

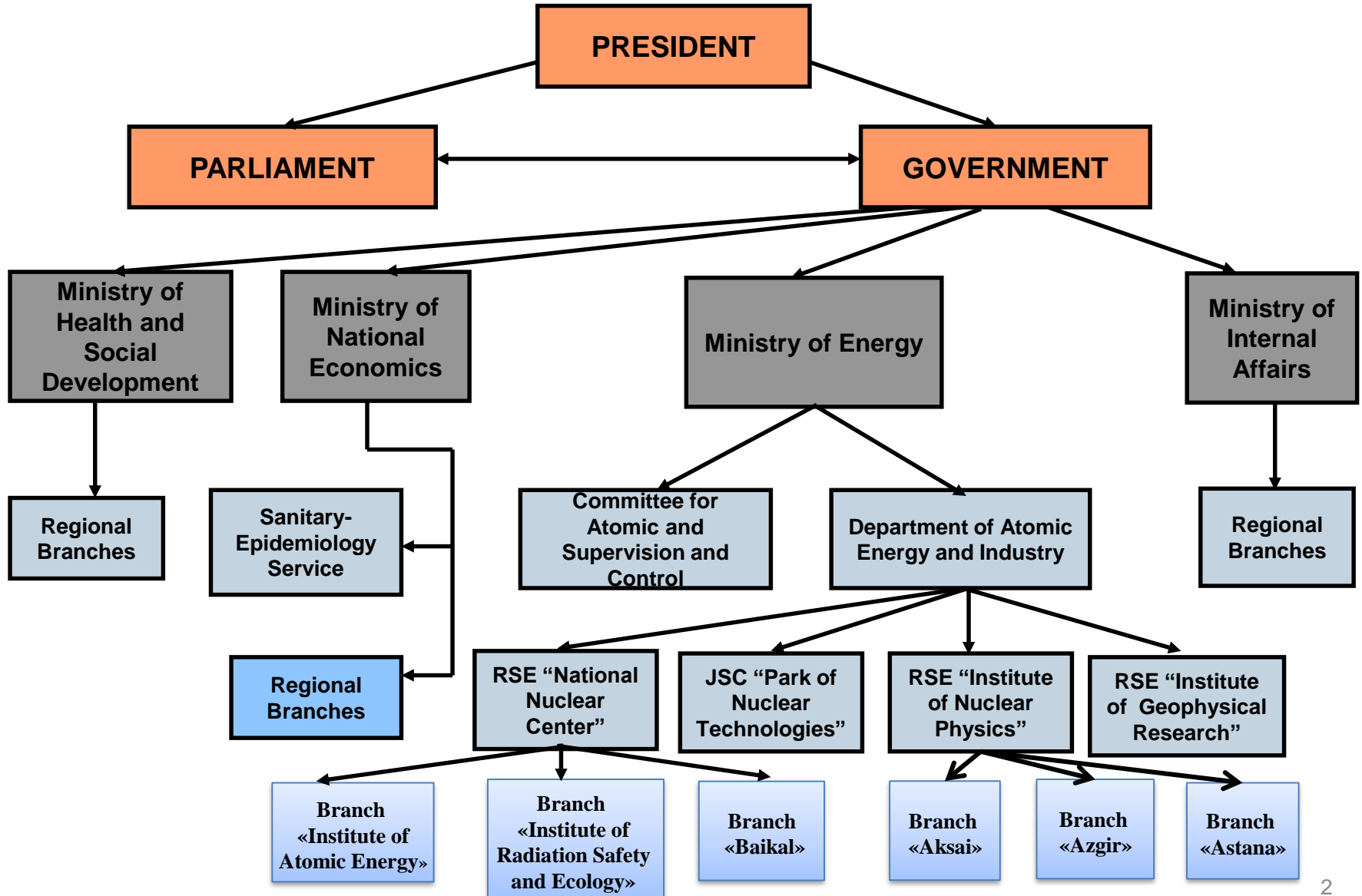
**Workshop on Safety Reassessment of Research Reactors in the Light of the
Lessons Learned from the Fukushima Daiichi Accident
2017 IGORR Conference, 4 to 7 December 2017, Sydney, Australia,**

**Safety reassessment of WWR-K RR related
to HEU/LEU conversion and feedback from
accident at the Fukushima-Daiichi NPP**

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State Structure for Atomic Energy Use Regulations



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The Fukushima NPP accident calls for necessity of critical review of measures on prevention of the same or similar accidents and timely response to emergency situations to eliminate the consequences of arising accident that makes to take a fresh look at the state of nuclear and radiation safety in the Republic of Kazakhstan including the entire list of measures to ensure nuclear and radiation safety of nuclear facilities, starting from the stage of site selection, design, licensing, commissioning, operation, safety assessment and inspections, emergency preparedness plans and emergency response programs, procedures for warning and informing, as well as the further.

One can highlight two items:

1. Improvement of regulatory framework of Kazakhstan;
2. WWR-K reactor modernization.

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1. Improvement of regulatory framework of Kazakhstan

Laws

- Law on Atomic Energy Use (January 10, 2016)
- Law on Radiation Safety of Population (April 23, 1998)
- Ecology code (January 9, 2007)
- Law on permissions and notifications (May 16, 2014)
- Entrepreneurial code (October 29, 2015)

International Conventions

- Convention on Physical Protection of Nuclear Material, 22.12.2004
- Convention on assistance in the case of a nuclear accident or Radiological Emergency, 08.04.2010
- Convention on early notification of a Nuclear Accident, 08.04.2010
- Convention on Nuclear Safety, 08.06.2010
- Joint convention on the safety of spent fuel management and on the safety of radioactive waste management, 08.06.2010
- Vienna Convention on Civil Liability for Nuclear Damage, 10.02.2011
- Amendment to the Convention on the Physical Protection of Nuclear Material, 19.03.2011

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Regulations

- Order of the Minister of Energy of the Republic of Kazakhstan “On Approval of Technical Regulations “Nuclear and Radiation Safety”, February 20, 2017, N 58;
- Order of the Minister of Energy of the Republic of Kazakhstan “On Approval of Technical Regulations “Nuclear and Radiation Safety of Research Nuclear Facilities”, February 20, 2017, N 59;
- Order of the Minister of Energy of the Republic of Kazakhstan “On Approval of Technical Regulations “Nuclear and Radiation Safety Nuclear Power Plants”, February 20, 2017, N 60;
- Hygienic regulations “Sanitary–Epidemiological requirements to Radiation Safety Assurance”, Order of the Ministry of National Economics №155 - 2015,
- Sanitary rules “Sanitary–Epidemiological requirements to Radiation Safety Assurance”, Order of the Ministry of National Economics №261 - 2015,
- Sanitary rules “Sanitary–Epidemiological requirements to Radiation Dangerous Facilities”, Order of the Ministry of National Economics №260 – 2015

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Orders of the Ministry of Energy (2016)

- physical protection regulations for nuclear material and nuclear facilities;
- physical protection regulations for sources of ionising radiation and storage facilities;
- rules for the decommissioning of nuclear and radiological facilities;
- qualification rules for organisations providing reviews of nuclear and radiation safety and nuclear security;
- regulations for the state accounting for nuclear material;
- regulations for the state accounting for sources of ionising radiation;
- safety rules for the handling of radionuclide sources;
- regulations for the transport of nuclear material;
- regulations for the transport of radioactive substances and radioactive waste;

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Orders of the Ministry of Energy (2016 Cont.)

- qualification improvement rules for personnel employed at objects of use of atomic energy
- certification rules for personnel employed at objects of use of atomic energy;
- procedure for approval of transport packaging designs, approve transport packaging designs and verify certificates of approval thereto, approved by designated authorities of other countries, for application in the Republic of Kazakhstan;
- regulations for the collection, storage and disposal of radioactive waste and spent nuclear fuel;
- Qualification requirements and list of documents for licensing in the field of atomic energy use

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Licensing

- Law on Permissions and Notifications, May 16, 2014
- Order of the Ministry of Energy Qualification requirements for Activities related to usage of Atomic Energy, April, 2017
- Entrepreneurial Code, October 29 , 2015
- Law on Atomic Energy Use, January 10, 2016

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In spite of adopted abovementioned documents there is a gap connected with the operation of the reactor. There is technological procedure of RR WWR-K operation, ISM-TR-03-15.01-42-01-2016 approved by the Institute of Nuclear Physics. This technological procedure is based on documents which are not adopted juridical in Kazakhstan. They are documents of the former Soviet Union. But according to item 19 of Technical Regulations “Nuclear and Radiation Safety” “List of used engineer-technical norms and rules for constructions, systems and elements of nuclear, radiation and electro-physical facilities corresponding to requirements of technical regulations or international requirements or requirements adopted in the origin country is defined by project enterprise and operator approves it with regulatory body in the sphere of atomic energy use”. On the basis of the item 19 of abovementioned technical requirement the Institute of nuclear physics made a list of documents used for safety operation of the reactor and approved it with the Committee for Atomic and Energy Supervision and Control (CAESC) of the Ministry of Energy of the Republic of Kazakhstan in October of 2016 which is the regulatory body. List of documents contains as national documents as some documents of the former Soviet Union and Russian Federation. Works on elaboration, update and adoption of documents are in a progress.

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1.2 WWR-K reactor modernization

The research reactor (RR) WWR-K is located in Alatau settlement near Almaty, (Fig.1 and Fig.2). Operator – RSE Institute of Nuclear Physics of the ME RK. It is tank type reactor with thermal neutrons spectra. Coolant and moderator are desalinated water, reflector is desalinated water and/or beryllium. The reactor was put into operation in 1967, operated on the thermal power of 10 MW up to 1988 without deviation from the normal operation [26]. The Research Manager of the RR WWR-K project is a Russian Research Center "Kurchatov Institute", the Chief Designer of the reactor – NIKIET, the General Designer of the WWR-K – SSDI. All of these organizations are located in the Russian Federation. In addition to fundamental nuclear physical and materials scientific researches and in-situ tests, the reactor is used for production of medical and industries radioisotopes and neutron activation analysis.



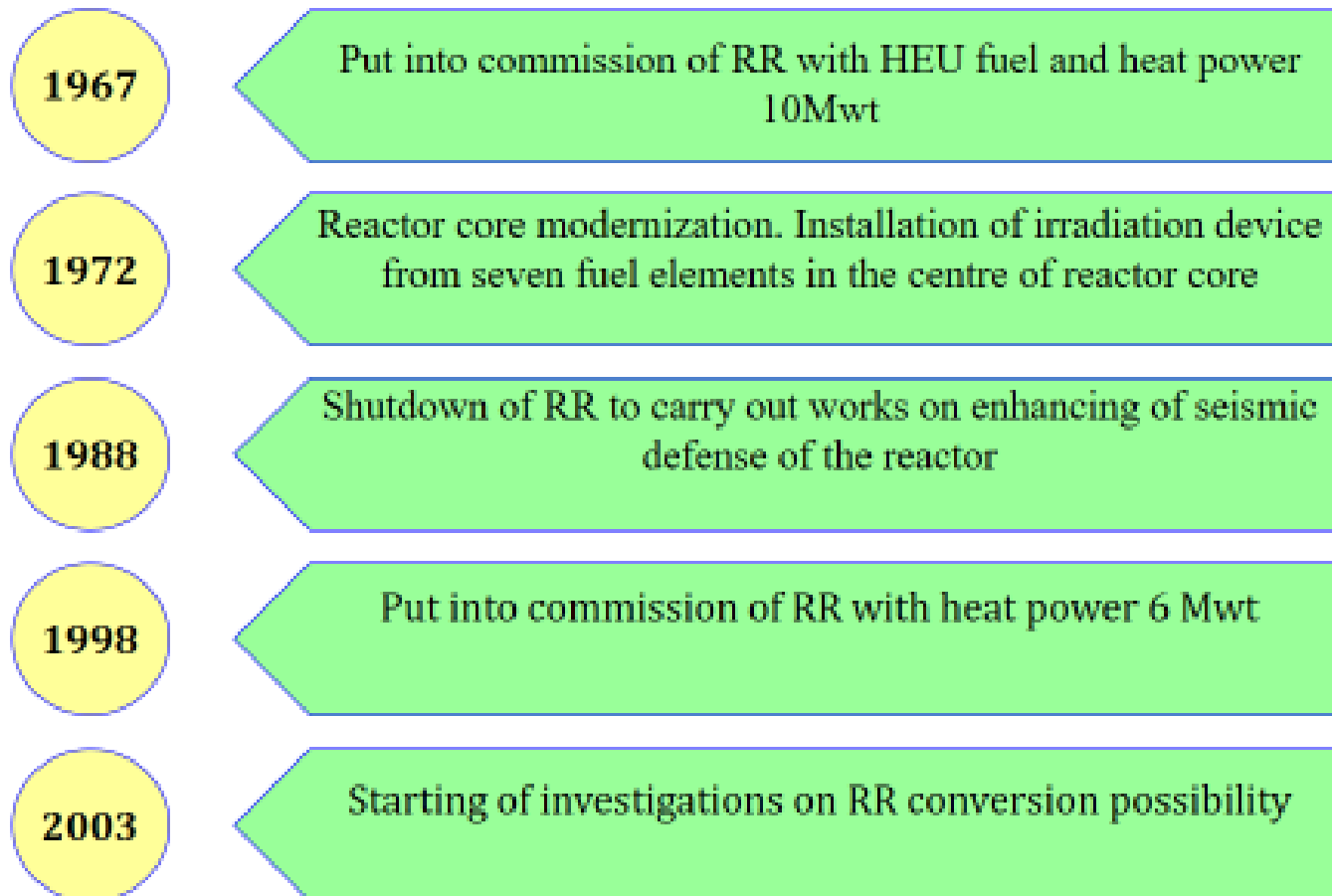
Utilizations:

- RI production;
- Fuel/material testing;
- Neutron activation analysis;
- Scientific research;
- Gemstone coloration (R&D);
- Transmutation doping of silicon (R&D)

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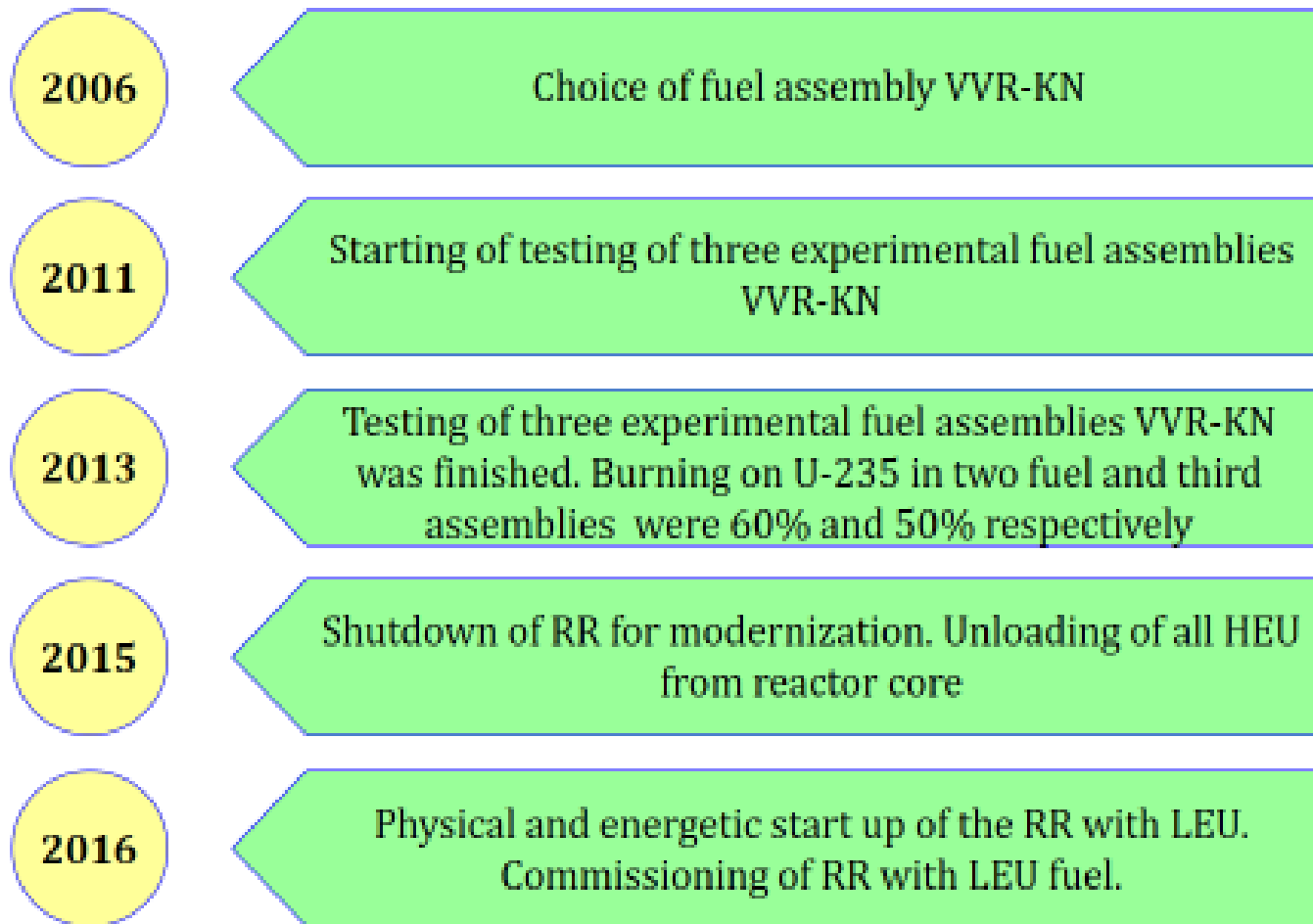
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Important Historical Phases of RR WWR-K

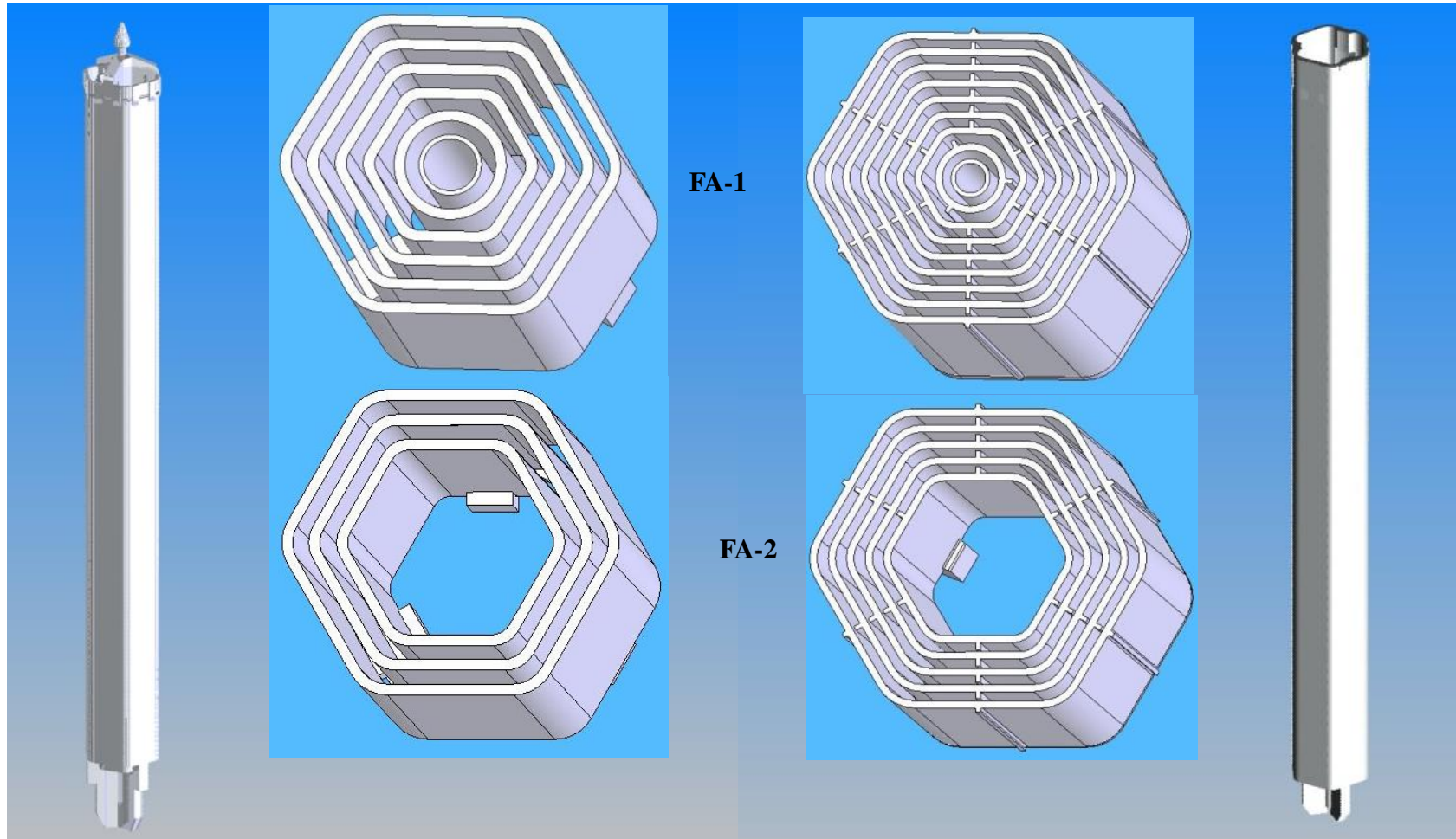


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Important Historical Phases of RR WWR-K



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VVR-C (left) and VVR-KN (right) FA

UPGRADES OF WWR-K REACTOR SYSTEMS

2015 - 2016

I&C system

- Replacement of electronics
- Replacement of control rod drive mechanisms

Emergency cooling system

- Replacement of pumps, some tubes and valves
- Installation of uninterrupted power supply

Emergency core sprinkling system

- Replacement of sprinkler and pumps

Primary cooling system

- Replacement of gaskets
- Inspection of vessel and piping

Secondary cooling system

- Installation of additional new cooling towers

Radiation monitoring system

- Complete replacement

Gas and aerosol emissions monitoring system

- Complete replacement

I&C SYSTEM - ELECTRONICS

- ❑ Designed and manufactured by JSC SNIIP-Systematom (Moscow, Russia)
- ❑ The factory acceptance tests carried out in May 2015
- ❑ It was delivered in Almaty in July 2015
- ❑ Initial visit the manufacturer's experts in September 2015
- ❑ Installation started in October 2015
- ❑ Testing and commissioning – February, March, 2016



UPS 3 kVA for each channel

← **Control room**

**Modern and digital
instrumentation based
computer (include record
and archive data)**

I&C SYSTEM – CONTROL ROD DRIVE MECHANISMS

CRD Mechanism includes drive, control rod and housing channel

- ❑ Designed and manufactured by ŠKODA JS a.s. (Plzen, Czech Republic)
- ❑ Factory acceptance testing in May 2015
- ❑ Delivered to Almaty in September 2015
- ❑ Installed and tested in February 2016



←CRD Mechanism

In new CRD mechanisms used electromagnet grip and if loss of electrical power supply, all rods insertion in core by gravity force

EMERGENCY COOLING SYSTEM



**Installation of 2 pumps, 45 m³/h each,
instead of 10 m³/h for HEU core**



**Installation of additional uninterruptible
power supply, with power 30 kW, 6 hours**



**Two diesel-generator with power
30 kW for each**

Table 1. LEU VVR-KN FA versus HEU VVR-C FA

VVR-C	Parameter	VVR-KN
36	Enrichment in U-235, %	19.7
UO₂-Al	Fuel composition	UO ₂ -Al
1.3	Uranium density, g·cm ⁻³	2.8
111	Amount of U-235, g in FA-1	245
86	in FA-2	198
5	Number of fuel elements in FA-1	8
3	in FA-2	5
2.3	Thickness of fuel element, mm	1.6
0.9	Thickness of fuel meat, mm	0.7
0.7	Thickness of fuel element clad, mm	0.45

Taking into account of Fukushima accidents and conversion it was adopted the decision to increase production capacity of pumps of emergency cooldown and put into operation uninterruptible power supply.

Four cooling towers had been put into operation instead of eight old one.

One of the most important items is the provision of the radiation safety of personnel, population and environment. As an example of this provision is the automatic system of radiation control.

Conversion of the main reactor system responsible for safety had been updated. As it was reflected in the report of the IAEA Integrated Safety Assessment of Research Reactor (INSARR) mission held from 27 February to 3 March 2017 safety level of the RR WWR-K corresponds to international requirements.

Prior the physical startup of the reactor, Safety analysis report of the WWR-K reactor with LEU was developed. SAR includes such main chapters as principles of safety assurance, analysis of potential accidents, operational limits and safe operation limits, nuclear safety, etc.

After the conversion of the WWR-K reactor, thermal neutron flux density was double increased in the center of core.

In accordance with legislation after physical and power startups of reactor WWR-K some amending had been put in safety analysis report. Now the updated SAR is under consideration of regulatory body.

Operation of the WWR-K reactor with LEU fuel was started from 1 September 2016.

CONCLUSIONS

- ❑ On 2015-2016 carried out upgrade of WWR-K RR safety systems – ensured safety operational;
- ❑ On 2016 carried out physical and power startups of WWR-K RR with LEU fuel;
- ❑ Operation of the WWR-K reactor with LEU fuel was started from 1 September 2016
- ❑ Safety reassessment of WWR-K RR carried out related HEU/LEU conversion and feedback at the accident of Fukushima Daiichi NPP.
- ❑ IAEA Integrated Safety Assessment of Research Reactor (INSARR) mission held from 27 February to 3 March 2017 conclusion - safety level of the RR WWR-K corresponds to international requirements

Thank you for your attention!





Hard Job of INSARR mission. 27 February-3 March 2017