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OVERVIEW OF THE IAEA'S JOINT WORKING GROUP ON INTEGRATED SAFETY CASE FOR DUAL PURPOSE CASKS

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ABSTRACT

Spent nuclear fuel is generated from the operation of nuclear reactors and needs to be safely managed following its removal from reactor cores. Spent nuclear fuels are usually stored in a reactor pool for a short period of time after defueling, and then they are shipped to its next destination for reprocessing, disposal, or further storage.

In some countries, a concept of Dual Purpose Cask (DPC) is considered as an attractive option for further storage. This is because of that the concept increases flexibility for storage capacity, as well as its economic efficiency that can reduce the complexity of handling highly radioactive spent fuels.

The management of spent fuel using a DPC involves storage of spent fuel as well as on-site and off-site transportation before and after storage. Most countries require package design approval for the DPC to be transported. In addition, it is required in many countries to have a license for storage of the spent fuel in the DPC or a license for a storage facility that contains DPCs. Therefore, demonstration of compliance of the DPC with national and international transport regulations as well as with the storage requirements is necessary.

In June 2010, the IAEA organized "International Conference on Management of Spent Fuel from Nuclear Power Reactors". In this conference, many countries expressed their interest on harmonizing both transport and storage safety cases for DPCs that has a possibility to establish an effective and integrated regulatory framework in a holistic manner.

Taking into account the increasing needs among Member States, the IAEA set up a new working group following the conference to discuss how to develop an integrated safety case for both transportation and storage.

This activity is planned to be completed in 2013. Currently, a technical report is being prepared as an outcome of this activity.

In this paper, the IAEA's approach to demonstrate the safety of DPCs in a holistic manner is described first, followed by the overview of the draft document. It also presents the difference between the conventional transport cask concept and the DPC concept.

INTRODUCTION

The management of spent fuel from nuclear power reactors is an important concern relating to use of nuclear energy. While a majority of countries have yet to decide on the final destination of spent fuel, storage period is de facto increasing.

In June 2010, the IAEA hosted the International Conference on Management of Spent Fuel from Nuclear Power Reactors. This conference was organized to exchange information on the state-of the art technology on spent fuel storage, on the perspectives for long term storage and on the operation of storage facilities. The conference was also intended to discuss the safety framework of spent fuel management and to discuss issues related to spent fuel ageing, integrity and long term data management. The conference was attended by more than 200 participants from over 40 countries. Discussions addressed themes such as strategic issues and challenges of spent fuel management, safety and licensing of spent fuel storage and transportation, operating experience in spent fuel storage, advancement and lessons learnt on current practices and technological innovations for spent fuel storage.

During the conference, several Member States presented their projects for utilizing the concept of dual purpose cask (DPC) as an attractive option due to their flexibility and efficiency in the handling of spent nuclear fuel. A DPC is a cask that is designed for both transportation and storage of spent nuclear fuel. The management of spent fuel using a DPC involves both storage of spent fuel and its transport before and after storage. At present, most Member States utilising DPCs require a transport licence to be held for the transport of DPCs. In many Member States, a licence for the storage of spent fuel in DPCs or a licence for a storage facility that contains DPCs is also a requirement. To improve the effectiveness of the licensing process for DPCs, the concept of a 'holistic approach' was proposed at the conference [(1)]. This approach considered the interface issues arising between both storage and transport, and recommended the development of integrated safety case for both transport and storage with supporting safety assessments. At the conference, Member States agreed to move forward with this initiative in developing guidance for integrated safety cases for both storage and transport of DPCs. It was suggested that the IAEA take the lead in exploring this issue with Member States that are confronted with this issue.

To address the conference recommendation, the IAEA initiated a "Joint Working Group on Guidance for an Integrated Transport and Storage Safety Case for Dual Purpose Casks for Spent Nuclear Fuel" (WG)[(2)] in April 2011 to develop guidance for an integrated safety case for both transport and storage by DPCs under the support of the Transport Safety Standards Committee (TRANSSC) and the Waste Safety Standards Committee (WASSC). TRANSSC and WASSC are the standing bodies of senior experts from Member States in waste and transport safety. Members of the committees provide advice on the development, review and revision of IAEA Safety Standards relating to waste or transport safety. Their functions are not only to develop Safety Standards, but also to recommend activities and areas for improvement to enhance the overall programme including the application of the safety standards. Since the WG is intended to develop a technical document that supports the IAEA Safety Standards in relation to the transport and waste safety, both TRANSSC and WASSC supported this activity as a joint programme.

2. OBJECTIVES AND SCOPE

2.1 Objectives

The project started in 2011 and was envisaged as a 3 years project in 2011. The intention was to develop an IAEA technical document on an Integrated Safety Case for a DPC as well as providing recommendations for changes to be made to existing IAEA Safety Standards relevant to the licensing and use of transport and storage casks for spent nuclear fuel to the IAEA Safety Standard Committees as necessary.

The document is to be prepared as a supporting document to the relevant IAEA Safety Standards, such as Regulations for the Safe Transport of Radioactive Material (SSR-6)(3) and Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material Safety Guide (TS-G-1.1)(4) for transport safety, and Predisposal Management of Radioactive Waste General Safety Requirements Part 5 (GSR Part 5)(5) and Storage of Spent Nuclear Fuel (SSG-15) (6) for waste safety. The document aims to assist designers, vendors, operators, applicants, regulators, technical support organizations, etc. in the development and review of the safety case and supporting safety assessment. The document contains guidance that can be used, irrespective of how the safety case and safety assessment process is addressed within individual national regulatory frame works.

An Integrated safety case for a DPC aims to support the application for the package design approval for transport and the application for the licensing of the storage facility as part of the safety case for the storage facility. The integrated safety case for a DPC is considered as a collection of scientific and technical arguments, justifications and evidence in compliance with international and national regulations for both transport and storage.

2.2 Scope

At the beginning of the project, it was decided that the storage period considered in this activity would be limited up to about 100 years. Some Member States anticipate much longer storage periods and several research activities have been conducted to gain confidence on such an extended storage period. However, taking into account the definition described in SSG-15(6), the storage period is limited to less than approximately 100 years in this activity.

It was also decided that this project only considers dual purpose metal dry storage and transport casks. If a canister is contained within a DPC as a part of its internals, it is considered as a component of the DPC in this document.

Note that the integrated safety case for a DPC defined in this activity does not cover a safety case of a DPC storage facility. Therefore, it needs to be complemented by another safety case for storage facilities where the DPC will be stored if necessary.

3. CONCEPT OF INTEGRATED SAFETY CASE FOR A DUAL PURPOSE CASK

Regarding the storage of radioactive waste, GSR Part 5 requires that

"*Waste shall be stored in such a manner that it can be inspected, monitored, retrieved and preserved in a condition suitable for its subsequent management. Due account shall be taken of the expected period of storage, and, to the extent possible, passive safety features shall be applied. For long term storage in particular, measures shall be taken to prevent degradation of the waste containment*".

The management of spent fuel using a DPC involves storage of spent fuel as well as on-site and off-site transportation before and after storage. It is required in many countries to have a licence

for storage of the spent fuel in the DPC and/or a licence for a storage facility that contains DPCs. In addition, most countries also require package design approval for the DPC to be transported.
Therefore, safety assessment and approval or licensing procedures need to consider the differences between the two DPC configurations, i.e., the DPC transport package design and the DPC storage cask design. A DPC provided for transport is usually equipped with impact limiters and often has a one-lid closure system. The DPC transport package needs to be designed not only to comply with current transport regulations, but also to be potentially used in an operational mode that is different from usual transport packages. More specifically, the DPC transport package needs to be transported after several decades of storage and therefore it needs to use ageing-resistant packaging components.
A DPC when used for storage is usually not equipped with transport impact limiters, but often has a closure system with additional lids, with lid interspace pressure monitoring. The DPC storage package needs to be designed so that it meets regulations for on-site activities including storage and on-site transport, which are very often different from transport regulations. Nevertheless, most of the safety relevant DPC components are the same for both purposes.
The concept of an integrated safety case for a DPC aims to support the application for the package design approval for transport and the application for the licensing as a storage cask (as part of the safety case for the storage facility). The integrated safety case for a DPC can be a collection of scientific and technical arguments including safety assessments in support of:

(a) The demonstration of compliance with the IAEA transport regulations SSR-6 for off-site transport, including transport after storage,
(b) The demonstration of compliance with the international standards and national regulations for dry storage of spent fuel as they apply to the DPC during its storage period and with the regulations for associated on-site transport.

In this project, the concept of the integrated safety case for a DPC was developed taking into account the IAEA recommendations on the Safety Case and Safety Assessment for the Predisposal Management of Radioactive Waste (GSG-3)[8]. Also, the concept was linked to the transport and storage approvals as follows:

(a) The basic information for the safety case is the description of the DPC and its contents, the impact conditions and acceptance criteria. The term impact conditions means all basic data for the safety assessment arising from normal, off-normal, and accident conditions of storage and routine, normal, and accident conditions of transport. The impact conditions for off-site transport are given in SSR-6. The impact conditions for storage need to be specified based on national regulations and an assessment of the operational conditions at the storage facility.
The concept of acceptance criteria in this document is shown in Fig. 1. The acceptance criteria for off-site transport are given in the transport regulations. The acceptance criteria for storage need to be specified based on international standards, national regulations. It can also include criteria from an assessment of the operational conditions of the storage facility.
(b) This basic information is complemented by instructions for operation and maintenance.
(c) The DPCSC needs then to demonstrate that a DPC of the specified design loaded with the specified contents and being exposed to the defined impact conditions, operations and maintenance meets the specified acceptance criteria.
(d) This demonstration could be assessed by a regulatory body leading to an approval of the DPC package design. Assuming that approval will be given only if

compliance with the transport regulations has been demonstrated in the DPCSC, the design can be approved as a transport package. Regarding storage, the DPCSC could qualify the DPC package for storage in a specific facility.

This concept leaves some freedom to the DPC designer in defining impact conditions and acceptance criteria. In either case the transport requirements are not so flexible and need to be met. For storage an incorrect choice of impact conditions or acceptance criteria could lead to problems in obtaining a licence for the storage facility, if the DPC package as defined in the DPCSC does not meet the regulatory requirements and operational limits of the storage facility. Therefore it is suggested that the impact conditions and acceptance criteria be selected based on a careful review of the regulatory requirements and operational limits and conditions of the storage facility. Of course, the acceptance criteria can also be set in a much restrictive manner. In this case, the assessment of current and future storage facilities will be able to gain some additional safety margin.

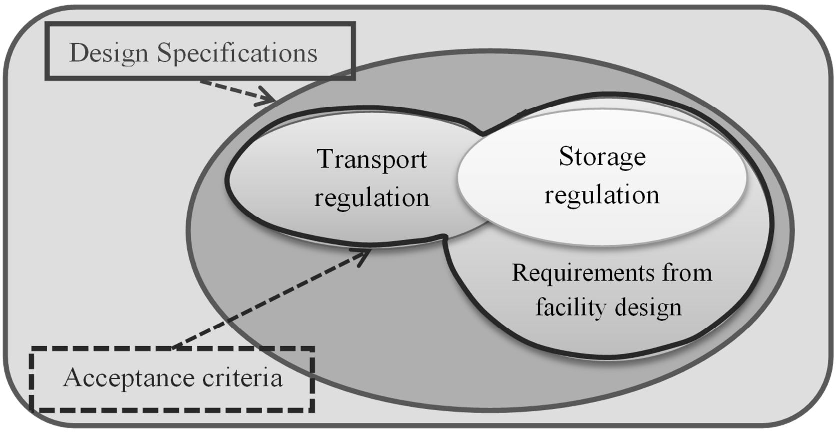

Figure 1. Conceptual drawing of the relationship between acceptance criteria, design specifications, and regulations

4. GUIDANCE FOR PREPARATION OF A SAFETY CASE FOR A DUAL PURPOSE CASK CONTAINING SPENT FUEL

This section provides an overview of a technical guidance document developed by the WG. The WG is developing a document titled "Guidance for preparation of a safety case for a Dual Purpose Cask containing spent fuel". At the beginning of the project, it was decided to develop this guidance document utilizing a structure of a technical guide on Package Design Safety Reports for the Transport of Radioactive Material (European PDSR Guide)[7], which was developed for transport casks. Since an integrated safety case for a DPC needs to consider scientific and technical arguments and provide evidence in support of demonstration of compliance with international standards and national regulations during its storage period, considerations on ageing management are important.

One of the challenging issues for the integrated safety case for a DPC is how to deal with interface issues. Examples of interface issues discussed by the WG were:

- How to manage the interfaces between the safety cases for the DPC, storage facilities, nuclear power plants and the final destination of the DPC.

- How to define all of the acceptance criteria that the spent fuel must meet. Fuel is usually subjected to a number of processes before it is stored in a cask, including irradiation in the reactor, handling operations and pool storage. The entire history of the spent fuel before cask storage can influence the physical integrity of the fuel rods and the structural components. Therefore, this information provides important input for the safety case. In the safety case, there should be well defined acceptance criteria that the spent fuel must meet before it is considered to be fit for both cask storage and transport.
- How the safety case for DPCs relies on the availability of hot cells, cooling pools, reserve storage capacity and other maintenance facilities which may be present at the storage sites or at other remote sites. As a basic concept, DPCs can be designed so that the lid, which is part of the primary containment boundary, does not need to be opened for inspection or maintenance during storage or transport after storage, as long as safety is demonstrated using elementary test results, mock-up test results or computer analysis, etc.. This is a great advantage of dual purpose metallic casks because actions to open lids require additional equipment, such as hot cells, and such actions may themselves cause unnecessary accidents. However, some systems use casks which have a single containment boundary. In such circumstances, it is necessary to provide maintenance facilities which can be used to handle the cask in the event of failure of that containment boundary.

The WG proposed a structure of an integrated safety case for a DPC as shown in Fig. 2 taking into consideration the important aspects on safety case for predisposal waste management facilities described in IAEA General Safety Guide on The Safety Case and Safety Assessment for the Predisposal Management of Radioactive Waste (GSG-3)[8]
In this structure, Part 1 provides a generic consideration and contents of the safety case. Part 1 also provides information on administrative matters, specification of radioactive contents, specifications of the DPC, DPC performance criteria, and compliance with regulatory requirements, operation, maintenance, and management systems as a part of the safety case. Part 2 provides both generic and specific considerations for technical assessments of the safety case.
In the following subsections, overview of some key issues on developing an integrated safety case for a DPC is described.

4.1 Ageing issue

Safety-related components are subject to degradation mechanisms and ageing processes which depend on the component itself and its operational and environmental conditions. In order to maintain the licensing not only for storage but also for transport after storage, it is essential to consider ageing issues carefully and to have a sustainable ageing management plan. Therefore, the proposed structure of the integrated safety case has a separate section "Ageing considerations".
For licensing of the DPC for any storage facility or for any transport campaign, it has to be ensured that the entire history of ageing of the DPC and contents is considered and that the specified maintenance and monitoring had been completed. Components of the fuel and container/packaging are especially important because of the potential for degradation processes to lead to fuel fragmentation, loss of container integrity, and other structural alterations that could directly impact containment, subcriticality control and/or retrievability of the internals. Thus, it is important to evaluate the potential degradation phenomena over time and their impact on the functions important to safety.

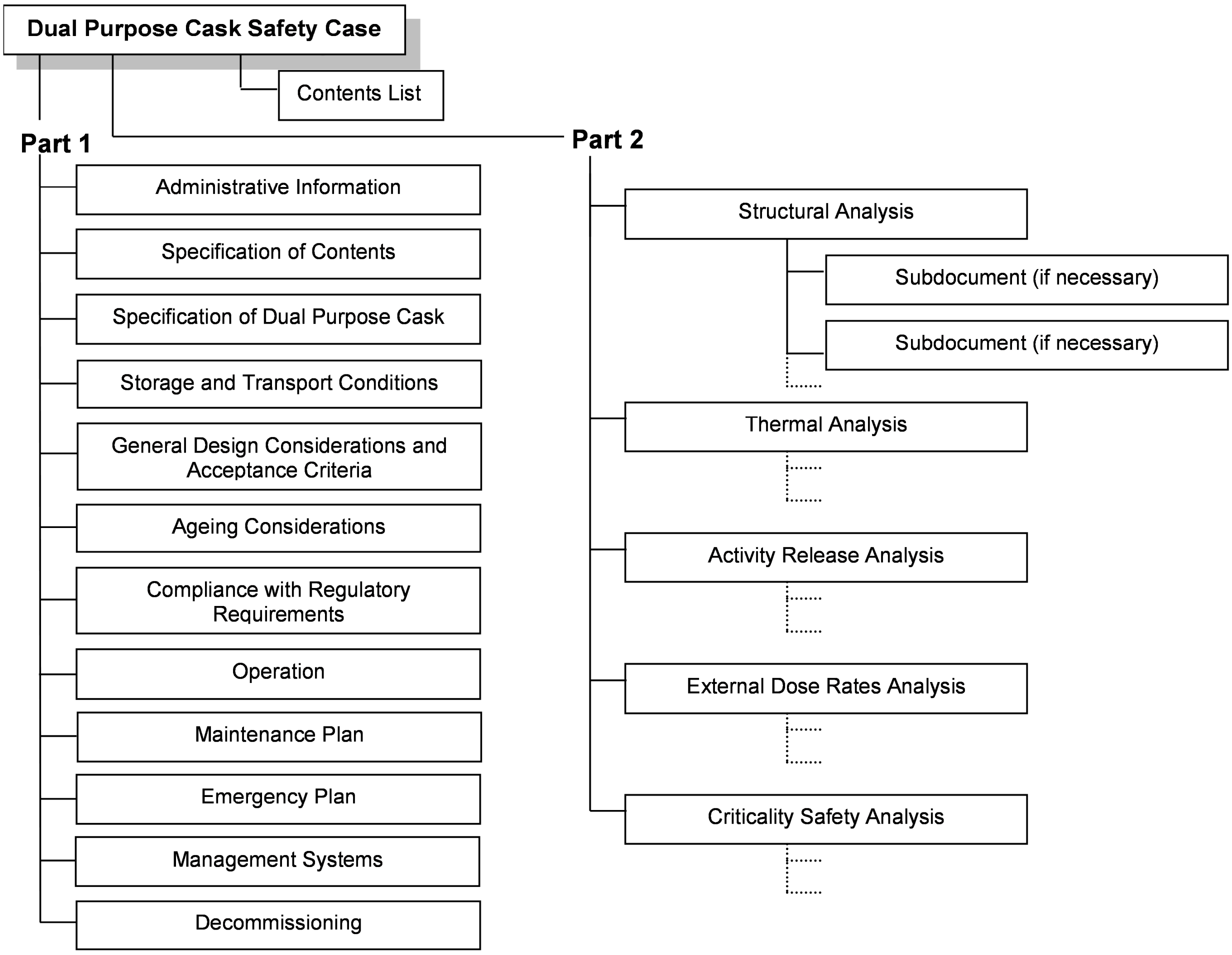

Fig. 2 Proposed structure of a safety case for a Dual Purpose Cask

In the proposed safety case structure, the section "Ageing consideration" addresses possible ageing factors for each safety-related component. Design considerations against ageing deterioration needs also to be addressed in this section. In addition, it is important to describe how to inspect the integrity of the DPC and its contents for ensuring safety of transportation after the storage period. When spent fuel is transported, generally various inspections are required such as;

1) External appearance
2) Leak tightness
3) Pressure retention
4) Dose rate
5) Subcriticality
6) External surface temperature
7) Lifting capability
8) Weight measurement
9) Condition of contents
10) Surface contamination

Of these, items 3), 5), and 9) are difficult to perform after storage. Therefore it is important to consider alternate means of inspection in combination with the ageing evaluation in order to give assurance that the DPC can be safely transported even after a long storage period.

Storage in a DPC can be generally licensed with state-of-art knowledge. However, periodic reassessments of the condition of the DPC system with respect to new regulations and advancements in technology are important to ensure that the DPC licensing basis remains in compliance throughout the storage period during which ageing mechanisms may cause changes from the original licensing basis.

Since an ageing programme for the DPC over the period of long term storage has an important role to minimize uncertainties in the safety relevant functions of the system for which may otherwise be impaired by ageing mechanisms, an ageing management programme needs to be addressed also under the section "Management systems". Since the operational period of the DPC is considered to be longer than several decades, it is important to establish a systematic action plan and to describe it in the safety case so as to provide confidence that the storage and transport systems will perform adequately and that specified requirements will be fulfilled.

4.2 Gap Analysis

It is important to periodically update the safety case from the beginning of the design until the end of transport after storage. Since the operational period of the DPC package is considered to continue for at least several decades, a gap analysis needs to be conducted and the safety case has to be updated appropriately whenever the related regulations are changed or new technology is developed during storage.

A transport package design approval is normally issued for a period of a few to several years. At the end of the approval period the licence needs to be revalidated for the next period by a demonstration of compliance with the current transport regulations. Since the transport regulations as in particularly defined in SSR-6 may change from time to time, it is important to perform gap analyses between the current and the revised provisions with every change of regulations. If a gap is revealed, it is important to consider transitional provisions as appropriate so that DPCs licensed under the old transport regulations can be transported, when they comply with the specified transitional provisions. Regarding a storage licence (storage facility operational licence), it could be issued for a period of up to several decades. Nevertheless it is important to conduct a gap analysis and the safety case needs to be updated if any associated regulations are changed or new technology is developed during storage.

In the proposed structure of the safety case for the DPC, the consideration on gap analysis is addressed under "Compliance with Regulatory Requirements" and "Management Systems".

5. CONCLUSIONS

A number of Member States have been utilizing DPCs or showing interest on DPCs as an attractive option for storage of spent fuel. The DPC needs to be designed and operated so that it can be safely stored and transported even after long period of storage. Since the DPC's lifecycle is generally considered longer than several decades, it is important to develop and maintain an integrated safety case that considers both storage and transport. The WG has been developing a technical guidance document describing an integrated safety case. The WG has also provided recommendations for further improvement of the IAEA Safety Standards related to the transport and waste safety. On completion of the work, this technical document is expected to be published to support the IAEA Safety Standards on transport and storage of spent fuel.

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