Proceedings of the 19th International Symposium on the Packaging and Transportation of Radioactive Materials
PATRAM 2019
August 4-9, 2019, New Orleans, LA, USA

Recent developments in the licensing and manufacturing control procedures of DPCs

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ABSTRACT

Background
Since 2001 high active waste and spent fuel is stored in various designs of DPCs. A specific Swiss challenge is the variety of fuel types. Until 2006 all Swiss Utilities sent spent fuel for reprocessing. This included the return of equivalent amounts of high active vitrified waste for dry storage. The reprocessing products were used for manufacturing MOX- and U_{rep}-elements, which were again used in the PWR-reactors. The stop of reprocessing changed the utilities fuel strategy to maximum enrichment and burnup with subsequent dry storage. As a consequence DPC designs had to be adapted to accommodate the increasing heat load and radioactive inventory.

Licensing and Regulatory Control
ENSI has implemented following licensing strategy: Transport design certificates according to /1/, and specific design approvals for storage facility as specified /2/.
Early approvals concerned unmodified foreign DPC designs. Hence the foreign transport certificate could easily approved based on the simplified validation process. This changed when the specific Swiss fuel characteristcs had to be adressed in DPC designs: such designs require a dedicated full scope check of the transport safety assessment report (SAR). In parallel and for each DPC design the storage safety analysis report (TSAR) has to be approved. SAR and TSAR are closely correlated and modifications of one most probably also leads to updates of the other, which is why Switzerland started early activities on the idea of an integrated safety case analysis report covering both areas and one of the next applications for design approval will be based on an integrated safety analysis report.
ENSI published a guide on implementation of comprehensive ageing management programs /3/.
This paper intends to give a comprehensive overview on the Swiss regulatory approach to DPC licensing and correlated regulatory activities and corresponding most recent international developments.

INTRODUCTION

Currently in Switzerland there are 5 operating reactors at 4 sites - 2 BWR and 3 PWR with different design and different age. These reactors use fuel from different vendors with different fuel characteristics. Until 2006 most of this diverse fuel has been transported for reprocessing to La Hague or Sellafield. Therefore, the differences in the fuel characteristics were not so important because nonetheless the same transport package could be used by all Swiss utilities. In 2006 the Swiss government established a moratorium to stop reprocessing for 10 years which was extended after 10 years, and finally put into national law /4/. This had a major impact on the backend strategy of the Swiss utilities and lead to the following decisions:

- Change of the fuel management strategy to the use of high enriched fuel
- Intensive use of the fuel with the consequence of spent fuel with high burn up fuel
- Change of the backend strategy by using prolonged wet storage, even in separate pools,
- Intensive use of DPCs for dry storage

- licensing of new DPC designs or modifications of approved DPC designs

As these decisions also had consequences for the regulatory body ENSI took an active part in a IAEA working group to set up international transport requirements /5/ and national storage requirements /6/ for DPCs. After setting up the different requirements the approval of the safety analysis reports (SAR for transport and TSAR for storage) of DPCs has also to be managed by the regulatory body.

Status

To understand the main changes in the strategy, some important parameters of the fuel and the DPCs will be described in the following from the beginning of interim storage in Switzerland until now.

Frontend:

To reduce the quantity of necessary fuel elements the enrichment, fuel element design and operational strategy were optimised. Following this principle all Swiss utilities increased the amount of fissile products in their spent fuel elements, which at the time was not addressed in the safety files of available DPCs designs. As this optimisation based on increased enrichment and burnup major issues in spent fuel management are a higher heat load and the different radiological characteristics of the spent fuel elements. Additionally in the meantime all Swiss Pu from reprocessing has been used in the form of MOX-fuel in the Swiss PWRs. So, the characteristics of spent fuel show a high variety in relevant parameters and the DPC designs already licenced in 2006 had to be updated. Especially for the spent MOX-fuel new designs had to be development to ensure that the fuel pools in the NPP can be unloaded and consequently still guarantee enough capacity.

Backend

In general, there was only a need of one transport package design to ship all the different fuel element from the Swiss utilities to the reprocessing plants in Sellafield and La Hague. Since 2006 the Swiss utilities needed various designs and amounts of DPCs every year. One main difference is that the transport package must fulfil only the requirements of the transport regulations (SSR-6 /5/) and can be easily replaced if there is for example a change in the regulations as it is only used for short periods. A DPC has to fulfil both, the transport regulations and the interim storage requirements, and is not easy to replace once it is loaded with spent fuel.

In 2001 and 2002 two utilities started to store some spent fuel in DPCs to open a new possibility for the backend. However, the management strategy continued to be reprocessing. From 2004 to 2006 the utilities stored fuel which had been cooled several years in wet storage. The idea was to go back to reprocessing after the ending of the 10 years moratorium. Then for some years only a few DPCs were loaded and stored because the bases of approved DPC designs (SAR and TSAR) did not cover the full spectrum of Swiss spent fuel characteristics with respect to the new backend strategy. After modifications in the licences of the approved DPCs and also after approval of new DPC designs in Switzerland, the utilities loaded more DPCs in the last years. A detailed statistic describing the numbers of DPCs stored in Switzerland over the last 20 years is presented in Figure 1.

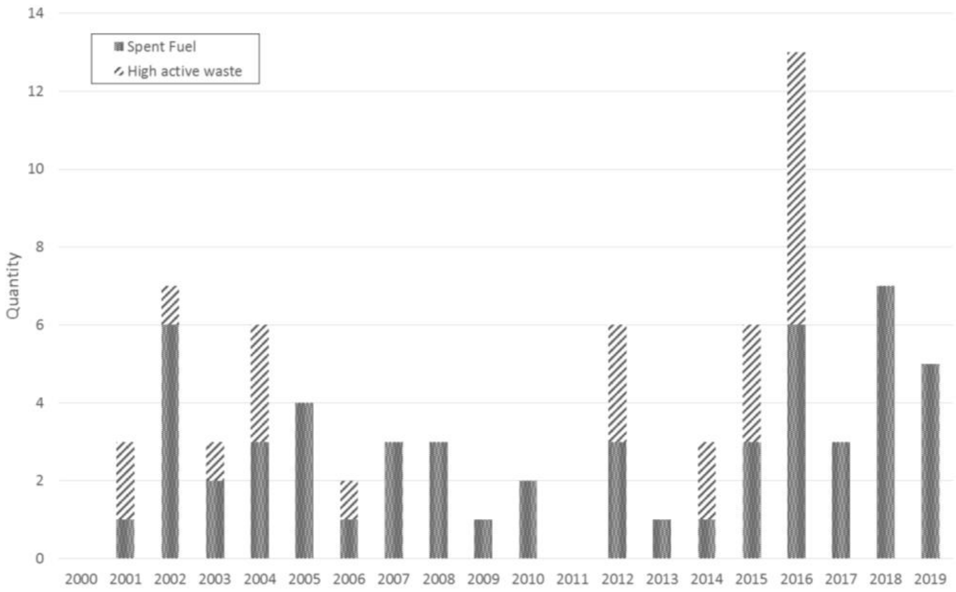

Figure 1: DPC loadings and storage in Switzerland

Including the consequences of the frontend and backend changes, the heat capacity of each loaded DPC slowly increased over the years after the moratorium. Additionally, the planning of the Swiss utilities will lead to even higher heat load for the DPCs in the next years. Exemplarily in Figure 2 the thermal capacity of loaded DPCs since 2004 is shown for one NPP in Switzerland. The different heat steps are also coming from the qualification process of non-standard materials for the basket. If there would have been no restrictions by the regulatory body due to aging behaviour of the non-standard material /7/, the increase of the heat capacity would have been much faster over the years.

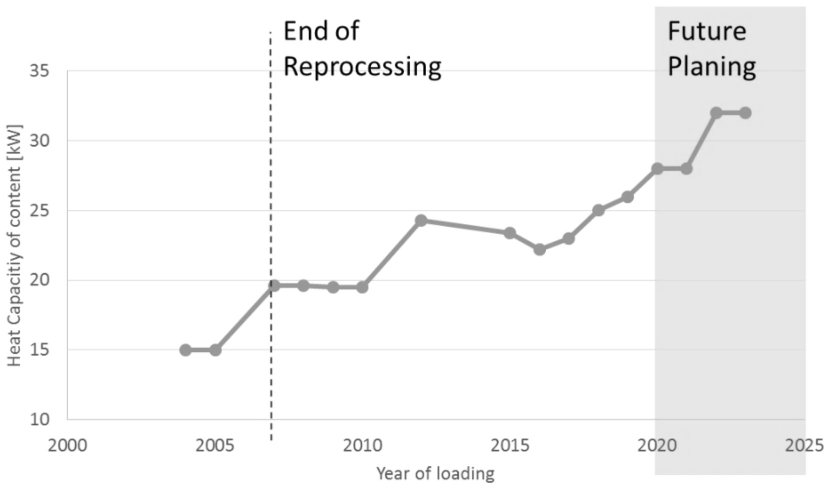

Figure 2: Heat capacity increase over the years

As a consequence of the moratorium also new designs are requested for approval at the regulatory body and old designs are modified. This is illustrated in Figure 3, which shows the different DPC designs and the year of the request for approval for storage in Switzerland. As a direct consequence, the Swiss utilities directly updated the safety files of approved DPC designs after the stop of reprocessing in Switzerland. They also introduced new designs. They ask for approval after the safety files are written, which needs up to the 2 years. Then the fuel strategy was also adapted and the old designs were updated again and additional new designs were ask for approval.

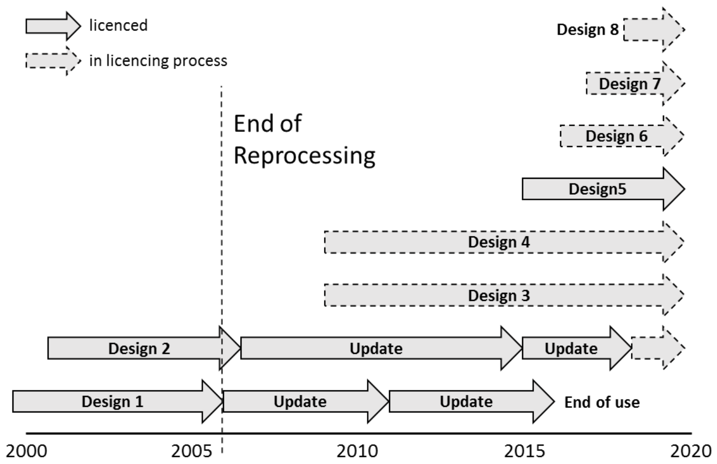

Figure 3: Requests for modifications and new designs of DPCs for spent fuel in Switzerland

CONSEQUENCES

DPC Design

As a DPC is used for many years only to store one and the same load of spent fuel, designers are trying to simplify the designs, to reduce the manufacturing time and the costs. On the other hand, the DPC design must fulfil the transport and storage requirements over a long period. According to the Swiss disposal concept all DPCs will be unloaded before final disposal of the spent fuel in another type of package still under development. Hence DPCs are only of temporary use and cost optimisation is a real issue for utilities and designers which leads to completely new designs of DPCs. In the past transport packages with a lot of different contents were adapted to storage needs. Now the needs are more driven by maximising the licensable storage content as well as reducing the manufacturing time and costs of each DPC. All the new designs must still fulfil the requirements for transport /5/ and storage /6/ but the way how to transport is also changing. For a DPC there are normally one or two transports on public roads. One to the interim storage facility onsite or offsite and then after several decades of interim storage just another one to the final repository. So, the main focus is interim storage and not transport. Therefore, the designers try to find ways to fulfil the transport requirements while also increasing the maximum content and simplifying the design for easier manufacturing.

Such design optimisations consequently have implications for all four main safety functions (containment, heat removal, dose rate and subcriticality) which will be described in the following.

The requirements for the containment analysis for public transport are still the same as in 2000. This also applies for the national storage requirements in Switzerland. The methods how the mechanical analysis is preformed are also still the same. Mostly the analysis uses finite-element-analysis which is occasionally validated by physical tests, including for example drop test. Such mechanical validation tests are usually requested by the competent authority in case of mayor novel design features. Nowadays these calculations can be done with greater model sizes and new materials but the basics of the finite-element-analysis are still the same.

For transport package designs the main developments are in the field of the shock absorbers. In the past, a lot of DPCs and transport packages had small light shock absorbers on the bottom and the lid. To these shock absorbers some additional absorbers are mounted around the cask body. New designs have much greater shock absorbers at the bottom and the lid to reduce the accelerations during normal and accident conditions for transport. These bigger shock absorbers can help to fulfil the requirements also if the thickness of the cask body is reduced in order to increase the maximum content.

Another issue for DPCs is the fact that there could be no need of an instantaneous manufacturing of the bigger shock absorbers if the first transport is an onsite transport to an onsite storage facility.

In storage configuration the lid area can be protected by a physical protection cover. Normally this area is the most sensitive part of the DPCs during an accidental mechanical load.

For thermal analysis there are some other changes ongoing. The designers of DPCs try to find better material to ensure the heat transfer from the fuel through the basket and the cask body to the cask surface. In the past steel and/or sandwich structures including steel for mechanical strength and aluminium alloys for heat removal were used in the basket designs. To increase the heat capacity of a DPC the designers try to use exclusively aluminium alloys for the basket. This has the additional advantage to reduce the mass of the internal arrangements leading to an increase of the content while still covering the mechanical analysis. The negative aspect is, that there are ageing effects of the aluminium alloys if they are used under high temperatures like inside a loaded DPC /7/. These effects imply limitations to the maximum allowed temperature inside the DPCs and therefore the loading patters have to be modified. This means that each basket lodgements can be loaded with a different heat capacity of the fuel. This modification leads to the so-called heterogenic loadings instead of homogenic loadings where each fuel has nearly the same heat capacity.

Another aspect of heat removal is that the maximum surface temperature of the package in transport is defined in the SSR-6 /5/ but by installing a thermal barrier like a fence around the package during transport the surface temperature of the package can be increased. In storage configuration if there is a temperature limitation of the storage pad the DPC can be mounted on a desk also to increase the maximum heat capacity of the content.

For the dose rate calculations on the surface of each DPCs new software packages were validated to calculate the source terms. This software can be used to calculate the source terms more precise including different loading patterns such as heterogenic loadings.

New neutron moderator materials were developed containing higher specific boron and/or hydrogen concentrations and ensuring the thermal resistance of these materials. The latter aspect turned out to be quite demanding as these materials typically show time dependant changes in their material properties under thermal load.

For sub criticality calculations the designers try to take credit from different aspects. One aspect is the moderator exclusion under accident conditions. Others are increasing the B-10-content of the basket materials or use of burnup credits for PWR fuel or Gd-credit for BWR fuel. All these aspects are intended to allow to a higher fissile inventory of the cask.

There are a lot of changes in the designs and the management strategies of DPCs over the years. All aspects intend to increase the maximum possible content of each DPC while reducing the costs of manufacturing.

Licencing process

The Swiss competent authority ENSI has applications for different DPC designs. Therefore, the licencing process was updated direct related to the following points.

- Consequences of working with two safety analysis reports for transport (SAR) and for storage (TSAR)

The following issues have been identified by ENSI during recent projects for the approval of the different DPC designs from different designers. In addition to the changes by the designers two other aspects had a significant influence on the licencing procedures recently.

In general, ENSI follows the international idea on the process of licencing a package for public transport by relying on transport licences issued by the competent authority of the country of originof the DPC-designers. These authorities focus on the examination of the analysis to fulfil the transport requirements. If there were additional needs coming from the national storage requirements from different countries they are not considered in the transport certificate at first hand but only when issuing the national storage design approval based on the TSAR.

Future changes in the safety file of transport (SAR), if it was accepted by another competent authority, will have to be addressed by the authority which issued the storage design approval and vice versa. However previous TSAR versions will continue to be valid as storage approvals of already loaded DPCs had been based on them.

The worst situation could be a significant change in the SAR which would lead to the consequence that some or all already stored casks are no longer transportable after storage. Another difficulty is that normally the foreign licencing competent authority have no interest to examine a package after 40 or 50 years when the final transport to the final repository is scheduled. The change in the SSR-6 that the last transport must be included in the transport licences address this problem but how should a foreign competent authority know what could be happen with the package during storage if the interim storage is in another country?

To address all these points ENSI changes the strategy by fully relying on a foreign transport certificate for DPCs /8/. Separate Swiss transport certificates for DPCs which are valid only used in Switzerland are issued by ENSI based on:

- transport certificates by the country of origin and/or
- Analysis examined by other competent authorities (e.g. if only the content is different and all the containment analysis are still covered).

If previous support is not available full scope assessment of the analysis to fulfil the transport requirements for DPC designs. To combine and optimise the assessment of the transport and storage safety file ENSI will follow the way of an integrated safety case which was introduced by a joint working group at IAEA /9/.

- Consequences of prolonged storage period

The second aspect with a large impact on the licencing process was that there is delayed availability of the final repository. Originally the foreseen interim storage period for DPC was up to 40 years. Due to modified procedures in the site selection of the Swiss deep geological repository, the so called “Sachplanverfahren” a storage period of at least 50 years for the oldest DPCs must be assumed. As a consequence:

- For DPCs which are actually stored in the interim facilities additional aging justifications must be performed by the cask owner. For guidance to such additional aging justifications ENSI has published a specific aging management guide /3/ in 2018.
- For DPC designs currently in production and licensing ENSI will include the following issues in the licencing process:
  - A design lifetime of at least 50 years must be assumed throughout the TSAR and corresponding SAR (in case of Swiss certificate) accordingly.
  - For each material it must be shown that the used material parameter in the calculations and analysis are fulfilled over the time of use. For standard material normally, this is done in the standards; for non-standard materials like neutron absorber materials specific qualifications must be provided by the DPC designer.

    - In the storage design approvals ENSI includes an additional requirement for a periodic safety evaluation of each DPC every 10 years with the scope of transportability, storability and the changes in the organisation following the aging management guide /3/.

With respect to the design modifications of the DPCs ENSI has updated the process of the licencing for transport and storage.

- Recent focus was on modifications of shock absorbers for which specific license relevant issues were identified: Transportability must be checked separately for each mode of transport. For example, the increased size of a shock absorber may be o.k. for road but not for rail transport. Therefore, a transportability study must be presented by the applicant.
- An increasing number of designs create problems in multimodal transport situations: In some cases, the trunnions are fully covered by the bottom and lid shock absorbers. So, the handling must be done with the separate cradle frame. The configuration of handling must be addressed in the safety file including any consequences of operational occurrences and accidents.
- Usually ENSI requests cold trials for each handling procedure before loading the first DPC of a new design to avoid any handling problems loading shipment reception and emplacing in the storage facility.

To address changes in the thermal analysis ENSI implemented the steps/issues in the licencing process:

- Development of an independent software using other methods than the DPC designers to verify the calculated heat dissipation. The software is validated by physical tests. /10/
- For each DPC design a thermal validation must be performed with the first manufactured DPC.
- Non-standardized materials must be qualified to show that the material parameters used in the calculations are ensured in reality.
- Clarifications of the input parameters of the thermal calculations used in the safety files to set up clear methods for the users of the DPC.

To address the changes in the shielding analysis ENSI implemented the following steps in the licencing process:

- Independent calculation by using a different calculation code. This includes also the handling procedure to optimise the overall dose rates.
- Control of the loading documents and calculations for each loading including in dependent verification by measurements after loading.

To address the changes in the criticality safety analysis ENSI has implemented the following issues in the licencing process:

- Request for physical examination of spent fuel to find out the fuel characteristic. The main scope is behaviour for the fuel rods with high burnup. /11/
- Validation of the used methods on the basis of physical tests.

Additionally, ENSI actively promotes bi- and multilateral exchange with other competent authorities to share the information about examinations of safety files. Mainly with these authorities which have given transport certificates for DPC used in Switzerland to learn about their examination and to give feedback on the behaviour of the DPC during storage.

All these points were implemented in the licencing process of ENSI to guaranty that all safety requirements for transport /5/ and storage /6/ are fulfilled by each DPC design in Switzerland during their whole operational lifetime.

Manufacturing surveillance

A consequence of a Swiss storage design approval for the manufacturing process of each individual DPC is the application of a product based quality control system the requirements of which are specified in the regulatory guide G05 /6/. /12/

The implementation of quality control during manufacturing is also addressed in an implementation guide /13/ describing the translation of ADR requirements into the specific Swiss situation. This includes not only manufacturing but also the qualification process. This process must be performed by the DPC designer and may include one or more of the following issues:

- Use of non-standard material
- Application of non-standard manufacturing technologies
- Change of supplier of non-standard material
- New manufacturer or change of manufacturer performing a key process for safety

The main target is to ensure the safety functions of the DPCs and the fulfilment of any material specification used in the safety files during the complete time of use. Therefore ENSI has set up a specific process for the qualifications:

1. The DPC designer must prepare his own qualifications without the competent authority and send a qualification report including a knowledge report und the applied manufacturing documents to the competent authority.
2. The competent authority will examine these report i and eventually will request additional tests for a qualification or first of a kind manufacturing under surveillance of the competent authority or a third-party organisation.
3. After successful qualification a final report addressing all safety relevant parameters is provided by the DPC designer and is given to the competent authority for examination.
4. For non-standard materials the competent authority will refer to this final report in the certificate for transport and storage design approval to ensure fabrication according to the qualification documents.
5. The series production can start based on the manufacturing documents which were the basis for the qualification. Major changes in the manufacturing documents will lead to new qualifications.

In Switzerland all qualification will be under surveillance of an independent technical support organisation SVTI-N.

At the end of manufacturing SVTI-N will issue a detailed surveillance report for each individual DPC to the competent authority. This report and the declaration of conformance by the designer is the basis for the registration of the new DPC as a licensed package under a Swiss transport certificate. The owner of the package will also be registered. At this point the responsibility for the DPC is on the owner.

CONCLUSIONS

Recent developments and changes introduced by the competent authority have been presented, which were implemented in the licensing procedure and the licence management; this includes specific Swiss transport certificates, the approval process to harmonise the basis for the transport and the storage safety assessment and corresponding reports (SAR and TSAR), the manufacturing surveillance including qualifications for example for non-standard materials and the operational use of the casks by implementing a specific aging management process. .

By implementation of all these activities a comprehensive regulatory oversight from design and pre-licensing activities until the final transport of DPCs has been established in Switzerland. This will ensure that the safety margins concerning the international transport requirements and the national storage requirements will continuously be respected for each DPC during the entire operational lifetime.

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