THE DTI FSU NUCLEAR LEGACY PROGRAMME: SPENT NUCLEAR FUEL MANAGEMENT AT ANDREEVA BAY

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ABSTRACT

Andreeva Bay is located in the Zapadnaya sea inlet at the extreme North-West of the Kola Peninsula (Russian Federation), about 40km from the Norwegian border and 80 km from Murmansk to the south-east.

Spent nuclear fuel (SNF), arising from the operations of the former Soviet Union's Northern Fleet, was initially stored in two large pools within Building 5. However, after serious leaks in the early 1980s the fuel was transferred to an external "drystore" constructed by adapting three existing concrete tanks, previously allocated for the storage of liquid radwaste. This was intended to be a temporary solution to the emergency situation. There are currently approximately 20,000 spent fuel assemblies (SFA) stored within the three tanks. The condition of the dry storage units is poor with inadequate roofs which have allowed water ingress to the tanks. Inspection of the cells has indicated very high activity levels in the interstitial water.

The UK Government's Department of Trade and Industry (DTI) Former Soviet Union (FSU) Nuclear Legacy Programme has been supporting a project concerned with SNF management at Andreeva Bay since 2002. RWE NUKEM is the project management consultant to the DTI for this and other projects, under this Programme. The Programme forms part of the UK's contribution to the G8 Global Partnership Initiative.

The progress of the project is described in this paper. The underlying objective of the project is to identify and implement solutions for existing safety, security and environmental problems of SNF storage at Andreeva Bay, which are acceptable to both the DTI and all key Russian stakeholders.

BACKGROUND

The Andreeva Bay Coastal Technical Base was established in the early 1960's and was used for the refueling of nuclear powered submarine cores and for storing spent nuclear fuel from submarines and nuclear powered ice-breakers. The Base was also used for interim storage of the solid and liquid radioactive wastes resulting from nuclear submarine operations and maintenance.

Andreeva Bay is located in the Zapadnaya sea inlet at the extreme North-West of the Kola Peninsula (Russian Federation), about 40km from the Norwegian border and some 80km from Murmansk to the south-east.

Spent nuclear fuel (SNF) was initially stored in two large pools within Building 5, however in the early 1980's, after serious leaks from the pools, the fuel was transferred to an external "drystore" constructed by adapting three existing concrete tanks, previously allocated for the storage of liquid radwaste. There are currently approximately 20,000 spent fuel assemblies (SFA) stored within the three tanks.

The site currently contains very large inventories of radioactive waste. This is principally present as spent fuel, in the dry storage units (Tanks 2A, 2B and 3A). The potential inventory in the three dry storage units is of the order of 10^{17} Bq. Another very contaminated facility is Building 5, the former pond storage facility for spent fuel.

The dry storage units were designed to store the spent fuel for 6 years. The tanks are currently in poor condition and are no longer proof against rain and snowmelt and from ground water penetration. Water is now present in many of the cells and is in contact with the fuel as the water is contaminated. The activity of the water has been observed to be increasing since 1999 suggesting that there is continuing fuel degradation in the tanks. There are no facilities or equipment on the site to allow improved management of this fuel. One of the dry storage units in particular, Tank 3A, is more susceptible to the penetration of rain water and snow melt as it has no cover other than concrete slabs covered with bitumen (Figure 1). The other tanks have roofs that allow some, but not full, protection.

Fig. 1. Dry storage Unit 1 (facility 3A)

Until recently there has been very little infrastructure to support operations at Andreeva Bay. None of the existing facilities had been maintained over the last 30 to 40 years and there were no services (electricity, water, roads, health physics, monitoring, decontamination, waste management) at the site. The old pier remains in very poor condition and adjacent areas are very contaminated. The new pier was never completed and is not in an operational condition.

UK Programme

The Department of Trade and Industry (DTI) on behalf of UK Government Departments manage the UK Nuclear Legacy Programme for the Former Soviet Union. DTI conducted a tendering exercise in 2002 to select a Programme Management Consultancy team for this Programme. RWE NUKEM Ltd was successful and the contract commenced in the summer of 2002. The programme is currently addressing Andreeva Bay spent nuclear fuel management, Submarine Decommissioning in North-West Russia, AMEC (Arctic Military Environmental Co-operation) projects, an interim SNF store at Mayak and Fast Reactor decommissioning in Kazakhstan.

The UK DTI project at Andreeva Bay started in August 2002. The underlying objectives of the project are to identify solutions for existing safety, security and environmental problems of SNF storage at Andreeva Bay, which are acceptable to both the DTI and all key Russian stakeholders, including the relevant regulatory bodies.

The process by which projects are established is for the Federal Agency for Atomic Energy (FAAE) of the Russian Federation (Rosatom) to identify both projects and participating institutes. This Project Identification includes a brief description of the objectives, scope of work and outline costs and timescale. This is reviewed by RWE NUKEM who make recommendations to DTI for acceptance or otherwise. The next stage is for the project to be defined in detail. This phase is funded by the DTI and involves a detailed description of the issues, optioneering studies to determine the optimum way of achieving the objectives and preliminary analyses of risk and environmental impact. A detailed cost estimate, work breakdown structure and project programme is also developed at this stage. Relevant regulatory approvals are also obtained.

Once the Project Definition stage is completed and accepted by DTI, the project moves into design and implementation phases.

The FAAE has nominated three institutes to have responsibility for various areas at Andreeva Bay. These are NIKIET, who are addressing spent fuel management at the site, ICES who are responsible for investigations into Building 5 and SevRAO who are the site operators and are specifically tasked with improving the condition of the spent fuel tanks.

Each of these organizations has identified projects that they wanted to undertake in their specific areas of concern. In summary the Tasks address the characterization of the existing conditions at the site and it’s facilities, the development of options to improve the situation and the development of facilities and systems to allow safe working at the site now, and in the future. These projects are now nearing completion of the project definition phase.

The current Tasks are summarized below and progress for each is described in some detail in the following sections.

Task Number	Lead Organization	Topic
Task 1	ICES	Characterization of Building 5
Task 2	NIKIET	SNF Management Options Study
Task 3	SevRAO	Establishment of safe conditions for interim storage and management of spent nuclear fuel in the dry storage tanks
Task 4	SevRAO	Radiation Protection
Task 5	SevRAO	Site Surveys
Task 6	ICES	Integrated database
Task 7	SevRAO	Criticality Monitoring

Task 1: Characterization of Building 5

This Task is concerned with establishing a comprehensive dataset for Building 5 so that both short-term and long-term management plans for the building can be developed by Russia. The Task has addressed the collection of existing data, establishment of a data base, a preliminary survey of Building 5 and an analysis of the data obtained for consistency and completeness.

Currently the work is focusing on defining the requirements of, and methodology for carrying out, a comprehensive survey to complete the data set on the current condition of Building 5. The best means of carrying out the survey has been established through a formal options exercise. ICES has been developing the methodology and planning the arrangements for the survey in more detail. An outline for this is given below:

Pools
There is a need to examine the bottom of the pools which are 6.5 m deep. There are overhanging beams making access difficult, and there are high radiation fields of up to 0.4Sv/hr. ICES are therefore proceeding on the basis of using a self-propelled robot to carry out the survey. The robot would be equipped with high coverage video equipment, a manipulator for recovery of samples / debris, and equipment for measuring γ, β dose rates.

The pool walls will be examined using of the bridge crane. Equipment would be mounted on a table / platform hanging from the crane, the crane would then be used to traverse the equipment along the pool walls.

Main Hall
It is proposed that the survey of the interior of the main hall will be carried out manually using hand held instruments. This will be supplemented using the bridge crane mounted equipment to examine the hall walls up to crane rail height.

The manual measurements will include radiological measurements and structural measurements on the concrete and its reinforcement.

Roof
It is proposed to survey the roof externally by man access. The survey will include visual, sampling, radiation mapping, and opening up the roof in one place for examination of the fabric.

Foundations
The condition of the foundations will be examined by exposing them at six pre-determined locations. The foundations will be photographed and structural tests carried out. Radiological measurements will also be made.

Basement
Survey of the basement is considered important particularly as it contains two columns which support one end of the pools. Simple access to the basement is not possible at present as access via the hall is closed off by plates, and access via the external door is prevented by earth piled against the door. These measures may indicate very high radiation levels within the basement. These may be associated with the basement being used as a dump for the chains used to support the fuel canisters when the pools were in use.

The proposal is to drill or cut a hole in the door and insert an endoscope and radiation detector into the basement to establish the overall situation within it.

The man-entry surveys took place in late November 2004. The robotic surveys will take place in 2005.

Task 2: SNF Management Options

This task is concerned with conducting an options study to determine the optimum SNF management strategy for the site.

The team put together by NIKIET to conduct the optioneering was very broadly based with up 14 separate organizations involved from a range of technical and regulatory backgrounds. The team members were invited to propose options for SNF management, propose the criteria against which these should be assessed and to identify the information they thought necessary in order to make a judgment between options.

The preliminary list of options accepted for evaluation were:

- Remove all SNF from site and send for reprocessing
- Disposal of SNF
- Remove SNF from the site, reprocess where possible, store or dispose of damaged SNF

The preliminary criteria to evaluate the options were:

- Cost
- Environmental Impact
- Dose
- Timescale
- Risk
- Socio-political events

- Technical flexibility
- Secondary waste generation
- National strategy

The conclusion was that the best option for SNF management was to remove all the fuel from the site for reprocessing at Mayak. There will also be continued consideration of the option of removing the intact fuel, sending it for reprocessing and storage of damaged fuel (prior to reprocessing).

The optioneering has continued with a detailed consideration of how the SNF may be retrieved and transported from the site. This has resulted in a final two options being selected for comprehensive analysis.

Option 1

- removal of the canisters with SFA from the DSU (Dry Storage Unit) cells;
- SFA repacking into new canisters and temporary storage of the canisters in DSU No. 2 (2A) cells;
- loading of the new canisters to the cells of SNF storage facilities at nuclear service and storage vessels Imandra or Lotta of OAO Murmansk Shipping Company;
- transportation of new canisters by nuclear service and storage vessels to FSUE Atomflot;
- transfer of the new canisters from SNF storage facility at nuclear service and storage vessels to transport containers TK-18 at FSUE Atomflot;
- loading of the containers with SNF to containers cars and their transportation to PO Mayak by railway.

Option 2

- removal of the canisters with SFA from the DSU cells and their transfer to a shielded facility in a SNF handling complex;
- SFA repacking in a special building of the SNF handling complex;
- canisters loading into transport containers TK-18 (TUK-108/1) in a special building of the SNF handling complex;
- temporary storage of containers TK-18 (TUK 108/1) at the storage pad;
- loading of containers TK-18 (TUK 108/1) to a ship (a special container ship, cargo hold of nuclear service and storage vessel Lotta or to the reequipped technical tanker, design 1150 Amur);
- transportation of containers TK-18 (TUK-108/1) to FSUE Atomflot;
- transfer of containers from a ship to container cars for transportation to PO Mayak by railway.

These options have been developed in detail and a decision conference was held in November 2004, at which all key stakeholders participated. The design principles and features for the SNF management strategy at Andreeva Bay were agreed to at this meeting.

The objectives of the strategy are that it should not make the SNF storage conditions worse and that it should enable the earliest, safe and secure SNF retrieval from the Dry Storage Units (DSUs) and transport off-site.

The design principles and features for the SNF management strategy at Andreeva Bay were identified and describe the default condition for the SNF management strategy. However, alternative procedures could be proposed if these have been comprehensively described and justified. Detailed safety cases and environmental impact assessments should be made for all phases of the proposed activity. The key design principles and features are described below:

- General
  - Optimization of Safety
  - Radiation safety
  - Physical Protection
  - Secondary waste management
  - Coordination of all site activities between all parties
  - Monitoring (including criticality)
  - Minimize canister handling
  - Minimize maintenance requirements
- Pre-operational Activities
  - Site/SNF characterization
  - Decontamination
  - Demolition of redundant facilities
  - Safe construction environment (shielding if required)
  - Early provision of radiological and conventional safety related infrastructure
  - Early provision of non-standard equipment
- Environmental Control
  - Controlling water ingress and discharge
  - Controlling atmospheric discharges
- SNF Retrieval
  - Engineered enclosure and controlled environment
  - Design to be fault tolerant and for retrieval of SNF in all conditions
  - Design for safe care and maintenance
  - Design for ease of decommissioning
- SNF Repacking
  - Engineered enclosure and controlled environment
  - Design to be fault tolerant and for repacking of SNF in all conditions
  - Design for safe care and maintenance
  - Design for ease of decommissioning
  - Allow for SNF inspection
  - Nuclear materials accountancy
  - The form of the repackaged SNF should allow acceptance at Mayak
- SNF Transfer/On-site Transport Operations
  - Provide containment
  - Nuclear materials accountancy
  - Minimize lifting operations for canisters and casks

- SNF Storage
  - Engineered enclosure and controlled environment
  - Sufficient capacity to accommodate transfer/transport disruption
- SNF Transport Off-site
  - Cask transport
- Timescales
  - Early stabilization of SNF conditions
  - Early start to SNF recovery
  - Early completion of SNF recovery, repacking and safe storage

The preparation of the pre-design and design documentation (OBIN) will address these design principles and features and will identify and develop the required infrastructure to implement them.

Task 3: Establishment of Safe Conditions for Interim Storage and Management of Spent Nuclear Fuel in the Dry Storage Tanks

This Task is concerned with improving the conditions of the SNF tanks both in the short-term and in the long-term. In the short-term a temporary weatherproof cover has been designed, approved, constructed and installed over Tank 3A. This is essentially a low-pitched steel roof with facilities for ventilation and filtration (Figure 2). It has been constructed in a clean area adjacent to the SNF area and was lifted into position using the existing crane.

The long-term option will provide facilities for access to and inspection of the fuel and, potentially, retrieval of the fuel in all three storage Tanks (Tanks 2A, 2B and 3A). This Task is clearly closely linked with that of Task 2.

Work is ongoing to produce the required documentation, a Design Assignment, Declaration of Intent (DON) and Feasibility Study (OBIN) for the design and construction of buildings and facilities for the handling of SNF as well as infrastructure required to support all activities. The OBIN will include an Environmental Impact Assessment for Andreeva Bay and a Technical Safety Assessment. Once this documentation has been approved by all of the relevant authorities the project will proceed to a conceptual, then detailed, design phase leading to construction.

Fig. 2. Temporary cover installed over dry storage Unit 1 (facility 3A)

Task 4: Radiological Protection

The main aim of Task 4 is the establishment of an overall Radiological Management System (RMS) for the Andreeva Bay site including the provision of appropriate radiological protection equipment and facilities. Progress to the end of 2004 is summarized below:

Sanitary Pass - A mobile Sanitary Pass has now been fully installed in the SNF area at the entrance to the SNF tanks. This provides monitoring, change facilities and shower arrangements for up to 10 workers in the SNF area. The Sanitary Pass was used during the installation of the temporary cover over Tank 3a. A second mobile Sanitary Pass has also been fully installed at the entrance to Building 5 (Figure 3). This was used during the building survey work in November 2004. Design work has started on a larger, medium term, modular, Sanitary Pass for use during the site characterization and construction phases to implement the SNF management strategy

Monitoring – Work has begun on the design of the environmental monitoring and physical protection systems.

Decontamination - The decontamination pad adjacent to the SNF area was completed during November 2004 (Figure 4). This work involved the preparation of the foundations and the facing of the foundations with stainless steel. A power cable was laid and equipment and materials for the water supply system, drainage system, ventilation and lighting system purchased. The area around the decontamination pad was also being developed, land filling work has been completed and the road structure and water management system constructed.

A number of specialized vehicles and equipment have been procured:

- Water-retrieving vehicle ARS-14D
- Portable decontamination devices
- Painting unit Finish
- Two water semi-trailers (bowsers)
- Engine heater MP-3ER.
- Tractor T-50

Laboratories – An engineering survey of B50 has been undertaken with a view to evaluating whether this building is capable of long-term use (with renovation) as a radiation protection control station. A ventilation system has been installed in the Norwegian village so that the laboratory facilities there can be used,

Secondary Waste Management – Materials and equipment for secondary SRW and LRW management have been purchased. A feasibility study for a system for handling secondary radwaste handling during SNF handling is being conducted.

Fig. 3. Installation of the mobile sanitary pass at Building 5

Fig. 4: The decontamination pad under construction near the SNF area.

Future work will address the establishment of an environmental monitoring system and a permanent, and larger, sanitary pass station. SevRAO are also producing a radiation and safety management plan which will cover the systems of work at the site.

Task 5: Site Surveys

The Andreeva Bay site requires characterization of its geology, hydrogeology and contaminative state for:

- construction of new facilities both for infrastructure and improving SNF management;
- establishment of groundwater and surface water management systems (particularly with respect to the SNF area);
- protection of the health of the site operators from uncontained contamination;
- protection of the environment in the long-term with decisions on the future of the site and its final state.

These require measurements of the site's topography, its geological structure, the geotechnical properties of that geology in locations around proposed new facilities and those whose long-term stability requires checking, spatial distribution of contamination, etc. This work has been supported to date by Norwegian funding.

Some additional work has been identified; further boreholes around the DSU's and an engineering survey of the pier which will be supported by the UK.

Task 6: Integrated Database for Andreeva Bay

This Task to develop an integrated database has arisen due to the expanding programme of work that is being undertaken at Andreeva Bay and the need to manage the data and information being generated as part of this work. The initial objective of the database is to improve the coordination between tasks (including those funded by all Donors) by providing easy access to technical information, objectives and progress of tasks, completed and planned work, available and required machinery and equipment.

This Task is in its early stages and is identifying the user requirements and required functionality for the database.

Task 7: Criticality Monitoring

The FAAE have proposed the establishment of a criticality monitoring system for the DSU's. Whilst this has been accepted in principle by the UK, the actual specification of the equipment has yet to be defined. This in turns requires an understanding of the potential criticality events, and the physical phenomena which will result from these. Once this is determined the Task will proceed to determining the optimum monitoring system.

CONCLUSION

The UK has been funding projects at Andreeva Bay since 2002. Substantial progress has been made by the Russian Federation in characterizing the condition of the Site and its facilities; improving the radiation protection infrastructure and systems; improving the condition of DSU 1 (Tank 3A) and developing detailed options for the retrieval and transport of SNF from the site.