Research Reactor MARIA - Poland

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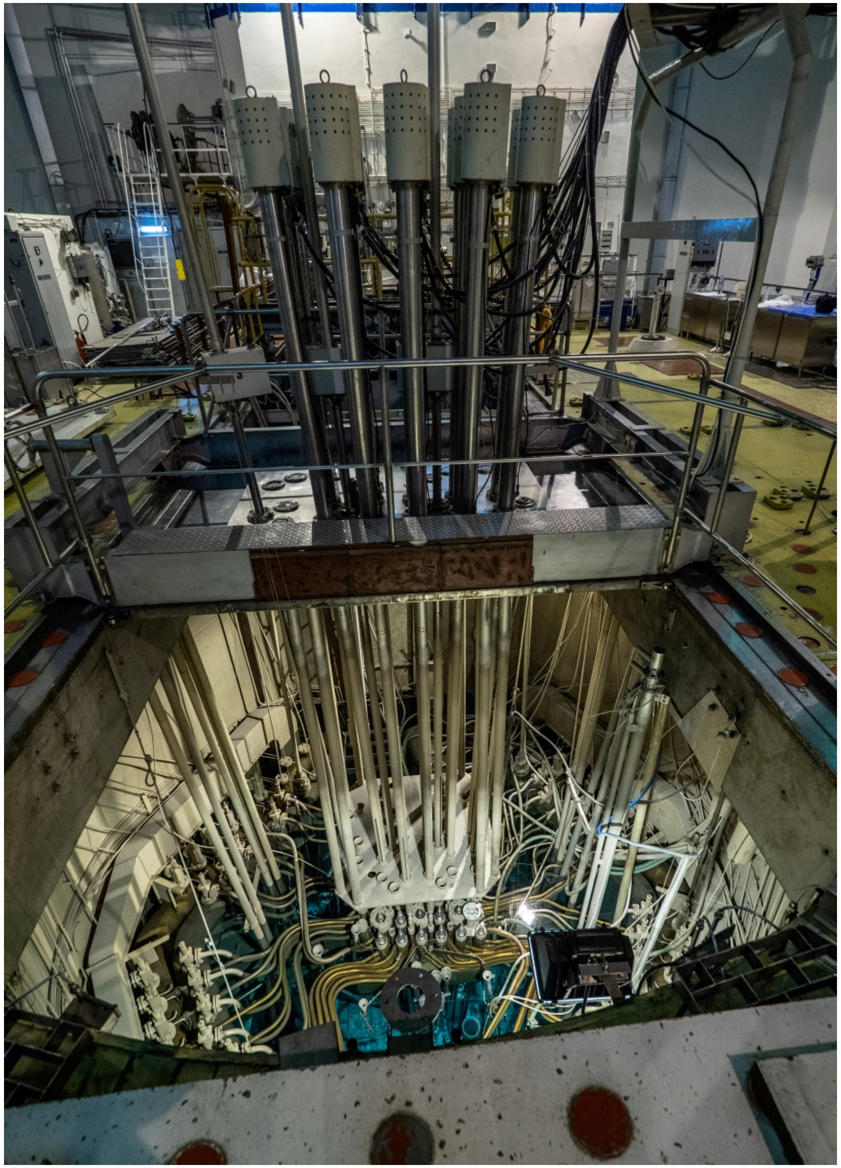
General characteristics of MARIA reactor

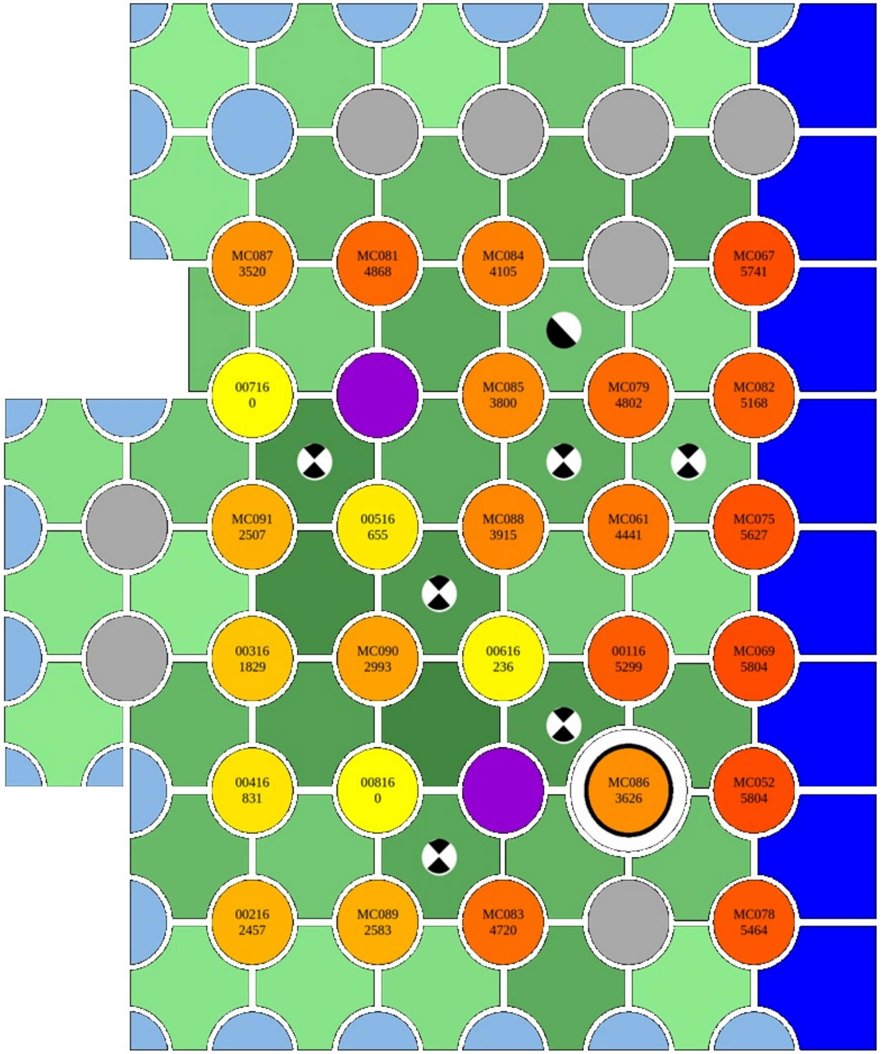
- Designed and constructed by Polish industry
- First criticality was reached in December 1974
- 1985 ÷ 1992 – modernization period
- 2013 modernization fuel channels cooling system



General characteristics of MARIA reactor

Reactor type	pool-type reactor with pressurized fuel channels
Thermal power	30 MW, limit 1,64 MW per fuel element
Fuel	MC-5 19,7 % 485 g U-235 U_3Si_2 MR-6 19,75 % 485 g U-235 UO_2-Al
Thermal neutron flux	$2,5 \times 10^{14}$ $n/cm^2 \cdot s$
Fast neutron flux	2 x 10^{14} $n/cm^2 \cdot s$
Moderator	H_2O 70 % ; beryllium 30 %
Reflector	graphite
Control	6 safety rods; 6 control rods; 1 automatic control rod

Core configuration



Summary of exploitation

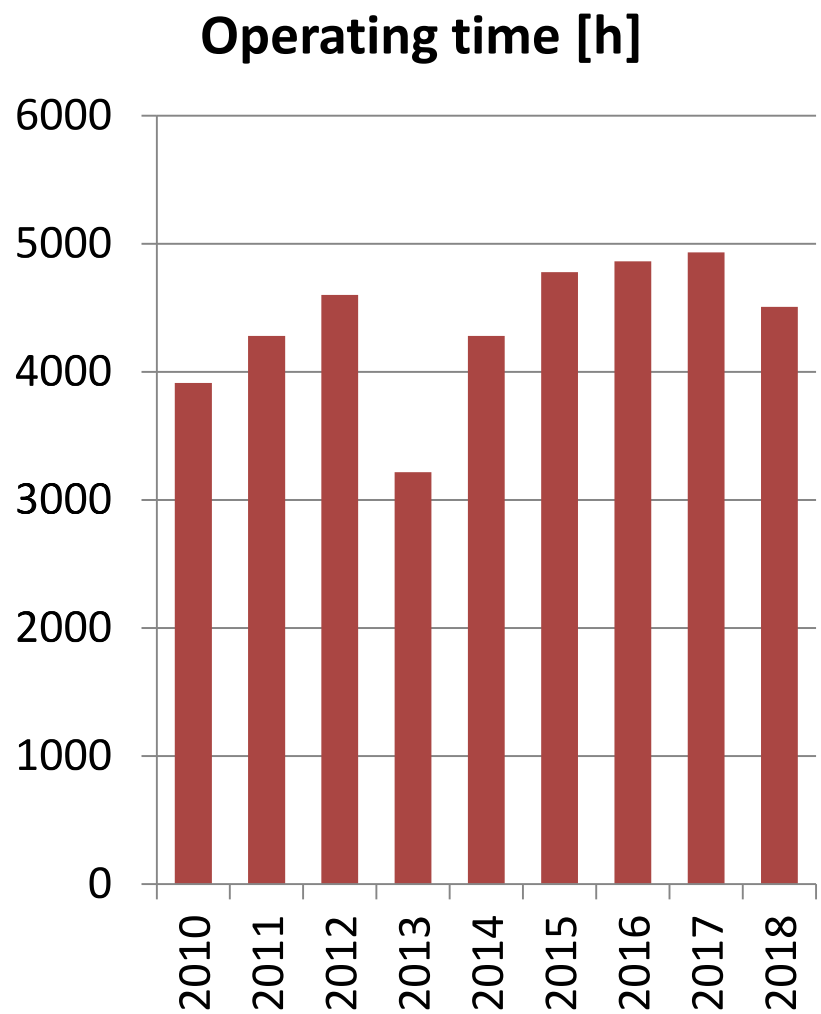
2018

- In operation 4508 h power to 25 MW
- Irradiated 3049 trays of isotopes (Tellurium, Sulfur (P-32), Samarium, Cobalt, Iridium…
- Uranium plates for the production of molybdenum (LEU)

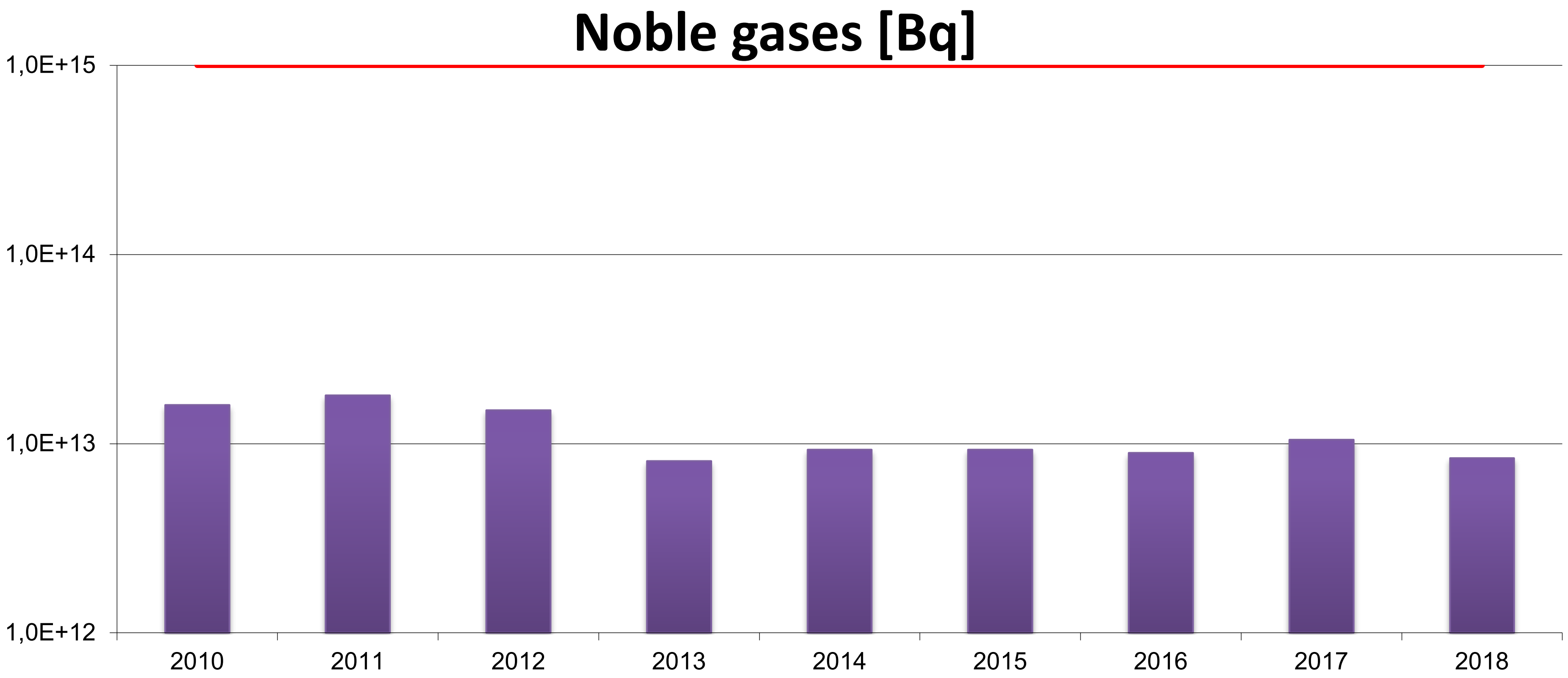
In 2018, were 5 unplanned shutdowns:

- instrument error for measuring the flow rate (pressure fluctuations due air in the system)(3),
- external power supply disturbances (2).

all of them happened in the first half of the year

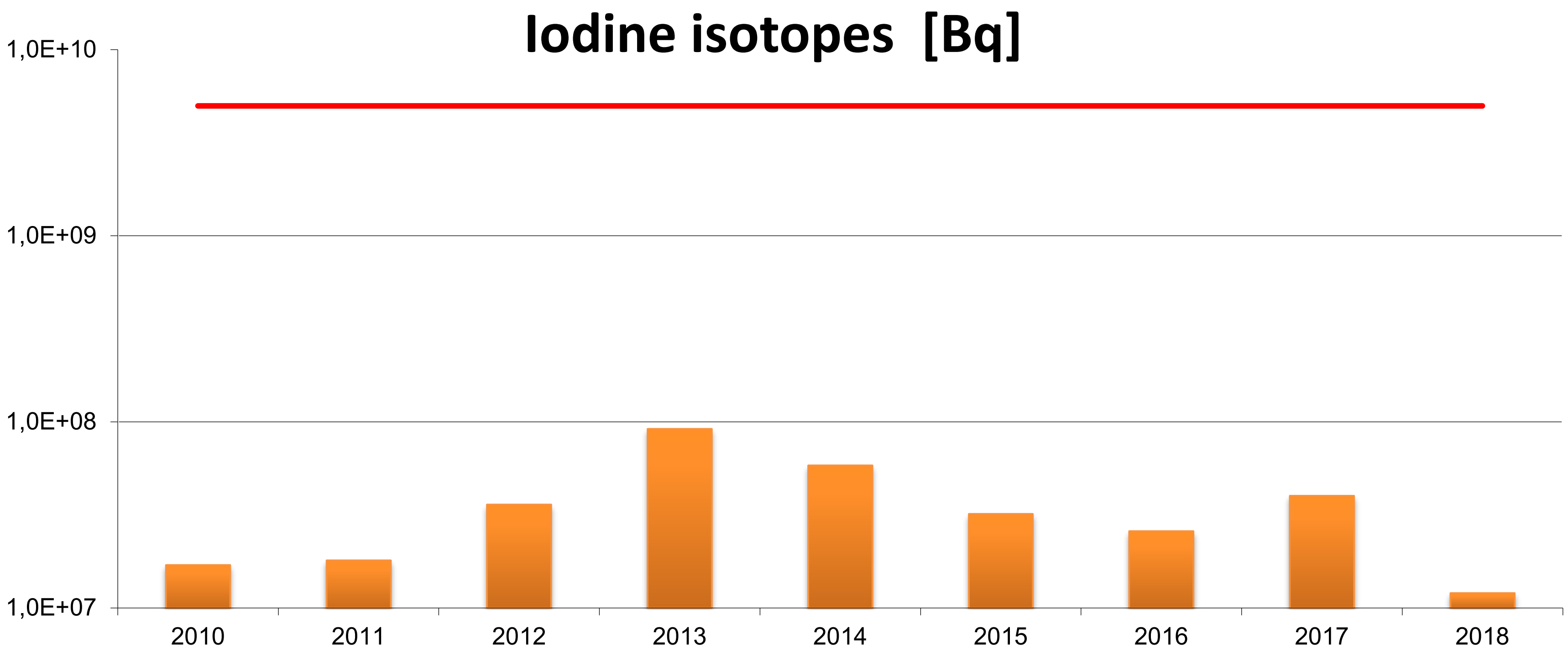


The release of volatile radioactive substances into the atmosphere



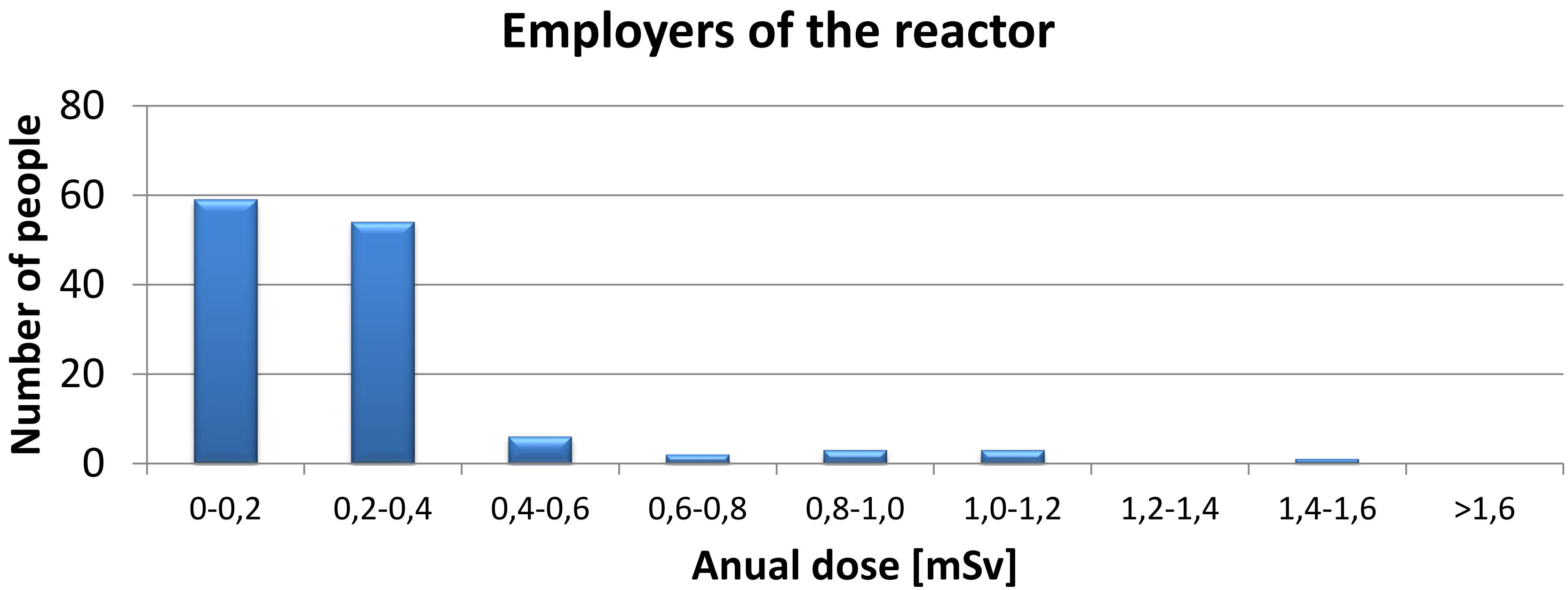
In 2018, noble gases emission (^{41}Ar and Xenon and Krypton isotopes) to the atmosphere were 8.4 x 10^{12} Bq, less than 1.0 % of annual emission limits

The release of volatile radioactive substances into the atmosphere



The emissions of radioactive iodine (131I, 132I, 133I, 134I, 135I) were $1,2 \times 10^7$ Bq, less than 0,25 % of annual emission limits.

Exposure of personnel to ionizing radiation



In 2018, 128 employees were covered to individual control. The average value of registered annual effective doses was 0.295 mSv, and the maximum value was 1.46 mSv.

Maintrance, Upgrade

- During the 2018 were not being done modernization, were done only of the necessary repairs, inspection and calibration of process systems and control and measuring equipment,
- Was prepared project of modernization of the power supply system (2020),
- Was prepared project modernisation of control room and visualisation system (in 2019 will tested, 2020),
- Are being replaced one main and residual heat removal pumps of second cooling system,
- Has been started the procedure of added a new start-up channel (IEAE) and replacing the existing one.

Ageing Management Program

The SSC within the scope of the effective AMP implemented in MARIA reactor are divided into 9 groups:

- Reactor core
- Reactor pool and spent fuel pool,
- I&C systems,
- Containment building,
- Reactor core cooling systems,
- Electrical units and cables,
- Ventilation and air filtration,
- Dosimetry system,
- Infrastructure.

Inspections, tests and surveillance programs

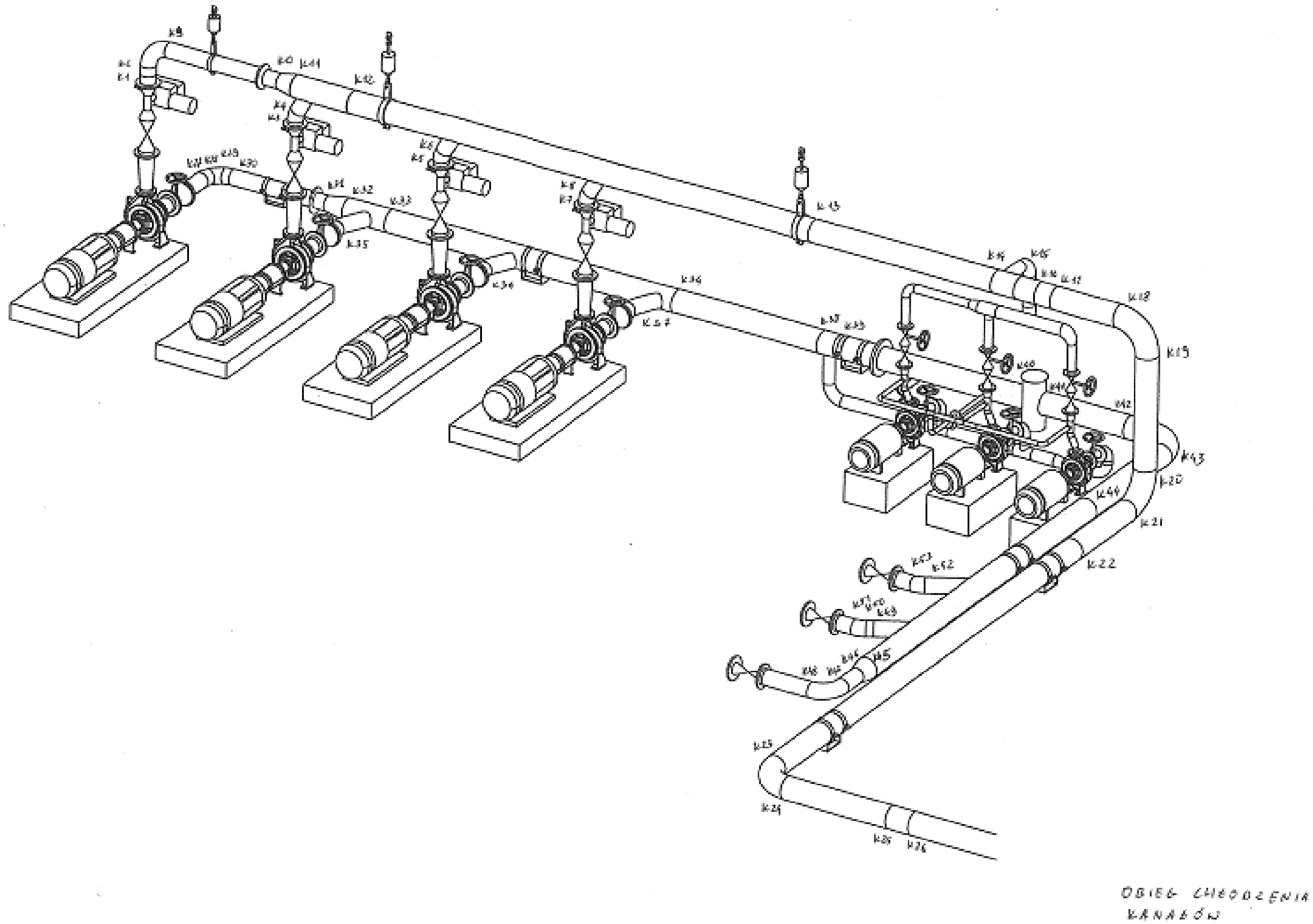
Inspections and tests:

- NDT of primary cooling pipes welds,
- Graphite blocks x-ray,
- Beryllium blocks visual inspection
- Safety and control rods inspection,
- Tightness of reactor pool, spent fuel pool and sluice test,
- Tightness of primary heat exchangers test,
- Tightness of containment building test,
- Measurement of isolation and conductor resistance,
- Calibration of I&C measuring instruments,
- Pressurizer inspection.

Ultrasonic testing of weld pipe cooling system

- Each year 20 welds out of 100.
- Test performed by a specialized laboratory in accordance with national legislation.

Figure of cooling system



Beryllium and graphite blocks ageing

Evaluation of beryllium blocks

- Calculations beryllium neutron fluence

  The fluence of beryllium blocks subjected the highest fluxes amount to $1,2x10^{22}$ n/cm^2 in compare to fluence limit $2x10^{22}$ n/cm^2

- Visual inspection

Evaluation of graphite blocks

- Calculations graphite neutron fluence

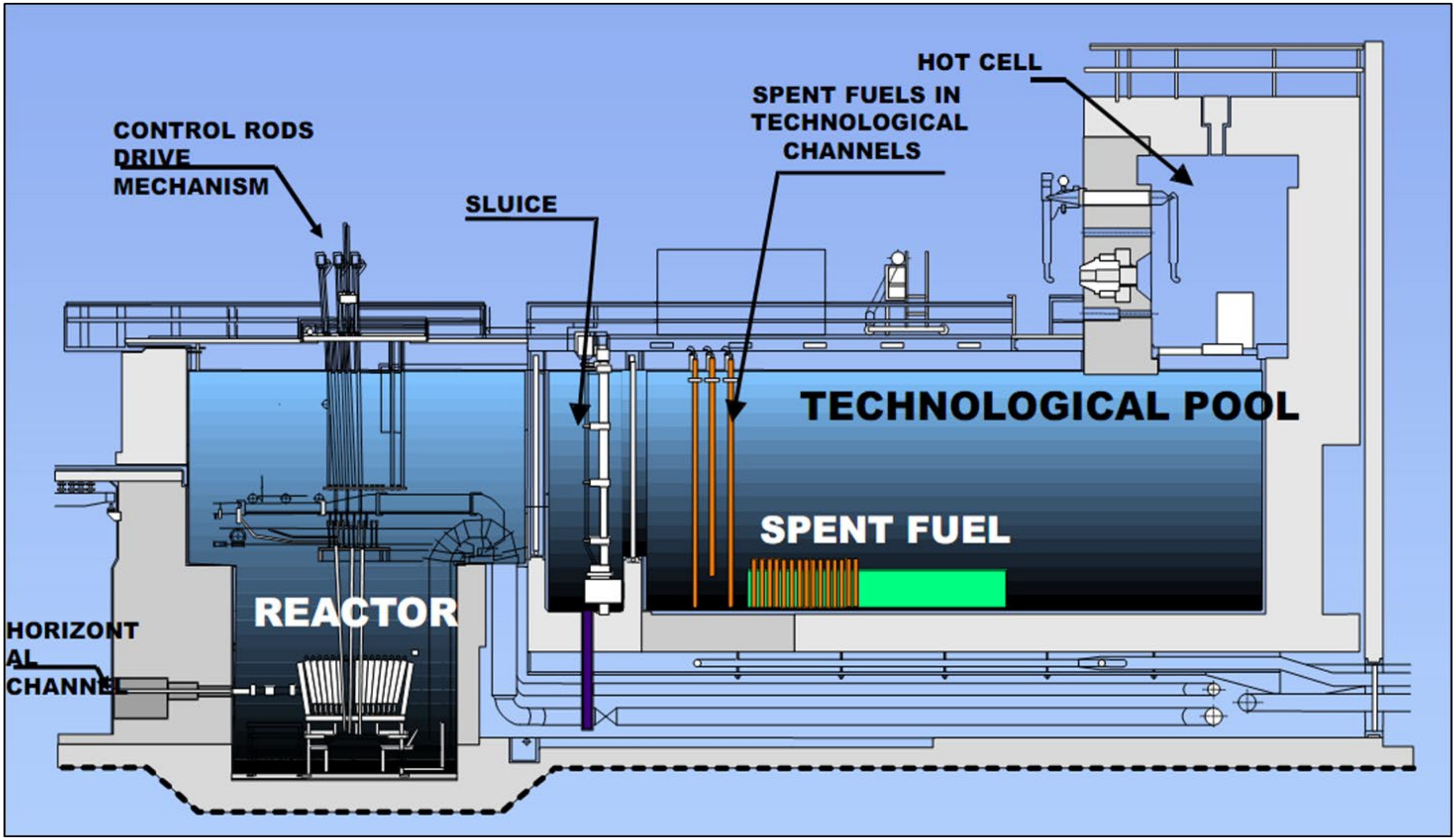
  The maximum fluence $1x10^{22}$

- Radiography of graphite gap
- Visual inspection

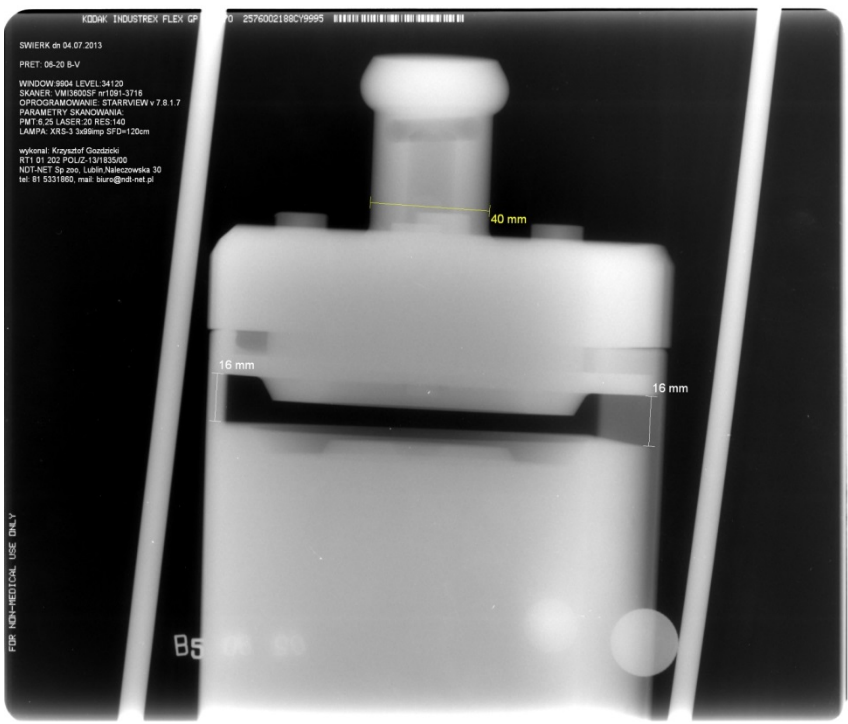
Calculations graphite neutron fluence

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
P					3,6E+20 3,6% 06-6				1,9E+17 0,0% 06-127	1,1E+20 1,1% 06-30	7,7E+16 0,0% 06-67	1,6E+16 0,0% 06-123				
O					1,0E+20 1,0% 18-1			7,5E+19 0,7% 06-16	3,1E+20 3,1% 06-25	4,0E+19 0,4% 06-29	4,5E+19 0,4% 06-35	5,5E+20 5,5% 06-11	2,4E+18 0,0% 06-73			
N			8,4E+17 0,0% 06-141		2,3E+20 2,3% 06-98			1,0E+20 1,0% 06-7	9,7E+19 1,0% 06-5	2,6E+19 0,3% 06-28	1,1E+19 0,1% 06-46	2,0E+18 0,0% 06-71	2,4E+18 0,0% 06-77	1,8E+20 1,8% 06-142		
M					2,1E+20 2,1% 06-108	3,2E+20 3,2% 06-15	4,4E+20 4,4% 06-9	3,2E+20 3,2% 06-10	3,0E+20 3,0% 06-23				1,2E+18 0,0% 06-44	1,0E+17 0,0% 06-82	7,2E+19 0,7% 06-126	
L	1,7E+20 1,7% 06-137												4,2E+18 0,0% 06-50	3,5E+19 0,4% 06-37	4,6E+19 0,5% 06-17	2,4E+15 0,0% 06-19
K	2,9E+18 0,0% 06-129	4,2E+19 0,4% 06-45	0,0% 06-128										8,9E+18 0,1% 06-81	2,3E+19 0,2% 06-64	3,1E+18 0,0% 06-2	2,8E+19 0,3% 06-13
J				7,0E+21 69,8% 1/2									4,2E+20 4,2% 06-18	3,3E+19 0,3% 06-38	1,2E+21 12,1% 06-118	1,8E+20 1,8% 06-133
I			1,4E+21 14,3% 06-112										9,1E+18 0,1% 06-84	4,5E+19 0,5% 06-72	7,4E+20 7,4% 06-155	2,4E+20 2,4% 06-94
H			2,1E+21 21,3% 06-8										2,2E+19 0,2% 06-87	1,5E+20 1,5% 06-33	9,0E+20 9,0% 06-117	5,2E+19 0,5% 06-103
G		1,8E+20 1,8% 06-111	1,4E+21 14,2% 06-154										3,1E+19 0,3% 06-92	2,9E+19 0,3% 06-39	4,4E+20 4,4% 06-115	1,8E+20 1,8% 06-146
F	1,0E+22 100,0% 06-114	1,1E+21 10,6% 06-145											3,6E+21 36,0% 11-18	1,1E+18 0,0% 06-51	2,7E+16 0,0% 06-122	1,9E+17 0,0% 06-21
E	3,0E+18 0,0% 06-85	7,3E+20 7,3% 06-74											1,8E+20 1,8% 06-156	5,8E+19 0,6% 06-91	1,3E+16 0,0% 06-153	1,9E+14 0,0% 06-55
D				3,1E+20 3,1% 06-78	7,7E+20 7,7% 06-3	1,8E+21 18,1% 06-14	1,7E+21 17,0% 06-20	1,6E+21 15,5% 06-26					2,6E+20 2,6% 06-152	2,9E+20 2,9% 06-149	2,1E+21 20,7% 06-106	
C			2,5E+19 0,2% 06-12	4,6E+19 0,5% 06-54	3,9E+20 3,9% 06-143	3,6E+20 3,6% 06-136	3,4E+20 3,4% 06-130	2,0E+20 2,0% 06-140	4,1E+20 4,1% 06-58	4,6E+19 0,5% 06-62	2,0E+20 246,3% 16-5	2,6E+18 0,0% 06-86	8,8E+17 0,0% 06-135	7,6E+16 0,0% 06-59		
B				4,5E+19 0,4% 06-79	1,1E+19 0,1% 06-166	2,8E+19 0,3% 06-151	3,6E+19 0,4% 06-131	3,5E+20 3,5% 06-105	4,5E+20 4,5% 06-116	7,4E+18 0,1% 06-100	5,4E+18 0,1% 06-104	2,7E+19 0,3% 06-99	2,1E+18 0,0% 06-69			
A					1,1E+19 0,1% 06-147	1,7E+18 0,0% 06-138	1,1E+21 10,6% 06-148	4,1E+20 4,1% 06-120	1,7E+19 0,2% 06-60	7,8E+18 0,1% 06-96	2,5E+18 3,2% 13-3	6,5E+16 0,0% 06-66				

X-ray of graphite gap



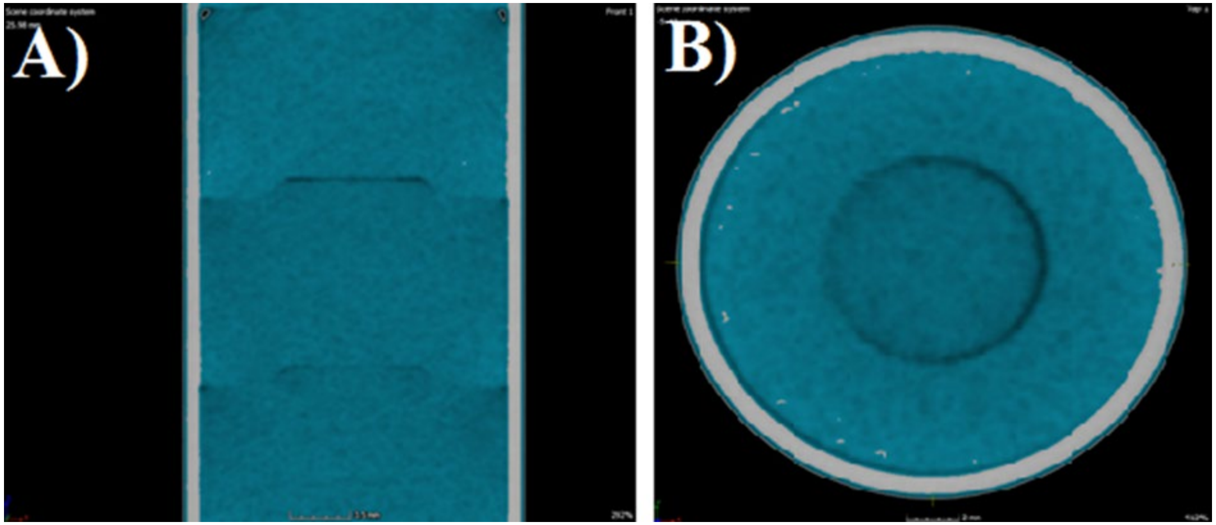
X-ray of graphite gap



- The graphite blocks are in an aluminum cladding.
- The top dimension of the block (overlay) is 140 mm, and 120 mm bottom. The height of the blocks with the pads is 1585 mm.
- Initially block has a 30 mm gap between the graphite and the upper cap.

Safety and control rods inspection

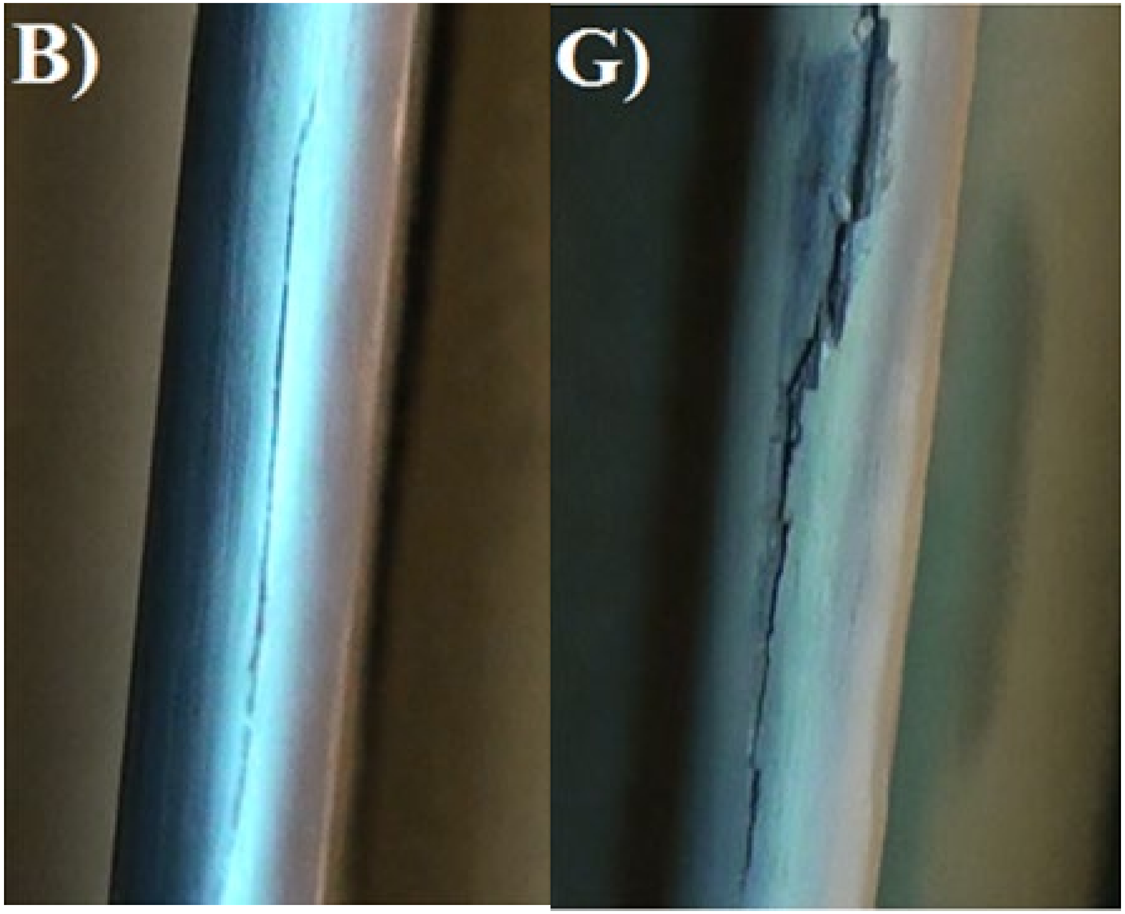
- diameter control,
- the force required to pull - max 5kG,
- visual surface inspection,
- control rod drop time.



Building: pellets 50% B_4C 50% Al, Al cladding,

Safety and control rods inspection

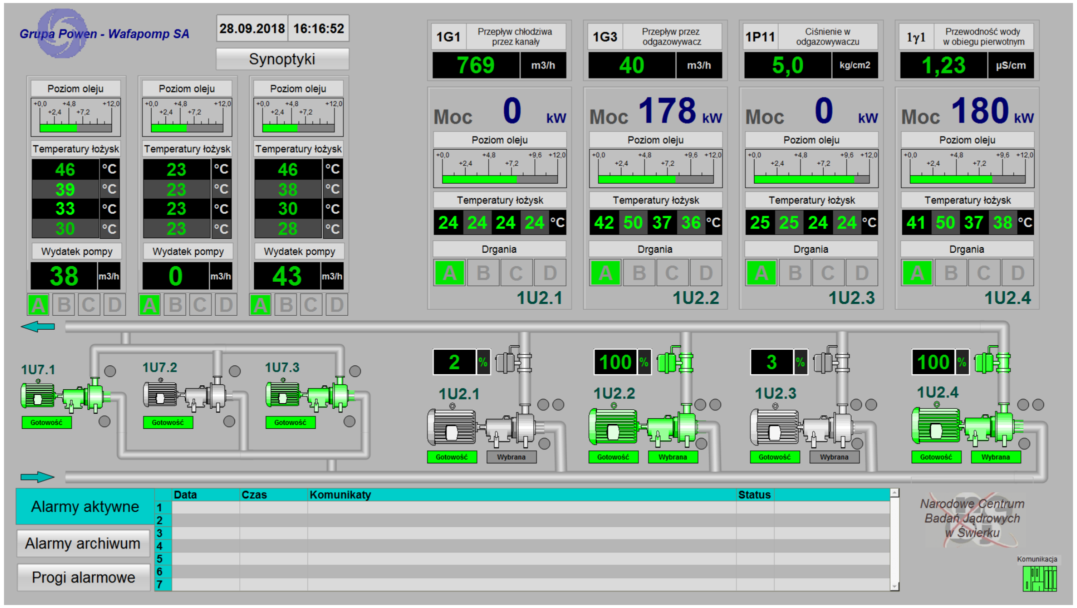
- Analyses of causes:
  - High pressure of gas in rod, $^{10}B(n,\alpha)^{7}Li$
  - swelling of B_4C pellets due to the absorption of thermal neutrons
- Corrective action
  - increasing the frequency of inspections the central rod
  - the introduction of a limit fluence (the procedure has been started)
  - changing the construction of the rod (gap)



Inspections, tests and surveillance programs

Using operational monitoring, the following parameters are monitored:

- Main and residual heat removal pumps bearing temperature,
- Residual heat removal pumps bearing vibration,
- Reactor building ventilators bearing temperature.

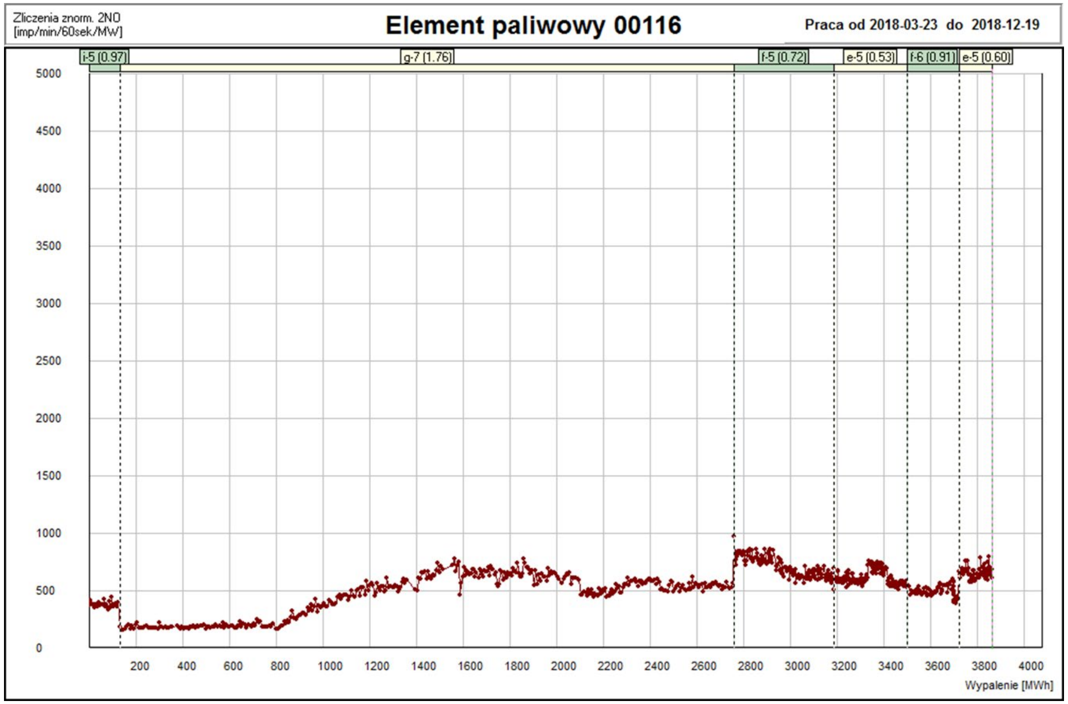


Fuel elements cladding integrity evaluation system

- Consists of sampling and detection systems for fuel channels and manifold,
- The gamma and delayed neutron radiation activity measurement in cooling water samples enables detection of cladding integrity,
- The limit value of fission products:

  $1.4x10^4$ ppm,

  - bellow that value – surface contamination,
  - above – cladding leak.



Preliminary plan for decommissioning the reactor MARIA

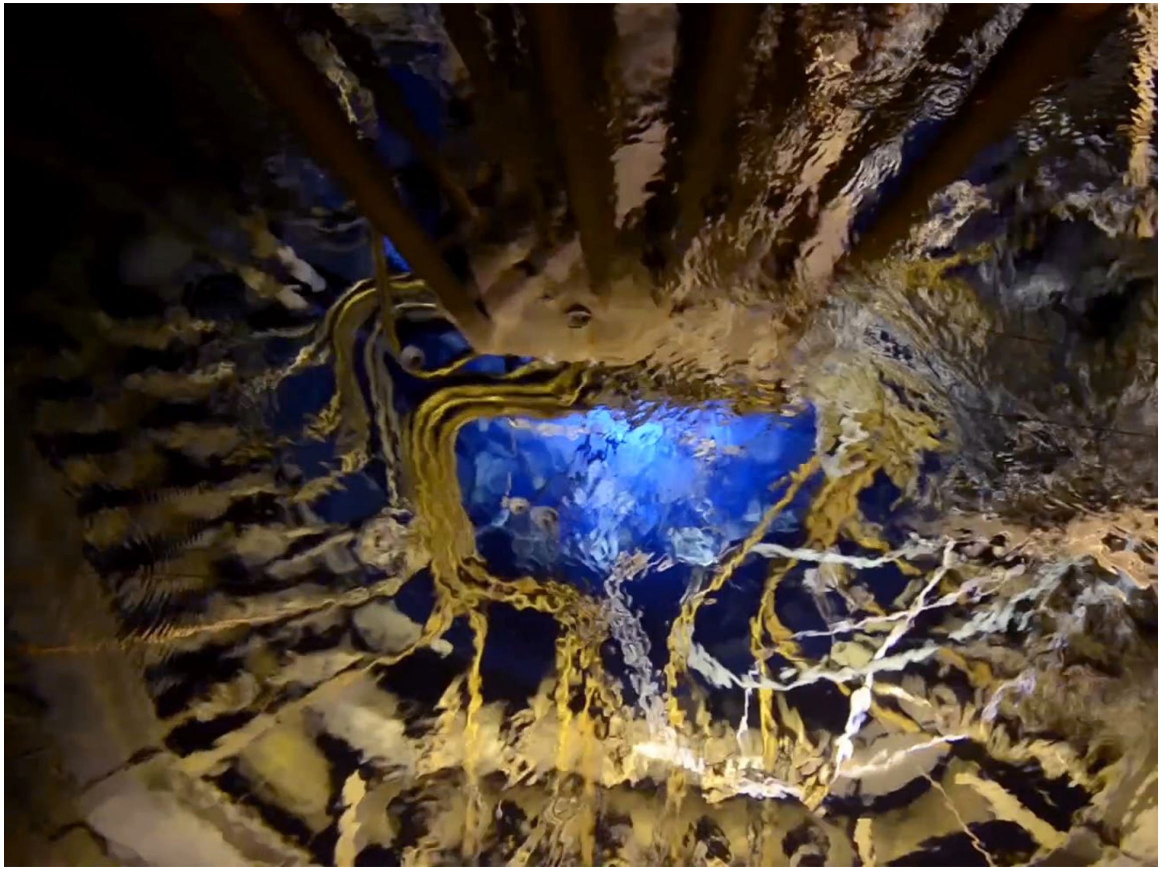
License to 2025 (2035).

We have basics plan for decommissioning.

Our strategy is to perform partial decommissioning, determinated by IAEA as „safe enclosure".

The scope of decommissioning includes:

- removing of fuel from the reactor core,
- evacuation of spent fuel from the spent fuel storage,
- removing of irradiated mobile parts,
- decontamination of technological circuits and rooms,
- facility under supervising.



Thank you for attention

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