Proceedings of the 15th International Symposium on the Packaging and Transportation of Radioactive Materials
PATRAM 2007
October 21-26, 2007, Miami, Florida, USA

LONG TERM INTERIM STORAGE FACILITY FOR NUCLEAR REACTOR COMPARTMENTS OF SUBMARINES - GERMAN SUPPORT FOR UTILIZATION OF NUCLEAR SUBMARINES IN RUSSIA -

Anton Erhard **Holger Völzke** **Volker Noack** **Wolfgang Weber** **Dietmar Wolff**

BAM Bundesanstalt für Materialforschung und –prüfung
(Federal Institute for Materials Research and Testing)
D-12200 Berlin
Germany

Dieter Rittscher **Holger Schmidt**

Energiewerke Nord GmbH (EWN)
Postfach 1125, D-17507 Lubmin
Germany

ABSTRACT

At the world economic summit in Kananaskis, Canada, in June 2002, the G8 heads of state decided on a global partnership against the distribution of nuclear weapons and materials of mass destruction. Based on this framework, the German Federal Ministry of Economics and Technology (BMWi) established a project in October 2003 concerning the storage of decommissioned Russian nuclear submarines. The basis was a German-Russian agreement. On the German side, project management of this 300 million euro project was assigned to **Energiewerke Nord GmbH (EWN)** and technical controlling to **BAM Bundesanstalt für Materialforschung und –prüfung** under respective BMWi contracts. On the Russian side, the Kurchatov Institute has the project management of the long-term interim storage facility in Sayda Bay, whilst the Nerpa shipyard, which is about 25 km away from the storage facility, is dismantling the submarines and preparing the reactor compartments for long-term interim storage.

The aims of the project - design and construction of a long-term interim storage facility (i.e. for a period of about 70 years) for 150 reactor compartments and 28 other radioactive big components of vessels at Sayda Bay near Murmansk - are foremost in this presentation. The interim storage facility is a precondition for effectively decommissioning and dismantling almost all of the nuclear-powered submarines in the Russian Northern Fleet. In July 2006 the first stage of the reactor compartment storage facility was commissioned, and the first seven reactor compartments have already been delivered from Nerpa shipyard. Further transports of reactor compartments to the storage facility are expected in 2007. Details about construction work progress at the storage site and the preparation of reactor compartments up to the beginning of operation in summer 2006, as well as some information about technical recommendations will

also be briefly illustrated. Within the scope of this paper, experience and lessons learned from constructing and commissioning of the storage facility and logistical challenges, including preparation and transportation of reactor compartments from the shipyard to the storage area wharf, will also be discussed. In particular, the hydraulic keel blocks, developed and supplied by German subcontractors, which are used for the transport of reactor compartments at the shipyard, the dock and the storage facility are described.
In the second part of the present contribution, the construction process on site will be outlined.

INTRODUCTION

The pros and cons of the storage of highly active civilian nuclear waste or spent nuclear fuel elements have been under political discussion in countries with nuclear facilities from the beginning of nuclear plant operations. Since then, two basic types of storage facilities are currently constructed, built or accordingly still under process. These are interim storage facilities for wet or dry temporary storage of spent fuel elements and also final disposal sites for spent nuclear fuel and high-level radioactive waste. Some of the interim storage facilities are within a proximate distance to or located directly at the site of nuclear plants. Central interim storage facilities are located a certain distance away, and transportation of spent fuel or highly activity waste (HAW) is thus necessary. Final disposal sites for spent fuel elements or HAW have not been established on the earth at present, but several investigation programs of mostly deep geological formations are still going on. Different countries have different repository concepts, for example the USA plan a repository at Yucca Mountain, Nevada, that is currently still under construction. The Swedish Company SKB is planning to store spent fuel elements in a deep repository (500 m below the ground) in the Oskarshamn region. In Germany discussions are still continuing regarding further exploration of the Gorleben salt-mine. The above concepts and discussions relating to storage facilities are primarily concerned with civilian nuclear waste. However, military nuclear waste in the world can not be neglected, for example waste from nuclear driven submarines and mass destruction weapons materials.

Based on the G8`s decision (renewed at the G8 summit 2007 in Heiligendamm, Germany) against the distribution of nuclear weapons and materials of mass destruction, the German Federal Ministry of Economics and Technology (BMWi) established a project supervising for the interim storage of reactor compartments from decommissioned Russian nuclear submarines in October 2003. In Germany the management of this project (with a budged of 300 million euro and in the meantime increased to 600 million euro) was assigned to **EWN** and the technical surveyance and evaluation are performed by **BAM**, both under respective contracts with BMWi.

Disposal of spent nuclear fuel is carried out in the program Arctic Military Environmental Cooperation (AMEC) based on an agreement between the Defence Ministries of Norway, Russia and the United States and initiated in 1996 [1]. The present paper focuses on the activities of EWN and BAM concerning design and construction of the **L**ong **T**erm Interim **S**torage **F**acility (**LTSF**) being constructed in Sayda Bay near Murmansk.

SUBJECTS AND AIM OF THE PROJECT

The subjects of the project are defined in article 1 of the agreement between the German Federal Ministry of Economics and Technology and the Russian Ministry for Atomic Energy, dated 9. October 2003 [2, 3]. These subjects are:

1. Erection of an onshore long-term interim storage facility for reactor compartments at Sayda Bay, including respective infrastructure.
2. Optimization of the material and technical situation and the equipment of Russian companies, to accelerate disposal of nuclear submarines.
3. Establishing of conditions for safe handling of waste products, generated in the disposal of nuclear submarines in the northern region of the Russian Federation.
4. Creation of an ecologically status of the environment at Sayda Bay.

Fig. 1: Construction area for building the LTSF

Design and basic idea about the construction at the site of the LTSF are schematically pictured in Fig. 1. This aerial photo gives a good view of the whole construction area on site. The blue colored area shows the long-term interim storage facility for about 150 reactor compartments from decommissioned Russian Northern Fleet nuclear submarines and 28 other components from nuclear vessels such as icebreakers and service vessels. This facility, which will allow safe and secure storage of radioactive compartments for roughly 70 years without harm to the environment, will be erected 50 km north of Murmansk at Sayda Bay and covers an area of about 5.5 hectares. Transportation of the heavy compartments will be carried out along rails. A drain around this storage area guarantees that contaminated water is certainly collected and stored in the waste-water treatment facility. The general aim of the project can, therefore, be summarized as follows:

Construction of a long-term interim storage facility for 178 radioactive compartments at Sayda Bay near Murmansk with the following features:

- storage platform with rails and drains
- physical protection
- pier for floating dock
- indoor reactor compartment repair hall
- auxiliary buildings
- radiation protection system
- roads and external infrastructure

TECHNICAL SURVEILLANCE

BAM´s surveillance work includes immediately accompanying of the EWN throughout the project and reporting continually to BMWi. Goal oriented project management and BMWi supervision are therefore necessary all the time.

The milestones of the technical surveillance are in the first part of the project:

- Building progress of the long-term interim storage facilities
- Evaluation and, if necessary, modification of technical tasks
- Transportation of heavy reactor compartments from the Nerpa shipyard by a floating dock to the storage place at Sayda Bay
- Conditioning of reactor compartments

Only a few of the above mentioned goals can be described in more detail in the present paper. Other problems caused by the design and construction of the first part of the LTSF are briefly discussed, if relevant. Transportation of reactor compartments from the floating dock to the interim storage on rails was a critical goal of the technical surveillance and, therefore, a big challenge to the future of the project. The rails are specially designed and constructed for the transportation of the heavy reactor compartments with a maximum permissible mass of 1600 metric tons. A view of the rail system constructed at the LTSF at Sayda Bay is showed in Fig. 2. The crossing rails can be clearly recognized as well as one of the reactor compartments at the entrance of the LTSF. For the transportation of these heavy compartments, special carrier equipment, or a so-called Keel Block Carrier (KBC), was developed and tested under BAM supervision at the Peenewerft Wolgast shipyard. The aim of these tests was to determine the principle capability of the developed KBC in relation to steering and handling. Since most functions are based on hydraulic principles, the KBC required several cable connections to the power unit, and the safe handling capability of this large cable bundle needed to be ensured. It turned out being an important factor during the development of the KBC, especially because 4 to 5 KBC units are required for the transportation of one reactor compartment. After extensive tests a solution to the cable duct was found. This was the start of checking procedures by on-site testing. First tests showed that the practical application of the KBC was different from tests performed under more or less laboratory conditions. Nevertheless, due to the experience gained from the feasibility tests, these problems could also be solved. Fig. 3a shows a reactor compartment together with 4 KBC units for transportation in the LTSF and Fig. 3b illustrates the problem with

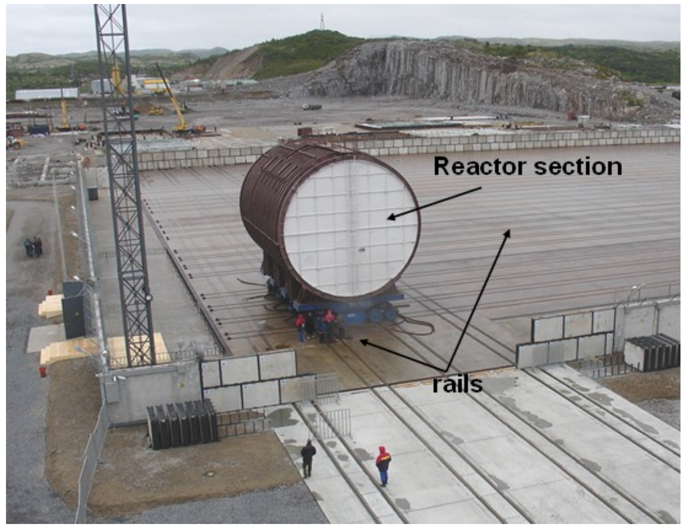

Fig. 2: Crossing rail system at the 1. part of the LTSF

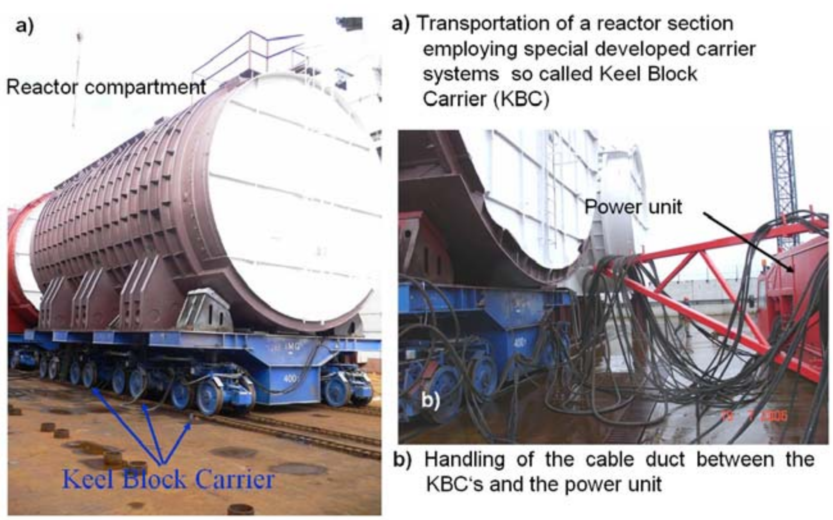

Fig 3: KBC on action and cable duct situation

the cable bundle. The KBC power unit is partially shown on the right hand side (red). At present, transportation of these heavy compartments takes place more regularly than in the past, and we are learning with experience. This is also exciting work and one should, therefore, be prepared for some surprises.

Another key point of the project involved the docking manoeuvre of the floating dock with the fixed rails on the permanent dock side. Special extra features were necessary for the solution of this problem. Design and construction on the sea as well as land side were well completed in an astonishingly short time period. All possible influences were considered during the design and the construction but, as usual, the devil lies in the details. A troubled sea together with boulder motion on the underground of the dock place caused unforeseen difficulties.

Fig. 4: Mismatch between the floating dock and the dry dock

Fig. 4 shows an example of such a problem needing to be overcome as the project progresses. A difference in height between the dock and the floating dock is clearly visible. This situation is shown in the picture on the right side. The mismatch of a few centimetres was bridged with rails shown on the left side. Nevertheless, challenges in a project of this size are often unavoidable and require quick solutions. But they should not create insurmountable hurdles although maybe costing valuable time and money before a solution is found.

A detail view of the loaded compartments is in Fig. 6. The reactor compartments are painted red, brown or white. Primarily, the paint should provide protection against corrosion. Corrosion and its relevance for long-term safety is part of an ongoing discussion in this project although it was not a key point at the beginning. Generally, proper corrosion protection of metal components needs a qualified coating material as well as proper surface preparation procedures to ensure long-term, stable adhesion under the environmental conditions. As a result, it was decided that, in the future, the painting quality shall be improved but at the same time it is recognised that the painting process for the first reactor compartments had not been carried out properly and the protection against corrosion could worsen. However, this is not certain and even in this case no direct safety concerns exist. Maintenance options could solve the problem. A more relevant safety issue might be possible crevice corrosion between the reactor compartments and their bearings, which could influence the stability under the heavy load of the compartment. Only periodical, in-service inspections can avert possible damage.

CONSTRUCTION PROCESS ON SITE

The situation at Sayda Bay before starting the project is illustrated in Fig. 5 on the right side. Parts removed from old submarines are still lying in the sea. In general, these former submarine parts consist of three sections with the reactor compartment located in the middle (Fig. 5 left). Dismantling of 3-sectional compartments from old submarines and formation of the (one section) nuclear reactor compartments capable for storage at the LTSF will be done at the Nerpa vessel repair dockyard located in a neighboring bay. This requires the transportation of the reactor compartments by sea with a floating dock to Sayda Bay. Some of the first problems created by the docking were described above (Fig. 4).

Fig. 5: Situation at Sayda Bay before starting the project

Part one of the project was the erection of an onshore long-term interim storage facility for reactor compartments at Sayda Bay, including respective infrastructure. As mentioned before, this first part was divided into different steps. In the first six months of 2006, the initial construction phase of the long-term storage facility at Sayda Bay was completed. The next step, preparation and transportation of nuclear reactor compartments from Nerpa to Sayda Bay, was planned in 2006. In July 2006 the maiden voyage with 7 compartments on-board was commenced [4].

Fig. 6 shows from the sea and land the floating dock with 7 reactor compartments. The transportation from the floating dock via the dock to the LTSF was carried out with the KBC units. After dealing with some minor problems, the first reactor compartment was moved towards the LTSF as pictured in Fig. 6 on the right. At this moment the consortium achieved their first goal. After reflection, a résumé at the present time would indicate that the transportation between the two bays is possible, both technically and logistically and almost with the planned number of compartments, too.

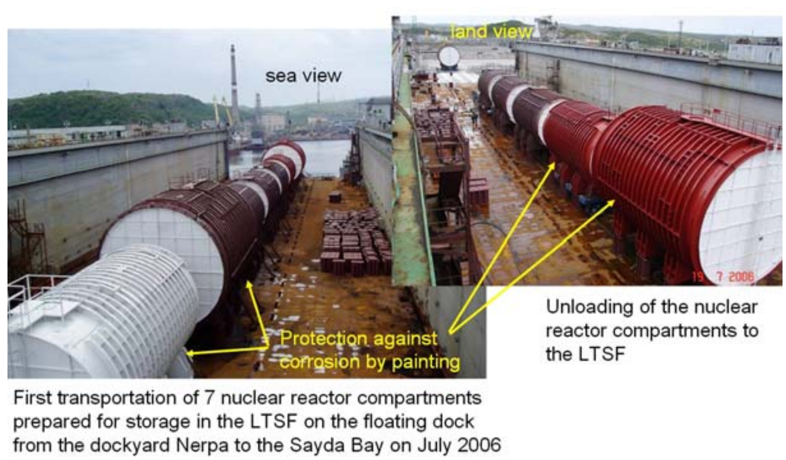

Fig. 6: The first 7 nuclear compartments at Sayda Bay

The dock load capacity is 14.000 metric tons. A maximum of 8 compartments can be carried on a single tranport. After demonstrating successful carriage of the heavy reactor compartments with the floating dock and the KBC, the time was right for the inauguration of the first construction stage of the storage facility as shown in Fig. 2 and in Fig. 7.

On July 18, 2006 after only two years of construction, this first segment of the facility, which can accommodate up to 40 reactor compartments, was officially opened by the German Minister of Economics and Technology and handed over to SevRAO, the Russian provider that will be operating the facility. Following this commissioning ceremony, the first seven reactor compartments were transported on the floating dock PD-42 from Nerpa shipyard to the long-term interim storage facility, where the compartments were put in storage (Fig. 7 right). The picture on the left in Fig. 7 shows quite impressively the bearing construction for nuclear reactor compartments at the LTSF. The final result of the successful logistics challenge, including the formation of reactor compartments, is presented in Fig. 8. All of the reactor compartments are stored in the LTSF.

Fig. 8: After successful demonstration of storage

CONCLUSIONS

The problem of submarine disposal has become a high priority in Russia, and safe storage of reactor compartments is a central goal of submarine dismantlement activities, as programmes in other countries also indicate [5]. The German-Russian G8 project focuses on the speedy construction of a land-based interim storage facility for reactor compartments at Sayda Bay. In 2006, after only two years of construction, the first segment of the facility was put into operation. The realization of this onshore long-term interim storage facility is a key project for further dismantlement of nuclear submarines from the Russian Northern Fleet. It will allow for safe defuelling and dismantling of additional nuclear powered submarines through Russian Federation funding, but also considerable financial and logistical assistance from other G8 Global Partners.

Although the first construction stage was only finalized after a delay of about six months, the project is now proceeding well. Considering the large temperature differences during the year, language barriers and the distance between Germany and Sayda Bay with limited travel options, the delay in the first step of the project was negligible. Therefore, results at present can be summarized as follows:

- The first construction stage of the LTSF has been finished. The planning for the next steps and the building construction of the two other parts of the LTSF are well under way.

- The dismantling of the 3-sectional compartments and the formation of nuclear reactor compartments suitable for storage in the LTSF were carried out successfully. The first 7 reactor compartments were founded by Germany.
- The Demonstration of transport procedure with the floating dock between the Nerpa dockyard and Sayda Bay was successful, especially under the circumstances that several unforeseen difficulties had to be overcome.

Some of the next steps in 2007/2008 include erection/completion of power energy complex, transformer station, receiving inspection building, administration building, a watch tower at the northern corner of the LTSF and, finally, starting the second construction stage. This stage will more than double the size of the first storage area. Nevertheless, independent of these activities, the dismantlement of decommissioned submarines, the formation of reactor compartments and the transportation to the LTSF are continuing. Additionally, the dismantling of further 13 3-sectional compartments and the formation of nuclear reactor compartments suitable for storage in the LTSF are financed by Germany.

For the second part of the Global Partnership, Germany and the Russian Federation plan to expand the Sayda Bay project by erecting a regional centre for radioactive waste management.

REFERENCES

[1] R. S. Dyer and E. Barnes, U.S. Environmental Protection Agency, Washington D.C.
R.L. Snipes, Oak Ridge National Laboratory, Oak Ridge, Tennessee, United States,
S. Høibråten and H.C. Gran, Norwegian Defence Research Establishment, Kjeller, Norway
E. Foshaug, Institute of Energy Technology, Halden, Norway V. Godunov, ICC Nuclide, St. Petersburg, Russia:
Completion of the first integrated spent nuclear fuel transhipment/interim storage facility in NW Russia, WM'03 Conference, February 23-27, 2003, Tucson, AZ

[2] Brochure: "The G8 Global Partnership, German-Russian Cooperation", May 15, 2004, published by the Federal Ministry of Economics and Labour, – Sherpa-Group, Preparation of the World Economic Summit.

[3] D. Wolff, H. Völzke, W. Weber, V. Noack, BAM Federal Institute for Materials Research and Testing and G. Bäuerle, Federal Ministry of Economics and Labour (BMWi):
Long-Term Storage Facility for Reactor Compartments in Sayda Bay - German Support for Utilization of Nuclear Submarines in Russia – (paper: ICEM07-7083), Proceedings of the 11th International Conference on Environmental
Remediation and Radioactive Waste Management, ICEM2007, September 2-6, 2007, Oud-Sint-Jan Hospital Conference Center, Bruges, Belgium

[4] Brochure: "Long term interim storage facility (LTSF) and radioactive waste storage facility (RWSF) at Sayda Bay", Federal Ministry of Economics and Technology, Public relation section P3, July 2006,
http://www.bmwi.de/English/Navigation/Service/publications,did=192148.html,
http://www.bmwi.de/English/Navigation/energy-policy,did=131408.html.

[5] V. Akhunov: „Progress on dismantlement of Nuclear Submarines under the Global Partnership International; Cooperation", NDEP-NOCICEG workshop on SMP-2, London, April 12 2007.