

AECB 1107Transportation of Radioactive Materials by Air

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1. Basis of the Regulations
 - 1.1 Canadian regulations for the transportation of radioactive materials are based on IAEA Regulations for the Transportation of Radioactive Materials 1973 Revised Edition Safety Series No. 6 STI/PUB/323, International Atomic Energy Agency, Vienna.
 - 1.2 The Atomic Energy Control Act, section 9(d) gives the Atomic Energy Control Board the power to make regulations regulating the transportation of radioactive materials.
 - 1.3 The Atomic Energy Control Regulations, section 23, give the requirements for shipping radioactive prescribed substances which are as follows:

Shipping Radioactive Prescribed Substances

23. (1) No person shall ship any radioactive prescribed substances unless the shipment thereof complies with the requirements respecting packaging and labelling and any other requirements prescribed

(a) by any body having jurisdiction by statute over the proposed mode of transport; or

(b) by the Canadian Transport Commission, if no requirements have been prescribed by any body described in paragraph (a).

(2) Notwithstanding subsection (1), the Board may exempt any shipment of radioactive prescribed substances from the provisions of paragraph (1)(b) upon such conditions as the Board may specify.

Expédition des substances prescrites radioactives

23. (1) Il est interdit d'expédier une substance prescrite radioactive, à moins que l'expédition de ladite substance ne soit conforme aux prescriptions relatives à l'emballage et à l'étiquetage et à toutes autres prescriptions

a) d'un organisme qui, pour ce qui est du mode de transport proposé, a la compétence en vertu d'une loi; ou

b) de la Commission canadienne des transports, s'il n'existe aucune prescription émanant d'un organisme décrit à l'alinéa a).

(2) Nonobstant le paragraphe (1), la Commission peut, à ses conditions, exempter toute expédition de substances prescrites radioactives de l'application des dispositions de l'alinéa (1)b).

1.4 The applicable regulations are given in Table 1.1.

Table 1.1

Regulatory Authorities and Applicable Regulations

<u>Mode</u>	<u>Regulatory Authority</u>	<u>Applicable Regulations</u>
Rail	Director of Operation Railway Transport Committee Canadian Transport Commission	Regulations for the Transportation of Dangerous Commodities by Rail, 10th Amendment
Road	Acting Regulatory Authority Atomic Energy Control Board	As above
Air	Director, Aeronautical Licensing & Inspection Branch, Civil Aeronautics, Transport Canada	International Air Transport Association. IATA Restricted Articles Regulations 19th edition
Marine	Director Ship Safety Branch Canadian Coast Guard Transport Canada	Intergovernmental Maritime Consulta- tive Organization IMCO International Maritime Dangerous Goods (IMDG) Code
Post	Post Master General Canada Post Office	Post Office Regu- lations Section 23, Prohibited Mail Regulations

2. Transportation by Air

Subsection 800(1) of the Air Regulations states that "Explosives and other dangerous articles or substances shall not be carried on board any aircraft except as authorized by the Minister".

NOTAM A1/76 dated 1 June 1976 as issued by the Director General, Civil Aeronautics that "dangerous Goods and magnetized materials shall be carried in accordance with the IATA Restricted Articles Regulations, as amended, and the Atomic Energy Control Board Regulations. Notam A1/76 also requires that

- (1) personnel handling dangerous goods shall complete a training course approved by the Director General, Civil Aeronautics and
- (2) the pilot in command be notified in writing of the materials being carried.

NOTAM A1/76 will become effective 1 June 1977. For air shipments to the United States the requirements of 49 CFR Part 175 must also be met. These requirements are given in "The Official Air Transport Restricted Articles Tariff" published by the Air Transport Conference of America.

The main differences between the U.S. Regulations (See 49CFR Part 175) and IATA Restricted Articles Regulations are:

- (1) Plutonium may not be shipped by air on either passenger or cargo aircraft within, into or from the United States. Under IATA regulations shipments of plutonium are permitted but are restricted to approximately 5 g on passenger aircraft.
- (2) Only exempted quantities of radionuclides and radionuclides used in research or medical diagnosis or treatment may be shipped by passenger aircraft within the United States. Under IATA regulations the limitations are determined by Transport Index (TI) requirements, size of package, and other requirements.

- (3) Present U.S. Regulations (49 CFR Part 175) permit shipments on passenger aircraft of packages with transport indices as high as 10, although shipments with TI's greater than 5 are seldom made. Under IATA regulations, the allowable TI is dependent on the height of the package and the separation distance from the passenger compartment. For Canadian aircraft, a package with a TI of 10 can be shipped on board the Boeing 747, but for most other aircraft the TI per package is limited to 3.
- (4) Present U.S. regulations are based on the 1967 edition of the IAEA regulations. The 19th edition of the IATA regulations will contain two sections covering radioactive materials, one based on the 1967, and one based on the 1973 IAEA Regulations. This will provide a period of time for changeover to the new regulations.

3. The IATA Restricted Articles Regulations

A most important task for the carrier of radioactive materials is to ensure that the shipping documents and the "Shippers Certification for Radioactive Materials" is properly completed and to ensure that the information given on the package corresponds to that given in the documents. Part 2 of the IATA regulations gives the requirements for the transportation of radioactive materials by air. Section 1 of Part 2 is titled "How to use these regulations". By following this section step-by-step, one can determine

- (1) what can be shipped
- (2) how it has to be packaged, labelled and carried
- (3) what documentation is necessary.

It is my intention to discuss the requirements of the shipping document and Shippers Certification and explain the requirements for different types of packaging. This can be done in the following way.

3.1 How to use these regulations.
Follow this section step-by-step to determine what the shipper is required to do.

- 3.2 Definitions See section 2.
- (1) Exempt quantities See section 5.
 - (2) Low level solids
 - (3) Low specific activity materials
 - (4) Fissile radioactive materials. See section 8.
 - (5) Type A quantities. See section 3.
 - A₁ Special form
 - A₂ Other forms
 - (6) Type B quantities
 - Type B(U) Unilateral
 - Type B(M) Multilateral
 - (7) Special Arrangement

The following is a brief summary of the items mentioned. Consult IATA Regulations, Part 2, Radioactive Materials for further details.

(1) Exempt Quantities

Exempt quantities are related to the A₁/A₂ values, which will be discussed below. The exempt quantity limits are given in section 5, Table 7. For materials these values are:

<u>Form</u>	<u>Contents</u>	<u>Package Limits</u>
Solids	Special form	$10^{-3}A_1$
	Other form	$10^{-3}A_2$
Liquids		$10^{-4}A_2$
Gases	Special form	$10^{-3}A_1$
	Other form	$10^{-3}A_2$

The shipper's certification is not required for exempt quantities other than fissile materials. The air waybill must be marked "Exempted Radioactive Material". The inner container must be marked "Radioactive".

(2) Low Level Solids (LLS)

Solids such as waste materials, activated materials, contaminated equipment in which the activity is not greater than $2 \times 10^{-3} \text{Ci.g}^{-1}$.

(3) Low Specific Activity Materials (LSA)

- (a) Such materials as uranium or thorium ores and physical or chemical concentrates of those ores.
- (b) Unirradiated natural or depleted uranium or unirradiated natural thorium.
- (c) Tritium oxide in aqueous solution up to 10 Ci tritium per litre.
- (d) Materials in which activity is not greater than $0.1 \times 10^{-3} \text{Ci.g}^{-1}$.

(4) Fissile Radioactive Materials. See section 8

Fissile material shall mean ^{238}Pu , ^{239}Pu , ^{241}Pu , ^{233}U , ^{235}U . Unirradiated natural or depleted uranium do not come under this definition.

(5) Type A Quantities. See section 3

Packaging for Type A quantities is intended to withstand the damage incurred under normal transport conditions. The quantities designated as A_1/A_2 are limited so that a radiation injury would not result even if the package were completely destroyed.

An example of the change in limits with the introduction of the 1973 IAEA Regulations for several radionuclides which are regularly transported is given in Table 3.1.

Table 3.1

Nuclide	1967 IAEA Regs.			1973 IAEA Regs.	
	Transport Group	Special Form	Normal Form	Special Form	Normal Form
²⁴¹ Am	I	Ci 20	Ci 0.001	Ci 8	Ci 0.008
¹³⁷ Cs	III	20	3	30	9
⁶⁰ Co	III	20	3	7	7
¹³¹ I	III	20	3	40	10
¹⁹² Ir	III	20	3	20	20
⁹⁹ Mo	IV	20	20	100	100
²³⁹ Pu	I	20	0.001	2	0.002
²²⁶ Ra	I	20	0.001	10	0.05
⁹⁰ Sr	II	20	0.05	10	0.4
Mixed fission products	II	20	0.05	10	0.4

(6) Type B Quantities

Type B quantities are those which exceed the limits A_1/A_2 permitted in Type A packaging. Type B packaging is designed to withstand the damaging effects of a transport accident as demonstrated by the required tests. The package must be able to withstand both the tests required for Type A packaging and the subsequent tests designated for Type B packages.

There are two kinds of Type B packaging designated as unilateral Type B(U), and multilateral, Type B(M). Both kinds must meet certain basic requirements. The major difference is that permitted release in one week from a Type B(M) package under accident conditions is higher by a factor of 1000 than the Type B(U), and the Type B(M) package may incorporate a pressure release device.

For Type B(U) packages, the shipper must obtain design approval from the competent authority of the country of origin. For Type B(M) packages design approval must be obtained from the competent authorities of all countries to or through which the package will pass. Type B(M) packages may not be carried on passenger aircraft. For air shipments, the temperature of the accessible surfaces of any package must not exceed 50°C, even when transported as full load.

(7) Special Arrangement

Consignments which do not meet all the applicable requirements may be transported by special arrangement, under conditions required by the competent authority of the country of origin and approved for shipment on the multilateral basis as indicated previously.

3.3 Packing, Labelling & Marking

(1) Labels

Category I	White
Category II	Yellow
Category III	Yellow

	<u>Radiation Level</u>	
	<u>At surface</u> mrem·h ⁻¹	<u>At 1 m</u> mrem·h ⁻¹
Category I - White	less than 0.5	less than
Category II - Yellow	50	1
Category III - Yellow	200	10

(2) Transport Index (TI)

The transport index (TI) is the radiation level in mrem·h⁻¹ at 1 m from the package. For Fissile Class II and III, the TI is the larger of the value as measured above or the number obtained by dividing 50 by the allowable number of packages.

The transport index permitted on Canadian passenger aircraft is limited by the package height and the height of the baggage compartment. The allowable TI on most aircraft seldom exceeds 3.

Packages should be placed at maximum distance from the space occupied by passengers and cabin crew, which generally means on the floor.

(3) Type

Type A packages should be marked

CTC Spec 7A Type A

(4) Competent Authority Identification Mark or Number

All Type B, fissile and special arrangement shipment packages must bear this mark. These packages should not be accepted for shipment unless the mark on the package and on the Shipper's Certification agree. For Type A packages containing special form capsules an identification mark is also required, but this identification will not appear on the package.

(5) Labels indicating "This End Up" or "This Side Up" must be used for packages containing radionuclides shipped as liquids.

(6) Packages permitted on "CARGO AIRCRAFT ONLY" must bear the appropriate label.

3.4 Shipper's Certification - See Section 9

The shipper's certification must be signed by the shipper only, and may not be signed by the cargo agent or freight forwarder. The shipper is punishable by law for failure to comply with these requirements.

3.5 Shipping Documents - See Section 9

Particulars of consignment must be properly entered on the air waybill.

3.6 Handling and Loading - See Section 10

(1) Storage

For category II-yellow and category III-yellow package, the number of packages stored in any one place shall be so limited that the total of the transport indexes does not exceed 50, and a distance of 6 m must be maintained between packages. In the case of fissile materials, this distance must be maintained to avoid the possibility of a criticality incident. Under normal storage conditions packages should be stored at a distance from positions continually occupied by people, since the radiation level varies inversely with the square of the distance from the package.

(2) Carriage

Packages bearing Category I, II, or III labels shall not be carried in passenger compartments. Care must be taken to ensure that packages which are heat sources (i.e. more than $15 \text{ W}\cdot\text{m}^{-2}$) are adequately ventilated.

(3) Separation from Passengers

The conditions of storage on aircraft must be adhered to, in order to minimize exposure of passengers and cabin crew. These conditions are specified in operating instructions to cargo handlers.

3.7 Governmental and Carrier Exceptions - See Section 11

Section 11 of Part 2 must be consulted before shipment to determine whether or not there are any governmental or carrier exceptions to the transport of the particular material which is to be transported.

4. Shipments and Accidents

A brief summary of shipment and reported incidents which have occurred in the transportation of radioactive materials is given in Table 4.1.

The present number of shipments in Canada excluding shipments of uranium and thorium ores and chemical concentrates is approximately 60,000 shipments per year. Recent studies in the United States estimate 600,000 shipments per year which are distributed as follows:

	%
Pass. air and van	55
Cargo air and van	30
Truck	15
	<u>100</u>

Applying similar figures to the Canadian estimate of 60,000 shipments per year we can expect that there may be 33,000 shipments by passenger aircraft, 18,000 shipments by cargo aircraft, 9,000 shipments by truck. However, since the availability of cargo aircraft in Canada is limited, one may expect these shipments to be carried mainly by truck or van.

If we use the 1974 U.S. breakdown for types of material shipped we arrive at the following distribution for Canadian shipments.

Table 4.2

<u>Type of Material</u>	<u>Number of Packages Shipped</u>	<u>% of Total</u>
Radiopharmaceuticals	50,000	83
Medical Research	7,000	12
Other Research	2,400	4
Industrial	600	1
Total	<u>60,000</u>	<u>100</u>

Table 4.1

Incidents by Year
Compared with
Number of Shipments 1957-1975

<u>Year</u>	<u>No. of Incidents</u>	<u>No. of Shipments</u>
1957	1	2760
1962	2	7030
1967	5	14420
1972	3	48170
1973	8	50440
1974	8	52090
1975	13	54750
Totals		
1957-75	61	402210

Large quantities of radioactive materials are shipped by truck and rail, and those which are exported are shipped by all modes.

With regard to transport incidents Table 4.3 indicates the mode and location of the 61 incidents reported from 1957-1975.

Table 4.3

Incidents by Mode and Location

<u>Mode</u>	<u>In Transit</u>	<u>Terminal</u>	<u>Total</u>
Air	10	8	18
Road	30	5	35
Rail	1	1	2
Sea	3	3	6
	<u>44</u>	<u>17</u>	<u>61</u>

Table 4.4 indicates the degree of severity of aircraft incidents on a scale of I to IV. Some comments on the more serious incidents follow.

Table 4.4

Severity of Air Transport Incidents

<u>Class</u>	<u>Description</u>	<u>Transit</u>	<u>Terminal</u>	<u>Total</u>
I	Package not damaged	5	3	8
II	Package damaged No loss of contents	4	3	7
III	Package failure Increase in radiation	1		1
IV	Package damaged Contents spilled		2	2
		<u>10</u>	<u>8</u>	<u>18</u>

The package failure in Class III occurred in December 1965 when a package containing 56 Ci of iridium-192 was shipped from Philadelphia to Toronto. The device holding the source in position was broken.

The source then moved to a less shielded position. Several passengers may have been exposed to doses up to 5 rem and airport workers to 14 rem at this time.

The damaged packages in Class IV from which the contents were spilled contained 2 mCi of carbon-14 and 200 mCi of molybdenum-99. Exposure of airport workers was minimal and contamination was removed without difficulty.

It is evident that accidents will occur during the transport of radioactive materials by air, but no incidents to date have resulted in serious radiation exposure to passengers, aircraft crew or airport workers. Care must be taken in the transfer from road carrier through the terminal and from the terminal to the aircraft to ensure that packages are not mishandled in such a fashion that they can be damaged by airport vehicles.

