RECENT PUBLICATIONS ON TRANSPORT AND STORAGE OF RADIOACTIVE MATERIALS

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Abstract

The paper introduces three books recently published on transport and storage of radioactive materials. The transport and storage technologies have been established through the related experiences and researches. Such works should be shared by public and the future generations to advance the technology effectively.

The first book "Safe and Secure Transport and Storage of Radioactive Materials" reviewed best practice and technologies in the following areas.

— Operational safety in the nuclear transport industry.
— Package design and performance.
— Packaging, transport and storage of uranium concentrates and uranium hexafluoride, fresh and spent fuel, large radioactive components and medical and industrial radioactive materials.
— Long-term storage and subsequent transport of spent fuel and high-level radioactive wastes.

The second book "Basis of Spent Nuclear Fuel Storage" showed demonstrative test results conforming the safety requirements:

— for metal cask storage, heat removal, containment, subcriticality, structural integrity, seismic performance, severe accidents, interaction between transport and storage,
— for concrete cask storage, heat removal, shielding, structural integrity, earthquake resistance, and long-term integrity.
— for spent fuel, integrity in normal and accident storage conditions, and inspection method for ageing.

The third book "Basic of Transport and Storage of Radioactive Materials", reviewed the preceding books and provided new and advanced information so that readers could have wide spectrum of the technologies. It systematically provided findings from lots of valuable researches on safety and security of transport and storage of radioactive materials under normal and accident conditions that constituted the basis of safe regulations, designs, and operations. It described safety and security of transport and storage, which have been rarely addressed in the same book.

1. INTRODUCTION

Transport and storage technologies have been established through the related experiences and researches. Such works should be shared and used by readers and the future generations to advance the technology effectively. The paper introduces three books recently published on transport and storage of radioactive materials.

2. SAFE AND SECURE TRANSPORT AND STORAGE OF RADIOACTIVE MATERIALS

The first book is "Safe and Secure Transport and Storage of Radioactive Materials" [1]. The contents are shown in Fig. 1. It reviewed best practice and emerging techniques in the following areas from 2.1. to 2.4.

Section 2.1 covers operational frameworks and management systems used for transport and safety, including radiation protection and as low as reasonably achievable (ALARA) concept.

Section 2.2 covers the package design and performance aspects for transportation specifically. Because the transport of spent fuel occurs on public conveyances, rules and regulations governing safe transport are quite different than those for storage, and in most cases are more stringent.

Section 2.3 covers packaging, transport, and storage of radioactive materials in a very wide range of physical and chemical forms. Although the rules and regulations for these materials stem from a common basis, design and operational aspects must be considered specifically addressing the nature of the characteristics of the material.

Section 2.4 discusses long-term storage options as well as transportation after long-term storage. As final disposition continues to be future planned activities, spent fuel will be stored for longer period.

2. SAFE AND SECURE TRANSPORT AND STORAGE OF RADIOACTIVE

2.1. Frameworks for Operational Safety

2.1.1 Requirements for the design of transport packages
2.1.2 Training in the nuclear transport industry
2.1.3 Public relations for the nuclear transport industry
2.1.4 Risk assessment approaches for the transport of radioactive material
2.1.5 Responding to emergencies associated with the transport of radioactive material

2.2. Package design and performance for transport

2.2.1. Structural performance of packages for radioactive materials
2.2.2. Thermal performance of transportation packages for radioactive materials
2.2.3. Radiation protection by shielding in packages for radioactive materials
2.2.4. Criticality analysis of packages for radioactive materials
2.2.5. Sea transport of irradiated nuclear fuel, plutonium and high-level radioactive wastes

2.3. Packaging, transport and storage of particular types of radioactive materials

2.3.1. Packaging, transport and storage of uranium ore concentrates and uranium hexafluoride
2.3.2. Packaging and transport of unirradiated uranium dioxide fuel and nonirradiated mixed oxide fuel
2.3.3. Transport and storage of spent nuclear fuel
2.3.4. Packaging transport, and storage of high, intermediate, and low-level radioactive wastes
2.3.5. Packaging, transport and storage of large radioactive components
2.3.6. Packaging, transport, and storage of medical and industrial radioactive materials

2.4. Long-term storage and subsequent transport of spent nuclear fuel and high-level radioactive waste

2.4.1. Wet storage of spent nuclear fuel
2.4.2. Long-term storage of spent nuclear fuel and high-level radioactive waste: strategies and implications for package design
2.4.3. Transportation of spent nuclear fuel and high-level radioactive waste after long-term storage

FIG. 1. Contents of the book "Safe and Secure Transport and Storage of Radioactive Materials".

3. BASIS OF SPENT NUCLEAR FUEL STORAGE

The second book is "Basis of Spent Nuclear Fuel Storage" [2]. Main contents are shown in Fig.2.

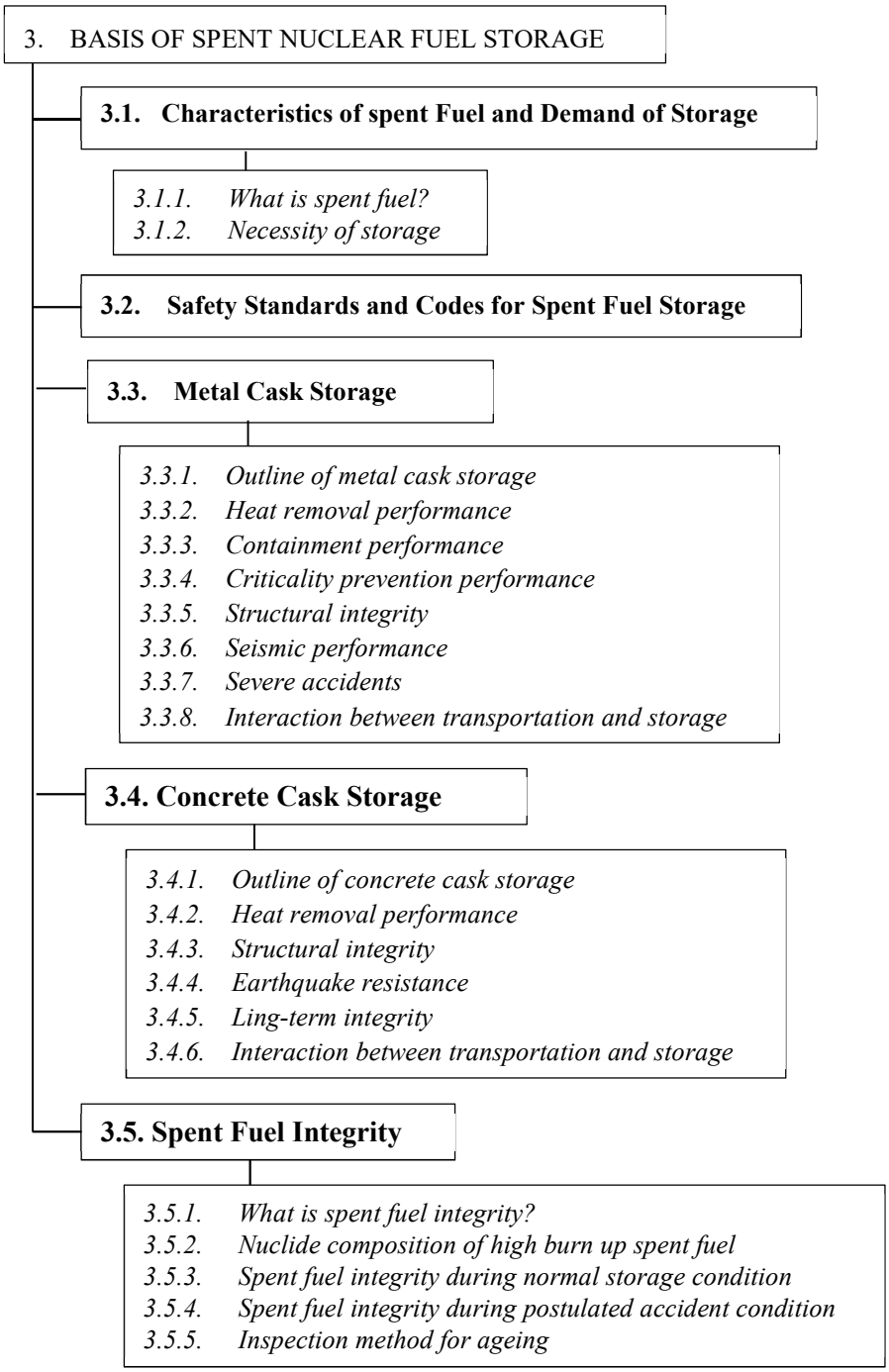


FIG. 2. Major contents of the book "Basis of Spent Nuclear Fuel Storage".

It firstly addressed safety standards and codes for spent fuel storage in Section 3.2. Then, demonstrative test results conforming the safety requirements were provided.

For metal casks storage, heat removal, containment, subcriticality, structural integrity, seismic performance, severe accidents, interaction between transport and storage were addressed in Section 3.3.

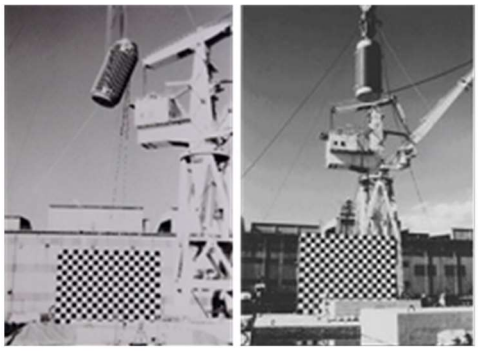
For concrete cask storage, heat removal, shielding, structural integrity, earthquake resistance, long-term integrity in Section 3.4.

For spent fuel, integrity in normal and accident storage conditions, and inspection method for ageing in Section 3.5.

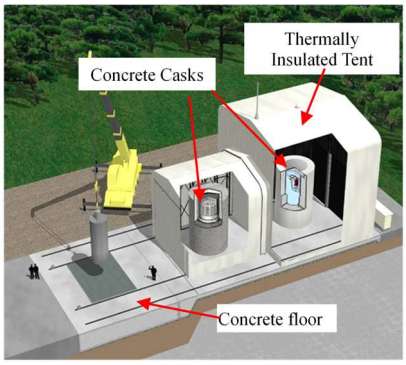
Typical demonstrative tests using full-scale cask models are shown in Fig.3.

(a) Full-scale model of cask lid for leak test

(b) 9 m drop of DCI cask at -40 C



(c) 17 m drop tests of DCI cask



(d) Concrete cask test yard

(e) Concrete casks for thermal tests

(f) 6 m drop test of canister

FIG. 3. Typical demonstrative tests using full-scale cask models. (Copyright: CRIEPI).

4. BASIS OF TRANSPORT AND STORAGE OF RADIOACTIVE MATERIALS

The third book is “Basic of Transport and Storage of Radioactive Materials” [3]. The contents are shown in Fig.4. After reviewing the preceding books, it provided new and advanced information so that readers could have knowledge of the current technologies. It systematically provided findings from lots of valuable researches on safety of transport in Section 4.1 and storage in Section 4.3 of radioactive materials under normal and accident conditions that constituted the basis of safe regulations, designs, and operations. Characteristically, it described security of transport and storage in Section 4.2, which have been rarely addressed in the same book.

5. CONCLUSION

The three books introduced here represent status quo for transportation and storage of radioactive materials. The transport and storage technologies have been established by accumulation of experiences and researches. Such works should be shared and used by readers and the future generations to advance the technology effectively.

The books are recommended to wide range of readers including persons in charge of siting, design, construction, safety evaluation, licensing, operation, and communication with public.

4. BASIC OF TRANSPORT AND STORAGE OF RADIOACTIVE MATERIALS

4.1. Transport

4.1.1. Safety of transport
4.1.2. Performance of UF_6 packages under water immersion
4.1.3. Performance of UF_6 packages under fire accident conditions
4.1.4. Radiological and toxic impacts and preparedness for transport accidents involving release of UF_6
4.1.5. Performance of packages with transport frame under drop accidents
4.1.6. Internal cask content collision during drop tests
4.1.7. Codification of ductile cast iron cask
4.1.8. SNF and HLW package assessment under fire impact
4.1.9. Ageing management for transport (Post-storage transport of dual-purpose package for spent fuel)
4.1.10. Probabilistic risk assessment of transport of spent nuclear fuel)
4.1.11. Internal pressure build-up of waste packages
4.1.12. Radiological impact of sea transport accident
4.1.13. Design loads and allowable stresses
4.1.14. Experience feedback for assessment of transport package design safety reports

4.2. Security of transport and storage

4.2.1. Security of transport and storage
4.2.2. Enhancement of physical protection measures reflecting the accident of Fukushima Daiichi NPP and INFCIRC/225/Revision 5

4.3. Safety of storage

4.3.1. Safety of storage
4.3.2. Long-term metal seal performance
4.3.3. Ageing management program for spent fuel storage
4.3.4. Chloride induced stress corrosion cracking
4.3.5. Advanced monitoring of containment of canister
4.3.6. Probabilistic risk assessment of spent nuclear fuel storage

FIG. 4. Contents of the book "Basic of Transport and Storage of Radioactive Materials"

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[1] SORENSON, KEN B., Safe and Secure Transport and Storage of Radioactive Materials, Woodhead Publishing, Cambridge, UK (2015). ISBN: 978-1-78242-309-6 (print), 978-1-78242-322-5 (online).

[2] CENTRAL RESEARCH INSTITUTE OF ELECTRIC POWER INDUSTRY, Basis of Spent Nuclear Fuel Storage (in English), ERC Publishing Co., Ltd., Tokyo, Japan (2015). ISBN: 978-4-900622-55-5.

[3] SAEGUSA, T., SERT, G., VÖLZKE, H., AND WILLE, F., Basic of Transport and Storage of Radioactive Materials, World Scientific, Singapore (2018). ISBN: 978-981-3234-03-1.