Developments in Spent Fuel Transport in Germany – Measures for Contamination Protection

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Abstract

Following the detection of contamination on the surfaces of transport flasks for spent fuel and on railcars in 1998, the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) established 10 criteria for the resumption of spent fuel transports to avoid contamination problems in future.

To fulfil these criteria German NPPs and the reprocessing plants of COGEMA, France, and BNFL, UK, developed certain actions and measures and identified a number of key parameters which required formal agreement. On this basis transports were resumed in Germany in April 2001 encompassing

- additional protection measures for flask surfaces during loading and unloading under water,
- common measurement standards for contamination controls and enhanced number of such measurements during each transport cycle,
- improved documentation of contamination measurement results and of technical measures during flask handling and
- organisational measures to clearly define competencies and responsibilities within the NPPs and among the involved parties and to improve the associated communication.

About three years after transports had been resumed, the additional measures are proving to be successful: No real contamination event occurred during this entire period.

The reports on experiences issued by German NPPs and by the reprocessing plants in 2002/2003 mention no relevant difficulties arising from the additional measures. However, with regard to the number of contamination measurements, some modifications have been suggested and a reduced contamination control program for “routine transports” was developed in accordance with the BMU-criteria.

According to German legal requirements spent fuel transports to reprocessing plants have to terminate by 30 June 2005. On these grounds and based on the positive experiences most German NPPs decided not to apply for any relevant modifications. Furthermore, experience shows that the additional collective doses to personnel were in fact not as high as anticipated, due to the enhanced measures and contamination controls, and did therefore not require substantial changes.

It can be concluded that the introduced system of improvements was successful in avoiding the contamination problem.

1 Introduction

Since April 1998 surface contamination of transport flasks for spent fuel and on wagons is a topic of major interest in Germany. At this time it became internationally apparent that limits for the non-fixed surface contamination fixed in the International Transport Regulations (ADR/RID [1]) at 4 Bq/cm² for β/γ emitting and 0,4 Bq/cm² for α emitting radionuclides had been exceeded by a percentage of spent fuel transports in different countries.
While other affected countries like France and Switzerland resumed routine-transports after 3 respectively 17 months, the moratorium of spent fuel transports in Germany lasted until April 2001.
During these three years various actions were taken and initiated by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), the federal authority responsible for nuclear safety and radiation protection, and by the German Federal Railway Authority (EBA), the competent authority in charge of rail transports of radioactive material by German railway companies. The aim was to find out causes and to develop measures in order to avoid contamination problems in future.

The assessment of the contamination problem, the analyses of causes and deficiencies as well as a survey of remedial actions are the main topic of a contribution to PATRAM 2001 [2].
The following focuses on the experiences in Germany over the last three years after transports were resumed with application of additional measures. The following aspects are considered:

- initial situation in Germany
- summary of actions and measures
- experience with application of measures and actions
- conclusion.

2 Initial Situation in Germany

Analyses of the contamination problem in 1998 revealed the following situation:

- Considering all transports of empty spent fuel flasks from the reprocessing plants of BNFL (United Kingdom) and COGEMA (France) to German nuclear power plants (NPPs) from 1988 to 1998 and all transports of loaded spent fuel flasks from German NPPs to the reprocessors from 1995 to 1998, the highest percentage of contamination events (17 %) can be found for wagons of loaded flasks arriving at COGEMA's transfer station in Valognes.
- The percentages of contaminated flask surfaces are much smaller (1 to 6 %). But all kinds of transports (empty and loaded flasks, to COGEMA and BNFL) are concerned.
- The analyses of transport data before May 1998 do not indicate a dependence between contamination events and flask designs which can be separated in two basic types: flasks with cooling fins and flasks with spikes in the cooling zone. In consequence all types of flasks were considered in the subsequent development of measures and actions. In addition to transports to the reprocessing plants transports to German central interim storages and HAW transports were included. Since transports of these types are considerably fewer, the following remarks focus on transports to the reprocessing plants. But they generally apply to the other types of transports mentioned above.
- A set of possible causes was found which included
  - a lack of awareness of possible contamination problems,
  - some deficiencies in procedures for handling, cleaning and contamination control of the flasks,
  - organisational matters, such as insufficient definition of responsibilities among the involved parties and of competencies of staff in NPPs as well as insufficient information flow among involved parties and to the authorities and
  - differences in standards for contamination measurements and documentation.

3 Actions and Measures

The basis for the development of measures to avoid contamination in future was laid down by the BMU in May 1998 in ten points for the resumption of spent fuel transports [3]. They were later elaborated in a "Catalogue of Criteria" [4] which highlights the main requirements to be implemented for future transports:

- The resumption according to a "Phase concept" in three phases which include
  - Phase I: cold handling of one flask of each flask type in each NPP,
  - Phase II: enhanced contamination measurement programme for 3 – 5 flasks of each type,
  - Phase III: routine transports.
- The realisation of a so called "closed transport cycle" for every cycle of a flask from the reprocessing plant to the NPP and back to the reprocessing plant. This means that a flask starts its cycle at the reprocessing plant in defined conditions with surface contamination well below the transport limits. Since the entire large surface cannot be cleaned and controlled during the cycle (at transfer stations and in NPPs), technical or administrative measures at each station of the cycle have to ensure that no surface contamination of the flask or the vehicle occurs due to handling or cross contamination. This has to be checked by sample inspections and documented.
- Introduction of technical measures designed to protect the flask surface during handling and to avoid cross contamination,
- Insurance of common standards for contamination measurements and documentation at all stations of the transport cycle,
- Organisational structures which assign clear responsibilities between institutions involved and inside NPPs,

- Exchange of experience and communication flow.

These criteria were considered in the detailed documents submitted by the German NPPs and the reprocessing plants covering technical and organisational measures for the whole transport cycle. These documents were evaluated by GRS and Oeko-Institute on commission of EBA. They were approved by EBA after recommendations, formulated in the qualification report, had been incorporated into the documents. They comprise the following points:

Avoiding contamination and checking surface contamination:
- Technical measures to protect the flask surfaces during handling under water for loading and unloading of spent fuel. The effectiveness of technical protection measures has to be proved during phases I and II of the phase concept.
- Decontamination and contamination checks of equipment and working environment before and during handling of flasks to avoid cross contamination.
- Radiological controls during and after handling of the flasks which are suitable to prove the success of the protection measures.
- Agreement on common standards for radiological controls among the involved parties.
- Introduction of an enhanced measurement program for contamination controls of flasks and vehicles at arrival at and departure from NPPs and reprocessing plants as well as at the transfer stations during the phases I and II.

Documentation:
- Improved documentation of contamination measurement results in the official transport documents and of the internal documentation of technical measures and contamination measurement results during flask handling.

Organisational measures:
- Inside the NPPs: Introduction of the position of a responsible person for nuclear transports, clear definition of responsibilities and competencies of individuals and organisational units involved in spent fuel transports, regular training of all persons involved.
- Between involved institutions: Clear definition of responsibilities of all institutions for each stage of the transport cycle.
- Guaranteed exchange of information and experience inside the NPPs, between all German NPPs involved and between NPPs and the reprocessing plants.

Information system:
- Introduction of a “Transport Control- and Information System” by the NPPs, a data base which contains contamination relevant data of all German spent fuel transports. (Additionally a federal data base was established under control of BMU where contamination relevant data are collected by the authorities).

For the implementation of these measures the following conditions had to be considered:
According to BMU’s Catalogue of Criteria [4] the technical and control measures must not lead to disproportional increase of radiation exposure for the personnel involved.
The technical and organisational measures which are implemented by the reprocessing plants have to be agreed between the reprocessing plant and the respective German NPP.
For the German part of the transport cycle all relevant steps and measures regarding surface contamination are laid out in general sequence plans and radiation protection instructions. They have to be implemented in detailed working instructions by the individual NPPs.

4 Experiences

First of all it can be stated that the improvements described above have been successful in avoiding contamination problems. Since April 2001, no surface contamination above transport limits occurred until today.

A summary of experiences gained during phase II of the phase concept for the resumption of spent fuel transports was given by most of the German NPPs and the reprocessing plants in a report of experiences. These reports are based on transports of an average number of six flasks of one type from each individual utility.
They form a basis for the transition to phase III of the phase concept and were assessed by a team of examiners including Oeko-Institute on behalf of EBA. In connection with findings from examinations during the handling of flasks in the NPPs and the transfer stations the following experiences can be pointed out from the point of view of the examiners. All those aspects dealing in detail with the technical protection measures to avoid surface contami-

nation of the flask and the vehicles and the experiences which were made in this context are not addressed in this paper as they are included in the presentation “Experiences with contamination protection of spent fuel transport packages in Germany since 2000/2001” [5].

Influence of protection measures on radiation exposure of personnel

Avoiding disproportional increase of radiation exposure of personnel as a consequence of technical protection measures and enhanced contamination controls was one of the relevant factors which had to be checked on the basis of experiences.

The reports on experiences show a wide range of collective doses connected with the handling of flasks in the NPPs which vary between

- 0,3 mSv and 3,6 mSv for gamma radiation and
- below tracebility limit and 4,1 mSv for neutron radiation.

Data for neutron doses are only reported by four NPPs while data for gamma doses are available for six utilities. On the basis of these data average values of the collective doses can be calculated to 1,9 mSv for gamma radiation, 1,2 mSv for neutron radiation and 3,2 mSv for the total collective dose.

For handlings of flasks in the period before 1998 for single NPPs values are given in the range of

- 1,0 mSv to 1,5 mSv for gamma radiation and
- 0,3 mSv to 1,25 mSv for neutron radiation.

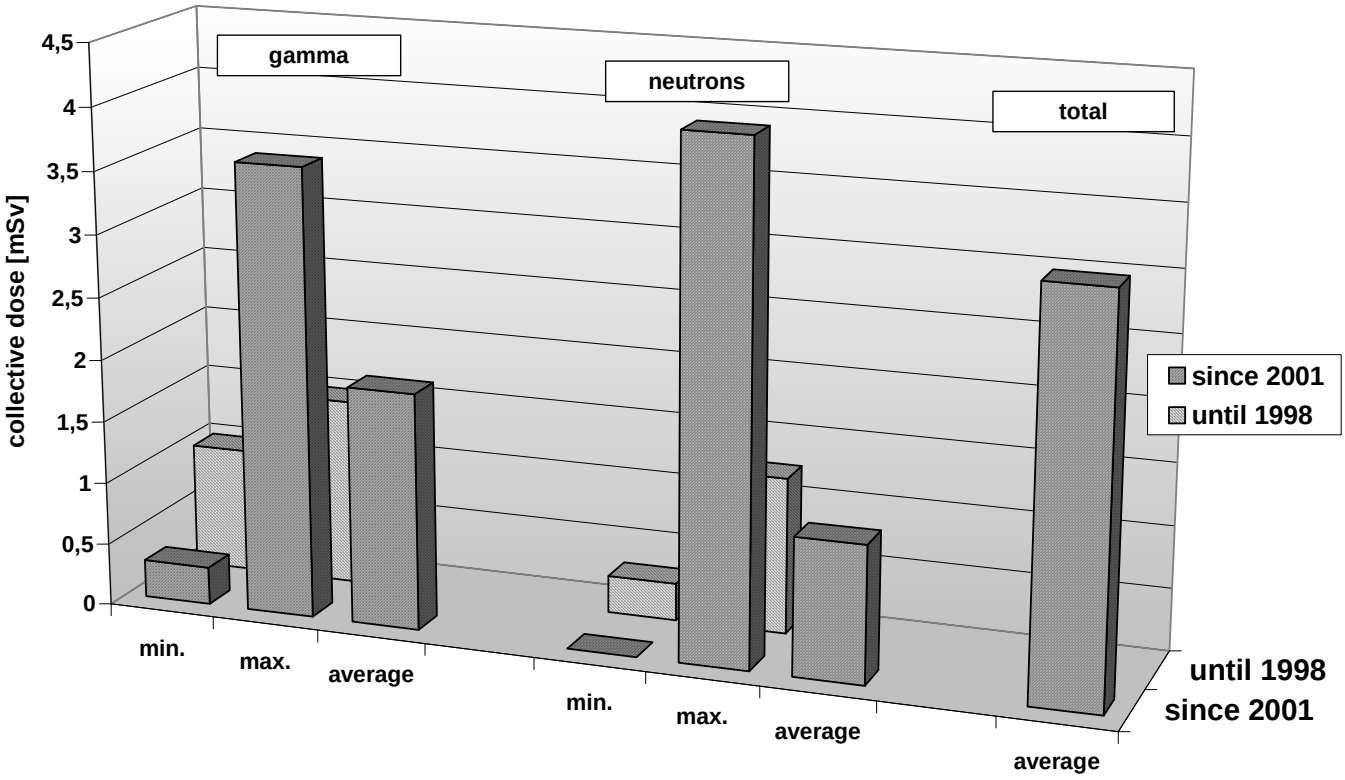

Figure 1: Collective doses per flask handling in German NPPs

According to conclusions in the reports on experiences the collective doses since 2001 are noticeably higher than they had been before the implementation of additional measures.

However, a detailed comparison with regard to the individual measures, that had been implemented, is not possible on the basis of the given data. This would require the assessment of personal-doses applicated during individual procedures connected with flask handling in the NPPs.

As some NPPs realise very low collective doses there is no evidence that general concerns about the implemented measures including the enhanced contamination control program are justified.

In the process of optimising the technical protection measures efforts are made in the NPPs to minimise the amount of time the personnel spends near the (loaded) flask.

Contamination control program

As stated above, phase II of the phase concept includes an enhanced contamination control program to ensure the effectiveness of the implemented protection measures. When it became evident that most of the plants involved handled a lot more flasks of one type in phase II than it had been foreseen in the phase concept, the competent authority agreed on a reduction of certain radiological controls in various cases before the transition to phase III. For different reasons, until today only COGEMA and one German NPP applied for the transition to phase III. In these cases a relevant reduction of contamination controls had been realised which has been fixed by various modifications of COGEMA's transport documents. In this context further minor changes and optimisations of technical measures, documentation and the agreements between COGEMA and the NPPs have also been carried out.

According to German legal requirements spent fuel transports to reprocessing plants have to terminate by 30 June 2005. On these grounds and taking into consideration positive experiences and the moderate influence of additional measures on the radiation exposure of the personnel it is unlikely that further utilities will apply for transition to phase III. The efforts of modifying the whole set of internal and official documents are estimated by the utilities as undue compared to the advantages of a reduced contamination control program for a small number of flasks still to be transported to reprocessing.

Documentation

Documentation of spent fuel transports is realised on the one hand in internal papers which give evidence of the performance of relevant technical and health physics measures including internal contamination controls of the flask, the working equipment and the working areas. These papers are kept within the utilities and may be inspected by the competent authorities or their authorised experts. On the other hand, the relevant data according to International Transport Regulations are put together in a transport documentation which gives proof of the status of the flask and the vehicle especially of non-fixed surface contamination and dose rates of the package. This documentation stays with the package during the whole transport cycle.
Extensive modifications of the transport documentations had been performed before the resumption of transports in 2001. During practical use some potential for further minor improvements became evident which was considered in the case of COGEMA's transport documents during transition to phase III. On the whole it can be stated that the modified transport documents used since 2001 give a clear summary of the relevant data of spent fuel transports. They are the basis for the data bases kept by the German utilities and the BMU as well as for the evaluation of experiences both inside the utilities and between the utilities. In this way they support the backflow of experiences which is an essential condition for optimisation of safety relevant processes in general.

Internal organisation

An adequate internal organisation is essential to a clear definition of responsibilities and competencies of individuals and organisational units and to ensure the necessary flow of information.

Once they had introduced the position of a responsible person for nuclear transports the German NPPs also defined the organisational structure of the whole team involved in spent fuel transports. Figure 2 gives an example of a model organisation of a project team.
Representatives of the different organisational units are actively involved in all stages of spent fuel transports including preparation and final evaluation of each transport campaign.
Experiences show that clarifications of the organisational structure and integration of the relevant organisational units in the whole process support the internal flow of information and the backflow of experiences inside the utilities as well as between the utilities involved.

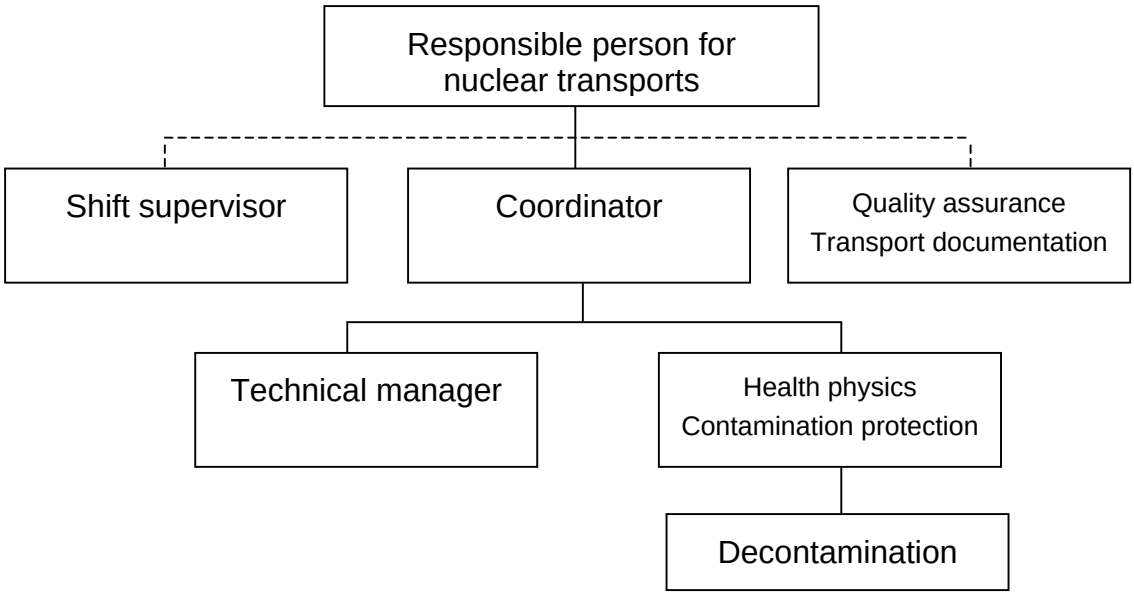

Figure 2: Exemplary organisational structure of a project team for spent fuel transports in NPPs

Organisational improvements have been complemented by regular training of all persons involved in spent fuel transports in the NPPs. One of the main topics of these trainings is to give background knowledge of the contamination protection concept in order to raise awareness of the personnel for contamination risks. This procedure considers the results of evaluations of contamination problems before 1998 which gave strong evidence that careful handling of the flasks is reflected in the avoidance of surface contamination. An adequate training program supports competency of the personnel which goes beyond the isolated knowledge required for a specific task: The program aims at familiarising each person involved with the safety objectives and at enabling the personnel to fit their own tasks within the scope of the process as a whole.

Exchange of information and experience

Besides the measures of internal organisation which support the flowback of experiences as stated above there are different ways which ensure the exchange of information and experience between the NPPs concerned and between NPPs and the reprocessing plants:
The NPPs have established regular meetings of the responsible persons for nuclear transports. Furthermore, a working group “Technical and radiological matters” with representatives from all NPPs concerned was initiated to deal with all kinds of general questions arising in connection with spent fuel transports. This working group also establishes a forum for exchange of information with the reprocessors and the German rail carrier. Intense exchanges of information and experience took place between NPPs and reprocessors e.g. during optimisation of the transport documents when COGEMA proceeded to phase III.

There are two further important means which ensure that experiences are not only exchanged but evaluated:
- The phase concept which includes the evaluation of experiences in a report at the end of phases I and II and
- the implementation of general sequence plans and radiation protection instructions which fix all relevant working steps and measures for the German part of the transport cycle.

Both means lead to an intense evaluation process of experiences which ensures that the potential for optimisation gained in one NPP is available for each NPP and is introduced when appropriate.

5 Conclusions

The measures implemented at the resumption of spent fuel transports have been successfully put into action at all transports which have been performed since 2001 until today.

For the technical protection measures which are connected with an enhanced contamination control program it can be pointed out that from the point of view of radiation protection there is no evidence that they cause disproportionate collective doses. Potential for technical optimisation has been used by the NPPs to reduce duration when handling the flasks. The enhanced contamination control program was suitable to prove the effectiveness of the implemented protection measures.

The second group of measures encompasses organisational improvements. They have contributed to the successful implementation and optimisation of the technical protection measures. Essential aspects are the clear definition of competencies and responsibilities and the improvement of the flow of information and experiences as well as the evaluation of experiences in order to identify optimisation potential. The organisational measures applied can be clearly assigned to elements which are generally referred to in recommendations for safety management systems, e.g. in [6]. In so far they do not represent special or undue requirements.

All together the measures form a system of improvements which is highly reliable in avoiding any contamination events.

References

[1] Regulations concerning the International Carriage of Dangerous Goods by Rail (RID), Annex I to the Uniform Rules concerning the Contract for International Carriage of Goods by Rail, Appendix B to the Convention concerning International Carriage by Rail of 9 May 1980

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[4] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU): Criteria for the transport of empty transport flasks, of flasks loaded with irradiated fuel assemblies from power plants and of flasks containing vitrified fission products, 7 June 1999

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[6] IAEA Safety Standards Series: The Operating Organization for Nuclear Power Plants, Safety Guide, NS-G-2.4, Wien 2001