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RUSSIA-U.S. JOINT PROGRAM ON THE SAFE MANAGEMENT OF NUCLEAR MATERIALS

Fred E. Witmer
U. S. Department of Energy
(301)903-2270

Paul F. Krumpe
U. S. Department of Energy
(301)903-2356

David D. Carlson
Sandia National Laboratories
(505)844-8497

Mary L. Young
Sandia National Laboratories
(505)844-8003

Leslie J. Jardine
Lawrence Livermore National Laboratory
(925)423-5032

K.L. Peddicord
Texas A&M University
(409)862-2831

M. Lee Hyder
Westinghouse Savannah River Company

Leonard N. Lazarev, Victor N. Dushin,
Mikhail M. Moshkov, Boris F. Petrov,
and Valeriy N. Romanovskiy
V.G. Khlopin Radium Institute
St. Petersburg, Russia

ABSTRACT

The Russia-U.S. joint program on the safe management of nuclear materials was initiated to address common technical issues confronting the U.S. and Russia in the management of excess weapons grade nuclear materials. The program was initiated after the 1993 Tomsk-7 accident. This paper provides an update on program activities since 1996. The Fourth U.S.-Russia Nuclear Materials Safety Management Workshop was conducted in March 1997. In addition, a number of contracts with Russian Institutes have been placed by Lawrence Livermore National Laboratory (LLNL) and Sandia National Laboratories (SNL). These contracts support research related to the safe disposition of excess plutonium (Pu) and highly enriched uranium (HEU). Topics investigated by Russian scientists under contracts with SNL and LLNL include accident consequence studies, the safety of anion-exchange processes, underground isolation of nuclear materials, and the development of materials for the immobilization of excess weapons Pu.

I. INTRODUCTION

The U.S. and Russian weapons dismantlement processes are producing hundreds of tons of excess plutonium (Pu) and highly enriched uranium (HEU) fissile materials. The Russia-U.S. joint program on the safe management of nuclear materials was initiated to address common technical issues confronting the U.S. and Russia in the management of excess weapons grade nuclear materials. The program was initiated after the 1993 Tomsk-7 accident.

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DISCLAIMER

In 1993 an explosion occurred at the Tomsk-7 reprocessing plant in Tomsk, Russia after nitric acid was added to a nuclear fuel reprocessing tank. The tank contained degraded organic solvent floating on top of an aqueous uranyl nitrate solution. The reaction of a degraded tributyl phosphate (TBP) solvent with nitric acid is thought to have caused the chemical explosion.[1] A U.S.-Russian review of the accident concluded that the root cause of the accident was that two established rules and procedures were not followed. The staging tank had not been cleared of accumulated organic phase material, and nitric acid was added to an unstirred process tank and not stirred for two hours. The amount of radioactivity released was approximately 30 TBq of beta-gamma-emitting nuclides and approximately 6 GBq of plutonium-239.[2]

The U.S. is on a two-path approach for disposition of excess Pu: (1) use of Pu in existing reactors and/or (2) immobilization of Pu in glass or ceramics followed by geologic disposal. Russian plans are to fuel reactors with excess Pu. The U.S. and Russia are both converting and blending HEU into low enriched uranium (LEU) for use in existing reactors. Fissile nuclear materials storage, handling, processing, and transportation will be occurring in both countries for decades.

The following table provides a history of the major events comprising the Russia-U.S. joint program on the safety of nuclear materials. A paper delineating program efforts was delivered at the SPECTRUM '96 conference. This paper provides an update on program activities since then.

The history of the joint U.S.-Russia effort to promote the safe management of nuclear materials.

Date	Location	Activity
June 1993	TOMSK-7 Russia	U.S. DOE Technical Team on-site review of TOMSK-7 incident
September 1993	Hanford, Wa. U.S.A.	First joint U.S.-Russia meeting on Radiochemical processing safety
November 1994	St. Petersburg and Krasnoyarsk-26 Russia	Second U.S.-Russia Joint Workshop on Radiochemical Operational Safety
August 1995	Los Alamos, NM U.S.A.	Third U.S.-Russia Workshop on Non-Reactor Nuclear Safety
August 1996	Seattle, Wa. U.S.A.	Program Review and Planning Meeting for Future Technical Exchanges
March 1997	Amarillo, Tx. U.S.A.	NATO Advanced Research Workshop: Fourth U.S.-Russia Workshop – Nuclear Materials Safety Management Initiative

II. NATO ADVANCED RESEARCH WORKSHOP, MARCH, 1997

In March, 1997 in Amarillo, Texas, a group of specialists representing the U.S. DOE and the Ministry of the Russian Federation for Atomic Energy (Minatom) conducted a workshop on nuclear material safety management. The focus of the workshop was on the non-reactor components and facilities of the nuclear fuel cycle.

The workshop had four objectives:

- To continue to exchange technical information on nuclear materials safety management
- To continue the development of a joint Russia-U.S. safety initiative
- To continue to expand contacts between U.S. and Russian technical specialists to promote significant technical exchanges related to common safety issues

- To evaluate the participation of other nuclear countries

Technical presentations were made in the following areas:

- Nuclear materials storage, transportation and handling safety
- Mixed oxide (MOX) fuel production, transportation and handling safety management
- Spent fuel storage, transportation and handling safety
- Geologic disposal, waste and environmental safety issues
- Status of ongoing joint safety management and safety technology activities

Workshop participants noted the importance of nuclear materials safety considerations, especially relating to the safety of the public and the environment, during the conversion, separation, storage, transportation and handling of spent fuel, excess nuclear materials, and waste. Both countries possess extensive capabilities that support mutually beneficial efforts to identify and resolve problems in nuclear materials safety management.

Participants agreed that technology exchanges in nuclear materials safety management should be continued. These exchanges should include the sharing of:

- environmental, safety and health assessments
- safety management methods
- risk analysis methods
- supporting operational guidance

Follow-up efforts should focus both on safety management and safety technology development for weapons-related nuclear materials (exclusive of safety programs relating to nuclear reactor technology, weapons dismantlement processes, and other areas where Memoranda of Cooperation exist between DOE and Minatom). Participants also agreed that the technical exchange supported by this program should be formalized with the establishment of a Memorandum of Cooperation between DOE and Minatom.

III. U.S. SPONSORED RESEARCH AT RUSSIAN INSTITUTES

A number of contracts with Russian Institutes have been placed by Lawrence Livermore National Laboratory (LLNL) and Sandia National Laboratories (SNL). These contracts support research related to the safe disposition of excess Pu and HEU materials. The following topics have been investigated by Russian scientists under contracts with SNL and LLNL:

- Refinement and validation of consequence assessment methodologies for postulated accidental atmospheric releases of radioactive material
- Safety of anion-exchange processes in nitric acid media
- Ensuring safety for underground isolation of nuclear materials containing long-lived radionuclides
- Development of ceramic materials and glasses for immobilization of excess weapons Pu.

A. Refinement and Validation of Consequence Assessment Methodologies

In January, 1995 a collaborative effort to improve radiological consequence analysis methods and tools was initiated between the V.G. Khlopin Institute (KRI) and Sandia National Laboratories (SNL). The purpose of the collaborative effort was to transfer SNL's consequence analysis methods to KRI and identify opportunities for collaborative efforts to solve mutual problems relating to the safety of radiochemical facilities. A second purpose was to improve consequence analysis methods by incorporating KRI experience with accidental radiological releases.

The initial collaborative effort identified:

- safety criteria that radiochemical facilities in Russia must meet
- analyses/measures required to demonstrate that safety criteria have been met

- data required to demonstrate the safety basis of a facility

In addition, SNL staff presented a one week consequence workshop hosted by KRI. The workshop included an introduction to the MELCOR Accident Consequence Code System (MACCS).[a] KRI developed MACCS sample problems of mutual interest to KRI and SNL in order to exercise the analysis methods presented in the workshop and gain experience in radiological consequence analysis.

Currently, SNL has contracts in place with the Khlopin Institute to add an explosive plume formation model to the MACCS2 code and to compare MACCS2 estimates to field data gathered after the 1957 waste tank explosion at Chelyabinsk.[b]

B. Safety of Anion Exchange

The efficient recovery of Pu by anionites necessitates the use of solutions with high concentrations of nitric acid. There is a risk of highly energetic chemical reactions during the recovery process that are accelerated by temperature increases and/or intense irradiation. Under certain conditions, a thermal explosion is possible, resulting in the destruction of the ion-exchange column and the release of radioactive material. Such incidents have occurred in the U.S. and Russia. Therefore, determining safe processing conditions is of great importance. KRI completed experiments designed to evaluate the effects of temperature increases and irradiation of the anionite resin (VP-1AP) in nitrate form. Data on gas evolution, changes in resin mass and its operating characteristics were obtained. It was found that the presence of water-soluble anionite synthesis products significantly increases gaseous formation during the anion-exchange process. In addition, it was found that a thermal explosion of the anionite VP-1AP in nitrate form is possible only in the absence of a liquid phase. A safe anion-exchange process must maintain the presence of a solution over the anionite layer in sorption columns. In addition, removing water-soluble anionite synthesis products significantly decreases gaseous formation during the anion-exchange process.

C. Safety of Underground Isolation of Long-Lived Radionuclides

KRI is involved in the evaluation of alternative methods for the safe disposal of radioactive wastes. The Institute has applied the principles of geological similarity to study the efficacy of alternative approaches. Natural deposits of uranium are studied to determine the properties of deposits that provide for safe isolation of radioactive material over millions of years and properties that provide channels for material migration. KRI studies indicate that:

- a layer of argillaceous rocks provide an effective cover for radioactive waste repositories
- the backfill for a repository should be composed of argillaceous rocks
- the degradation of engineering barriers must result in the creation of a subalkali medium

D. Glass/Ceramic Immobilization of Weapons Grade Pu

The principle of geological similarity is also used by KRI to evaluate alternative matrices for the immobilization of long-lived radionuclides. Concentrators of natural radionuclides are very widespread. The crystalline state is one of the most stable structures in nature. Crystalline materials hold and isolate radioactive elements over millions of

[a] MACCS was originally developed under U.S. Nuclear Regulatory Commission sponsorship to estimate the offsite consequences of postulated accidents a commercial nuclear reactors. MACCS2 is a version of the code that contains additional capabilities for the analysis of non-reactor nuclear accidents.

[b] Approximately 74,000 TBq (2 MCi) of radioactive material was released as a result of the radiological waste tank explosion that occurred at Chelyabinsk in 1957. The impact of the release on the environment and on human health was closely monitored and extensive data is available.

years. KRI studies indicate that a crystalline matrix has a number of advantages in comparison with a glass borosilicate matrix including:

- greater thermal and radiation stability
- the possibility of creating synthetic analogues of natural minerals that have retained actinides in their crystalline lattice for 10^5 years and longer

IV. CONCLUSIONS

The U.S.-Russia Joint Nuclear Materials Safety Management Program has enabled a synergistic application of Russian and U.S. resources to address nuclear safety issues common to both the U.S. and Russia. Although no additional funding for this program was provided by the U.S. DOE for FY98, this program has advanced the safety of nuclear materials management in both the U.S. and Russia and has provided Russian and U.S. specialists important experience in working together to solve common problems.

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