ENGINEERING SERVICES ASSOCIATED WITH DISMANTLING OF IGNALINA NUCLEAR POWER PLANT REACTOR CORES

ANNEX F1

Description of the Object to be dismantled

CONTENTS

1. INTRODUCTION

This Annex to the Terms of Reference provides information of a descriptive character on the object to be dismantled - reactor zone R3 and its interfaces with other decommissioning projects. SE Ignalina NPP (the Client) will provide further required information at its disposal to the Consultant during the contract implementation according to the requests made as described in the contract.

The data and technical characteristics of the reactor structures are presented, principally for the reactor facility of Unit 1. For comparison of the reactor facilities of Unit 1 and Unit 2, it is necessary to consider the following:

- for both Units the structures of the reactors and main circulation circuits (which are the basic sources of corrosion products) are the same and are manufactured of very similar materials;
- the effective operating time and power generation of the reactor of Unit 2 exceeded that of Unit 1 by 23 %. Also, the quantity of leaking fuel rods at Unit 2 was higher, which has probably led to higher contamination of Unit 2.

2. REACTOR BUILDING AND IGNALINA NPP SITE

The reactor building (hereinafter – Block A) has a rectangular cross-section of 90x84 m, with a protruding part of 24x18 m. The top of the building is at +62.6 m. The reference mark ±0.00 m is on the floor of main circulation pumps (MCP) premises.

The structures of the building are made from reinforced concrete (heavy grade γ=2.4 t/m^3 of density M300 on durability). Monolithic walls and floors of the premises of the “hot” cell are manufactured from super heavy concrete of dense structure γ=4.2 t/m^3 of grade M300 on durability.

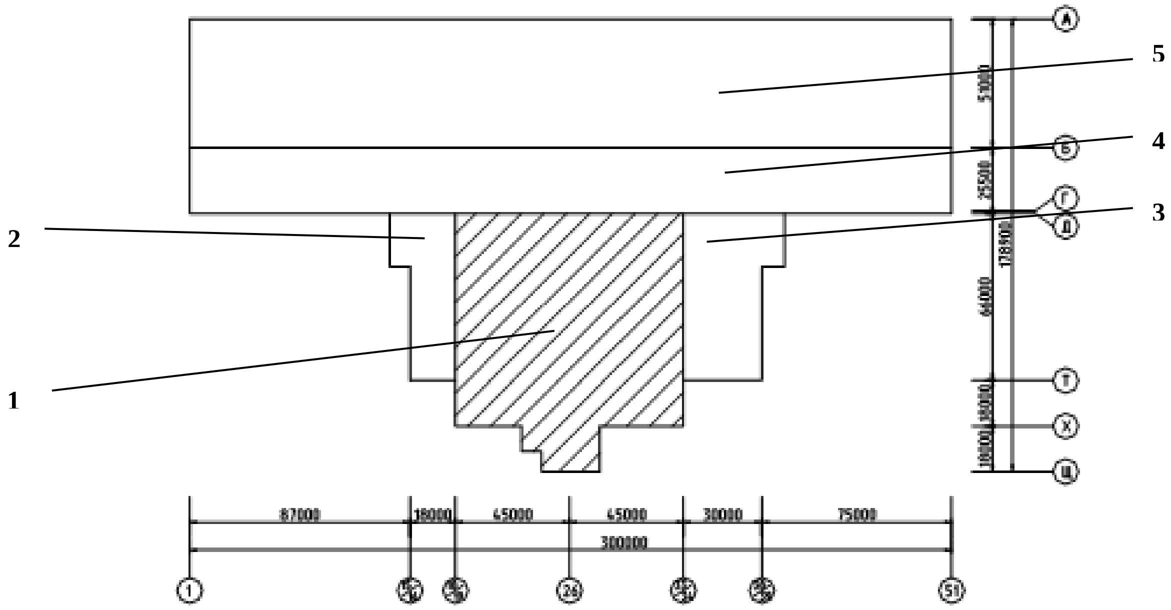
Floors with a thickness of more than 1000 mm and a span of more than 7 m, as well as with a great number of openings and embedded details are manufactured from monolithic reinforced concrete. Floors with a thickness up to 1000 mm and a span up to 7 m are manufactured as a precast and cast-in-situ variant with ridge modular floorings and monolithic reinforced concrete.

Reinforced concrete walls and floors of leak-tight confinement premises, as well as storage pools for the spent nuclear fuel assemblies are lined on the inside with carbon or stainless steel. Concrete surfaces of the premises with high operational temperature are protected by special thermal insulation with air blown layers.

The building of Block A together with buildings of Blocks B, V, D and G is a part of the main building of the power unit (Building 101).

The arrangement of the premises, adhered to geodetic marks, in the building of Block A1 (Block A2) is specified in the document “Layout Plans of Building 101/1, Block A-1”, code PTOed-0921-78 [1] (“Layout Plans of Building 101/2, Block A-2”, code PTOed-0921-651 [2]).

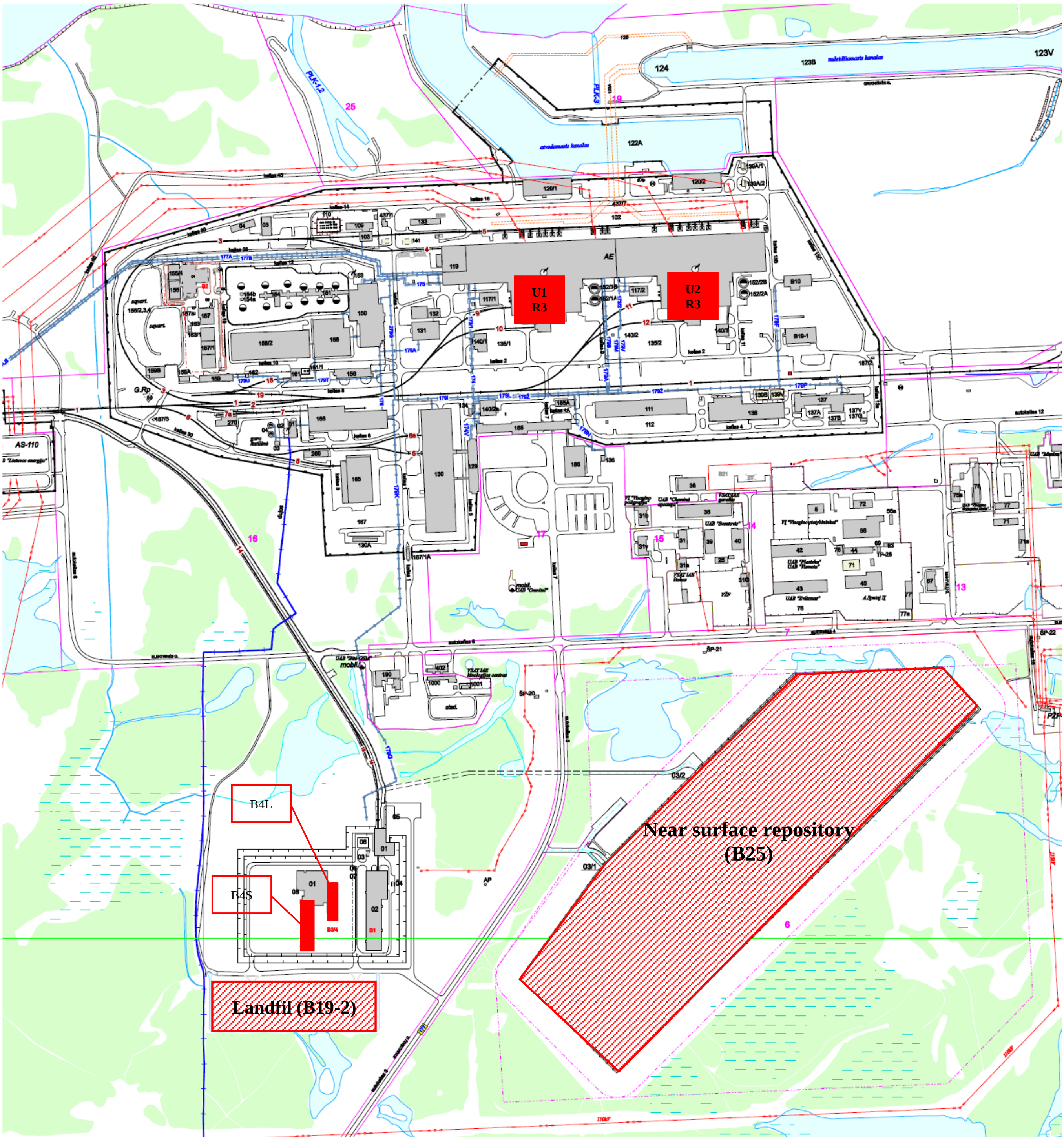
Figure 1 Configuration of the buildings of the main building of the power unit



1 – unit A; **2** – unit V; **3** – unit B; **4** – unit D; **5** – unit G

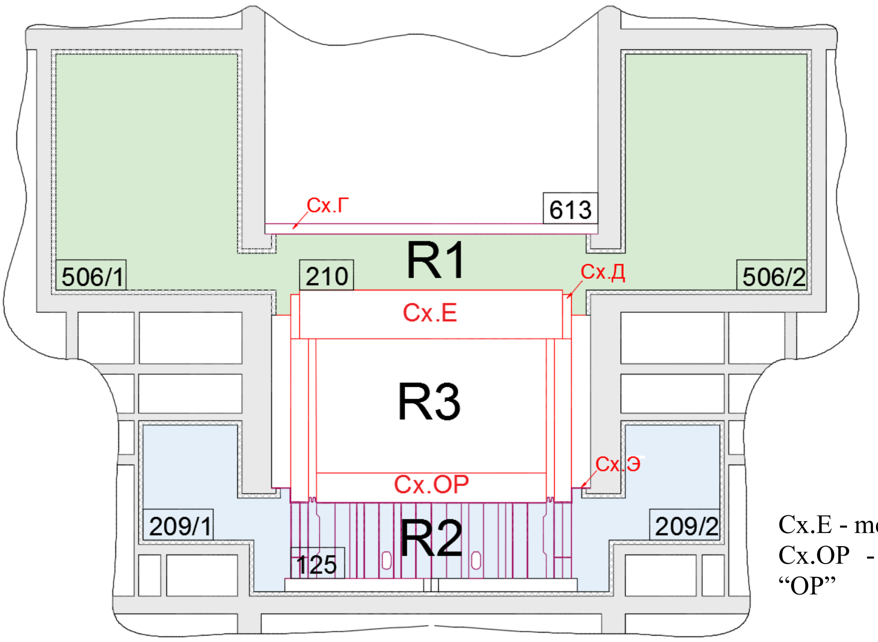
The arrangement of main buildings on the INPP site is presented in Figure 2.

Figure 2 Location of reactor buildings and associated waste management facilities



3. DESCRIPTION OF STRUCTURES IN THE ZONE R3

When planning the dismantling of the reactors, the characteristics of their structures were taken into consideration and three zones were defined: R1, R2 and R3. The scheme of the reactor with depiction of the dismantling zones is presented in Figure 3.



Cx.E - metal structure “E”
Cx.OP - metal structure “OP”

Figure 3 Reactor dismantling zones

Zone R1 includes reactor components (steam-water pipelines) located in the reactor vault (room 210) and partially in rooms 506/1, 2, which are located above level +20.70 (above scheme (metal structure) “E”) and the reactor fuel channels and control and protection system channels.

Zone R2 includes reactor components (lower water communication lines) located in the reactor vault (room 125) and partially in rooms 209/1,2, which are located above level +0.9 m up to +5.95 m (below scheme (metal structure) “OR”).

Zone R3 includes metal structures of the reactor located only in the reactor vault (room 210) from level +5.95 m up to level +20.70, the graphite stack and filling materials. The dismantling of this zone will be implemented within the scope of project 2103 (as defined in the Client’s project structure), after dismantling of zones R1 and R2. The arrangement of the main components of the reactor included in Zone R3 is presented in Figure 4.

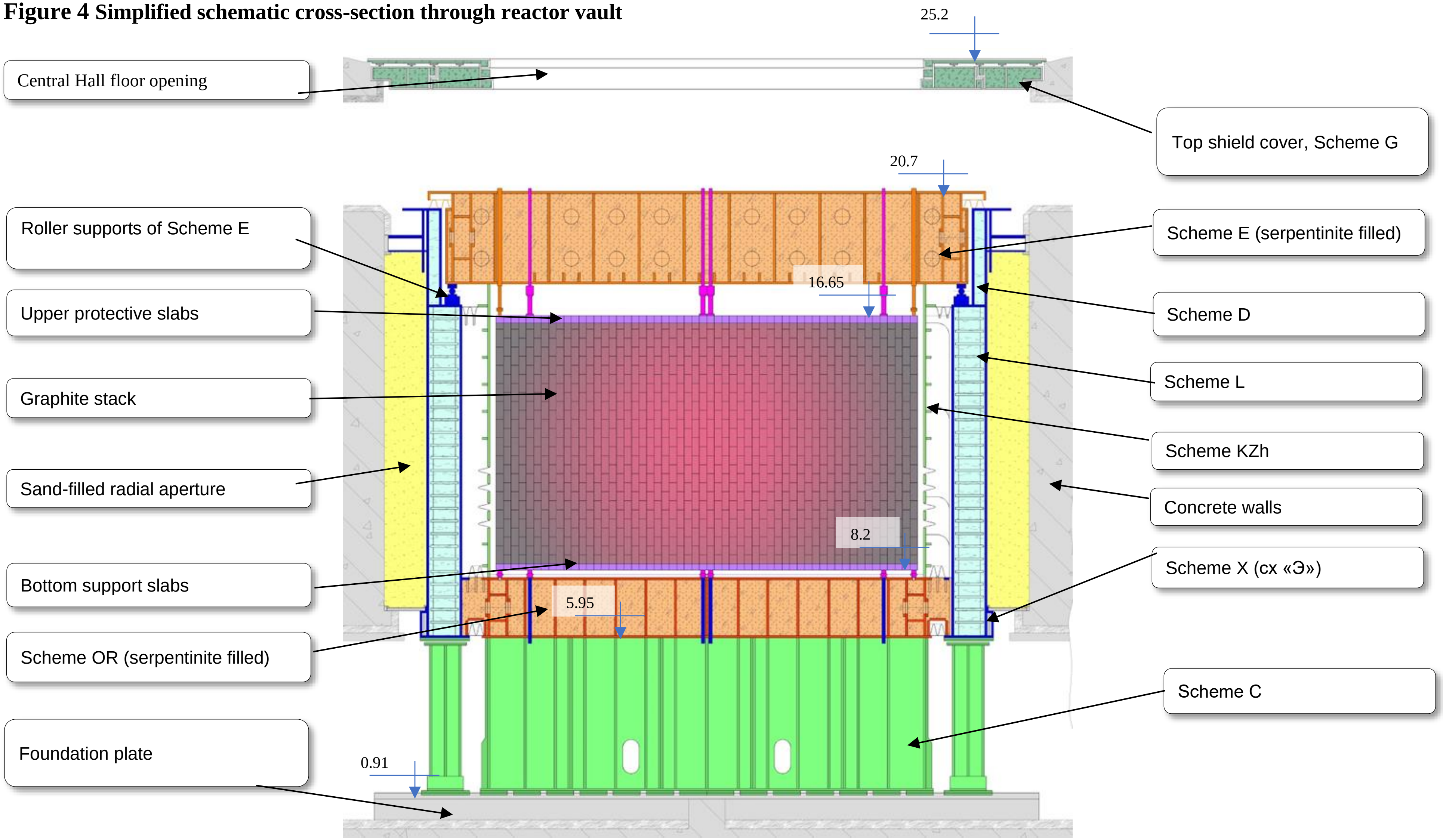
Certain irradiated components removed during the dismantling of Zone R1/R2 are included into the scope of Zone R3 project in terms of waste processing. These comprise:

- 306 Reflector Cooling Channels (153 per Unit) from stainless steel,
- 30 temperature channels steel components (14 from Unit 1 + 16 from Unit 2),
- 2 gas-sampling channels with steel assemblies (1 per Unit).

All these components will be placed for temporary decay underwater in the SPH awaiting technology for their fragmentation, processing and packaging. Because INPP has no established technology for removing the graphite rings/sleeves from these components, they will remain attached to the channels.

Also, the upper reactor cavity vacuum pipeline (which is a part of Zone R1) will be left in place in order to maintain under pressure in reactor cavity.

Figure 4 Simplified schematic cross-section through reactor vault



3.1. Metal structure (scheme) "E"

The metal structure of scheme "E" is load bearing reactor component, providing leak tightness of the internal reactor space and biological shielding.

Overall dimensions and weight of the scheme "E":

External diameter	17 650 mm;
Thickness	3 000 mm;
Weight[1] of the metal structure	~ 440 tons;
Weight of the filling of the compartments, not less than	~ 1005 tons.

The design of scheme "E" is a cylindrical structure, assembled from large-sized parts E1 - E6. Parts E1 - E6 (assembled in factory), are welded steel boxes, strengthened from inside by vertical stiffness plates.

The top and bottom lattices of scheme "E" were manufactured from steel 10XH1M (10XH1M-Ш) with thickness of 40 mm and connected with the shell by welded seams, and between themselves by vertical stiffness plates(the diaphragms) welded to the top and bottom lattices. Stiffness plates are manufactured from steel 10XH1M with thickness of 30 mm. Stiffness plates form compartments which are filled with a serpentinite mix of crushed stones and pebble stones..

In the top and bottom lattices there are openings through which technological communication pipelines of the reactor pass - mainly channels, as well as pipes of supply and removal of a gas mix and auxiliary pipes. In the lattices of scheme "E", the following components are welded:

- top guide tubes of the fuel channels, control and protection system channels and reflector cooling channels (originally marked as РБМ-К15. сб.25; РБМ-К5. сб.21 and РБМ-К5. сб.23 respectively);
- guide tubes of the temperature channels (РБМ-К5. сб.27, сб.09);
- guide tubes of the out-core ionization chambers (РБМ-К5. сб.155, сб.157);
- control guide tubes (РБМ-К5. сб.46);
- guide tube of a television camera (РБМ-К5. сб.45);
- gas pipes (РБМ-К5. сб.171): pipes of removal of steam gas mixture from the reactor cavity (pipelines of the system for protecting the reactor cavity from increasing pressure), pipe sleeves of supply and removal of nitrogen from cavities of the scheme.

The lateral surface of the welded metal structure, limited by cylindrical shell, consisting from lateral surfaces of parts E1-E6 and steel sheets connecting the parts, external surfaces of the shell and the top lattice, as well as the surface of compensators are metallized by aluminum and were coated with paint OC51-03.

[1] Hereinafter in the text the design weight is indicated, but since the as-built documentation is not available real parameters may slightly differ from those of the design.

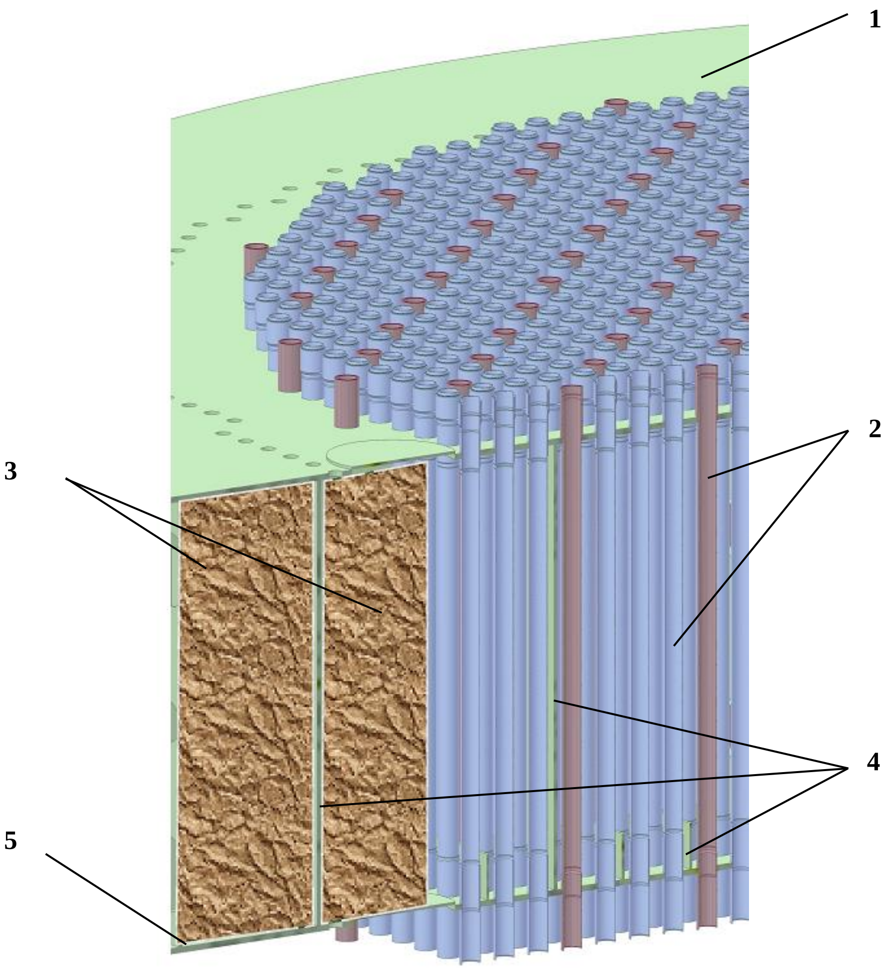


Figure 5 Sketch of the metal structure “E” (fragment)

1 - The top lattice
2 - Pipe assemblies of guide tubes of technological channels and guide tubes of channels of the control and protection system
3 - Serpentinite filling of the compartments (filling of the peripheral compartments is shown)
4 - Stiffness plates
5 - The bottom lattice

The metal structure of scheme “E” is located on 16 roller supports located on the top sheet of the metal structure of scheme “L”.

Drawings of scheme “E” are presented in the document “RBM-K15. Detailed Design. Working drawings of metal structures of reactor RBM-K15. Part 4: Mounting scheme “E” (with amendments)”, code ArchPD-1859-2557v1_4 [3].

In 2016, a partial examination of rigidity [4] was performed in order to check how cutting of steel structures could be performed to create access to internal components of the reactor.

For cutting of internal components (top guide tubes of the fuel channels (РБМ-К15. сб.25) and control and protection system channels (РБМ-К5. сб.21)), equipment for cutting of guide tubes from inside by means of remote mechanical cutting [5] was developed in 2017.

Results of initial radiological characterization are provided in reports [6, 7, 8, 9]. A preliminary distribution of waste by classes is presented in Annex 2.

In 2018, the sampling of the filling from compartments of scheme “E” of the reactor of Unit 2 was conducted; the results are presented in the report [10]. It is necessary to note, that the physical sizes (fractions) of filling material in scheme “E” of Units 1 and 2 differ, comparative technical characteristics are reflected in the report [11].

3.2. Metal structure (scheme) “D”

The metal structure of scheme “D” is an element of the lateral biological and thermal shielding. Structurally it is a ring tank divided into 16 tight compartments filled with water.

The metal structure of scheme “D” is placed on the wider metal structures of scheme “L”, also filled with water (note - circulation of water is not carried out since 2010). Water volumes of lateral metal structures of scheme “D” and “L” are connected. Cooling water is supplied to the metal structure of scheme “L” and removed from the top part of metal structures of scheme “D”.

The external shell of scheme “D” is surrounded by a two-layer steel screen for protection from γ - radiation. From the external side of the shell there are four hatches for access to compartments of scheme “D” (used during construction only).

Into the top sheet of the metal structures of scheme “D” the following are welded:

- pipelines for water supply and removal from compartments of the scheme (РБМ-К7. сб.175-2);
- guide tubes of thermocouples (РБМ-К5. сб.172);
- control guide tube (РБМ-К5. сб.63).

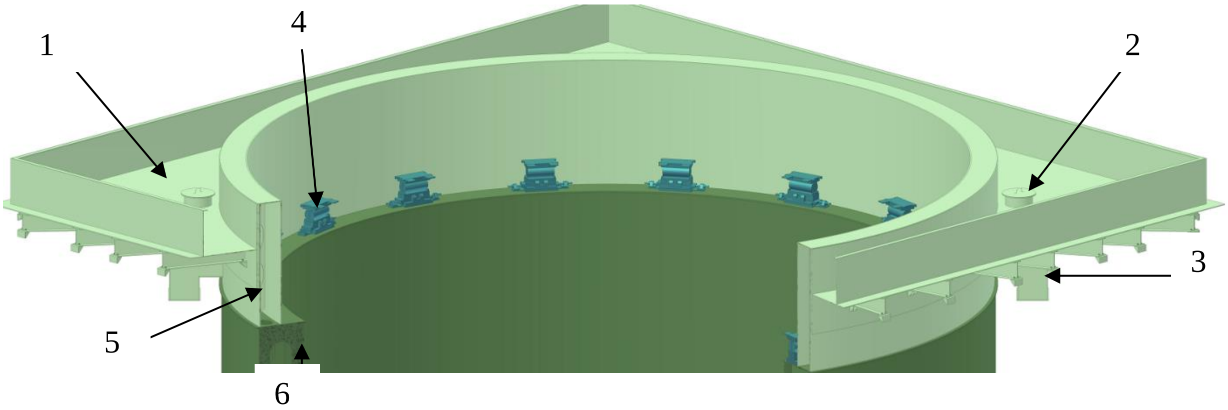
The metal structures of scheme “D” also include the cover of the mounting space of the reactor vault - a sheet flooring of metal structures of scheme “D”, manufactured from plates of metal (parts D1-D7) with 20 mm thickness of steel of grade 10ХН1М.

The mounting space is filled with a mixture of sand and gravel. Under the floor of the mounting space, there are four tanks for reception of drainage and emergency waters from the flooring of metal structures of scheme “D” and “G” [12], drainage pipelines RBM-K5. сб.176 from the plate flooring of scheme “G” are led into the tanks.

Overall dimensions for shells and weight of the scheme “D”:

External diameter	19 000 mm;
Internal diameter	17 800 mm;
Height	3 170 mm;
Total weight of the metal structure	~ 225 t.
Weight of the metal structure without the floors	~ 153 t.

Figure 6 Sketch of the metal structure of scheme “D” together with mounting space cover



1- Sheet flooring of metal structures of the scheme “D”;
2- Hatch into the scheme “D”;
3- "enclosure" into the scheme “D”;
4- Roller supports, РБМ-К5 Сб. 08;
5- Metal structure of scheme “D”;
6- Metal structure of scheme “L”;

Drawings of the metal structure of scheme “D” are presented in the document “Working drawings of metal structures of reactor RBM-K15. Part 7: Mounting scheme “D” (with amendments)”, code ArchPD-1859-2557 [13].

Results of initial radiological characterization of the Unit 1 reactor mounting space cover are provided in reports [6, 8, 14].

3.3. Metal structure (scheme) “L”

The metal structure of scheme “L” is an element of the lateral biological and thermal shielding and load bearing structure for schemes “E” and “D”.

The metal structure of scheme “L” is a ring tank consisting of external and internal shells and limited from the end faces by horizontal sheets. Water tight partitions divide scheme “L” tank into 16 separate sections. On the top sheet of scheme “L”, there are places for 16 roller supports (РБМ-К5. сб.08) for scheme “E”. On the top sheet, there are openings by means of which water volumes of scheme “L” and “D” are connected. Ionization chamber baskets (РБМ-К5. сб.157-2 and сб.155-2) are welded into the upper sheet.

The following internal components are situated in the tank:

- 16 water supply pipes (РБМ-К5. сб.171);
- 24 drainage pipes from out-core ionization chambers baskets (сб.171);
- 16 guide tubes of thermocouples (РБМ-К5. сб.172).

The metal structure of scheme “L” is manufactured from steel of grade 10ХН1М and 10ХН1М-Ш. External surfaces of scheme “L” are metallized by aluminum and coated with paint ОС51-03.

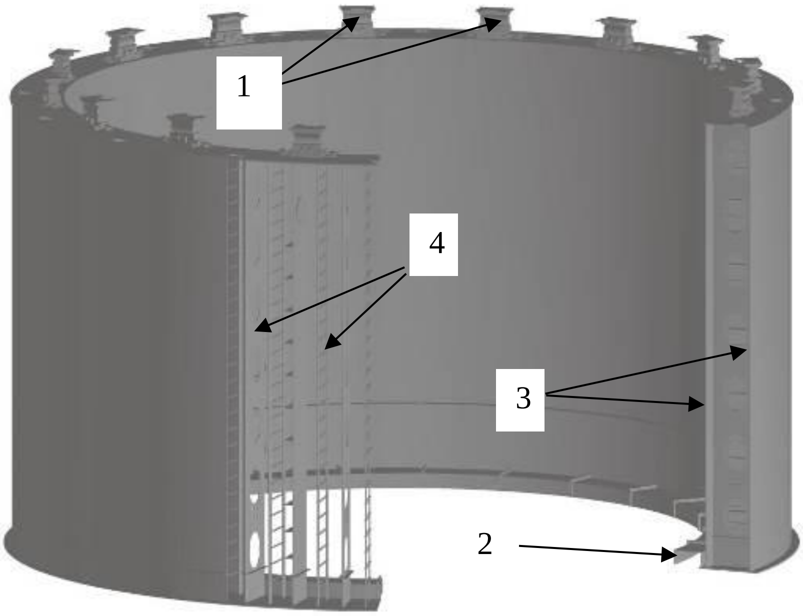
Overall dimensions and weight of the scheme “L”:

External diameter	19 000 mm;
Internal diameter	16 600 mm;
Height	11 050 mm;
Weight of the metal structure	~ 575 t.

Scheme “L” lies on the stands of metal structure of scheme “C”.

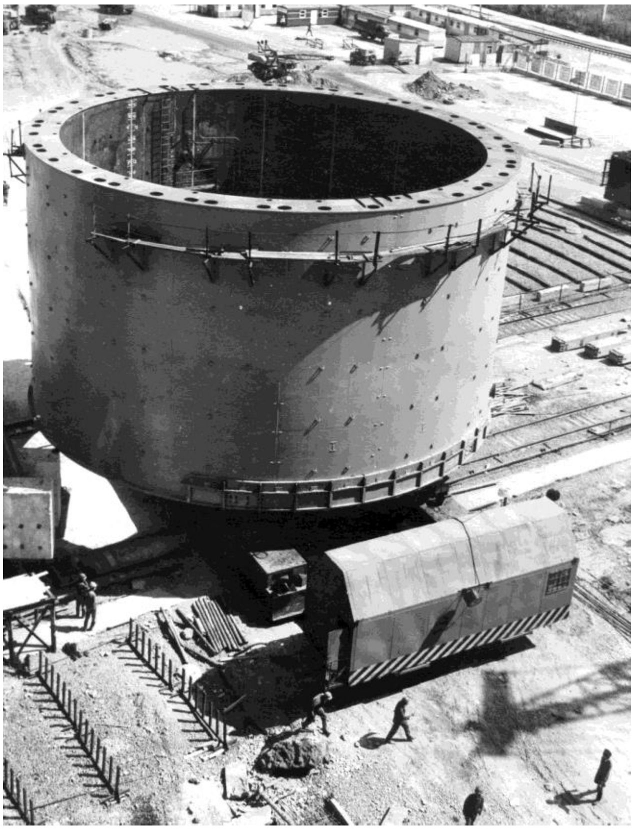
Drawings of the metal structure of scheme “L” are presented in “Working drawings of metal structures of reactor RBM-K15. Part 6: Mounting scheme “L” (with amendments)”, code ArchPD-1859-2557v1_6 [15].

Figure 7 Sketch of the metal structure "L"



1. Roller supports РБМ-К5 Сб.08
2. Box of the bottom compensator of metal structures of the scheme "OR"
3. Internal and external shell of metal structures of the scheme "L"
4. Internal elements of rigidity of metal structures of the scheme "L" (watertight and perforated partitions)

Figure 8 The photo of the metal structure "L" during its installation



Samples of materials of schemes “E”, “KZh”, “L” were retrieved from Unit 1 in year 2012. Results of radiological investigation are given in the report [6].

3.4. Metal structure (scheme) “KZh”

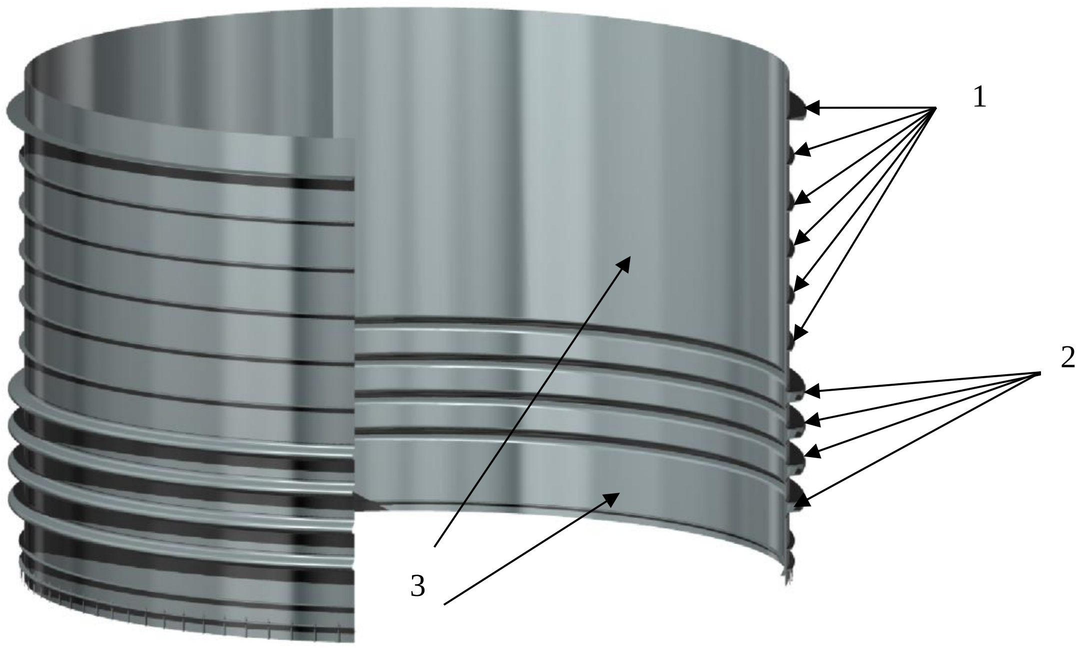
Scheme “KZh” is the shell of the reactor. The metal structure of scheme “KZh” together with the bottom lattice of metal structures of scheme “E” and the top lattice of metal structures of scheme “OR” form a gas-tight cavity around the graphite stack – the reactor cavity in which, during the operation, a nitrogen-helium gas mixture circulated.

The structure of scheme “KZh” is manufactured from two cylindrical shells, connected by 4 compensators for thermal expansion forming a casing of 14.5 m in diameter (manufactured from the steel 10ХН1М and 10ХН1М-Ш sheets with thickness of 16 mm with four ring compensators with thickness of 8 mm. On the external surface of the casing the stiffness edges are welded. For reduction of pressure in the compensators during operation of the reactor facility, the metal structure of scheme “KZh” is welded to the bottom lattice of the metal structure of scheme “E” and the top lattice of metal structure of scheme “OR” with pre-tension.

Overall dimensions of scheme (D x H) 14 520 x 9 750 mm.

Weight of metal structures ~ 77 t.

Figure 9 Sketch of the metal structure “KZh”



1 - edges of rigidity; 2 - ring compensators; 3 – shell

Drawings of the metal structure of scheme “KZh” are presented in “Working drawings of metal structures of reactor RBM-K15. Part 3: Mounting scheme “KZh” (with amendments)”, code ArchPD-1859-2557v1_3 [16].

In 2013, samples of the steel were taken (from the guide tube (сб.45) of the television camera) at Unit 1, results of radiological characterization are presented in the report [6]. The same sampling at Unit 2 was carried out in year 2018.

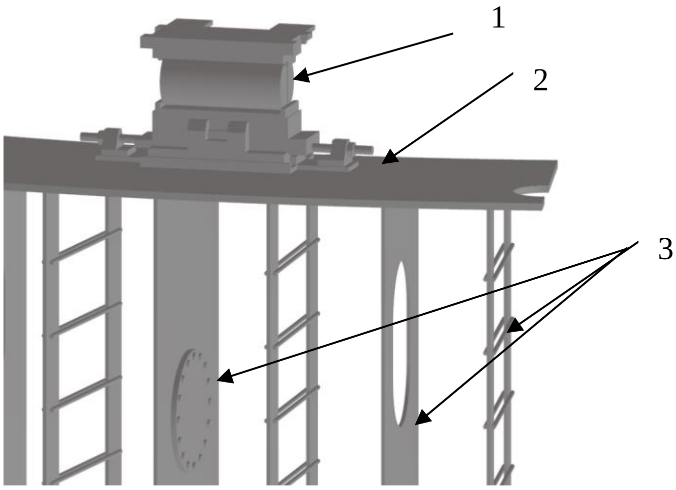
In the space between the metal structures of schemes “KZh” and “L”, the gas and drainage pipes of the reactor are situated, which pass through the metal structures of schemes “E” and “OR”. The description of the gas and drainage pipes is presented in the drawing “RBMK. Detailed design

602830. РБМ-К5. Сб.171 (682.486) Duplicate No. 1. Duplicate inventory No. 556. Distribution of the gas and drainage pipes of the reactor. Assembly drawing. List of specifications. Assembly units: РБМ-К5. Сб.171-... (682.486...). Details: РБМ-К5.171-... (682.486...)", code ArchPD-1859-24175v1 [17].

3.5. Roller supports

16 roller supports located on the top sheet of the metal structure of scheme "L", serve as a support structure for the metal structures of scheme "E". The description of roller supports is presented in drawings "RBM-K5. Сб. 08. Roller supports. Assembly drawing", code ArchPD-1859-20008v1 [18].

Figure 10 Sketch of roller supports



1 - Roller support РБМ-К5. Сб.08; 2 - Top sheet of metal structure of scheme "L"; 3 - Internal elements of stiffness of metal structure of scheme "L"

3.6. Reactor Space Elements

The metal structure of scheme "KZh" together with the bottom lattice of the metal structures of scheme "E" and the top lattice of metal structures of scheme "OR" form a gas-tight reactor cavity where the graphite stack (together with supporting elements) is situated.

3.6.1. Graphite stack

The graphite stack of the reactor consists of 2488 columns with axial openings.. The cross-section of each graphite block is 250x250 mm; they are 600 mm in height but the last blocks of columns are shortened (200, 300, 500 mm) so the joints between blocks of adjacent columns do not coincide. The blocks were made from graphite ГР-280 according to ТУ 48-20-83-76 with a density of 1.64-1.71 g/cm^3. The total equivalent diameter of the stack is 13.8 m (diameter of the core is 11.8 m, thickness of the lateral reflector is 1 m). The height of the stack is 8 m (height of the core is 7 m, thickness of the top and bottom reflectors is 0.5 m each). The weight of the stack (calculated) is approx. 1 759 tons.

Figure 11 Parts of the graphite stack of the reactor

The three outermost rows of graphite columns form the lateral reflector. In the openings of peripheral columns (156 pieces) steel bars (external pipes of the reflector cooling channels) are installed, fixing the graphite stack in the radial direction (internal pipes of the reflector cooling channels will be removed in the frame of the dismantling project for zones R1/R2, but external pipes should be dismantled within the project for zone R3). In the remaining openings of the columns of the reflector, graphite rods assembled from separate cylindrical parts with heights of 600, 500 and 280 mm were placed.

The number of graphite columns where fuel channels, reflector cooling channels and control and protection system channels are installed is 2 052 pieces. The number of columns with graphite rods - 436 pieces.

Each graphite column is installed on the support, which stands on the support sleeve attached to the upper lattice of bottom structure scheme „OR". Also, on support sleeves a steel diaphragm with thickness of 5 mm is fastened.

For monitoring of the state of the graphite stack, 17 special channels were used (16 temperature and 1 gas channel).

All channel tubes (fuel channels, reflector cooling channels and control and protection system channels) will be removed in the frame of the dismantling project for zones R1/R2.

The drawings of the graphite stack РБМ-К5. Сб.05 are presented in the document "RBMK. Detailed Design. РБМ-К15. Сб.05. Stack. Assembly drawing. The List of reference documents. The complete set of spare parts", code ArchPD-1859-2559v1 [22].

In 2012-2013, radiological investigations of the graphite stack of the reactor of Unit 1 were carried out. Sampling (test cores) from graphite blocks of 16 channels (fuel channels and control and protection system channels) were taken, together with reference graphite plugs from temperature channels. The results are provided in reports [19, 20, 21].

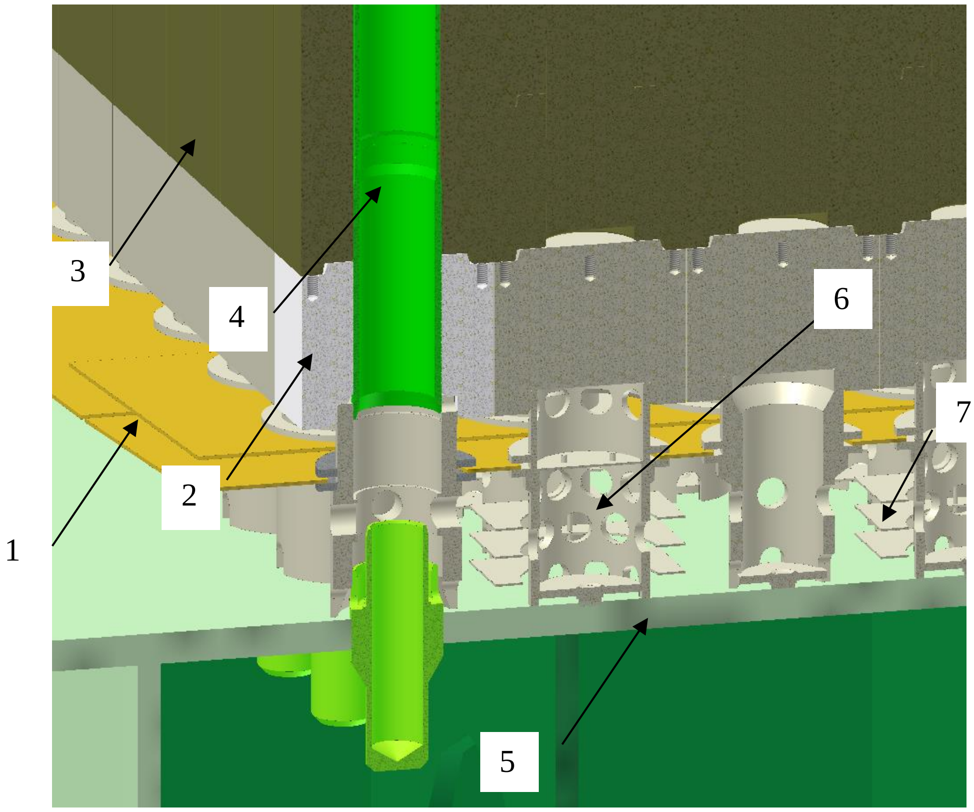
In 2015, a survey of 10 graphite columns was carried out at Unit 1 with the purpose to reveal possible cracks of graphite blocks. According to the results of the survey [44], the internal surfaces of the graphite blocks and upper protective slabs have no traces of cracks with opening. the internal surfaces of graphite blocks of 10 graphite columns display roughness, slight (insignificant) chipping, etc.; however, it is not known when the chipping and scratching occurred since there are no previous photos.

3.6.2. Graphite columns fastenings

The graphite columns fastenings serve for installation and centering of columns and consist of the top and bottom units.

The bottom units are located on the upper lattice of the metal structure of scheme “OR” and consist of the support slabs (different types), diaphragm РБМ-К7. сб.06 and support sleeves (different types).

Figure 12 Sketch of a fragment of the bottom fastening (reflector part assembly)



1 - Diaphragm РБМ-К7.сб.06;
2 – Bottom support slab РБМ-К7.сб.18.6;
3 - Blocks of the graphite stack сб.05 (reflector);
4 - Reflector cooling channel;
5 - Upper lattice of metal structures of the scheme “OR”;
6 - Support sleeve РБМ-К7.сб.18.2;
7 – Support plates РБМ-К7.сб.18.5

Support sleeves are welded [23] to the top lattice of scheme “OR”.

Figure 13 Sketch of diaphragm РБМ-К7. сб.06

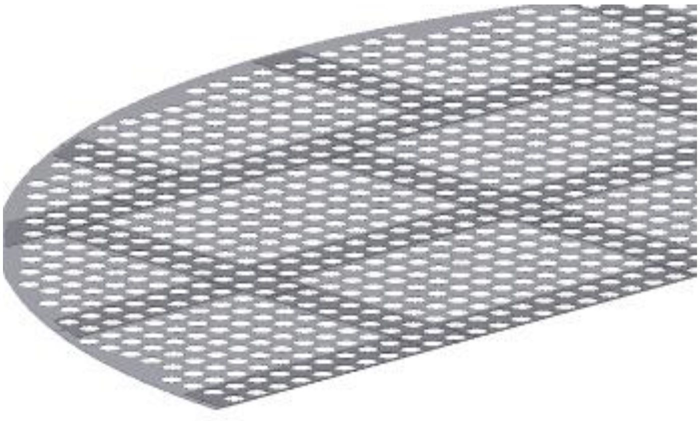
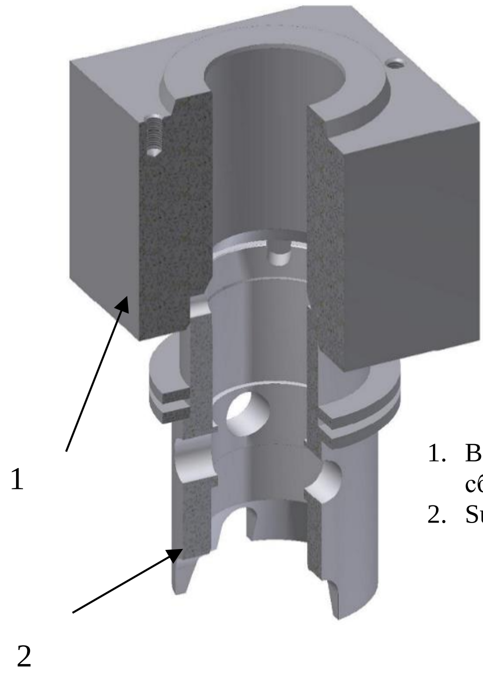
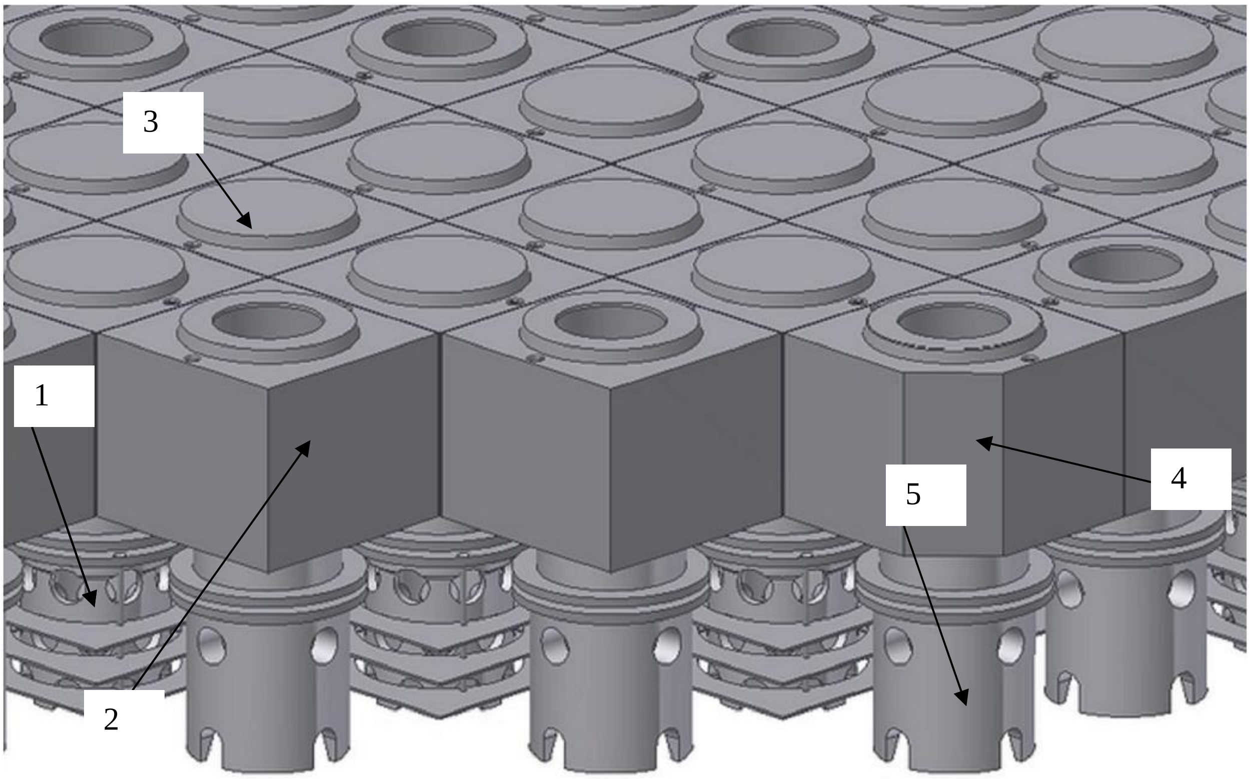


Figure 14 Sketch of a bottom fastening assembly (support slab on support sleeve)



1. Bottom support slabs РБМ-К7. сб.18.4.
2. Support sleeve РБМ-К7. сб.18.1

Figure 15 Sketch of a fragment of the bottom fastening



1. Support sleeves РБМ-К7 18.2;
2. Bottom support slabs РБМ-К7 18.4;
3. Bottom support slabs РБМ-К7 18.7;
4. Bottom support slabs РБМ-К7 18.6;
5. Support sleeves РБМ-К7 18.1

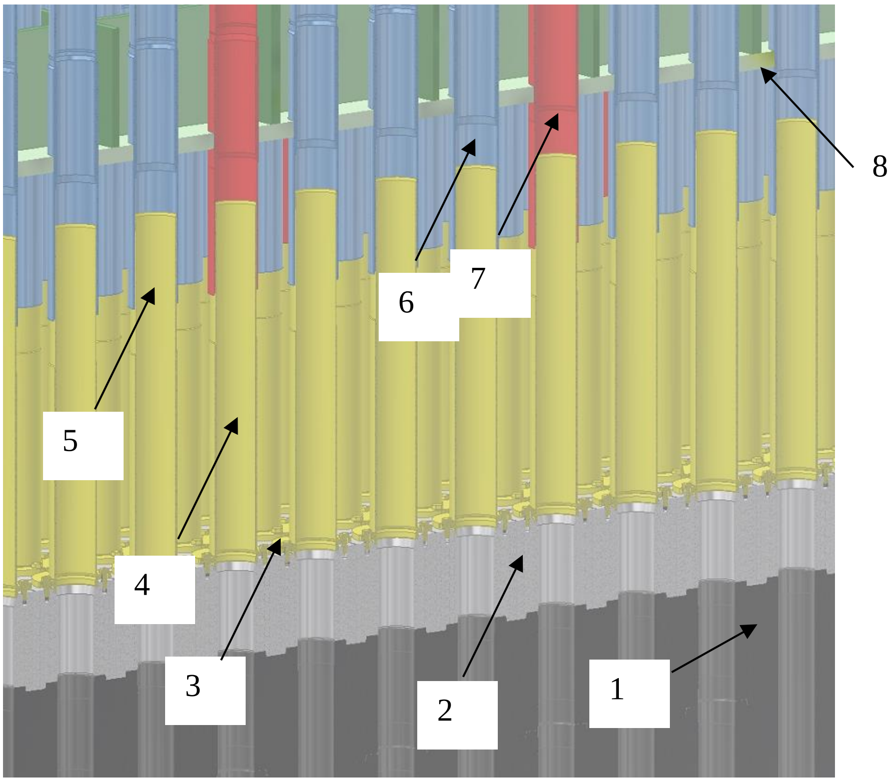
More information about bottom fastenings of graphite columns are presented in the following drawings:

- “Support slabs RBMK 7 сб.18. Assembly drawings. Sleeves support, protection shields. Details. The List. The complete set of delivery. The passport (PS)”, code ArchGD-1061-22538v1 [24];
- RBMK. Detailed Design. РБМ-К7. Сб.03. Fastening of the reflector. Assembly drawing. Assembly units. Details”, code ArchPD-1859-20007v1 [25];
- RBMK. Detailed Design. РБМ-К5. Сб.19. The reflector cooling channels. Assembly drawing. The List of specifications. The List of reference documents. Assembly units. Details”, code ArchPD-1859-2321 [26].

The top fastenings have sliding connection with elements, welded into the bottom lattice of the metal structure of scheme “E” and consist of the following elements:

- upper protective slabs (different types);
- a flanges in assembly (РБМ-К7 сб.21-6), attached by bolts to the upper protective slabs and consisting of flanges (РБМ-К5 сб.21-28) and pipes (РБМ-К5 сб.21-27), located inside of a upper guide tubes;
- upper guide tubes (РБМ-К5 сб.25-25) together with pipes (РБМ-К5 сб.21-27) provides a centering of the graphite column in height and compensates thermal expansion of the column in height .

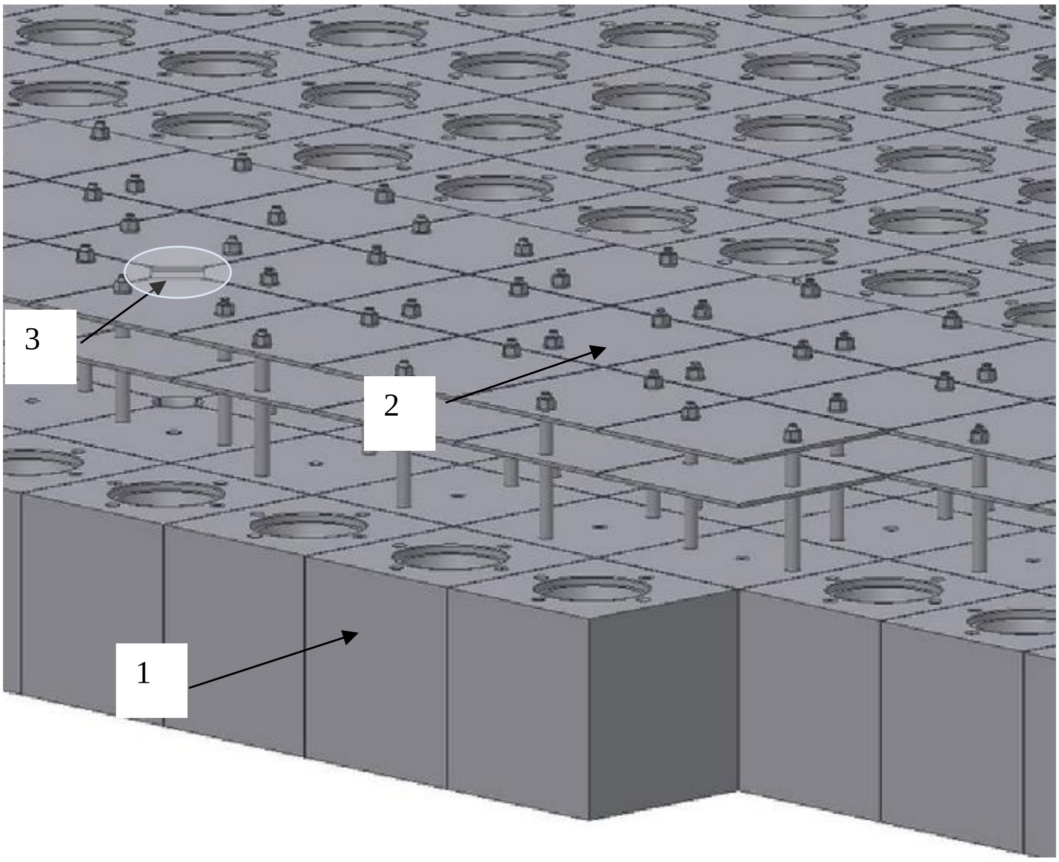
Figure 16 Sketch of a fragment of the top fastening



1. Graphite block RBM-K7 сб.05;
2. Upper protective slabs РБМ-К7 сб.07;
3. Flange РБМ-К5 сб.21-28;
4. Pipe РБМ-К5 сб.21-27;
5. Flange in assemble РБМ-К5 сб.21-6 (3 + 4);
6. Top guide tube for fuel channel сб.25-25;
7. Top guide tube for control and protection system сб.21-5;
8. Bottom lattice of metal structures of scheme “E”.

The upper protective slab (Сб.07) is inserted into the top part of the top graphite block. The material of the protective and support plates is steel of grade 25 (external surfaces are metallized by aluminium). The three outer protective slabs of the reflector have no central openings and the protection shield RBMK7.07.3(5) is fastened on them.

Figure 17 Sketch of the top fastening (reflector part)



1. Upper protective slabs РБМ-К7 сб.07 with openings under reflector cooling channels;
2. Protective shield RBMK7.07.3 (5);
3. Opening for temperature channel.

More information about top fastenings of graphite columns is presented in the drawings:

- "RBMK. Slabs protective. Passport РБМ-К7. Сб.07PS …..", code ArchПD-1035-22550v1 [27];
- "Top guide tubes of technological channels. РБМ-К15 .Сб.25", code ArchPD-1859-31524v1 [28].

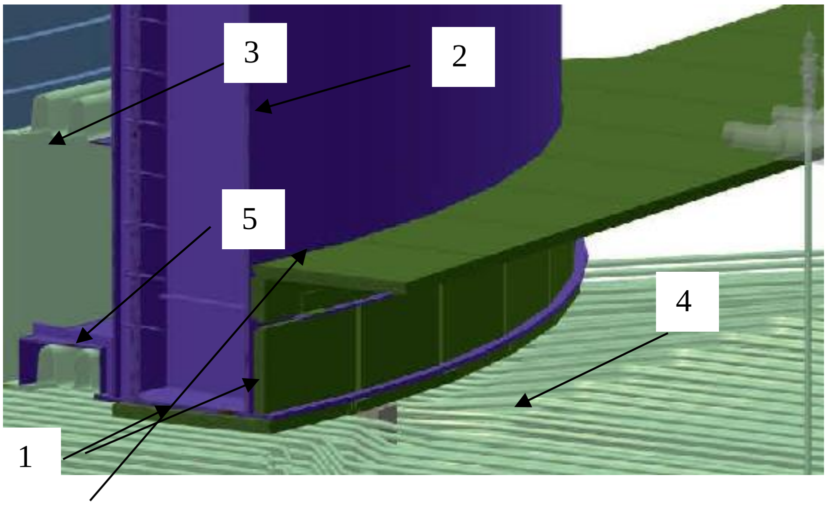
In 2013, radiological investigations of Unit 1 were carried out. Sampling (cuttings from drilling) from the upper protective slabs were taken; the results are provided in reports [19].

During operation, the physical and mechanical properties of constructional materials of the reactor changed. Available results of the assessment of changes in the properties of irradiated steels (according to witness samples) and irradiated graphite (according to the special plugs) are presented in [43].

3.7. Metal structure (scheme) “Э”

Scheme "Э" is intended for protection of the lower water communication lines and their premises from γ - radiation.

Figure 18 Sketch of a fragment of metal structures of the scheme “Э”



1. Plates of metal structures of the scheme “Э”
2. Metal structures of the scheme “L”
3. Lower cavity between compensators
4. Lower water communication pipelines
5. Box of the bottom compensator of scheme “OR”

At level +6.95, the set of steel plates is the basis for the bottom sheet of the metal structures of scheme “L”. At level +7.15, the set of steel plates is the bottom floor of reactor vault and is support for the “drainage pallet” of the sand and gravel filling of reactor vault.

Scheme “Э” is assembled from steel plates with a thickness of 100 mm. The material of plates is steel of grade 3 (covered by paint OC51-03). The weight of scheme is ~ 54 t.

Drawings of the metal structure of scheme “Э” are presented in “Working drawings of metal structures of the reactor RBM-K15. Part 5: Assembly scheme “Э” (with amendments)”, code ArchPD-1859-2557v1_5 [29] and “Building 101/1, Unit A1. Metal structures. Working drawings of the metal structures of the pallet under sand and gravel filling in mounting space of the reactor vault, Room 210. Explanatories to the design”, code ArchPD-1859-8556 [30].

3.8. Metal structure (scheme) “OR”

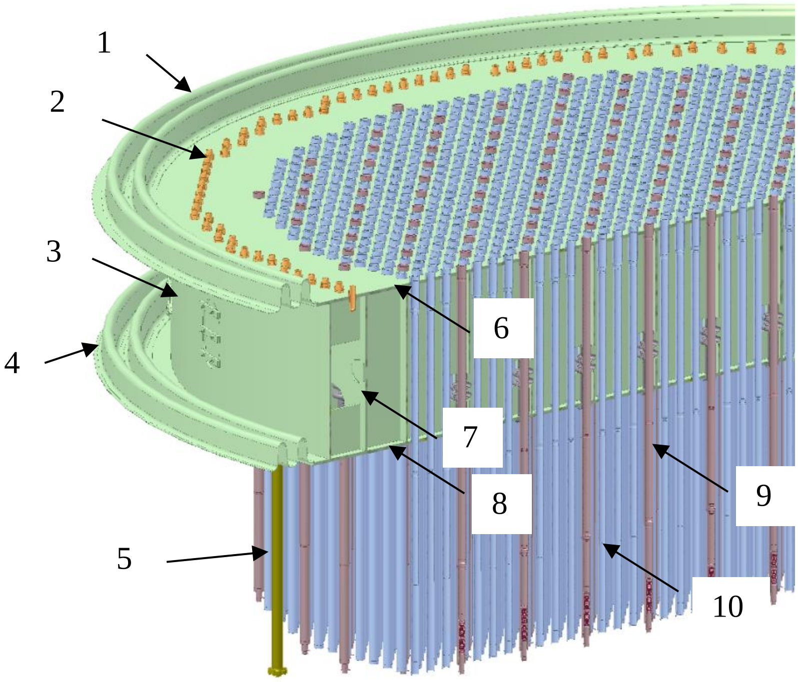
Scheme “OR” serves as the bearing structure of the graphite stack and carries out the role of the bottom biological shielding. It consists of a cylindrical shell, top and bottom lattices. The structure is strengthened by vertical stiffness plates. The lattices are assembled from separate sections (parts OP1... OP5). Scheme “OR” is connected to scheme “L” by two compensators for thermal expansion. Into the lattices of scheme “OR”, the following components are welded:

- bottom guide tubes of fuel channels, control and protection system channels and reflector cooling channels (РБМ-К5. сб.26, РБМ-К5. сб.28 and РБМ-К5. сб.24-4 respectively);
- control guide tubes (РБМ-К5. сб.47);
- sleeves of thermocouples (РБМ-К7. сб.160);
- parts of reflector cooling channels;
- gas and drainage pipes (РБМ-К5. сб.171): four pipes of nitrogen-helium mixture supply into the reactor cavity, pipes of drainage from the top lattice, pipelines for supply and removal of nitrogen from cavities of the metal structure.

Cavities of the scheme and space between upper and lower compensators are filled with serpentinite mixture of crushed stones and pebble stones. The lateral sides of the shell and the bottom lattice, as well as the surfaces of compensators, are metallized by aluminum and coated with paint OC51-03.

Overall dimensions of the scheme	Ø 14500x2000 mm.
Weight of the metal structure	~ 287 tons
Weight of the filling	~ 425 tons

Figure 19 Sketch of a fragment of metal structures of the scheme "OR"



1. Top compensator
2. Parts of reflector cooling channels
3. Shell of metal structures "OR"
4. Bottom compensator
5. Control guide tubes
6. Top lattice of metal structures "OR"
7. Stiffness plates
8. Bottom lattice of metal structures "OR"
9. Bottom guide tubes for control and protection system channels
10. Bottom guide tubes for fuel channels

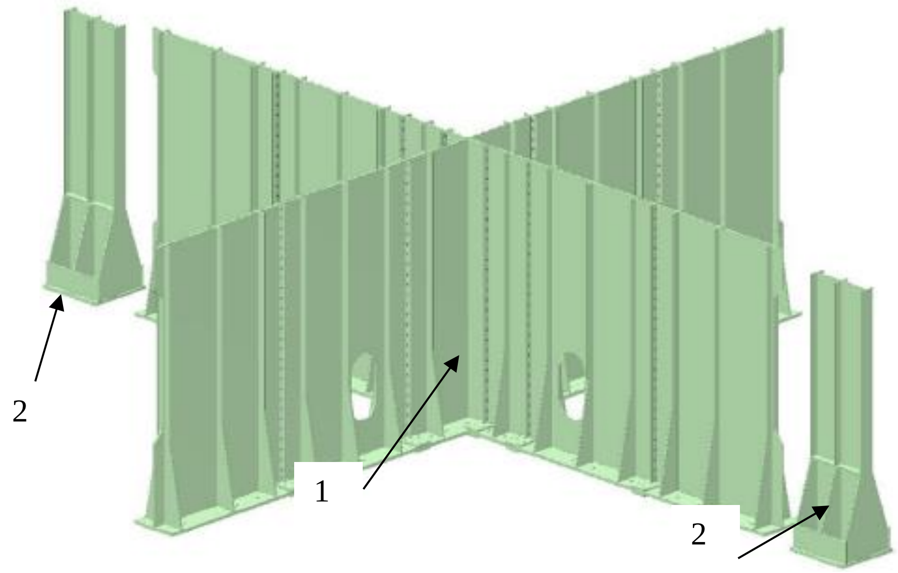
Drawings of the metal structure of scheme "OR" are presented in "Working drawings of metal structures of reactor RBM-K15. Part 2: Assembly scheme "OR" (with amendments)", code ArchPD-1859-2557v1_2 [32].

In 2013, samples (in the form of metal cuttings from 4 control guide tubes) were taken. The results of radiological examination are presented in reports [8, 31]. In 2018, samples were taken from Unit 2 (witnessing samples of serpentinite filling and steel, loaded into control guide tubes, were taken out, also samplings of the steel from the top lattice).

3.9. Metal structure (scheme) "C"

The metal structure of scheme "C" is a support structure of the reactor in the form of a cross and two stands made from steel 10XH1M, with height 5.0 m, strengthened by vertical stiffness plates. The metal structures of scheme "C" are assembled by bolt connections from separate welded blocks. The blocks are manufactured from sheet steel with a thickness of 40 mm, and stiffness plates - from steel of thickness 30 mm. All elements of the scheme are covered with heat-resistant paint OC51-03.

Figure 20 Sketch of metal structures of the scheme "C"

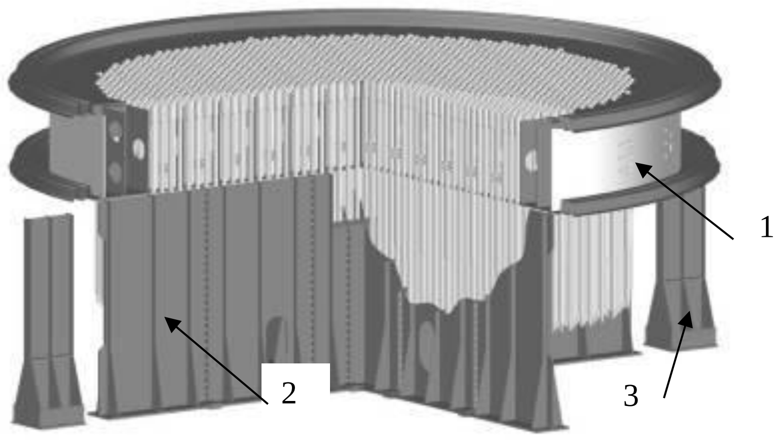


1 - "cross" (made from parts C1, C2, C3, C13); 2 – stands (part C4)

The metal structures of scheme "C" are installed on a crosswise foundation plate from heat resisting concrete, transferring on to it the weight of metal structures of scheme "OR", the graphite stack and the bottom water communication lines. Two separate stands (part C4) serve as supports for scheme "L".

Overall dimensions of scheme "C" - 15 000 x 15 000 x 5 160 mm; Weight ~ 97 463 kg.

Figure 21 Sketch of metal structures of scheme "OR" and scheme "C" together



1. Metal structures of the scheme "OR"; 2. Metal structures of the scheme "C"; 3. Stands C4

Figure 22 Photo of the metal structure "OR" and "C" in assembly

Drawings of the metal structure of scheme "C" are presented in "Working drawings of metal structures of reactor RBM-K15. Part 1: Assembly scheme "C" (with amendments)", code ArchPD-1859-2557v1_1 [34].

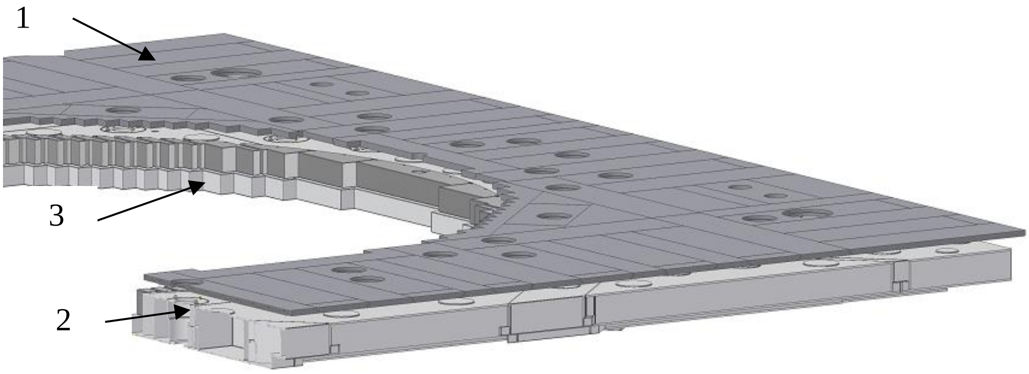
3.10. Metal structure (scheme) "G"

The metal structure of scheme "G" together with slab РБМ-К15. сб.11 flooring form thermal and biological shielding of the central (reactor) hall.

The metal structure of scheme "G" consists of the following:

- welded beams and boxes;
- top and bottom removable boxes;
- plates with thickness of 100 mm, removable and fixed, making the top part of the construction.

Figure 23 Sketch of metal structure of scheme "G"



1. Steel plates; 2. Boxes of the top part; 3. Boxes of the bottom part

In the metal structure, there are hatches for out-core ionization chambers guide tubes, guide tubes of thermocouples, control guide tubes, and various hatches.

The space between the top part of the scheme and the bottom, formed by beams and boxes, is used for laying cables of servo-drives for control and protection rods, instrumentation and control cables.

The ends of the beams are supported by details embedded into the walls of the reactor building and are load-bearing for other elements of metal structures of scheme "G". Removable boxes are supported by embedded details of building constructions on one edge, on the other by bearing beams. The plates are based on the supports fixed on the boxes.

The top side of metal structures of scheme "G" is lined by stainless steel sheet of grade 0X18H10T with thickness up to 5 mm. Surfaces of beams and boxes are metallized and covered by organic-silicate paint OC51-03. Unlined surfaces of the plates are coated with the paint of the same grade. The beams and boxes are filled with a mixture of cast-iron or steel shot and serpentinite.

Material of the metal structure - steel of grade 10ХСНД-12

Weight of the metal structure - ~ 590 t;

Weight of the filling - ~ 800 t.

The filling of scheme "G", a mixture of serpentinite pebble stones (14 % by weight), and cast-iron or steel shot (diameter 2-3 mm) was affected during the years of operation by temperature and leaks of contaminated fluids. There is a probability that fillings may be contaminated and hardened (more information can be found in reports [6, 8, 14].

Drawings of the metal structure of scheme "G" are presented in the "Working drawings of metal structures of reactor RBM-K15. Part 8: Assembly scheme "G" (with amendments)", code ArchPD-1859-2557v1 [35].

Under scheme "G", at level 23.55 in compartment 210, are situated components of the ventilation system (WZ51) for the above-reactor space. Drawings of the ventilation of the above-reactor space are presented in "Building 101/1, Unit A1. Ventilation. Ventilation of the above-reactor space OB." code ArchPD-1859-12183. [48].

On the top surface of the boxes and beams of scheme "G", a special grounding circuit for the reactor is located, basically produced from copper busbar with cross-section 120*10 mm and laid along the perimeter of the reactor in the boxes and beams of scheme "G" at level 24.9. Drawings of the special grounding circuit of the reactor are presented in the document "Cable routes in the premises of "hot" areas. The layout of the special grounding circuit of the reactor, cross-sections to the layout", code ArchPD-1859-19477 [49].

3.11. Filling of the mounting space of the reactor vault

The reactor vault mounting space is limited in the radial direction by an external cylindrical shell of metal structures of schemes “L” and “D” and the reinforced concrete walls of the reactor vault. In the axial direction, it is limited by the top of metal structures of the scheme “D” (at the top) and by metal structures (drainage tray) of the scheme “Э” (at the bottom,).

In the corners of the reactor vault (at level +17.2), there are four tanks for reception of drainage water from the top of scheme “G” and sheet flooring of metal structures of the scheme “D” [12].

The mounting space is filled by a mixture of sand and gravel (with fractions of different granularity). At level ~ 6.0 ÷ 10.0, the so-called “reverse filter” [36] is made, which consists of 3 layers - sand (size of particles 0.2-1 mm), gravel (1.2-10 mm and 20-40 mm size)..

In the period 2011 – 2013, at Unit 1 samples of filling were taken, results are presented in reports [37, 38, 39, 40]. Samples from Unit 2 were taken in 2018. The results of the examination [41, 42] showed the presence of unexpectedly larger stones (sizes 50-100 mm) which were absent in the samples from Unit 1.

The volume of the filled mounting space is 2500 m^3. The filling material density specified in the design is 1.3-1.4 t/m^3, so its weight should be ~ 3375 t. However, results of sampling and analysis shows that density of the filling at Units 1 and 2 is higher than specified in the design. Also it is necessary to note that at Unit 2 there is a tendency to agglomeration of the filling.

Results of radiological examination of the filling materials taken from Unit 1 [9, 14] indicates that the filling layer above (~0.5m) and below (~2m) the drainage tanks is contaminated (contrary to Unit 2).

3.12. Reactor vault walls

The walls of the reactor vault are not subject to dismantling in the context of this project, but in order to create access to the components of zone R3 it may be necessary to make openings in the walls of the vault.

The reactor vault is a building compartment with inner cross-section 21.6m x 21.6m and 25m height (as specified in the design, in reality it may slightly differ). The thickness of the walls is ~ 2m, the walls are made from the reinforced concrete with density γ=2.4 t/m^3 of grade M300. A layer of thermal insulation was placed in the upper and bottom parts.

Samples of the concrete were taken from walls of Unit 1 in the period 2012-2013, [37, 38, 40]; examination results are presented in reports [8, 9, 14]. Similar sampling and examination at Unit 2 was carried out in 2018 [10]. Examination results show that the concrete does not contain radionuclides of activation; however, contamination to a depth of several centimeters is possible.

4. INITIAL STATE OF THE EQUIPMENT AND INTERACTION WITH THE OTHER DECOMMISSIONING PROJECTS

By the beginning of the reactor zone R3 dismantling, through the implementation of other projects, it is planned to achieve the following status:

- spent nuclear fuel (SNF) will be completely removed from reactor building;
- all components of the main circulation circuit (main circulation pumps, pipelines, headers, etc.) will be dismantled;
- drum-separators and steam pipelines will be dismantled.
- refueling machine will be dismantled;
- pumps and heat exchangers of scheme “L” and “D” water cooling system will be dismantled (however tanks of schemes “L” and “D” will remain filled with water);
- all technological channels, control and protection system channels and reflector cooling channels will be removed from the reactors;
- guide tubes above scheme “E” and under scheme “OR”, water / steam pipes and reactor cables and will be dismantled (cutting places and isolation solutions are determined in the frame of dismantling of zones R1 and R2);
- in certain SNF storage pools, which will remain filled with water, there will be long components (reflector cooling channels and special channels consisting from graphite sleeves), from dismantling in zones R1 and R2.

Figure 24 shows a cutaway of the compartments surrounding the reactor in the current state (prior dismantling of equipment in Zones R1, R2 and MCC). Figure 25 is a cutaway of the compartments surrounding the reactor prior the start of Zone R3 dismantling.

Figure 24 Cutaway of the Zone R3 and neighbouring compartments (before dismantling)

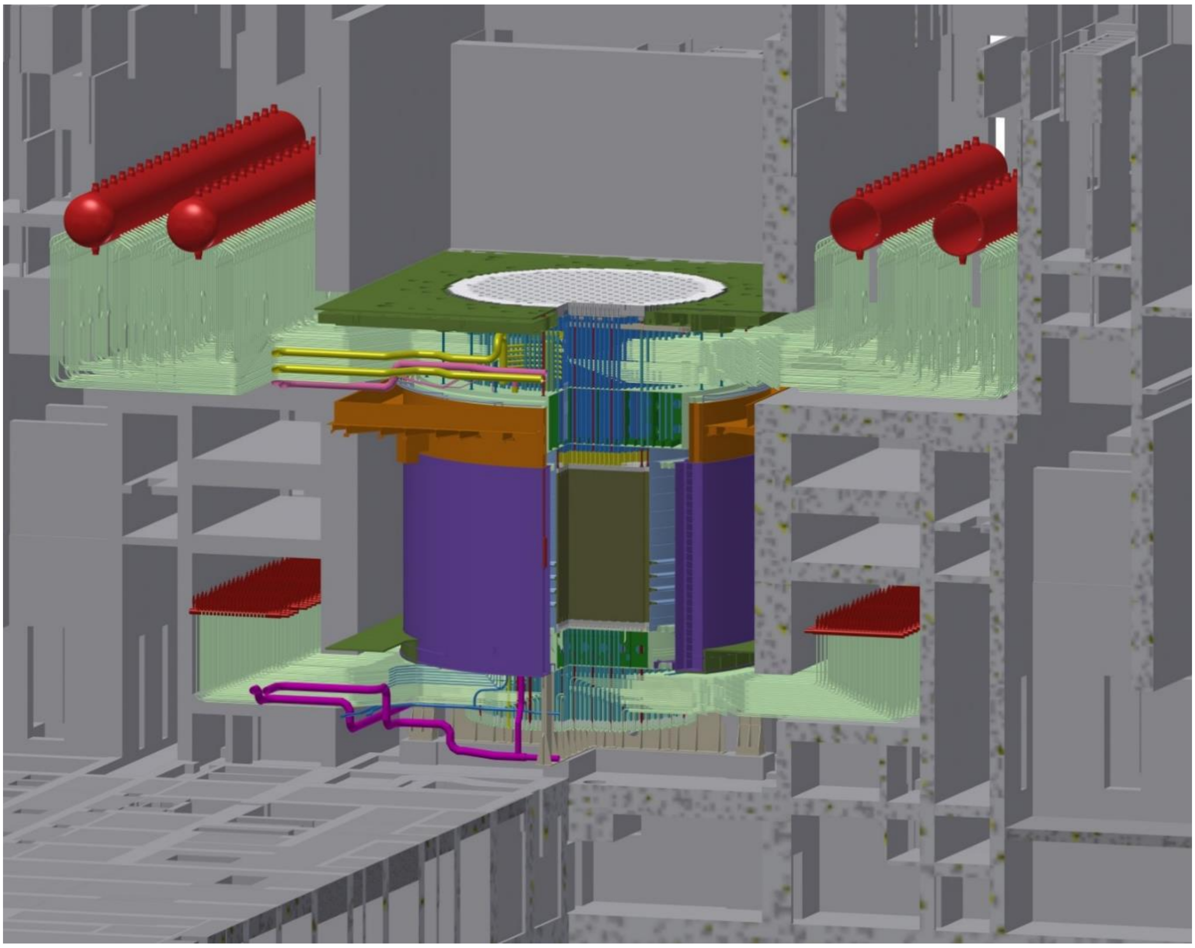
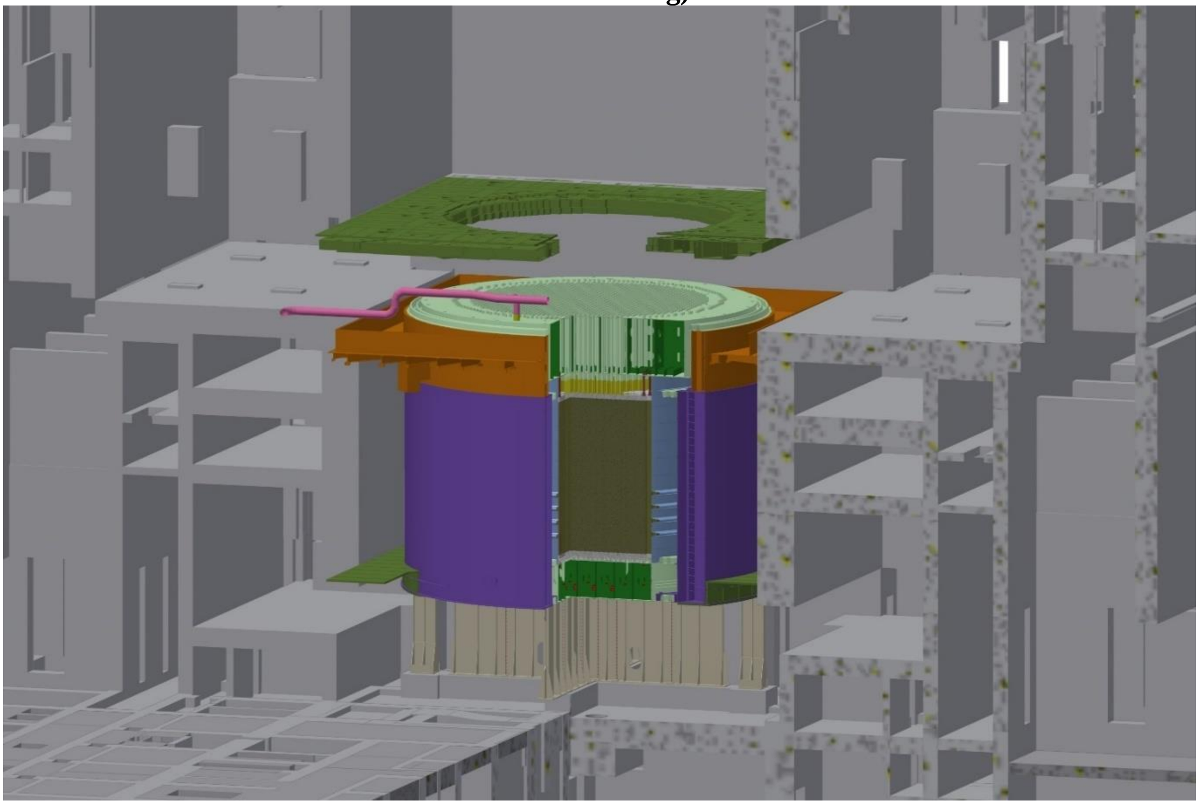


Figure 25 Cutaway of the Zone R3 and neighbouring compartments after dismantling (prior Zone R3 dismantling)



The Reactor building compartments will be available for in-air operations for waste processing, accumulation and packaging. Some compartments (such as the transportation canyon from the Central Hall to the Storage Pools Hall and redundant spent fuel pools) will be available for underwater operations for processing, waste accumulation and packaging of waste with excessive dose rates of gamma radiation.

Existing utilities and infrastructure in the reactor building compartments (such as drainage, ventilation, lighting, power supply, water supply, compressed air supply, radiation monitoring, cranes, security, etc.) will remain available.

No other unrelated activities shall take place during Zone R3 dismantling in the adjacent areas: central (reactor) hall, storage pool hall, drum-separator compartments, group distribution header compartments, transport shafts and adjacent corridors.

From 2010 to the end of 2018, Ignalina NPP has dismantled over 50 thousand tons of equipment and even more equipment will be dismantled until start of dismantling in Zone R3. Waste management equipment from predecessor projects will remain available and shall, to the extent technically achievable and economically rational, be reused for Zone R3 waste management.

In respect of interfaces and transition the following predecessor projects should be considered:

- Project 2101 “Dismantling of Reactor Facility (R1, R2 zones) of Unit 1”. Technological design for dismantling works (TDD) [47]. and SAR of 2101 project are under VATESI review. Preparatory works are in progress. Dismantling completion target date – end of 2025.
- Project 2203 “Dismantling of equipment in INPP Building A1" (Phase 1). TDD [46].and SAR of 2203 project are under VATESI review. Preparatory works are in progress. Dismantling completion target date – end of 2026;
- Project 2102 “Dismantling of Reactor Facility (R1, R2 zones) of Unit 2”. TDD, SAR of 2102 project are under INPP development. Dismantling completion target date – mid 2028.
- Project 2210 “Dismantling of equipment in INPP Building A2 and V2". TDD, SAR of 2210 project are under development by INPP. Dismantling completion target date – end of 2029.

Within the scope of these projects additional equipment for waste processing, packaging and characterization will be installed. TDD developed in the frame of these projects will define the separation lines for equipment to be dismantled in the scope of those projects, requirements for auxiliary systems, etc., which may be important for Zone R3 dismantling.

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