a more efficient fire shield in the form of a steel thermal radiation barrier. The cost of modifications and/or additions to the packaging is more than justified by the unrestricted acceptance of these Canadian-approved packagings in other countries to which Canadian radioisotopes are shipped.

Regulations are being developed by the Working Group on IAEA Regulations for recommendation to the federal and provincial road transport regulatory authorities. Until these regulations are adopted, the Board is applying the IAEA Regulations to Canadian road transport.

The IAEA Regulations have been widely adopted on an international scale. The United States of America adopted these regulations at the same time as Canada. The United Kingdom was one of the main participants in the development of the IAEA Regulations and has been applying these regulations for a considerable period of time. The European countries, which are tied together by transport conventions for rail, road, and inland waterway modes, have also been using the IAEA Regulations for several years. The USSR and other eastern bloc countries also have adopted the IAEA Regulations into their own format. International transport organizations such as the Inter-Governmental Maritime Consultative Organization and the International Air Transport Association have also used the IAEA Regulations as a basis for their own.

Although transportation regulations provide a high degree of safety even under severe accidents, it would be unrealistic to assume that very severe or un-anticipated types of accidents will not occur. To be prepared for this low-probability event, a nation-wide emergency procedure has been organized in cooperation with the police forces, federal and provincial departments of health, and the Atomic Energy Control Board. This emergency procedure is based upon the police being among the first at the scene of an accident. Upon identifying the presence of radioactive material (by vehicle placard or package label), the police call to the scene of the accident a designated radiation expert to identify the degree of hazard. The police are also provided with basic radiation safety instructions for guidance while awaiting the arrival of the radiation expert. This emergency procedure is now organized on a national scale with the Royal Canadian Mounted Police, the Ontario Provincial Police, and the Quebec Provincial Police and is being expanded to include local police forces not affiliated with these major police forces.
The international regulations require much liaison to promote efficient international application. To facilitate this liaison, the Radioactive Transport Study Group was organized in 1968. This informal, self-appointing group is made up of the regulatory authority or his advisor of the various countries having significant radioactive trade with each other. Present membership includes Australia, France, Germany, Italy, Sweden, United Kingdom, United States, and Canada. Japan and Poland have been invited to become members beginning with the 1971 meeting. The Study Group identifies and attempts resolution of problems which arise in the international application of the regulations. At its 1970 meeting, the Study Group made a number of recommendations to the IAEA re proposed regulatory changes.

The past ten years have seen significant progress with the completion of the IAEA Regulations and the adoption and application of these regulations by the various national regulatory authorities and international transport organizations of the world. This progress has brought significant benefit to the shippers, carriers, and users of radioactive materials including the Canadian nuclear power program.

3) POTENTIAL

There is significant potential for improvement in the transportation of radioactive materials. These potential improvements may be identified within the areas of regulations, packaging design, information dissemination, and industry participation.

Much scope exists for regulatory improvement. Some criticism has been directed at the IAEA Regulations because of their length, complexity, multiple cross-references, and general format. Some of this criticism is deserved. However, an opportunity exists to correct this problem with the IAEA Regulations being revised in anticipation of the publication of a 1972 edition. The purpose of this revision is to improve the format of the regulations and to update them technically to reflect past experience and to fulfill new needs. The first review panel was held in February 1970 at IAEA Headquarters in Vienna and the second and final panel is expected to be held in mid-1971. Several technical and administrative improvements of significance to Canadian shippers have been proposed by the first panel and these proposals will be considered in the near future by the Working Group on IAEA Regulations.

With the publication of the 1972 Edition, the IAEA Regulations will not be further revised until ten years hence, i.e., 1982. This timing requires a good anticipation of future
needs and careful review before finalization. The ten-year revision period also provides the necessary regulatory stability which promotes user familiarity with the regulations and which minimizes packaging modification or obsolescence due to regulatory revision.

Further regulatory improvement may also be achieved through direct adoption of the IAEA Regulations into national modal regulations. At the present time in Canada, the IAEA Regulations are re-written into four different sets of regulations - one for each mode. Invariably, this multiple re-writing results in small differences of format and content with a resultant loss of uniformity. Direct adoption by reference of the IAEA Regulations by the modal authorities is the most efficient regulatory approach and has the advantage of providing regulations in both French and English since the IAEA Regulations are published in those languages as well as Spanish and Russian.

At the present time, Canada accepts the technical provisions of the IAEA Regulations but does not completely accept the administrative provisions - especially the unilateral approval concept which means acceptance by all other countries of the originating countries' packaging design or shipment approval. The reasons for Canada's non-acceptance of this concept are legal restrictions, desire for more approval experience, and some exceptions to technical provisions. The adoption of the 1972 IAEA Regulations would seem to be an appropriate time by which to overcome these reasons and adopt the full unilateral approval concept. The Board plans to recommend this action to the Working Group on IAEA Regulations and to the modal authorities.

Related to the acceptance of unilateral approval is the broadening of scope of the U.S.A. - Canada reciprocal agreement on the acceptance of each other's packaging and shipment approvals. It is planned to initiate discussions on this subject with American and Canadian modal regulatory authorities in the near future.

Another opportunity for regulatory streamlining is the elimination of the need for regulatory authority approval of packaging designs for Type B packagings. At the present time, the packaging designer must submit his design and its regulatory compliance report for evaluation and issuance of an approval certificate by the regulatory authority. All this requires considerable effort by both parties and may result in some delay, depending upon the regulatory authority workload. It is planned to eliminate the approval certificate requirement for Type B packagings in the near future and require only that the designer maintain on file evidence of regulatory compliance for examination by the regulatory authority as necessary.
At the present time, the Canada Post Office prohibits the transmittal of any quantity of radioactive material by post. This prohibition is not consistent with the United Kingdom, United States and several other national post offices which permit exempt quantities to be transmitted in accordance with the regulations of the Universal Postal Union. I am aware that the CNA Sub-committee (of the Safety Committee) on Transportation of Radioactive Materials plans to present a brief to the Canada Post Office requesting its consideration of transmittal of exempt quantities of radioactive materials in accordance with Universal Postal Union requirements. Such a change would be very useful for transmitting small sources, samples, luminous devices, etc.

The St. Lawrence Seaway has long appeared to be an attractive route for the shipment of irradiated fuel from inland reactors. To date, no such shipments have been made because no shipper has undertaken to convince the St. Lawrence Seaway Authority and its American counterpart, the St. Lawrence Seaway Development Corporation, that such shipments may be made safely and without significant financial risk. Negotiations are currently underway for the shipment of irradiated Douglas Point reactor fuel to France via the St. Lawrence Seaway. These negotiations could result in a precedent-setting shipment during this year.

Much scope remains for improvement through the design and development of improved packaging for the transportation of radioactive materials. The IAEA regulations, by being stated in terms of performance standards give full scope to the designer for the utilization of his own ingenuity and most recent technology and materials in a packaging design which optimizes to a high degree, the functional, economic, and safety requirements. A good understanding of the IAEA Regulations and their bases is an essential prerequisite to optimum packaging design.

Specification packagings, for which details are published in the regulations, are very advantageous to shippers because of their ready availability and the absence of design and approval costs. More specification packagings are required and these must be developed by industry organizations such as the Canadian Nuclear Association and proposed to the regulatory authorities.

Effective dissemination of information on the packaging and shipment of radioactive materials is essential both within the nuclear industry and to a lesser degree, within the transportation industry. Much unnecessary duplication of design and development effort may be avoided by a more comprehensive literature search or by closer cooperation between companies either directly or within industry organizations such as the Canadian Nuclear Association. Carriers and transport facility operators need guidance and assurance from the nuclear industry
to help overcome some of their fears and misapprehensions about handling radioactive materials and to maintain a good safety record.

Seminars and symposia are one of the most effective means of information dissemination and a special effort should be made by shippers, packaging designers, and carriers to participate in these events. Forthcoming seminars and symposia include an IAEA Seminar on Test Requirements for Transport Packaging for Radioactive Materials planned for February 1971 in Vienna and the Third International Symposium on Packaging and Transportation of Radioactive Materials planned for Richland, Washington during August 1971. Incidentally, it is hoped to host the Fourth International Symposium in Canada during 1974.

The final means by which the full potential of the transportation of radioactive materials can be achieved is by an active industry participation in the regulation-setting process. The Working Group on IAEA Regulations has been very fortunate to have had representatives from the Canadian Nuclear Association, Atomic Energy of Canada Limited, and Ontario Hydro at its meetings. These industry representatives have provided a very excellent theoretical and practical input to the regulations. The period of the next year will be a very important time for a continuing high quality of industry participation in the regulation-setting process because the 1972 Edition of the IAEA Regulations will be finalized for use during the next ten-year period.

4) CONCLUSION

Significant progress has been made in the transportation of radioactive materials with the completion of the IAEA Regulations and the adoption and application of these regulations in Canada and the many nations of the world. In the Canadian case, this progress has been the result of close cooperation between the nuclear industry and the regulatory authorities.

Much potential remains to be achieved in the transportation of radioactive materials. Improvement of regulations and their application, improvement of packaging design and development of additional specification packagings, information dissemination, and active industry participation will assure the achievement of this potential. As in the case of the progress, the potential will be more readily achieved by the continuing close cooperation between the nuclear industry and the regulatory authorities. In this respect, the Atomic Energy Control Board pledges its full support.
APPENDIX 1  RADIOACTIVE MATERIAL TRANSPORT REGULATORY AUTHORITIES

IN CANADA
<table>
<thead>
<tr>
<th>MODE</th>
<th>REGULATORY AUTHORITY</th>
<th>REGULATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAIL</td>
<td>Director of Operation, Railway Transport Committee, Canadian Transport Commission</td>
<td>Regulations for the Transportation of Dangerous Commodities by Rail, 8th Amendment.</td>
</tr>
<tr>
<td>MARINE</td>
<td>The Chairman, Board of Steamship Inspection, Marine Regulations Branch, Department of Transport.</td>
<td>Presently using IAEA Regulations pending formal adoption of IMCO &quot;International Maritime Dangerous Goods Code&quot;.</td>
</tr>
<tr>
<td>ROAD</td>
<td>Acting regulatory authority: Atomic Energy Control Board.</td>
<td>IAEA Regulations are used as a guideline under the Shipping Containers Order 1/200/63.</td>
</tr>
<tr>
<td>POST</td>
<td>Post Office Department</td>
<td>Canada Official Postal Guide, Section 335.</td>
</tr>
</tbody>
</table>

APPENDIX 2

CANADIAN REGULATORY AUTHORITIES AND THEIR REGULATIONS
<table>
<thead>
<tr>
<th>Type of Packaging</th>
<th>Mode of Transport</th>
<th>Total</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rail</td>
<td>Road</td>
<td>Marine</td>
</tr>
<tr>
<td>Type B</td>
<td>9</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Large Radioactive Source</td>
<td>27</td>
<td>32</td>
<td>26</td>
</tr>
<tr>
<td>Fissile Class I</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fissile Class II</td>
<td>8</td>
<td>9</td>
<td>3</td>
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<tr>
<td>Fissile Class III</td>
<td>3</td>
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<td>0</td>
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<tr>
<td>Special Arrangements</td>
<td>3</td>
<td>35</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>105</td>
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</tr>
<tr>
<td>Percent of Total</td>
<td>24</td>
<td>49.5</td>
<td>21.2</td>
</tr>
</tbody>
</table>

APPENDIX 3

ANALYSIS OF PACKAGING AND MODAL APPROVALS ISSUED

SINCE ADOPTION OF IAEA REGULATIONS IN JANUARY 1969