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AIR TRANSPORTATION OF RADIOACTIVE MATERIALS PECULIARITIES

Viktoriia Ivannikova[1], Roksolana Novytska[2]
[1, 2]National Aviation University, Kyiv, Ukraine
E-mails: [1]vicg@bigmir.net, [2]lananovytska@ukr.net

Abstract. There are strict limits for radioactive materials shipments by air. The safe transport of radioactive materials is achieved by tight compliance with all possible regulations. The worldwide philosophy of radioactive material transport is that it should be safe.

Keywords: radioactive, package, hazard.

1. Topic actuality

Persons transporting radioactive material both shippers and carries by any mode of transportation and especially by air transport shall be deemed in compliance with the strict regulations. The article presents the most useful and the most complicated rules

Radioactive materials are very important in our lives since they are the vital part of modern society. They are used in such fields as industry, medicine, research, defense, and power production. To be used, most radioactive materials must first be transported by trucks, trains, ships or airplanes. Transporting such kinds of goods stands for important part of safety policy.

Radioactive material is any material that contains unstable (radioactive) atoms. The unstable atoms emit radiation. Radioactivity is the process of unstable (or radioactive) atoms trying to become stable. This is done by emitting radiation in the form of alpha particles, beta particles, neutron particles, and gamma rays. Uranium ores, nuclear fuel assemblies, spent fuel, radioisotopes, and radioactive waste are the few examples of most transportable radioactive materials. For purposes of transportation, radioactive materials are defined as those materials which spontaneously emit ionizing radiation and have a specific activity exceeding 70 Becquerel per gram of material (Bq/g), or 0.002 microcurie per gram of material (μCi/g) [3].

There are strict limits for radioactive materials shipments by air. The only exclusion is for radiopharmaceuticals. They are medical substances used to diagnose or treat illnesses. They are small and of light weight and they are peculiar because of short living. They must be delivered quickly to hospitals and medical laboratories, so air shipment is generally the best method [1].

After analyzing the data about radiological shipments, the conclusion is evident: the biggest part of all shipments include medical substances and subsequently they are transported by aircraft.

Table 1. Radioactive materials shipments structure

Radiological Shipments by Industry	
Medical/Research	54.50%
Waste	14.80%
Miscellaneous	12.00%
Uranium Compounds	10.70%
Empty Containers	6.00%
Nuclear Fuel	1.80%
Spent Fuel	0.20%

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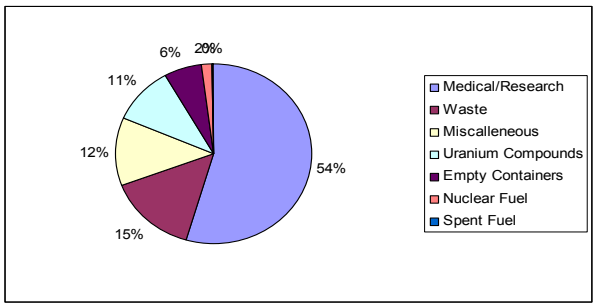

Fig. 1. Radioactive materials shipments structure

2. Rules and regulations

The safe transport of radioactive materials is achieved by tight compliance with all possible regulations. The International Atomic Energy Agency (IAEA) is the main regulatory body for this case. It issues both standards, based on more than 50 years of research and experience with the transportation of radioactive materials, as well as regulations that serve as a model for use in governing the safe packaging, handling, and transport of radioactive materials in international trade. International shippers use IAEA consensus standards to safely transport radioactive materials. The IAEA governs international shipments with help of cooperation the International Civil Aviation Organization for air transport.

3. Transportation of ram

The worldwide philosophy of radioactive material transport is that:

- Safety should be primarily focused on the package. Packaging is the first line of defense.
- Package integrity should be directly related to the degree of hazard of the material [3].

The accidents involving radioactive materials are very rare and that is only due to prevention of them by proper preparation, packing and providing all needed conditions. Radioactive materials are transported by any kind of transport mode depending on the type of the material, size and weight of its packages and distance to be covered. Peculiarly air transport is used for short-lived contents such as medical treatment s, and they may be transported with other commodities in one and same aircraft with no risk due to performance-oriented and certified packaging. After radioactive materials are placed in the proper packaging, they are sealed, surveyed with special instruments to determine that radiation is within regulatory limits, and checked for external contamination. The package is then marked and labeled to provide information about its contents.

4. Packages

All radioactive materials must be properly packaged so that the radiation level at the package surface does not exceed allowable limit. This protects package all stuff working with material and shippers against receiving excess dose rates.

Alpha, beta, and gamma radiation have different penetrating powers. All three forms can be damaging and require different shielding materials.

Four basic types of packaging are used:

1) Excepted – used to transport materials with extremely low levels of radioactivity and must meet only general design requirements (smoke detectors).

2) Industrial (IP) – used to transport limitedly hazardous materials(contaminated equipment and concrete). These are also known as strong, tight containers[1]. There are three subcategories: IP-1, IP-2 and IP-3.

3) Type A packaging's – used to transport highly concentrated radioactive materials (radiopharmaceuticals and low-level radioactive wastes). Typically, may include an inner containment vessel made of glass, plastic, or metal and packing material made of polyethylene, rubber, or vermiculite.

4) Type B packaging's – used to transport high radioactivity level materials (radioisotopes such as cesium-137). May be presented as small drums and heavily shielded steel casks that sometimes weigh more than 100 metric tons (98 tons).

5. Packaging tests

To ensure safe transportation all the packages are properly tested. The tests are developed in different countries such as USA, Germany and Japan based on real-life data of actual accidents.

The strictest are test for type A and B packages because other types can meet only general requirements.

Type A tests include such tests to ensure their tightness, there should be no radioactive content release:

- to simulate rainfall - water spray for 1 hour;
- penetration test by dropping a 6-kilogram bar vertically onto the package from a height of 1 meter;
- 1 hour on a vibrating platform so that the package will be raised high enough for a rigid material;
- compression test of at least 5 times the weight of the package for at least 24 hours;

  drop of the package onto a flat, hard surface – free-drop test.

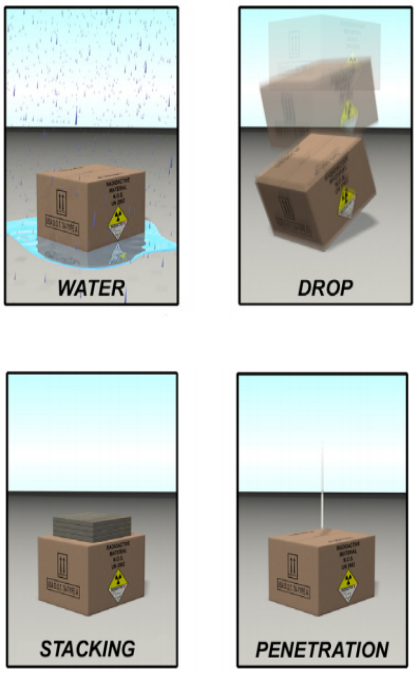

Fig. 2. Representation of Type A packages tests

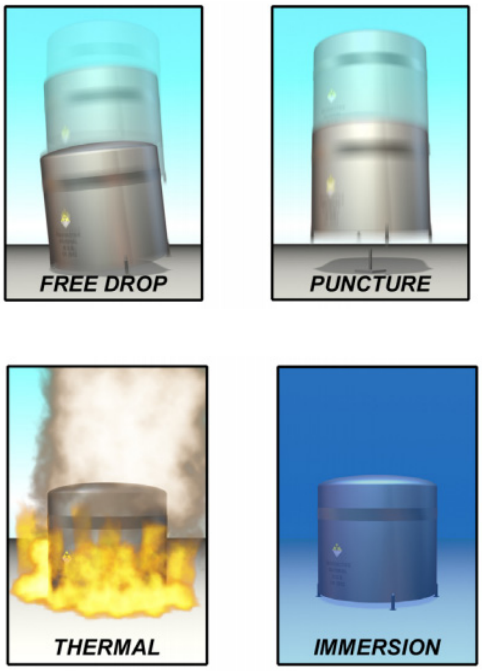

Fig. 3. Representation of Type B packages tests

Type B test are computer-based, more complicated and determine the structure of packages. This structure is changed every five years. The tests are:

- free drop impact: a 9-meter drop onto a flat surface so that the package's weakest point is struck. the drop yields an impact speed of about 50 km/h [2];
- puncture: a free drop onto a steel rod, striking at the most vulnerable spot of the package;
- a dynamic crush test is required for low-density or light-weight packages. it consists of dropping a 500-kilogram mass from 9 meters onto the package;
- testing of heat resistance is due to exposure of the entire package to 800°c for 30 minutes.

Immersion test: package immersed under 0.9 meters of water in a position where maximum leakage is expected.

6. Responsibilities

Radioactive materials are prepared for transport, classified and packed, marked and labeled at the origin point by shipper, who also has to fill papers. Shipper is to ensure and certify the correct data and proper usage of marking.

The carrier who transporting has to examine papers' certification validity, check materials and vehicles for labeling and their stowing and security. If there is an accident, appropriate organization should be reported by carrier.

Routes for vehicles with radioactive materials are chosen according to strict rules and regulations to minimize the hazard of radiation exposure.

There are several factors taking into account while choosing a carrier or mode of transportation. These are:

- carrier's equipment for scaling availability and suitability;
- both origin and destination terminal facilities;
- pickup service and delivery;
- estimated time in transit;
- carrier's safety and security measures.

7. Marking and labeling

Placards are required on vehicles transporting one or more packages [1]. Markings should include name of shipper, his emergency number, his name and address, and other. All the packages should have labels on opposite sides to identify easily the contents and its level of radioactivity level. Labels notify a hazard index for proper handling.

One of three labels is usually used by shipper: Radioactive White I, Yellow II, or Yellow III. Although the package required for transporting radioactive material is based on the activity INSIDE the package, the label required on the package is based on the radiation hazard OUTSIDE the package. [4] The transport index which is to be marked on the label is measured by dividing the highest radiation dose rate (μSv/hr). Low-level-radioactivity shipments presenting no severe hazard are not labeled [4].

Table 2. Determination of hazard level

Label	Surface Radiation Level		Radiation Level at 1 Meter
White I	Does not exceed 0.5 mrem/hr		Not applicable
Yellow II	Does not exceed 50 mrem/hr	AND	Does not exceed 1 mrem/hr
Yellow III	Exceeds 50 mrem/hr	OR	Exceeds 1 mrem/hr

Fig. 4. Class 7 Dangerous goods labels (Radioactive)

References

1. Training for packaging, transportation and storage of radioactive materials.
2. *IAEA-TECDOC-702.* The air transport of radioactive material in large quantities or with high activity. IAEA, Vienna, 1993. ISSN 1011-4289. 48 p.
3. Training by Office of Nuclear Safety. <training.fema.gov/EMIWeb/downloads/is302/ss_mod05_sg.pdf>
4. Labeling. <http://www.nrc.gov/reading-rm/basic-ref/teachers/labeling.html>
5. University of Alberta Safety Manual < http://www.ehs.ualberta.ca/DocumentsandProcedures/~/media/Environmental%20Health%20and%20Safety/Documents/Manuals%20and%20Documents/Microsoft_Word_-_Packaging_and_Transport_of_Radioactive_Material.ashx>