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A Study of Availability of Fuel Data for Sweden's Spent Nuclear Fuel

Main Review Phase

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SSM perspektiv

Bakgrund

Strålsäkerhetsmyndigheten (SSM) granskar Svensk Kärnbränslehantering AB:s (SKB) ansökningar enligt lagen (1984:3) om kärnteknisk verksamhet om uppförande, innehav och drift av ett slutförvar för använt kärnbränsle och av en inkapslingsanläggning. Som en del i granskningen ger SSM konsulter uppdrag för att inhämta information i avgränsade frågor. I SSM:s Technical note-serie rapporteras resultaten från dessa konsultuppdrag.

Projektets syfte

Inför slutförvar av använt kärnbränsle är det viktigt att relevant och korrekt information om materialet är tillgängligt. Informationen är nödvändig för bl.a. kärnämneskontrollen som ett led i att försäkra sig om att allt använt kärnbränsle slutligen hamnar i slutförvaret. Valet av verifieringsmetod direkt före slutförvaret kan innebära olika krav på den information som ska vara tillgänglig.

Följande studie syftar till att kartlägga vilken information som finns om använt bränsle som ska placeras i slutförvar. Avsikten är att undersöka om den tillgängliga informationen är tillräcklig för att uppfylla de informationsbehov som finns för att Sverige ska kunna uppfylla sina avtal rörande nukleär icke-spridning. Resultat kommer också att användas som underlag till kommande krav på bevarande av information om bränslet.

Författarens sammanfattning

Studien omfattar alla typer av bestrålat bränsle som kommer att placeras i slutförvaret. Den gjordes genom att välja ett urval av bestrålat bränsle och undersöka den informations som finns tillgänglig på kärnkraftverken, centralt lager för aktivt bränsle (Clab) och Studsvik.

Resultaten visar att för bränsle som urladdats efter 1980 finns de data som krävs tillgängligt. För bränsle om laddats ur före 1980 kan data återskapas men de finns inte alltid lagrade elektroniskt och kräver en viss arbetsinsats för att återskapas. Dessutom visade studien att information för kärnämneskontroll kan återskapas på antingen kärnkraftverken eller Clab. Ytterligare data kan emellertid endast återskapas på kärnkraftverken.

Projektinformation

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Aktivitetsnummer: 3067010-12

SSM perspective

Background

The Swedish Radiation Safety Authority (SSM) reviews the Swedish Nuclear Fuel Company's (SKB) applications under the Act on Nuclear Activities (SFS 1984:3) for the construction and operation of a repository for spent nuclear fuel and for an encapsulation facility. As part of the review, SSM commissions consultants to carry out work in order to obtain information on specific issues. The results from the consultants' tasks are reported in SSM's Technical Note series.

Objectives of the project

Final disposal of spent nuclear fuel will require that relevant and correct information about the material is available. The information is necessary for the accountancy and control of nuclear material and as a way to assure that all spent nuclear fuel will be disposed of. Different verification methods just before the fuel is disposed of may require different information.

This study aims to map what information is available on the spent nuclear fuel that is to be disposed of. The intention has been to investigate if the available information is sufficient to fulfill the Swedish obligations in respect to nuclear non-proliferation. The results will also be used as a basis for future requirement on saving the information about the fuel.

Summary by the author

The study covers all types spent fuel planned to be placed in the final repository. It was carried out by selecting a sample of spent fuel and investigating the information available at the Nuclear Power Plants (NPP's) in Sweden, the Central interim storage facility (Clab) and Studsvik.

The results indicate that the required data is available and can be obtained for fuel unloaded after 1980. For fuel unloaded before 1980 most data can be retrieved but all data are not stored digitally and require some effort to retrieve. Furthermore, the study shows that data for basic safeguard requirements can be retrieved from either NPPs or Clab. However additional data may currently only be retrieved from the NPPs.

Project information

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List of abbreviations

BWR – Boiling Water Reactor
Clab - Central interim storage facility (in Sweden)
MOX - Mixed oxide
NPP – Nuclear Power Plant
PSP - Particular Safeguards Provisions
PWR – Pressurized Water Reactor
SSM – Swedish Radiation Safety Authority
SKB – Swedish Nuclear Fuel and Waste Management Co

1. Introduction

Operation of the final repository for the spent nuclear fuel is planned to start within the next decade in Sweden, if the Swedish government issues a license for such an operation. The spent fuel content is hazardous to humans and the environment and it can be transformed into destructive weapons. The fuel is also of potential economic value. Consequently it is important to keep a record of material to be placed in the repository. In the present report a study of availability of fuel data for Sweden's spent nuclear fuel will be presented.

1.1. Background

The responsibility for safely depositing the spent fuel rests with the Swedish Nuclear Fuel Management Company, SKB. The State supervises that SKB takes this responsibility and the State has also the overall responsibility after the closure of the repository. The Swedish Radiation Safety Authority (SSM), as an administrative and expert authority of the state, needs to secure knowledge about the repository and its contents for future needs.

1.2. Purpose

The objective of this study is to examine:

1. If a set of essential data for spent nuclear fuel is available
2. How the desired data for spent nuclear fuel is stored and how easily it can be obtained.

1.3. Scope

The scope for the study covers all spent fuel planned to be placed in the final repository. The study is carried out at the Nuclear Power Plants (NPP's) in Sweden: Ringhals, Oskarshamn, Forsmark and Barsebäck. The Central interim storage facility (Clab) and Studsvik are also included.

1.4. Target group

The focus is primarily SSM's needs. However, the study may also be used as input for international work carried out by the European Commission's Safeguards Authority (DG-ENER) and the International Atomic Energy Agency (IAEA).

2. Method

The study was carried out as a sample study. A sample selection of fuel elements per decade and plant was used to give representative information about data availability, see 2.2. For each fuel element the availability of a set of data was examined. Selected set of data is further described in 2.1.

The study was performed by requesting the NPP's and SKB to compile required data or the availability of required data for the selection of fuel elements.

2.1. Selection of data

The set of data used in the present study was defined in collaboration with a group of experts at the SSM. Selected data is shown below:

1. Fuel ID
2. Fuel type, initial weight and enrichment
3. Geometrics
4. Weight of U and Pu after irradiation
5. Weight of transuranium and fission products
6. Date of final unload
7. Burn-up
8. Operating data (by cycle)
9. Pin exchange
10. Damage, leakage
11. Inserts (PWR)
12. Shipment date (to Clab)

The data was selected to cover not only safeguards needs but also to cover needs for verification of thermal rest power, criticality and radiation protection. The data can give information on the fissile content, the content of other radioactive isotopes, decay times, etc. This will allow deduction of important parameters.

2.2. Sample selection of fuel elements

A sample selection according to Table 1, Table 2 and Table 3 was used. The selection was chosen in collaboration with NPP's and SKB to present representative information for different plants and decades of operation. For example since Ringhals 1 and 2 are different types of reactors (BWR and PWR) elements from both reactors were chosen for 1970's fuel. On the other hand since Ringhals 2, 3 and 4 are all similar types of PWR's with similar routines of operation only ele-

ments from Ringhals 4 were chosen to represent Ringhals PWR's in 2000's.
The sample selection of fuel elements at the NPP's is summarized in Table 1. The selection of fuel elements for each decade of operation was made by the NPPs. The selection could include damaged elements if possible. A similar selection was used for Clab but one, instead of three, samples per decade was used, see Table 2. A German MOX element and one element from the closed down Ågesta reactor were also included in Clab's selection. For Studsvik two rod segments from Ringhals 1 used during 2000's were selected, see Table 3.

Table 1. Sample selection of fuel elements at the NPP's. Number of fuel elements per plant and decade of operation.

Plant	**Commercial start up**	**Shutdown**	1960's	1970's	1980's	1990's	2000's	2010's
Ringhals 1	1976	-		3			3	
Ringhals 2	1975	-		3				
Ringhals 3	1981	-			3			
Ringhals 4	1983	-					3	
Forsmark 1	1980	-			3			
Forsmark 2	1981	-					3	
Forsmark 3	1985	-				3		
Oskarshamn 1	1972	-		3				
Oskarshamn 2	1975	-				3		
Oskarshamn 3	1985	-			3			
Barsebäck 1	1975	1999		3				
Barsebäck 2	1977	2005				3		
								Total number of fuel elements 39

Table 2. Sample selection of fuel elements at Clab. Number of fuel elements per plant and decade of operation.

Plant	Commercial start up	Shutdown	1960's	1970's	1980's	1990's	2000's	2010's
Ringhals 1	1976	-		1			1	
Ringhals 2	1975	-		1				
Ringhals 3	1981	-			1			
Ringhals 4	1983	-					1	
Forsmark 1	1980	-			1			
Forsmark 2	1981	-					1	
Forsmark 3	1985	-				1		
Oskarshamn 1	1972	-		1				
Oskarshamn 2	1975	-				1		
Oskarshamn 3	1985	-			1			
Barsebäck 1	1975	1999		1				
Barsebäck 2	1977	2005				1		
Ågesta	1963	1974		1				
German MOX					1			
								Total number of fuel elements 15

Table 3. Sample selection of rod segments at Studsvik. Number of rod segments per plant and decade of operation.

Plant	Commercial start up	Shutdown	1960's	1970's	1980's	1990's	2000's	2010's
Ringhals 1	1976	-					2	
								Total number of rod segments 2

3. Legal requirements on fuel data

Requirements through SSM regulations SSMFS 2008:3 (10, 11§§) states that the operator must keep adequate information to allow for identification and verification of nuclear material. The operator must also be able to declare the amount and contents of nuclear material in the spent fuel. However, what data that should be included is not specified in detail. Furthermore the operator should file safeguard data for as long a period as nuclear activities are carried out. Data for research, development, installation etc should be stored for at least five years.

A previous work done by SSM on data which is desirable for safeguards as well as a national record can be seen in [1]. Much of the data covered in [1] must be retrieved form NPP and/or Clab. These include as an example isotopic composition and operating data.

4. Results

In Table 4, shown on the next page, the availability and storage of data is summarized. In the table it is shown whether the data is available and whether it is available electronically (marked AE) or in paper archives (marked PA). In most cases the operators not only stated they have the data but they also confirmed this by actually showing the data. These "verified" data has been marked as bold and underlined ("**AE**"). For data not marked as "verified" the NPPs/Studsvik/Clab have stated that the data exists but no actual data have been shown.

Table 4. Availability and storage of data

DATA	Barsebäck B1/B2	R1	Ringhals R2/R3/R4	Oskarshamn O1/O2/O3	Forsmark F1/F2/F3	Studsvik*	Clab**
1. Fuel ID	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**
2. Fuel type, initial weight and enrichment	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**
3. Geometrics	**AE**	**1. 1970's - PA, information may only be available in paper. 2. After 1970's - AE.**	**1. (R2) 1970's - PA, information may only be available in paper. 2. After 1970's - AE.**	**AE**	**AE**	**AE**	**AE**
4. Irradiated weight, U and Pu	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**
5. Weight of transuranium and fissionproducts	**AE**	**AE**	**AE**	AE	AE	NA	NA
6 Date of final unload	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**
7. Burn-up	AE	AE	AE. Includes axiell burn-up from 1980's	AE. Includes axiell burn-up from late 1980's/early 1990's	AE. Includes axiell burn-up	AE	AE
8. Operating data	1. 1970's data can be reconstructed 2. After 1970's - AE.	1. 1970's data can be reconstructed 2. After 1970's - AE.	AE	1. 1970's and early 1980´s - NA 2. Late 1980's and after - AE	AE	AE	NA
9. Pin exhcange	**AE**	1. 1970's - PA, some information may only be available in paper. 2. After 1970's - AE.	1. (R2) 1970's - PA, some information may only be available in paper. 2. After 1970's - AE.	AE, however data on relocation may only be availible in paper archives	AE, however data on relocation may only be availible in paper archives	AE	**AE**
10. Damage, leakage	**AE**	**AE**	**AE**	**AE**	AE	AE	**AE**
11. Inserts (PWR)	-	-	**AE**	-	-	-	**AE if applicable**
12. Shipment date (to Clab)	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**

AE= available electronically
PA= available in paper archives
NA= Not available

*Sample data from R1
** includes all NPP's, Ågesta and MOX

4.1. Availability of spent fuel data at the nuclear power plants

The results indicate that all types of data that are asked for in the study can be retrieved from archives at the NPPs for fuel elements from any decade of operation. All data currently required for safeguard needs are available in databases. Most complementary data can also be found in electronic archives or databases. However data for fuel elements used in the earlier decades (1970's and 1980's) may not have been completely digitalized. Furthermore, data for earlier fuel elements are not as detailed as for newer elements in some aspects, for example the number of fission products for which weight is calculated. Regarding operating data for earlier fuel elements it may not be available directly but can be reconstructed.

4.2. Availability of spent fuel data at Clab

Results from the survey at Clab indicate that all data currently required for safeguard needs are available in databases (DARK, PLUTO). Geometrics for early fuel elements were only available in paper archives. However SKB have conducted a study covering the geometrics for different fuel types [2]. Additionally it was noticed that Clab also keep record of other data such as fuel fabricator and date of first loading, although this wasn't included in the study.

Complementary data, as detailed data on weight of fission products and operating data was in this study not found to be available.

4.3. Error sources and uncertainties in the study

The possibility can not be excluded that the studied fuel elements have been selected arbitrarily and therefore does not reflect data for all fuel elements. Since fuel assemblies have been selected from different years, different decades and different plants the result is expected to give an adequate view of the overall status on availability of fuel data.

5. Conclusion

The study indicates that the required data is available and can be obtained for fuel unloaded after 1980. For fuel unloaded before 1980 most data can be retrieved but all data are not stored digitally and require some effort to retrieve. Furthermore the study shows that data for basic safeguard requirements can be retrieved from either NPPs or Clab. However additional data may currently only be retrieved from the NPPs.

References

[1] Fritzell, A.,(2011) , *The Back-End of the Nuclear Fuel Cycle in Sweden – Considerations for safeguards and data handling*. SSM: Research report 2011:02

[2] SKB, (2011), *Spent nuclear fuel for disposal in the KBS-3 repository*, TR-10-13

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The Swedish Radiation Safety Authority has a comprehensive responsibility to ensure that society is safe from the effects of radiation. The Authority works to achieve radiation safety in a number of areas: nuclear power, medical care as well as commercial products and services. The Authority also works to achieve protection from natural radiation and to increase the level of radiation safety internationally.

The Swedish Radiation Safety Authority works proactively and preventively to protect people and the environment from the harmful effects of radiation, now and in the future. The Authority issues regulations and supervises compliance, while also supporting research, providing training and information, and issuing advice. Often, activities involving radiation require licences issued by the Authority. The Swedish Radiation Safety Authority maintains emergency preparedness around the clock with the aim of limiting the aftermath of radiation accidents and the unintentional spreading of radioactive substances. The Authority participates in international co-operation in order to promote radiation safety and finances projects aiming to raise the level of radiation safety in certain Eastern European countries.

The Authority reports to the Ministry of the Environment and has around 315 employees with competencies in the fields of engineering, natural and behavioural sciences, law, economics and communications. We have received quality, environmental and working environment certification.

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