IGORR-IV Meeting

The state of the PIK reactor construction

K.A.Konoplev
Petersburg Nuclear Physics Institute
Russia

1. Parameters and destination.

1.1 The PIK reactor complex [1] was designed as the national centre of the USSR for neutron research on the c-w reactor. Now, it is considered as the Russian Centre and, possibly, as the International Centre. At present, only four middle-class research reactors with the flux of the order 10^{14}n/cm^{2}s operate in Russia, on which the work with beams is carried out. These are the reactor WWR-M in Gatchina commissioned in 1959, the reactor WWR-S in Obninsk (1964), the reactor IWW-2M in Ekaterinburg (1963), and the reactor IR-8 in Moscow.

The pulsed reactor IBR-2 at JINR (Dubna) is the only modern source in Russia giving about 10^{16}n/cm^{2}s in a pulse but its mean flux is about 10^{13}n/cm^{2}s.

Principle concepts of the PIK reactor project were stated late in the 60's but its construction was started in 1976. By the year 1986 the initial project was realised by approximately 70% but then, (after Chernobyl accident) the construction was essentially frozen to adjust the project to the revised nuclear safety regulations. The revised project was approved only in 1990 when the country was on the threshold of serious economic problems.

The PIK reactor is a source of neutrons(core volume ~ 50l) placed in the heavy water reflector. The fuel - uranium-235 (90% enrichment) of total weight 27 kg. Light water is used as moderator and coolant.

Design parameters:

- thermal power - 100 MW
- thermal neutron flux
  in the reflector - 1.2x10^{15}n/cm^{2}s
  in the central vertical beam tube - 5.10^{15}n/cm^{2}s.
- a number of horizontal beam tubes -10
- diameter of beam tubes - 10 cm with the possibility of their replacement with beam tubes up to 25 cm in diameter.
- a number of inclined beam tubes - 6

- a number of vertical tubes
  for irradiation of samples - 6

The reactor will be equipped with sources of hot, cold (2 pieces), and ultracold neutrons to obtain beams in different parts of energy spectrum.

The low temperature circuit will make it possible to irradiate samples at helium temperatures.

The branched system of neutron guides (4 for cold neutrons and 4 - for thermal neutrons) of total length ~ 300m allows to transport beams into pure (backgroundless) conditions of neutron guide room adjacent with the reactor building. The total number of positions on beams for arrangement of experimental installations - 50 [1]

The reactor has three series cooling circuits. Emergency core cooling systems in LOCA are duplicated and in emergency power supply system is triplicate.

The PIK reactor has no single common containment but four separate systems: for pipelines and units of the first circuit, for heavy water reflector, for operating hall, and for experimental beam tubes hall. Requirements for retention of radioactive products, in accordance with expected consequences of initial events, are imposed on each of them. Naturally, in case of accident, fission product yield is the highest and the most severe requirements are imposed on containment in which the first circuit is placed. The containment of the operating hall which walls serve as exterior walls of the building is constructed as double with an air gap across all the area.

2. The state of construction and prospects

The vast majority of buildings and construction (27) of the complex have been built (fig.) though finishing work have been completed not in all of them.

At present we are lacking of:

- building for a reserve diesel station and for a simulator which were called for during inspection of the project (the foundation has been laid);
- building and a group of satellite objects of the plant for isotopic purification of reflector heavy water (actually they will be needed within three years after the start-up when tritium will be accumulated);
- building for special fire depot;
- shower water purification system.

All these objects are not included into the starting-up complex, except the first one, and may be completed later.

All the problems of power supply are practically solved:

- energy supply of the first category of safety is performed by three already installed independent high voltage lines (power substation is in the stage of construction);

- water is supplied from available artesian wells with a special system for purification and softening;

- heat supply is performed from central boiler operating on the territory of the institute (heat is supplied to all the construction blocks now).

The construction of the double-fenced, instrumented security barrier around the territory of the complex has been completed. It is planned to be put into service in full in 1995.

1995 it is planned to complete the work on reinforcement of ceilings over the main and operating halls (shield containment) that will make possible the erection of the reactor itself as well as systems of the first circuit ("pure zone").

The equipment of the intermediate circuit as well as that of the power supply block is practically mounted in full.

Today the lack of sufficient financing actually prevent mounting work at other objects of the complex.

The critical assembly - a full-scale model of the PIK reactor operating at the power up to 100 W was created and put into operation. This assembly enables to check experimentally, under actual conditions, neutron - physical parameters of the PIK reactor and to optimise them.

At this moment, constructional readiness of the complex is evaluated as approximately 80%, completeness with equipment - as 65 - 70%.

The assessment of uncompleted work $30 million (without the plant for isotopic purification of heavy water). This estimate is approximately 3 times higher that made in 1992. It coincides in the digit 30 but in the year 1992 it included all the objects of the complex and partially, the social sphere. Since that time inflation of the rouble, increase in estimated cost in the field of building, and change of exchange rate have led actually to 3 times increase of the cost of construction in dollars. The assessment of potentialities of industrial enterprises producing equipment as well as those of erection organisations carrying out work at the complex shows that in case of guaranteed and regular financing the work at the starting up complex may be completed within 2,5 - 3 years.

Attempts to internationalise the project, i.e. attraction of financial resources of western partners at the level of governments of a number of leading countries of the West, which were made in 1992-1993 (a special resort of Gaydar E.T. acting chairman of the Government, to leaders of a number of countries) with obligations of the Russian party to organise the International Neutron Research Centre on the basis of the PIK reactor, did not give any results, in spite of the positive, in a whole, conclusion of international experts.

At the present time the project is financed on the lowest level. This resources are sufficient to complete reconstruction of the reactor block, which primarily consists in completion of construction of the containment for operating hall as well as in completion of security barrier of the territory according to high enriched uranium storage regulations. A part of these resources is also intended for design work connected with replacement of the reactor control system with modern element base.

The heavy water purification and processing plant [2] is, probably, the most attractive for possible commercial investors.

At PNPI the original procedure of such reprocessing was developed and tested on experimental plants. The detailed design of large - scale plant has been developed. Its realisation requires capital investments at the level of $10 million. Plant capacity ~ 40 t/year of high conditioned D^2O.

Prior the reactor start-up and over the first three years of its operation, all these capacities and then, approximately a half of them may be used for servicing outside customers.

Estimated time of invested expenses justification will constitute 3 years , taking into account the construction, raw and operation expenses,

3. Discussion of the project with "Goskompriroda"

Some years ago, new requirements on authorisation of projects, prior their construction, with nature protection body were introduced. These requirements include also the discussion with the public. Although the construction of the PIK reactor was started many years ago, it was decided to apply this procedure to the PIK reactor reconstruction project.

The discussion with the public was turned aside to nuclear power development or to non - acceptance of nuclear physics as science. In the positive part it was adopted that PNPI had increased cultural potential of the town Gatchina, that a great contribution had been made to development of engineering infrastructure of the town. The creation of town sewage treatment plant as the first stage of the construction of the PIK reactor was especially pointed out, as well as the contribution to development of social sphere of the town, i.e. living houses, a school, kindergartens, sport complex, and so on. At this point it is appropriate to draw attention to a considerable warming - up in attitudes of the public to the PIK reactor and to nuclear power , as a whole. Late in the 80's and early in the 90's it was extremely difficult to protect NPP in public discussions and it caused a protest in itself, but now, the discussion is much businesslike in character. It may be explained by the fact that the population made certain decision of thoughtlessly of slogans on shut down of NPP.

In the work with experts on the technical part of the project calculations of dose commitments at design and hypothetical accidents of the reactor were discussed most seriously. Calculations were made by independent organisations and using different programs. Experts claimed to consider the full melting of the core though, according to design basis events, such melting had not taken place. The full melting of the core implied more rigid requirements for tightness of containment of the reactor, which were adopted as additions to existing measures on localisation and mitigation of accidents.

The demand on creation of the system for purification of shower waters from the reactor area, prior their discharge to a river, was put forward. It should be noted that it will be the first similar system in the town of Gatchina.

Of requirements of experts which influenced the project volume it should be noted the development of local automated radiation monitoring system of 20 posts situated on the territory of PNPI as well as in the exclusion area and supervision zone and also, full-scope replica training simulation.

The rest requirements only slightly effect the project and are, generally, referred to operation conditions of the reactor.

4. R & D

Specific investigations were carried out in connection with the opportunity of increase of reactor parameters and further study of safety problems.

4.1. The possibility to increase the reactor working cycle.

The introduction of the absorbent to heavy water circulating in the gap between two walls of the core tank when reactor is about subcritical releases a part of reactivity on control rods to increase a cycle duration. According to calculation confirmed on a critical assembly it is possible to increase the working cycle approximately by 4 days. In case of this procedure no alteration in the reactor design and core occur.

The use of roads with burnable absorber instead of dummy one in fuel assemblies enables also to prolong the operation by 6 days. The work on validation of the design model is being continued on the basis of available experimental data.

4.2.

The work on substitution of materials for fuel assembly shroud of stainless steel on zirconium is continued. Such substitution will make it possible the increase of burn up in spend fuel elements by approximately 5% . New fuel assemblies should stand all the test cycle of their safety use to get authorisation.

4.3. Substantial prospects of improvement of parameters of the PIK reactor are connected with replacement of steel core tank with aluminium alloy tank. In so doing, the increase of the thermal neutron flux in the reflector is possible as well as the increase of the reactor service life without replacement of its tank. The work goes rather slowly due to the need in data on radiation damage stability of aluminium alloys up to fluences 2.10^{22} n/cm^{2}s that demands sizeable funds.

4.4. Development and manufacturing of the in-service inspection system for equipment were stopped due to limited funds but available diagnostic devices were used to inspect the equipment which was bought and already mounted. This work is carried out in parallel with surveillance tests of existing equipment in conformity with new requirements for reliability of separate units. Additional calculations and inspection allow to come to decision as to measures on preserve, on necessity of reinforcement or replacement of one or another unit. Thus, of 17 units examined in 1992, 16 were certified by the state safety commission as suitable for future operation and one unit needs additional reinforcement.

Acknowledgement.
It is a pleasure to express grateful to my colleges who assisted in this report preparation S.L.Smolsky, Yu.P.Semenov, V.D.Trenin, Z.K.Krasotsky, N.D. Schigolev, L.M.Ploschansky, V.I.Didenko and A.S.Zakharov.

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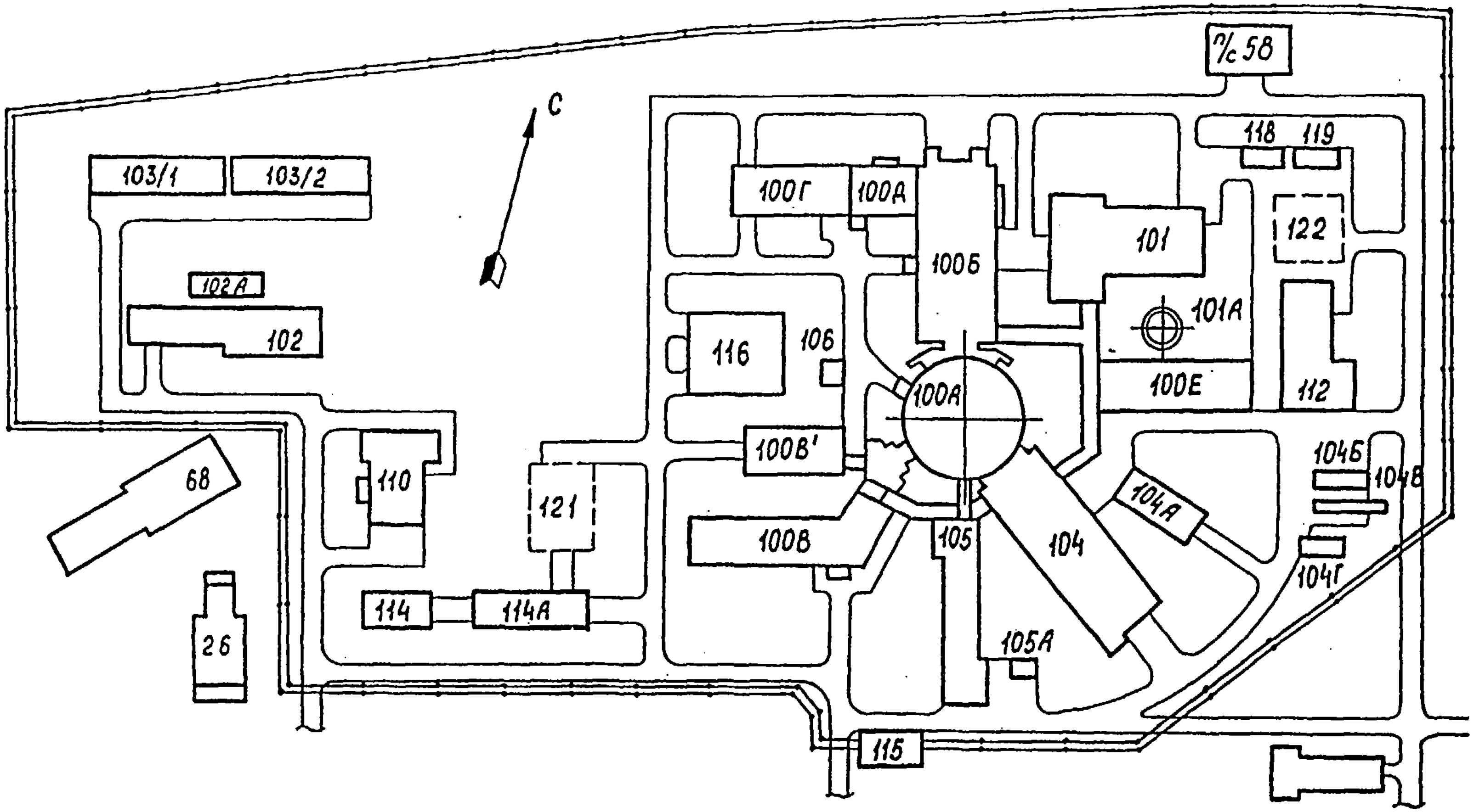
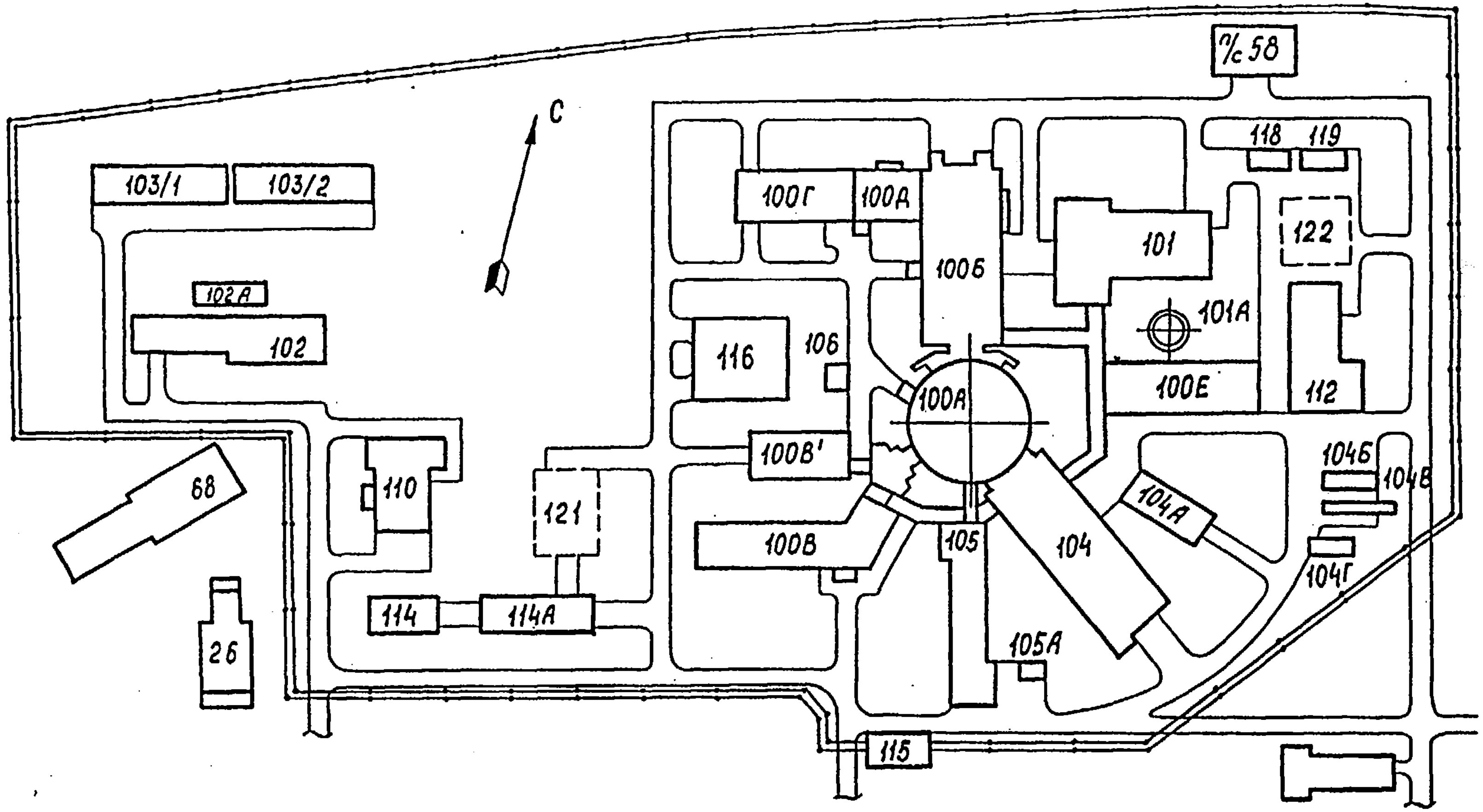


Fig.1. General layout of PIK complex Notations

—fence,
— buildings under construction,
— buildings in design stage.

100A — reactor and physical research laboratories
100B — primary circuit pump station and hot cells
100B — personnel sanitary entrance and ventilation system
100Г — intermediate circuit pump station
100Д — nuclear power unit
100E — cryogenic station
101 — ventilation center
101a — ventilation chimney
102 — circulating water supply pump station
102A — cold water tank
10[illegible] — co[illegible])wers
104 — neutron guide halls and laboratories
104A — technical block
104Б — circulating water supply pump station
104B — cold water tank
104Г — cooling tower
105 — physical research laboratories
105A — storehouse
106 — carbon dioxide
110 — compressor station
112 — isotopic purification plant
118 — nitrogen shop
114 — storehouse
114a — storehouse
115 — guardians office
116 — emergency diesel power plant
58 — power substation
28 — chemical water purification plant
68 — emergency tanks
121 — simulator
122 — liquid radioactive waste state



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