# SAFE TRANSPORT OF RADIOACTIVE MATERIALS

**Transport of radioactive materials is of vital importance for the full international development of the peaceful uses of atomic energy. The Agency's Regulations for the Safe Transport of Radioactive Materials (1964 Revised Edition) were prepared for the purpose of aiding international cooperation in transport, of making full use of all available expertise and of easing the tasks of the carriers of such material. The following article has been prepared from a lecture delivered to Agency staff by Mr. George Appleton, of the IAEA, Division of Health, Safety and Waste Disposal.**

Provided that due consideration is given to the control of its several hazards, radioactive materials may be moved as easily as the "conventional" dangerous goods which are everyday consignments on most transport systems. Such a thesis logically suggests making full use of the trained staff and expertise of the consignor (or producer of the radioactive material) thus requiring no more onerous attention from the carrier than is given to the other dangerous goods. It is on such a pattern that the Agency's Regulations were prepared.

The care which has to be taken with radioactive materials arises from the damaging effects of its radiations upon living tissue either from material outside the body, termed an external radiation hazard, or from material within the body, termed an internal radiation hazard. Though there is no doubt about the necessity of controlling the former, and it may be done in a simple manner, the control or prevention of the latter is of paramount importance due to the chronic conditions which may ensue. On the premise that the regulations should aim at a uniform standard of safety it would be illogical to apply the same controls to all radioactive materials. They may therefore be grouped according to their risk potential. Such a philosophy is already followed in radioisotope laboratories throughout the world.

The majority of everyday substances contain trace quantities of radioactive material. It is thus necessary to define "radioactive material" as being material with a specific activity greater than a certain specific activity, which has been chosen to be 0.002 microcuries per gramme.

The hazards of radioactive materials, so defined, depend, among other factors, on the concentration of radioactivity per unit mass of material i.e. on specific activity. In general the lower the specific activity the lower the potential risk. Thus as a first step in the grading of radioactive materials in respect of the

risk involved we may consider two general classes — low specific activity radioactive materials and radionuclides. Examples of low specific activity materials are natural uranium and thorium ores, concentrates and metals (unirradiated). Radionuclides are further divided into groups reflecting their relative hazard potential; ideally each radionuclide should be treated separately but for practical purposes they are classified into eight groups.

There is also the question of the quantity of activity involved; a range of limits has therefore been established ranging from so-called "exempt quantities" to those requiring the maximum controls, termed large radioactive sources. Related to these in respect of the radionuclides, is the relaxation given to material which is in a form unlikely to be dispersed — termed special form material. This may be intrinsically non dispersible and non radioactive, or encapsulated to provide such properties.

Some radioactive materials have fissile properties. Control here is quite separate from controls applied in respect of the radiological hazards — but the same philosophy is followed as far as possible. Thus small quantities of radioactive materials which are also fissile are defined for which no additional controls are required. The transport of the larger quantities of fissile materials is mentioned later.

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A group of Type A packages for radioactive material. (Photo from IAEA film, "Safe Transport of Radioactive Material".)

A picture from the IAEA film, "Safe Transport of Radioactive Material" shows a possible accident — a radioisotope type A package being run over by a lorry — within a sequence describing procedures to be taken in cases of accidents.

## METHODS OF SAFETY CONTROL

The two essential methods of radioactive safety control are containment and shielding. The former is concerned with preventing dispersal and intake of the material into the body; the latter with reducing the radiation emitted to an acceptable and safe level. In workplaces such controls may be effected by equipment supplemented by skilled handling procedures; in transport it is essential that they should be inherent in the packaging. This should be able to withstand the conditions likely to be encountered in transport.

It is comparatively simple to provide packaging which will withstand normal conditions of transport. Under accident conditions such packaging could be completely destroyed and the contents dispersed. The simplest solution would be to require that all radioactive materials, to be transported, be packed in robust packaging able to withstand severe accidents. However, it can be shown that even if small quantities of radionuclides are dispersed under accident conditions the potential exposure of persons will be within acceptable limits. Furthermore a very large percentage of current radioactive material shipments are made in small quantities for which the requirement for robust packaging would be unduly restrictive and unnecessary. Therefore in the Regulations small quantities of radionuclides have been defined which may be carried in packagings required to withstand only the normal conditions; such packagings are called Type A. Larger quantities of radionuclides may only be transported in packagings able to withstand severe accidents, called Type B packagings.

For low specific activity materials the small quantities of activity present, plus its dilution justifies a relaxation to use strong industrial packagings such as metal drums or lined sacks, or to transport the materials in bulk.

To facilitate the acceptance of a packaging plus its radioactive contents (termed a package) for international transport it is necessary that it should comply with some internationally accepted standards. This is provided for in the regulations in the form of a series of design principles for Type A and Type B packagings supplemented by a series of mechanical and physical tests, simulating to the extent possible both normal and accident conditions. A package, of Type A or Type B, should be able to withstand the appropriate series of tests without loss or dispersal of the radioactive contents or loss of shielding efficiency.

The packaging will contain and shield the radioactive contents during transport. However, during the filling of the packaging radioactive material may come into contact with and remain on the external surfaces of the package. The Regulations state the levels of such contamination at or below which a package may be handed over for transport.

## MARKING AND LABELLING

By proper attention to the material, limitation of quantity and use of adequate packaging, the completed package may enter the transport environment as an inherently relatively safe unit. The only information required on

the outside is to the effect that it contains radioactive material, and a statement, in easily understood terms, of the level of radiation emitted — not at the surface for which permissible limits are laid down, but at 1 metre from the centre of the package, termed the transport index; the latter is used by the transport operator in selecting the proper stowage position. This information is provided on labels which must be affixed to two opposite sides of the package.

For very small quantities of radionuclides, or small quantities incorporated as integral parts of instruments and apparatus it is only required that the packaging prevent leakage under normal conditions of transport, or that it be strong. No labelling on the exterior of the package is required but it is necessary that the external radiation and any contamination on the surface be at, or below, prescribed levels.

For low specific activity materials which may be transported in strong industrial packages or in bulk there are no requirements other than that under normal conditions, there should be no escape of material to the exterior of the packages or of the vehicle or compartment in which the materials are carried in bulk. However, because there is no control of the contamination on the external surfaces of the packages or in loading the bulk material it is required that all such consignments travel as "full loads" which means they have sole use of a vehicle, or hold, or compartment and are loaded, unloaded, and handled in accordance with the instructions of the consignor or consignee. On completion of the transport operation, and if the vehicle or hold is not to be used for such materials again, the consignor is responsible for ensuring that the space is cleaned or decontaminated to, or below, the levels of contamination specified in the Regulations.

Provision is also made for certain low specific activity materials, unirradiated natural uranium and thorium in all forms other than gaseous or liquid, to be transported in strong industrial packages in other than full load consignments. Each such package must be appropriately labelled, must not contain activity in excess of the limits for Type A packaging and must comply with the requirements regarding external radiation emission and external surface contamination.

## LARGE SOURCES AND FISSILE MATERIALS

Large radioactive sources will usually represent many thousands of curies of activity and can include large shipments or irradiated fuel. The regulations require that the packaging used be a Type B but thereafter the additional provisions are laid down for the package (packaging and contents). The essential additional requirements are aimed at ensuring satisfactory conditions of temperature and pressure within the package, particularly since liquid or other heat transfer medium may be present, and the limitation of the temperature at accessible positions on the external surface of the package.

To facilitate international acceptance the regulations contain internationally accepted and detailed criteria for package design. In addition to the approval of the design of a package the actual shipment must also be approved.

Additional provisions are also laid down for consignments of fissile material. These are aimed at ensuring that no condition in which a nuclear chain reaction could be caused will arise. The methods are to limit the quantity (mass) per package; to design the package properly, or to limit the number of packages permitted to be assembled together. Packages fall into three classes: Fissile Class I packages which are safe in any number and in any arrangement, accomplished by design; Fissile Class II packages which are safe in limited number in any arrangement, controlled in part by the package design; and Fissile Class III packages which can be moved only under special arrangements. For the control of the Fissile Class II Package allowable numbers the transport index is used; by limiting the total number of transport indices on packages permitted in one stowage position to the same that is permitted for external radiation control the transport operator can apply the same stowage rules to all labelled packages without any complication. Naturally large safety factors have been introduced for the case when more than the permitted number of packages would inadvertently come together.

The Regulations contain internationally accepted criteria for the design of Fissile Classes I and II packages. It is important to have international accord in the design of such packages since consignments which may "meet" during transport must be compatible with each other, i.e. producing no dangerous interactions.

## FULL LOAD STOWAGE

Stowage of a consignment is, generally, the responsibility of the carrier. With regard to radioactive material however this is only partly true since there is the condition of "full load" stowage of which all handling is the responsibility of the consignor, consignee or their representatives.

Full load stowage may be used for the carriage of any consignment but there are certain loads for which it is mandatory. The latter are those which present conditions abnormal from those provided for generally under the Regulations, and therefore necessitating a certain degree of restricted access. For example where there is an increased external radiation field around a package when the transport index, or the number of milliroentgen per hour at 1 metre from the centre, exceeds 10; where there is a relatively high external surface temperature above 50°C in the case of a large radioactive source; and where there is a contamination problem as in the case of unlabelled packages of low specific activity materials, or bulk loads of those materials.

The carrier will provide the vehicle, or part of a vehicle, and the consignor or his representative in stowing the materials must observe the conditions laid down in respect of any stowage restrictions with other goods and

Irradiated fuel on a journey in England (IAEA film, "Safe Transport of Radioactive Material")

the limitation of external radiation dose rate at the boundaries of such vehicles, or spaces, and at specified distances from them, or in spaces occupied by crew or passengers.

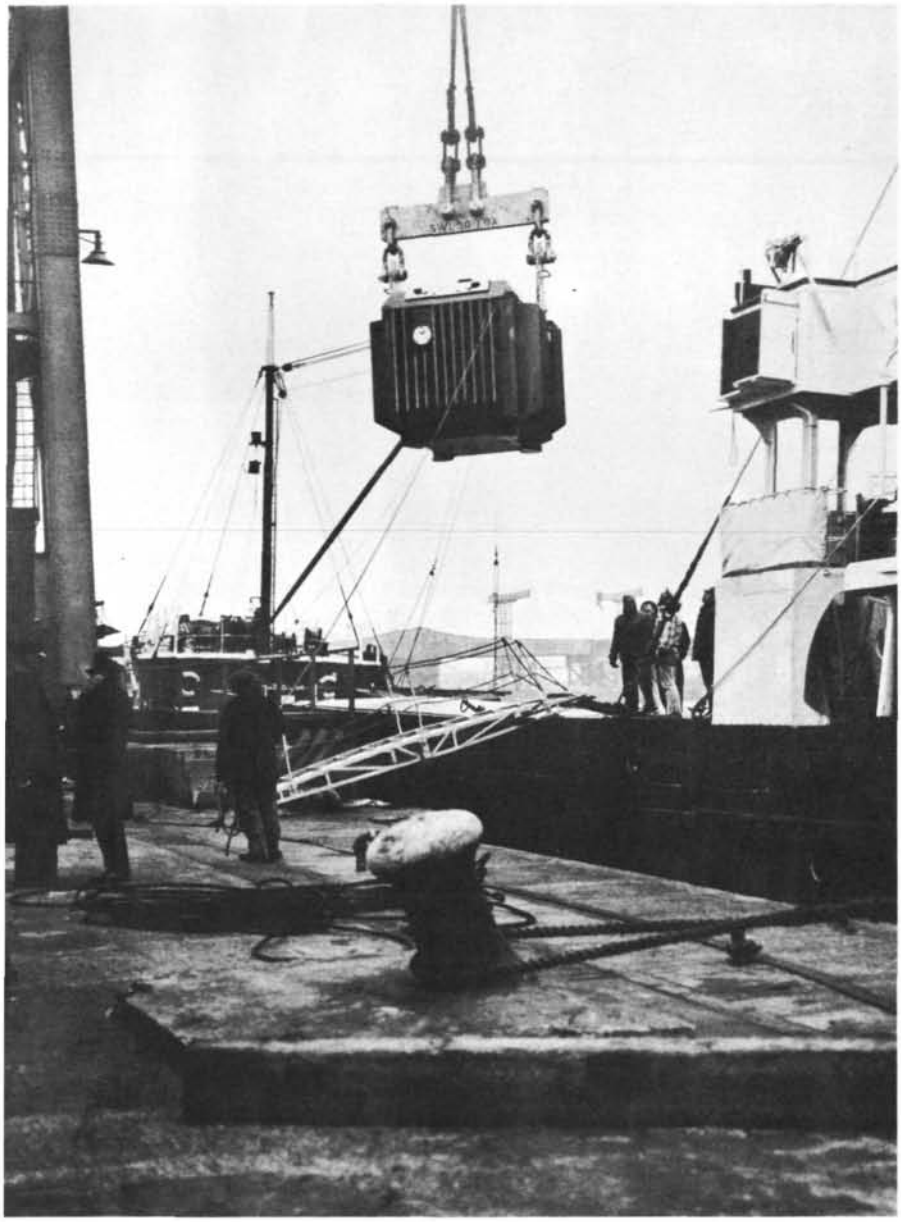
## DOCUMENTATION

The link between the consignor's commitments and the role to be played by a carrier is the certificate that the radioactive material is packed and marked in accordance with the relevant requirements and is in a proper condition for transport. In providing such a certificate the consignor is implicitly responsible for ensuring that all the packaging, packing and labelling provisions are fulfilled.

In some cases he has to obtain the approval of an independent body or Competent Authority. Certificates or copies covering such approvals must be attached to the consignor's certificate.

The approval of the Competent Authority is required for the designs of Type B packaging and encapsulation for special form material, for the designs of packages for pyrophoric radioactive materials, large radioactive sources and

Fuel elements from the Latina Nuclear Power Station (Italy) in a 50-ton steel flask being unloaded in England (UKAEA photo).



Fissile Classes I, II and III packages, and for the shipment of large radioactive sources and Fissile Class III packages.

Fundamentally, in international transport, approvals, where applicable, are required from Competent Authorities in all the countries through which or into which a consignment of radioactive material will pass. However if there exists an internationally accepted set of standards or criteria against which approval may be given then it will suffice if only one Competent Authority approve that the criteria are met; for convenience such a Competent Authority is logically that in the country where the design of a packaging or shipment originates. It is on that basis that the system of Competent Authority approvals has been developed in the Agency Transport Regulations. Thus where a detailed set of standards has been established, as for the design of Type B packaging, only unilateral approval is required i.e. of the Competent Authority in the country of origin; where such detailed standards do not exist or are incomplete multilateral approval is required i.e. approval of the Competent Authorities in all the countries en route.

It is further required of a consignor that he make available, at the time of delivery of the consignment for transport, full details of the nature, amount and packaging of the radioactive material. That information need not necessarily accompany the consignment but it should be available at loading, unloading and any transhipment.

## THE CARRIER

The carrier's role in the transport of radioactive materials begins when the consignment, — properly labelled and accompanied by the necessary documents, — is handed over to him as a complete unit and is limited to ensuring that it is adequately and properly stowed for the journey. All the information that the carrier requires in this respect is given on the label.

Consignments of radioactive materials must be stowed away from consignments of other dangerous goods which may react detrimentally with the inherently safe packages. The label indicates that radioactive material is present and it is necessary to keep it away from packages carrying labels appropriate to the other dangerous goods.

The external radiation dose rate in spaces occupied by crew or passengers, resulting from the presence of the radioactive material consignment, must also be controlled. The label informs the carrier as to the degree of such control required; White — Category I packages require no such consideration whereas the yellow — Categories II and III packages require a varying degree of control. The method of control is to place the consignment at adequate separation distances from occupied spaces; the separation distances are obtained from previously prepared tables as a function of the total number of transport units, indicated on the labels, present in a consignment or load.

The above requirements are the only additional day-to-day duties placed upon the carrier of radioactive materials. He is however required to keep the radiation exposure of transport personnel as low as possible and to carry out periodic assessment to ensure that no overexposures occur. Similarly he is required to carry out periodic checks for contamination build-up in vehicles, or spaces, used regularly for the carriage of radioactive materials.

Finally the carrier needs to be advised of the action to be taken in the event of accidents causing damage to packages and the consequent potential dispersal of material. This consists essentially of restricting all access and sending for expert attention in respect of the damaged packages, any dispersed material and other packages, equipment, persons or the spaces which may become contaminated due to the dispersed radioactive material. It is in such events that the detailed information discussed above will be most useful.