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International Collaboration With The Shutdown Of The BN-350 Reactor

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Abstract- *Representatives from the United States and the United Kingdom discussed areas where collaboration on the shutdown of the BN-350 Reactor in Aktau, Kazakhstan would benefit not only Kazakhstan, but would also help to assure the successful shutdown of the reactor. A fundamental understanding of the basis for collaboration has been for each side to 'add value' to each of the project areas, rather than simply substitute for each other's experience. This approach has brought distinct technical and management benefits to the decommissioning activities in Kazakhstan.*

I. INTRODUCTION

As the global threat posed by the proliferation of nuclear material has grown, numerous countries have established goals supporting nonproliferation projects. However, due to issues such as a shortage of funding, lack of technical expertise, or lack of international agreements, many of these projects are never initiated. In some situations, the nonproliferation goals of one country are directly aligned with those of another. Providing a vehicle for these countries to pursue nonproliferation projects would help in reducing the global proliferation threat.

By combining resources, both capital and intellectual, countries can work together to reduce the risk posed by the proliferation of nuclear material, leveraging their limited resources to initiate and complete nonproliferation projects.

Recently teams from the United States and the United Kingdom combined resources to resolve nonproliferation projects associated with the shutdown of the BN-350 reactor in the Republic of Kazakhstan.

II. BACKGROUND

In 1999, the Republic of Kazakhstan made the decision to shut down the BN-350 reactor in Aktau, Kazakhstan. The reactor was a sodium cooled breeder reactor, used to produce plutonium for the Soviet Union weapons program. The U.S. Energy and State Departments pledged assistance in this effort, because the irreversible shut down supported the goal of reducing the threat posed by the proliferation of nuclear materials. Funding came from the State Department's Nonproliferation Disarmament Fund (NDF), and was earmarked for use within the Republic of Kazakhstan (RK) for the irreversible shutdown of the reactor with emphasis on decommissioning planning, decontamination of the primary sodium, sodium draining, sodium processing, and residual sodium deactivation.

From 2001, the UK Department of Productivity, Energy and Industry (DPEI) had funding available for work within Kazakhstan as part of the UK's contribution to the G8 Global Partnership against the Spread of Weapons and Materials of Mass Destruction. At meetings dealing with the shutdown of the BN-350 reactor hosted by the International Atomic Energy Agency (IAEA) in Vienna, the U.S. and UK sides discussed areas where collaboration would benefit not only Kazakhstan, but would also help to assure the successful shutdown of the reactor.

Areas where the collaborative efforts were applied included some ongoing programs being funded by the U.S. through the International Science and Technology Center (ISTC). ISTC was established to provide meaningful work to former weapons scientists in the former Soviet Union, and was a means for the DTI to influx funds into Kazakhstan without an indemnification agreement established between the two countries. Additionally, the U.S. and UK are collaborating on providing training to individuals within Kazakhstan. The areas of training have included training in decommissioning planning, off-site training in decommissioning issues (including radiation protection, liquid metal handling, and the development of cement technology for liquid radioactive waste conditioning), vocational training for decommissioning workers, international finance management training and training in modern project management methods.

III. ISTC PROJECT COLLABORATION

Several ISTC projects have been funded within Kazakhstan relating to the shutdown of the BN-350 reactor. These projects include the preparation of a decommissioning plan, decontamination of the primary sodium coolant, design and implementation of a control system for the operation of the sodium processing facility, formulation of the process and design for the final waste form from the sodium processing operations (geocement stone), a study of alternatives to geocement stone, and processing of the residual sodium remaining in the primary and secondary circuits after draining.

The discussions below detail the individual ISTC projects where collaborative efforts between the UK and U.S. are being undertaken or planned.

III.A. Decommissioning Planning

The preparation of a "Top Level Decommissioning Plan", meeting IAEA standards and requirements, was originally funded by the U.S. through ISTC. The Decommissioning Plan was prepared by RK personnel, and underwent international reviews followed by final editing, with the assistance of UK experts. This first version of the Decommissioning Plan was submitted in 2003 for independent international peer review organized by the IAEA. Results of this peer review yielded extensive comments requiring resolution. To assist the RK in resolution of these comments, the UK and U.S. sent participants to Kazakhstan to aid in the preparation and issuance of an action plan addressing each individual comment. This action plan has been issued, and the RK is responsible for incorporation of the comments into the decommissioning plan in accordance with the action plan. The UK and U.S. sides have pledged additional support to the RK by providing subject matter experts to aid in the comment incorporation, preparation, and review of the plan. These experts will be provided upon request.

III.B. Primary Sodium Decontamination

After shutdown of the BN-350 reactor, the primary sodium coolant contained high levels of cesium-137. This fission product was released to the sodium coolant during in-core fuel failures, and was the primary source of radiation in the primary system. In order to make handling of the sodium safer during draining and processing operations, an ISTC project, funded by the U.S., was established to "trap" the cesium from the sodium using the technology used at the Experimental Breeder Reactor – II (EBR-II) at the Idaho National Laboratory (INL, formerly Argonne National Laboratory – West).

This process involved fabricating a series of seven traps containing reticulated vitreous carbon (RVC). This RVC is proven to be effective in the adsorption of cesium.

Using the INL design as a basis, RK scientists and engineers designed the traps and system to decrease the cesium concentration in the primary sodium. A total of seven traps were fabricated and used for this process. This project was successful in that the concentration of cesium in the primary sodium was decreased by a factor of >800. [1]

Operation of the cesium traps was an essential pre-requisite for draining and processing primary sodium. However, it was also recognized that the high radioactivity content and the high chemical reactivity within the traps represents a continuing hazard during their secure storage at the reactor. Heightened awareness of the possibility of the traps becoming a future terrorist target has also been a factor in the desire to seek a longer term solution for the traps, consistent with their eventual consignment to a disposal facility. Accordingly, the ISTC project has been extended to study the options for safe disposal, provide for any necessary testing, and determination of the ultimate disposition of the traps.

The UK and U.S. are collaborating on the disposition of these traps. The process of "optioneering", fairly common in the UK but not widely used in the U.S., was proposed by the UK contingent to determine the most reasonable options for cesium trap disposition. Two optioneering sessions were facilitated by RWE NUKEM to clarify the path forward for this ultimate disposition. These sessions, one in the UK and the other in Kazakhstan, were attended by experts from all three involved nations. The sessions were designed to identify the options for disposal, and to narrow the list of options to those that would be evaluated in the extension to the ISTC contract. This contract extension has been funded by the U.S. and the UK and is currently underway.

The next phase of cesium trap disposition, forecast to be funded by the UK, will do any necessary testing to substantiate the results of the study. Finally, the cesium traps will be dispositioned as the last phase of the ISTC program.

III.C. Geocement Stone

The EBR-II sodium was processed into a 70 wt % sodium hydroxide solution. This solution is a solid at room temperature, and is an acceptable waste form for disposal in the State of Idaho. In Kazakhstan, further processing is necessary to satisfy the waste disposal requirements.

Kazakhstan has proposed producing a geocement stone using the sodium hydroxide from the sodium processing and mixing it with materials such as slag, clay, and Portland cement. This geocement stone would be an acceptable waste form for disposal in Kazakhstan.

An ISTC project was formed to evaluate this proposal. This project was initiated using U.S. funds, and was scoped with the study of material availability, determination of the "recipe" for the mixture, and conducting tests of the product on a lab scale to verify that the waste form would comply with land disposal requirements.

The UK, with substantial experience in the cementation of waste, hosted a workshop at the Winfrith Technology Center to share liquid waste solidification techniques with the RK participants. This workshop was also attended by a representative from the U.S.

The initial phase of the ISTC program has been successfully completed, with an acceptable waste form produced in the lab. A proposal is being prepared by RK to continue work on this program, to include full scale testing, design of the facility and process for full scale production of the final waste form, and procurement of process equipment. This next phase of work is being jointly funded by the UK and U.S.

III.D. Alternatives to Geocement Stone

Since the RK proposal to produce geocement was feasible but unproven, it was viewed as a high risk to the successful completion of the project. As a means of mitigating the risk, the UK funded an ISTC project to evaluate alternatives to geocement stone.

This project is currently underway. Since the initial results from the geocement study have shown promise, this project has been directed to explore methods to handle the schedule issues associated with the delay between the completion of the Sodium Processing Facility and the geocement facility. The U.S. funding for sodium processing is tied to schedule, so it is imperative that the processing is not delayed due to the lack of the facility that will produce the geocement product.

III.E. Residual Sodium Reaction

In order to ensure that the primary and secondary sodium systems are in a safe configuration for the period between draining of bulk sodium and ultimate dismantlement, the quantities of residual sodium remaining in these systems must be treated. As part of the NDF program, a study was performed on methods for processing/passivating the residual sodium remaining after the bulk sodium was drained.

The NDF program identified the process for treatment of the residual sodium. The method of reaction with moist carbon dioxide was chosen, based on the process used at EBR-II. It was also specified that some of the major components would be removed from the systems and treated separately.

The U.S. funding covered only the study of the residual reaction methodology. The actual implementation funding was not identified. Realizing the importance of the performance of residual sodium reaction, the UK has decided to fund the implementation phase through an ISTC project. This project is currently in the proposal stage and will be funded during the current UK fiscal year cycle.

IV. TRAINING

Several areas where RK personnel could benefit through training sessions were identified. These areas included off-site training in decommissioning and technical issues, vocational training for decommissioning workers, international finance management training, and project management training. It was decided that the UK and U.S. would collaborate in these areas by providing funding, training materials, and training personnel.

IV.A. Project Management Training

The concept of project management and its applications was fairly new in the RK. The performing organizations within the country were anxious to receive training in the basics of project management, and embraced the concepts.

An introductory course in project management principles was conducted in Almaty in November 2003 to familiarize participants from key organizations in the basic principles and practice of modern project management. UK and U.S. personnel collaborated on the preparation of training materials, and the first one-week session was presented by experts from both countries. This session was attended by 18 RK participants, and many of the techniques presented have been applied on ongoing and subsequent projects.

A second course in project management was also conducted in Almaty in June 2004. This course began with training on Microsoft Project® software, and concluded with practical applications of the software. Eleven participants completed the training, all passing the test on the comprehension of the software program.

The third session of project management training was also conducted recently in Almaty. This included parallel sessions; one a repeat of the introductory project management principles to a different audience, and the second a more advanced session on schedule recovery and acceleration. Ten participants were involved in the introductory session, which included several detailed assignments and class participation. The schedule recovery session, attended by nine participants, concentrated on the schedule for the geocement stone facility design. The participants appeared to grasp the concepts of this training. Both of these sessions were taught by teams comprised of UK and U.S. personnel.

IV.B. International Finance Management Training

Plans are being formulated for a course on international finance management training. The Republic of Kazakhstan has been contacted to perform a needs analysis, recommend specific training, and provide a list of selected participants. It is anticipated that this training will take place during the current UK fiscal year.

IV.C. Technical Training

Alkali Metal Handling, Processing and Residues Treatment Workshop

In March 2004, a group of ten technical participants from RK attended a Workshop at Dounreay in Scotland, where the UK's liquid metal cooled fast reactors are undergoing decommissioning. The training covered the basics of handling, transport and disposal of alkali metals and the associated safety issues. There were briefings on progress with disposal of sodium and treatment of residual sodium at the Prototype Fast Reactor and with decommissioning of the Dounreay Fast Reactor.

Radiation Protection Workshop

In November 2004 a Workshop on radiation protection was held at Harwell and Oxford in England. Ten participants from RK attended this workshop, which addressed the particular radiological safety aspects of decommissioning a sodium-cooled reactor and also covered:

- The importance of risk assessment for non-standard tasks.
- Techniques for internal dosimetry.
- Modern radiological detection equipment.
- Waste management and land remediation.

V. CONCLUSION

Collaboration between the United States and the United Kingdom in their support to the Republic of Kazakhstan for the decommissioning of the BN-350 fast reactor has been a key feature of each country's nonproliferation program in recent years. The collaboration has been beneficial in "adding value" to the contribution each side can make towards the safe and timely completion of early decommissioning activities, supporting the reduction of the threat of nuclear materials.

REFERENCES

1. O. G. Romanenko et al, "Cleaning Cesium Radionuclides from BN-350 Primary Sodium", *Nuclear Technology,* Volume 150, Number 1, April 2005, pp. 79-99.