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DESIGN FOR THE DISMANTLING OF THE WWR-M PRIMARY COOLING CIRCUIT

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Abstract

The WWR-M is a light-water cooled and moderated heterogonous research reactor with a thermal output of 10 MW. The final decommissioning planning for the Kiev's research reactor WWR-M is in progress now. The general dismantling strategy consists of the dismantling and removal of the separate bulky elements as whole pieces without preliminary segmentation. The dismantling of the primary cooling circuit is considered as one of the key tasks; a separate dismantling design has been developed. The baseline principles of the technical solution and safety assessment are presented in the given paper.

Keywords

WWR type reactor, decommissioning, primary cooling circuit, dismantling, exposure dose

1. Introduction

The research reactor WWR-M was designed and constructed in 1957-1960, the first criticality was achieved in February 1960. This is a heterogeneous water-moderated pool type research reactor operating with thermal neutrons at a power level of 10 MW_{th}, giving a maximum neutron flux of 1.5×10^{14} $cm^{-2}s^{-1}$ at the core centre. Today the reactor is still in operation; it is located on the site of the Institute for nuclear research (INR) in the Goloseev district of Kiev city**.** The Institute is the reactor operator and possesses all necessary licenses and permissions for the reactor operation.

Since May 2001 INR has the permanent license for the reactor operation, which will be in force until the reactor's final shut-down. The timeframe of the reactor final shut-down has not been specified yet and the reactor operation is carried out now in accordance with separate permissions issued for several years. The basis of such extension of permission is the revised operational Safety Analysis Report. The current timeframe of operation had been continued by the decree of the Regulatory Body (in May 2009); it was in force until the end of 2013 and then a new permission for the reactor operation should be issued.

The present technical condition of the reactor allows its safe operation following an upgrading of some systems and elements. Most of the reactor systems had been upgraded or replaced (completely or partially) during the reactor operation. Previously, it was intended to operate the reactor until 2015, but now a further extension is considered; moreover, the possibility of comprehensive modernization aimed at the reactor vessel replacement is under discussion as well [1].

At the same time in accordance with the existing national legislation the decommissioning of a reactor must be considered by the operator as early as possible, independently of a possible life-time extension. Requirements for the planning of the decommissioning of nuclear installations as well as for the activities directly related to the decommissioning (for example, the spent fuel and radwaste management, the licensing etc.) are established by the Ukrainian legislation, which corresponds with good international practice and complies with the recommendations of IAEA, ICRP and other international organizations [2, 3]. Following this, a decommissioning planning is carried out at three levels: Initial, Ongoing and Final. For a given nuclear installation, the degree of detail will increase from the initial to the final decommissioning plan. Consequently, the preliminary decommissioning planning was initiated in the document "Decommissioning Concept of the WWR-M reactor" issued in 2001.

The next step of decommissioning planning was the document "Decommissioning Program of the WWR-M reactor", which was approved by the Regulatory Body at the end of 2009 [4]. This document conforms to the on-going decommissioning planning; therefore, it contains the basic directions for further decommissioning planning aimed at the timely preparation of the reactor decommissioning. The Decommissioning Program foresees the strategy of immediate dismantling with reference to the plans for the further site use [5]. In accordance with the selected decommissioning strategy, the sequence of decommissioning stages was established along with the scope of works and measures at these stages, their durations as well as the necessary conditions and infrastructure for the timely and effective decommissioning execution. The ultimate goal of the reactor decommissioning is unrestricted site use with transfer of the reactor building, part of the existing infrastructure for the reactor operation provision and the reactor auxiliary building to the separate laboratory for the development and application of radiation technologies.

The final step of decommissioning planning foresees the development of a detailed decommissioning program for WWR-M, which is aimed at a timely preparation of all necessary documents for the planning and implementation of the decommissioning process as a whole [6]. An internally-consistent cost-effective detailed decommissioning program with a set of substantiating and supporting documents will be a result of the present project [7]. The core of this program should be the dismantling design elaborated for the separate equipment, systems and elements of the reactor. Analysis of the technical tasks has revealed that these components should be considered separately and, therefore, a specific design for each of them must be developed along with the selection of a suitable method for dismantling. The general dismantling strategy consists of the following: a) the dismantling itself will be performed "from top to bottom" for the preservation of stability; b) the dismantling and removal of the separate bulky elements should be performed as a whole pieces, without preliminary segmentation; c) the subsequent segmentation of such elements, if necessary. Available foreign experience from the similar reactors [8-11] has just confirmed given technical solution. As a result, at first the design for the vessel removal was proposed [12] and then the dismantling design for the primary cooling circuit was elaborated. The description of the technical solution with the relevant safety assessment is the subject of this paper.

2. PCC layout and composition

2.1. Premise

The main reactor building is composed of two parts; the first is the reactor hall (21.5×26.5×16.0 m) with the experimental facilities and auxiliary systems, the second is the four-storied laboratory-service building (60.0×15.0 m). The facility consists of the reactor (reactor vessel, core internals and biological shielding), and the main circuits and systems: primary and secondary cooling circuits, their auxiliaries, the distilled water circuit (used also as the emergency core cooling system), ventilation system, water supply system, power supply system and other auxiliary systems.

The purpose of the ***primary cooling circuit*** (PCC) is the provision of coolant circulation from the reactor to the heat exchangers and return. The primary circuit coolant (distilled light water) is directed top-down through the core and beryllium reflector and then, by means of outlet pipeline, is directed to the pumps and heat-exchangers. The coolant is returned by means of inlet pipe-line. The ***secondary cooling circuit*** (SCC) is designed for cooling the primary circuit coolant. Cooling of the heat exchangers is carried out by means of a water-filled, closed loop composed of pipework of different diameters together with pumps and a cooling tower. The PCC ***water cleaning system*** (WCS) is employed for the removal of contamination (crud) from the primary circuit water generated due to the contact of constructional materials with the coolant (the corrosion and erosion of these materials and any fission products from failed fuel or tramp uranium). Primary circuit water is cleaned by a filter system and consists of thermal-oxidative ion-exchange filters (anionic and cationic filters).

The PCC, SCC and WCS equipment are located in the pump-premise (with floor area of about 100 m^2) below the reactor on the ground floor at a level of -5.4 m. The pump-premise walls are made from heavy concrete with a thickness of 1.0 m; the floor of 1.4 m thickness is the ground of the reactor hall. There are two technological openings between the pump-premise and the reactor hall. The pump-premise is equipped with a cat-crane with a lifting capacity of 1 t. The niche is adjacent to the pump-premise, where the bottom of the reactor vessel with the connecting flanges is located. The niche is attended by staff only for the control of the vessel and pipe-lines conditions. The niche dimensions are equal to 5.0 m (height) and 2.7 m (diameter).

2.2. Equipment

The layout of equipment in the PCC pump-premise is shown in Fig.1; a general view of the PCC pipe-lines is shown in Fig.2. A detailed scheme of the PCC pipe-lines is shown in Fig.3; the weight of relevant segments is presented in Table 1.

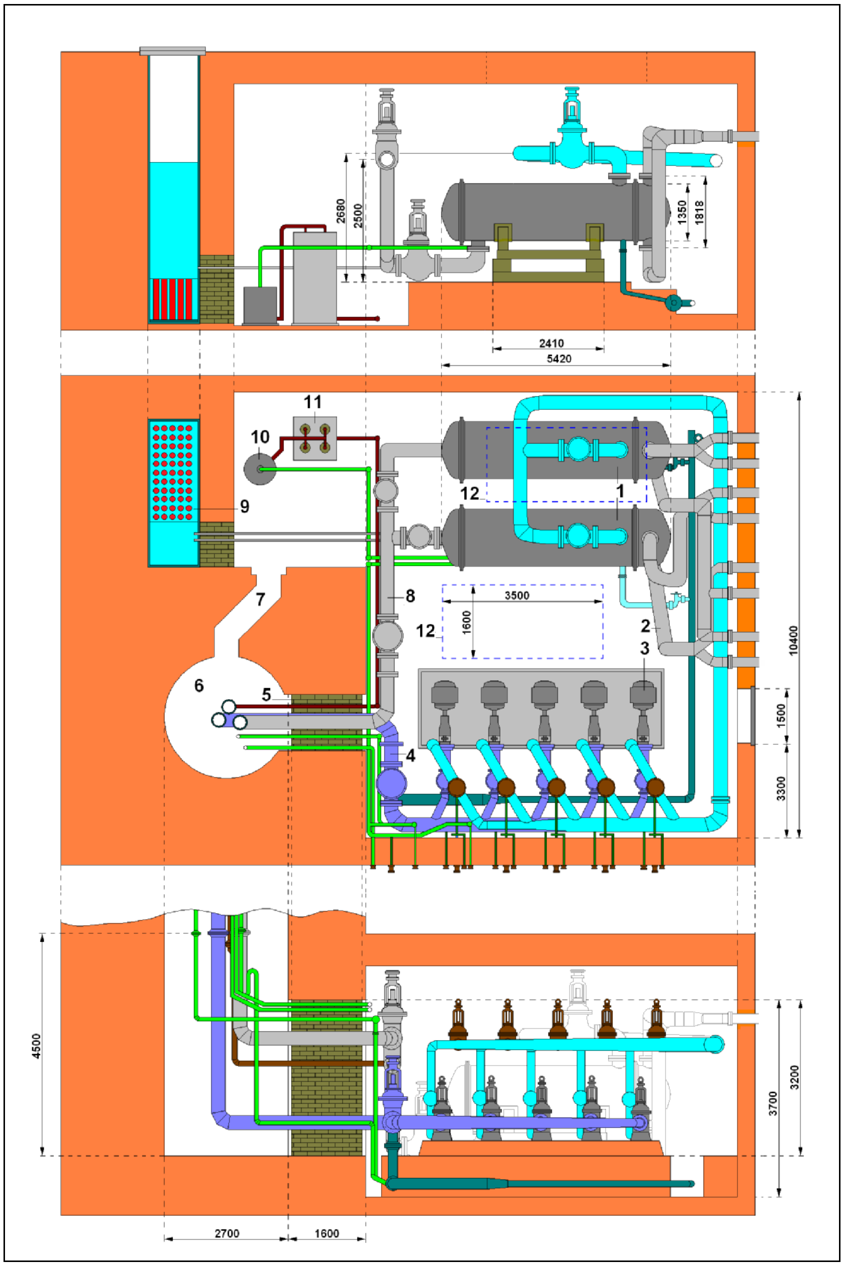


Figure 1. Layout of equipment in the PCC pump-premise: 1- HE; 2 - SCC pipe-lines; 3 - pumps; 4 – PCC inlet pipe-line; 5 – brick wall; 6 – under reactor space (niche); 7 – labyrinth; 8 – PCC outlet pipe-line; 9 – at-reactor cooling pond (SF storage); 10 – thermal-oxidative filter; 11 – ion-exchange filter; 12 - projection of technological hatches

Figure 2. General view of the PCC pipe-lines

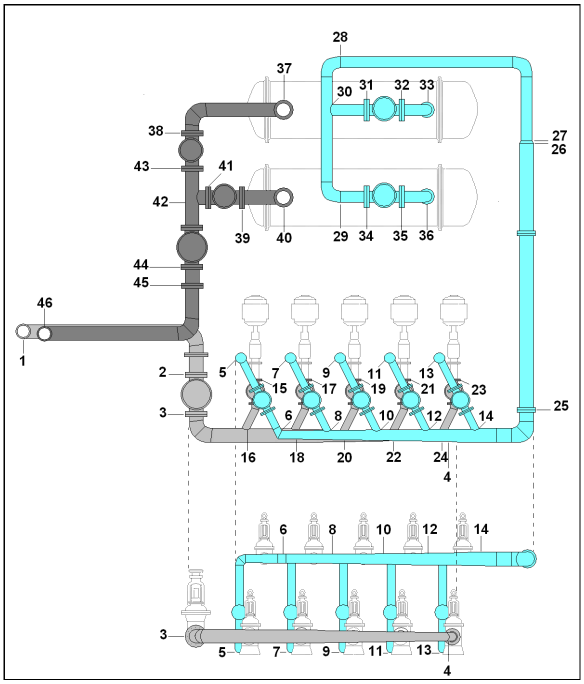


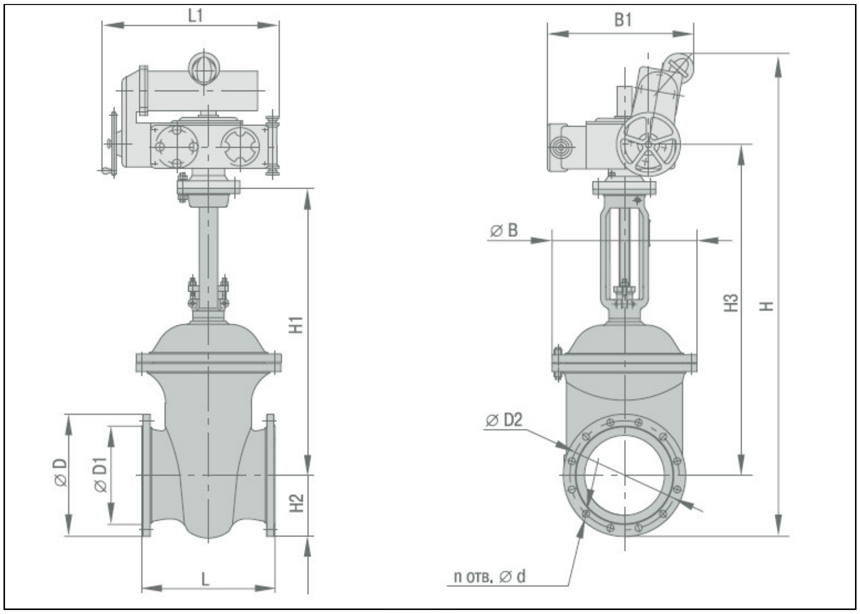
Figure 3. Scheme of the PCC pipe-lines

Table.1. PCC pipe-lines

Pipe seg-ment	*Diameter×wall thickness, mm*	*Length, m*	*Weight, kg*
1 – 2	370×10	8.57	276.2
3 – 4	370/219×10	6.89	473.2
5 – 6	219×12	3.30	204.7
7 – 8	219×12	3.30	204.7
9 – 10	219×12	3.26	202.2
11 – 12	219×12	3.33	206.6
13 – 14	219×12	2.96	183.6
15 – 16	219×12	1.45	90.0
17 – 18	219×12	1.47	91.2
19 – 20	219×12	1.51	93.7
21 – 22	219×12	1.56	96.8
23 – 24	219×12	1.40	86.9
6 – 25	219/370×10	5.60	384.5
25 – 26	370×10	7.40	665.4
27 – 28	325×12	6.10	572.2
28 – 29	325×12	2.60	243.9
29 – 34	325×12	0.80	75.3
30 – 31	325×12	0.85	79.7
32 – 33	325×12	1.20	112.6
35 – 36	325×12	1.20	112.6
37 – 38	325×12	4.78	448.4
39 – 40	325×12	1.80	168.9
41 – 42	325×12	2.88	279.5
43 – 44	325×12	1.40	129.7
44 – 45	370×12/325×12	0.32	26.1
45 – 46	370×10	6.27	202.1
		TOTAL WEIGHT (kg):	5710.7

Figure 4. Flanges to the reactor vessel.

Figure 5. Window in the concrete wall.



Value	D350	D300
L (mm)	550	500
H (mm)	1680	1820
H1(mm)	1085	1085
ØB (mm)	545	545
ØD (mm)	520	460
Weight (kg)	439	468

Figure 6. Valve gate

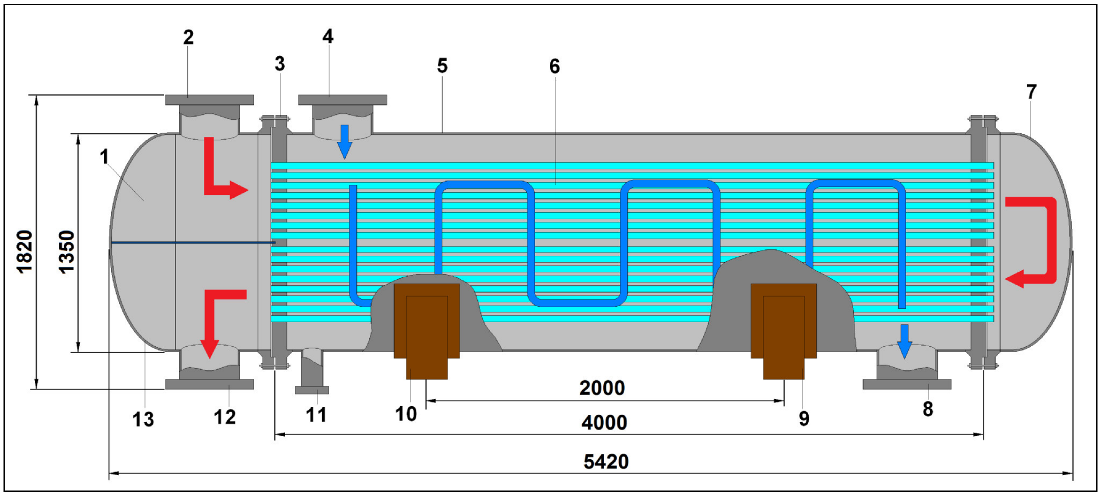


Figure 7. Heat-exchanger: 1 – distribution chamber; 2 – PCC input flange; 3 – guide grid; 4 – SCC input flange; 5 – HE shell; 6 – tube bundle; 7 – detachable lid; 8 – SCC output flange; 9 – moving support; 10 – stationary support; 11 – drain flange; 12 – PCC output flange; 13 - detachable lid.

Figure 8. Pumping unit.

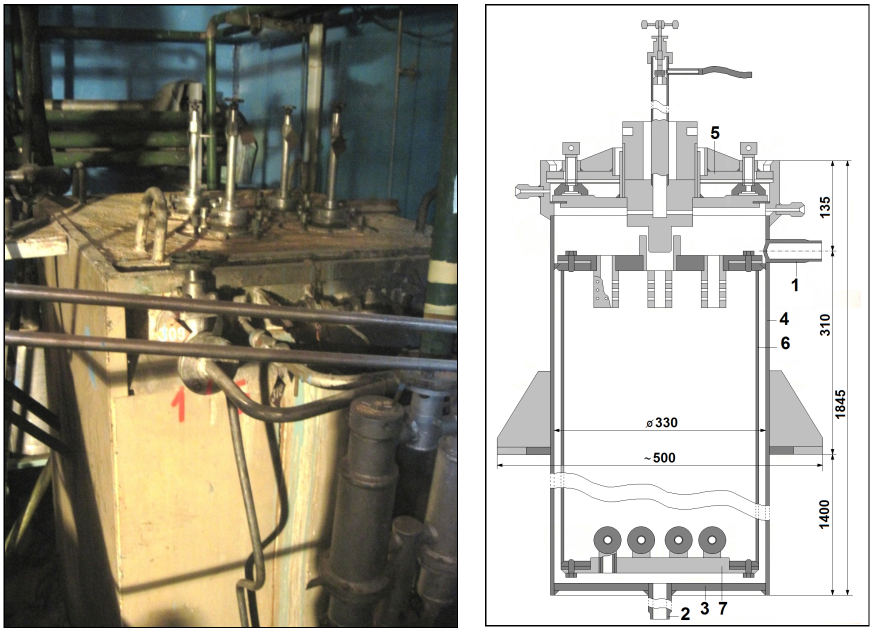


Figure 9. Filters: general view (left) and drawings (right): 1 – input pipe; 2 – output pipe; 3 – bottom; 4 – external sidewall; 5 – cover; 6 – internal sidewall; 7 – bed plate.

As can be seen on Fig.1, two flange connections are located in the upper part of the niche below the reactor vessel at a height of 4.5 m. The flanges are tightened by the radiation-resistant lining and fastened by the steel bolts M20 (12 for each flange, Fig.4). The PCC inlet and outlet lines are routed to the pump-premise through the window in the concrete wall (Fig.5), which has sizes 3.2×1.2 m and piled with the brick wall. The PCC inlet and outlet lines are made from aluminum alloy SAV (98% Al); with a diameter of 370 mm, wall thickness of 10 mm, and lengths of 8100 and 6200 mm, respectively. The valve gates D350 (Fig.6) and D300 for the pipe-lines have a weight of 439 kg (manual control) and 468 kg (remote control, equipped with electromotor). Altogether 16 valve gates of different sizes and destinations are located in the PCC, namely, one ahead and behind of the pumping unit (10 items); one ahead and behind of the heat-exchangers (4 items); and one ahead and one behind the reactor vessel (2 items).

The ***heat-exchangers (HE)*** of horizontal type are made from steel (Fig.7). The distinction of such HE construction is the rigid piped bunch, i.e. the bunch is fastened inflexibly with the tube lattice and this prevents pipe displacement inside encasement. The SCC water pressure was maintained higher than in the PCC with the goal to prevent SCC radioactive contamination in the case of seal failure.

There are ***five pumping units*** (three are running; two are reserves), each of them consisting of pump and electric motor on a common bed plate (Fig.8). The stop valve is installed ahead of each unit; the check valve and stop valve are located behind the unit; this allows the unit to be switched off for repair and maintenance. The unit dimensions are 1910×675×724 mm (length×width×height); the weight is 837 kg.

Thermal-oxidative filter is for the water cleaning from the colloidal and suspended particles. This filter is a cylindrical vessel made of stainless steel (diameter of 328 mm; height of 2000 mm) fulfilled by sorbent (Fig.9). ***The unit of ion-exchange filters*** is composed by 4 similar filters with resin. Each filter is a cylindrical vessel made from stainless steel (diameter of 330 mm; height of 1700 mm); the resin is located in an internal storage-cell..

The ***SCC pipe-lines*** are made of the pipes of different diameters and lengths, which provide the water circulation between the heat-exchangers and the water cooling tower (at a distance of 80 m from the reactor building) by means of the SCC electric motors. Only a small part of these pipes is located in the PCC part of these pipes is located in the PCC pump-premise.

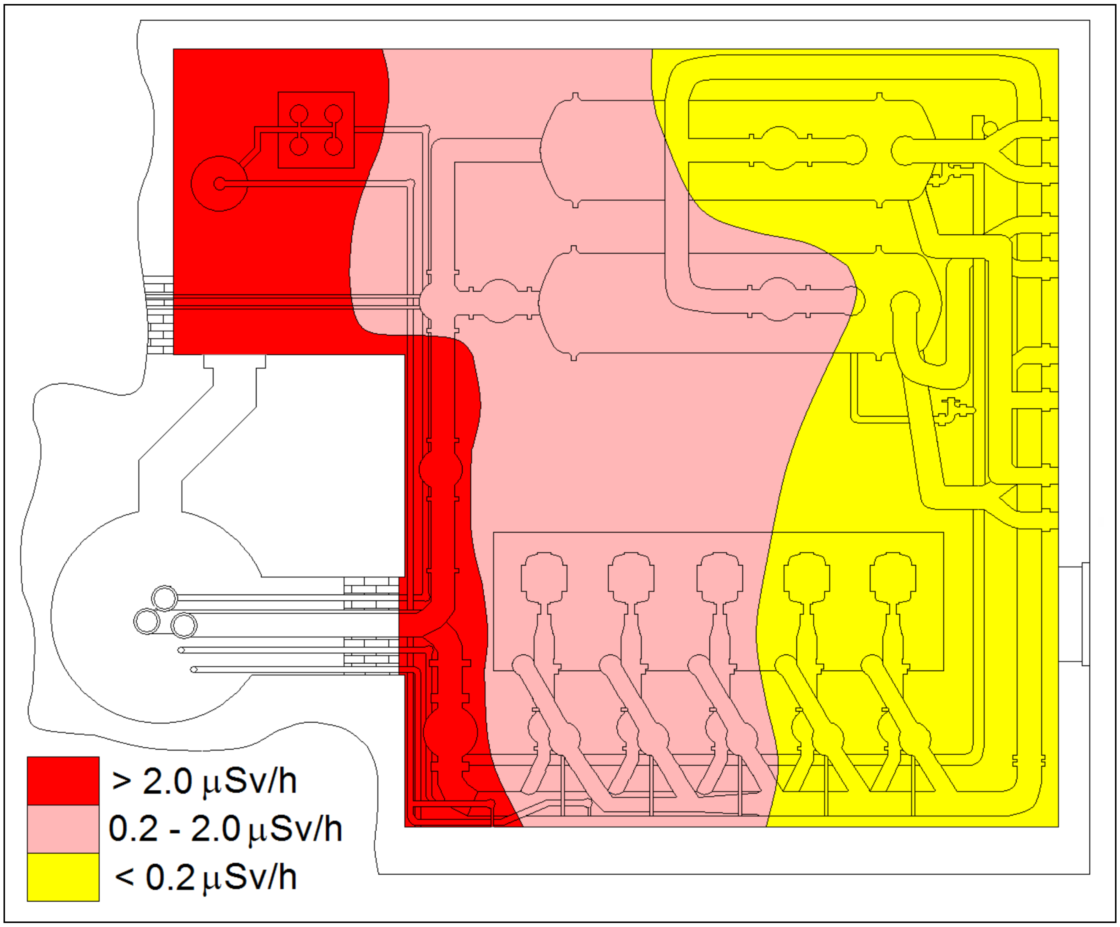


Figure 10. Radiation map of the PCC pump-premise.

2.3. Radiation conditions

The PPC pump-premise is the most radiologically hazardous area; however this area is unattended by personnel and continuous radiation monitoring is performed here by means of five fixed area detectors. The initial estimations of the radiation conditions at the working area for the work planning were performed by means of available information collected during normal reactor operation mode. For an actualization and clarification of the radiological information an additional and more detailed inspection of the radiation conditions was carried out [13]. This inspection included the direct dose rate measurements using portable devices, composition of the radiation field area map and determination of the surface contamination by means of wet smear sample analysis. These measurements were performed with all fuel elements removed from the core and the PCC completely drained.

The results of the radiological inspection revealed that the dose rate is predominantly due to activation of both the vessel and in-vessel components materials, while the contribution to the dose rate from the internal contamination was minor. The measured ratio of the cobalt and caesium activities lies in the range from 60:40 to 90:10 %. The alpha-spectrometry results on smear samples showed that uranium isotopes contamination is practically negligible (~10^{-4} Bq/cm^2).

In summary, these measurements yielded the following dose rates (in mSv/h):

- 5 to10 – close to the flange connections;
- 0.1 to 0.3 - at the niche periphery;
- 0.1 to 0.2 – in the niche passage;
- 0.3 to 0.5 – close to the valve gates;
- 0.01 to 0.03 – in the accessible free space of the pump-premise.

The outlined map of the radiation measurements made during characterization of the pump-premise is shown in Fig.10. This formed the necessary basis of information to give a description of the health physics conditions and a good overview of the parts that had been contaminated.

3. Schedule of the dismantling activities by stages

3.1. General considerations

The dismantling of the reactor is to be carried out in three main stages. The first stage includes the dismantling of the equipment around and inside the reactor and in the biological shielding. The second stage includes the dismantling of the PCC equipment. The demolishing of the biological shield is carried out at the third stage. Consequently, stage one should be completed first for the realization of stage two.

Dismantling of the PCC includes:
- removal of the heat-exchangers;
- dismantling of the primary circuit components;
- dismantling of the ion exchange and electrophoresis filters;

Dismantling is simply a matter of cutting and disconnecting all components requiring removal. The operations themselves are simple but very labor intensive. They generally require the use of the protective clothing. The dismantling of components in the pump-premise is a challenging task due to their heavy weight, large dimensions and narrow area. This task requires detailed planning in order to reduce the exposure for the dismantling staff involved to be as low as reasonable achievable.

The starting point for the dismantling operations in the pump-premise is assumed to be when the reactor vessel has been extracted and transferred to the storage place. It is planned that the demolishing of the brick wall (between the niche and the pump-premise) will have been performed already in stage one.

The preparatory works in the PCC pump-premise includes the following:
- removal of the operation media from the closed circuits;
- electrical disconnection;
- removal of the pump lubricants;
- removal of the combustible materials, which are not necessary for the dismantling works;
- opening of the hatches to the reactor hall;
- decontamination of external surfaces;
- additional survey for the actualization of radiation conditions;
- testing of the tools and equipment;
- installation of additional lighting, local ventilation and dust-depression means.

3.2. HE extraction

Being part of PCC, the heat-exchangers are contaminated inside. First, the heat exchanger detachable lids, which are bolted, will be removed and transferred without much difficulty. The internal pipes, on the other hand, will not be so easy to remove. The heat exchangers can also be removed as a single piece. This task can be solved by means of the technological hatches between the PCC pump-premise (in the basement) and the reactor hall. The starting point is the removal of the detachable lids on the hatch, which will provide an access of sufficient size.

The heat exchangers will then be dismantled from their base support in order to be lifted intact by a crane. Torch cutting methods (oxy/acetylene) may be used, if required, for dismantling. Mechanical saws or hand tools may also be used. Before removal, all the openings will be sealed. The last operation is the lifting of the heat exchangers by means of a bridge crane to the reactor hall for subsequent transportation to the disposal site (Fig.11).

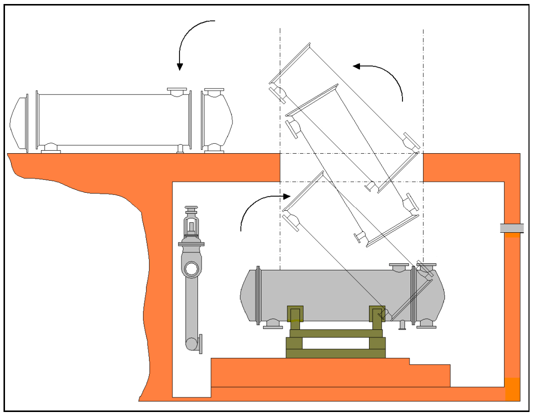


Figure 11. Scheme of the HE extraction.

It was decided that the pipes from the heat exchangers, which all have surface contamination, will not be cleaned. This decision was made on the basis of trials with the selected pipe sections, where some cleaning was probed. This turned out to be an inefficient and in-effective method in terms of resources. All the pipe segments could fit into containers.

3.3. Pipes and gates dismantling

The PCC components that will be dismantled can be categorized as follows: pipes, piping hangers, valves (check and isolation valves), pumps, supports, instrument gauges, flanges, screws and gaskets. The first actions should be taken before the cutting on disassembling the mentioned equipment wherever possible so as to reduce the cutting points. Specifically, the isolation and check valves, the pumps and the supports will be unscrewed and disassembled from the system without cutting. Any liquids or sludge present in the piping should be drained and tested to determine the final disposition method. Liquids or sludge should be emptied into drums, capped and packaged for removal. The PCC pipes, after disassembling will be cut into pieces to the dimensions required for effective decontamination and/or characterization clearance. The pipes will be cut to pieces of 2-3 m length, since this size will enable a relatively easy transfer of the segments. The piping will be cut using circular mechanical saws. Sheets will be put on the ground and at the wall around the cutting position when this is considered necessary for contamination control. During cutting, the operator will act according to a "cutting map" showing where to cut and how to dismantle the pipe pieces.

Cutting procedure planning will have to consider:

- shape and geometrical dimensions of the component;
- weight, retaining structures, transport equipment;
- material composition;
- removable surface contamination;
- non-removable surface contamination;
- radiation field in the working area;
- dimensions of cutting volume.

Being part of the PCC, the pipe system is contaminated inside. Items that could not be cleared are defined as radioactive waste and disposed of. All items that could be cleared on the site are disposed of as regular scrap. Since pipe dimensions will be small and the volume is insignificant, it is decided to dispose of the pipe system as radioactive waste.

3.4. Filters removal

The WCS (the thermal-oxidative and ion-exchange filters) are connected to the PCC. These objects will be cut off in order to be lifted by crane. The filters are shielded by lead blocks, which will be removed initially. Torch cutting methods (oxy/ acetylene) will be used to disassemble the columns from their support base. Mechanical saws, air powered saws, or hand tools may also be used.

3.5. Segmentation

The cutting area is arranged in the reactor hall (Fig.12). Size reduction will be carried out in situ; then the segmented parts will be exported to the interim storage. A supplementary extract ventilation system will be used to limit the spread of contamination. The PCC components that are difficult to be further segmented, such as the heat exchangers, will be removed intact and temporarily stored in an appropriate place in order to be appropriately managed in the future.

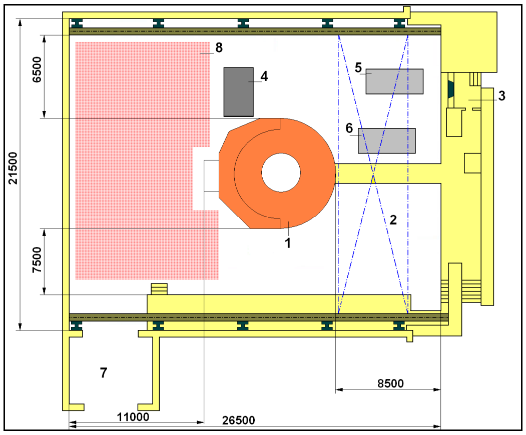


Figure 12. Reactor hall: 1 – biological shielding; 2 - bridge crane; 3 – crane cabin; 4 – at-reactor cooling pond (SF storage); 5,6 - technological hatches to the PCC pump-premise; 7 – tambour to BV-2; 8 – cutting area.

4. Safety provision at the dismantling

4.1. Exposure dose estimation

It is clear from the PCC layout that the dismantling works need be performed in a confined space where protective shielding and remote working can not be provided. Therefore, proper work planning and implementation of effective radiation protection is a most important feature of this dismantling project. From the point of view of radiological protection, the dismantling of any type of equipment presents a series of features that range from the changing nature of the radiological and conventional risks to the performance of work on equipment that have never before been touched.

Table 2. PCC dismantling tasks

TASK	***Work time (hours)***	***Number of exposed individuals***	***Work-force, man× hours***	***Estimated external dose rate (μSv/hr)***	***Individual dose per individual a) (μSv)***	***Collective dose (μSv)***
HE extraction						
Removal of pipes at the upper part of both HE (segments 30-33; 29-36; 28-29)	12	4	48	7÷10	84÷120	336÷480
Unpiping at the lower part of both HE	6	4	24	10÷12	60÷72	240÷288
Detachment of the detachable lids and removal to the reactor hall	10	4	40	5÷8	50÷80	200÷320
Separation of HE from the supporting piers	4	3	12	5÷6	20÷24	60÷72
Lifting of HE to the reactor hall	4	3	12	0.5÷1.0	2÷4	6÷12
Dismantling of the supporting piers	10	4	40	3÷5	30÷50	120÷200
Sub-total:	***46***		***176***		***246÷305***	***962÷1372***
Pipes and gates dismantling						
Dismantling of the input pipes and valve gates	16	4	64	5÷8	80÷128	320÷512
Dismantling of the output pipes and valve gates	25	4	100	7÷10	175÷250	875÷1000
Dismantling of the drain-pipes and valve gates	10	3	30	3÷5	30÷50	90÷150
Dismantling of the pipe supports and mountings	8	3	24	3÷4	24÷32	72÷96
Dismantling of the pumping units (5 pieces)	15	4	60	3÷5	45÷75	180÷300
Dismantling of the deaeration circuit	10	3	30	1÷3	10÷30	30÷90
Dismantling of the auxiliary pipes	10	3	30	0.5÷2.0	5÷20	15÷60
Successive lifting of segmented parts to the reactor hall	16	4	64	0.2÷0.6	3.2÷9.6	12.8÷38.4
Sub-total:	***110***		***402***		***372÷595***	***1595÷2246***
Filters removal						
Dismantling of the filter drain-pipes	8	3	24	4÷6	32÷48	96÷144
Removal of the thermal-oxidative filter from the concrete frame	3	4	12	6÷8	18÷24	72÷96
Removal of the ion-exchange filters (4 pieces)	8	3	24	4÷6	32÷48	96÷144
Removal of the filter frames and shielding	4	3	12	0.5÷0.8	2÷3,2	6÷9.6
Successive lifting of segmented parts to the reactor hall	16	4	64	0.2÷0.6	3.2÷9.6	12.8÷38.4
Sub-total:	***39***		***136***		***87÷133***	***283÷432***
TOTAL:	***195***		***714***		***705÷1033***	***2840÷4050***

a) on assumption that one person took part in all dismantling works

The radiation protection of personnel during dismantling is based on the same radiation protection principles as applied during reactor operation with the objective of ensuring proper implementation of the ALARA principle [14]. These principles are: prior determination of the nature and magnitude of radiological risk; the classification of workplaces and workers depending on the risks; the implementation of control measures; the monitoring of zones and working conditions, including, if necessary, individual monitoring. Setup of the radiation protection system at the dismantling will be a logical continuation of the currently existing system. This system will be rearranged and adopted for the needs resulting from the nature and content of decommissioning works.

Ukrainian legislation limits occupational exposure of staff to 20 mSv/year. Single exposure up to 50 mSv/year is allowed provided the average annual effective dose over five years does not exceed 20 mSv/year [15, 16]. The control levels of the reactor staff exposure were established in accordance with the legislative requirements, features of technologies and experience of the operational works at the reactor as well as on the basis of achieved level of radiation safety. These values are established at a level below the relevant dose constraint for the execution of operational radiation control in the premises, namely, the value of 14 mSv/year is accepted. At the same time the exposure up to 4 mSv/shift is permissible if necessary.

Analyses of possible staff radiation exposure during dismantling operations were performed using the scheme:

- work breakdown into individual activities;
- estimation of required working times and staff;
- estimation of local radiation fields for each activity;
- collective dose calculation.

The doses incurred during dismantling have been estimated by considering the duration of each activity to be undertaken, the number of times it is performed and the dose rate. The estimated doses from each dismantling operations are summarized in Table 2.

As can be see from Table 2, the collective dose for the dismantling works has been estimated as equal to 4.05 man-mSv. This is a conservative estimate, i.e. the work planning is performed taking into consideration the worst estimates regarding the maximum dose rates, the maximum working time and the minimum distance from the source. In practice, the staff achieved completion of the works in less time and at larger distances than that estimated, thereby minimizing occupational exposure in accordance with the ALARA principle and reducing the collective dose by more than factor of two. The total dose to a hypothetical individual would be 1 mSv on assumption that this person took part in all dismantling works. The results of the estimations showed that the radiological criterion of 14 mSv/year in effective dose is met during cutting procedure.

4.2. Emergency cases

Any dismantling activity covers a lot of different operations related to the cutting and lifting of segmented parts of equipment. Dropped load accidents can occur during various stages. Consequences of dropped equipment, tools or segments can vary significantly due to different size, weight, drop height and contamination involved.

The following main hazards with potentially significant consequences associated with the dismantling operations were identified:

- drop of heavy loads; this is one of the most common hazards creating risk of structure damage, airborne release, workers injury or fatality. Falling heavy items can damage building structures and live services;
- failure of lifting mechanisms when the load is on the crane hook.

The first one can be caused, for example, by the rope failure or malfunction of the brake gear. The damage repair can be performed by the shift on duty (4 persons) taking about 1 hour and additional personnel are not necessary. The second one can be caused by power disconnection or the breakage of an electric motor. The availability of the electrician on duty is foreseen for such a case; approximately the same time will be needed for the fault clearing.

5. Conclusions

The design for dismantling of the primary cooling circuit of the WWR-M reactor has been developed. The dismantling of components in the pump-premise is a challenging task due to their heavy weight, large dimensions and tight area. This task requires detailed planning in order to reduce the exposure for the staff involved. The proposed design is based on an approach which foresees the dismantling and removal of the separate bulky elements as whole pieces, without preliminary segmentation. Proper work planning and implementation is considered central to achieving this goal. Radiation protection performance is based on the application of appropriate measures in order to prevent unnecessary exposure of staff and this allows reduction of the collective dose.

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