The Optimized Integration of the Decontamination Plan and the Radwaste Management Plan into Decommissioning Plan to the VVR-S Research Reactor from Romania - 8471

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ABSTRACT

The paper presents the progress of the Decontamination Plan and Radioactive Waste Management Plan which accompanies the Decommissioning Plan for research reactor VVR-S located in Magurele, Ilfov, near Bucharest, Romania.

The new variant of the Decommissioning Plan was elaborated taking into account the IAEA recommendation concerning radioactive waste management. A new feasibility study for VVR-S decommissioning was also elaborated.

The preferred safe management strategy for radioactive wastes produced by reactor decommissioning is outlined. The strategy must account for reactor decommissioning, as well as rehabilitation of the existing Radioactive Waste Treatment Plant and the upgrade of the Radioactive Waste Disposal Facility at Baita-Bihor. Furthermore, the final rehabilitation of the laboratories and reusing of cleaned reactor building is envisaged.

An inventory of each type of radioactive waste is presented. The proposed waste management strategy is selected in accordance with the IAEA assistance.

Environmental concerns are a part of the radioactive waste management strategy.

INTRODUCTION

VVR-S Nuclear Reactor is a light water cooled, moderated and reflected, heterogeneous, thermal reactor. The reactor was designed on Former Soviet Union to provide experimental facilities for research and radioisotopes production in the neutron flux up to $2x10^{13}$ n^0/cm^2sec, at an operating power level of 2 MW (th). Construction of the VVR-S Nuclear Reactor started in 1955 and criticality was obtained on July 29, 1957 with a fuel loading of 4.5 kg of ^{235}U. Its last shut down was on July 1997. All the fuel (10% ^{235}U up to 1984, and 36% ^{235}U after this date) was removed from reactor core to the Cooling Pond (Reactor Hall) and Spent Nuclear Fuel Storage Ponds (away from the reactor, Building No. 20).

In 2002, by Governmental Order No.418/2002, the Romanian Government decided the final shut down of VVR-S Nuclear Reactor and its future decommissioning..

The Immediate Dismantling Strategy was selected for decommissioning the VVR-S reactor. Implementation of the strategy is based on the Decommissioning Plan, the associated Decontamination and Waste Management Plans and the Project Management.

On the same site there are many other nuclear facilities which will be decommissioned in the future, considering that the local communities are in a faster economic developing process.

The radioactive waste streams will be safely managed taken into account the Radioactive Waste Treatment Plant situated in the immediate vicinity of the VVR-S reactor and the National Repository for Radioactive Waste-Baita –Bihor, after an updating program.
The duration of the decommissioning project is 12 years; the funding mechanisms are based on the public funds as an investment process.

BOUNDARIES OF DECOMMISSIONING PROJECT

The decommissioning project of VVR-S Nuclear Reactor (see the Fig.1), take in considerations the buildings with activated or contaminated structures.
Decommissioning, decontamination and waste management activities are developed on a surface of 7500 m^2 (2397 m^2 occupied by buildings, metallic structures, underground facilities):

- Main building of nuclear reactor (building no. 22) with all the three structures (Reactor Hall, Laboratories Building and Experimental Pavilion) 1718m^2;
- Spent Nuclear Fuel Store (part a building 20) 401m^2;
- Technological ventilation (building no. 30); 170$m^{2;}$
- Underground arrangement containing the 30 m^3 tank for contaminated water; 40m^2;
- Metallic construction for the material storage (building no. 23); 68 m^2
- Underground channel system for ventilation and pipes for radioactive liquids.
- The ground where the Nuclear Reactor is located.

RADWASTE CHARACTERIZATION

The radwastes generated by VVR-S reactor decommissioning process are classified as follows:

- activated radwastes;
- contaminated radwastes;
- secondary wastes resulted from decommissioning activities.

The main activated materials and their activities after 10 years since the reactor was shut down are presented in Table I.

Table I. Activities and weights of decommissioned materials

Material	Weight (kg)	Activity (Bq) after 10 years since shut off
Aluminum	6950	2.93 E11
Stainless steel	82200	9.58E12
Concrete	685100	1.35E12
Graphite	9332	5.95E8
Total	783582	1.12E13

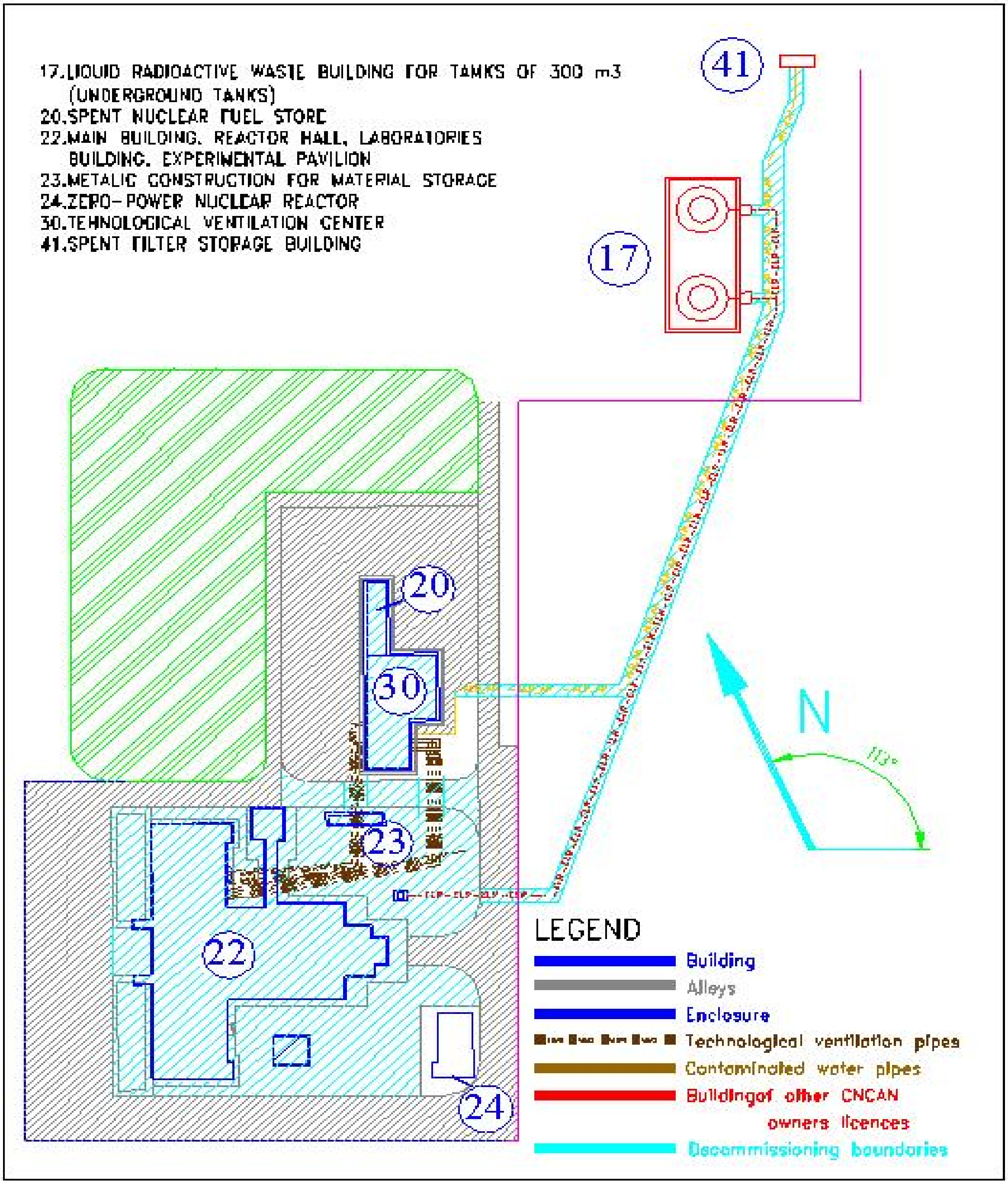

Fig. 1. Boundaries of decommissioning project

RADWASTE CLASSIFICATION CRITERIA

According to the Romanian Regulatory Body Order No.156/2003 classification of all radioactive wastes generated from the decommissioning activities can be included in the following classes:

- Exempt waste
- Very low active waste
- Low active and intermediate active Short lived waste (LILW-SL)

- Low active and intermediate active Long lived waste (LILW-LL)

Spent fuel will be returned to the competent Authority from RUSSIA.

In case of VVR-S IFIN-HH research reactor decommissioning the identification of materials contaminated with long life radio nuclides and of the materials which are not accepted for disposal in NATIONAL RADWASTE REPOSITORY at Baita-Bihor is essential for each radwastes management phase and it determines the storage requirement in an intermediate storage facility. The separation of the very low active waste will be also taking into account from economical reasons.

The Romanian specific Decommissioning Plan contain phases which are different in comparation with reference IAEA stages of Decommissioning Plan.

Starting from the radiological characterization of the equipment, systems and structures, the partial or total decontamination activities for all the materials shall be stated.

Function of the contamination degree, the decontamination technologies can be applied before, during or after the demolition.

The main targets of decontamination are:

- Reduction of volume for the radwastes category which need to be stored as solid radwastes; namely conditioning for storage in shielded / unshielded flasks and intermediate storage in special containers;
- Enhance of possibilities for recycling and the use of equipment, materials or rooms;
- Reduction of radiation exposure of personnel involved in decontamination activities.

According to the design team, two alternative solutions are considered:

- Decontamination, dismantling and decommissioning of equipment, systems and structures, activated and/or contaminated, with the possibility of building ventilation to be reused for nuclear research purposes;
- Decommissioning and dismantling of the equipment systems and demolition of all structures including the main buildings and auxiliaries until the unrestricted use of the land.

Finally the alternative with reuse the decontaminated building has been selected.

The new class of very low activity waste will have an evident benefic economical impact. The identification of this type of wastes will be a great challenge for the designers and operators. It is envisaged that about of 20-30% of low level waste to be transferred in this class with huge economical effect.

SOLID RADIOACTIVE WASTES

Following to VVR-S reactor decontamination and decommissioning activities, important quantities of solid wastes which are to be managed under nuclear safety conditions are expected.

The main materials in the reactor construction are represented by:

- Aluminum, which is improper for disposal in existing capacity at Baita Bihor Repository. The entire quantity of aluminum is to be cut, brought to storage flask of container sizes function of the level of activity for average term storage. Stabilization in the drum and/or container by sand and fine gravel filling of the empty spaces (possibly available after the reactor demolition) is considered; the alternative consists in melting and reuse non activated metal parts.
- Graphite, which is also improper for disposal in existing capacity. The entire quantity of

graphite is to be stored by stabilization in containers which are to be disposed in an in-depth repository, which is to be commissioned in the year 2055 according ANDRAD strategy; the alternative consists in transfer to the Subsidiary of Nuclear Research at Pitesti for treatment.

- Stainless steel, containing both activation products and contaminated surfaces. After dismantling measurements on the surfaced contamination degree are developed. If required, surface decontamination by foam or films followed by pilling may proceed.

Measurements shall develop on job site and the decontamination operations are developed in the especially dedicated tent in the reactor hall. The secondary materials resulted from decontamination are collected in drums and sent to RWTP. Therein they are subject to advanced decontamination for possible recovery of materials. The alternative consists by melting non activated metal by a mobile installation.

- Carbon steel and cast-iron containing activation products and showing contaminated surfaces will be similarly treated and conditioned; the alternative consists also of melting non activated metal by a mobile installation.
- Concrete, heavy concrete, debris and other wastes resulted form demolition, activated or contaminated materials, which after sorting out are stabilized by cement pouring in drums for final disposal or are transferred to common garbage management system; the new class of very low level waste can reduce the quantities of waste directed to Baita-Bihor Repository with of about 20-30% of total quantity.
- Insulation plastic materials, linoleum, are the auxiliary materials that are treated, as the case, by incineration or thermal compression and conditioned by cement pouring;
- Copper from electric and I&C components which are generally decontaminated down to the level for clearance from the license requirements, representing recyclable waste. The main decontamination process will imply plastic isolation dismantling; now, this operation is possible to be performed by a special equipment.
- The exempted waste will be reused (metallic components), recycled or directed to common garbage management system;

LIQUID RADWASTES

The main radioactive waste results from emptying the system and the equipment system and structure decontamination activities.

According to IAEA recommendations, decontamination which requires large quantities of water need to be avoided as much as possible.

Yet it is estimated that liquid wastes may be generated as a result of the following activities:

- water discharge from the spent fuel pool after the spent fuel transfer, the water will be treated by local filtration and transferred to Radioactive Waste Treatment Plant (RWTP);
- the primary circuit decontamination following the approved procedure;
- hot cell decontamination by decontamination solutions;
- decontamination at the end of Phase 2 decommissioning operations and preparation of Phase 3;
- auxiliary decontamination, protection equipment flushing, etc.

  An inventory of all activities was done and the proper procedures will be elaborated soon.

DECONTAMINATION PLAN

The Decontamination Plan which accompanies the Decommissioning Plan and the Radwastes Management Plan, includes the following components:

- decontamination of work areas, if it would be necessary;
- decontamination of equipment systems and structures;
- decontamination of liquids;
- decontamination of protection suits;
- decontamination of personnel.

In order to minimize the personnel exposure during decommissioning, proper protection measures so to provide the proper conditions for the decommissioning activities, shall be taken according to national standards and harmonized with IAEA and UE recommendations.

Measures to keep clean the surfaces in the rooms with the decommissioning activities shall be developed.

Decontamination of equipment, systems and structures is integrated in the decommissioning plan by the measures taken in the decommissioning area and the subsequently, in RWTP, where advanced decontamination methods are applied. All liquids employed in decontamination processes ale locally collected and transferred to RWTP, where they are treated correspondingly. The new trend is to use the minimum quantity of water for decontamination.

The protection suits used during the decommissioning process will be decontaminated in the RWTP laundry.

Personnel involved in decommissioning processes, accidentally contaminated will use the showers in the airlock for decontamination.

If afterwards the contamination is still present, such personnel will be taken to hospitals for to continue the medical treatment.

RADWASTES MANAGEMENT PREREQUISITES

Based on real necessities, the following technical solutions are selected at feasibility phase:

- Refurbish the solid treatment plant, improving compaction, incineration and cementation lines, and including decontamination and cutting systems;
- Build a new interim storage facility or remediate the existing capacity.

The feasibility study phase provides for the acquisition of a new liquid treatment installation which will be set up in the refurbished existing building.

The radwastes management plan associated to VVR-S nuclear reactor decommissioning plan starts from the prerequisite that the IFIN – HH RWTP is in operation and available to treat and condition radioactive solid wastes generated by VVR-S reactor decommissioning namely:

- non-combustible solid waste treatment facility for compacting the waste by a 750 t average compactor;
- solid waste treatment facility compatible by incineration;
- non-treatable radwaste cutting facility;
- conditioning facility for radwaste embedding in concrete-filled containers/flasks;
- plastic material thermal compression facility.

Also, some liquid waste treatment facilities are considered to be available as follows:

- chemical treatment installations by precipitation;

- filtering installations for slug;
- new liquid radwaste evaporation facility;
- ionic filtering installation.

The decontamination centre shall be operational and include the following installations:

- water and steam jet decontamination cabinet;
- chemical decontamination vessel;
- installation for decontamination by brazing;

For the radwaste management operations, RWTP need to be outfitted with the following equipment and installations:

- Concrete preparation station for 200 ÷ 800 packages/year with waiting deck for 30 days;
- Incinerator for about 2000 kg/y textiles, paper, wood, organic materials;
- Thermal forming press for 3000 kg/y plastic materials in grains;
- Plastic material cutting machine with maximum 200 kg/day processing capacity;
- Ultra-compactor for:
  - Aluminum wastes (chopped components) – about 5 t/y;
  - Steel wastes (steel sheets and chopped components) – about 10 t/y.
- Mobile station for entrapping radioactive contaminants and impurities from water, for flow rates of about 20 ÷ 30 l/min.;
- Shielded transport devices for the transport of 30 ÷ 120 packages/month.
- Equipment for metallic aluminum melting, eventually mobile installation by contract basis.

All these equipment and installations are assumed to exist on the date of Phase 1 start-up in this radwaste management plan.
It is also consider that Baita – Bihor NATIONAL RADWASTE REPOSITORY is having the license for final disposal of conditioned radwaste resulted for WWR-S reactor decommissioning.
The National Disposal facility was adapted in a former uranium mine in the central-western part of the Bihor mountains in Transylvania. Two galleries at a depth of 840 m were selected. The Repository capacity is about 4200 m^3, available capacity being now about 70%.

The operation of this disposal facility involves the following stages:

- the stage of disposal room preparation;
- the stage of operation;
- the stage of rooms closing;
- the stage of disposal facility closing;
- the stage of institutional surveillance.

The existing capacity can accommodate the WWR-S decommissioning waste.

RADWASTE MANAGEMENT PLAN

Treatment, conditioning, storage and disposal of radwaste resulted from decommissioning activities of VVR-S reactor and auxiliary installations are presented at the general level in Fig. 2.

The standard package consists of a standard 220 liter drum arranged and approved for disposal. After IAEA expert revising the drum painting will be changed with more resistant epoxy type paint.

During Decommissioning Phase 1, the waste resulted from the irradiated fuel transfer, namely, management of the low contaminated water from the spent fuel storage and of the wastes resulted from the reactor electric and I&C systems dismantling, are manages.

Dismantling of the mixed bed filter and its substitution to satisfy the decommissioning conditions in Phase 2 are provided.

Action shall be taken to prepare the rooms for decommissioning Phase 2 by the decontamination of some contaminated surfaces and protection of all the surfaces in the room where decommissioning activities will develop, if it is necessary after dossymmetric measurements.

Radwaste management activities in Phase 1 consist in the treatment of liquids resulted from the cooling down pond by evaporation and of other liquid waste resulted from decontamination.

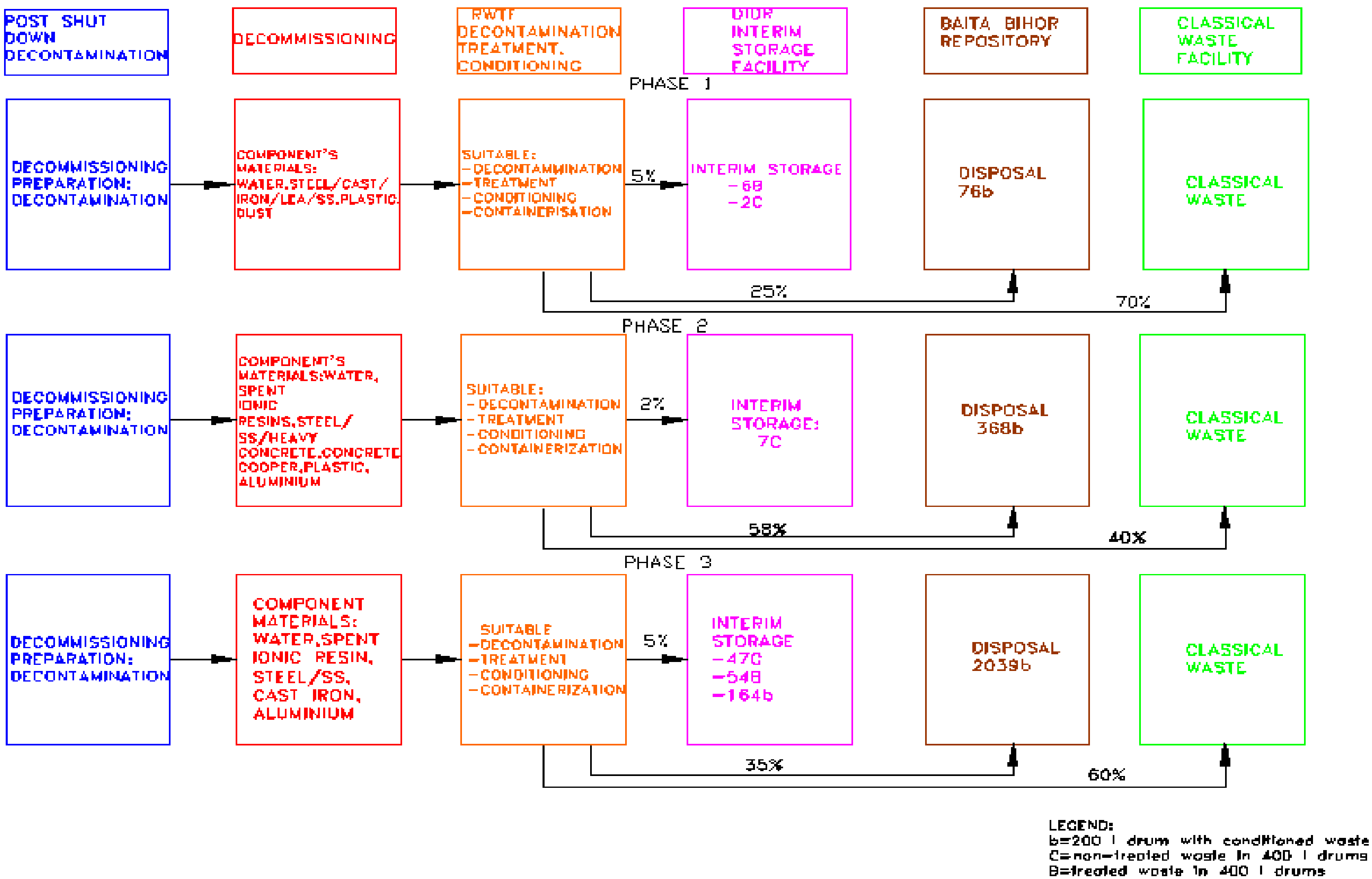

Fig. 2. General flow-sheet VVR-S +auxiliary facilities integrated decontamination + decommissioning + radwaste management

The radioactive concentrate resulted from the evaporation is cement embedded and the packages formed as such for final disposal are sent to Baita Bihor NATIONAL RADWASTE REPOSITORY.
The solid wastes from VVR-S reactor decommissioning packed in special containers or drums protected by re-usable plastic sheets are treated as the case by available methods.
First, the test to determine the contamination level, the adherence degree and the depth of contamination must be carried out.
Function of the test results, the proper decisions for slight decontamination with recovery of the part, advanced decontamination with recovery of materials or the consideration as radioactive waste that need to be treated by cutting, super-compacting, thermal compression or incineration, as the nature of the material, need to be taken.
Phase 2 will include activities related to the primary circuit decontamination, dismantling, the mixed bed filter dismantling, the biologic protection dismantling, secondary circuit dismantling, and discharge of waste from hot cells, dismantling of sub-systems of the reactor block, the decontamination and refurbishment of inside finishing.
The radwaste management activities in Phase 3 consist in the treatment of the water in the nuclear fuel storage and they are to continue with the dismantling activities, demolition of the reactor block, of the hot cells, of the cooling pond, secondary circuit, distilled water circuit, biologic protection and all the auxiliary systems, including the underground ventilation and active drainage systems.
All decommissioning operations are accompanied by radioactive and non-radioactive waste management activities, evidencing the quantities of waste which are to be disposed off in Baita Bihor NATIONAL RADWASTE REPOSITORY, in the intermediate storage or in an ordinary storage facility.
The storage capacity may be obtained by remediation of existing capacity at RWTP.
Figure 2 includes all the decommissioning activities which involve radwaste management operations and the quantities of packages to be transported to the Baita Bihor NATIONAL RADWASTE REPOSITORY and the number of packages to be stored for a 50 years period.

NON-RADIOACTIVE WASTE MANAGEMENT

Non-radwastes are collected and sorted out, and stored on the platform near the reactor building.
Materials will be so sorted-out to recover the valuable metals, namely, stainless steel, copper as well as other material that can be reused.
By slight decontamination, some of the dissembled components of systems can be reused and following to advanced decontamination, some of the materials (ferrous and non-ferrous) can be re-melted. A large part of the other materials can be recycled. Proper garbage containers, provided with covers will be used.
During the system decommissioning activities all the non-radioactive wastes which are to be sorted and reused, recycled or directed to the Magurele town garbage disposal system, are identified.

THE MAIN CHARACTERISTICS OF THE INTEGRATED DECONTAMINATION& DECOMMISSIONING & WASTE MANAGEMENT PLAN

After ten years after VVR-S reactor shut down, the decontamination with high flux of water is considered a not efficient method.

According IAEA recommendations, the main decontamination activity before decommissioning will be concentrated on wet paper wash out instead other decommissioning technique. Thus the secondary waste from decontamination activities will be minimized.
In the Integrated Decontamination & Decommissioning & Radwaste Management Plan were established the main 76 decommissioning activities together associated decontamination and waste management activities and also supplementary 5 specific auxiliary waste management activities (see summary in Fig.2).
In the First Phase of decommissioning were identified 5 decommissioning activities with associated decontamination and waste management activities.
For the radwaste management was established the following effort:

- Estimated period: 2 month;
- Estimated cost: 116000-160000 EUR

Resulted radwaste packages: - 76 pieces of 200 l drums;
- 6 pieces of 400 l drums with treated waste for interim storage;
- 2 pieces of 400 l drums with non treated waste for interim storage;

It is possible that about 20% of this waste to be transferred to the very low level waste repository.
About of 70% of total managed waste can be directed to classical store as unconditioned released waste.
In the Second Phase of decommissioning were identified 25 decommissioning activities with associated radwaste management activities below assessed:
- Estimated period: 32 month;
- Estimated cost: 298000-411000 EUR.

Resulted radwaste packages: - 368 pieces of 200 l drums;
- 7 pieces of 400 l drums with non-treated waste for interim storage;

It is possible that about 20% of this waste to be transferred to the very low level waste repository
About 40% of managed waste can be directed to classical store as unconditioned released waste.
In the Third Phase of decommissioning were identified 46 decommissioning activities with associated radwaste management activities below assessed:
- Estimated period: 84 month;
- Estimated cost: 4100000-5658000 EUR.

Resulted radwaste packages: - 2039 pieces of 200 l drums;
- 54 pieces of 400 l drums with treated waste for interim storag
- 47 pieces of 400 l drums with non-treated waste for interim storage;
- 164 pieces of 200 l drums with waste for interim storage.

About 60% of managed waste can be directed to classical store as unconditioned released waste.
Taking into account only reactor decommissioning, without Hot Cells and Auxiliary Laboratory, the waste management effort presented in Fig.3, means 935 pieces of 200 l drums for disposal, 20 pieces of 400 l drums with treated waste and 28 pieces of 400 drums with non treated waste for interim storage (see Fig. 3).

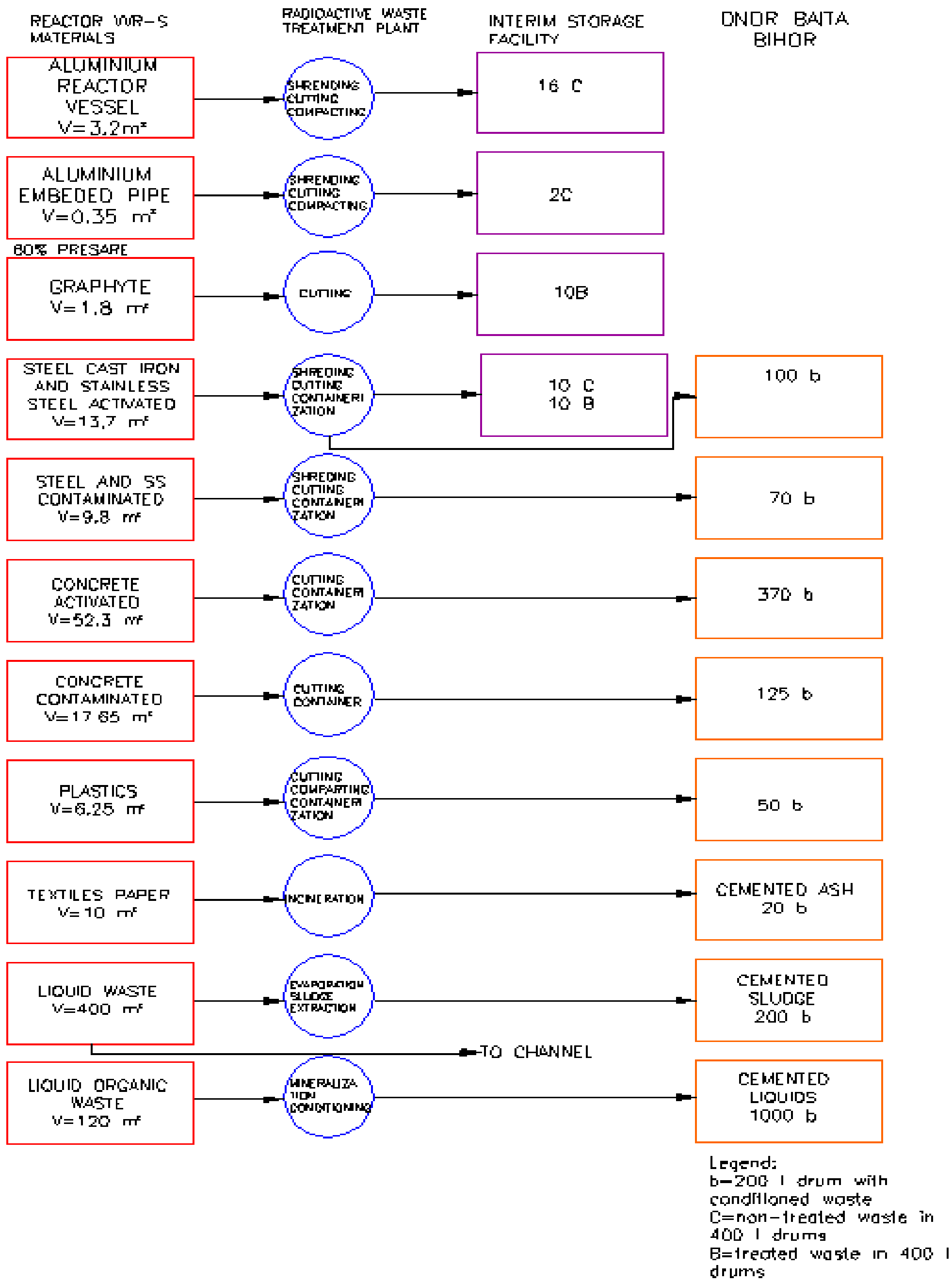

Fig. 3. General radwaste management flowsheet of VVR-S reactor decommissioned materials-reactor materials only

MAIN ALTERNATIVE ENVISAGED

The following main activities can influence the waste management and the total quantity of radioactive waste:

- Decontamination of primary circuit by water washing and chemical solutions, or by mechanical methods-blaster

- Dismantling of the internal components of Research Reactor.
- Minimization of Al and graphite activated materials
- Demolition of reactor protection shielding or not.

The preliminary cost-benefit assessment is very dependent by Sv.man cost which was not calculated yet. The first tentative to calculate this factor indicate a value for Romania of ten times lower than Canadian similar factor. In this case the blaster method for decontamination of primary circuit can be more advantageous.

RELEASE CRITERIA UNDER THE AUTHORIZATION REGIME

The Romanian legislation framework which controls the release process under authorization regime of both materials and equipment obtained as a result of VVR-S decommissioning, as well as the afferent buildings and the site of this nuclear installation, is represented by the following standards (norms):

- NRS-01 – The Radiological Safety Fundamental Norms approved by CNCAN Order no. 14, 2000;
- NDR-02 - Norms regarding release from authorization regime of all materials resulted in the authorized practices in nuclear field, approved by CNCAN Order no. 62/2003.03.31;
- NSN-15 - Norms for Nuclear Installations and Objectives Decommissioning, approved by CNCAN Order no. 181/2002.05.09.

The release criteria under the authorization regime provided in these norms are the following:

- The release under the authorization regime of both materials and equipment resulted from the WWR-S reactor decommissioning does not imply risks for population and environment, whether, analyzing the exposure ways, the results will be:
  - it is less probable that the effective annual dose received by an individual of population as a result of that release under the authorization to exceed 100 μSv; and
  - it is practical impossible that annual dose received to exceed 100 μSv.
- The release under the authorization regime is made only after the CNCAN approval.
- Release under the authorization regime can be either non-conditioned or conditioned, so that:
  - materials and equipment non-conditioned released under the authorization regime can be used without restrictions, yet;
  - both material and equipment conditioned released under the authorization can be recycled/reused only as per release conditions.
- Requirements regarding the levels of non-conditioned release:
  - materials which meet release requirements mentioned in Appendix 2 of the Radiological Safety Fundamental Norms (NSR-01) can be non-conditioned released under the authorization regime only with CNCAN approval;
  - solid material which cannot meet the excluding requirements mentioned in Appendix 2 of the Radiological Safety Fundamental Norms (NSR-01), but which meet the provisions in Appendix 2 of NDR-02 will be able to be non-conditionally released under authorization regime, only in condition of:
    - obtaining, by NIPNE-HH, the Health Ministry authorization, as per Low 111/1996, regarding the development, under safety conditions of nuclear

activities; and
- approval, emitted by CNCAN, to use the release values provided in NDR-02 as levels of non-conditioned release under the authorization regime for the respective materials and equipment.

IFIN-HH applied these requirements at Waste Management Plan performance. The implementation of these criteria will reduce the total quantity of the radwaste with 20-30%.

The final site radiological surveillance have the purpose to verify whether the decontamination was performed so that the level of residual activity on site will be, at the end of operation, less than that established by the release criteria .

The results obtained within the surveillance process should be found in the Final Radiological Surveillance Report and have to reflect the final conditions of both the installation and site, at the end of decommissioning activities (to certify the fact that all criteria regarding the release under authorization regime have been met).

THE MODERNIZATION OF THE NATIONAL DISPOSAL FACILITY

The National Disposal facility was adapted in a former uranium mine in the central-western part of the Bihor mountains in Transylvania. Two galleries at a depth of 840 m were selected.

The operation of this disposal facility involves the following stages:

- the stage of disposal room preparation;
- the stage of operation;
- the stage of rooms closing;
- the stage of disposal facility closing;
- the stage of institutional surveillance.

In order to improve the sealing of disposal rooms and the overall activity, it is necessary to achieve the following objectives:

a. The construction of a road to ensure year-round access of trucks to the disposal facility.
b. The construction of a technological building including a hangar for discharging drums.
c. Reconstruction of drainage channels.
d. The attainment of a physical protection system.
e. Waterproofing of 200 meters of main access gallery and supplementary works to disposal rooms.
f. Reconstructing the power supply.
g. Reconstructing the ventilation system.
h. Utilities supply for technological building.
i. The collection of the waters from decontamination.
j. Purchasing the necessary equipment (dosimetric equipments, transportation equipment, concrete mixer, etc.).
k. Developing new drum immobilization technology.

In order to ensure permanent access to the National Radioactive Waste Disposal Facility, an access road (~3 km) from the existing road in administration of National Uranium Company will be constructed. Presently, a provisional macadam road is in operation, one that renders access during snowy winters almost impossible.

CONCLUSION

The paper presents the improvements included in the Draft Decommissioning Plan of the VVR-S Reactor in order to be approved by Regulatory Body

The current version 8 of the Draft Decommissionig Plan which include the Integrated concept of Decontamination & Decommissioning & Rawaste Management, reflects the substantial work that has been incorporated by IFIN-HH in collaboration with SITON, which has resulted in substantial improvement in document

The decommissioning strategy must take into account costs for VVR-S Reactor decommissioning, as well as costs for much needed refurbishments to the radioactive waste treatment plant and the Baita-Bihor waste disposal repository. Several improvements to the Baita-Bihor repository and IFIN-HH waste treatment facility were proposed.

The quantities and composition of the radioactive waste generated by VVR-S Reactor dismantling were again estimated by streams and the best demonstrated practicable processing solution was proposed. The estimated quantities of materials to be managed in the near future raise some issues that need to be solved swiftly, such as treatment of aluminum and lead and graphite management. It is envisaged that these materials to be treated to Subsidiary for Nuclear Research (SCN) Pitesti.

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