CURRENT TASKS OF THE DECOMMISSIONING PLANNING FOR THE KIEV’S RESEARCH REACTOR WWR-M

Presented by
Yuri Lobach
INR NASU

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The main nuclear installations in Ukraine

- WWER-440 (Rovno NPP)
- WWER-1000 (Zaporizhzhya NPP, Rovno NPP, South Ukraine NPP, Khmelnitsky NPP)
- РБМК-1000 (Chernobyl NPP)
- Research reactor (Nuclear Research Institute in Kiev, Sevastopol Nuclear Energy Institute)
- State special enterprises for RW management “Radon”
- Uranium mining enterprises
As a whole, the normative-legal basis of Ukraine is sufficient for the decision on present-day tasks connected with the provision of safety and protection of the personnel, population and environment at the decommissioning of NPPs and RRs in Ukraine. In this area the normative-legal basis is corresponding to the international practice, accounts the recommendations of IAEA, ICRP and other international organizations.
The definition of term “decommissioning”:

*Decommissioning means such set of measures after nuclear fuel removal that excludes the operation of the facility in purposes for which it was constructed and provides personnel and the public safety and the environment security.*
Following to this definition, the goal, scope and possible ways are determined:

- Decommissioning of the facility is undertaken for the excluding of the possibility of further use of the given facility with the purposes for which it was constructed.
- Decommissioning of the facility is undertaken for the achievement such site conditions that reduces maximally any restriction on the site use. It provides for:
  - stage-by-stage removal of the sources of ionizing radiation being subject to regulatory control;
  - abolishment of the restriction regime and reduction of radiation monitoring in the supervision zone and sanitary-protective zone of the facility.
Normative Document NP 306.2.02/1/004-98 “General Provisions on Safety Assurance of Decommissioning of NNPs and RRs”

Final shut-down          SF removal

Operational licence

Permission for the termination of operation stage

Decommissioning licence

Permission for the final closure stage

Permission for the dismantling stage

Reactors is in operation

Reactor is finally shut-down

SF in pond

SF outside reactor

DECOMMISSIONING CONCEPT

Implementation Program for the termination of operation stage

Implementation Program for the final closure stage

Implementation Program for the dismantling stage

DECOMMISSIONING PROGRAM

Implementation Program for the termination of operation stage

Implementation Program for the final closure stage

Implementation Program for the dismantling stage

SAR for the termination of operation stage

SAR for the final closure stage

SAR for the dismantling stage

Technological rules for the termination of operation stage

Technological rules for the final closure stage

Technological rules for the dismantling stage

Final report

Unlimited use of the site

Cancelation of licence
The WWR-M reactor is a heterogeneous water-moderated pool type research reactor operating with thermal neutrons at a power of 10 MW$_{\text{th}}$, giving a maximum neutron flux of $1.5 \times 10^{14}$ cm$^{-2}$s$^{-1}$ at the core center.
Layout of the buildings and constructions on the reactor site:

1 – reactor building;
2 – reactor sewage system pipeline;
3 – reactor waste tanks;
4 - observation holes;
5 – workshop;
6 – tambour of reactor hall;
7 – physical protection fence;
8 – site wall;
9 - store building;
10 – hot cells sewage system pipeline;
11 - water-tower;
12 - cooling tower;
13 – ventilation center;
14 – gasholder;
15 – secondary circuit pump-house;
16 - hot cells building;
17 - hot cells waste tanks;
18 - evaporator installation;
19 – experimental hall on the horizontal channel
“Strategic Plan for the use of research reactor WWR-M of the Institute for Nuclear Research” was approved by the National Academy of Sciences of Ukraine in July 2004. Plan determines the strategic goal as the extension of the reactor operation till 2015.
The term of operation was continued by the decree of the SNRCU’s Board (No 11 from 21 May 2009) and then a new permission for the reactor operation will be issued:

- to continue the reactor operation till 31.12.2013;
- to convert the reactor on the stage “termination of operation” from 1.01.2014;
- in the case of the operator’s decision concerning the reactor’s further operation, to prepare and agreed with the SNCRU the possibilities and conditions of the reactor operation.
CURRENT STATUS OF DECOMMISSIONING PLANNING

Preparation for the further decommissioning of the Kiev’s research reactor was started in the framework of the *Decommissioning Concept* issued in 2001.

This document contains a common decommissioning approach and measures, which must be detailed and updated with the goal of preparation of the justified decommissioning plan.

The next step of decommissioning planning is the development of the detailed *Decommissioning Program*, which was elaborated during 2007-2009 and approved by the Regulatory Body decision from 4 November 2009.

This document determines and substantiates the main technical and organizational measures for the decommissioning preparation and implementation, the sequence of works and measures, necessary conditions for their execution and provision. Special attention is concentrated on the *ecological safety* of decommissioning due to the reactor location in the megapolis.
The most likely option will be the use of the reactor’s building with the “hot cells” as *the separate laboratory for the development and application of radiation technologies*.

The variant of *immediate dismantling* was selected for the WWR-M reasoning based on the plans for the further site use with the removal of spent fuel and radwaste outside Kiev and site return for the unrestricted use.

In accordance with the preliminary estimations, the decommissioning timeframe will not exceed 6 years.
DECOMMISSIONING PROGRAM of the RESEARCH REACTOR WWR-M (2009)

1. MAIN CONDITIONS OF PROGRAM
   1.1. Introduction
   1.2. Purpose, goals and tasks of the Program
   1.3. Basic regulations
   1.4. Scope
   1.5. Revision of Program

2. DESCRIPTION OF THE REACTOR SITE
   2.1. Geographical and demographic characteristics of the environment
   2.2. Meteorology
   2.3. Hydrology
   2.4. Geology and seismology

3. REACTOR DESCRIPTION
   3.1. Purpose, type and technical parameters of the reactor
   3.2. Reactor design
   3.3. Main buildings
   3.4. Auxiliary buildings
   3.5. Building construction state and conditions on the reactor site

4. HISTORY OF REACTOR OPERATION
   4.1. Reactor utilization
   4.2. Reactor operation
   4.3. Modernization of the reactor systems and refurbishment of the equipment
   4.4. Reactor accidents and personnel dose loading
   4.5. Records on reactor inspections
   4.6. Radiation conditions at the reactor
   4.6.1. Radiation conditions in the reactor hall
   4.6.2. Radiation conditions in the reactor building
   4.6.3. Radiation conditions in the pump house and adjacent premises
   4.6.4. Radiation conditions around reactor

5. PLANS FOR USE OF THE SITE, MATERIALS AND COMPONENTS
   5.1. Plans for use of the site
   5.2. Plans for use of the materials and components

6. DECOMMISSIONING STRATEGY

7. SEQUENCE OF DECOMMISSIONING
   7.1. Activity for the preparation of decommissioning at the reactor operation
   7.2. Termination of operation
   7.3. Final closure
   7.4. Dismantling

8. RADWASTE MANAGEMENT PROGRAM
   8.1. Solid RAW generation and accumulation
   8.2. Liquid RAW generation and accumulation
   8.3. Order of the RAW transfer to the special enterprise
   8.4. Organizational scheme for the RAW management
   8.5. RAW account and control
   8.6. Radiation control at the RAW management
   8.7. Analysis of accidents at the RAW management
   8.8. Quality assurance at the RAW management
   8.9. Measures for the RAW minimization
   8.10. Implementation of the modern methods for the RAW management
   8.11. Decommissioning radwaste

9. SAFETY PROVISION
   9.1. Nuclear safety
   9.2. Radiation safety
   9.3. Physical protection system
   9.4. Fire safety
   9.5. Industrial safety
   9.6. External monitoring
   9.7. Emergency response

10. PROGRAM OF RADIATION PROTECTION
    10.1. Control (limitation) levels for the personnel
    10.2. System of radiation and dosimeter control
    10.3. Control of the staff external exposure
    10.4. Control of the radioactive pollutants
    10.5. Organizational measures aimed at the radiation dose reduction
    10.6. Modernization of the radiation control system
    10.7. Radiation protection system at the reactor decommissioning

11. SUPPORT INFRASTRUCTURE FOR THE DECOMMISSIONING WORKS
    11.1. Power supply
    11.2. Water supply
    11.3. Heat supply
    11.4. Sewage systems
    11.5. Mechanical workshop
    11.6. Roads and transportation

12. DECOMMISSIONING PLANNING AND MANAGEMENT
    12.1. Technical management
    12.2. Scientific support
    12.3. Administration
    12.4. Quality assurance group

13. DOCUMENTATION FOR THE DECOMMISSIONING

14. QUALITY ASSURANCE

15. PERSONNEL UTILIZATION

16. SOCIAL PROTECTION OF THE REACTOR STAFF

17. PUBLIC RELATIONS ON THE DECOMMISSIONING PROBLEMS

ATTACHMENTS

1. Legislation and normative documents
2. The results of environmental external radiation monitoring in the WWR-M reactor's zone of influence
3. "Hot cells" application
4. Calculations of DSA at the WWR-M reactor decommissioning
5. Preliminary program of the complex engineering and radiation inspection
6. List of the reactor system's equipment
7. List of the radiation control system equipment.
Radiation Material Study Department

Available facilities:

- heavy hot cells allowing the investigations of samples with the activity up to 25000 Ci;
- light hot cells (up to 250 Ci).

The laboratories are fitted out with the remotely-operated equipment for the study of physical-mechanical characteristics of materials irradiated with the high neutron doses, surveillance specimens of the reactor vessel metals of the Ukrainian NPPs.
INR has been appointed as the leading organization for the scientific support of the safe operation of the WWER-440 and WWER-1000 type reactor vessels.

Main directions of scientific activity:

- Determination of mechanisms of radiation damage of the solids, selection of the most advanced structural materials for nuclear reactor industry.
- Radiation material science aspects of operating reactors safety, investigation of the radiation embrittlement of the reactor vessel steels and determination of the WWER-1000 type reactor vessels safe operation lifetime in particular.
# Principal Reactor Systems:

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>Complete dismantling</th>
<th>Utilization at the decommissioning</th>
<th>Utilization after decommissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Reactor vessel</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2 Primary and secondary circuits</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3 Water cleaning system (primary circuit)</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 Control rod system</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5 Water supply system</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6 Emergency cooling system</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7 Electric power supply system</td>
<td>-</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>8 Special ventilation system</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>9 Radiation protection system</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10 Radiation control system</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>11 Special sewerage system</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>12 Fresh fuel storage</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>13 Spent fuel storage (CP-1)</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>14 Spent fuel storage (CP-2)</td>
<td>-</td>
<td>-</td>
<td>?</td>
</tr>
<tr>
<td>15 Experimental installations</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16 “Hot-cells” (4 cells)</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>17 Fire protection system</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>18 Physical protection system</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>19 Loading tools (cranes)</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>20 Heat supply system</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

*In accordance with accepted decision for the utilization of the reactor building with the “hot-cells” as the separate laboratory (after the transfer of the main reactor building, the part of existing infrastructure and the auxiliary buildings to such laboratory)*
Activity for the preparation of decommissioning during the reactor operation

At the reactor operation it will be performed the set of works directed toward the preparation of decommissioning. The following measures are carried out permanently:

- classification, accounting and forecast of the radwaste volumes, which will be generated during the reactor operation and decommissioning;
- collection, processing and storage of information related to the buildings, the constructions and the reactor systems and elements, which will be required for the reactor decommissioning;
- works aimed on the preparation and removal of the spent nuclear fuel;
- gathering of the material and technical resources for the decommissioning;
- development of the decommissioning documentation;
- request and approval of the decommissioning license;
- public relations on the decommissioning problems.
<table>
<thead>
<tr>
<th>Equipment type</th>
<th>Main material</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>REACTOR WWR-M</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Reactor vessel (\Phi 2300 \times 5705)</td>
<td>CAB-1</td>
<td>3600</td>
</tr>
<tr>
<td>2. Beryllium reflector (\Phi 2920 \times 570 \times 500)</td>
<td>beryllium</td>
<td>835</td>
</tr>
<tr>
<td>3. Thermal columns</td>
<td>steel, cast iron, graphite</td>
<td>15000</td>
</tr>
<tr>
<td>4. Thermal column rolling-off mechanism</td>
<td>steel</td>
<td>3884</td>
</tr>
<tr>
<td>5. Shielding with channels</td>
<td>steel, cast iron, lead</td>
<td>65000</td>
</tr>
<tr>
<td>6. Thermal column shield</td>
<td>steel, cast iron</td>
<td>30550</td>
</tr>
<tr>
<td>7. Deaerator (\Phi 1620 \times 5520)</td>
<td>CAB-1, cast iron</td>
<td>4220</td>
</tr>
<tr>
<td>8. Distiller tanks (3200 \times 2300 \times 1500)</td>
<td>steel 1X18H9T</td>
<td>1880 \times 4 = 7520</td>
</tr>
<tr>
<td>9. Spent fuel storage (4000 \times 2840 \times 840)</td>
<td>CAB-1, steel 1X18H9T</td>
<td>19000</td>
</tr>
</tbody>
</table>

**Total weight of materials (kg):** **149609**

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>Main material</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRIMARY CIRCUIT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Main pipelines</td>
<td>steel 12X18H10T</td>
<td>6044</td>
</tr>
<tr>
<td>2. Circulation pump</td>
<td>steel 1X18H9T</td>
<td>837</td>
</tr>
<tr>
<td>3. Stop valves</td>
<td>steel 1X18H9T</td>
<td>5320</td>
</tr>
<tr>
<td>4. Heat-exchangers - 2 pieces</td>
<td>steel 12X18H10T</td>
<td>2 \times 7694 = 15388</td>
</tr>
<tr>
<td>5. Cooling pipelines</td>
<td>steel 12X18H10T</td>
<td>1800</td>
</tr>
<tr>
<td>6. By-pass purification system</td>
<td>steel 12X18H10T</td>
<td>1337</td>
</tr>
<tr>
<td>7. Emergency cooling system</td>
<td>steel 12X18H10T</td>
<td>1700</td>
</tr>
</tbody>
</table>

**Total weight of materials (kg):** **32426**

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>Main material</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SECONDARY CIRCUIT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Main pipelines</td>
<td>steel 207</td>
<td>39222</td>
</tr>
<tr>
<td>2. Circulation pumps</td>
<td>steel, cast iron</td>
<td>773 \times 3 = 2320</td>
</tr>
<tr>
<td>3. Stop valves</td>
<td>cast iron</td>
<td>7659</td>
</tr>
</tbody>
</table>

**Total weight of materials (kg):** **49201**

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>Main material</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AUXILIARY SYSTEMS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Special sewage system</td>
<td>steel 1X18H9T</td>
<td>12748</td>
</tr>
<tr>
<td>2. Reservoir - 2 pieces</td>
<td>steel 1X18H9T</td>
<td>22576</td>
</tr>
<tr>
<td>3. Ventilation chimney</td>
<td>brick</td>
<td>23580</td>
</tr>
<tr>
<td>4. External ventilation airways</td>
<td>steel 1X18H9T</td>
<td>19450</td>
</tr>
<tr>
<td>5. Ventilation unit of special ventilation system – 8 pieces</td>
<td>steel 3</td>
<td>3200</td>
</tr>
</tbody>
</table>

**Total weight of materials (kg):** **81554**

**TOTAL (kg):** **312790**
WORKS CARRIED OUT DURING 2009 - new SFSF
SF reloading operations (November 2009)
SF shipment (May 2010)
AVAILABLE DECOMMISSIONING EXPERIENCE

The exchange of heat-exchangers (4×95 = 380 m² → 2×329 = 658 m²) and pipe-line segments.

Sequence:

- the reactor core reloading and removal of heat-carrier to the special drainage system;
- the dismantling of experimental equipment at the horizontal channels located above the primary circuit pump-house;
- the dismantling of covering plates in the primary circuit pump-house;
- the dismantling of equipment and pipelines, which are a subject of replacement in the primary circuit pump-house;
- the removal of dismantled equipment from the primary circuit pump-house and reactor hall by means of load-lifting mechanisms (crane 10 t; telpher 10 t);
- the decontamination of external surfaces of the dismantled equipment and pipelines; packing into protective film;
- the loading on special transport car in the reactor hall tambour and transportation to the disposal place.

Total amount of removed contaminated equipment:

- heat-exchanger 4 items – 5000 kg×4 = 20000 kg
- pipelines - Ø 325×12 = 3500 kg

Altogether: 23500 kg
Removal of the reactor vessel (Rez, 1989; Rossendorf 2002)
FURTHER PLANS AND EXPECTED DIFFICULTIES

- removal of HEU fuel \textit{(completed in May 2010)};
- elaboration and partial implementation of the \textbf{CERI} Program \textit{(Complex engineering and radiation inspection = Radiological survey)};
- sequence of dismantling procedures \textit{(inverted sequence of assembling)}; dismantling design:
  - reactor internals;
  - reactor vessel;
  - concrete biological shield;
  - pump-house and primary circuit;
- SAR and EIA for decommissioning stages;
- cost estimations for sub-options
STRUCTURE OF DECOMMISSIONING DOCUMENTATION

ASSEMBLING DRAWINGS
(Draft of dismantling) (1976)

DECOMMISSIONING PROGRAM (2009)

OPERATIONAL TECHNOLOGICAL RULES (2009)

2010

PROGRAM of CERI

CERI REPORT

PROJECT of SEPARATE LABORATORY

DECOMMISSIONING TECHNOLOGICAL RULES

SF storage (CP-2)

DISMANTLING DESIGN

SAR for decommissioning

EIA for decommissioning

FINAL DECOMMISSIONING PROGRAM

Termination of operation stage

Final closure stage

Dismantling stage

2012

2013
Further reactor operation is assumed now as the main task. Operation license will be in force till 2014.

*Decommissioning Program* was approved by Regulatory Body at the end of 2009. This DP is considered as the intermediate stage of decommissioning planning.

Development of necessary decommissioning documents and detail time schedule is in progress now. Prioritisation for such development is established.
AVAILABLE PUBLICATIONS

1) Yu.N.Lobach, E.V. Svarichevskaya, V.V.Trishin
   Peculiarities of the environmental impact assessment at the decommissioning of the research reactor WWR-M
   Nuclear and radiation safety, 11, No3 (2008) p.29-34

2) Yu.N.Lobach, T.G.Ludanova, M.V.Lysenko, V.N.Makarovsky, V.N.Shevel
   Preparation for Decommissioning of WWR-M

3) Yu.N.Lobach
   Decommissioning planning for the Kiev’s research reactor WWR-M,
   in IAEA-TECDOC-1602 Innovative and adaptive technologies in decommissioning of nuclear facilities, 2008, p.251-266

4) Yu.N.Lobach, V.N.Makarovsky, V.N.Shevel
   Radioactive management at the decommissioning of the WWR-M reactor

5) Yu.N.Lobach, T.G.Ludanova, M.V.Lysenko, V.N.Makarovsky, V.N.Shevel
   Principal provisions of the decommissioning program for the WWR-M reactor

6) Yu.N.Lobach, V.N.Shevel
   Radiation protection tasks on the Kiev’s research reactor WWR-M

7) Yu.N.Lobach, M.V.Lysenko, V.N.Makarovsky
   Substantiation of the decommissioning strategy selection for the research nuclear reactor WWR-M
   Nuclear and radiation safety, 12, No3 (2009) p.46-51
THANK YOU!