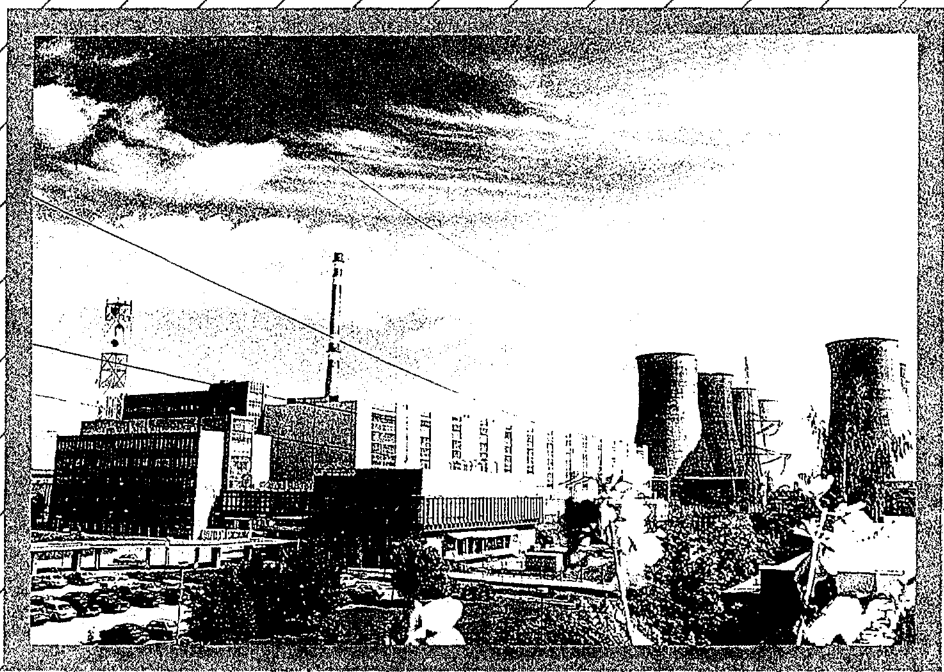
NUCLEAR POWER PLANT V-1



Beginning of construction
24 April 1972

Reactor Unit 1		**Reactor Unit 2**
	First controlled reactor power	
27 November 1978		**15 March 1980**
	Connection to the grid	
17 December 1978		**26 March 1980**
	Commercial operation	
1 April 1980		**7 January 1981**

NPP V-1 CONSTRUCTION

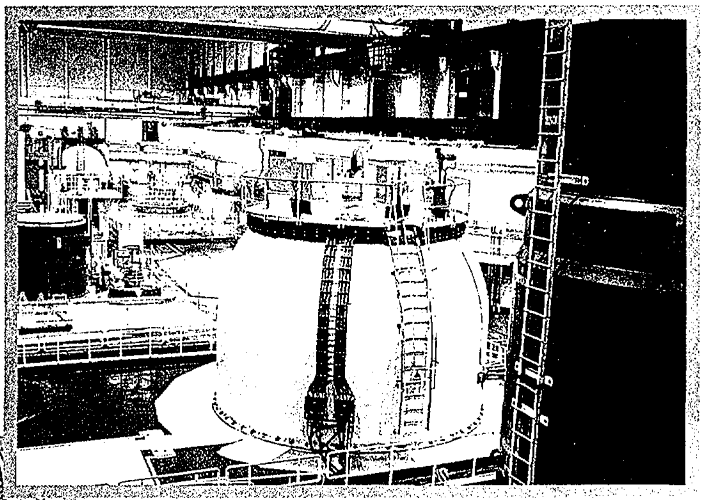
In the 1970s the national economy development in the former Czechoslovakia required to solve essential issues of fuel-power engineering basis by means of searching for new power resources. Solving the increasing needs for electric power, basic structural changes were accomplished in the power engineering area orientated towards the nuclear power engineering.

In 1970 governments of Czechoslovakia and the Soviet Union made an agreement on the construction of twin reactor units VVER 440 (type 230) in the area of Jaslovské Bohunice (NPP V-1). The heavy water programme was practically finished by signing of this agreement and the transition to the light water programme was commenced. The pressurized water reactor orientation turned out to be correct, because this type holds the dominating position worldwide due to its simplicity, reliability and compactness.

The NPP V-1 construction was commenced by the power plant auxiliary facilities erection on April 24, 1972. This happened in the area where some facilities were already available to contractors, as there was a construction site equipped during the preceeding NPP A-1 construction. A year later, on April 25, 1973 the main generation building foundation-stone was laid.

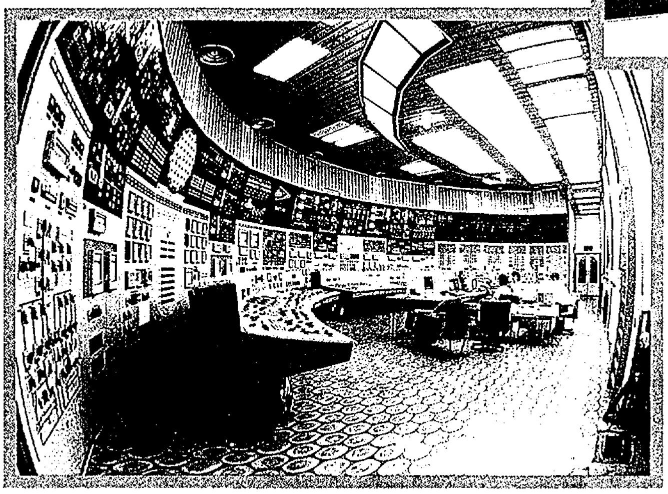
Both preparations and performance of the NPP construction including its commissioning were made in mutual co-operation of specialists and companies from Czechoslovakia and the former Soviet Union. The prevailing part of the power plant primary - nuclear - part deliveries came from the Soviet Union, whereas secondary - non-nuclear - part equipment were delivered by Czechoslovak companies.

The Soviet design company Teploelektroprojekt, its Leningrad branch LOTEP, acted as the General Designer of the nuclear power plant primary part. Energoprojekt Company Prague was the Czechoslovak General Designer. Hydrostav Bratislava became the General Contractor of the construction part. Škoda Company, its branch "Výstavba jaderných elektráren" Plzeň-Bolevec, acted as the Senior Contractor of the secondary part and Contractor of the primary part assembly.



Reactor hall

Main control room



The total construction time of the NPP V-1 reactor units 1 and 2 did not exceed 6 years. 1.5 million cubic metres of earth were dug up at the construction site, 337,000 cubic metres of concrete were poured, 70,000 tons of prefabricated elements and 15,000 tons of steel structures were used during the construction. Methods of association of both construction and erection activites, as well as the system of preerection into suberection units were applied to a considerable extent which resulted in shortening the running construction terms. This system was later applied to other nuclear power units and power plants.

The NPP V-1 in Jaslovské Bohunice became the first Czechoslovak industrial type nuclear power plant with fully mastered and serially produced equipment, as well as a significant electric power producer in Slovakia.

MAJOR TECHNOLOGICAL EQUIPMENT

PRIMARY CIRCUIT

The primary circuit of the nuclear power plant provides the heat transfer from the reactor into steam generators.
The primary circuit comprises the reactor, pressurization system and six loops running in parallel.

Nuclear Reactor

The reactor is a source of heat used for electric power generation. The VVER 440 type reactor runs on the basis of thermal neutrons, it is cooled and moderated by chemically treated, demineralized and pressurized light water. The reactor assembly comprises the reactor pressure vessel body, upper block, reactor core barrel, core barrel bottom, core basket, protection tube system, fuel assemblies, tandems of fuel assemblies and absorption rods connected by tie rods to drives installed in upper block casings on the vessel closure head.

There is the reactor core located inside the reactor pressure vessel. The core is made up by a special structure shaped as a stainless steel basket.

Fuel assemblies are located in idividual nests in the reactor core. Slightly enriched uranium oxide formed into pellets is used as nuclear fuel. The pellets are gastightly inserted in the fuel rod cladding. The fuel rods are assembled into fuel assemblies.

The reactor control system comprises control rods and a chemical control system based on boric acid. Boric acid concentration levels are used to compensate slow changes in reactivity (fuel burn up), to flatten the neutron flux spatial distribution and provide scheduled reactor shutdowns.

The reactor operation cycle is 10 to 12 months. The scheduled reactor shutdown takes place once a year. Major overhaul of both primary and secondary circuits equipment is performed, as well as refuelling actions are taken during the shutdown period. The refuelling is made by means of the refuelling machine under a protection water layer (shielding). One third of fuel assemblies are refuelled.

The reactor is installed in the reactor cavity. The reactor outer shielding consists of the following components: the water biological shield in a steel tank surrounding the reactor pressure vessel opposite the reactor core and heavy concrete (specific weight of 3.6 t/m^3) in the other parts.

Steam generators

Steam generators are heat exchangers between the primary and secondary circuits. The heat-carrying medium - water - circulates in steam generator primary side tubes. Saturated steam is produced on the steam generator secondary side. It is led to turbine generators.

The steam generator is of the evaporation type, being fitted with a bundle of horizontal tubes installed inside a horizontal boiler body. A couple of primary circuit collectors are located in the central part of the body; one of them (hot) providing the coolant inlet, the other (cold) providing the coolant the outlet.

There are 5,536 heat-exchanging tubes inside each steam generator. In addition, each steam generator has a heat-exchanging margin of 25% available.

Reactor Coolant Pumps

Reactor coolant pumps provide the heat-carrying medium circulation within the primary circuit. They are designed as vertical sealless centrifugal pumps with built-in asynchronous electromotor. Each pump is equipped with an auxiliary device assuring its operation function.

Primary Circuit Auxiliary Systems

The following auxiliary circuits and systems are installed to assure both the reactor and primary circuit operations:
- pressurization system - it produces the primary circuit heat-carrying medium pressure and assures its stabilization at specified operation mode parameters,
- primary circuit water purification system - it provides a continual purification of active waters,
- primary circuit make up and boric acid control system - it compensates for organized leakage of the circulating coolant and controls boric acid concentration,
- emergency states localization and liquidation system - it consists of a spray system installed inside the hermetic confinement, boric acid high pressure injection system into the primary circuit and overpressure dampers
- refuelling equipment - it assures all actions related to fresh and burned up fuel: acceptance, storage, and refuelling,
- treatment and disposal of solid and liquid radioactive wastes (for their long term storage),
- ventilation stack and special heating, ventilation and air conditioning equipment (air exchange in active rooms).

SECONDARY CIRCUIT

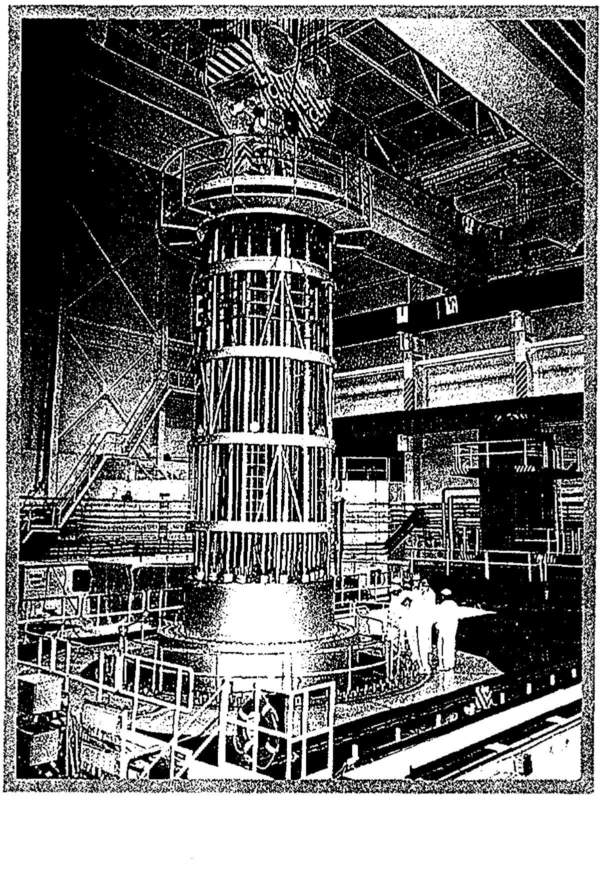
The secondary circuit is a set of equipment providing the conversion of pressure and thermal powers contained in steam generated in steam generators into electric power. Besides, the secondary circuit assures the gradual warm up or cool down of the primary circuit during the reactor unit start-up, standard and transient modes and shut-down.

The nuclear power plant secondary circuit machinery does not basically differ from the conventional thermal power plant machinery. This includes steam pipelining, control and stop valves, steam turbines, condensers, all kinds of pumps, feedwater treatment equipment, heat exchangers, steam separators, steam dumps into condensers, low- and high-pressure regeneration, primary circuit aftercooling system, protection and control devices.

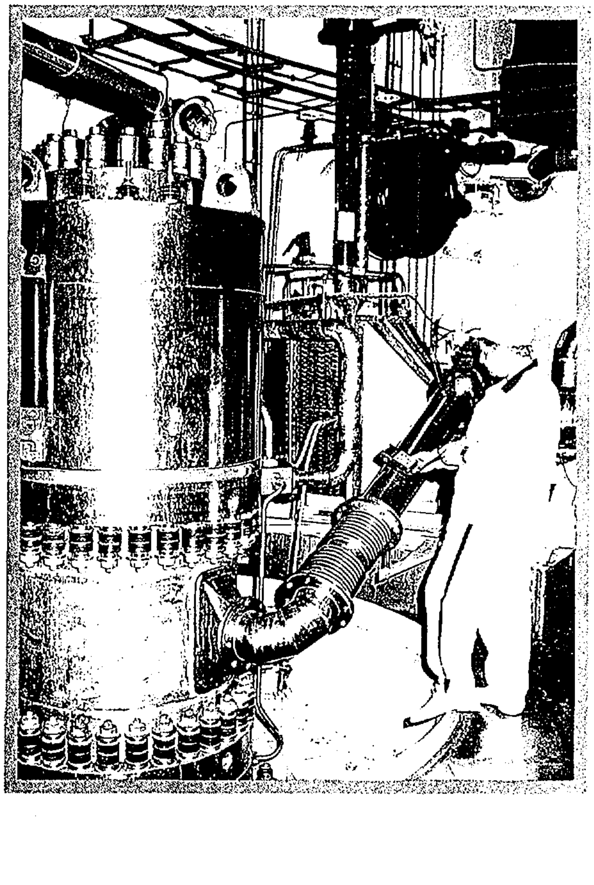
Turbine Generators

A reactor unit includes a couple of turbine generators of 220 MW each. The turbine is of the condensating type. It consists of a single medium-pressure stage and two low-pressure stages and is designed to use saturated steam. A water

Reactor pressure vessel upper block



Reactor coolant pumps platform



separator - steam reheater is installed between the medium- and low-pressure parts of the turbine. Besides, steam is taken from the turbine and led to steam generators feedwater regeneration warm up system and to the heat-exchanging plant.

The main generator is a three-phase generator with combined direct and circulation cooling of both stator and rotor. In addition to the main generator, there is a house load generator installed on the common shaft with the turbine. Reactor coolant pumps (power output of 6 MW each) and excitation sets are supplied from the house load generator. The turbine generator accessories are as follows:

- steam dumps,
- cross surface condensers,
- condensers cooling system,
- auxiliary accessories.

Nuclear Power Plant Electrical Equipment

The essential part of both electrical equipment and cable distribution systems, measurement, regulation and control systems is located within the main generation building.

Increased requirements for reliability of electrical consumers and drives power supply are involved in the house load power supply system. Both the consumers and drives are divided into three categories in compliance with the power supply interruption time. The house load emergency and reserve power supply is assured from coasting turbine generators, off-site transmission lines 110 kV and 220 kV and on-site diesel generator plant.

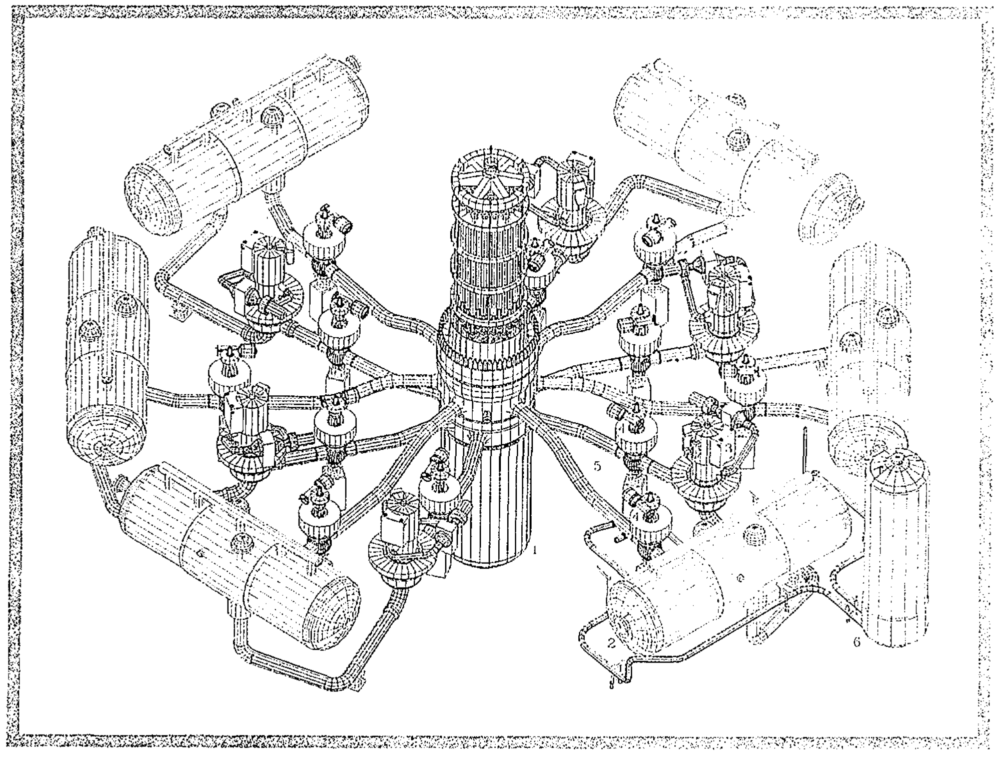
OTHER POWER PLANT SYSTEMS AND BUILDINGS:

- pumping plant in Pečeňady,
- main pumping plant of cooling, service and fire fighting water,
- cooling towers with natural draught,
- chemical water treatment plant,
- compressor and cooling plant,
- gas storage plant,
- auxiliary heating plant,
- oil storage plant,
- waste water purification plant,
- diesel generator plant.

Power Plant Control

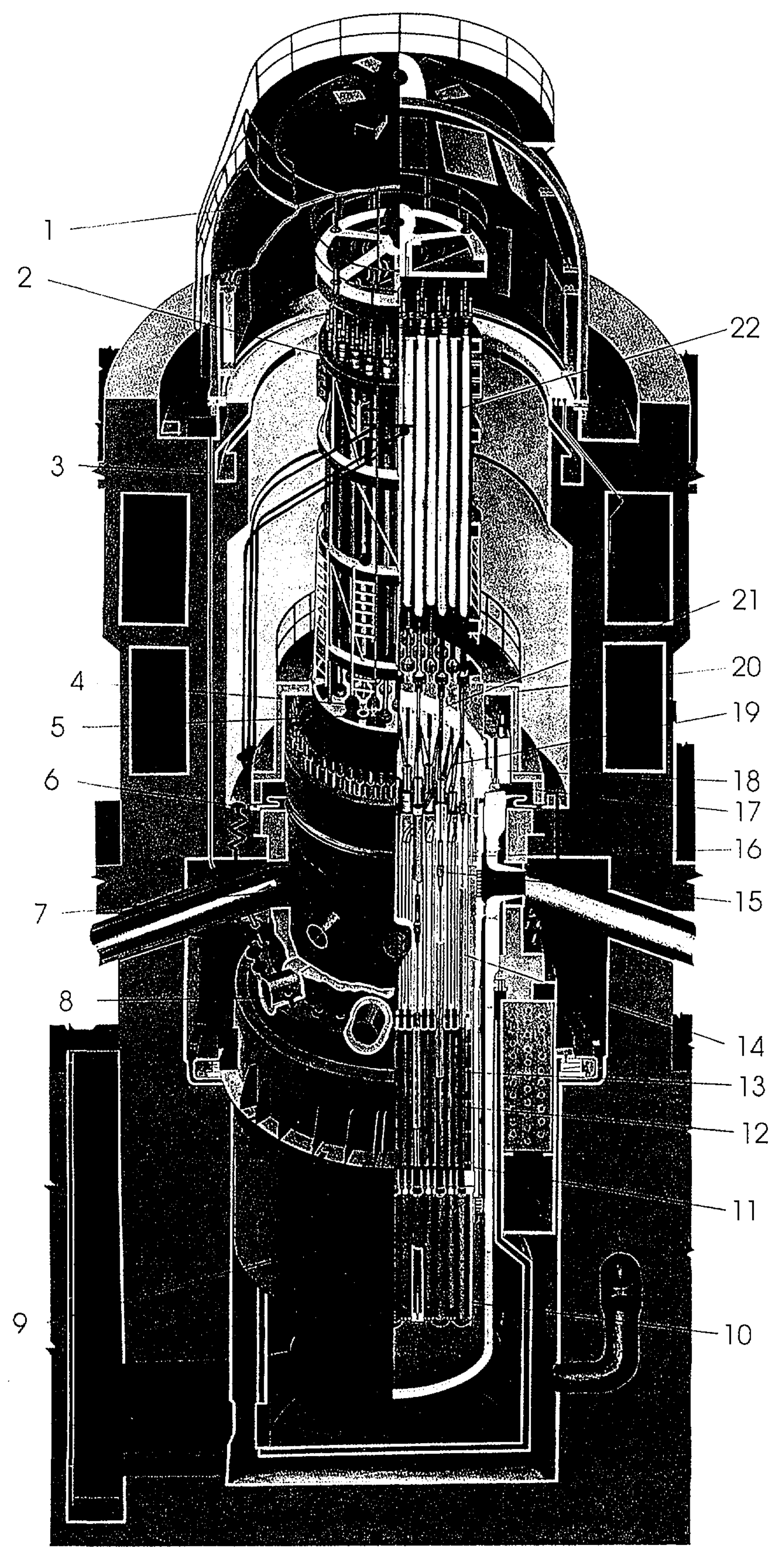
The power plant is controlled from two main control rooms where operation, control, measurement, alarming equipment, as well as protection devices and automatics are concentrated. The proper functioning of controllers of automatics is supervised by the operation crew consistingof a Unit Supervisor, Reactor Operator, Turbine Operator and Electrical Equipment Operator. The main control crew can apply the remote control measures to the equipment, if needed (equipment testing, repairs), or in extraordinary situations. The central process information system provides continual monitoring and storage of several thousands of data and information items that are subsequently presented to highly-qualified personnel to enable them to control the power plant in an optimum way.

VIEW OF THE NPP V-1 PRIMARY CIRCUIT



1. Reactor
2. Steam generator
3. Reactor coolant pump
4. Main isolation valve
5. Main circulation pipeline
6. Pressurizer

REACTOR VVER 440 V230



1. Protective cover
2. Upper block
3. Ionization chamber channel
4. In-core neutron flux measurement
5. Temperature measurement channels
6. Diaphgram-operated valve
7. Reactor pressure vessel
8. Main circulation pipolino
9. Water biological protection tank
10. Reactor core barrel bottom
11. Reactor core basket
12. Fuel assemblies
13. Fuel part of the control rod
14. Absorber portion of the control rod
15. Coupling rod
16. Protecting tube block
17. Sealing ring
18. Thrust ring
19. Temperature measurement channels
20. Thermal isolation
21. Rack
22. Control rod drives

TECHNICAL DATA

Number of reactor units	2
Installed capacity of power plant	2 x 440 MW
Thermal output of reactors	2 x 1375 MW
REACTOR	
Reactor type	VVER 440 V 230 heterogenous with thermal neutrons
Coolant and moderator	demineralized water
Reactor pressure vessel	
Dimensions	
- Diameter (mm)	3,840
- Height (mm)	11,800
- Weight (t)	215
Material	carbon, low-alloy and high-temperoture steel
Reactor core	
- Diameter (mm)	2,880
- Height (mm)	2,500
Number of fuel assemblies	292
- Shape	hexagonal prism
- Diameter (mm)	144
- Height (mm)	3,200
Number of dummies	20
Number of fuel rods in an assembly	126
- Diameter (mm)	9,1
- Height (mm)	2,500
Cladding material	Zr + Nb alloy
Fuel assembly enrichment (% U 235)	1.6 2.4 3.6
Number of control rods	37
- Shape	hexagonal prism
- Diameter (mm)	144
Fuel load (t)	42
Inlet coolant temperature (°C)	265 ± 2
Outlet coolant temperature (°C)	294 ± 2
Water pressure (MPa)	12.26
Primary water inventory (m³)	223
STEAM GENERATOR	
Number of steam generators per reactor unit	6
Inner dimensions	
- Length (mm)	11,800
- Diameter (mm)	3,210
Weight (t)	145
Steam output (T/h)	452
Steam pressure (MPa)	4.6
Steam temperature (°C)	256
Feedwater temperature (°C)	158; 223
Number of heat-exchanging tubes	5,536
Heat-exchanging surface (m²)	2,510
REACTOR COOLANT PUMP (RCP)	
Number of RCPs per reactor unit	6
PRC electromotor power input (MW)	2.05
Voltage (kV)	6.3
Speed (rev/min)	1,470
Coolant flow rate (m³/h)	
- Reactor unit 1	42,950
- Reactor unit 2	43,140
TURBINE GENERATOR (TG)	
Number of TGs per reactor unit	2
Rated output (MW)	220
Speed (rev/min)	3,000
Turbine	three stages condensing 1 medium-pressure stage 2 low-pressure stage
Steam temperature (HP) (°C)	256
Steam pressure (HP) (MPa)	4.22
Steam temperature (LP) (°C)	216.5
Steam pressure (LP) (MPa)	0.363
Output voltage (kV)	15.75
Cooling	water/hydrogen
CONDENSER	
Number of condenser parts	2
Design	2 [illegible] chambers each
Volume flow rate of cooling water (m³/h)	[illegible]
Maximum temperature of cooling water (°C)	[illegible]
Number of heat-exchanging tubes	[illegible]
Heat-exchanging surface (m²)	[illegible]
Condenser cooling mode	circulation cooling towers with natural draught
COOLING TOWERS	
Number of cooling towers	4
- Height (m)	120
- Lower diameter (m)	84.4
- Upper diameter (m)	53

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