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CHALLENGES AND EXPERIENCES ON THE PERFORMANCE OF THE FIRST SECURITY TRANSPORT OF SNF ON INLAND WATERWAYS IN GERMANY – *PRESENTATION 1140*

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ABSTRACT

For decades DAHER NUCLEAR TECHNOLOGIES GmbH (DNT) has successfully been planning and conducting several national and international security transports of spent nuclear fuel assemblies and products from the reprocessing of nuclear fuel such as LLW, ILW and HLW in heavy cargo casks type CASTOR® 440/84 mvK[1], CASTOR® V, CASTOR® HAW28M etc. on road, rail and sea. Situated in Hanau, Germany the company licensed for the transport of highly sensitive radioactive material owns specialized heavy cargo and high-level security transport equipment and has specifically trained and experienced staff at its command for security transports up to category 1.

In 2013 NPP operator Energie Baden-Württemberg AG (EnBW) – also owner of the closed down NPP Obrigheim and NPP Neckarwestheim (still in operation) – started to consider feasible options to transfer the remaining 342 spent nuclear fuel (SNF) assemblies, stored in fifteen CASTOR® 440/84 mvK casks (see Fig. 1), from the Obrigheim wet storage to the interim storage facility of the closely located NPP Neckarwestheim (approx. 50 kilometers distance).
Based on several transport feasibility studies in combination with DNT's extensive experiences with SNF transportation of highly sensitive material and a high public awareness media attraction, DNT succeeded to sign a contract with EnBW for the shipment of its SNF by river barge on inland waterways (river Neckar).

The presentation will give an overview of the challenges DNT and its cooperating partners were facing during all project steps and the experiences gained during planning, preparing and conducting a category II, FS security transport. It will focus on two main aspects: (1) the chosen mode of transportation – a combined road / river barge transport, which made the EnBW project a first-of-its-kind, since there never had been a security transport of spent nuclear fuel on inland waterways in Germany. (2) the influence of the more stringent new German Transport Security Guidelines Road / Rail, which were expected to become effective during the project's realization phase. The revision of the Transport Security Guidelines had never been implemented before and was essential for obtaining the § 4 AtG [5] transport license, that is required for any SNF transport performed in Germany.

INTRODUCTION

For decades DNT has successfully been planning and conducting several national and international security transports of spent fuel assemblies and reprocessing products such as LLW, ILW and HLW in heavy cargo casks type CASTOR® 440/84 mvK, CASTOR® V, CASTOR® HAW28M etc.

[1] CASTOR® (cask for storage and transport of radioactive material) is a trademarked brand of dry casks used to store spent nuclear fuel. The trademark is registered by GNS - Gesellschaft für Nuklear-Service mbH situated in Essen, Germany.

Fig. 1 Drawing of CASTOR® 440/84 mvK
including dimensions.

Based on several transport feasibility studies in combination with DNT's extensive experiences with SNF transports of highly sensitive material and a high public awareness media attraction, DNT succeeded to sign a contract with EnBW for the shipment of its spent nuclear fuel assemblies from Obrigheim to Neckarwestheim.

In this paper we report on the challenges and experiences the EnBW project presented to DNT and its cooperating partners on planning, preparing and conducting a category II[2], FS security transport of 342 spent nuclear fuel assemblies.

The paper focuses on two main aspects: (1) the chosen transport mode 'combined road / river barge transport' and (2) the influence of the more stringent new German Transport Security Guidelines Road / Rail, hereafter also referred to as "SEWD directive"[3] which is the defined basis for the security concept. The chosen mode of transportation made the EnBW project a first-of-its-kind project in Germany, since there never had been a security transport of spent nuclear fuel on inland waterways. Hence, many considerations and decisions concerning the transport mode 'river' had to be made for the first time ever.

At the time when DNT was contracted with the EnBW project it was already public that there would be a revision of the SEWD directive Road / Rail, issued by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU – Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit). The revision was expected to become effective in the year 2016, which coincided with the potential time slot for the performance of the SNF transports from NPP Obrigheim to NPP Neckarwestheim. Consequently, the requirements of the new SEWD directive had to be considered during the project's preparation and realization phase.[4] A respective SEWD directive for river barge transportation in Germany was non-existent at that time and still on an early stage of expert assessment and formation.[5]

[2] This category is equal to the classification according to IAEA publication referenced in [7].
[3] SEWD directive stands for 'Directive for the protection against disruptive actions or other interference by third parties' in the transport of nuclear fuels on rail and road referenced in [4].
[4] Having passed all committees, the new German Nuclear Transport Security Guideline Road/Rail became effective July 15th, 2018.
[5] The Nuclear Transport Security Guidelines for Sea and River Transportation are still in the process of being prepared.

TRANSPORT OF CASTOR® 440/84 MVK CASKS UNDER THE TERMS OF THE NEW GERMAN TRANSPORT SECURITY GUIDELINES ROAD / RAIL

Combined Road / River Barge Transport

Based on the results of DNT's feasibility study the most suitable mode of transportation for this category II, FS security transport, promised to be the combined road / river barge transport using a Roll-on/Roll-off (RoRo) river barge.
Both NPPs are in close proximity to the river Neckar and had direct road access to the NPP's own ports, which resulted in very short distances for the road transport in a secured corridor and the loading and unloading process of the RoRo river barge (see Fig. 2 and Fig. 3).

Fig. 2. Nuclear Power Plant Obrigheim including berth with RORO ramp.

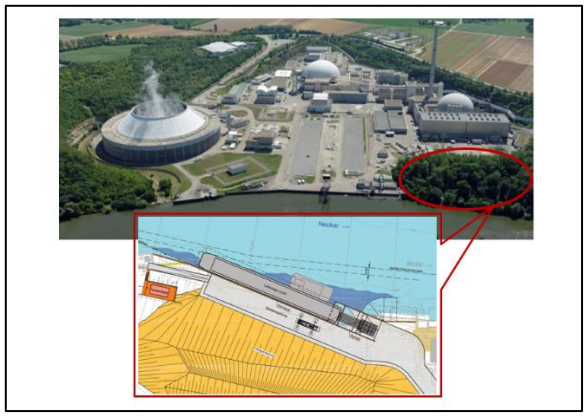

Fig. 3. Nuclear Power Plant Neckarwestheim incl. construction drawing of new RORO ramp.

None of the NPPs was connected to the rail network, which made transporting via railway unfeasible, since it would have included two additional transshipments of the casks from road truck to rail wagon and vice versa via crane. Due to the design of the package (lifting without shock absorbers and transport frame) and the design package approval of the CASTOR® 440/84 mvK only a special crane certified for nuclear sites with high safety margins would have been applicable for lifting the casks.

Further benefits of the inland waterway transport referred to the infrastructure and equipment required for this security transport. (1) Both NPPs had a berth of their own even though the one in Neckarwestheim had to be modified first, to meet the RoRo logistic requirements.
(2) The river barge offered significantly more loading space compared to a truck or a rail wagon. This was essential to the project because the additional loading space allowed for the implementation of constructional and technical measures (key component: 'shelter') needed to meet the requirements of the new Transport Security Guidelines and the applied Design Basis Threat (DBT)[6].
(3) The transport mode 'river' offered a better clearance to height of bridges, width of route and distance to housing areas. A transport via road would have involved a lot of restrictions with respect to

[6] According to the IAEA a Design Basis Threat is defined as 'The attributes and characteristics of potential insider and/or external adversaries, who might attempt unauthorized removal or sabotage, against which a physical protection is designed and evaluated' [6].

the heavy-duty character of the package[7], i.e. regarding the load bearing capacity of bridges, the passage of cities with narrowed roads, underpasses and roundabouts, as well as topographical challenges such as steep streets with gradients up to thirteen percent.
(4) Suitable class seven equipment was generally available, even though modifications had to be performed, due to the new and more stringent SEWD directive.
(5) The Ro/Ro procedure made crane operations for unloading the river barge obsolete, which was a significant advantage due to the lifting issue connected to the design approval of the CASTOR® 440/84 mvK already discussed on the previous page.
(6) The combined road / river transport ensured a maximum distance to housing areas and residentials during the transport performance and limited the interference in the road traffic to a minimum.

Based on these findings DNT prepared a customized security concept and on March 27th, 2014 officially applied for the transport license for a combined road / river barge transport to transfer fifteen laden dry casks type CASTOR® 440/84 mvK from NPP Obrigheim to the on-site interim storage facility of NPP Neckarwestheim. The application included the usage of heavy-duty truck-trailers, that would perform the Ro/Ro operations onto and off the specially modified river barge type LD40. Once safely loaded, the river barge would be pushed by a pusher tug (see Fig. 4).

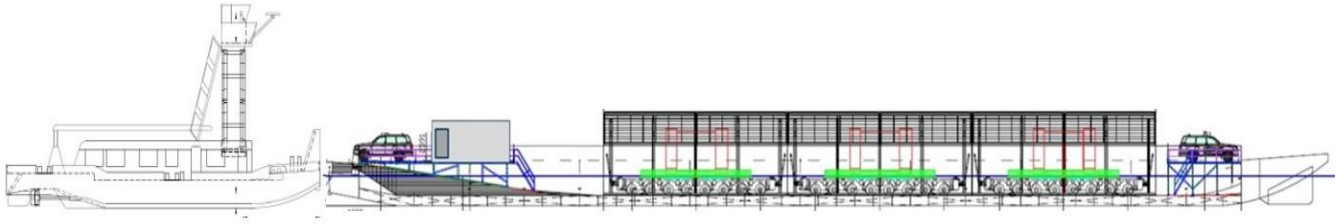

Fig. 4. Pusher tug and specially modified river barge type LD40 –
also referred to as 'pushing unit'.

Implementation Of New German Transport Security Guidelines For SNF Shipments

In the face of the new (and now much more stringent) SEWD directive the EnBW project and DNT were confronted with a new security category called SK II, **FS**. According to the IAEA categorization this new category equals to the IAEA category 'category II, irradiated nuclear fuel' by requiring additional measures to meet the physical protection objectives [7].
The main challenge the new category SK II, **FS** poses to the applicant of a transport license is the requirement to prove to the licensing authority BfE [1], that conceptional, constructional, technical as well as organizational and administrative measures are taken, which effectively and reliably limit the effect of a potential release of cask inventory to the public on a public route. The requirement relies on the underlying assumption that the release of cask inventory is caused by a specific threat as defined in the DBT issued by the BMU (confidential classified document)[8]. The applicant has to provide objective evidence (e.g. calculations, drawings, expert reports etc.) to the licensing authority and its appointed experts, considering all transport modes involved, the entire transport equipment dedicated to the transport, as well as the applied transport route including any transshipments of the casks. The

[7] The package consisted of the following units: one dry cask incl. two shock absorbers and one transport frame plus one 8-axles heavy-duty trailer and one heavy-duty truck. The weight of the package amounted to approx. 169.000 kg.
[8] Based on the recommendations of the German Federal and State Security Forces the BMU applies certain Design Basis Threats to each category.

security concept represents the document, that consolidates all the objective evidence provided. Moreover, it specifically describes and explains the conceptional, constructional, technical as well as organizational and administrative measures intended for the SNF transport. The quality of the security concept is essential for obtaining the § 4 AtG[9] transport license. Without the acceptance of the security concept the licensing authority will not grant the transport license.

Licensing Process for SNF according to § 4 AtG

When applying for a § 4 AtG transport license one of the main requirements is that the applicant has to categorize the inventory of the cask(s) based on the SEWD directive [7] by taking into account that an inventory has to be summarized in case of more than one cask on a means of transport or in a convoy. In this case the inventory was classified as Category II, FS[10] material. And the applicant has to provide a security concept.

DNT decided to follow an iterative approach for drawing up the security concept since, based on experience, it promised to be the most viable procedure. In Q1 2015 a draft security concept with main key points was issued to the BfE and its independent expert. After the results of this initial appraisal were provided to DNT a detailed security concept was created and submitted. This new concept implemented the results from the first evaluation and consisted of all relevant data (construction drawings, data sheets, calculations, etc.) and a full description of the entire organizational and administrative measures, including respective sequence plans.

The security concept evolved during a continuous assessment process, which was based on frequent assessments by the BfE, the independent expert and the members of the security committee[11]. The assessment phase was complemented by mutual status meetings, that finally led to new adjustments in the document. This process was reiterated several times, which resulted in additional requirements such as the request of additional administrative measures, and the condition to factor in contingencies. Each new requirement had to be implemented within a revision of the security concept, which restarted the assessment process.

Meanwhile, DNT and its customer, EnBW, decided to start the procurement, construction and preparation process, knowing that potential changes to the security concept might require respective alterations to the equipment and preparations already implemented. This decision was based on the common understanding of both parties, that time eventually would become a critical factor for the project's successful completion, and, that it was imperative to accelerate preparations to save time whenever reasonably possible.

In spring 2017 the security concept was ready to be submitted to the security committee for its final assessment. On May 16th, 2017 DNT was granted the transport license by the BfE, which paved the way for the transport of the fifteen casks type CASTOR® 440/84 mvK from NPP Obrigheim to the on-site interim storage facility of NPP Neckarwestheim.

The following figure (Fig. 5) illustrates the iterative approach applied to develop the security concept and to obtain the § 4 AtG transport license.

[9] The act on the peaceful utilization of atomic energy and the protection against its hazards – Atomic Energy Act (AtG–Atomgesetz),

[10] FS means release relevance of cask inventory. A substantial amount of cask inventory might be released to the public, exceeding the predefined dose threshold (emergency reference level), caused by a certain Design Basis Threat specified by the BMU.

[11] The security committee, also referred to as KoSiKern (= acronym for the German title 'Kommission Sicherung und Schutz kerntechnischer Einrichtungen' in English 'Commission for Security and Protection of Nuclear Installations'), consists of representatives of the federal state ministries of the interior as well as representatives of other federal authorities, that are essential for evaluating the security measures taken for any spent nuclear fuel transport in Germany [3].

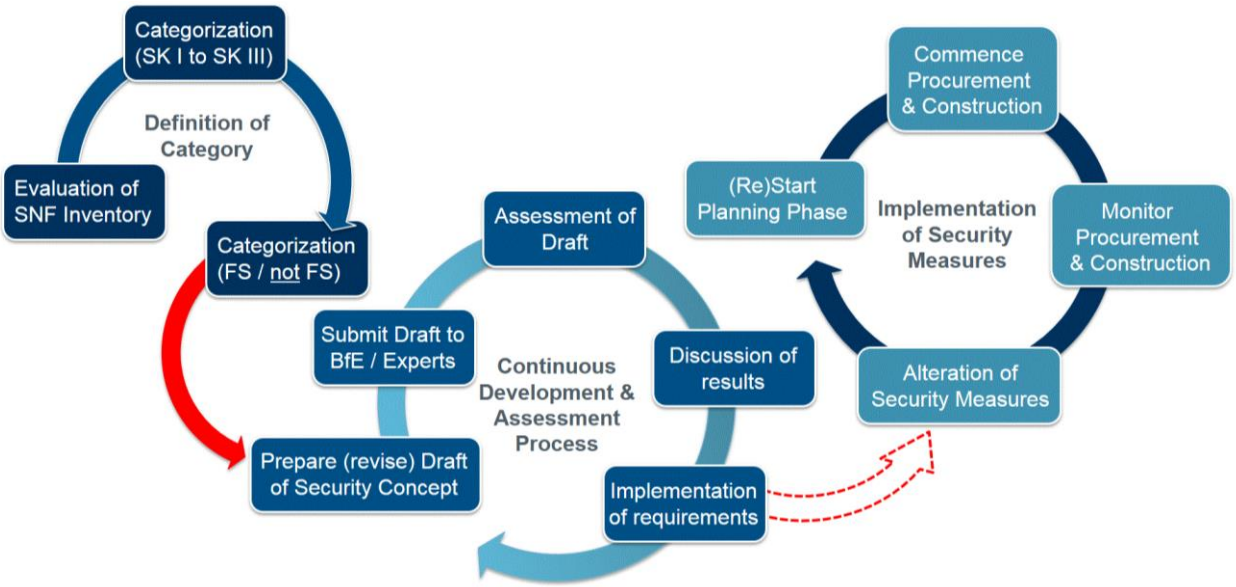

Fig. 5. Schematic diagram of iterative approach.

Essential Adjustments To The Transport Equipment

Due to the tight project schedule, DNT and EnBW decided to already start the transport preparations during the ongoing licensing process. This included the procurement of new transport equipment, as well as the modification of the already existing equipment, on the risk of both parties.

A special challenge connected to the task of modifying the transport equipment was the determination of effective security measures for the river transport. Since the licensing authority applied the same level of safety to the transportation of radioactive waste by inland waterway, as it did for the transportation by road or rail, the draft of the new SEWD Directive Road and Rail was used as basis for defining effective security measures.

Even though the pusher tugs, river barge and heavy-duty truck-trailers did already meet the regulations regarding the transport of class seven dangerous goods (ADN [9] and ADR [8]), they did not yet comply with the requirements defined in the draft of the new SEWD Directive. The equipment had to be modified so that it would efficiently protect the casks against interference of third parties. Besides, further arrangements guaranteeing the safety of the transport in the event of a maritime accident had to be implemented [2].

In addition to the modifications of the vessels and vehicles the new SEWD Directive specifically required a separate physical protection for the casks during the transport on inland waterways. Simultaneously, the ‘shelter’ had to provide a constructional solution, which would allow for the dissipation of decay heat, caused by the inventory of the casks for the duration of the river transport to comply with safety limits for type B(U)F packages for the duration of the transport. This led to the construction of a ‘shelter’ (see Fig. 6 and Fig. 7) installed on the river barge including an additional ventilation system to manage the decay heat. The entire modification process was continuously monitored by the authorities and their independent experts. The modifications of the transport equipment were time-consuming and complex, but were successfully completed in due time, so that everything was ready, when the transport operations finally commenced.

Fig. 6. River barge type LD40 during modification (lifting of component part of security enclosure).

Fig. 7. River barge type LD40 after modification (incl. new security cover with blinds).

Transport Performance

The first SNF RoRo transport from NPP Obrigheim to the on-site interim storage facility of NPP Neckarwestheim started with the loading process of three laden casks type CASTOR® 440/84 mvK on June 27th, 2017. The trailers were pushed by a heavy-duty truck and had to cover approx. 200 meters on road before they were rolled via a heavy load mobile ramp system onto the vessel (see Fig. 8).

Fig. 8. Loading of cask type CASTOR® 440/84 mvK at the berth of NPP Obrigheim.

The heavy-duty trailers were pushed one by one to their positions within the 'shelter' of the vessel and were safely tied down to the load bed of the river barge. Nautical checks (e.g. measuring the freeboard of the vessel) and transfer of ballast water into the numerous ballast tanks were performed during this procedure. On June 28th, 2017 the convoy consisting of the river barge type LD40 and the pusher tug (accompanied by a second pusher tug) left the RoRo berth of NPP Obrigheim (compare Fig. 9) heading to the fifty kilometers distant interim storage facility at NPP Neckarwestheim.

During its journey on the river Neckar six locks and twenty-three bridges had to be passed. The convoy was accompanied by security staff and police forces on waterways and roads. Security arrangements included that each road and lock had to be closed for public traffic by the police, before the convoy was allowed to pass the respective lock or bridge. This also encompassed the prerogative to be treated

Fig. 9. Departure of river barge and pusher tug ‘RONJA’
from RORO berth of NPP Obrigheim.

with priority compared to other vessels waiting to use the lock (see Fig. 10). Additionally, the waterway section on which the convoy was traveling was closed for the remaining ship traffic.

Fig. 10. Passing the lock of Lauffen/Neckar.

After approx. eleven hours the convoy finally arrived at the RORO berth of NPP Neckarwestheim, where the river barge was tied to the pier after the pusher tug had maneuvered it to its unloading position (see Fig. 11). As soon as the security staff’s transition from night to day shift had been completed and the external ramp had been attached to the river barge via crane, the discharging process started (see Fig. 12).

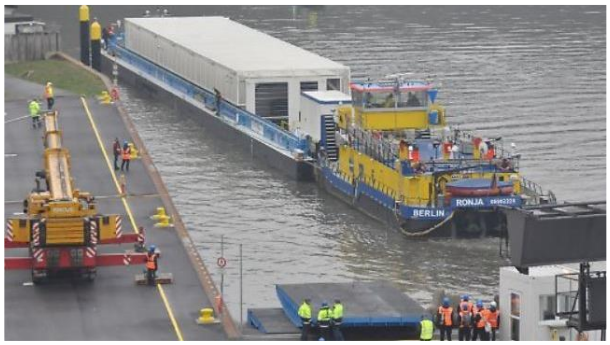

Fig. 11. Arrival at RORO berth of NPP Neckarwestheim.

Fig. 12. Unloading Road Trailer with cask from river barge
at the RORO berth of NPP Neckarwestheim.

Two heavy-duty trucks pulled the heavy-duty trailers out of the vessel's 'shelter', after the trailers had been untied from the load bed. The cask was rolled off the vessel and got transferred to the on-site interim storage facility of NPP Neckarwestheim, where it was discharged from the heavy-duty trailer and prepared for its storage. The heavy-duty trucks returned to the RORO berth to unload the next CASTOR® 440/84 mvK. This process was reiterated until all three dry casks were safely stored within the interim storage facility of NPP Neckarwestheim.

This first transport from NPP Obrigheim to NPP Neckarwestheim was followed by four equally successful SNF transports performed in September, October, November and December 2017, though they were accompanied by different challenges. The second SNF transport for instance was originally scheduled for August 2017 but had to be postponed due to a pending court decision by the Berlin Administrative Court. On June 20th, 2017 the Court's judgment was published [4], transport preparations were resumed and the second SNF transport was successfully completed in the first week of September 2017.
The last three transport batches fell into the autumn/winter period, which made transporting on the river more challenging because of the season specific weather conditions (e.g. icy grounds, impaired sight caused by fog, flooding caused by rainfall etc.). Constant heavy rainfall accompanied by an increased current and risen river levels eventually resulted in two additional transport postponements in November and December 2017. Both postponements caused considerable efforts, since all transport participants had to rearrange their preparations (e.g. deployment of personnel incl. accommodation) at short notice. The experiences gained during the first three transports, as well as the highly experienced and well-trained staff, in combination with the excellent teamwork demonstrated by all transport participants, made it possible to successfully overcome these hurdles and finish the transport campaign safely and in due time.

CONCLUSION

Fifteen laden casks type CASTOR® 440/84 mvK were successfully transferred from NPP Obrigheim to the on-site interim storage facility of NPP Neckarwestheim. The chosen mode of transportation was a combined road / river barge transport, using specifically modified transport equipment for the performance of Roll-on/Roll-off operations and the very first transport of SNF on a German inland waterway. The first-of-its-kind project posed several challenges to DNT and all transport participants. One of the fundamental challenges proved to be the interpretation and implementation of the newly

revised SEWD Directive Road and Rail. The revised version of the directive had never been implemented before and was essential to the preparation of the security concept, which in turn was imperative for obtaining the § 4 AtG transport license. DNT successfully managed to obtain the transport license, after considerable and elaborate calculations had been performed and extensive and complex constructional and technical alterations to the transport equipment had been made within a short period of time. External influences like weather conditions and protest activities (e.g. lawsuit of the Municipality Neckarwestheim or anti-atomic activists on and alongside the river Neckar during the transport performance) were handled professionally by all transport participants. Despite various challenges DNT managed to fulfill the expectations of its customer EnBW and successfully completed the project safely and on schedule.

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