Important projects of the Division

Division for Radiation Safety, NPP Decommissioning and Radwaste Management has successfully carried out variety of significant projects. The most significant projects that were realised, are implemented and possible future projects are introduced in the following part of presentation.

Project of the A1 NPP Decommissioning – Stage I: "Overall project description"

Project involved solution and implementation of 35 tasks related to environment and outside buildings, main generating unit, radioactive waste treatment and technical support for decommissioning.

The first group of tasks related to environment and outdoor objects of the A1 NPP includes for example emptying, decontamination and physical separation of underground tanks in area of the Active Water Purification Station, redevelopment and treatment of waste stored in a special storing facility of solid radioactive waste, displacement of initial and construction of new tube drainage in active tube channels or elaboration of concept of management of contaminated soils located in the A1 NPP outside objects.

Priority tasks of second group were mainly activities related to decontamination of various rooms and technology equipment of the Main generating unit. Hot cell was renewed after decontamination, new equipment was added and it's prepared for operation at the present time. The most complicated is decommissioning of long-term storage facility of the A1 NPP, mainly because of complex radiation situation. Within the implementation of the project special interim storage facility used for storage of vitrification products and used sealed sources was constructed in the Main generating unit.

Third group of tasks within the Project was focused on treatment and conditioning of radioactive waste, which were created during operation, termination of operation and decommissioning of the A1 NPP. Movable cementation facility for treatment of sludge was developed, delivered and commissioned. Fixation of the special radioactive sludge from the bottom of long-term storage facility pool is done in-situ on delivered remotely handling equipment into special geopolymer matrix. Discontinual bitumination facility for treatment of spent resins and working place for treatment of used air-conditioning filters were also developed.

Fourth group of tasks represented methodology and technical support for fluent and safe implementation of all other tasks within the Project. Decommissioning database for optimal planning of various activities was created. Some of the NPP A1 rooms were scanned by three-dimensional laser scanners in order to create 3D as-built models of civil engineering part and installed technology.

Within the framework of the NPP A1 Decommissioning Project VUJE together with sub-contractors developed several technology equipment and modern methodologies. One of the important innovative technologies is remote handling manipulator DENAR-41, developed for decontamination of underground tanks. Another mobile remote handling equipment – sludge-walker and gravel-walker – were developed for retrieval of radioactive sludge and gravels from underground tanks. Remote handling robotics arms had to be used for decontamination and dismantling activities in the Active Water Purification Station because of difficult radiation situation.

Process of preparation of documentation required for licence application for stage II of the NPP A1 decommissioning project started in 2005, so that the NPP A1 decommissioning can fluently continue in 2008.

Project of the A1 NPP Decommissioning – Stage I

Introduction

Nuclear power plant A1 was the first NPP in former Czechoslovakia. Designing works started in 1956 and the plant was designed as experimental one. Construction of the A1 NPP started in 1958. It was commissioned on 25th December 1972 by synchronization to electric distribution net. During 19 261 hours of operation it produced 1464 GWh and supplied 916 GWh to the electrical network. Technical complexity of some technological equipment, e.g. transport-technology equipment of gas system or steam and heavy water heat exchangers caused failures, which resulted in operation events with leakage of radioactive substances to the working environment and production of liquid and solid radioactive waste. After LOCA accident in January 1976, in February 1977 happened another accident additionally assessed by INES level 4. The plant was never commissioned after that.

On 17th May 1979 the Government of former CSSR decided that the A1 NPP had to be decommissioned (Decree No. 135). Consequently it was necessary to solve very complex technical problems related to liquidation of impacts of operational events including transport of nuclear fuel to the Russian Federation.

Important contribution of experimental A1 NPP was also fact, that besides conceptual, physical, technical and economical assets the generation of physicists, scientists, operators and maintainers was educated on high technical level. The part of these specialists worked and works for VUJE and supports reliable and safety operation of power sources including decommissioning and radioactive waste management.

In tender in 1998, Nuclear Power Plants Research Institute, Inc. at that time, was selected as a general supplier of the Project.

Project of the A1 NPP Decommissioning – Stage I

The main tasks of this most significant decommissioning project in the Central Europe region, managed by VUJE from 1999 to 2007, were as follows:

- Environment
- Main generating unit
- Treatment and conditioning of radioactive waste
- Technical support of decommissioning

Project included solution and implementation of 35 tasks.
The main solutions and realizations were as follows:

- Retrieval of RAW, existing in various forms, from reservoirs, facilities and shafts, pre-treatment of selected RAW and its transport to processing lines, eventually re-storing of present RAW to reservoirs satisfying legislation criteria;
- Decontamination of surfaces of reservoirs, walls and floors of areas, facilities, intermediate storing of originated RAW and proposal of technological procedure of its treatment;
- Inspection of integrity of original reservoirs and decision on their next treatment;
- Reconstruction, modification or construction of new pipeline channels, assuring mutual interconnection of storing reservoirs and processing technological lines necessary in the future;
- Discharge and decontamination of the long-term store, disposal of casings and sludge of the long-term store, as well as liquidation of low contaminated facilities of transport-technological part;
- Proposal and execution of auxiliary technological facilities, proposal of procedures for optimal treatment of individual types of RAW;
- Preparation of documentation for decision on construction of storage capacities for treated products, which cannot, because of any reasons, be stored in the National RAW Disposal Facility;

- Solution of problems necessary for successful execution of activities of Stage I of the A1 NPP decommissioning and assurance of continuation of other stages of decommissioning. At the same time, the solutions must take into consideration the up-to-date level of knowledge of the given problem, as well as requirements of currently valid legislation.

Some activities of decommissioning of the A1 NPP in Stage I continue also after 2007, and, simultaneously, Stage II of so-called Continual Variant of A1 NPP Decommissioning will start in 2008. Stage II is going to last, as it is supposed, till 2016. In the next course of A1 decommissioning two four-year stages and concluding nine-year stage of decommissioning are supposed. Stages of the A1 decommissioning chosen in this way correspond well to requirements for preparation of individual stages and create condition of their good preparation.

Innovative technologies and methodologies

Within the Project of the A1 NPP Decommissioning – Stage I VUJE together with its sub-contractors developed a lot of technical equipment and modern methodologies. The most important innovative ones are as follows:

Remote handling manipulator DENAR-41

Remote handling manipulator DENAR-41 was developed for the decontamination of underground tanks located in the so-called "garden" of the Active Water Purification Station (outside building of the A1 NPP). The tanks were dedicated to collection of different liquid waste streams from the A1 NPP reactor building. Some of tanks were part of decontamination technology process. Generally, after years of operation and more strict safety requirements valid at the present, underground tanks are not suitable for safe storage of liquid radioactive waste anymore. Tanks were designed in fifties of 20th century as single-barrier and during their operation failures of barrier occurred (concrete skeleton covered by polyester fibreglass laminate). The part of contaminated water leaked to vicinity of underground tanks, where it caused contamination of soil in its immediate area.

This manipulator DENAR-41 has massive modular load-bearing structure that can be placed over each storage tank. Manipulator bears hydraulic arm(s) installed on vertical telescopic mast. The main difficulties in the development of the DENAR-41 were the large diameter of the storage tanks and the small opening for the inspection access (approx. 540 mm x 540 mm), through which the manipulator's telescopic mast is inserted into tanks. The DENAR-41 could also hold and manoeuvre robotic arm MT-80 and/or tools that are required to assist in decontamination and waste retrieval.

Manipulator was designed as modular equipment – for work in tanks with diameter of 16 m and for work in smaller tanks (diameter 6 m). Six underground tanks have been retrieved and decontaminated by manipulator DENAR-41 up to now.

Equipment for fixation of sludge ZFK

Mobile cementation facility for the in-situ treatment of the so-called bottom sludge from underground tanks have been developed, delivered and commissioned. In-drum cementation technology in 200 l drum is applied. Modular equipment ZFK is installed in standard transport ISO containers located near underground tanks. Such location minimizes length of transportation trace of radioactive waste. Equipment ZFK has been in successful operation from 2006.

Sludge-walker and gravel-walker

Two mobile devices – sludge-walker and gravel-walker – were designed for retrieval of radioactive sludge, sand and gravel from underground tanks. These two devices are located at the bottom of underground tanks in the layer of radioactive sludge, gravel and water. Equipment are remotely controlled and visually monitored by cameras. Discharge hopper is systematically loaded up with radioactive waste by loading paddle and after its loading it is retrieved and emptied. Working cycle is regularly repeated. Both devices are able to destroy sedimented radioactive waste, pump RAW and sprinkle the bottom and in limited scale also walls of tanks.

Robotics arm MT-80 and MT-80A

Non-operational technology equipment was dismantled directly within some rooms of the Active Water Purification Station. With regard to complex radiation situation, utilization of remote handling dismantling and demolishing equipment was needed. VUJE, together with its sub-contractors, developed remote handling robotics arms MT-80 a MT-80A. The general-purpose manipulators are equipped with hydraulic engines, have 5 degrees of freedom, a 1.8 m reach and a payload of 80 kg. Wrist of arms are able o hold various decontamination extensions (end-units). Control unit makes it possible to manually control movement of arms, to programme movement and to control movement by so-called teaching – primary demonstration.

Robotic arms were also used during decontamination of underground tanks in cooperation with remote handling manipulator DENAR-41.

Computer-aided technologies

Computer-aided technologies were used for the implementation of certain specialised activities. Scanning technology works on the basis of three-dimensional laser scanning of space and it was used for acquisition of as-built state of construction and technology within the A1 NPP (so-called reverse engineering). 3D as-built model we subsequently developed in computer with help of applicable program.

Used and developed software tools

Besides the standard programmes and codes used during implementation of large-scale decommissioning projects also special software tools were developed and used. Code VISIPLAN used for support of planning and simulation of activities within radiation area belongs to the first of the above-mentioned group of programs. Some of very important decommissioning activities were simulated on computer with help of special codes.

Special code OMEGA was developed within the Project. Code is dedicated to calculation of costs and other decommissioning parameters as well as optimisation of decommissioning process.

Preparation of documentation for the A1 NPP decommissioning – Stage II

Process of elaboration of documentation needed for permission to implement the A1 NPP decommissioning – Stage II started in 2005. Decommissioning of the A1 NPP continues in 2008 and in terms of plan for Stage II the main emphasis will be given to decommissioning of the A1 NPP outside buildings. Implementation of the A1 NPP decommissioning is planned for 2008-2016. Documentation for the Stage II, required by relevant laws, is being finalised at present.

Project of the A1 NPP Decommissioning – Stage I: "Environment"

This group of tasks included activities outside the Main generating unit.

Active Water Purification Station

The part of the Active Water Purification Station is adjacent "garden" with underground tanks initially dedicated for collection of liquid radioactive waste. Tanks were direct part of decontamination technology process of active wastage water collected in the purification station. Tanks were designed as single-barrier and during its operation this barrier (reinforced concrete segments inside covered by polyester bitumen) had been damaged under effects of various factors. The part of contaminated water leaked out into the tanks surrounding and caused the contamination of soil.

Within the Project underground tanks were emptied, physically separated from the other technology of Active Water Purification Station, decontaminated and radiation survey of outside area was performed.

Some of non-operational technology equipment was dismantled whereby emptying of some rooms was achieved. These works had positive influence on improvement of radiation situation in the building of purification station.

Special storing facility of solid radioactive waste

Special storing facility of solid RAW was designed as a systems of shafts accumulating solid waste. However during the operation of facility the system of solid RAW collection didn't ensure sorting of waste in accordance with standard categories (burnable and non-burnable, pressable and non-pressable). Moreover, the serious problem was leakage of water into individual shafts because its civil engineering construction wasn't designed as the barrier against possible leakage of the water. This effect increased contamination of soil in surrounding area of the storage facility and caused contamination of underground water in part of the A1 NPP locality.

Inventory of radioactive waste was retrieved from each individual shaft, sorted, again repacked and thus prepared for either treatment or temporary storing before its future treatment. Shafts were decontaminated and modified for temporary storing of solid RAW with elimination of percolation of water. Liquid radioactive waste was pumped out from the storing facility and treated.

Active piping channels

Active piping channels were dedicated for transport of liquid radioactive waste from the place of its production (mainly from the Main generating unit) to treatment facilities. Initial piping drainage in active piping channels didn't fulfilled requirements on safety transport of liquid waste, some of them were in inconvenient technical state and control of potential leakages from piping wasn't possible.

Initial piping in active drainage was decommissioned after previous flushing, emptying and physical separation from technologies in operation.

Within the framework of this task duplicate traces (tube in tube) for transport of liquid radioactive waste between the Main generating unit and technologies for radioactive waste treatment were also constructed. Three piping lines between the Bitumination plant and Active Water Purification Station were constructed, a new active piping channel for transport of liquid RAW from the main change rooms to special canalisation, a new piping channel for transport of liquid RAW from collective tanks to the building of Bohunice Waste Treatment Centre and piping channels between outside buildings and Active Water Purification Station were reconstructed.

Contaminated soil

Problem of contaminated soil management in the locality of the A1 NPP was also solved within the Project. Soil was contaminated by liquid radioactive waste from underground storage tanks, non-observation of operational and technological procedures in the past and by the storm rainfall of the outside buildings. This open system between tanks and shafts caused the leakage of part of radionuclides inventory to environment. Created deposits of contaminated soil were further distributed by the rain and ground water.

Conception of contaminated soil management in outside buildings of the NPP A1 was elaborated and verified by various studies for further solution of this problem.

The amount of contaminated soil and level of contamination were estimated at the beginning of the Project, what was the basic disadvantage for the first conceptions. Program of drilling geological research of surroundings and background of selected underground tanks was implemented for the more detailed specification of contaminated soil management conception.

Project of the A1 NPP Decommissioning – Stage I: "Main generating unit"

This group of tasks included activities in the Main generating unit.

Hot cell

The initial goal of the Project was to liquidate the hot cell. Various experimental manipulations with spent nuclear fuel were done in the hot cell (the A1 NPP was experimental type of plant) and in one case inflammation and burning of the fuel assembly had occurred. Despite the high level of contamination the decision was made about renewal of the hot cell operation. Chamber of the hot cell was decontaminated and some important equipment were repaired and/or added (e.g. new manipulators, lighting, system of cameras, dosimetry system). The hot cell is ready for the operation at the present time.

According to prepared proposal the process of the liquidation of the hot cell acid egg, which served for the pumping of liquid radioactive waste to treatment facilities, started. The acid egg will be dismantled after the removal of all sludge residuals and pre-dismantling decontamination.

Decontamination of high-pressure gasholder

High professional activity was implementation of pre-dismantling decontamination of the high-pressure gasholder in one of the A1 NPP rooms. This equipment was used for pumping of chrompik from fragmentation and drainage place to interim storage tank in 1991. Volume activity of solution used for the first wash down was on level of 10^{10} Bq/dm^3. The high-pressure gasholder is empty and prepared for dismantling at the present time.

Decommissioning of the A1 long-term storage facility of spent nuclear fuel

Within the Project working place for treatment of long-term storage facility casks was delivered. All casks in which spent nuclear fuel assemblies weren't stored were fragmented. Modification of fragmentation facility for cutting of upper part of casks is being done at the present time.

Decommissioning of the long-term storage facility will be longer process, mainly from the viewpoint of complex radiation situation. Within the Project a lead shielding above the pool of storage facility was constructed, level of water was decreased and all casks, not used for the storage of spent fuel assemblies in the past, were fragmented. Remote handling equipment for the in-situ fixation of sludge at the bottom of pool was delivered. Casks with chrompik containing sludge were removed to newly constructed storing facility in the A1 NPP reactor hall. Chrompik on the bottom of these panels had been fixated to solid geopolymers matrix. More detailed specification of radionuclides inventory in the facility was very important contribution to overall solution of the long-term storage facility decommissioning. Results of monitoring and analysis have significant impact on further planning of activities within the long-tem storage facility overall decommissioning process.

Other activities

Modifications of several rooms were done in the Main generating unit. These rooms serve as storing facilities of solid radioactive waste at the present time. Some of the rooms are used for interim storage of waste and institutional radioactive waste before their treatment and disposal at the National Disposal Facility of Radioactive Waste in Mochovce. Similarly a special interim storage facility for the storing of vitrification products and used sealed sources was constructed.

Modifications of high-capacity decontamination facility and extended technical capability of fragmentation facility for fragmentation of electrical cables and separation of various types of materials from cables were performed within the Project.

Central monitoring working place for free release of materials into environment was established and the system of free release of materials was resolved. The system is used mainly for free release of metal and concrete crushed materials.

Procedures and design of techniques for decommissioning of transport-technology part of the A1 NPP were prepared during stage I of the Project. Implementation of these activities will start in stage II of the Project and refuelling machines located in the reactor hall will be decommissioned as the first technology.

Project of the A1 NPP Decommissioning – Stage I: "Treatment and conditioning of RAW"

This group of tasks included activities focused on treatment and conditioning of radioactive waste.

Treatment of sludge

Mobile cementation facility for the in-situ treatment of the so-called bottom sludge from underground tanks was developed, delivered and commissioned. Approximately 50 m^3 of sludge was in every underground tank, but physico-chemical characteristics and radionuclides inventories were/are different depending on the tank. Procedures for the treatment of every type of sludge were prepared so that the resultant product is disposable at the National Disposal Facility of Radioactive Waste in Mochovce.

The part of the solution of problem with radioactive sludge treatment was development of new packed forms dedicated to its compaction.

The drainage station was added to the above-mentioned equipment. The drainage station allows, in case of needs, to re-store sludge from initial tanks to the new ones, which have waterproof certificate. Similarly the fixation procedures for sludge from cleaning of outside buildings tanks, which were stored in various containers were developed and optimalised.

Management of contaminated soil

Documentation for the implementation of landfill layers deposition in the locality of the A1 NPP was developed. Lysimeter experiment was organized for study of prevention of radioactive contaminants migration and various types of sorbents were examined. These were identified within the group of sorbents, which could be used as a barrier in landfill dumping place.

Conception of contaminated soil management within the A1 NPP locality was defined and management of contaminated soil in outside building of the A1 is a part of it.

Management of contaminated concrete

Within the decommissioning process of nuclear facility management of civil engineering part of buildings is very important, i.e. demolition of decommissioned buildings or performance of such measures that buildings can be used for another exploitation. Implementation design of working place for management of contaminated concrete was developed. Concrete crushed material from various construction modifications of the Main generating unit and outside buildings, which have been stored up to now, will be sorted at the above-mentioned working place. Several decontamination techniques of civil engineering surfaces were proposed and tried out in practice and process of declaration of fulfilment of free released criteria to environment was approved.

Treatment of spent resins

Discontinual bitumination facility has been designed and constructed for the treatment of spent resins descended mainly from the system of decontamination of radioactive water. Procedure/prescription was tried out for the fixation of resins to bitumen matrix and important characteristics of stability of resulted products (e.g. differential thermal analysis or thermogravimetry) were established. Facility is prepared for the active complex testing at the present time.

Other activities

Self-activities were treatment of chromium-sulphur acid (descended from the decontamination of equipment contaminated mainly by tritium) and conditioning of ash from the incineration facility so that resulting product will be technically easily and safely encased to fibre-concrete container.

During the operation, termination of operation and decommissioning of NPP high amount of aerosols filters is produced. These filters are used mainly for the absorption of aerosols (on which radionuclides from the given exhausted area could be fixed) from air in a system of ventilation before its discharging to environment. Facility for the treatment of aerosols filters was established in the Main generating unit. Facility for the treatment of used filters is before active complex testing now.

Facility for the vitrification of chrompik went through complex testing and it's ready for the active complex testing of vitrification of chrompik with activity to 10^{11} Bq/dm^3.

Project of the A1 NPP Decommissioning – Stage I: "Technical support of decommissioning"

Decommissioning planning

Conceptual decommissioning plans of Bohunice Radwaste Treatment Centre and Bitumination Facility and Intent for decommissioning of the A1 NPP after the termination of the stage I (EIA process) were elaborated according to requirements of relevant legislation. Three decommissioning options were assessed – entombment, safe enclosure with surveillance and continuous decommissioning. Last option was approved for the A1 NPP decommissioning after the termination of the stage I.

Decommissioning database

Decommissioning database dedicated to preparation and planning of various decontamination and dismantling activities of the A1 NPP has been created. Database contains input data for the created computer tool OMEGA used for the effective planning of the equipment, rooms and buildings decommissioning process preparation. Obtained software can relatively exactly calculates duration of work as well as manpower, costs and other parameters of the decommissioning process.

As-built documentation

Creation of as-built documentation was important activity in the phase of preparation for decommissioning. Rooms, where decontamination and dismantling will be done in the near future, were photographed, video recorded and scanned by three-dimensional laser scanner. As-built models of rooms and technology equipment were created on the basis of these input data, because the part of the initial documentation was lost or was not updated. Models served for the most effective and the most exact planning of decommissioning activities. These models were used later together with program VISIPLAN for 3D ALARA planning.

Remote handling manipulators and other equipment

Within the Project several remote handling manipulators and other equipment for the needs of various tasks were designed, manufactured and delivered. These are for example a remote handling holder of tools dedicated for the cleaning and retrieval of sludge and gravel from underground tanks, a remote handling manipulator DENAR-41, design of the system for checking of effectiveness of construction surfaces decontamination, equipment for treatment of sludge from high-capacity decontamination facility as well as regeneration of decontamination solutions used by this facility.

Radiation protection

Independent monitoring of the A1 NPP surroundings was done by standard procedures as a part of the observation of decommissioning influence on the environment. It included continual radiological monitoring of weekly aerosols, monthly fallouts and instant values of dose rates at one reference point. Workplaces monitoring within planed working programmes and 3D dose rate modelling supported radiation protection of workers were performed as well.

ALARA principles were implemented into all working procedures of decommissioning on the basis of the approach to alternative working scenario applied in the famous ALARA planning tool VISIPLAN. It enabled to reduce the collective doses within individual working programmes using spatial models of working trajectories in surrounding of volumetrical sources of ionisation radiation and respective construction structures and shieldings.

Characterisation of selected radioactive waste streams from decommissioning of A1 NPP was systematically carried out. It was based on sampling of radioactive waste streams and semiconductor gamma spectrometry analysis of the dominant radionuclide (^{137}Cs). Furthermore, estimation of 18 hard-to-detect radionuclides (HD-RN) contents in radioactive waste streams and decommissioning radioactive materials prescribed by the Slovakian Nuclear Regulatory Authority was carried out. Our own methodology based on the calculated radionuclide inventory in spent fuel (ORIGEN) and an empirical tracer radionuclides database for four groups of HD-RN (gap, grain boundary, matrix and construction material releases) was established and used.

Free release of decommissioning materials to environment

Important area of decommissioning is a free release of materials to environment. Procedures for estimation of HD-RN contents in decommissioning materials were developed on the basis of the above-mentioned methodology (ORIGEN+tracers) and respective radionuclide vectors. For HD-RN estimation the routinely determined ^{137}Cs content in these materials was applied. The methodology allowed assessment of radiological significance as well. It was shown, that the only dose commitment significant radionuclide from point of view of free release is the dominant ^{137}Cs.

Disposal of radioactive waste

During several years of the Project implementation safety analyses for the National Radioactive Waste Disposal Facility in Mochovce were performed. New packed forms of radioactive waste were included into the safety analysis when these started to be used within the decommissioning process. On the basis of safety analysis limits and conditions for the disposal of radioactive waste were reviewed in the Disposal Facility in Mochovce.

Experimental research in geotechnical laboratory continued together with mathematical modelling of main functional elements of the National RAW Disposal Facility final cover behaviour, when it will be fulfilled and closed. Various parameters of functionality of the cover under the clay layer will be monitored during following 15 or 20 years.

Monitoring of the fibre-concrete containers lifetime and experimental verification of their mechanical and physical properties represented a separate task. One of the Project goals was to increase safety and capacity of transport of the filled containers to Disposal Facility by combined ways (railway and truck transport).

Completion of National Radioactive Waste Disposal Facility in Mochovce

National Disposal Facility of Radioactive Waste is dedicated to disposal of low and intermediate radioactive waste from operation and decommissioning of nuclear facilities, research institutes, hospitals and other institutions. Basic construction of disposal facility was done from 1986 to 1992. After assessment of Pre-operational safety analysis report and audits of International Atomic Energy Agency the Nuclear Regulatory Authority of the Slovak Republic had additional requirements to improve construction of disposal facility before its commissioning.

General supplier of technical improvements of disposal facility was VUJE, Inc. and the project was implemented in 1997-1999 period. The goals of the project were mainly as follows:

- To increase safety level during radioactive waste handling,
- To improve protection of environment,
- To ensure monitoring of static, hydrology a radiohygienic characteristics of disposal facility and its surrounding area,
- Assessment of safety of radioactive waste disposal (safety analyses).

Cover hall above the facility was also constructed and gave to facility its current image. Nuclear Regulatory Authority issued licence for permanent operation of Disposal Facility in December 2001.

Seismic strengthening and extension of storage capacity of the Interim Spent Fuel Storage Facility in Bohunice

VUJE in the position of general supplier ensured seismic strengthening of the Interim Spent Fuel Storage Facility in Jaslovske Bohunice and extension of its storage capacity without interrupting its operation. The need of seismic strengthening was given by new safety requirements. The extension of storage capacity was necessary, because of commissioning of new nuclear units.

General supplier VUJE, Inc. implemented project from 1996 to 2007. By demanding modifications of both civil construction and process parts of the building, a seismic strengthening complying with the conditions specified by the Slovak Nuclear Regulatory Authority was provided. The total storage capacity of the facility was increased by a factor of 2.8.

Increasing of the storage capacity was achieved by using of new compact baskets for spent fuel KZ-48 with the same number of existed pools. Seismic strengthening of the selected building constructions and technology systems were done (8° MSK on free terrain).

The part of the project was liquidation of previous casks for spent fuel T12.

Interim Spent Fuel Storage Facility is in full operation at the present time. Spent fuel from NPP Jaslovske Bohunice and part of fuel from NPP Mochovce is stored there. Monitoring of state of building constructions, technology systems and stored fuel is performed.

Liquid RAW Final Treatment Facility for NPP Mochovce

Initial project was prepared in 2003, operational design and production of components was done in 2004 and 2005. Construction of the building started in August 2004 and individual non-active testing of systems was implemented between April and September 2006. Active pre-complex and complex testing started after evaluation of non-active testing from February 2007. Trial testing operation of the treatment facility started after the license was obtained in October 2007.

Method of three-dimensional modelling was used in the phase of preparation of the operation design for solution of possible collisions and the coordination tasks. This method was used for the design of axonometric proposals of mounting documentation of piping systems and also for the planning and verification of feasibility of necessary changes compared to initial design documentation.

Treatment facility is operated by campaign way. Five campaigns of bitumination of concentrates per year and one campaign of bitumination of spent resins and sludge per year are planned. Cementation campaign for grouting of fibre-concrete containers free space is organized after every bitumination campaign. Overall treatment capacity during the above-described operation is 870 m^3 of concentrates and 40 m^3 of spent resins and sludge per year. 1205 drums with bitumen product are produced, which represents 172 fulfilled fibre-concrete containers per year.

Three basic technologies are used for the treatment of radioactive waste: bitumination on thin film evaporator with rotating wiping blades, discontinual bitumination and grouting with the cement grout prepared from the mixture of cement, additives and radioactive overconcentrate.

Bitumination on the thin film evaporator

Chemically conditioned and preheated radioactive concentrate together with melted bitumen are dosed to the thin film evaporator in a such rate, that produced bitumen product, created by the evaporation of water and mixing of salts contained in concentrate with bitumen, contains about 40 weight % of salts. The bitumen product is discharged into 200 dm^3 steel drums, lid of the drum is automatically installed after cooling down and the volume of the drum is measured for content of ^{137}Cs a ^{60}Co.

Discontinual bitumination unit

Suspension of mixture of spent resins and sludge transported from the Auxiliary Services Building is pumped into operational tanks, where parameters for further treatment are adjusted. Mixture is dosed to decanter, where the transport water is separated and sediment is discharged to mixed dryer unit heated by steam. Dry sediment is subsequently dosed to mixer-homogeniser with rotating wiping blades, where mixture of melted bitumen and polyethylene is prepared. Bitumen product is discharged into 200 dm^3 steel drums after the short mixing. The rate of components is adjusted so that resultant content of resins and sludge mixture in bitumen is about 40 weight %.

Discontinual cementation unit

Required overconcentrate with content of salts about 400 g/dm^3 is prepared on recirculation concentrate evaporator from initial radioactive concentrate. Temperature of overconcentrate is kept on 40°C before treatment. Prescribed components are gradually dosed to mixer with rotating wiping blades. Radioactive overconcentrate is mixed with lime in the first phase, then cement with zeolite is added and after homogenisation the mixture is pumped into the free space of fibre-concrete container. Volume of batch is about 500 dm^3.

Grouting with cement grout is used for preparation of the final form of radioactive waste. Drums with bitumen product are put into the fibre-concrete container with free volume about 3,1 m^3 and the rest of the free space is fulfilled with cement grout. Content of salts in this grout is about 15 weight %.

Cementation Facility for Nuclear Research Centre in Salaspils, Latvia

On the basis of international tender opened by the IAEA in 2001, VUJE was chosen as the supplier of cementation facility for Nuclear Research Centre Salaspils in Latvia, where the pool type of Russian research reactor is decommissioned.

The purpose of the Cementation Facility is to immobilize radioactive solid waste into concrete containers. The cement grout is prepared from radioactive liquid waste (tritiated pool water) and cement is used as immobilization matrix. The tritiated pool water or clean water is mixed with cement to create homogeneous mixture under prescribed criteria.

A reference example of such facility is VUJE Experimental cementation facility at the NPP Jaslovske Bohunice site.

Design, manufacture of equipment, off-site installation and training of operators were done from November 2001 to June 2002 in Trnava. On-site installation and beginning of operation was performed from July to August 2002 in Salaspils.

Main parameters of equipment:

Volume of Salaspils concrete container	1 m^3
Performance of cementation facility	3,6 m^3 of cement grout per shift (8 hrs)
Capacity of cement hopper	11 t of cement
Volume of cement mixer	120 dm^3

On the basis of obtained experience the upgrade of Cementation Facility was done after one year of operation. Equipment for transport of cement from 50 kg bags to the existing cement hopper (shaftless spiral conveyor) and upgrade of computer control system were completed during 2003 including additional training of operators, customisation and testing of equipment.

The Cementation Facility is now in full operation and tens of containers have been cemented. Thanks to this facility treatment of radioactive waste from Salaspils research reactor decommissioning can be implemented.

Reconstruction of system for coolant radiation monitoring in the primary circuit of Paks NPP

VUJE was chosen as a turnkey supplier of reconstruction of the radiation monitoring system of the primary circuit coolant for all four units of the Paks NPP in 2006. Newly installed system of the radiation monitoring is based on couple of redundant sampling measurement pipelines and continuous on-line measurements by semiconductor gamma spectrometry as well as on measurement of dose rate at room No. 305 in the hermetic zone of VVER-440/213 reactor.

Sampling place for the sampling measurement pipelines was placed just behind the additional cooler of special primary cooling water cleaning system (SOV-1) in order to ensure water flow in the sampling pipelines even in the case of respective resin filters outage. Pressure gradient on heat exchangers of the special active water treatment unit SOV-1 relevant line is used for the assuring of sufficient coolant flow.

For this measurement VUJE designed a redundant gamma spectrometry monitor of primary cooling water (GSP MOIO) consist of: shielding house (own design) with manually tucked slot collimator, monitor control application SW developed in VUJE, Canberra-Packard Lynx MCA, electrically cooled Cryo-Pulse 5 HPGe detector and basic gamma spectrometry SW Genie2k.

The part of the delivery is also VUJE participation in reconstruction of radiation monitoring system of water in the spent nuclear fuel pool. This system is based on a pair of redundant sampling lines and continuous on-line measurements with NaI detectors (from company MGPI) applied to impulse tube (creation of algorithm for assessment of volume activity of fission and corrosion products and engineering activities on testing and commissioning of equipment).

Shaft No.1 decontamination of Paks NPP 2nd unit in Hungary

During the cleaning of fuel assemblies from depositions on their surfaces happened an accident on 11th April 2003. Damage of 30 pcs of fuel assemblies and subsequent contamination of the shaft No.1, the cleaning container and adjacent pipes on 2nd unit of the Paks NPP occurred. VUJE obtained contract for the decontamination of the cleaning container, shaft No.1 and the renewal of operational conditions of the shaft No.1.

Signed contract was divided into four independent phases:
- Decontamination of the shaft No.1 before the retrieval of damaged nuclear fuel assemblies from the cleaning container
- Decontamination of the cleaning container in the shaft No.1 after its emptying from damaged nuclear fuel assemblies
- Retrieval and additional decontamination of the cleaning container and ensuring of its storage
- Decontamination of the shaft No.1 and its connected pipes in order to ensure renewal of the operational function

Preparation of documentation in accordance with Hungarian legislation and acquirement of licence from Authorities for the production, installation, testing and operation of equipment were necessary for the implementation of the contract. After the licence was obtained and prototype technologies for the decontamination were developed, it was necessary to manufacture, test and install decontamination equipment directly at the Paks NPP. Decontamination itself was implemented only after the described preparation activities were finished.

Every phase of contract was prepared in close cooperation with the Paks NPP employees. Technologies for decontamination were determinated on the basis of laboratory testing of material exposed in the water of the shaft No.1 either during the accident or after it. Laboratory testing of decontamination was done in VUJE as well as at the Paks NPP.

Decontamination of the shaft No.1 at the 2nd unit before the retrieval of damaged fuel assemblies

Decontamination of walls of the upper part of the shaft No.1 was done by high-pressure spraying with boric acid solution performed by equipment named ROS-740 and MAOS-170. ROS-740 equipment is the hand device for spraying of walls of the shaft No.1 to depth 1,7 m under the footstall of the reactor hall. MAOS-170 equipment is the hand manipulator for spraying of the shaft No.1 to depths from 1,6 to 6,7 m. Both devices were designed, produced and tested as prototypes. Commercially available equipment Kaercher 1165 was used as a high-pressure source of boric acid solution.

Dose rate on walls of the shaft No.1 decreased from initial 0,1-2,5 mGy/h to values 0,02-0,1 mGy/h after the high-pressure spraying.

Decontamination of the cleaning container in the shaft No.1 before its retrieval

Internal surfaces of the cleaning container were chemically decontaminated after the handling and embedding of damage fuel assemblies to casks, after the cleaning of the container from mechanical impurities by Russian company TVEL and before retrieval of the cleaning container from the shaft No.1. Equipment ZDT-30 was used for chemical decontamination.

ZDT-30 is dedicated to laying on decontamination solution by low-pressure spraying. Equipment has tank for the preparation of decontamination solution, pump for a pumping of the decontamination solution and a pump for sucking of the used solution. Operation of equipment was remotely handled and controlled by camera system.

Dose rate on the cleaning container decreased from the initial 4,3-5,2 mGy/h to values 0,3-0,6 mGy/h (with hot spots 1,2-2 mGy/h) after the decontamination.

Retrieval and additional decontamination of the cleaning container and ensuring of its storage conditions

Electrochemical decontamination of external surfaces of the cleaning container was done by equipment DEKOZ-EPR after its retrieval from the shaft No.1. After the successful decontamination of external surfaces the cleaning container was packed and safely stored inside the Paks NPP.

Equipment DEKOZ-EPR is the hand device dedicated to semi-dry electrochemical decontamination of smooth and curved surfaces. Equipment was developed, designed and manufactured in VUJE on the basis of principle ALARA and minimization of radioactive waste produced during decontamination.

Surface contamination of external surfaces of the cleaning tank decreased from the initial 60-80 Bq.cm^{-2} to values 1-16 Bq.cm^{-2} after the decontamination.

Decontamination of shaft No.1 and its connected pipes in order to ensure renewal of the operational function

Electrochemical semi-dry decontamination of internal surface of the shaft No.1 was done by equipment MADES-440 and DEKOZ-EPR after the shaft was emptied. Chemical decontamination of curved surfaces was done by equipment ROS-740 and ZDT-30. Connected pipes were cleaned by existing system of pumps and cleaning station of the Paks NPP.

Equipment MADES-440 is the semi-automatic device for semi-dry electrochemical decontamination of curved surfaces with cylindrical shape and diameter about 3300 mm. Equipment was developed, designed and manufactured as prototype for the given task. Active parts of equipment – electrochemical heads – are copying cylindrical shape of the shaft No.1 and performed semi-dry electrochemical decontamination with following washing. Movement of heads on perimeter of the shaft and on the vertical axis is automatically controlled. Hand handling is done remotely with help of camera monitoring system.

Dose rate of internal surfaces decreased from the initial 4,3-5,2 mGy/h to values 0,3-0,6 mGy/h (hot spots on the bottom of shaft No.1 have 1,2-2 mGy/h) after the decontamination of the shaft No.1.

Preparation of basic documentation

for completion of 3rd and 4th unit of Mochovce NPP construction

Decision on completion of 3rd and 4th unit of the Mochovce NPP is great challenge for the Slovak and abroad organizations working in nuclear sector. VUJE, Inc. elaborates the basic documentation for the revision of the Initial design and prepares whole set of documentation within the engineering and design preparation of completion of construction. It is mainly revision of preliminary safety report and revision of the other safety documentation.

Within the revision of Initial design for the 3rd and 4th unit of the Mochovce NPP following significant documents were elaborated:

- Conception of solution of system of radiation monitoring
- Conception of minimisation of the liquid RAW production
- Conception of hand sampling and on-line chemical control and monitoring system for primary and secondary circuits
- Conception of after-accident sampling
- Conception of the on-line diagnostics and chemistry information system

Division for Radiation Safety, NPP Decommissioning and Radwaste Management also prepared part of documentation related to radiological conditions, emergency planning, radiological monitoring, system of management of radioactive matters concentration, RAW management, radiation protection, impact of nuclear facility on environment and procedures for decommissioning.

Preliminary plan for management of RAW and spent nuclear fuel, preliminary conceptual decommissioning plan, basic documentation for preliminary plan of physical protection and preliminary internal emergency plan were also prepared.

Technical support
of Ministry of Economy for establishment of Agency for Radioactive Waste and Spent Fuel Management

Consortium established by VUJE, Inc. and by Belgian research organization SCK.CEN won international tender for project PHARE 2003/5812.07 "Program for Community support in the field of nuclear safety", in part of the project "Technical support of Ministry of Economy for establishment of Agency for Radioactive Waste and Spent Fuel Management". During the solution of the project (12/2005 – 10/2006) 21 documents were prepared and delivered, which in accordance with Terms of Reference and its specifications covered following areas:

- The Comparative Analysis of radioactive waste and spent nuclear fuel management in selected countries of European Union and other countries
- The development of the institution design – Agency for Radioactive Waste and Spent Fuel Management
- The development of the plan of legislative, financial and organizational measures of the Agency
- Application of proposed systems and elaboration of required operational documents
- Design of paragraphs wording of Law on Nuclear Agency
- National strategy of safe management with radioactive waste and spent fuel including waste with long-term half-life period
- Technical support by the revision of the existing organisation units' operational documents.

Gamma scanner of fibre-concrete containers at National RAW Disposal Facility

Within the project PHARE 2003/5812.07 "Programme for Community support in the field of nuclear safety", in part of the project "Gamma scanner for national laboratory dedicated for verification of properties of packed forms of RAW during its receiving to the disposal facility" VUJE delivered objective scanner to the National RAW Disposal Facility in Mochovce. Project was successfully solved from 2005 and finished in October 2006. All resources of project PHARE were used in accordance with the project design.

Gamma scanner is the gamma spectrometry equipment used for control of fibre-concrete containers after its transport to National RAW Disposal Facility. Gamma scanner scanned gamma spectra on the surface of container in predefined points. After the processing of gamma spectra gamma scanner calculates summary activity of dominant radioactive isotopes ^{137}Cs and ^{60}Co and its distribution in volume of fibre-concrete container, summary activity of hard-to-detect isotopes and a map of dose rates on the surface of container.

Gamma scanner has two main parts, construction carrying gamma spectrometry detectors and electrical part. Construction of the gamma scanner carries gamma spectrometry detectors. Movable parts of the construction ensure adjustment of detectors to the required point of measurement and release of space around frame of controlled fibre-concrete container for its replacement and removal. Construction of the gamma scanner is equipped with engines, switches, temperature regulation of detectors, measurement of atmospheric parameters and two computers with passive cooling. The parts of gamma scanner construction are also two distribution electrical boxes.

Decommissioning of the A1 NPP – Stage II

Decommissioning of the A1 NPP is together with the preparation of the V1 NPP decommissioning one of the most significant large-scale projects in this field. Stage II of so-called Continual Variant of the A1 NPP Decommissioning is being prepared at the present time. This stage is supposed to continue up to 2016.

Implementation of the Stage II will be focused on decommissioning of the A1 NPP outside buildings. The main goal of the Stage II is decommissioning of useless technologies in the A1 NPP outside buildings, elimination of consequences from the A1 operation in construction parts and activities after the termination of operation. Radioactive waste from outside buildings will be also treated during implementation of Stage II. At the end of Stage II outside buildings will be decommissioned to so-called "green field" or transferred to objects system of RAW treatment and conditioning technologies which belongs to company JAVYS, Inc.

After the completion of Stage II in 2016 other decommissioning stages with expected end in 2033 will be in progress. All systems related to operation of the A1 NPP will be decommissioned.

Projects of BIDSF
Bohunice International Decommissioning Support Fund

VUJE, Inc. is active participant in the BIDSF (Bohunice International Decommissioning Support Fund) tenders to support the V1 NPP decommissioning. Consortium VUJE, Inc. – Relko, Ltd. has been performing project A2.1 "Development of Comprehensive Documentation Necessary for V1 NPP Decommissioning Licensing Phase and Decommissioning Implementation Phase" from 2006. The goal of this project is to elaborate complex safety and operational documentation for the period of termination of operation from 2006 to 2011. Specifically following parts of documentation are prepared:

- Modifications of safety documentation for the period of termination of operation
- Emergency documentation
- Limits and conditions
- Operational instructions and other documentation.

Project is implemented in accordance with approved procedure and separate deliverables are submitted in accordance with schedule of the Project, which will have been finished by 2009.

Currently VUJE is the leader of consortium, which won tender for project "The V1 NPP Decommissioning 1st Stage Plan & Other Licensing Activities". Other partners in the Consortium are companies DECOM, Inc. and VT Nuclear Services (Great Britain).

The BIDSF projects are still great challenge for our company in the near future.