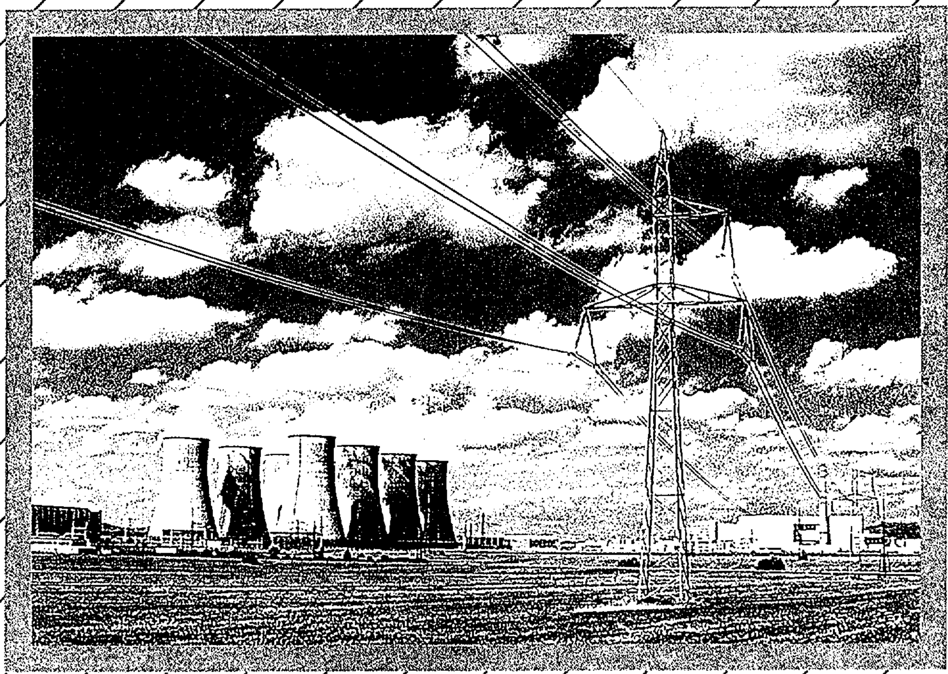
NUCLEAR POWER PLANT V-2



Beginning of construction
December 1976

Reactor Unit 1		Reactor Unit 2
7 August 1984	First controlled reactor power	2 August 1985
20 August 1984	Connection to the grid	9 August 1985
14 February 1985	Commercial operation	18 December 1985

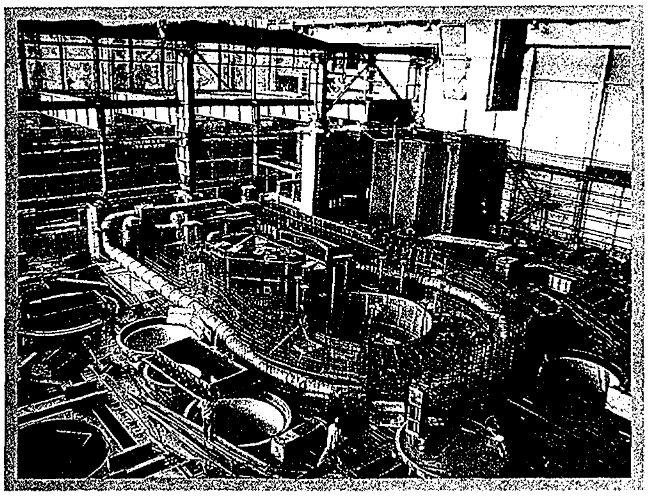
NUCLEAR POWER PLANT V-2 CONSTRUCTION

In order to utilize experience gained during the NPP V-1 construction, as well as existing facilities of construction and assembly companies, construction of another type nuclear power plant based on VVER 440-type reactors was commenced in the area of Jaslovské Bohunice in 1976. The NPP V-2 conceptual design complied with worldwide trends towards further improvement of nuclear safety parameters.

Energoprojekt Company Prague acted as the NPP V-2 General Designer, the Leningrad branch of Teploelektroprojekt Company only providing technical assistance. Hydrostav Bratislava continued to function as the General Contractor of the construction part. ŠKODA Company became the General Contractor of technological equipment, while the share of Czech and Slovak companies in the deliveries was increased.

The NPP V-2 is an upgraded type of VVER 440 equipped with reactors of V-213 type. Both the technological design and media parametres are equal to those of the neighbouring NPP V-1 except for some small differences. Significant differences consist in the way of nuclear power plant operation control, as well as in the safety systems equipment.

The NPP V-2 reactor unit 2 having been commissioned on 18 December 1985, the construction of the nuclear power engineering complex in Jaslovské Bohunice was completed and full-scale operation at electric power of 1760 MW was commenced.



NPP V-2 construction

MAJOR TECHNOLOGICAL EQUIPMENT

The main generation building comprising the reactor hall and machine hall is the central building of the power plant. The main generation building technological design comprises two circuits, i.e. the main generation building consists of a primary and a secondary circuit.

The primary circuit involves a reactor, pressurizer and six circulation cooling loops, each of them consisting of a steam generator, reactor coolant pump and interconnection pipelines.

The secondary circuit is constituted of turbine generators, steam lines, condensers, technological water and condensate regeneration and make up systems and condensers cooling water circle.

REACTOR

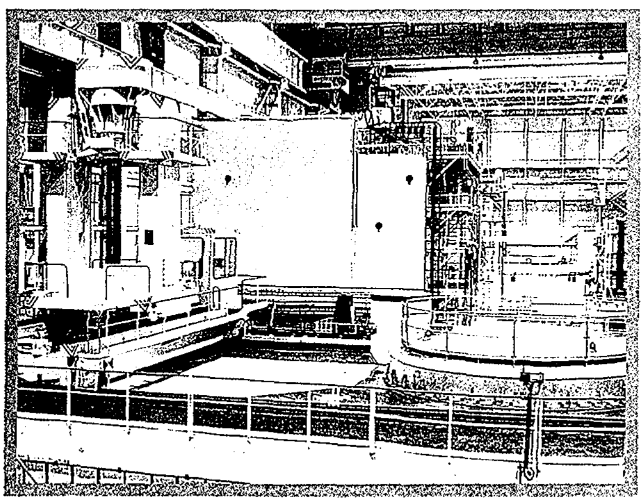
The reactor pressure vessel is among the most significant reactor components. It is made of chrome-molybdene-vanadium steel with a welded internal stainless steel liner. The reactor pressure vessel consists of three major parts: a cylindrical body, a vessel closure head that forms the upper block together with control rod drives, and a free flange. A reactor core support barrel is suspended inside the reactor pressure vessel. The barrel is a support structure to the reactor core and other reactor internals. At the same time the reactor core barrel separates the reactor coolant inlet and outlet spaces from each other. The thicker central part provides the protection of the reactor pressure vessel from irradiation effects.

A reactor core basket containing fuel assemblies is located inside the barrel. The reactor core is elastically pressed down by the protection tube system. Axial positions of fuel assemblies, as well as required fuel assembly heads spacings are fixed by the protection tube system. This system also provides control rods guiding, thermocouples guide tubes fixing and in-core measurements output from the reactor.

A core barrel bottom is suspended in the lower part of the reactor pressure vessel. The elliptical perforated core barrel bottom assures the coolant flow directing and calming down before the coolant enters fuel assemblies. Hydraulic dampers are installed in the lower part of the reactor core barrel bottom. They provide control rods movement damping during the reactor shut-down or scram.

Main control room

Reactor hall



NUCLEAR POWER PLANT OPERATION SAFETY

Nuclear safety of a nuclear power plant is conditioned by faultless and continuously reliable functioning of the whole equipment and all systems at the nuclear power plant. Those equipment and systems are included that:

- prevent emergency occurrences, or
- remove failure consequences,
- confine radioactive materials within specified space and
- prevent from their dispersion into the environment in case they are released.

The present nuclear reactors safety level provides the assurance that all reactor systems are able to manage failures independently including the maximum design-based accident without any danger to the population and environment.

SAFETY BARRIERS

The nuclear power plant safety principle is based on the principle of separation of nuclear materials from the environment by several barriers. The goal of the safety barriers application is to prevent radioactive materials from their leakage into the environment and to protect from ionizing radiation in any operational status even in case of a failure.

The first safety barrier is represented by the firm ceramic form of nuclear fuel - fuel pellets are hermetically closed in a metal thin-wall tube made of a zirconium alloy.

The second safety barrier is formed by hermetically closed pressure system of the primary circuit comprising the reactor pressure vessel. The primary circuit prevents from leakage of the cooling medium containing radioactive materials to the environment at all anticipated temperatures and pressures. There is a steel-concrete cylindrical coat around the reactor pressure vessel that protects man from a direct radioactive radiation.

The third barrier is the hermetic zone or confinement, capturing radioactive materials which can leak out as a result of eventual damaging of the first or second barrier.

Reliability of each barrier is of a high level and probability of simultaneous damaging of all the three barriers is very low.

SAFETY SYSTEMS

Individual safety barriers are complemented by the safety system at the nuclear power plant. The main task of the safety systems is:

- to assure heat removal from the reactor core,
- to prevent from the primary circuit failure and reduce the hermetic confinement pressure,

in order to protect individual safety barriers in any operational status even in case of the maximum design-based accident, i.e. primary pipeline rupture in a section towards the reactor.

The safety systems are divided into active and passive systems.

Active Safety Systems

They require an electric power source to be able to run and comprise the high- and the low-pressure emergency systems and the spray system.

HIGH-PRESSURE AND LOW-PRESSURE EMERGENCY SYSTEMS

High-pressure and low-pressure emergency systems consists of the tanks with the boric acid solution and of the pumps supplying the primary circuit with the boric acid, when the cooling water supply to the reactor broken off. Increasing the boron concentration in the main coolant stops the fission reaction. High-pressure system serves for keeping the pressure in the primary circuit on the required level. If the high-pressure system pumps would not be sufficient for water injection to the primary circuit, the low-pressure pumps are actuated to ensure the continuous coolant injection to the primary circuit. After the tanks are pumped out, the pumps suck water through the heat exchanger from the floor of hermetic boxes.

SPRAY SYSTEM

The spray system is activated in case that the hermetic confinement pressure has increased due to a primary circuit failure. The spray system activation results in decreasing the hermetic confinement pressure due to the steam-air mixture condensation.

Passive Safety Systems

They do not need any electric power source to function. They comprise hydraulic accumulators and the bubbler condenser system.

HYDRAULIC ACCUMULATORS

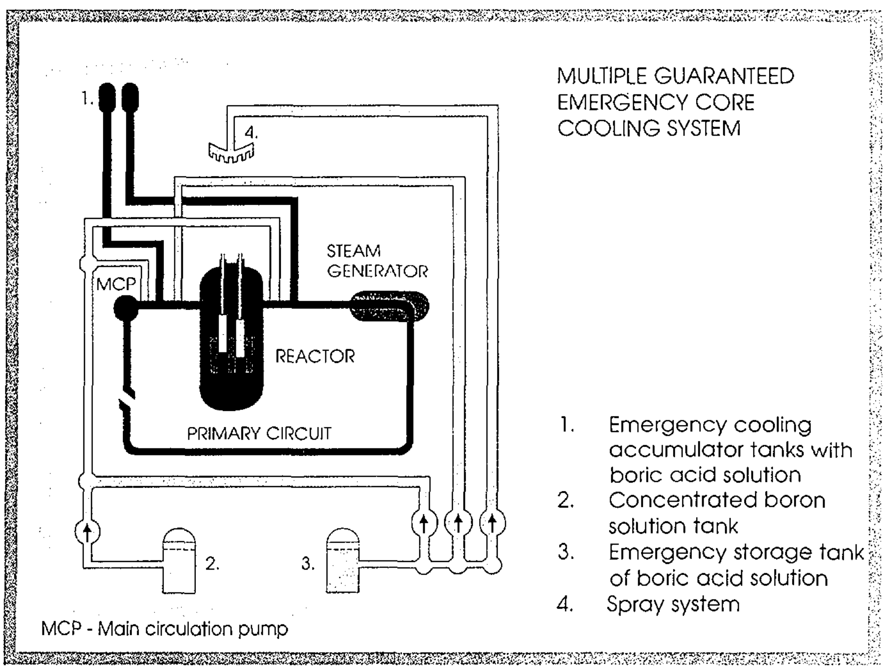
If the water pressure in the reactor drops below a certain value equal to the pressure in hydraulic accumulators containing boric acid, the accumulators begin to flood the reactor core and, at the same time, remove the core heat.

BUBBLER CONDENSER SYSTEM

The bubbler condenser system is a twelve-storey set of overlapped trays filled up with boric acid solution. The boric acid solution forms a water seal with a relative high total flow rate cross section and low hydraulic resistance. The lower space of the water seal is connected with the steam generator compartment, whereas the upper space of the water seal is connected to four air trap volumes via check valves.

In case of a loss of primary coolant accident within the hermetic confinement, the gas-steam mixture passes through the water seal and its steam phase is cooled down and condensed. The non-condensing air and radioactive gases pass through check valve units into air trap volumes where they remain trapped. Subsequently, they are purified by heating, ventilation and air conditioning systems.

All safety important systems are backed up in a multiple manner. Under normal operation, they are ready to start functioning immediately. They are independent and spatially separated from each other.



CENTRALIZED HEAT SUPPLY SYSTEM

After the completion of the centralized heat supply system of Trnava town from NPP Bohunice the nuclear power plant V-2 switched to the combined operation mode: both electric power and heat generation. The heat supply pipeline NPP Bohunice - Trnava is also a part of this system. It was commissioned on 6 December 1987.

The heat supply bears a heating character with the whole year operation. The heat is supplied by means of hot water of the following maximum parameters:

- V-2 NPP's heat-exchanging plant outlet temperature: 150 °C,
- maximum heat-exchanging plant outlet water pressure: 2 MPa
- return water temperature at the heat-exchanging plant inlet: 70 °C,
- heat-exchanging plant output: 240 MWt

The above mentioned parameters are valid for the local calculation temperature of -12 °C. The heat supply is controlled on the quality-quantity principle, i.e. the supplied thermal power is varied due to changes in the return water flow rate and outlet temperature.

The supplied heat is used by both communal and industrial areas for heating purposes in houses, flats and buildings and for service hot water preparations only.

The centralized heat supply system comprises the following components in the part of Trnava locality:

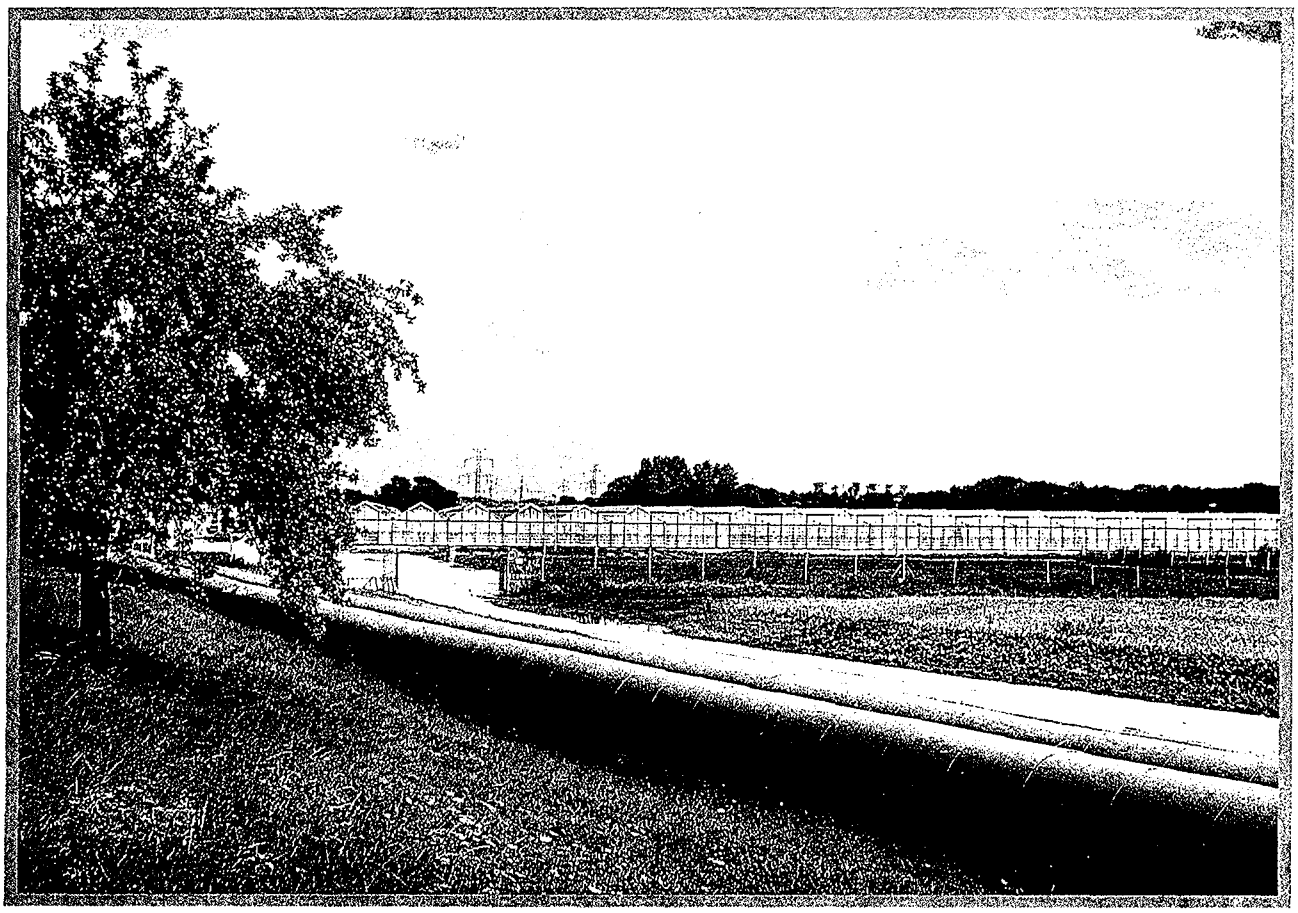
- The major heat-exchanging plant is installed within the NPP Bohunice site. The circulating water is warmed up by steam taken from turbines in basic and peak heat-exchangers of the "steam-water" system.
- The chemical water treatment plant is also located within the NPP Bohunice site.
- The pipeline part (its prevailing length is of 2 x DN 700 dimension, the dimension changes into 2 x DN 600 in a part of Trnava town area) with the length of 23.3 km. A pumping plant approximately at kilometre 13. The terminal heat-exchanging plant for the largest heat supplier - Trnavské automobilové závody (TAZ company) in Trnava. This heat-exchanging plant can also function as a back up heat source with the output of 60 MW. In this case it would be supplied with steam from a conventional thermal power plant located at TAZ company site in Trnava.
- Secondary heat-exchanging plants are located in branches of the pipeline part.

Besides heat consumers in Trnava town area, there are additional consumers on the pipeline part route:

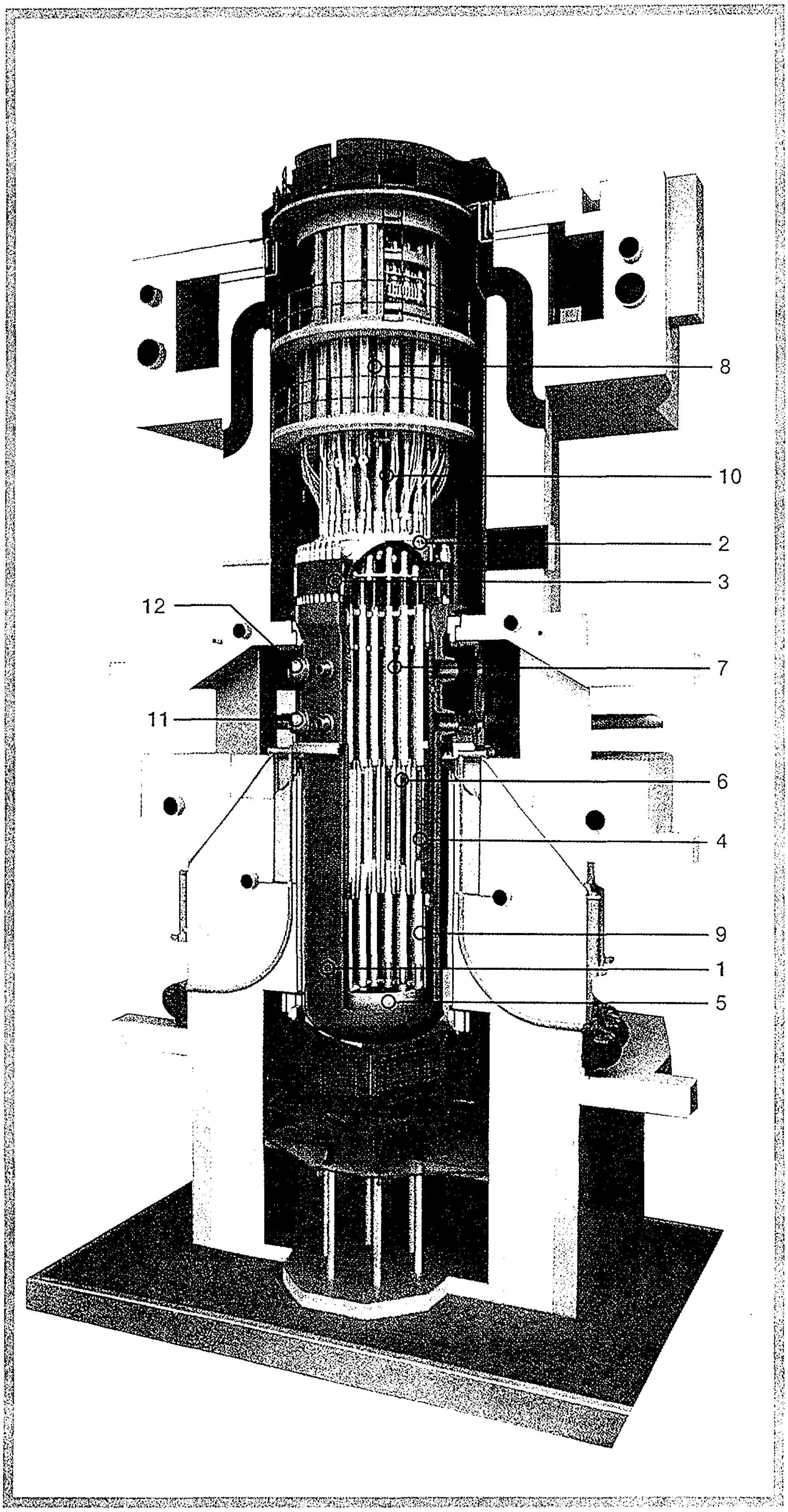
- greenhouse farm with the area of several hectars in Malženice village,
- Jaslovské Bohunice village where there are over 300 heat consumers, especially house owners.

The heat supply pipeline NPP Bohunice - Hlohovec that is under construction nowadays is also designed as a branch to the pipeline part of the heat supply system NPP Bohunice - Trnava. The branch is derived near the site of the Nuclear Power Plant Bohunice.

Greenhouse farm in Malženice



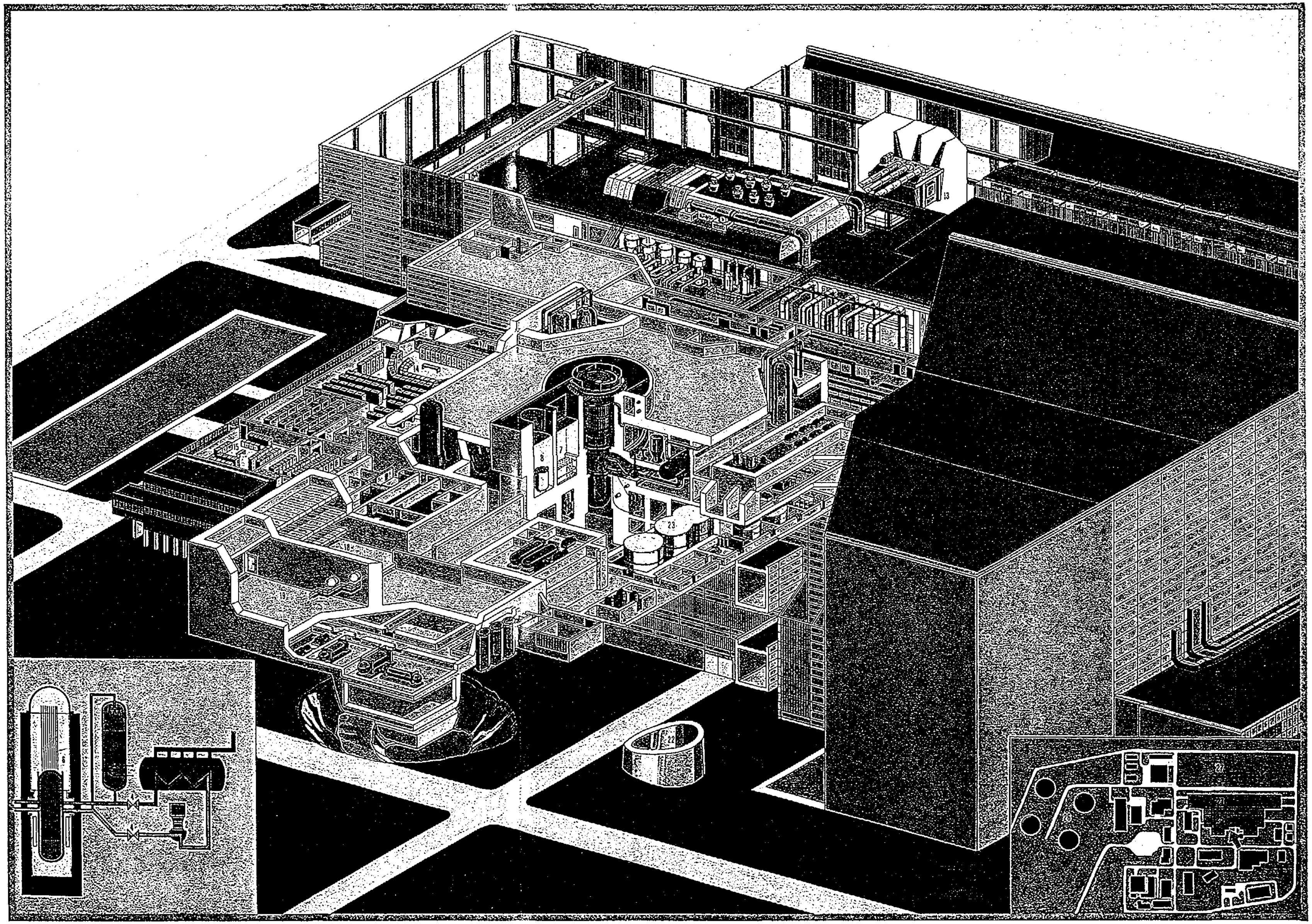
REACTOR VVER 440 V213



1. Reactor pressure vessel
2. Vessel closure head
3. Free flange
4. Reactor core barrel
5. Reactor core barrel bottom
6. Reactor core
7. Protection tubeblock
8. Upper block
9. Protection tubes with dampers
10. Control rod drives
11. Inlet nozzle
12. Outlet nozzle

BOHUNICE V-2 NPP

1. Reactor
2. Reactor coolant pump
3. Steam generator
4. Main isolotion valve
5. Pressurizer
6. Refuelling pool
7. Spent fuel storage pool
8. Transport container pit
9. Main steom header
10. Turbine generator
11. Low-pressure regenerative preheaters
12. High-pressure regenerative preheaters
13. Unit transformer
14. Main control room
15. Emergency control room
16. Electricol equipment rooms
17. Process computer system Uran
18. Bubble condenser system
19. Gas container
20. Reactor hall
21. Machine holl
22. Ventilotion stack
23. Safety injection systems
24. Hydraulic accumulators
25. Main generation building
26. Cooling towers
27. Switchyord 400 kV



TECHNICAL DATA

Number of reactor units	2
Installed capacity of power plant	2 x 440 MW
Thermal output of reactors	2 x 1375 MWt
REACTOR	
Reactor type	VVER 440 V 213 heterogenous with thermal neutrons
Coolant and moderator	demineralized water
Reactor pressure vessel	Reactor pressure vessel
Dimensions	
Diameter (mm)	3840
Height (mm)	11800
Weight (t)	215
Material	carbon, low-alloy and high-temperature steel
Reactor core	
Diameter (mm)	2880
Height (mm)	2500
Number of fuel assemblies	312
Shape	hexagonal prism
Diameter (mm)	144
Height (mm)	3200
Number of fuel rods in an assembly	126
Diameter (mm)	9,1
Height (mm)	2500
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)	267
Outlet coolant temperature (°C)	297
Water pressure (MPa)	12.26
STEAM GENERATOR	
Number of steam generators per reactor unit	6
Inner dimensions	
Length (mm)	11800
Diameter (mm)	3210
Weight (t)	145
Steam output (T/h)	452
Steam pressure (MPa)	4.6
Steam temperature (°C)	260
Feedwater temperature (°C)	223
Number of heat-exchanging tubes	5536
Heat-exchanging surface (m^2)	2510
REACTOR COOLANT PUMP (RCP)	
Number of RCPs per reactor unit	6
RCP electromotor power input (MW)	2
Voltage (kV)	6
Speed (rev/min)	1500
Coolant flow rate (m^3/h)	6500 - 7100
TURBINE GENERATOR (TG)	
Number of TGs per reactor unit	2
Rated output (MW)	220
Speed (rev/min)	3000
Turbine	three stages, condensing 1 medium-pressure stage 2 low-pressure stages
Steam temperature (HP) (°C)	256
Steam pressure (HP) (MPa)	4.3
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-part, 2 chambers each
Volume flow rate of cooling water (m^3/h)	35000
Maximum temperature of cooling water (°C)	33
Number of heat-exchanging tubes	29480
Heat-exchanging surface (m^2)	16300
Condenser cooling mode	circulation 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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