2. NEUTRON SOURCES

2.1. THE IBR-2 PULSED REACTOR

In the year 2000 the IBR-2 reactor operated in accordance with the approved working schedule. It operated for the physical experiment 8 cycles (~2073 h), including three with a cryogenic moderator, at W=1.5. Over the period there were 6 emergency shutdowns. Details of IBR-2 operation are summarized in Tables 1 and 2.

Table 1

The parameters of IBR-2 operation in the period from January 1, 2000 to January 1, 2001

Cycle	1	2	3	4	5	6	7	8	*Total*
Time of cycle	*16.01 – 27.01*	*14.02 - 25.02*	*13.03 – 24.03*	*10.04 - 21.04*	*15.05 - 26.05*	*23.10 - 3.11*	*13.11 - 24.11*	*04.12 - 15.12*	
Operation for physical experiment, h	266	260	269	256	263	253	258	248	**2073**
Operation of movable reflector, h	277	271	278	278	275	268	273	274	**2194**
Generated energy, MWh	405	394	406	399	393	385	394	378	**3154**
Number of emergency shutdowns,	1	1	-	2	1	-	-	1	**6**
including caused by:									
▪ Voltage drops	-	1	-	1	1	-	-	1	**4**
▪ Equipment malfunctioning	1	-	-	1	-	-	-	-	**2**
▪ Electronic equipment malfunctioning	-	-	-	-	-	-	-	-	**0**
▪ Personnel fault	-	-	-	-	-	-	-	-	**0**

Table 2

The parameters of the IBR-2 reactor state as of 01.01.2001

No.	Parameter (beginning from startup)	Fact	Rated
1	Total operating time for physical experiment, h	38567	
2	Total generated energy, MWh	71360	85000
3	MR-2P mechanical operating time, h	13866	18000
	MR-2P generated radiation, MWh. *(for flux density in the center of blade $5 \cdot 10^{13}$ n/cm^2 for neutrons with E>0.1 MeV)*	23694	36000
4	Maximum fluence on reactor jacket in the center of active zone (10^{22} n/cm^2):		
	• for En > 0.1 MeV	3.11	3.72
	• for En > 0.8 MeV	1.35	
5	Maximum fuel burn (%):		
	• pellet TVEL	5.36	6.5
	• spigot TVEL	5.76	8,2
6	Reactivity resource (%)	0.64±0.05	
7	Total number of emergency shutdowns	430	550

The 2000 Plan of Maintenance Work was executed in the scheduled period, June-September. During the period the movable reflector MR-1 decommissioned in 1987 was removed from the operative storeroom, which makes it possible to move MR-3 to the storeroom for the time of modernization.

In the year 2000 a diesel generator for 100 kW was bought from FRG and was erected outside the reactor building to provide reliable power supply for the IBR-2 reactor in case of break down of the regular power supply system. The startup of the diesel generator is scheduled for the 1st quarter of 2001.

The year 2000 saw essential advances in the modernization of the IBR-2 reactor as a result of signing of the Agreement on IBR-2 Modernization between the Atomic Energy Ministry of the Russian Federation and the Joint Institute for Nuclear Research on February 14, 2000 and Contract No. 6.06.19.19.00.950 of 15.03.2000 for the execution of research and construction work in IBR-2 modernization in the year 2001.

In the year 2000:

1. Working documentation of the movable reflector MR-3 is prepared.
2. Strength and elasticity investigations of the alloy ХН77ТЮРУ-ВД (ЭИ 437 БУ-ВД) in the thermally treated state are conducted (Report 23.6365).
3. Technical project (TP) and working documentation (WD) of fuel assemblies (FA) of IBR-2M are prepared.
4. Work to develop TP for the modernization of basic reactor equipment continued.
5. Development of the executive mechanisms of the control and emergency system (CES) started.
6. Manufacturing of the main and auxiliary reactivity modulators, MRM and ARM, and of the MR-3 jacket started in NIKIET.
7. Manufacturing of the following MR-3 blocks started in JINR:
   - cart;
   - platform;
   - technological frame;
   - transmission shaft;
   - dismountable shielding.

   The working schedule to manufacture MR-3 is presented in Fig 1.
1. Industry is prepared for the production of TVEL of the new loading, the necessary amount of plutonium dioxide is produced and its industrial tests are being carried out.
2. A complete set of items for TVEL of IBR-2M is produced and shipped to the Industrial Enterprize Maiak.
3. Documentation on transport of 2 decommissioned fuel assemblies (DFA) of IBR-2 for the purpose of examination after their 5% burn is prepared.
4. The possibility of using the step motor to trigger the emergency system was demonstrated on the test-rig. The results on the speed of response are inspiring.
5. Work to develop technical requirements for the CES electronic equipment of IBR-2 started in IAE (Swierk, Poland).

In the year 2000 financing of works on the project of IBR-2 modernization proceeded according to the financing plan (see Table 3).

No.	Work	Responsible	2000	2001	2002	2003
	MR-2P					
1.	Manufacturing of MR-2P					
1.1.	MMR and AMR	NIKIET				
1.2.	Jacket	NIKIET				
1.3.	Cart	CWS JINR				
1.4.	Transmission shifts	CWS JINR				
1.5.	Technological frame	CWS JINR				
1.6.	Platform	CWS JINR				
1.7.	Removable shielding	CWS JINR				
1.8.	Reduction gear	CWS JINR				
1.9.	Front support	CWS JINR				
1.10.	Piping arrangement	CWS JINR				
1.11.	Sensors	FLNP				
1.12.	Speed gear-box	FLNP				
1.	Assembling on test-rig	FLNP				
2.	Test-rig trials	FLNP				
3.	Moving of MR-3 to bldg. 117	FLNP				
4.	On-site assembling and tests in bldg. 117	FLNP				

Fig.1. Working schedule of the execution of the MR-3 Project

Table 3

The financing plan of the project "IBR-2 Modernization" for the year 2000 (k$)

Work	JINR		MAE		Σ	
	Plan	**Fact**	**Plan**	**Fact**	**Plan**	**Fact**
MR-3	73	**86**	136	**106**	209	**192**
TVELs	24	**34**	136	**160**	160	**194**
Basic equipment	95	**73**	28	**5**	123	**78**
Total	192	**193**	300	**271**	492	**464**

2001 Objectives:

1. Provide beam time in the volume of 2000 h for physical measurements (8 cycles per year, including 3 cycles with CM).
2. Manufacture MR-3.
3. Continue works on fuel loading.
4. Prepare technical project of modernization.

2.2. The IREN Project

The working schedule of the IREN project corrected in accordance with the recommendations of the JINR directorate formulated at the 87th Session of the Scientific Council is implemented in the main points during the year 2000.

The BINP in Novosibirsk completed the construction and tests of the accelerating tubes, buncher and the SLED system for the linac LUE-200 on time. In two test runs conducted with an accelerating tube prototype an acceleration of about 30 MeV/m was obtained, which is sufficiently close to the rated value. The final stage of test measurements carried out in October with participation of JINR experts showed that the shape of the electron energy spectrum differs from the expected. The achieved beam power is only is only 60% of the rated value. Regular financing enabled the shipment of two accelerating tubes to JINR in September. The buncher and the SLED system are due at the end of February, 2001. The design and construction of a powerful RF load and beam diagnostic elements has started in BINP in accordance with the terms of a recently signed contract. Copper tubes for the construction of a solenoid for the magnetic focusing system of the linac were partly ordered or produced. By the end of the first quarter of the year 2001 they will be delivered to JINR. Designing and manufacturing of a set of high-voltage supplies for this system started in BINP in October, 2000. Certain success is achieved in designing and modeling of a pulsed electron gun. By the end of this year a thermo-stabilization and a vacuum systems will be mounted on a full scale RF stand that FLNP assigned for testing of the accelerating tubes of LUE-200.

The contract with a known German firm, PPT, for designing and construction of two modulators for feeding of klystrons 5045 SLAC in LUE-200 is concluded and the designing will be completed in December 2000. It is financed from a long term German loan to the Russian Federation. The conditions of supply of two 5045 SLAC klystrons are agreed upon with the DOE of the USA in the respective agreement signed by JINR and DOE in 1993.

The «Mayak» plant completed the construction and received a license for the fuel elements of the multiplying target of IREN. They will remain at the plant until everything is ready for assembling of the new active zone in the reactor hall of the former IBR-30.

Specialized Moscow institutes, RINM and NIKIET, in close collaboration with JINR developed the technical project of the assembly of IREN in 2000. However, a short delay in financing as well as the necessity to do extra calculations of IREN safety caused by recently introduced stricter requirements for nuclear hazardous facilities in the Russian Federation resulted in a four-month shift of the completion date of the first stage of the technical project. This will obviously lead to a delay in receiving of the license for the decommissioning of the IBR-30 reactor and the construction of the IREN facility. However, there is still a possibility to have this license by the date of the final shutdown of IBR-30 at the end of June 2001.