In the course of transport by road, rail, sea and air, consignments of radioactive material are in close proximity to ordinary members of the public and in most cases they are loaded and unloaded by transport workers who have no special training or experience in the handling of radioactive substances.

The materials being transported cover a wide variety – ranging from small batches of short-lived radionuclides used in medical practice which can be transported in small sealed lead pots in cardboard boxes, to large, extremely radioactive consignments of irradiated nuclear fuel in flasks weighing many tons.

With the growing development of nuclear power programmes the transport of irradiated fuel is likely to increase markedly. It is clear that unless adequate regulations concerning the design and assembly of the packages containing these materials are precisely set down and strictly carried out, there would be a high probability that some of the radioactive contents would be released, leading to contamination of other transported goods and the general environment, and to the delivery of a radiation dose to the transport workers and the public.

An additional requirement is that the transport should proceed smoothly and without delay. This is particularly important for radioactive materials of short half-life, which would lose significant amounts of their total activity in unnecessary delays at international boundaries.

Therefore, it is essential that the regulations are also enforced, to ensure that the radioactive material is contained and the surrounding radiation level reduced to a value which poses no threat to other sensitive goods such as photographic film, or to transport workers and other passengers. These regulations should be as uniform as possible on an international basis, so that consignments can move freely from one country to another with as little delay as possible at the frontiers.

Development of the IAEA Transport Regulations

By 1959 various national and international regulations, which were mostly based on the rules of the United States Interstate Commerce Commission, permitted the transport of radioactive ores and relatively small amounts of radioactive materials for medical and industrial applications. Special permits had to be issued for the transport of larger quantities and for fissile materials. It was then realized that the IAEA was a suitable organization to develop truly international regulations and in July 1959 the Economic and Social Council of the United Nations requested that the Agency be entrusted with the drafting of recommendations on the transport of radioactive substances.
With the help of panels of experts from Member States and representatives of international organizations concerned with the transport of goods, the first IAEA Regulations for the Safe Transport of Radioactive Materials were prepared in 1960, approved by the Board of Governors and published in 1961. As approved, these Regulations are mandatory only for work performed by the Agency itself and for work in Member States for which the Agency provides substantial assistance under the terms of an agreement. During subsequent years, however, the Agency’s Regulations have been adopted by almost every international transport organization and by many individual Member States. They now form the basis of regulatory requirements for the transport of radioactive materials on land, on water and in the air, throughout the world.

The IAEA Regulations were reviewed at intervals between 1963 and 1966 by consultants and by panels of experts. As a result of these reviews, revised editions were published in 1964 and 1967. A comprehensive review of the regulations as a whole, based on almost ten years’ experience in their operation, was undertaken between December 1969 and October 1971. The revised text, presented in a more straightforward and simplified format, was approved by the Board of Governors in September 1972 and published as the 1973 Revised Edition.

The decision to review the Regulations in 1969 was not forced on the Agency because of any inadequacy in the existing text. It resulted from a wish to utilize the extensive operating experience that had accumulated by that time, and to clarify and simplify them as far as possible without any sacrifice of the standard of safety that had been achieved.

It is intended that in future comprehensive reviews of the Regulations should be undertaken every ten years. This will ensure that their general structure is as stable as possible and that changes are introduced only in response to a real need. At the same time, the Director General has been authorized by the Board to promulgate changes that might be necessary to keep the Regulations technically up to date, provided that written notice is given to Member States 90 days in advance and that due account is taken of any comments submitted by them.

During the 1969-71 review, technical material dealing with methods of meeting the basic regulatory requirements was deleted from the Regulations. This material, together with other material of an advisory nature prepared by a panel which met in November 1971, has been published as a companion volume under the title, “Advisory Material for the Application of the IAEA Transport Regulations”. This document will be reviewed at intervals of about 2 1/2 years to ensure that it remains technically up to date, and so that any useful additional guidance can be included.

**Basic Safety Requirements**

The basic safety requirements for the transport of radioactive materials are:

1. Adequate containment of the material.
2. Adequate shielding against the radiation emitted by the material.
3. The dissipation of the heat generated by high activity radioactive material.
4. Prevention of criticality, if the material is fissile as well as being radioactive.

When these requirements are adequately met, the radioactive substance can be transported as simply and rapidly as other potentially dangerous goods such as corrosive and...
oxidizing substances. If a radioactive substance has other hazardous properties, the appropriate regulations relating to those properties must also be complied with.

In developing the regulations for radioactive materials, the principle has been adopted that as far as practicable the necessary safety features are "built in" to the design of the package, and as few additional demands as possible are made on the carriers. This means that the consignor is responsible for the design and assembly of the package, and that the carrier is called upon only to observe some simple rules for separating the package from undeveloped film and from any persons, based on information provided on a label affixed to each package.

Containment and Shielding

Two main types of packaging, Type A and Type B, are provided for in the Regulations:

- Type A packaging is intended to provide adequate containment and shielding under normal conditions of transport, including the somewhat rough handling that packages must be expected to receive. In an accident, however, it is accepted that the containment will be breached and that some of the contents will escape. The maximum activity of each radionuclide that can be transported in a Type A package is therefore limited so that in the event of its partial release in an accident, the risk to transport workers and members of the public will not be unacceptable.

- Type B packaging on the other hand is intended to retain adequate containment and shielding even in the event of a very severe accident during any mode of transport.

Both Type A and Type B packagings must be capable of passing a prescribed series of tests that would be expected to produce the type of damage that would be encountered in rough handling and in accident conditions, respectively. For Type A packagings, this includes a water spray with impact test, free drop, compression and penetration tests. For Type B packagings, the series includes the Type A tests, as well as a nine-metre drop test on a flat target, a drop on a steel bar and a fire test. The Regulations allow the use of reasoned arguments to demonstrate the passing of the tests as an alternative to presenting the results of actual tests.

Upper limits are prescribed for the activities of individual radionuclides that can be transported in Type A packages; these are based on their radiotoxicity and on the radiation emitted. There is no regulatory upper limit on the level of radioactivities that can be transported in a Type B package. The upper limit for any particular package will, however, be specified in its design. Because of the greater potential hazards associated with the use of a Type B package, its design and, in some cases, its shipment require approval by a competent authority. Type B packages are classified in two groups:

- Type B(U) packages, which meet certain design criteria, must be approved by the competent authority of the country of origin only;

- Type B(M) packages, which do not meet all the design criteria, must be approved by the competent authorities of the country of origin and of all the countries through or into which the package is to be transported.

With regard to the shielding provided, packages are classified in three categories each associated with specified levels of external radiation at the surface of the package and at a
A typical Type-A package used for the transport of radionuclides with a limited activity. This particular package shows a "P-can" centralised by a cardboard spider inside an "X-carton". Photo: UKAEA

Before packages with radioactive materials are transported they are checked for surface dose-rates of irradiation. Photo: UKAEA

High-level solidified radioactive wastes will be shipped to the depositories in special containers. Typical of such a container is this shipping cask, located in the mid-portion of a specially constructed railcar and surrounded by heavy steel framework. Photo: Westinghouse Electric Corporation
distance of 1 metre from the surface. The radiation level at a distance of 1 metre from the surface is referred to as the transport index. The three categories are:

- Category I-WHITE,
- Category II-YELLOW,
- Category III-YELLOW.

The category to which a package belongs is indicated on a label fixed to its outer surface. The segregation distances which the carrier must observe can be determined from the entry in a table corresponding to the sum of the transport indexes of the packages.

Special provisions are made for the transport of materials and articles of low activity which are exempt from the packaging requirements, and for low specific activity and low level solid radioactive materials which, because of their greater inherent safety, do not have to meet the full packaging requirements.

Provisions are also made for the carriage of packages in freight containers, including rules for the selection of the category and the labelling of the container.

**The Dissipation of Heat**

Heat is produced by the radioactive disintegrations taking place in the material within the package. This heat must be dissipated in such a way that it does not damage the containment and shielding characteristics of the package, and to ensure that the temperature of the outer surface does not rise to such a level that the package could burn people or damage other neighbouring goods during transport. All Type B packages whose contents exceed the Type A package limits must be assessed for heat transfer. The competent authorities may require special stowage provisions if the surface heat flux of Type B(U) or Type B(M) packages exceeds 15 W/cm².

**Prevention of Criticality**

For the transport of fissile materials that do not qualify for exemption because of their small mass, three classes of packages are prescribed — Fissile Classes I, II and III.

- **Fissile Class I** packages are nuclearly safe in any number and in any arrangement under all foreseeable circumstances of transport. The package design may require unilateral or multilateral competent authority approval, but because no controls in respect of fissile properties are required during transport, no shipment approval is required.

- **Fissile Class II** packages in limited numbers are nuclearly safe in any arrangement under all foreseeable circumstances of transport. The allowable number of such packages can be determined from the transport index which is inscribed on the label. The package design may require unilateral or multilateral competent authority approval, but the shipment does not require approval.

- **Fissile Class III** packages are nuclearly safe under all foreseeable circumstances of transport by reason of special precautions, or special administrative or operational controls, imposed upon the transport of the consignment. The package design may require unilateral or multilateral approval and, because of the operational controls required during transport, multilateral competent authority approval of any shipment is required.
The aim of the prescriptions for these three classes is to achieve safety from criticality to an equal degree during transport. The contributions from the consignor through “built in” safety is greatest in Class I, while the contribution from the carrier, through control measures during transport, is greatest in Class III.

Administrative Requirements

Approval by the competent authority is not required for Type A packages unless they contain fissile material. Unilateral approval is required for Type B(U) package design and multilateral approval for Type B(M) package design, and for the shipment of Type B(M) packages of specified type and Fissile Class III packages. Competent authority approval is also required for special form material and for transport by special arrangement. Notification of the competent authorities of the countries concerned is required before the arrival of packages containing activities greater than specified large values.

Security of Packages

The Regulations require that the outside of each package shall incorporate a feature such as a seal, which is not readily breakable and which, while intact, will be evidence that the package has not been opened. That part of the packaging which provides the containment shall also be capable of being securely closed by a positive fastening device. Tie-down systems are provided for heavy packages, which prevent the package from moving during transport, and from being hurled violently out of position if the vehicle comes to a sudden stop.

These devices are intended to prevent the package from being opened inadvertently, thus releasing the contents, and to prevent the package from causing damage to the vehicle or to other goods. They are not intended specifically to prevent the diversion or theft of a package. The Regulations for the Safe Transport of Radioactive Materials are designed to enable radioactive and fissile materials to be transported as safely and rapidly as other potentially dangerous goods which for many years have been dispatched by all modes of transport.