JOURNAL OF RADIATION INDUSTRY

Original article

16(3) : 241-251 (2022)
https://doi.org/10.23042/radin.2022.16.3.241

Comparison of Imported-cargo Radiation Monitoring Regulatory Systems in Korea, the United States, the United Kingdom, and Japan

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Abstract After the Fukushima nuclear power plant accident in 2011, concerns have emerged regarding the exposure of radioactive materials to products imported into Korea. Hence, Korea enacted the Act on Protective Action Guidelines against Radiation in the Natural Environment. According to this law, radiation monitors must be installed and operated at airports and ports. Currently, radiation monitoring of cargo imported into Korea is performed by six governmental departments owing to the diverse types and high quantities of imported cargo. In this study, the radiation monitoring systems used for cargo imported into the United States, the United Kingdom, and Japan are compared with the Korean regulatory system. Radiation monitoring of cargo imported into the United States is performed to prevent the threat of terrorism via radioactive materials. Meanwhile, the United Kingdom and Japan implement radiation monitoring systems for the safe transport of radioactive materials. Additionally, the departments and legal systems associated with the radiation monitoring system for cargo imported into Korea are different from those of other countries. This analysis will improve the current radiation monitoring regulatory system for cargo imported into Korea.

Key words: Imported cargo, Radiation monitoring regulatory system, United States, United Kingdom, Japan

1. INTRODUCTION

Owing to the Fukushima nuclear power plant accident in 2011, the Korean National Assembly and civic groups have demanded the radiation monitoring of all products, including imported food and daily necessities. In 2011, Korea enacted the Act on Protective Action Guidelines Against Radiation in the Natural Environment. According to this act, radiation portal monitors must be installed and operated at airports and ports to prevent the inflow of unidentified radioactive materials. Currently, the radiation monitoring system for cargo imported into Korea is operated by six departments: the Nuclear Safety and Security Commission; Korea Customs Service; Ministry of Food and Drug Safety; Ministry of Environment; Ministry of Agriculture, Food, and Rural Affairs; and Korea Forest Service [1]. Although the United States operates a radiation monitoring system for imported cargo, the purpose and methods of monitoring are different from that of Korea. The radiation monitoring system in the United States is conducted based on the Port Safety Act, and the Department of Homeland Security (DHS) specializes in conducting radiation monitoring. In ad-

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Received 31 August 2022 **Revised** 14 September 2022 **Accepted** 16 September 2022

dition, various radiation monitoring programs, such as the Container Security Initiative (CSI) program, are in progress. The radiation monitoring purpose of the United Kingdom and Japan is to enable the safe transportation of radioactive materials. In the United Kingdom, laws are regulated based on the transportation method, and the monitoring system is formed by the Department for Transport (DfT) and its affiliated organizations, the Health and Safety Executive (HSE), and the Civil Aviation Authority (CAA). Similar to the UK, in Japan, laws are regulated based on the transportation method, and the monitoring system is operated by the Nuclear Regulation Authority (NRA), Ministry of Land, Infrastructure, Transport, and Tourism (MLIT), and Ministry of Health, Labor, and Welfare (MHLW). The objective of this study is to compare and analyze the radiation monitoring systems for cargo imported into the United States, the United Kingdom, and Japan with that used in Korea. Therefore, in this study, the purposes, organizations, ministries, and legal systems of radiation monitoring for imported cargo in each country are investigated.

2. RADIATION MONITORING REGULATORY SYSTEM FOR CARGO IMPORTED INTO KOREA

The possibility of radioactive contamination in products imported into Korea has increased since the accident at Japan's Fukushima nuclear power plant. In addition, recycled scrap metals contaminated with radioactive materials were imported into Gunsan Port in Korea in 2014. Therefore, the Act on Protective Action Guidelines against Radiation in the Natural Environment was enacted in July 2011, which comprises six chapters and 31 articles. The purpose of this act is to expand the scope of environmental radiation safety management and prevent unnecessary exposure of the public to natural radioactive substances in their daily life [2]. Owing to the enactment of this law, various measures have been implemented to reduce the risk of environmental radiation. The first is to prevent the inflow of unidentified radioactive materials by installing and operating radiation portal monitors at airports and ports to monitor radiation emitted from imported cargo. The Nuclear Safety and Security Commission installed and operated radiation monitors in ports and airports to prevent the inflow of recycled scrap metals contaminated with radioactive materials into the country. However, the types of cargo imported into Korea are diverse and large; therefore, all imported cargo is not included in the monitoring target of the Nuclear Safety and Security Commission. At the 2011 National Policy Coordination Meeting, a consensus was reached to delegate the radiation monitoring of imported cargo to six departments: the Nuclear Safety Commission; Korea Customs Service; Ministry of Food and Drug Safety; Ministry of Environment; Ministry of Agriculture, Food, and Rural Affairs; and Korea Forest Service [1]. Tables 1 and 2 show the legal basis for the radiation monitoring of imported cargo by the department and each department's monitoring items and standards, respectively [1-14]. The analysis results for the Korean regulatory system indicate that some government departments have unclear legal bases for the radiation monitoring of imported cargo. Additionally, duplicate inspections occurred because of the unclear allocation of monitoring items between some governmental departments.

3. RADIATION MONITORING REGULATORY SYSTEM FOR CARGO IMPORTED INTO OTHER COUNTRIES

3.1. United States

The radiation monitoring system for cargo imported into Korea focuses on protecting people from radiation by preventing the entry of cargo containing radioactive materials into the country. Although the United States operates a radiation monitoring system for imported cargo, the purpose of monitoring is different from that of Korea. In the United States, two approaches have been adopted to prevent the threat of nuclear terrorism since the September 11 attacks. First, radiation monitoring was implemented at airports and ports in the United States. A monitoring system was established to conduct comprehensive security monitoring of cargo distributed in the United States. The Customs and Border Protection of the United States DHS installed

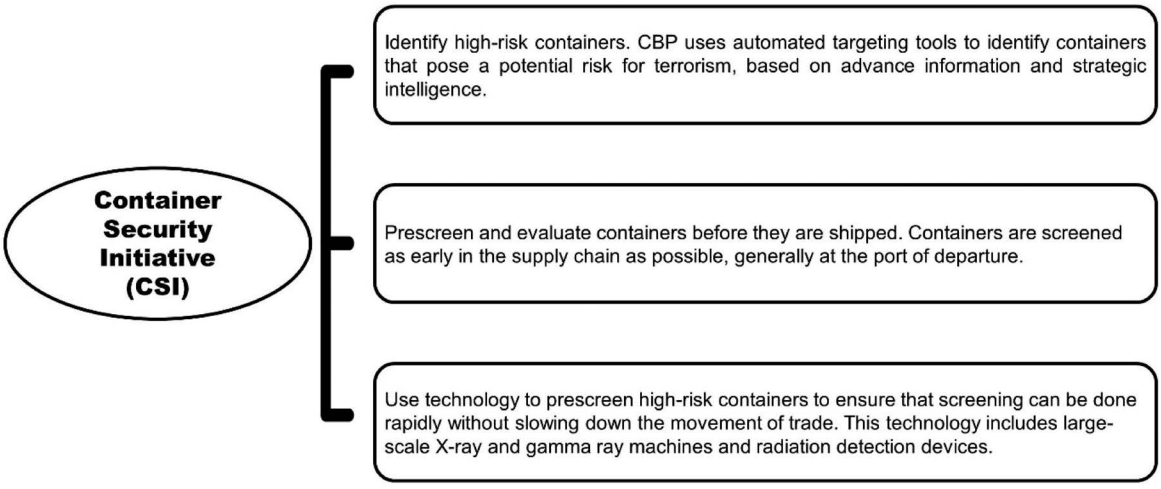

Fig. 1. Three main tasks of the Container Security Initiative (CSI) program [17].

Table 1. Cargo items and legal basis for radiation monitoring of imported cargo by Korean government departments

Department	Legal basis
Nuclear Safety and Security Commission	Act on Protective Action Guidelines against Radiation in the Natural Environment
Korea Customs Service	Working manual for the emergency response to radioactive leakage accidents in neighboring countries
Ministry of Environment	Act on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal
Ministry of Food and Drug Safety	Korean Food Standards Codex
Ministry of Agriculture, Food and Rural Affairs	Control of Livestock and Fish Feed Act, Feed Inspection Standards, Standards and Specifications for Feeds, etc.
Korea Forest Service	Act on the Sustainable Use of Timbers

radiation portal monitors at ports and border checkpoints to monitor all containers and personal vehicles entering the United States. Thus, more than 99% of the containers entering the port were monitored for radiation exposure. Second, radiation monitoring was performed on cargo exported from the United States via the installation of radiation monitoring equipment in overseas ports and a monitoring system. Unlike the radiation monitoring system used in Korea, all monitoring systems implemented in the United States focus on removing the threat of terrorism via close cooperation with organizations [14,15].

In 2006, the United States Congress enacted the Security and Accountability for Every Port Act of 2006 (or the Safe Port Act) to enhance port and cargo security [16]. This law includes the establishment of interagency operations centers for port security and the implementation of the Container Security Initiative to strengthen the security of ports in the United States. The Port Safety Act comprises eight chapters, some of which present provisions concerning radiation monitoring and terrorism threat monitoring for imported cargo containers, as follows: Chapter 1—Security of the United States Ports; Chapter 2—International Supply Chain Security; Chapter 4—Matters Concerning the Domestic Nuclear Detection Division; and Chapter 5—Establishment of the Domestic Nuclear Detection Division and Technology Development Strategy for Radiation Detection [16]. In Chapter 1, the security of ports in the United States, as well as legal contents

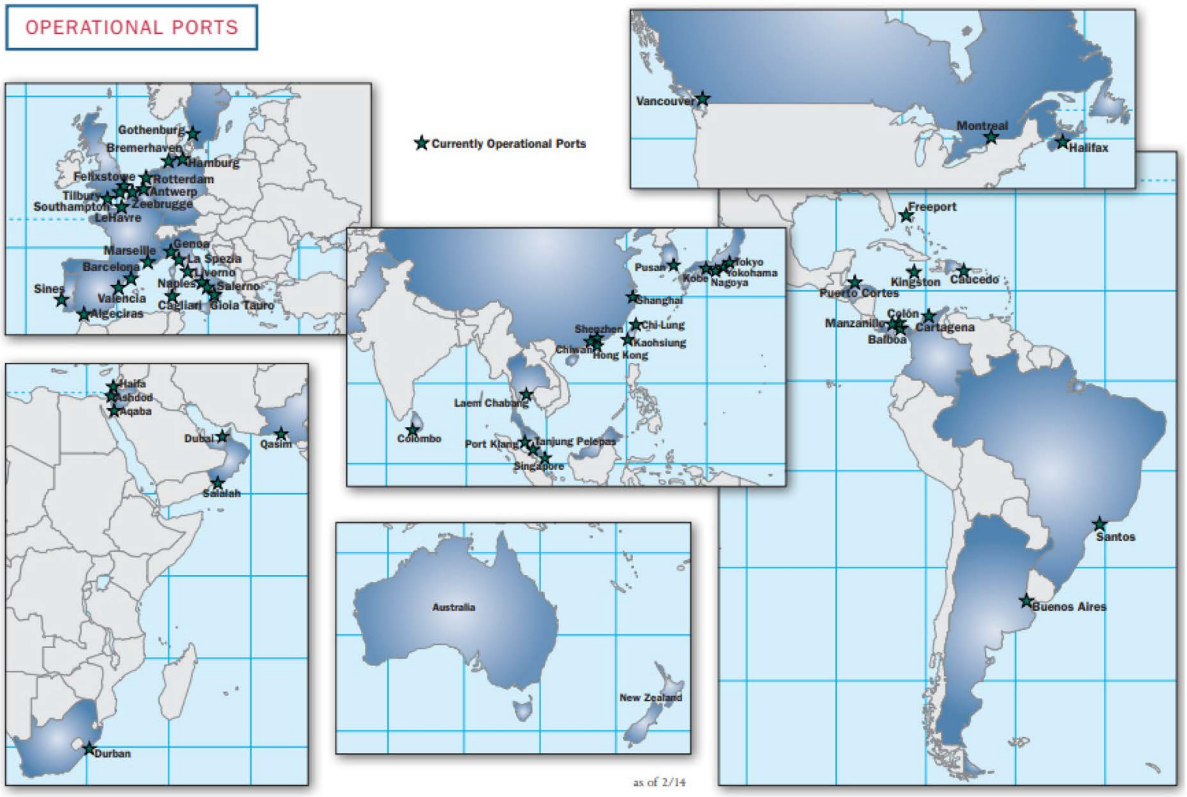

Fig. 2. Ports worldwide that have participated in the Container Security Initiative (CSI) program [18].

pertaining to port operation, radiation measurement, search for passenger ships entering the United States from abroad, and random search for containers are described. In fact, radiation monitoring is demanded all containers entering the United States through 22 major ports in the United States. Chapter 2 (International Supply Chain Security) discusses container security standards and procedures, and the CSI program conducted by the DHS. The aim of the CSI program is to conduct investigations and identify security risks of containers loaded from foreign ports and imported into the United States. Meanwhile, Chapter 5 provides information regarding the Domestic Nuclear Detection Office, which was established to detect the illegal use, development, movement, storage, possession, and importation of radioactive materials, fissile materials, and nuclear explosive devices into the United States and to eliminate their threats.

The CSI program focuses on preventing the importation of cargo containers by performing terrorist threat inspections of containers at foreign ports prior to their arrival in the United States. In this regard, three main tasks are conducted via the CSI program [17]. First, high-risk containers are identified. Second, the containers are evaluated before they are shipped. Third, the appropriate technology is utilized to prescreen high-risk containers such that screening can be performed rapidly without decelerating the trade movement. Figure 1 shows the three main tasks of the CSI program [17]. The DHS has designated foreign ports to participate in the CSI program based on several factors. At the designated foreign ports, containers exported from the United States are inspected to identify containers containing nuclear or radioactive substances, and relevant measures are conducted if significant materials are discovered. Through the CSI program, radiation monitoring equipment has been installed in 58 ports worldwide, including in North America, Europe, Asia, Africa, the Middle East, and South America. More than 80% of cargo shipped to the United States was prescreened. Figure 2 shows the ports worldwide that have participated in the CSI program [18].

Similar to the CSI program, the US Department of Energy (DOE) conducts radiation monitoring on cargo

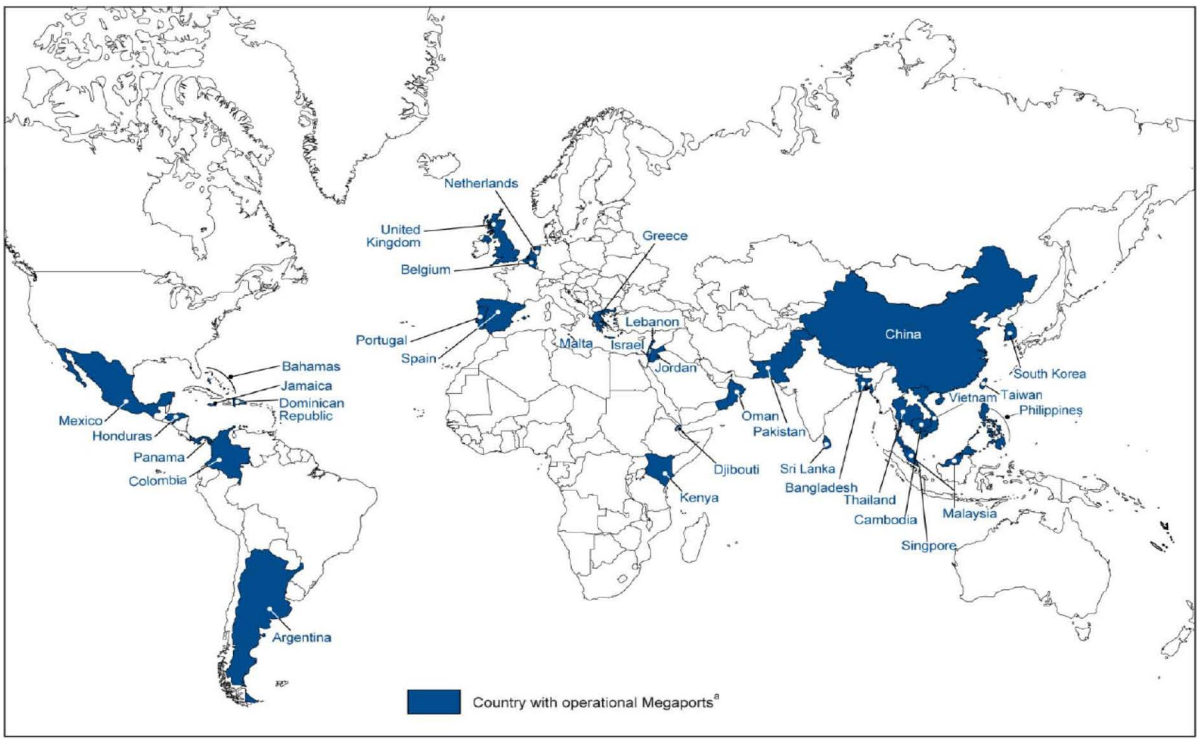

Fig. 3. Countries participating in Megaports Initiative (MI) program [19].

exported from the US. The National Nuclear Security Administration under the DOE established the Megaports Initiative (MI) program. Similar to the DHS's CSI program, the MI program was established to prevent the threat of nuclear terrorism against imported goods entering the United States by linking international hub ports. The National Nuclear Security Administration has collaborated with major foreign countries to provide financial support for installing radiation monitors in major ports in those countries. They conducted training for equipment operation and provided the financial and technical support necessary for surveillance system operation to the partner countries for three years. Henceforth, the partner countries operated monitoring directly. Figure 3 shows the countries that participated in the MI program [19,20]. However, because the MI program is not law based, the operation scope of the program is restricted because of reduced budgets. Although the departments involved in the two programs are different, some similarities are observed. Based on observation, radiation monitoring via the CSI program of the DHS based on the Port Safety Act is dominant.

3.2. United Kingdom

Radiation monitoring of cargo imported into the UK is performed for the transport of radioactive materials to manage hazardous materials, such as radioactive materials, explosives, and poisons. In addition, different regulations are applied, depending on the mode of transport (road, sea, and air). However, all regulations reflect the safe transport of radioactive material in No. SSR-6 (2018), which is a standard recommended by The International Atomic Energy Agency (IAEA) [21]. The UK regulatory departments for regulating the transport of radioactive materials include the Department of Trade and Industry, DfT, HSE, CAA, and Maritime and Coastguard Agency (MCA). The UK regulatory departments involved in the transport of radioactive materials are shown in Figure 4 [22].

First, to comply with the Radioactive Material (Road Transport) Regulations 2002 (No. 1093), the transport of radioactive materials by road is managed by the UK DfT [22]. In radioactive material (road transport) regulations, the following contents concerning the radiation monitoring of imported cargo are described: general provisions concerning transport regulations, provisions

Table 2. Nuclide and standards for radiation monitoring of imported cargo by Korean government departments

Department	Monitoring cargo items	Monitoring standards
Nuclear Safety and Security Commission	Source materials, byproducts from processing	Potassium-40 10 Bq g^{-1}
		Other natural radionuclides 1 Bq g^{-1}
	Processed products	Natural nuclides 1 mSv y^{-1}
	Recycled scrap metals	All nuclides Different values for different radionuclides
Korea Customs Service	Industrial products	– [a]
Ministry of Environment	Waste	– [b]
Ministry of Food and Drug Safety	All food	Iodine-131 ≤100 Bq kg^{-1} or Bq l^{-1}
	Manufactured food and milk for infants, milk and processed milk products, and ice cream	Cesium ≤50 Bq kg^{-1} or Bq l^{-1}
	Other food	Cesium ≤100 Bq kg^{-1} or Bq l^{-1}
Ministry of Agriculture, Food and Rural Affairs	Compound feed, single-ingredient feed, and feed supplements	Cesium 40~160 Bq kg^{-1} or Bq l^{-1} [c]
		Iodine-131 300 Bq kg^{-1} or Bq l^{-1}
Korea Forest Service	Lumber, preserved wood, flame-retardant wood, laminate, plywood, particleboard, oil plates, oriented strand boards, wood flooring, and wood-plastic composites	Cesium ≤300 Bq kg^{-1}
	Wood pellets, wood chips, and wood briquettes	Cesium ≤30 Bq kg^{-1}
	Molded wood and charcoal	Cesium ≤100 Bq kg^{-1}

[a]Not disclosed.
[b]Radioactive inspection report and the results of simple radiation measurement, which prove that cargo are not contaminated with radioactive nuclides of Iodine-131, Cesium-134, and Cesium-137.
[c]Cow and horse: 100; pig: 80; poultry: 160; aquaculture animals: 40; others: 100.

related to radiation protection and safety programs, general information, requirements and controls for transport, requirements for radioactive materials and packaging, and approval requirements for design and delivery.

The transport of radioactive materials by sea was enacted in 1997 based on the Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997 (No. 2367) and managed by the MCA, an agency of the DfT [21,23]. This regulation describes the following contents regarding the radiation monitoring of imported cargo: provisions on the transport of packaged goods, provisions on the bulk transport of dangerous goods or marine pollutants, provisions on space for the bulk transport of packages and dangerous goods in solid form, and provisions on enforcement. Radioactive materials in ports are managed by the HSE based on provisions pertaining to dangerous substances specified in the Harbor Areas Regulations 1987 (No. 37) in

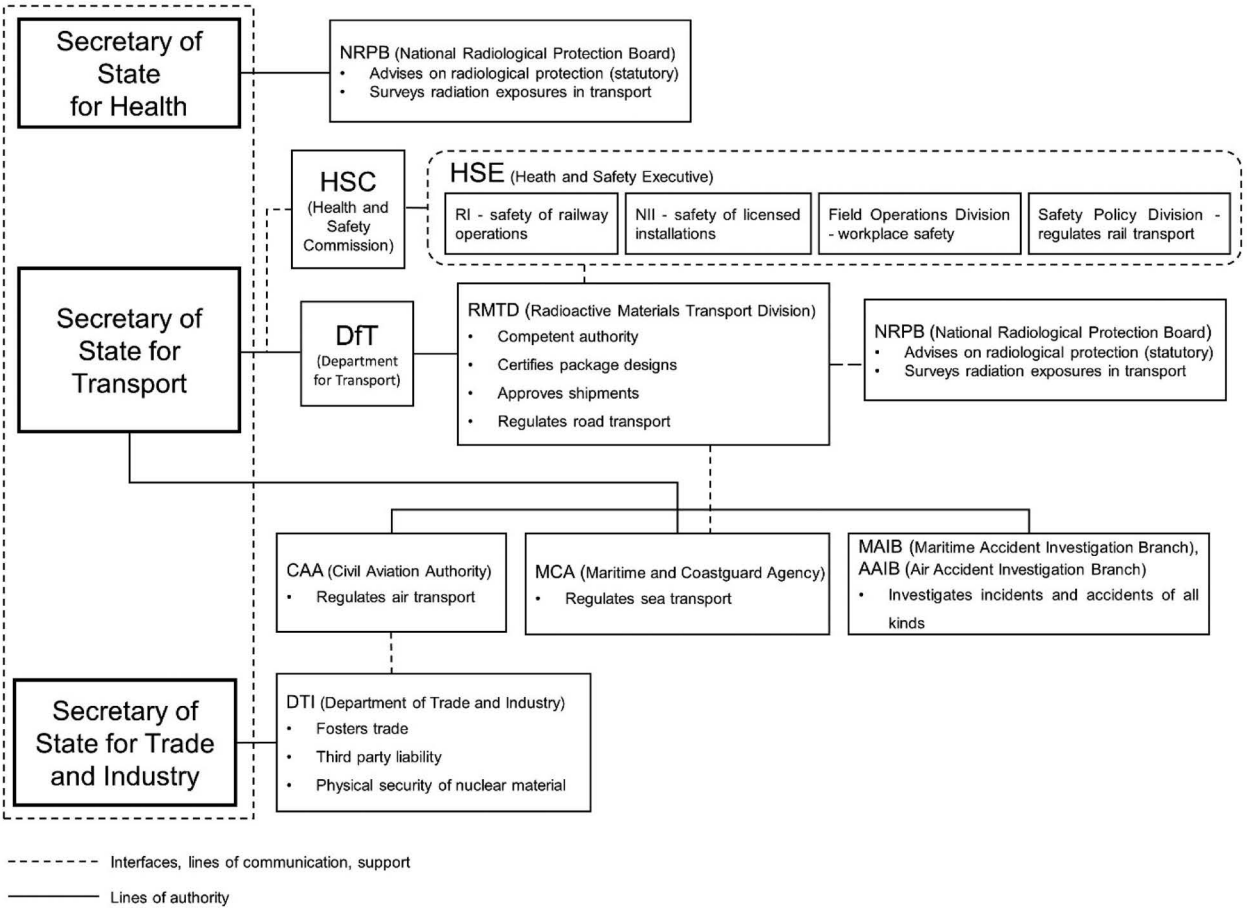

Fig. 4. UK regulatory departments involved in transport of radioactive materials [22].

1987 [24]. In particular, the following provisions concerning the radiation monitoring of imported cargo are specified: provisions on the introduction of hazardous substances into port areas, provisions on vessel marking and navigation, provisions on the handling of hazardous substances, and provisions on packaging and labeling. Both the Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations and the Dangerous Substances in Harbor Areas Regulations are based on the International Maritime Dangerous Goods (IMDG) Code [23]. The IMDG Regulations were developed as an international code for shipping dangerous goods by sea in packaged form to safely transport dangerous goods and prevent environmental pollution under the 1960 International Convention on the Safety of Life at Sea (SOLAS) program of the International Maritime Organization. As of January 2004, the IMDG Code has been necessitated for signatories to the SOLAS and has become a global rule book for shipping dangerous goods by sea. The code comprises nine classes, and radioactive materials are defined as Class 7. The classes of the IMDG code and their respective substances are shown in Table 3 [25,26].

The CAA manages the transport of radioactive materials by air based on air navigation (dangerous goods) regulation No. 2786 (2002) [27]. In this regulation, the following provisions pertaining to the radiation monitoring of imported cargo are described: provisions on transport requirements for dangerous goods, provisions on operator obligations, provisions on shipper responsibilities, and provisions on offering information regarding passengers and cargo. The International Civil Aviation Organization (ICAO) provides technical guidelines for radioactive materials through various agendas [28].

3.3. Japan

Similar to the UK, Japan regulates the transport of

radioactive materials to manage hazardous materials, such as explosives and poisons, through the radiation monitoring of imported cargo. Based on methods for transporting radioactive materials, laws have been enacted and regulated by classifying them into land, sea, and air transport methods. The legal framework for transporting radioactive materials was established based on international conventions, treaties, national laws, and various enforcement regulations. It is associated with international conventions and treaties that form the basis of the legal system, including the United Nations' recommendations for transporting dangerous goods and the IAEA regulations for the safe transport of radioactive materials [29]. Since Japan is a member of the ICAO and SOLAS, the technical guidelines and conventions of the ICAO, the IMDG Code, and the SOLAS Convention are the basis for constructing a legal system for the transport of radioactive materials in Japan. Japan's laws regarding the transport of radioactive materials were established separately for each method of transport (i.e., by land, sea, and air), and many legal prerequisites were specified in the regulations for the various types of radioactive materials to be transported. First, the Act on Land Transport (Road) was enacted for laws pertaining to the regulation of nuclear source materials, nuclear fuel materials, and reactors; the prevention of radiation hazards due to radioisotopes; and pharmaceutical affairs. Maritime transport laws include ship safety and port regulation laws [30]. Civil aeronautics law is a law of air transport. Figure 5 shows the legal system in Japan regarding the transport of radioactive materials [29].

Table 3. Classes in IMDG code and their respective substances

Labels of class	Substance
Class 1	Explosives
Class 2	Gases
Class 3	Flammable liquids
Class 4	Flammable solids; substances liable to spontaneous combustion; substances which, when in contact with water, emit flammable gases
Class 5	Oxidizing substances and organic peroxides
Class 6	Toxic and infectious substances
Class 7	Radioactive material
Class 8	Corrosive substances
Class 9	Miscellaneous dangerous substances and articles

For land transportation, applicable laws and management ministries differ depending on the material to be transported (nuclear materials, radioisotopes, and radiopharmaceuticals). The transportation of nuclear materials is managed by the NRA and MLIT under the

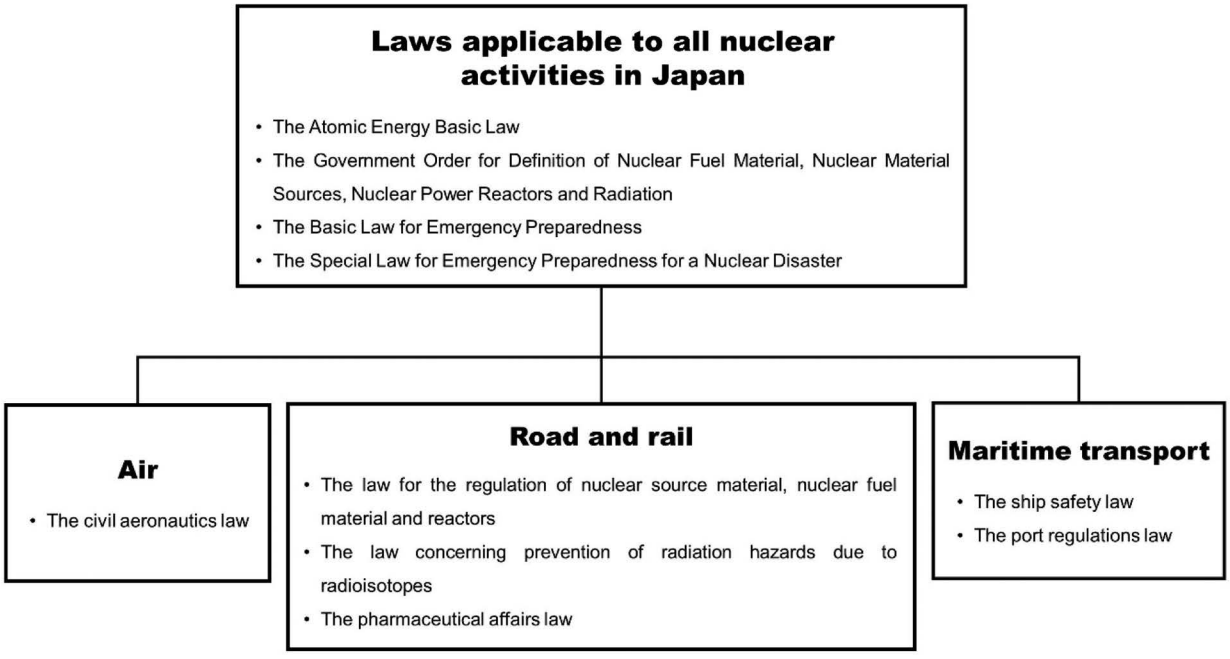

Fig. 5. Legal system of Japan concerning transport of radioactive materials [29].

Table 4. Comparison results of the current status of radiation monitoring systems in Korea, the United States, the United Kingdom, and Japan

Category	Korea	United Kindom	United State	Japan
Purpose	Protecting people from radiation by preventing the entry of cargo containing radioactive materials into the country	Preventing the threat of nuclear terrorism since the September 11 attacks	Transport of radioactive materials to manage hazardous materials, such as explosives and poisons	Transport of radioactive materials to manage hazardous materials, such as explosives and poisons
Law	Act on Protective Action Guidelines against Radiation in the Natural Environment; Working manual for the emergency response to radioactive leakage accidents in neighboring countries; Act on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal; Korean Food Standards Codex; Control of Livestock and Fish Feed Act, Feed Inspection Standards, Standards and Specifications for Feeds, etc; Act on the Sustainable Use of Timbers	The Port Safety Act	The Radioactive Material (Road Transport) Regulations; The Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations; The Harbor Areas Regulations; Air navigation (dangerous goods) regulation	The law for the regulation of nuclear source materials, nuclear fuel materials, and reactors; The Law concerning the prevention of radiation hazards due to radioisotopes; The pharmaceutical affairs law; The ship safety law; The port regulations law; The civil aeronautics affairs law
Department	Nuclear Safety and Security Commission; Korea Customs Service; Ministry of Food and Drug Safety; Ministry of Environment; Ministry of Agriculture, Food, and Rural Affairs; Korea Forest Service	Department of Homeland Security; Customs and Border Protection; Department of Energy; National Nuclear Security Administration	Department for Transport; Health and Safety Executive; Civil Aviation Authority; Maritime and Coastguard Agency	Nuclear Regulation Authority; Ministry of Land, Infrastructure, Transport, and Tourism; Ministry of Health, Labor, and Welfare

act pertaining to the regulation of nuclear source materials, nuclear fuel materials, reactors, etc., as well as related regulations [29]. The transport of radioisotopes is managed by the NRA and MLIT under the Radiation Hazards Prevention Act and related regulations. Radiopharmaceutical transport is managed by the MHLW under the Pharmaceutical Affairs Law, Regulations for Manufacturing and Handling of Radiopharmaceuticals, and Standard for Transport of Radioactive Material.

The transport of radioactive materials by sea is managed by the MLIT base on the following regulations and announcements: the Ship Safety Law, Act on Port Regulations, Regulations for the Carriage and Storage of Dangerous Goods by Ships, and Notice on the Details of Standards Concerning the Carriage of Radioactive Material by Ships [31,32]. In addition, Japan's regulations pertaining to the Ship Safety Act, Act on Port Regulation, and laws related to the maritime transport of radioactive materials were enacted based on the IAEA's Regulations on Safe Transport of Radioactive Materials, the IMDG code, and the SOLAS program [33].

The transportation of radioactive materials by air is managed by the MLIT based on civil aeronautics law and the standard notice regarding the transportation of radioactive materials [34]. Additionally, as a member of the ICAO, Japan has established technical guidelines (Annex 18: The Safe Transport of Dangerous Goods by Air) for the safe transportation of dangerous goods in conjunction with the Japanese Act on the Transport of Radioactive Materials by Air. This guideline (Annex 18) contains several regulations, such as guidelines for the operation of civil aircraft; guidelines for the definition,

classification, and handling techniques of dangerous substances; and guidelines for packaging and labeling [35].

4. CONCLUSION

Currently, the radiation monitoring system for cargo imported into Korea focuses on protecting people from environmental radiation by screening for imported cargo containing radioactive materials and implementing the necessary actions. Although the United States, the United Kingdom, and Japan have established and implemented radiation monitoring systems for imported cargo, the purpose of monitoring is different from that of Korea. First, the purpose of performing radiation monitoring on cargo imported into the United States is to prevent the threat of terrorism by radioactive materials. Two approaches are applied to achieve this purpose. The first is by installing radiation monitors at airports and ports in the United States, which is performed by the customs and border protection of the DHS. The second is to provide radiation monitoring equipment to overseas ports such that radiation monitoring can be conducted on cargo exported from the United States. Regarding the second method, the DHS operates a CSI program based on the Port Safety Act. In the UK, regulations are applied based on the transport method (road, sea, or air) to safely transport radioactive materials. All related regulations reflect the regulations pertaining to the safe transport of radioactive materials, as recommended by the IAEA. Japan's cargo radiation monitoring system is similar to that of the UK. The transport of radioactive materials can be classified into land, maritime, and air transport, and laws have been enacted and regulated for each. A legal system for transporting radioactive materials was established based on international conventions, treaties, national laws, and various enforcement regulations. In fact, Japan has enacted related laws for the safe transportation of radioactive materials, not for safety from radiation in daily life.

The radiation monitoring of imported cargo in the United States, the United Kingdom, and Japan are different from that in Korea. First, the radiation monitoring purpose of Korea is to protect people from environmental radiation, whereas that of the United States is to prevent the threat of terrorism caused by radioactive materials. Meanwhile, the radiation monitoring purpose of the United Kingdom and Japan is to enable the safe transportation of radioactive materials. In Korea, multiple departments conduct radiation monitoring based on legal and monitoring standards; however, in the United States, the DHS specializes in conducting radiation monitoring under the Port Safety Act. In the UK, laws are regulated based on the transportation method, and the monitoring system is formed by the DfT and its affiliated organizations, the HSE, and the CAA. Meanwhile, in Japan, laws are regulated based on the transportation method, and the monitoring system is operated by the NRA, MLIT, and MHLW. In this study, the current status of radiation monitoring systems in Korea, the United States, the United Kingdom, and Japan was analyzed to compare the purpose and legal system of radiation monitoring in each country. Table 4 shows the comparison results of the current status of radiation monitoring systems in Korea, the United States, the United Kingdom, and Japan. This analysis will provide a basis for improving the current radiation monitoring regulatory system for cargo imported into Korea.

Conflicts of interest. None.

ACKNOWLEDGMENTS

This work was supported by a research fund from Chosun University, 2022.

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