IAEA/ANL
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Technical and Administrative Preparations Required for Shipment of Research Reactor Spent Fuel to Its Country of Origin

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The Problems of Treatment of Irradiated Fuel at Russian Research Reactors

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THE PROBLEMS OF TREATMENT OF IRRADIATED FUEL AT RUSSIAN RESEARCH REACTORS

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TOPICS

- MODERN STATUS WITH RUSSIAN RESEARCH REACTORS
- TEMPORARY STORAGE IN THE POOLS OR IN THE VESSELS
- STORAGE IN THE REPOSITORY ON THE SITE OF THE REACTORS
- TRANSPORTATION OF THE FUEL TO THE REPROCESSING PLANT
- RUSSIAN RERTR PROGRAM, MODERN STATUS

MODERN STATUS WITH RUSSIAN RESEARCH REACTORS

- **18 REACTORS CONTINUE TO OPERATE**
- **LARGE VARIETY OF TYPES OF FUEL ASSEMBLIES**
- **MANY TYPES OF EXPERIMENTAL AND EXOTIC FUELS**
- **MAIN RUSSIAN INSTITUTES AND FACTORIES IN THE FIELD OF DEVELOPMENT AND FABRICATING OF FUEL ELEMENTS AND ASSEMBLIES FOR RESEARCH REACTORS:**

⇒ ***The designer of fuel elements is All-Russian Research Institute for Inorganic Materials;***

⇒ ***The designer of fuel assemblies is Research and Design Institute for Power Engineering;***

⇒ ***The main fabricators of fuel elements and assemblies are the Novosibirsk Chemical Concentrates Plant and the Machine-Building Plant in Elektrostal;***

⇒ ***The reprocessing plant is "Mayak".***

RUSSIAN RESEARCH REACTORS

	Facility Name	Date of Criticality	Reactor	Power,	Status	Age,	Enrichment of uranium,	Fuel type
1.	F-1	1946	graphit	0.024	Oper.	50	Natural	U_{met}
2.	IR-8	1957	pool	8.0	Oper.	39	90	UO_2 + Al
3.	MR	1963	channel	40.0	Shutdo	-	90	UO_2 + Al
4.	IIN-3M	1972	homog (l)	$1*10^4$ (in	Oper.	24	90	Solution
5.	ARGUS	1981	homog(l)	0.05	Oper.	15	90	Solution
6.	IR-50	1961	pool	0.05	Reconst	35	10	UO_2 + Mg
7.	IRT - MIFI	1967	pool	2.5	Oper.	29	90	UO_2 + Al
8.	AM[1]	1954	graphit	10.0	Oper.	42	4.4 & 10	UO_2 + Mg
9.	BR-10	1958	fast	8.0	Oper.	38	-	UN
10	WWR-TS	1964	pool	15.0	Oper.	32	36	UO_2 + Al
11	SM-3	1961	tank	100.0	Oper.	35	90	UO_2 + Cu
12	MIR-M1	1966	channel	100.0	Oper.	30	90	UO_2 + Al
13	BOR-60	1969	fast	60.0	Oper.	27	-	UO_2 + PuO_2
14	RBT-6	1975	pool	6.0	Oper.	21	63	UO_2 + Cu
15	RBT-10/1	1983	pool	10.0	Temp.shtd	13	63	UO_2 + Cu
16	RBT-10/2	1984	pool	10.0	Oper.	12	63	UO_2 + Cu
17	IVV-2M	1966	pool	15.0	Oper.	30	90	UO_2 + Al
18	WWR-M	1959	pool	18.0	Oper.	37	90	UO_2 + Al
19	IRT-T	1967	pool	6.0	Oper.	29	90	UO_2 + Al
20	RG-1M	1970	pool	0.1	Oper.	26	10	UO_2 + Mg
21	IBR-2	1977	pulse	4.0 ( )	Oper.	19	-	Pu
22	PIX	-	tank	100.0	Constr.	90	90	UO_2 + Cu

[1]First Nuclear Power Plant

TEMPORARY STORAGE IN THE POOLS OR IN THE VESSELS

- **CAPACITY OF THE STORAGES CORRESPONDS TO 8-10 YEARS OF OPERATION OF THE REACTOR AND IS ENOUGH FOR PROVIDING OF THE POSSIBILITY OF THE UNLOAD OF THE FULL CORE TO THE STORAGE IN THE CASE OF ACCIDENT**

- **PREVENTION OF INADVERTENT CRITICALITY**

- **PROVIDE AN ADEQUATE COOLING OF FUEL ELEMENTS**

- **AVOID CORROSION OF THE CLADDING OF THE FUEL ELEMENTS AND ASSEMBLIES**

- **STORAGE OF DEFECTIVE FUEL ELEMENTS AND ASSEMBLIES IN SPECIAL BOXES**

- **RECORDING AN INFORMATION IN A SPECIAL LOGS**

STORAGE IN THE REPOSITORY ON THE SITE OF THE REACTORS

- **DIVIDING ALL REPOSITORIES INTO 3 CLASSES DEPENDING ON THE POSSIBLITY OF THE REPOSITORY OVERFLOWING IN THE CASE OF SOME ACCIDENTS**

- **PREVENTION OF INADVERTENT CRITICALITY**

- **PROVIDE AN ADEQUATE COOLING OF FUEL ELEMENTS**

- **AVOID CORROSION OF THE CLADDING OF THE FUEL ELEMENTS; DRY REPOSITORIES ARE PREFERABLES**

- **STORAGE OF EXPERIMENTAL FUEL ELEMENTS AND ASSEMBLIES IS DIFFICULT PROBLEM**

TRANSPORTATION OF THE FUEL TO THE REPROCESING PLANT

- **USING THE TRANSPORT CASK DESIGNED SPECIALLY FOR TRANSPORTATION OF SPENT FUEL ASSEMBLIES FROM RESEARCH REACTORS**
- **DECREASING OF DECAY HEATING BEFORE TRANSPORTATION DURING 3 - 6 YEARS**
- **PREPARATION OF THE NECESSARY DOCUMENTS**
- **TRANSPORTATION ONLY UNFAILED FUEL ASSEMBLIES IN HERMETICAL TRANSPORT CASK**
- **IT IS POSSIBLE TO TRANSPORT ONLY STANDAR FUEL ASSEMBLIES INCLUDING IN SPECIAL STANDARD**
- **TRANSPORTATION OF SPENT FUEL ASSEMBLIESIN ACCORDING WITH SPECIAL PLAN**

Main technical characteristics of the cask-19

Characteristic	Value
Body wall thickness, mm	230
Bottom thickness, mm	220
Cap thickness, mm	220
Inner cavity diameter, mm	220
Outer diameter, mm	680
Diameter through trunnions, mm	910
Inner cavity height, mm	1430
Cask height, mm	2170
Loaded cask mass, kg, not more	4770
Empty cask mass, kg, not more	4700

CASK - 19

- SHIPMENT OF SPENT FUEL ASSEMBLIES FROM PRACTICALLY ALL RUSSIAN RESEARCH REACTORS
- OPERATION CYCLE OF CASK IS ABOUT 30 DAYS
- EACH CASK CONTAIN 4 FUEL ASSEMBLIES PLACED IN A BASKET
- COOLING TIME IS NOT LESS THAN 3 YEARS
- CASK-19 SATISFIES ALL THE REQUIREMENTS OF IAEA RULES
- TOTAL DECAY HEAT IN ASSEMBLIES IN CASK UP TO360 W
- THREE MODIFICATIONS OF INNER BASKET FOR DIFFERENT FUEL ASSEMBLIES

RUSSIAN RERTR PROGRAM,

MODERN STATUS

- START OF THE PROGRAM AT THE END OF SEVENTIETH
- DEVELOPOMENT OF DIFFERENT FUEL COMPOSITIONS
- URANIUM OXIDE IN ALUMINUM MATRIX
- URANIUM SILICIDE IN ALUMINUM MATRIX
- FIRST STAGE OF THE PROGRAM IS OVER - THE MODERN FUEL COMPOSITION PROVIDE THE DECREASING OF URANIUM FROM 90 % TO 36 %
- ACCORDING TO THE SECOND STEP OF THE PROGRAM THE ENRICHMENT SHALL BE DECREASE TO LESS THAN 20%
- NOW THE REACTOR EXPERIMENTS ON SECOND STAGE OF THE PROGRAM ARE IN PROGRESS

THE PROBLEMS OF TREATMENT OF IRRADIATED FUEL AT RUSSIAN RESEARCH REACTORS

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THE PROBLEMS OF TREATMENT OF IRRADIATED FUEL AT RUSSIAN RESEARCH REACTORS

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Abstract

This report describes the problems of the storage and transportation of the spent fuel from Russian research reactors.

Many research reactors continue to operate at Russia at present time. They use many different types of fuel elements and assemblies.

This report discusses three stages of the storage and transportation of the spent fuel:

· the temporary storage in the pool or in the vessel;
· the storage in the repository on the territory of the institutes;
· the transportation of the fuel to the reprocessing plant.

The future plans provide the solution of the problem of transportation and reprocessing of all types of fuel assemblies which are used in Russian research reactors and experimental facilities. Also the Russian Reduced Enrichment Research Reactors Program that was started late in 70th continuing now. The main results of this work would be increase the density of the fuel meat in the composition on the basis of uranium dioxide and the change of the fuel composition to uranium silicide in aluminum matrix or another.

1. Introduction

From 1946 to the present a large number of research reactors have been constructed in Russia. Twenty of them continue to operate at the present time. Moreover there are a certain number of prototype reactors, pulse type reactors, reactors for special purposes and zero power reactors (or critical assemblies).

The total power of all operating Russian research reactors is about 400 MW. The value of cumulative reactor years for all of them is more than 600 (see Table 1). During their operational lives the Russian research reactors accumulated and continue to accumulate a large number of irradiated fuel elements and assemblies of different types, including the experimental fuel elements and assemblies.

Naturally, these circumstances required the development of a system of treatment of irradiated fuel that could guarantee the nuclear and radiation safety of the storage and transportation of this fuel. Such system has been created and is continually updated.

The important peculiarity of Russian research reactors is the large variety of types of fuel assemblies that are used in different reactors. At the present time, more than ten types of fuel assemblies are in use. The fuel elements in these assemblies are of tube and rod types, the enrichment of uranium is 10, 36 and 90%, the height of the active part is from 35cm to about 2m (see some examples of Russian fuel assemblies on Figures 1 to 4). Different types of fuel materials are in current use, such as uranium-aluminum alloy, a dispersion of uranium oxide in aluminum matrix, etc.

Table 1

RUSSIAN RESEARCH REACTORS

	Facility Name	Date of Criticali	Reactor Type	Power, MW	Status	Age, year	Enrichment of	Fuel type
1.	**F-1**	1946	graphit	0.024	Oper.	50	Natural	U_{met}
2.	**IR-8**	1957	pool	8.0	Oper.	39	90	UO_2 + Al
3.	**MR**	1963	channel	40.0	Shut	-	90	UO_2 + Al
4.	**IIN-3M**	1972	homog (l)	$1*10^4$ (in	Oper.	24	90	Solution
5.	**ARGUS**	1981	homog(l	0.05	Oper.	15	90	Solution
6.	**IR-50**	1961	pool	0.05	Reconst	35	10	UO_2 + Mg
7.	**IRT -**	1967	pool	2.5	Oper.	29	90	UO_2 + Al
8.	**AM**[1]	1954	graphit	10.0	Oper.	42	4.4 &	UO_2 + Mg
9.	**BR-10**	1958	fast	8.0	Oper.	38	-	UN
10	**WWR-TS**	1964	pool	15.0	Oper.	32	36	UO_2 + Al
11	**SM-3**	1961	tank	100.0	Oper.	35	90	UO_2 + Cu
12	**MIR-M1**	1966	channel	100.0	Oper.	30	90	UO_2 + Al
13	**BOR-60**	1969	fast	60.0	Oper.	27	-	UO_2 +PuO
14	**RBT-6**	1975	pool	6.0	Oper.	21	63	UO_2 + Cu
15	**RBT-**	1983	pool	10.0	Temp.s	13	63	UO_2 + Cu
16	**RBT-**	1984	pool	10.0	Oper.	12	63	UO_2 + Cu
17	**IVV-2M**	1966	pool	15.0	Oper.	30	90	UO_2 + Al
18	**WWR-M**	1959	pool	18.0	Oper.	37	90	UO_2 + Al
19	**IRT-T**	1967	pool	6.0	Oper.	29	90	UO_2 + Al
20	**RG-1M**	1970	pool	0.1	Oper.	26	10	UO_2 + Mg
21	**IBR-2**	1977	pulse	4.0	Oper.	19	-	Pu
22	**PIX**	-	tank	100.0	Constr.	90	90	UO_2 + Cu

[1] First Nuclear Power Plant

In the former Soviet Union it was developed three generations of fuel elements and assemblies for research reactors on the basis of using of various aluminum materials (alloys and oxides).

Table 2

Generations of fuel elements in Russian research reactors

Generations	Years	Enrichment, %	Concentration of U-235, g/l	Thickness of fuel elements, mm	Specific heat transfer surface, m^2/l
First	1954-1970	10-36	50	10	0.098
Second	1963-1985	36-90	60	3.2-2.0	0.2-0.362
Third	1972-till now	90	68-130	1.4-1.25	0.525-0.66

The designer of fuel elements for Russian and Russian supplied research reactors is All-Russian Research Institute for Inorganic Materials, the designer of fuel assemblies is Research and Design Institute for Power Engineering.

The main fabricators of fuel elements and assemblies for Russian and Russian supplied research reactors are the Novosibirsk Chemical Concentrates Plant and the Machine-Building Plant in Elektrostal. The Machine-Building Plant in Elektrostal fabricates the fuel elements and assemblies only for SM-3 and AM reactors as the Novosibirsk Chemical Concentrates Plant fabricates fuel elements and assemblies on the base of the aluminum for all remaining research reactors.

The only reprocessing plant in Russia is “Mayak” near Chelyabinsk in Ural region reprocess all spent fuel elements from Russian research reactors.

Moreover many types of experimental fuel elements are tested in experimental loops and rigs. It is clear that this situation means that the safety analyses of storage and transportation of spent fuel elements requires a great deal of effort.

2. General

At first, it is important to note that the requirements of safety during the storage and transportation of spent fuel assemblies are described in many special Russian documents on the safety of research reactors.

In Russia there is a system of the management and storage of spent nuclear fuel at research reactors. The documents on safety of research reactors describes of the main features of this system. The top level document is: "General Requirements for Providing Safety at Research Reactors."[1] This document includes the main safety principles for the siting, design, commissioning, operation, modification and decommissioning of research reactors. It corresponds to such Agency documents as "Safety Standards on Design and Operation" (35-S1 & 35-S2).

The documents of the next level that describe the definite requirements for the safety systems of reactor are very numerous. They consider all of the general questions of the safety during the storage and transportation of spent fuel elements.

The following main safety requirements shall be provided in all stages of the movement of spent fuel from the core to the reprocessing plant:

- provision of sufficient subcriticality in the storage of the spent fuel elements and assemblies for nuclear safety;
- adequate heat removal from the spent fuel elements for the prevention of damage of the cladding of the fuel elements;
- provision of an adequate coolant chemistry for the minimization of cladding corrosion;
- physical protection of the nuclear fuel;
- exact registration of the quantity of nuclear materials at all stages of the storage and transportation.

3. Temporary Storage of Spent Fuel at the Site of the Reactor

After unloading the fuel assemblies from the active core they shall be transported to the temporary storage. All research reactors even the very low power reactors have a facility for temporary storage of spent fuel.

Rates and order of transportation and storage of the spent fuel elements shall be specified in the reactor design. A special document that discusses the problems of safety shall, be included in the design of the reactor. This document is entitled: "The Technical Basis for the Safety of the Reactor" and its contents are analogous to those of the "Safety Analyses Report." The Technical

Basis for the Safety of the Reactor such as its design shall be approved by the regulatory body.

The assemblies of spent fuel elements must be stored in special storage racks. These storage racks are located in the pool or in the vessel of reactor. Transfer of the elements from the active core to the storage racks is accomplished by moving the fuel assemblies through the water that provides adequate shielding. When the storage racks become full the spent fuel assemblies must be loaded into the temporary "wet" storage. Usually the capacity of the temporary storage is relatively big and corresponds to 8-10 years of operation of the reactor. In all cases the capacity of temporary storage must be enough for providing of the possibility of the unload of the full core to the storage in the case of the accident.

The storage of spent fuel assemblies shall be such as to prevent inadvertent criticality and to provide an adequate cooling of fuel elements. The most important safety parameter during the storage of the spent fuel assemblies is a step between fuel assemblies. Its value shall be calculated by the operational organization. According to the regulations [2] the subcriticality of spent fuel storage shall not be less than 0.05 in all accident situations such as mechanical damage of the facilities, loss of coolant in the storage, special internal and external events etc. These calculations shall be verified by the special division of the Institute of Physics and Power Engineering at Obninsk and after that be approved by the regulatory body.

To avoid corrosion of the cladding of the fuel elements the water chemistry in the storage pool shall be the same as in the primary circuit of the reactor. For example, for fuel elements with aluminum cladding the value of pH shall be from 5.5 to 6.5 and the specific conductivity shall be less than 1.5 $\mu S/cm$. Clearly, these parameters are also defined in special standards.

Conservative assumptions are used to provide an adequate safety margin. In particular, the calculations of criticality are carried out assuming that all fuel elements in storage are fresh, but in the calculations of the radiological consequences it is assumed that all fuel elements have the maximum possible burnup.

A special problem is the storage of defective fuel elements and assemblies, since there may be a possibility that fission products are released into the pool. These fuel assemblies must be install in special boxes to isolation them from the pool. However, it is emphasized that occurrences of failured fuel elements are very rare and at the majority of Russian research reactors such failures have not happened more than one or twice during the whole history of the reactor.

Information about all transport operations with spent fuel assemblies shall be recorded in a special log. These include the necessary information about fresh fuel assembly (in particular, the date of the construction of the fuel assembly, the charge of uranium in the fuel assembly, the enrichment of the uranium), the times of loading and unloading of the fuel assemblies from the core, the burnup of the fuel and the position of the fuel assembly in the storage. The order of the treatment of the fuel is described in the instructions for the safe transportation and storage of fresh and spent fuel, a document that is available at every research reactor.

4. Storage of the Spent Fuel in the Repositories

Once the decay heating has reduced to a level when the storage of the spent fuel assemblies is possible without cooling by pool water they can be transported to the repositories. Such a repository is always available at all institutes that have several research reactors and in several cases at the institutes having one research reactor.

The questions of nuclear safety during the transportation of the spent fuel assemblies to the repositories and storage of spent fuel assemblies in them is defined in the special document entitled: "Nuclear Safety Regulations for Transportation and Storage of Dangerous Fissionable Materials"[3]. According to these regulations, all repositories shall be divided into 3 classes depending on the possibility of the repository overflowing in the case of the flooding, failures of equipment in the neighbouring rooms and personnel errors. In the repositories of the first class overflowing is impossible even in the case of the flooding. It is obvious that these repositories are dry. In the repositories of the second class the penetration of subterranean waters in the repository is impossible in all cases. These repositories are also dry. The new repositories shall be designed only as the repositories of the first or second classes.

As we see from the name of this document it determines mainly the questions of nuclear safety. According to it, the subcriticality of spent fuel in repositories shall not be less than 0.05 for full repository and in all accident situations. The possible initial events of the accidents are earthquakes, flooding, fire, loss of electrical power supply, failure of transport cask, etc. The calculations of criticality must be carried out by the operational organization, then they shall be verified by special division of the Institute of Physics and Power Engineering at Obninsk and after that shall be approved by the regulatory body. This procedure is the same as for temporary storage of spent fuel assemblies.

The problem of corrosion of the cladding of fuel elements can arise during the storage of spent fuel assemblies in "wet" repositories but it is important to emphasize that the process of corrosion proceeds very slowly. However, the long-term storage of spent fuel assemblies in dry repositories shall be preferable.

The special problem is the storage of the spent fuel assemblies from experimental loops and rigs. It's necessary to say that the many of them were designed on unique technology that did not receive the continuation. In several cases we must to say about a few fuel elements.

5. Transportation of Spent Fuel to the Reprocessing Plant

It is necessary that before transportation of the spent fuel assemblies from the institutes to the reprocessing plant the level of decay heating become enough low.
The value of necessary time for the decreasing of decay heating varies from one fuel
assembly to another and may reach six years for fuel assemblies with very high specific power. The special standards determine these values of the times for every type of fuel assembly.

After the decay heating in fuel elements has reduced to a low level they can be transported to the reprocessing plant. The questions of nuclear safety during the transportation of the fuel assemblies are defined in special document: "Principal Safety and Physical Protection Regulations for the Transportation of Nuclear Materials" [4].

The transportation of spent fuel elements carry out in special dry containers -cask-19 [5]. The cask-19 has been developed specially for research reactor spent fuel assemblies transport. It is a thick-walled vessel tightly covered with a heavy cap.
The cask allows the shipment of spent fuel assemblies of different research reactors with various fuel types of different cross-sectional shapes and with a total decay heat of up to 360 W. The cask design assures nuclear safety, biological shielding, heat removal from fuel assemblies, hermetic sealing and strength in normal and emergency conditions of transportation.

Main technical characteristics of the cask are given in Table 3.

The cask-19 design satisfies all the requirements of IAEA rules on B (V) -type package safety. The cask-19 leak tightness is provided by the use of packing in the sealing units, made of rubber based on silicone as fillers and allowing short-term operation at 250 ^{o}C in emergency conditions.

Table 3. Main technical characteristics of the cask-19.

Characteristic	Value
Body wall thickness, mm	230
Bottom thickness, mm	220
Cap thickness, mm	220
Inner cavity diameter, mm	220
Outer diameter, mm	680
Diameter through trunnions, mm	910
Inner cavity height, mm	1430
Cask height, mm	2170
Loaded cask mass, kg, not more	4770
Empty cask mass, kg, not more	4700

The cask-19 allows the shipment of spent fuel assemblies from practically all Russian research reactors excluding AM, BOR-60. There are another transport cask for transportation of the spent fuel elements from these reactors.

Standard loading of fuel assemblies into the cask-19 should be performed in the cooling pool under protective water layer.

Transport of the cask-19 loaded with fuel assemblies is done in a railway cask-car in vertical position. The number of cask-19 loaded into a car depends on the spent fuel cooling time and spent fuel assemblies characteristics.

The cask operation regime is periodic. One operation cycle is about 30 days. The operation cycle includes: fuel charge, transport, discharge, preparation to a new cycle.

In the cask inner cavity a basket is situated. Because of the design differences of fuel assemblies shipped, the basket is made in three modifications differing by the basket inner cavity alone. As a rule, each cask may contain 4 fuel assemblies placed in a basket. The cooling time of spent fuel to be transported depends on the burnup, initial enrichment and fuel exposure time and, as a rule, is not less than 3 years.

The cask-19 may be used in the ambient air temperature from - 50 ^oC to + 38 ^oC with relative humidity 90% at + 25 ^oC.

The average service life of a cask is not less than 20 years.

It is impossible to transport spent fuel assemblies until the operational organization have prepared the necessary documents. These documents shall consider the questions of nuclear and radiation safety, they shall include the calculations of criticality and adequate cooling in normal conditions and in all accident situations. It's possible to transport only the unfailed fuel assemblies or failed fuel assemblies in hermetical transport cask.

To receive permission for the transportation of spent fuel assemblies, an operating organization must prepare the necessary documents that must then be approved by the regulatory body, representatives of security service and local authorities of those territories over which the transportation is intended.

The procedure to receive permission is not very easy. Moreover the permission can be received only if the reprocessing plant has adequate technology for reprocessing of the spent fuel in question. Taking into account the large number of fuel compositions that are used in Russian research reactors and their experimental facilities this problem is very complicated and for this reason many types of fuel elements stay in the repositories for many years.

There is a special standard for transportation of spent fuel assemblies from research reactors to the reprocessing plant. It includes all main fuel assemblies such as IRT-M, WWR-M, CM-2, MR fuel assemblies with EK-10 fuel elements. There is an adequate technology for reprocessing of these spent fuel assemblies and during several years this technology is use. Concerning the experimental fuel assemblies it is necessary to emphasized that the many of them were designed on exotic technology and this technology did not receive the continuation.

Special standards describe the requirements for the vehicle and the transport container. New transport containers shall be tested by the design organization and after the results of the test shall be approved by the regulatory body.

In the former Soviet Union there was a special plan of transportation of the standard spent fuel assemblies from research reactors to “Majak”. Now the quantity of the spent fuel assemblies at the sites of research reactors are very big but the financial possibilities of the institutes can not allow to transport of the spent fuel assemblies to reprocessing plant.

It is possible to construct a new storage at the site of the reactor but it is also a very expensive decision. The one real way of temporary solving of the problem of spent fuel is increasing of the capacity of existing repositories by means of decreasing of the step of placing of spent fuel assemblies .

6. Future plans

The most important difficulties with the treatment of irradiated fuel from Russian research reactors are the large variety of the fuel elements and assemblies used in the research reactors and their experimental facilities. For this reason in the near future we intend to finish the development of the safety standards and include in the final document standards for all of the types of the fuel elements and assemblies used in the past and at present. On the other hand, we want to use in the future not more than one or two fuel compositions in the fuel elements of research reactors. This will make it easier to solve the problems of reprocessing of spent fuel. But as before the reprocessing of experimental spent fuel assemblies would be remained the big problem.

The technical problems of storage and transportation of standard spent fuel assemblies from Russian research reactors to the reprocessing plant solved and only the bad financial situation prevents to the free of the storages at the site of research reactors.

We also propose to convert the composition using in the fuel elements of Russian research reactors for another reason. This is in connection with the problem of the reduction of enrichment of uranium in research reactors in accordance with the joint international efforts in nonproliferation policy [7].

At the present time the main type of the fuel composition in our research reactors is uranium oxide in aluminum matrix. With this composition it is possible to reduce the enrichment of uranium from 90% to 36%, but to reduce the enrichment to less than 20% it is necessary to use a new fuel composition e.g. uranium silicide in aluminum matrix or another composition.

The development of this composition in Russia is now in progress and we hope in the near future to begin using fuel elements with such a composition. Clearly, this development will create new problems of safety during the storage, transportation and reprocessing of spent fuel elements. In particular the reprocessing of spent fuel assemblies can be very complex problem.

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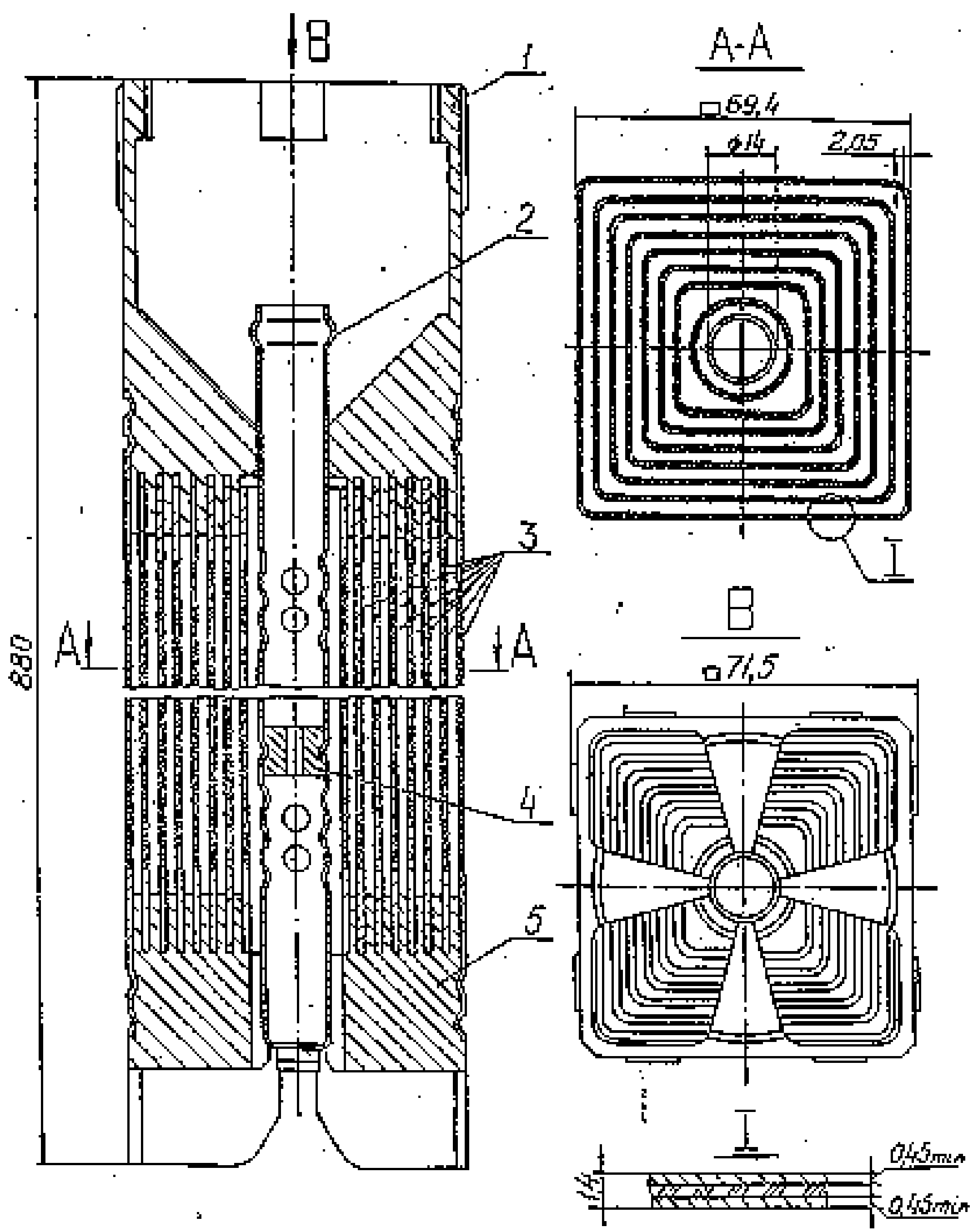


Fig.1. Fuel assembly of the IRT-3M type

1 - cap; 2 - displacer; 3 - fuel elements;
4 - pad; 5 - ending part

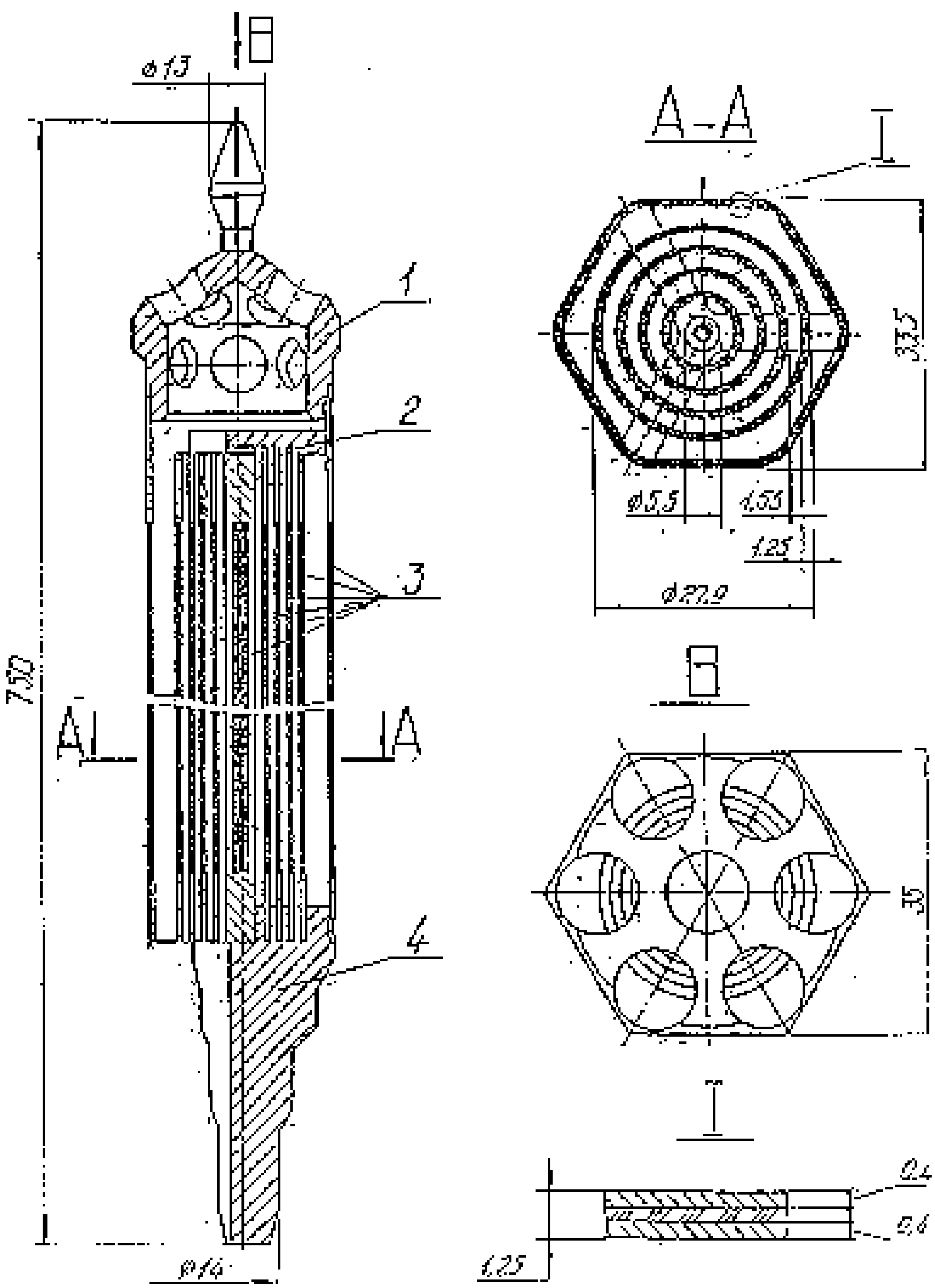
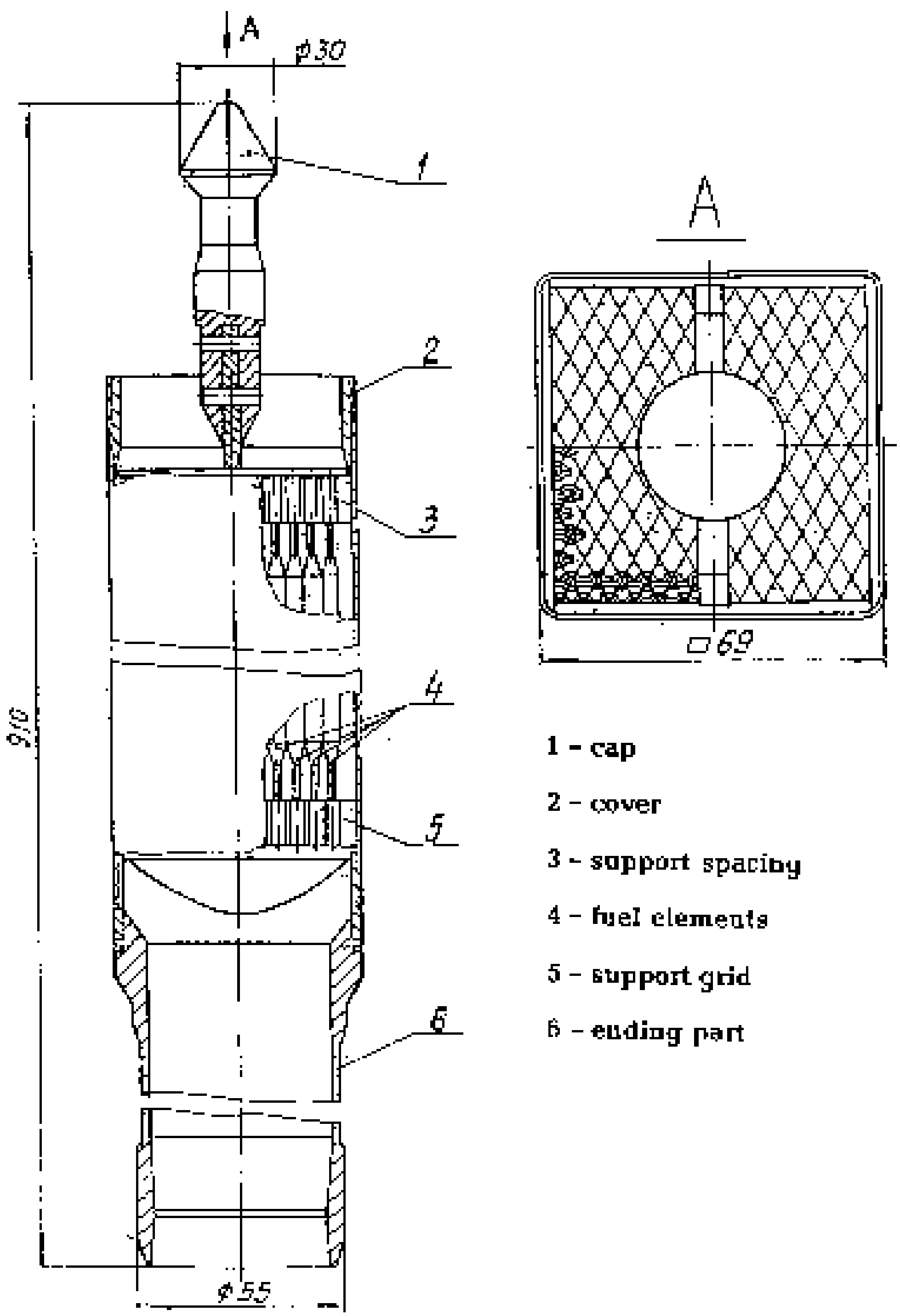


Fig.2. Fuel assembly of the reactor WWR-M
1 - cap; 2 - upper grid; 3 - fuel elements; 4 - ending part



1 – cap

2 – cover

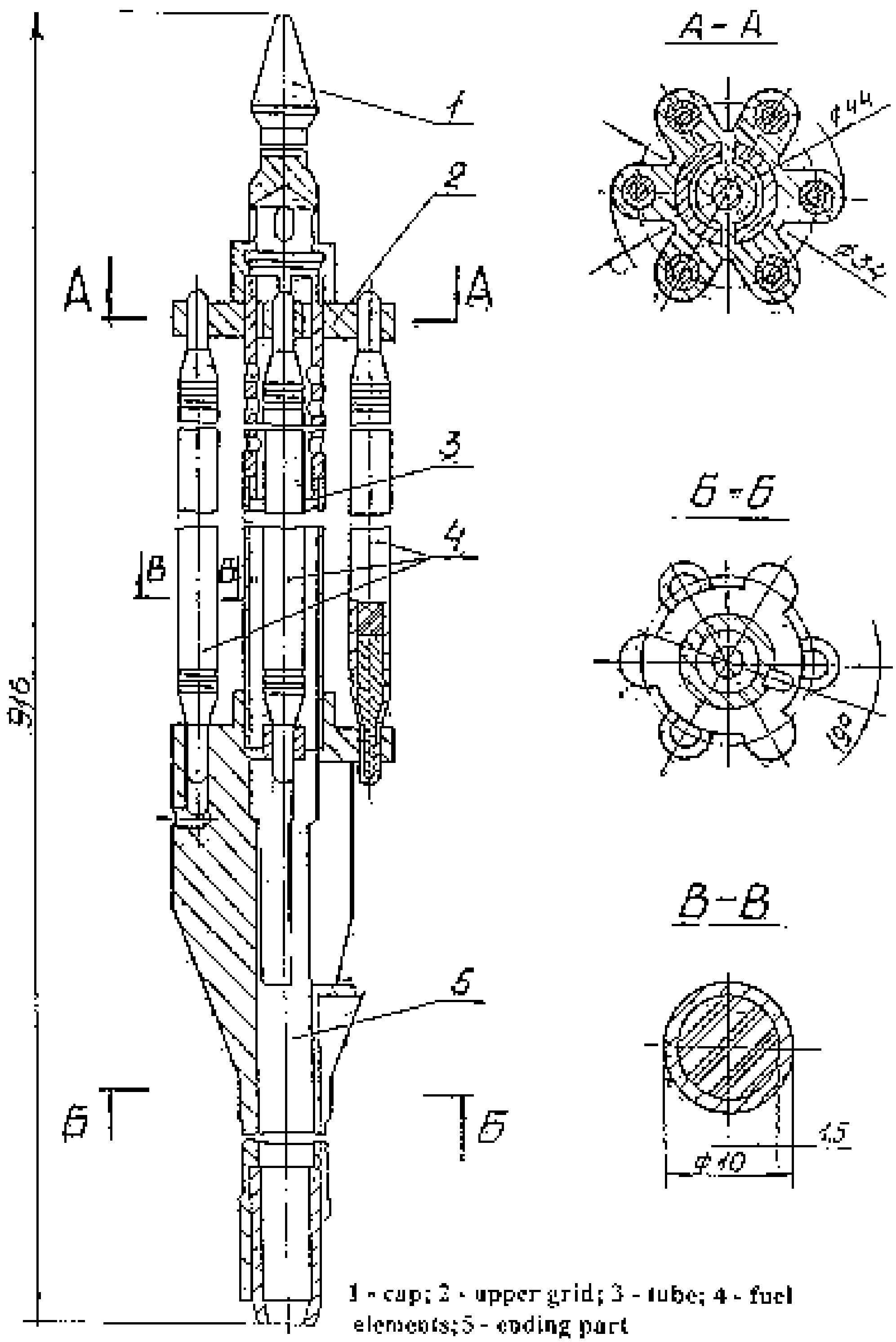
3 – support spacing

4 – fuel elements

5 – support grid

6 – ending part

Fig.3. Fuel assembly of the reactor CM-3



1 - cap; 2 - upper grid; 3 - tube; 4 - fuel elements; 5 - ending part

Fig.4. Fuel assembly of the reactor RG-1M

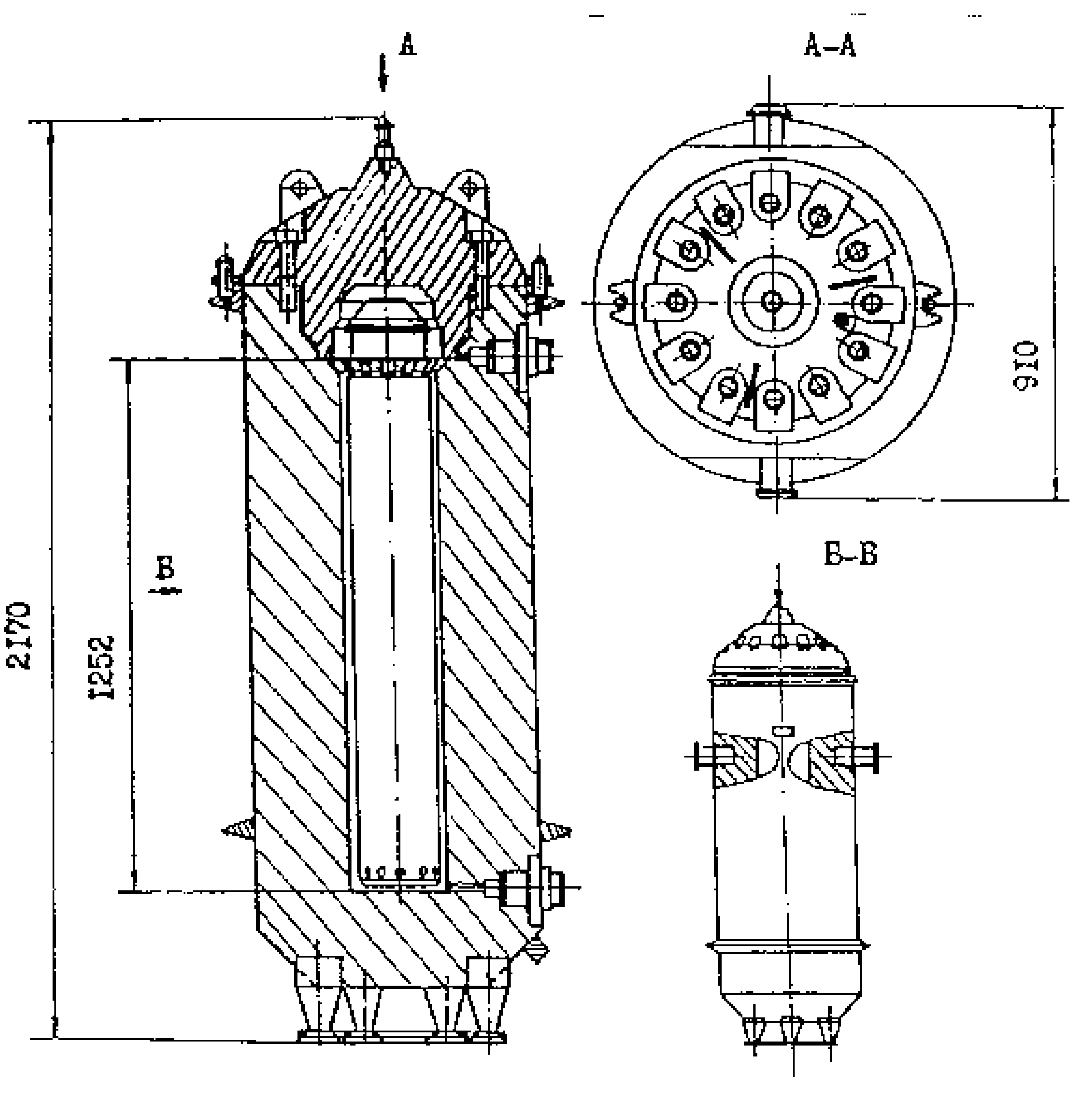


Fig.5. The cask-19 (cross section)