SURVEY OF RADIOACTIVE MATERIAL TRANSPORT IN CHINA

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China

Abstract

SURVEY OF RADIOACTIVE MATERIAL TRANSPORT IN CHINA.

The paper gives an outline of the transport of radioactive material in China. At present, the annual freight volume of packages of radioactive material is some 100 000 items. The total activity is about 1.8 PBq. The radioisotopes are mainly ^{131}I, ^{32}P and ^{198}Au. The available results show that individual doses to transport workers are rather low. The annual dose equivalent is less than 5 mSv/a. Much attention has been paid to the safe transport of the radioactive material. Hence, no accident with serious radiation effects has ever happened. A working group is preparing Chinese regulations for the safe transport of radioactive material on the basis of IAEA Safety Series No. 6 (1985).

1. CIRCULATION OF PACKAGES

1.1. Number of packages

The transport of radioactive material began in the early 1960s. At that time, the number of packages of such material transported each year was quite limited. There were only some 20 types of manufactured radioisotope articles. With the rapid development in the production and application of radioisotopes in China, the freight volume of packages of radioactive material has greatly increased. For example, packages of radioisotopes and their manufactured articles produced and distributed by the Institute of Atomic Energy of Beijing increased

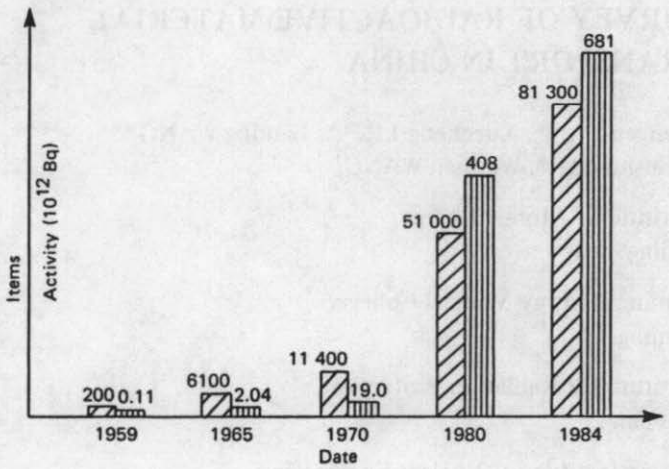

FIG. 1. Number of items and total activity of radioisotopes and related manufactured articles produced and distributed by the Institute of Atomic Energy, Beijing.

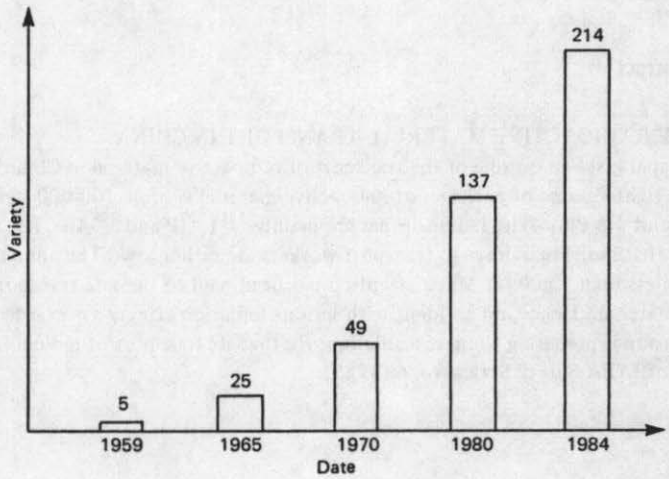

FIG. 2. Variety of radioisotopes produced by the Institute of Atomic Energy, Beijing.

from 200 in 1959 to 81 300 in 1984 (see Fig. 1). The variety of manufactured radioisotope articles has now increased to more than 300. For example, the types of radioisotope produced by the Institute of Atomic Energy increased from 5 in 1959 to 214 in 1984 (Fig. 2). The annual freight volume of different types of packages by all modes of transport is about 100 000 items, of which packages for industry, agriculture, medicine and scientific research account for more than 98%. The total activity is about 1.8 PBq (4.86×10^4 Ci). The radioisotopes involved are mainly ^{131}I, ^{32}P and ^{198}Au.

TABLE I. PROPORTION OF PACKAGES IN TRANSPORT CATEGORIES (1984)

Transport category	I	II	III	IV	Total
Number of packages (10^3)	94.9	2.6	0.2	6.5	104.2
Proportion (%)	91.1	2.5	0.2	6.2	100.0

TABLE II. PROPORTION OF DIFFERENT MODES OF TRANSPORT

Transport modes	Rail	Post	Air	Road and sea	Total
Number of packages (10^3)	48.5	46.8	3.2	5.7	104.2
Proportion (%)	46.8	44.9	3.1	5.5	100.0

1.2. Transport categories

In the past 10 years, the freight volume of radioisotope packages (of which about 60% is used for nuclear medicine) has greatly increased. The proportion of packages in the various transport categories in China in 1984 is listed in Table I. It can be seen from Table I that 90% of the packages belong to category I-WHITE (the radiation level at any point on the external surface does not exceed 0.01 mSv/h). Category III is very rare. For the sake of safety, packages with higher external radiation levels or radioactivity are always transported under exclusive use.

1.3. Transport modes

The proportion of the different modes is given in Table II. It can be seen that transport by rail is the main mode in China at the moment. Of course, most postal packages travel to their destination by rail as well. Hence, packages transported by rail actually amount to more than 90%. Those packages which need auxiliary transport by road when transported by rail, air, vessels and post are not included in the number transported by road in Table II.

2. PACKAGING

2.1. Packaging requirements for all packages

In order to achieve safe transport, different package requirements are prescribed according to the contents (five categories). For instance, for radioactive sources of ^{14}C, ^{55}Fe, ^{60}Co, ^{226}Ra, etc., it is required to have an inner container made of glass, plastic or metal. This container is tightly sealed (for gaseous radioisotopes, it must be made of metal sealed by welding). Then the inner container is put into an outer container made of metal or plastic. The gap between the two containers is filled with soft or absorbent material. An outer packaging such as a metal box, plastic bag (drum) or cardboard box, is used to wrap the whole arrangement after the lid of the outer container is screwed on.

2.2. Variety of packagings

There are some 20 kinds of packagings used in China at the moment, to transport all kinds of radioisotope products. A shipping flask for irradiated fissile material is under design.

3. RADIATION PROTECTION CONDITIONS AT TRANSPORT STATIONS

The radiation protection conditions for transport stations (including railway stations, airline terminals and ports) require warehouses appropriate for temporary storage of radioactive packages, transport workers specially trained in radiation protection, and radiation protection monitoring. According to some incomplete statistics, about 30% of transport stations have set up special warehouses or goods shelves. However, they are not well equipped, e.g. 'Ionizing Radiation' labels are not put up at some stations. Only a few stations have transport workers who have received special training. The local sanitation and antiepidemic stations are in charge of radiation protection monitoring, but a complete monitoring system has not been established,

4. EXPOSURE DOSE TO TRANSPORT WORKERS

4.1. Exclusive use

The loading and unloading and escort activities are generally undertaken by the consignor, and individual monitoring is provided. Table III shows the annual cumulative dose to radioisotope transport workers from the Institute of Atomic Energy in 1984. It can be said that the individual dose to transport workers

TABLE III. DOSES TO TRANSPORT WORKERS (INSTITUTE OF ATOMIC ENERGY, 1984)

Type of work	People monitored	Collective dose equivalent (man·Sv)	Average dose equivalent (mSv)	Maximum dose equivalent (mSv)
Porter	7	1.37×10^{-2}	2	5.2
Driver[a]	11	1.66×10^{-2}	1.5	4.8
Fork lift driver	1	5.0×10^{-4}	0.5	
Total	19	3.08×10^{-4}	1.62	5.2

[a] The drivers often carried packages.

is less than 5 mSv per year. The data from the Public Health Department of Jilin Province show that individual doses are: drivers 1 mSv/a, porters 2 mSv/a, escorts 1 mSv/a. These data indicate that the individual doses to workers involved in the transport of radioactive material in China are rather low.

4.2. General transportation

Part-time workers involved in the transport of radioactive packages have not been provided with individual monitoring because the packages transported by these workers are mostly category I-WHITE with a fairly low level of external radiation exposure; the operational frequency is low and working hours short. Hence, the annual dose equivalent to them may be considered as less than 5 mSv/a.

5. TRANSPORT REGULATIONS

5.1. Existing regulations of some departments

For transport by rail, draft regulations for provisional enforcement were completed in 1961. They were revised in 1972 as "Regulations for the Transport of Dangerous Goods" (trial use), in which radioactive material is classified under dangerous goods in 'Category 10'. The regulations prescribe exemption limits and content limits for packages (Table IV), packaging categories and requirements in transit, etc. In 1979, the General Civil Aviation Administration of China issued "Regulations for Chemicals" (trial use), in which Appendix V is "Regulations for the Transport of Radioisotopes". Besides transport categories and packaging

TABLE IV. LIMITS FOR RADIOACTIVE MATERIAL

Packaging category	Physical state	Maximum activity per package (Ci)	Maximum number of packages in a consignment of part-load or in a carriage or cabin for part-load goods (items)
I	Massive solid	25	40
	Powder, crystalline or liquid	1	40
II	Massive solid	25	10
	Powder, crystalline or liquid	1	10
III	Massive solid	35	2
	Powder, crystalline or liquid	1	2

and shipment requirements, these provide limits for the loading locations and number of items in different types of aircraft. In 1983, the Ministries of Public Health and Posts and Telecommunications jointly issued "Regulations for the Postal Transport of Radioisotopes", which prescribes that packages containing the radionuclide ^{125}I with an activity of less than 0.2 mCi (surface dose equivalent rate is less than 1.3 Sv/h) may be consigned for shipment at designated post offices. For transport by road, sea and inland waterway, there are not yet any special regulations.

5.2. Problems in existing regulations

The main problems in existing regulations are as follows:

(1) Some limits are different from those in IAEA Safety Series No. 6; these include exemption limits, transport categories, limits for the radioactive contamination on package surfaces and activity limits for a single package, etc. These differences are not conducive to international exchange.

(2) Requirements for the design, manufacture and testing of packaging are not clearly specified.
(3) Administrative measures are not very rigid. For example, no clear requirements for the design of packagings and for transport modes and routes have been established. Also, approval procedures and the organization of radiation protection measures have not been clearly defined.
(4) The contents of the regulations are not perfect. For instance, radiation protection conditions for transport stations, radiation protection monitoring in transit, annual radiation dose limits for transport workers, quality assurance, and optimization procedures in radiation protection during the transportation of radioactive material have not been stipulated.

6. ACCIDENTS

6.1. Types of accident

Because considerable attention has been paid to the safe transport of radioactive material, few accidents occurred within the past 20 years. The data from Beijing, Shanghai, Liaoning province and the Institute of Atomic Energy show that 17 transport accidents with some impact occurred during transport by rail and road. In the transportation by sea, inland waterways, air and post, accidents have never happened. Statistical data from Beijing, Liaoning province and the Institute of Atomic Energy show that radiation accidents in transit (including internal transport within an organization) account for some 8% of all radiation accidents. The proportion of accident types is listed in Table V. It can be seen that most transport accidents are those in which conveyance and working area were contaminated by radioactive material; these amount to 52.9% of the total accidents. Secondly, 'source missing' accidents constitute 29.4%. The contamination areas are mainly the warehouses at stations and the means of transport. However, there was one accident in which the traffic route was contaminated. That was when luminescent powder containing mesothorium (radium-228) was transported by truck; more than 100 km of road were contaminated because the glass ampoule containing luminescent powder was broken and not found in time. Fortunately, contamination was not serious. The total source activity for all 'source missing' accidents was less than 10^8 Bq.

6.2. Consequences

No accidents have resulted in a serious radiation hazard or environmental contamination because transport accidents involving strong radiation sources have never happened. However, accidents have had a considerable influence on public psychology.

TABLE V. PROPORTION OF ACCIDENT TYPES FOR 17 ACCIDENTS

Accident type	External exposure	Air pollution	Surface contamination	Source missing	Total
Number	2	1	9	5	17
Proportion (%)	11.8	5.9	52.9	29.4	100.0

TABLE VI. ANALYSIS OF CAUSES OF 17 ACCIDENTS

Cause of accident	Violations	Operating faults	Equipment defects	Natural factors	Total
Number	5	1	9	2	17
Proportion (%)	29.4	5.9	52.9	11.8	100.0

6.3. Analysis of accident causes

The main causes of the 17 accidents have been analysed and are listed in Table VI. It can be seen that accidents resulting from equipment defects are the most frequent; this kind of accident accounts for 52.9% of the total. The occurrence of accidents in which a radioactive source fell from a lead container was also high, 5 out of 17 accidents belonging to this category. It seems that the main lesson has not been learned and special precautions have not been adopted.

7. PERSPECTIVES

In order to increase safety in the transit of radioactive material to meet the needs of increasing numbers of radioactive packages and to facilitate international exchange and international through transport, a working group has been instituted. It is investigating national and international conditions pertaining to the transport of radioactive material and developing Chinese regulations for the safe transport of radioactive material on the basis of IAEA Safety Series No. 6 (1985). Subsequently, different departments will formulate appropriate guidance and regulatory measures.

Research will be carried out on raising the safety level of transport (e.g. developing standard containers, optimizing radiation protection in transit, etc.), establishing monitoring systems for different modes of transport, carrying out scientific administration and strengthening the education and training of transport workers, etc.