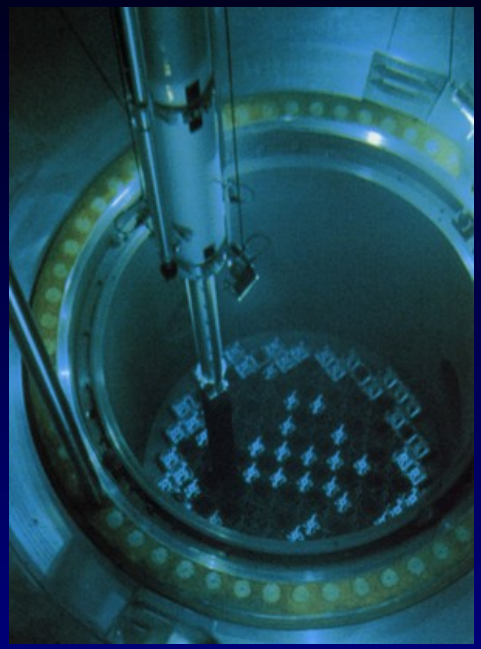

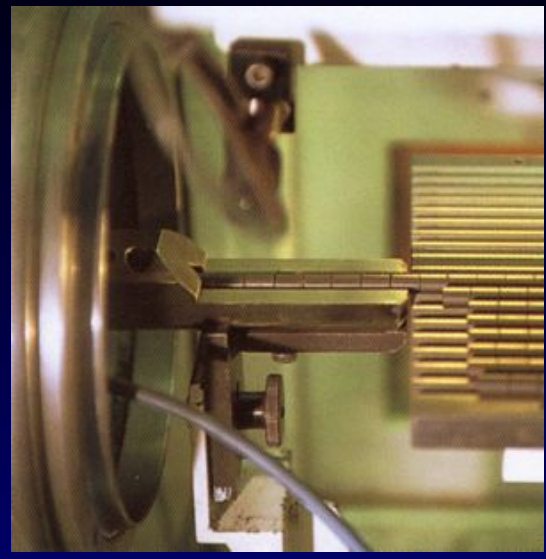

Module 04
WWER/ VVER
(Soviet designed Pressurized Water Reactors)

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VVER=
Veda-Vodyanoi Energetichesky
Reaktor=
Water Cooled Power Reactor

WWER 440/230
WWER 440/213
WWER 1000/320

Common Features of VVERs (1)

- Hexagonal fuel assembly cassettes
- Horizontal steam generator
- Primary circuit and secondary circuit using different materials
- Reduced inspection possibilities of components
- Little documentation (440/230)

Common Features of VVERs (2) mainly valid for 440/230

- Lack of indepentent control and regulatory supervision
- Quality lack in instrumentation, control and data processing
- Not reproducable safety analysis
- Low power density due to high ratio of water volume to thermal power

Common Features of VVERs (3)

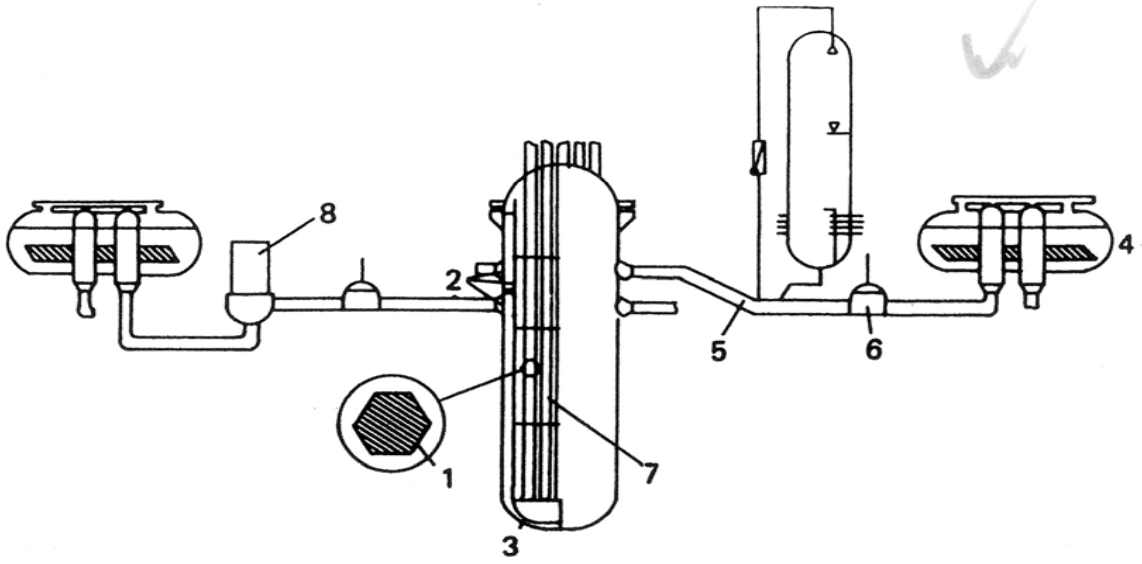


Abb. 1: Konstruktive Besonderheiten des WWER.

alle Typen

1 Sechseckige Brennelemente
2 Ein- u. Austrittsstutzen übereinander, perforierter Schachtring
3 Elliptischer Siebboden (nicht beim WWER-440/230)
4 Liegende U-Rohrdampferzeuger

WWER-440/230 u. 213

5 Schleifenabsenkung im heißen Strang
6 Hauptabsperrschieber, 6 Kühlkreisläufe
7 Steuerkassetten mit Brennelementunterteil

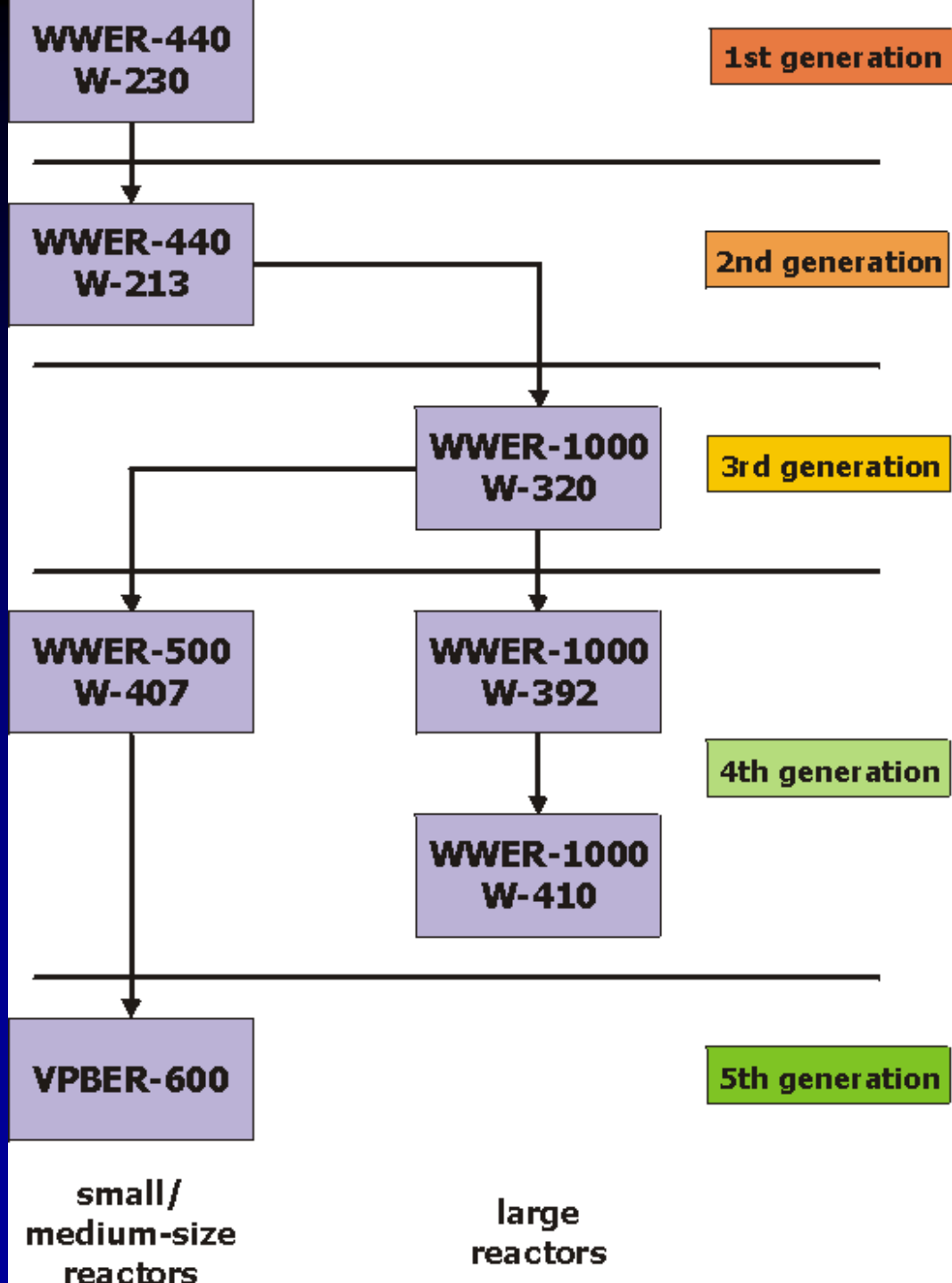
WWER-440/230

8 Vollgekapselte Hauptkühlmittelpumpe

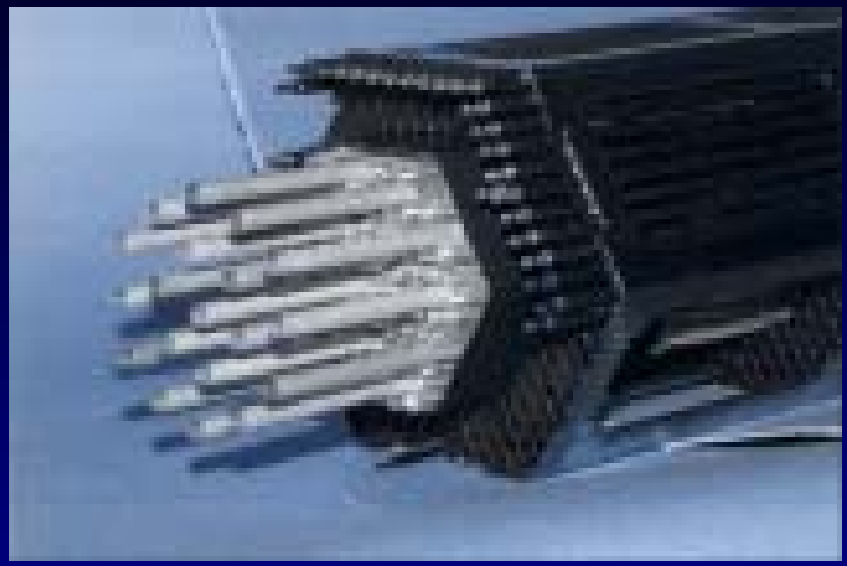
Technical Aspects of VVERs for 1st Generation

- VVERs are the „workhorses“ of former Sovietunion
- Simple, cheap and robust contructions
- Rely more on overdimension than on sophisticated computer codes
- Little automatisation, human reliability is higher than the reliabilty of I&C systems
- Accident prevented with choice of material and material dimension

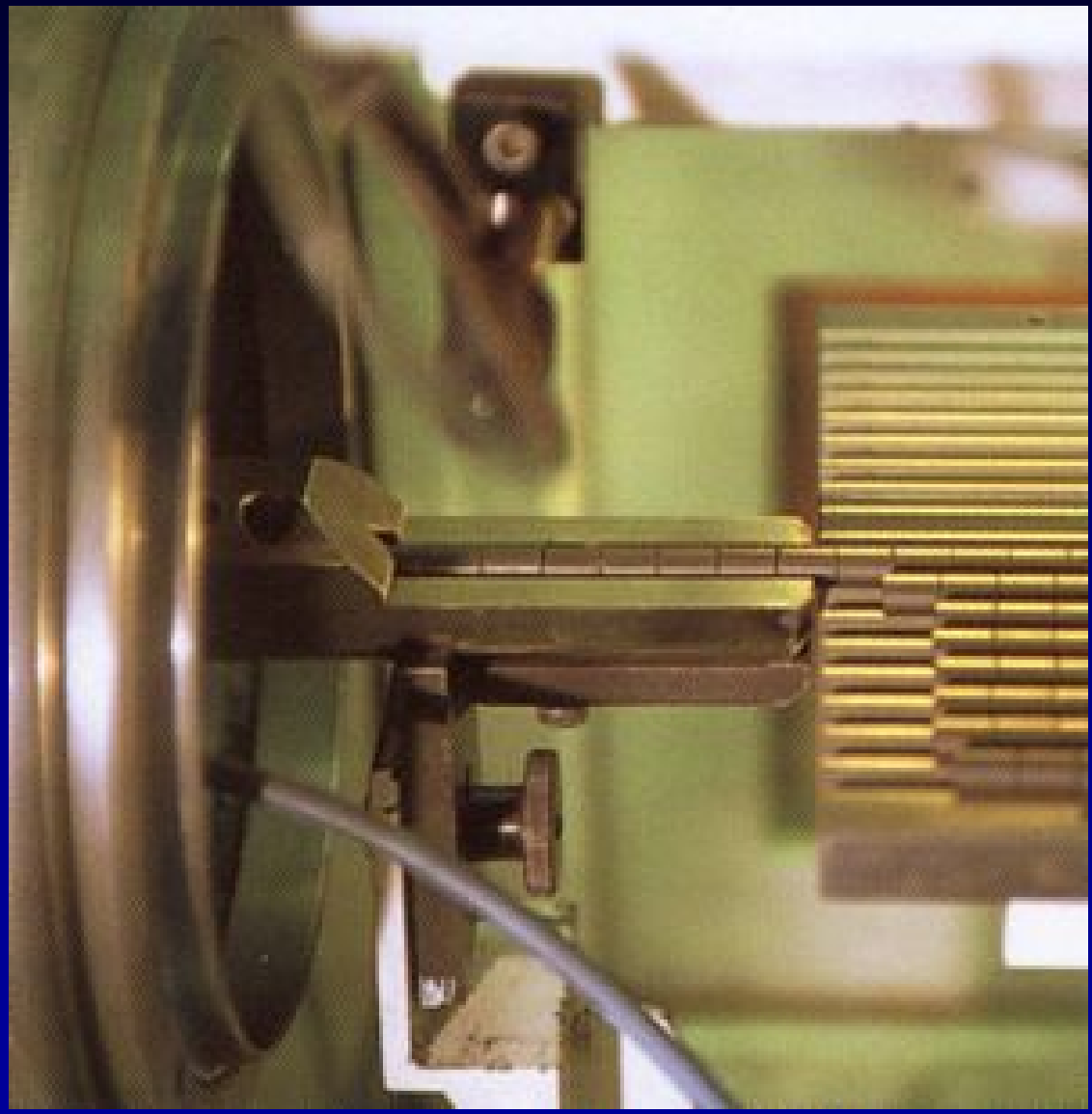
Development of VVERs



VVER Fuel Assembly

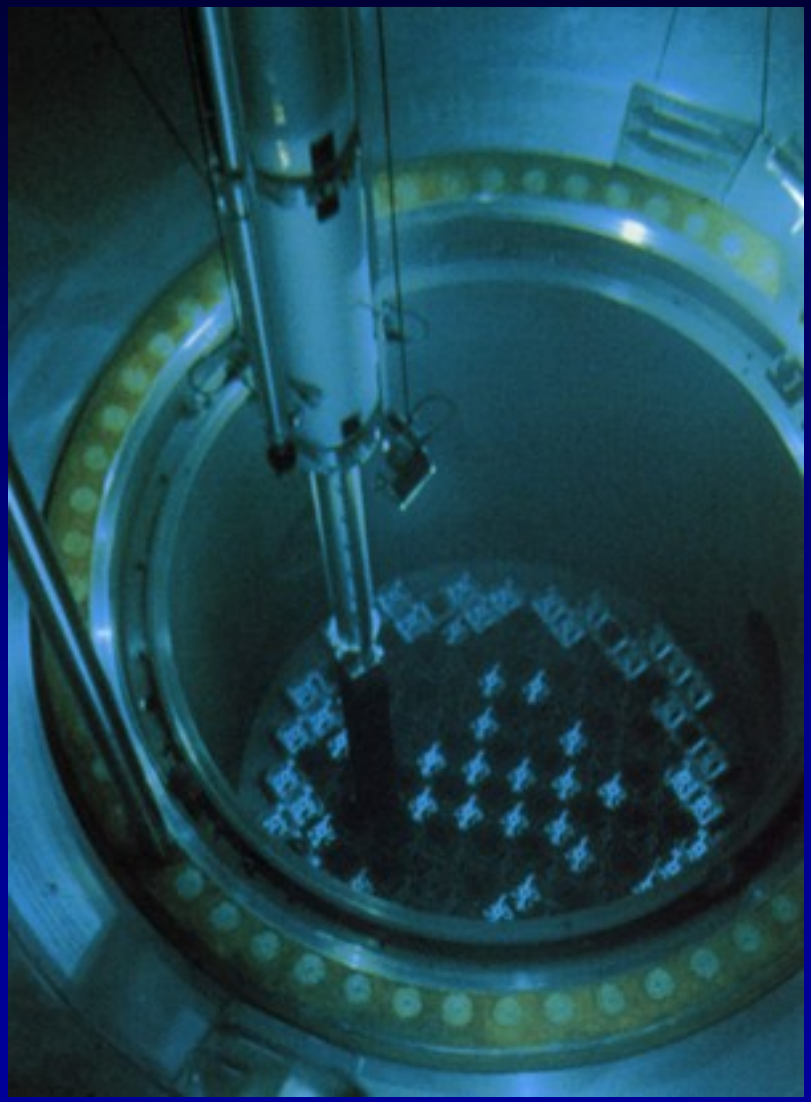


VVER Fuel Pellets



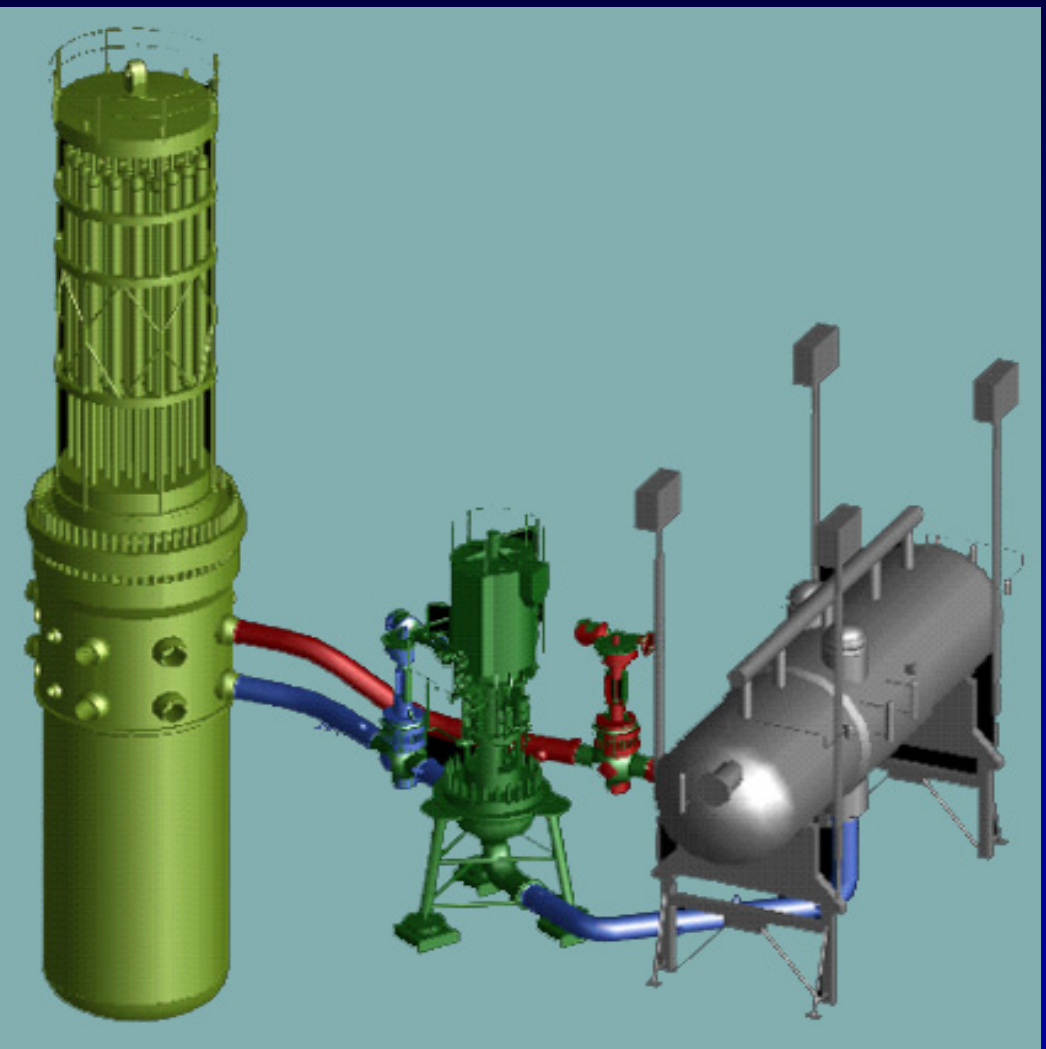
VVER

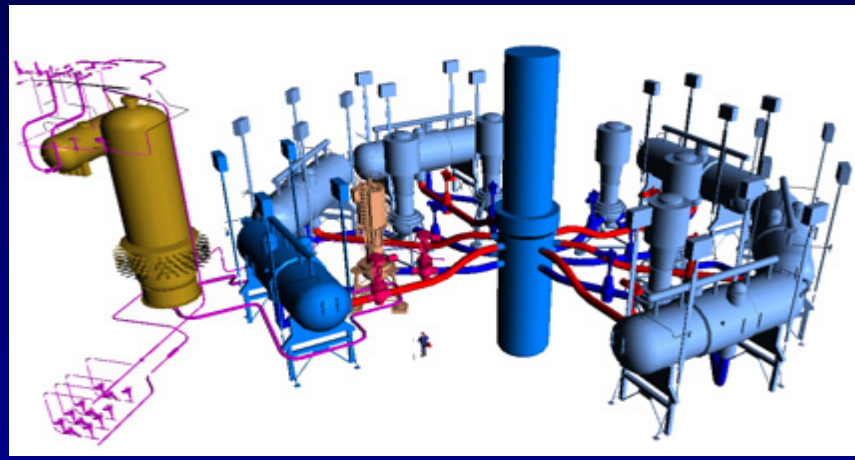
Refuelling



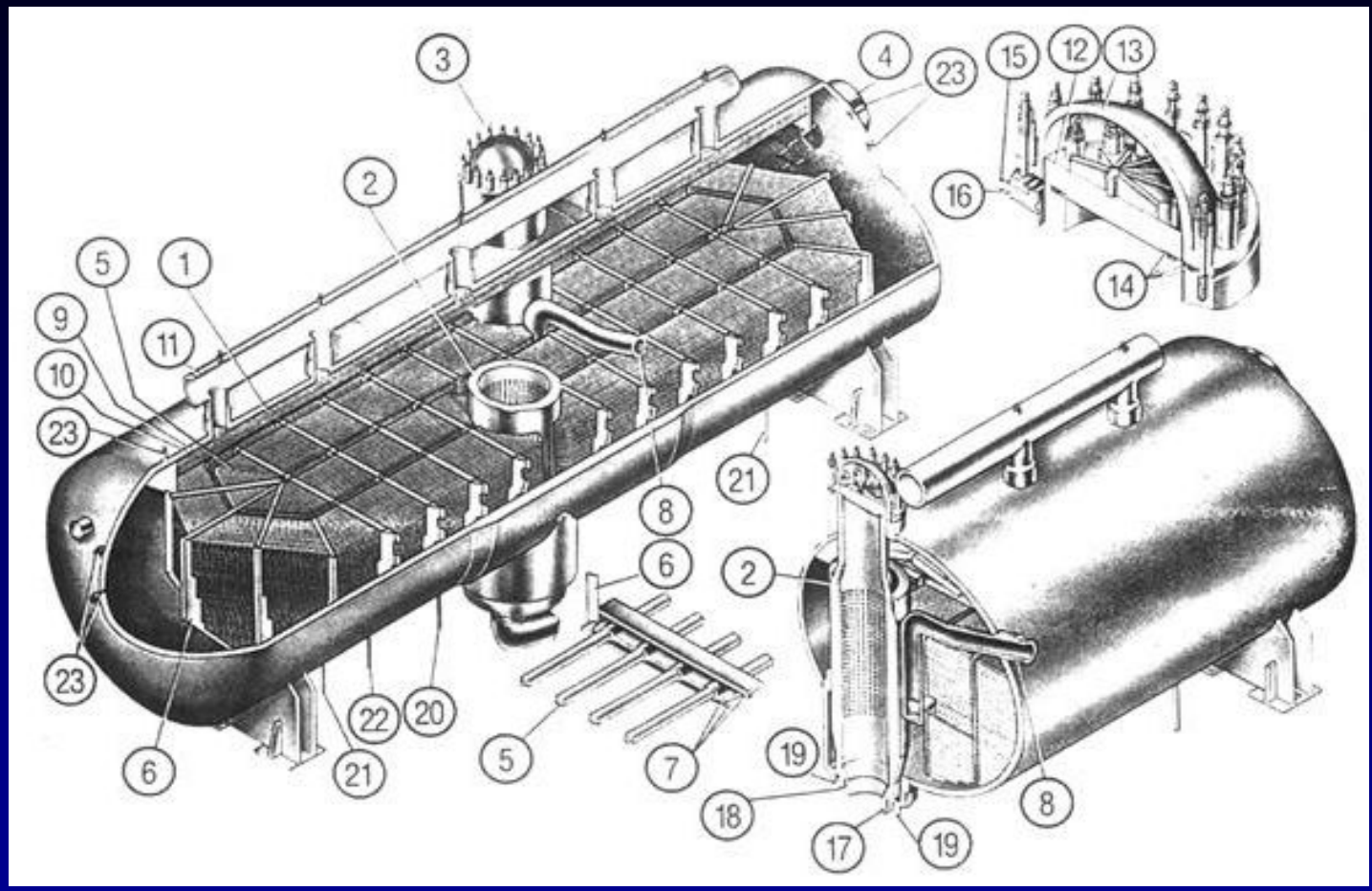
New Fuel

VVER Primary Circuit





VVER Steam Generator

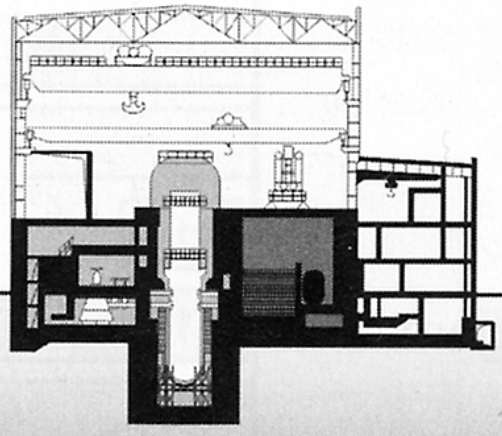


Structure of the steam generators in VVER-440 units

1 - steam generator body, 2 - primary cold leg collector, 3 - primary hot leg collector, 4 - manhole, 5 - heat exchanger tubes, 6 - vertical distance grid, 7- horizontal distance grid, 8 - feedwater pipeline, 9 - separator, 10 - perforated sheet, 11 - steam header, 12 - primary circuit header cover, 13 - secondary circuit header cover, 14 cover seals for the primary and secondary circuit, 15 - secondary circuit seal cover monitoring location, 16 secondary circuit air vent, 17 - primary circuit seal cover monitoring location, 18 - primary circuit air vent, 9 - header periodic blowdown, 20 - steam generator periodic blowdown, 21 - steam generator permanent blowdown, 22 - nozzle, 23 - pipe unions for steam generator level checking.

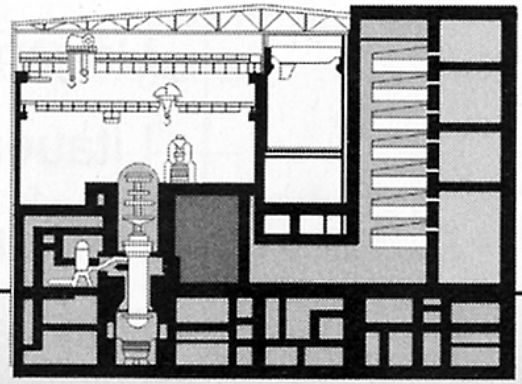
VVER Generations

1. Generation
WWER 440-W230



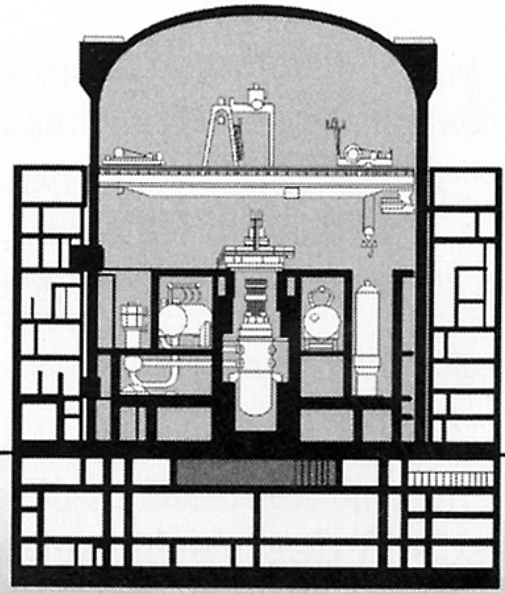
in Betrieb 11

2. Generation
WWER 440-W213



in Betrieb 16

3. Generation
WWER 1000



in Betrieb 20

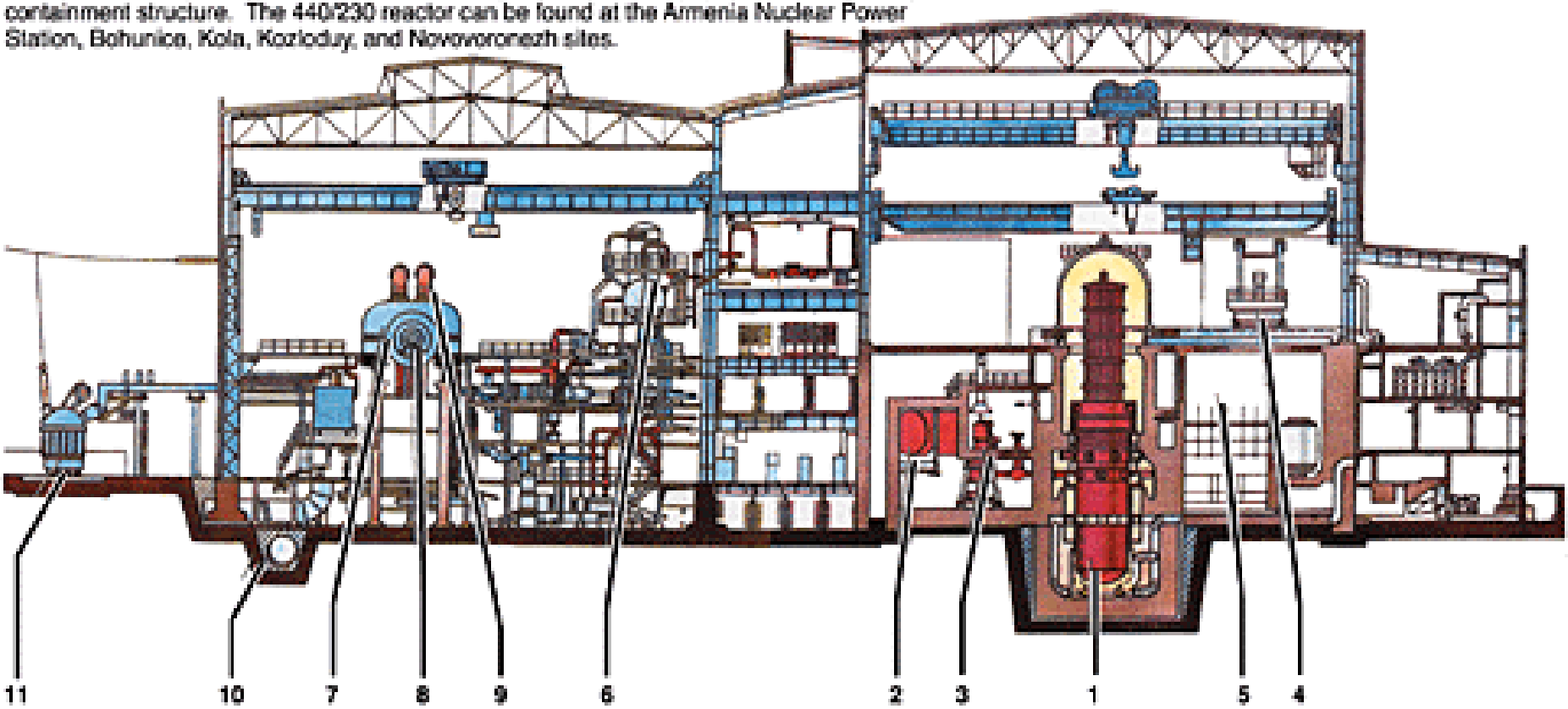
VVER-440 Model 230 Plant Layout

The VVER reactor is a pressurized, light-water cooled and -moderated reactor similar to Western pressurized water reactors (PWRs). There are three predominant models in operation, the VVER-1000 and two versions of the VVER-440.

The VVER-440/230 reactor was the initial civilian model of the Soviet PWR. It is similar to Western PWRs in that it uses low-enriched uranium oxide fuel, placed in thin metal-clad rods, to generate heat. The fuel rods are cooled by pressurized light water. The steam to run the turbine generator is produced when pressurized, heated water from the reactor is pumped through steam generators where it transfers its heat to a separate secondary coolant.

The steam is routed to the turbine generator, which produces about 440 megawatts of electricity. The VVER-440/230, although similar to Western PWRs, lacks a number of safety features, including fire protection systems, emergency core cooling systems, and a strong containment structure. The 440/230 reactor can be found at the Armenia Nuclear Power Station, Bohunice, Kola, Kozloduy, and Novovoronezh sites.

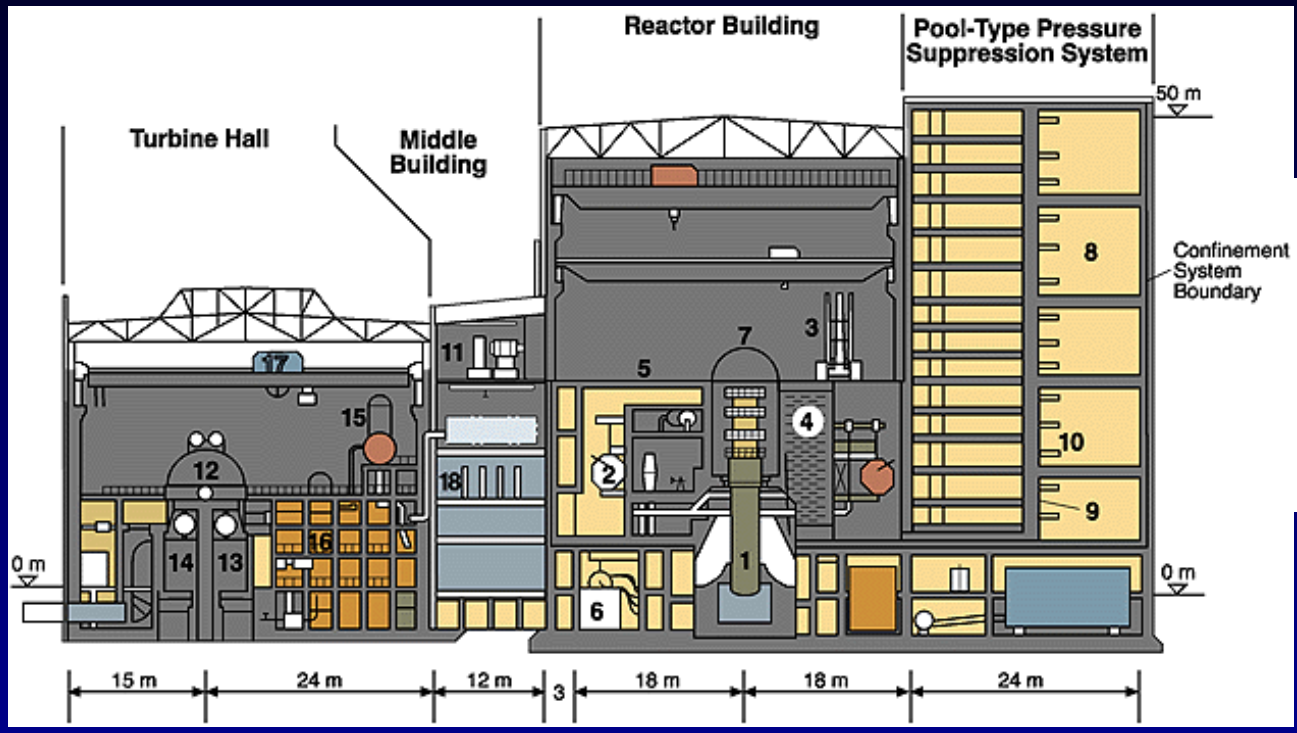
1. Reactor
2. Steam generator
3. Main circulation pump
4. Refueling machine
5. Spent fuel cooling pond
6. Deaerator
7. Steam turbine
8. Generator
9. Steam pipelines
10. Cooling water pipelines
11. Transformer

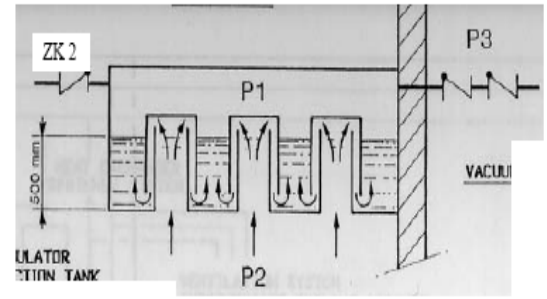


VVER 440 / 230 Safety Aspects

- Six primary loops
- Motor driven valves in all six loops
- Fuel follower control rods
- Two NPP on one site
- Common turbine generator hall for both NPPs
- Rooms designed to withstand higher pressure instead of full pressure containment
- No full capacity emergency core cooling system in case of main coolant pipe rupture
- Accelerated material embrittlement due to fast neutron irradiation of pressure vessel

VVER 440/213



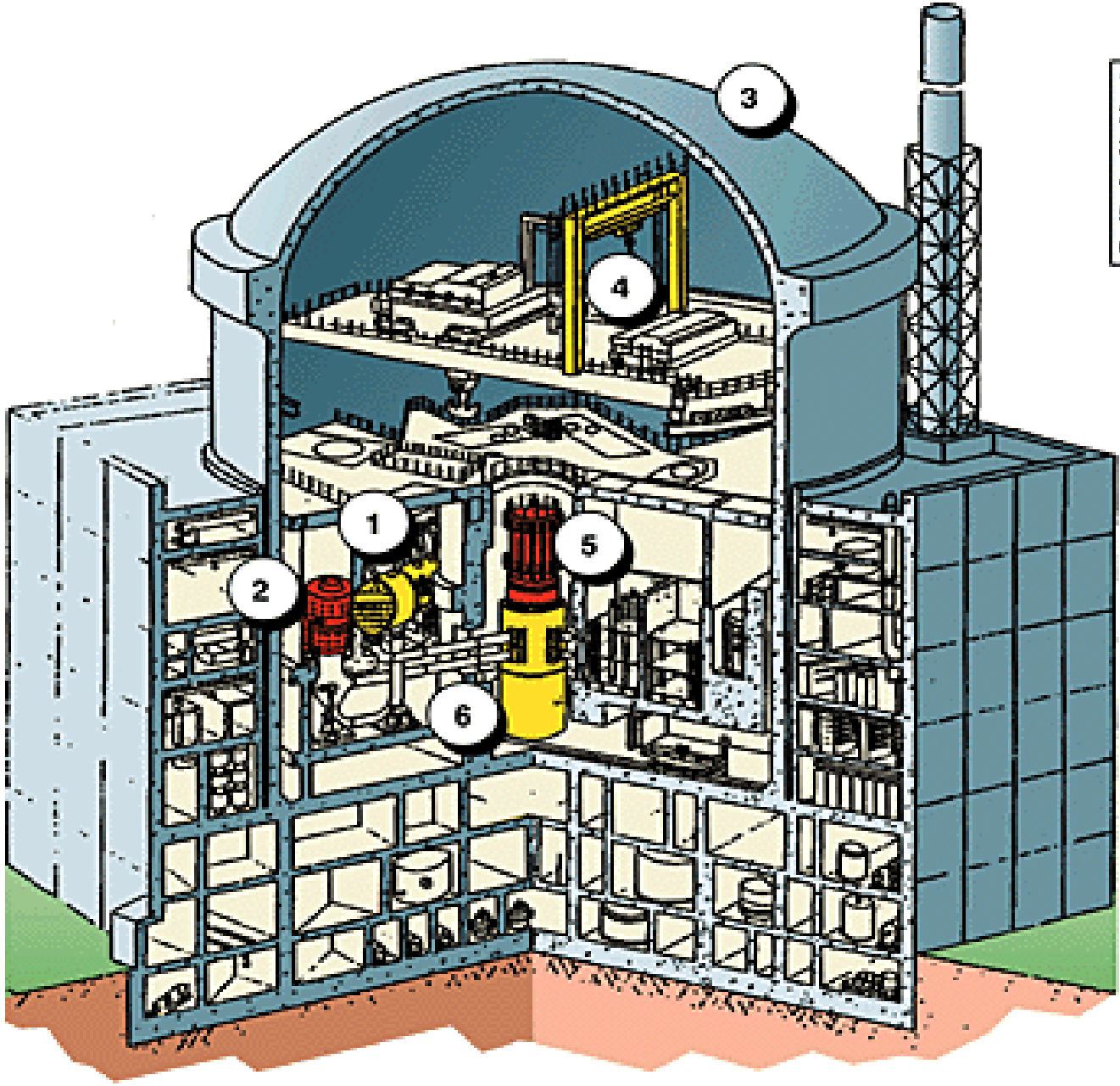


Legend: 1.Reactor pressure vessel, 2.Steam generator, 3.Refueling machine, 4.Spent fuel pit, 5.Confinement system, 6.Make-up feedwater system, 7.Protective cover, 8.Confinement system, 9.Sparging system, 10.Check vales, 11.Intake air unit, 12.Turbine, 13.Condenser, 14.Turbine block, 15. Feedwater tank with degasifier, 16. Preheater, 17.Turbine hall crane, 18.Electrical instrumentation and control compartments.

VVER 440/213 Safety Aspects

- Many safety deficits of VVER 440/230 removed
- Pressure suppression system through bubble condensor
- Emergency core cooling system designed for maximum LOCA
- Safety systems in 3 x 100% redundancy, separated from operational I&C system
- Improved fire protection
- Separated emergency control room
- Reduction of neutron fluence to pressure vessel wall
- Surveillance system of safety relevant primary components

VVER-1000 Plant Layout



1. Horizontal steam generator
2. Reactor coolant pump
3. Containment building
4. Refueling crane
5. Control rod drive assemblies
6. Reactor vessel

The VVER reactor is a pressurized, light-water-cooled and -moderated reactor similar to Western pressurized water reactors (PWRs). There are three predominant models in operation, the VVER-1000 and two versions of the VVER-440.

The VVER-1000 is the largest and newest of the VVERs. This third-generation design produces about 1000 megawatts of electricity and meets most international safety standards. The VVER-1000 employs safety systems common in Western plants, including emergency core cooling systems and a containment structure. The VVER-1000 can be found at the Balakovo, Kalinin, Khmelnytskyy, Kozloduy, Novovoronezh, Rivne, South Ukraine, and Zaporizhzhya sites.

VVER 1000/320 Safety Aspects

- Full pressure containment designed 0.5 MPa
- Emergency cooling system designed for whole spectrum of LOCA
- Improved materials for primary and secondary components
- Improved access for reinspection and maintenance
- Low leakage core loading to reduce neutron fluence to pressure vessel wall
- For Temelin only:
- Replacement of total I & C system, by Westinghouse
- Fuel elements produced by Westinghouse

NPP Temelin

- Czech Republic
- VVER 1000/320
- 2 Reactors
- 2 x 981 MWe

NPP Mochowce

- Slovak Republic
- VVER 440/213
- 2 Reactors
- 2 x 440 MWe

NPP Dukovany

- Czech Republic
- VVER 440/213
- 4 Reactors
- 4 x 440 MWe

References

- http://www.nti.org/db/nisprofs/russia/reactor/power/novovoro.htm
- http://www.npp.hu/index-e.htm
- http://www.nrc.gov/