

DECOMMISSIONING PLANNING FOR RESEARCH REACTORS IN CENTRAL AND EASTERN EUROPE

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ABSTRACT

The move towards development of market economy conditions in Central and Eastern Europe together with the break-up of the former Soviet Union have lead to significant repercussions for the nuclear programmes in the countries involved. A number of assistance programmes have been set up to help these countries in managing their nuclear legacies. The European Union, as an adjacent neighbour of these countries, has one of the largest supporting programmes of funding through areas such as the Tacis and Phare programmes. With due justification, efforts have concentrated in assisting operators of nuclear power stations and mitigating the environmental damage from nuclear fuel cycle work as well as accidents such as that at unit 4 of Chernobyl. Additionally, there are a large number of other facilities that supported the research and development programme for nuclear power and will now require decommissioning.

A large part of these supporting facilities were the numerous research reactors of several generic designs which were constructed and operated from the early stages of nuclear power research in the 1940s and 1950s. While the decommissioning legacy of just one research reactor is not significant compared to a nuclear power plant, there are tens of these facilities. Many of these reactors were of similar type and were built across many of the countries formerly aligned to the Soviet Union.

The decommissioning requirements for research reactors of the VVR-S type in the Czech Republic, Hungary, Poland and Romania are considered utilising current Western practices and standards and adapted to the circumstances of the particular country. This has lead to an interesting mix of Western and East European ideas and solutions to the problems of decommissioning research reactors. What all countries share in managing these nuclear liabilities is the limited funding to undertake decommissioning as well as developing regulatory requirements that are only now considering decommissioning as part of the nuclear facility life cycle. This constraint limits the decommissioning options available while producing inventive and unique solutions.

INTRODUCTION

This paper presents the results for project PH4.01/94: 'Regional Study of Soviet Designed Research Reactors' funded by the Directorate General IA of the European Commission. An earlier study identified that the Soviet-designed VVR type research reactors were more than 35 years old and that their safe and effective decommissioning was now becoming a significant issue requiring consideration.

The objectives of this regional study for each of the four Soviet designed, VVR tank-type research reactor complexes and for the region as a whole were:

- Evaluate the current status of the management of spent fuel, the management of radioactive wastes and the plans for decommissioning;
- Recommend future strategies for the continued safe management of spent fuel, radioactive wastes and for safe decommissioning to 'greenfield' status such that the site can be released from the requirements of the relevant national Atomic Law.

Common areas of concern on a regional basis were identified and a scope for a regional approach to strategy considered.

Brief Description and Current Status of Facilities

The four research reactor complexes and Beneficiary organisations were:

- The EWA research reactor at the Institute of Atomic Energy (IAE), Otwock-Swierk, Warsaw, Poland.
- The LVR-15 research reactor at the Nuclear Research Institute (NRI), Rez, Prague, Czech Republic.
- The Budapest Research Reactor (BRR) at the AEKI Institute, Budapest, Hungary.
- The VVR-S research reactor at the Institute of Physics and Nuclear Engineering (IFIN-HH), Magurele, Romania.

Figure 1 shows the BRR in Hungary and is a typical example of the VVR-S design in all four countries.



Figure 1. Budapest reactor at the AEKI Institute in Hungary

All the reactors are located on sites with other research facilities. The general services of the site support and complement the research reactor activities. Generally, the installations of a VVR-S research reactor include the main reactor building. This houses the reactor vessel (tank and internals), usually in aluminium alloy, with a core composed of highly enriched fuel

elements with aluminium alloy cladding and a set of boron carbide control rods, surrounded by the biological shielding of reinforced concrete. Additionally, auxiliary equipment, experimental devices, including beam tubes and graphite thermal column are coupled to the reactor core together with the primary cooling system, a set of primary pumps, the heat exchangers and the first part of the secondary cooling system. Usually, in the building, a set of hot-cells are located to work with radioisotopes produced. Spent fuel ponds are arranged in the reactor building and also outside in separate facilities. Other installations include waste treatment and storage buildings and other auxiliary installations.

The EWA reactor in Poland has operated from 1958 and prior to shutdown during February 1995, the reactor operated at 10 MW nominal thermal power following an upgrade during 1973. EWA is currently defuelled with all spent fuel stored in wet cooling ponds on site. Current plans are to remove the EWA reactor core internals using remote and semi-remote tools in a 3 year programme. The wastes generated will be subsequently conditioned by cementation into 200 l drums for disposal to the Rózan national disposal facility.

Some of the waste management facilities have been refurbished recently to modern standards with assistance provided by the International Atomic Energy Agency (IAEA). Liquid wastes are treated by chemical treatment, evaporation and cementation. Solid wastes are treated by mechanical size reduction using cutting devices and low force compaction. The Swierk facilities also process institutional wastes on a national basis.

The LVR-15 reactor in the Czech Republic has operated without incident since 1957 and plans to operate until 2018. The reactor was refurbished in 1989/90 with the removal of the aluminium reactor tank and internals in a single-lift operation and replacement with a stainless steel tank and primary circuit. The control room was also refurbished and the reactor power output raised to 10 MW thermal. All spent fuel is currently stored on site, with the early EK-10 fuel stored in iron-shot loaded, concrete-filled drums and later fuel in wet storage. A new dry storage facility for High Level Waste (HLW) opened in 1996 with phased transfer of drummed fuel to be completed in 1998/99. Spent fuel storage capacity is sufficient until 2001 after which the spent fuel storage will need extending. A significant amount of historic wastes are stored in poor condition but remedial actions are being planned. Current radiation protection and Quality Assurance programmes do not meet Western standards. Current decommissioning plans relate to a one-piece removal of the stainless steel tank in a similar manner to the operation carried out in 1988.

The national repository for Low Level Waste (LLW) and ILW (Intermediate Level Waste) - Richard II - is expected to continue to be operational until 2020. However, safety and operational conditions need to be improved.

The Budapest Research Reactor in Hungary has operated without incident since 1959 and plans to operate until 2022. In the period 1986-92 the reactor was reconstructed with replacement of the aluminium reactor tank, primary and secondary cooling circuits, refurbishment of the control room and control and instrumentation systems. The present thermal capacity is 10 MW.

All spent fuel is stored on site in wet storage with existing fuel storage capacity anticipated to last until 2010. Beyond this time further capacity on site will be required. There are no

significant quantities of stored wastes on the sites which are associated with reactor operations. Unlike the other three Phare countries, there is no processing of institutional wastes on this reactor site. Reactor operational wastes consist of small quantities of liquids originating from the primary coolant, ion exchange resins and solid and liquid wastes arising from decontamination and maintenance operations in the reactor building. Liquids are treated prior to discharge to the sewerage system. There is no solid waste conditioning plant on site nor are there incineration or compaction devices. Minor quantities of solid wastes are drummed and sent to the national waste disposal facility at Püspökszilágy which is planned to be operational until 2005. All wastes from the 1986 refurbishment activities except the reactor vessel (stored on site) and the fixed beryllium reflector (stored in the spent fuel pond) were sent to Püspökszilágy for disposal. However, this facility has no capacity to accept significant quantities of decommissioning wastes and cannot be extended. Two LILW repository sites are being investigated.

Decommissioning plans along Western lines do not exist for BRR with future plans for decommissioning outlined in the existing Safety Analysis Report. The method used for the 1986 dismantling forms the basis of the current decommissioning proposals.

The VVR-S reactor at Magurele in Romania has operated in unmodified form at 2 MW thermal power from 1957 until mid 1997 without fuel failures during operation. All spent fuel is wet stored on site with sufficient capacity for the final fuel charge. There is evidence that the fuel cladding is starting to corrode during wet storage with the minor release of small quantities of fission products, the gaseous components of which are free to escape to the atmosphere.

The difficulties to continue the reactor operation in accordance with the regulatory body requirements and the economic shortcomings determined the final reactor shutdown in early 1998.

Waste management facilities on site are obsolete with considerable accumulations of wastes from institutional sources. Extensive refurbishment is required to bring these facilities up to modern Western standards. IFIN-HH also operates the national waste disposal facility at Baita Bihor some 700 km from Magurele. The repository has galleries to accommodate wastes in 200 l drums and has a 40 year lifespan. The facility is currently 25% full and requires improvements in access for transport and handling facilities, particularly if large waste containers are to be used for decommissioning purposes.

Decommissioning planning for VVR-S has proceeded apace with considerable support from IAEA in the form of Expert Missions and Fellowships such that the Decommissioning Plan is now substantially well developed along Western guidelines.

LONG TERM MANAGEMENT REQUIREMENTS

Issues for Spent fuel

The options for spent fuel are shown in Figure 2.

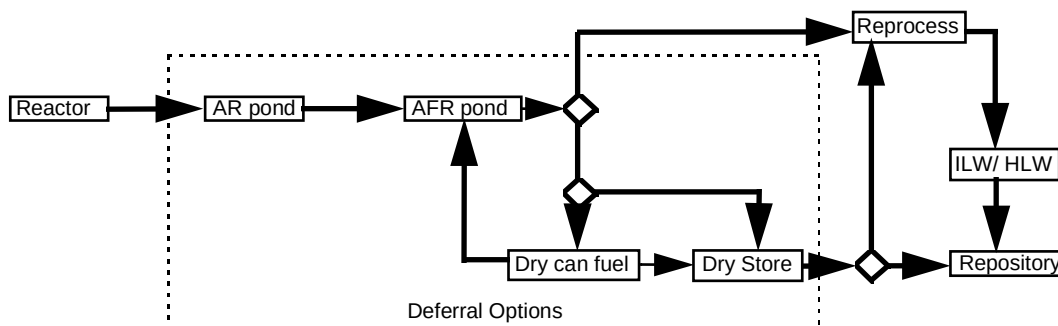


Figure 2. Options for spent fuel

The options are:

- To reprocess the fuel, and dispose of the radioactive wastes. The advantages of reprocessing are that it overcomes all the safety, technical, political and potentially the safeguards requirements as far as fuel storage is concerned but there are hurdles to overcome in terms of transport and waste disposal. It is also a relatively expensive option.
- To dispose of the fuel directly to a deep repository. Currently, there is no site for spent fuel disposal in any country in the world, and development in the countries in this study would be dependent on the needs of the country's nuclear power programme. The most difficult phase of the work will be finding a suitable site, demonstrating the site will provide adequate geological barriers to radionuclide transport and obtaining public acceptance. It is unlikely that any other country in this study would be prepared to accept spent fuel for storage.

For US supplied research reactors, it has been agreed that all the fuel up to a date in the future can be returned to the US for disposal. In the case of the Russian supplied research reactors in the four Phare countries, return of spent fuel permanently to Russia would currently be against Russian law. However, return to the country of origin has the advantage of using a single disposal site, rather than the complex process of attempting to provide disposal sites for relatively small amounts of fuel in each country, and would probably be cost effective. It is also likely to enable the work to be of sufficiently high profile internationally that international safety criteria would be used.

- To defer disposal and store the fuel either, as currently, in ponds, or to dry store the fuel. Deferral would be typically for 50 - 100 years, until disposal sites are available. The existing wet storage is not considered suitable for such a long period, and a dry storage option will be needed in the next 5-10 years. The options for a dry store are:

- To can the fuel and return it to the existing ponds
- To provide metal storage casks for the fuel
- To store the fuel in a vault of storage tubes.

In considering the general options for future spent fuel management, a number of factors need to be taken into account. The factors affecting safety include; the avoidance of criticality, radiation monitoring and protection, provision of containment barriers for the fission products in the fuel, the avoidance of degradation of these barriers, the structural integrity of the storage to prevent leakage, and the effects of abnormal conditions such as natural events (flooding, earthquake) or man-made events (aircraft impact, dropped loads).

Physical protection factors covers the prevention of misuse of the fissile material which is the aim of the IAEA safeguards requirements, as well as acts of terrorism or explosions near the fuel.

Technical factors consist of ensuring there is sufficient capacity for the expected fuel arisings, provision of satisfactory handling arrangements for the fuel on site or for transfer for reprocessing or disposal and treatment and conditioning of the fuel.

Political factors cover licensing arrangements and the public acceptability of spent fuel at any location or its transport to another location.

Cost factors cover the total management of the fuel into the future up to the stage where the wastes no longer represent a hazard. The costs cover all amounts arising from fuel management, including storage facilities, safeguarding the fuel, transport, reprocessing where appropriate and final disposal. Two types of cost are important, initial investment and overall investment expressed in terms of the net present value (that sum of money which invested now would cover all future costs as they arose).

For each country, after taking all these factors into account, an outline spent fuel management plan has been prepared which looks towards future reprocessing and disposal (preferably in Russia) as long term objectives, provides interim storage using some form of dry store depending on circumstances, and where appropriate, outlines short term measures for maintaining the wet stored fuel up to the introduction of the dry storage provision.

Issues for Waste Management

The general scheme proposed for waste management, including the three main waste streams is outlined in Figure 3.

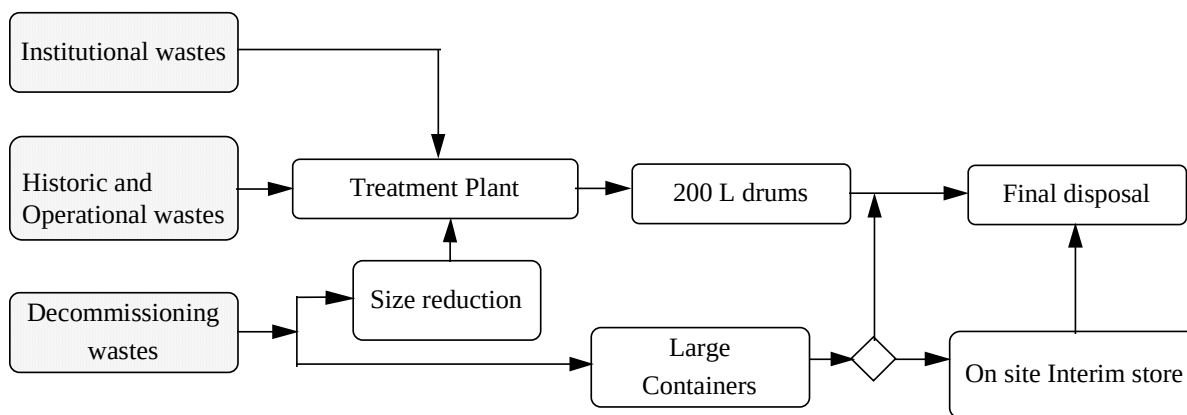


Figure 3. General scheme for waste management

An analysis of the current waste management situation has been carried out considering legislative development, availability of a repository for LLW and ILW and decommissioning of the research reactors. In addition, the current status has been compared with the best Western practices, standards and guidelines. Further, several options to solve the waste management concerns have been analysed in order to improve the current and future situation, these options have been evaluated considering safety, technical, economical and logistical factors. As a consequence of the analysis, the recommended options for waste management consist of the implementation of changes to the existing Radioactive Waste Treatment Plants (RWTP), as a short term approach, and to improve the existing solid waste treatment plants, as a medium and long term approach to treat both operational and decommissioning wastes.

In relation to the decommissioning wastes, a general strategy for the use of large containers has to be recommended since this is a favoured approach in Western practice to reduce the amount of size reduction needed during decommissioning and hence the man dose uptake.

Issues for Decommissioning

A set of generic Decommissioning Plans has been prepared for each reactor which follow IAEA recommended structure and contents (2). Three alternatives have been identified for the safe decommissioning of the reactors with a number of sub-options as appropriate:

1. Permanent shutdown of reactor and disabling of control systems to prevent re-starting followed by care and maintenance over an extended deferral period of up to 50 years. This is essentially IAEA stage 1.
2. As option 1 but to include the removal of all equipment peripheral to the reactor 'block'. This will include removal of cooling systems and pipework, experimental rigs etc to leave the reactor 'block' and remaining activated internals intact. The 'block' penetrations for pipework and service penetrations will be sealed. This is essentially IAEA stage 2.
3. Decommissioning to IAEA Stage 3 for site release with no periods of care and maintenance.

The 3 options provide a 'staged' approach to decommissioning essentially along the lines of the IAEA stages whereby the extent of the decommissioning actions varies according to the chosen option. Early removal of the major radioactivity inventory of spent fuel is a prerequisite for all options. Staged decommissioning can then take advantage of the radioactive decay during the deferral period. The options are sequential in nature which leaves open the alternative of proceeding from one option to the next.

The selection of the preferred decommissioning option for each of the four research reactors has been identified on facility basis using a simple evaluation of options which ranks the various considerations which are thought most important ie cost, dose, technical feasibility, provisions for waste management, plant condition and reuse of site. The analysis indicated that Option 2, removal of all equipment peripheral to the reactor 'block', followed by care and maintenance over an extended deferral period of up to 50 years (IAEA Stage 2) was the preferred option. This option requires the early removal of the mobile radionuclide inventory to reduce the future hazard potential. The remaining hazard is much reduced and requires minimal resources to maintain the integrity of the remaining structure in a safe state to prevent radioactive releases. Structural survey work will be required to identify any remedial work necessary prior to the deferral period. Country specific considerations also exist and discussed.

The Decommissioning Plans are 'top level' plans which form a substantial framework on which future decommissioning planning could be developed in line with national and regulatory requirements but also taking into account Western practice and IAEA methodologies.

CONCLUSIONS

Spent Fuel

- At all the reactors, the spent fuel is stored in cooling ponds with very limited deterioration to date. Further wet storage can be maintained for 5-10 years, subject to regular monitoring, provided that the water chemistry is maintained within the specified limits.
- Ultimate disposal of the fuel has not been resolved and requires European assistance in negotiations on possible return of the fuel to the country of origin.
- All the options for interim storage of spent fuel considered are based on well proven technology, and recommendations have been made for dry storage of the fuel on an interim basis in each of the reactors.
- A number of areas have been identified of common interest which could be approached on a regional basis. These cover further evaluation of reprocessing the fuel in Russia, including transport and the return of wastes, and pilot studies of options for future dry storage, including fuel canning procedures in Hungary and the Czech Republic, the use of the reactor vault after decommissioning the reactor in Poland, and the use of casks in Romania.

Waste Management

- The general situation for waste management changes from country to country with the level of nuclear power development varying between the four Phare countries, for example, Poland has no nuclear power and hence national facilities designed to cater for a national nuclear power industry are not available. Such strategic issues have an influence on the development of the waste management strategies.
- For all the Phare countries it is recommended to implement the applicable elements of the legal and organisational rules for radioactive waste management in accordance with IAEA Radwast guidelines.

Decommissioning

- By reactor decommissioning standards, the decommissioning of VVR-S tank-type research reactors is a relatively straightforward task - there are no safety, technical and logistical issues beyond the scope of normal nuclear practices. Currently, one of the four reactors is permanently shutdown (EWA in Poland). The Czech reactor, LVR-15, and the Hungarian reactor, BRR, have no plans for closure and it has been assumed in the study that they will operate until 2018 and 2022 respectively.
- Licensing for decommissioning is at an early phase in the four Phare countries with the recent introduction of new Atomic Laws supported by decrees to cover decommissioning. Decommissioning policy is currently being dealt with on a case-by-case basis. The developing policy generally follows IAEA guidelines.
- Unless there are overwhelming reasons for early re-use of the facility (as is the case in Poland) then a safe and cost effective approach is to defer decommissioning prior to the achievement of IAEA Stage 3. An IAEA Stage 2 approach is suggested with a 'safestore' decay period of 30-50 years following removal of all equipment peripheral to the reactor block. This option requires the early removal of the mobile radionuclide inventory to reduce the future hazard potential.

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