

## Radiation Protection Management for Category I Materials Transport

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## Abstract

Radioactive materials transport implements graded administration in China. Radioactive materials are divided into three categories. Category I materials have large radioactivity and may induce very serious consequence, including spent fuel, high level radioactive waste, class I radioactive sources, etc. Due to strong radioactivity and possible serious consequence caused, radiation protection shall be done carefully for Category I Materials transport. Consignor, carrier and consignee play important role during radioactive materials transport, which liabilities are introduced. *Radiation Protection Program, Emergency Response Program and Emergency radiation monitoring procedures* shall be prepared in advance. Radiation Monitoring for Package and Conveyance include start radiation monitoring, in transit radiation monitoring, end radiation monitoring and emergency Radiation Monitoring. Individual protection focus on workers and the public who may be affected by RM transport. Some workers dose data are provided. Doses to persons shall be below the relevant dose limits. The doses to individuals are subject to dose constraints within the restriction. Protection and safety shall be optimized.

## Introduction

Radioactive materials transport implements graded administration in China.<sup>[1, 2]</sup> According to the features of the radioactive materials transported and their potential harm to human health and environment, radioactive materials are divided into three categories. Category I materials have large radioactivity and may induce very serious consequence, including spent fuel, high level radioactive waste, class I radioactive sources, etc.

There are seventeen nuclear power plants with forty-three reactors in operation and thirteen reactors under construction at mainland of China as of October 30, 2018. More and more spent fuels

are produced at these NPP. The spent fuel assemblies need to be transport to reprocessing plant to produce recycle fuel. Thousands of class I sources need to be carried to or away hospital and irradiation station. A lot of high level radioactive wastes are waiting to be transport to disposal.

Due to strong radioactivity and possible serious consequence caused, radiation protection shall be done carefully for Category I Materials transport.

**Table 1 Directory of category I radioactive materials<sup>[2]</sup>**

| Radioactive materials   | Examples   | Container type | Package type         | UN No. |
|---|--|----------------|----------------------|--------|
| Radioactive materials With activity exceeding A <sub>1</sub> or A <sub>2</sub>            | Spent fuel;<br>High level waste  | B(U)           | B(U)                 | 2916   |
|   |  | B(U)F          |                      | 3328   |
|   |  | B(M)           | B(M)                 | 2917   |
|   |  | B(M)F          |                      | 3329   |
|   |  | C              | C                    | 3323   |
|   |  | CF             |                      | 3330   |
| 0.1 kg or more uranium hexafluoride   |  | H(U)<br>H(M)   | Uranium hexafluoride | 2978   |
|   |  | H(U)F<br>H(M)F | Uranium hexafluoride | 2977   |
| Radioactive material transported under special arrangement                                |  | T              | Special arrangement  | 2919   |
|   |  | X              |                      | 3331   |
| Fissile radioactive materials With activity no exceeding A <sub>1</sub> or A <sub>2</sub> | New fuel for reactor   | AF             | A                    | 3327   |
|   |  |                |                      | 3333   |
| LSA-III fissile material  |  | IF-2<br>IF-3   | IF-2<br>IF-3         | 3325   |
| LSA-II fissile material   |  | IF-2<br>IF-3   | IF-2<br>IF-3         | 3324   |
| SCO-I or SCO-II, fissile material   |  | IF             | Industry package     | 3326   |
| Classification I radioactive source   | Industrial irradiation source; radiotherapy source, raw material for Cf-252 source, etc. | B(U)           | B(U)                 | 2916   |
|   |  | B(M)           | B(M)                 | 2917   |

### Liability Subject

Consignor, carrier and consignee play important role during radioactive materials transport.

### Consignor

Consignor shall take effective radiation protection measures during transport and responsible

for nuclear safety, which is regulated in Law on Nuclear safety.<sup>[3]</sup>

Order 562 is the most important regulation for RM transport in China, in which the safety responsibility and radiation protection requirements for consignor and carrier are fitted. The Consignor shall formulate emergency plan for nuclear or radiation accidents, take effective radiation protection and security measures in transport, and be responsible for the nuclear or radiation safety of RM transport. The Consignor shall prepare the transport instruction, nuclear or radiation emergency response guide, safety protection guide.

### **Carrier**

Carrier shall be licensed for transport qualification to transport radioactive wastes, which is regulated in Law on Nuclear safety. Order 562 regulated that the Carrier shall have the qualification for dangerous goods VII, establish radiation protection regulations and nuclear or radiation accident emergency measures.

### **Radiation Protection Program**

According to the requirements of regulation and standardization on RM transport, all major consignors and carriers in China have gradually formed the systemized RM transport safety documents, including radiation protection program, the corresponding radiation monitoring procedure and record sheets, etc.

The consignor shall build up his own organization structure for radiation protection and establish radiation protection program. The purpose of the program is to make sure that the consignor has already built up the running organization system and cleared specific duties, ensured the dose limits of occupational exposure, raised relative safety protection measures to optimize the protection and safety.

Generally, the carrier shall make his own program or measures, and make them into the radiation protection system of the consignor.

### **Radiation Monitoring for Package and Conveyance**

#### **Start Radiation Monitoring**

The competent department of environmental protection of the province, autonomous region or municipality shall carry out supervision and inspection on the transport preparedness of the consignor for RM before shipment.<sup>[4]</sup> The consignor of Category I RM shall entrust a qualified radiation monitoring agency to monitor its surface contamination and radiation levels before shipment, and the radiation monitoring agency shall issue a radiation monitoring report.<sup>[5]</sup> Consignor shall provide the monitoring report to obtain the license for departure.

Dose rate and surface containment are measured usually on packages and vehicles. TI is checked for all kinds packages. For exclusive use shipment, the doses at surfaces and 2m distance from package surfaces are needed to measure.

#### **In transit Radiation Monitoring**

Monitoring in transit is necessary for detecting possible shielding weakness or leakage. According to Radiation Protection Program and Radiation Monitoring Program of consignor, dose

rate raised from photon and/or neutron is usually monitored. Surface contamination monitoring usually is unnecessary. The typical monitoring positions usually include the surface of packages and vehicles, certain distance from the surfaces of packages and vehicles, depending on shipment methods and packages features. The monitoring chances usually at before departing and after arrival every day. Portable equipment is more convenient. However, online monitoring located cab cage or safeguard conveyance can provide real-time monitoring.

### **End Radiation Monitoring**

End monitoring is carried out jointly by consignor and consignee, which is one of the receiving condition. Monitoring report shall be prepared to witness the radiation safety. The monitoring contents and methods usually should be the same as the start radiation monitoring.

### **Emergency Radiation Monitoring**

Emergency radiation monitoring plan shall be included in Radiation Protection Program and Emergency Response Program. Emergency radiation monitoring procedures shall be prepared in advance. Emergency monitoring should be prepared base on potential accident condition, which may be varied for different packages and shipment methods. Measuring is conducted usually by first arriving response personal, which usually is the team members. Radiation protection experts and measuring instruments may be backed up for most accidents.

Measuring shall be carried out at incident or accident conditions to detect the radiation levels at and around the packages to prevent personnel from the super-dose exposure. Damaged or suspected damaged packages shall be checked by measuring. Package integrity may be confirmed by Radiation level monitoring, aerosol monitoring, contamination sampling measurement, etc. Radiation dose rate in accident area and distribution for surface contamination shall be checked. Emergency personnel individual dose monitoring shall be done. Public person around accident point should be checked who may be affected. Monitoring equipment should have quick time response and enough wide dose rate range.

Radiation levels and contamination levels shall be confirmed by measuring for affected area after resumption.

## **Individual protection**

### **Workers**

The consignor and the carrier shall, in accordance with the relevant provisions of the national occupational disease prevention and control, carry out personal dose monitoring for workers who are directly engaged in the RM transport and establish personal dose documents and occupational health care documents.<sup>[1]</sup> For occupational exposures arising from transport activities, where it is assessed that the effective dose: (a) is most unlikely to exceed 1 mSv in a year, neither special work patterns nor detailed monitoring nor dose assessment programs nor individual record keeping shall be required; (b) is likely to be between 1 and 6 mSv in a year, a dose assessment program via work place monitoring or individual monitoring shall be conducted; (c) is likely to exceed 6 mSv in a year, individual monitoring shall be conducted.<sup>[6]</sup> When individual monitoring is conducted, appropriate

records shall be kept.

In fact, the everyone of workers wear dosimeters during transport period, and the cumulative dose are measured after every task or every three months and recorded in documents. For example, an investigation shows that data is documented for all workers, who engaged in the new fuel assemblies transport, although the personal annual dose is less than 1 mSv. The records show that the personal annual dose are from 0.26 mSv to 37 mSv for all of 23 escorts in 2010, from 0.19 mSv to 32 mSv for all of 23 transport workers in 2011, from 0.21 mSv to 33 mSv for all of 23 transport workers in 2012.

### The Public

The public is unnecessary to monitoring at normal transport. However, for providing sufficient protection, a dose restriction of 1 mSv in a year to the critical group in areas where the public has regular access is used to calculate segregation distances, with accounting taken of exposures expected to be delivered by all other relevant sources and practices under control. For example, the dose constraint value for public alone line is less than 0.03mSv/a, which is approved by NNSA for the Daya Bay spent fuel transport activity by road with 4 packages/a.

### **Conclusions**

The rays and particles from arising nucleus decay or reaction can't be seen, smelled or listened, unless instruments are used. Materials classed to category I may induce more serious hazard to people and environment, more attention should be pay on radiation protection during transport. Doses to persons shall be below the relevant dose limits. The doses to individuals are subject to dose constraints within the restriction. Protection and safety shall be optimized. Radiation protection shall be arranged in advance. Emergency conditions shall be considered at the same time.

### **References**

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