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RITM-200 Reactor Core for Small-Sized NPPs

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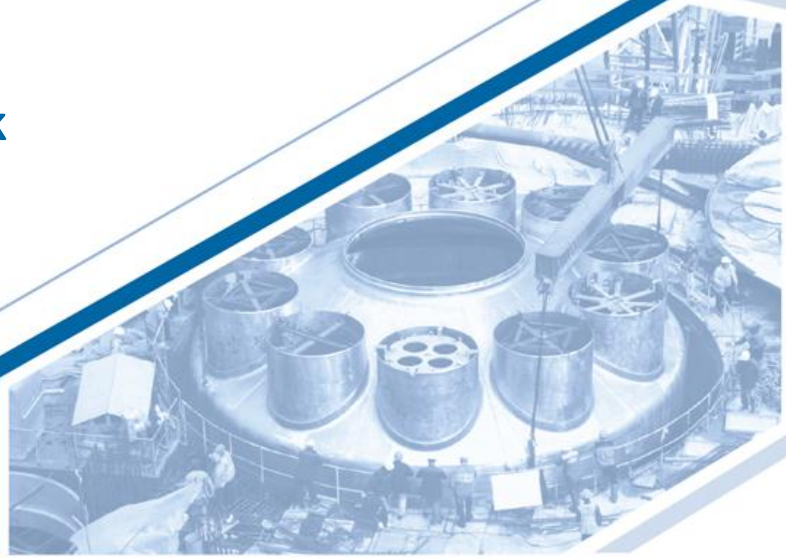

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Assigned Characteristics

Characteristics	Values	
	Option 1	Option 2
Rated power, MW	**175**	**165**
Average operation power, $\%N_{rated}$	**95**	
Refueling interval, years	**~5**	**~6-7**
Stored energy, TW-h	**7.0**	**8.0**
Life time, h	**40,000**	**48,500**
Core height, mm	**1,650**	
Number of FAs, pcs.	**199**	
Enrichment in U-235, %	**< 20**	

Design Characteristics

An analogue reactor core: KLT-40S reactor core for a floating power unit (FPU)

A reactor core similar in design: RITM-200 reactor core designed for a multipurpose nuclear icebreaker (MNI)

<table>
<tr><th>Characteristics</th><th>SNPP</th><th>MNI</th><th>FPU</th></tr>
<tr><td>Core circumscribed diameter, mm</td><td colspan="2">1566</td><td>1220</td></tr>
<tr><td>Core height, mm</td><td>1650</td><td>1200</td><td>1200</td></tr>
<tr><td>FA arrangement pitch, mm</td><td colspan="2">101</td><td>100</td></tr>
<tr><td>Number of FAs, pcs.</td><td colspan="2">199</td><td>121</td></tr>
<tr><td>Number of drive mechanisms of compensating group rods, pcs.</td><td colspan="2">12</td><td>8</td></tr>
<tr><td>Number of drive mechanisms of safety rods, pcs.</td><td colspan="2">6</td><td>3</td></tr>
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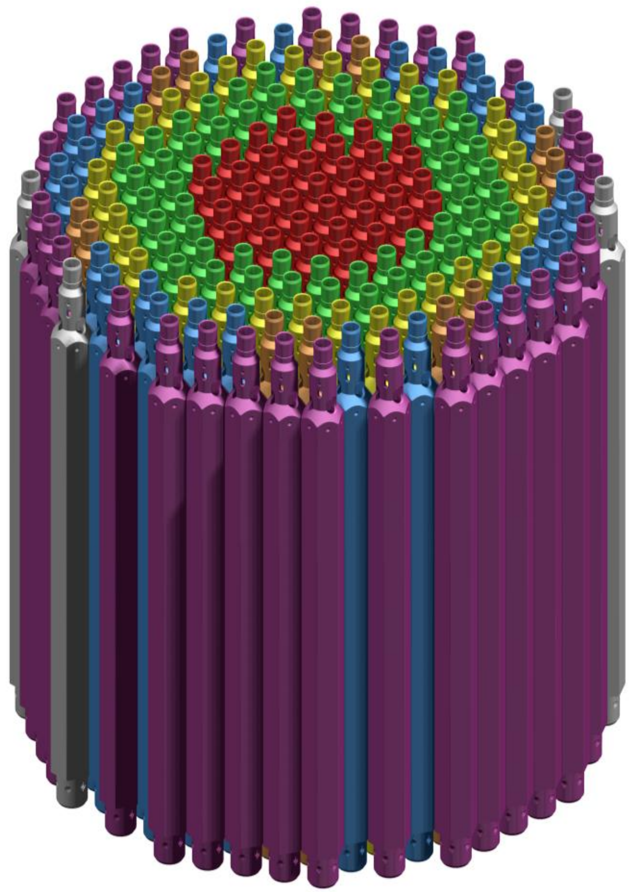
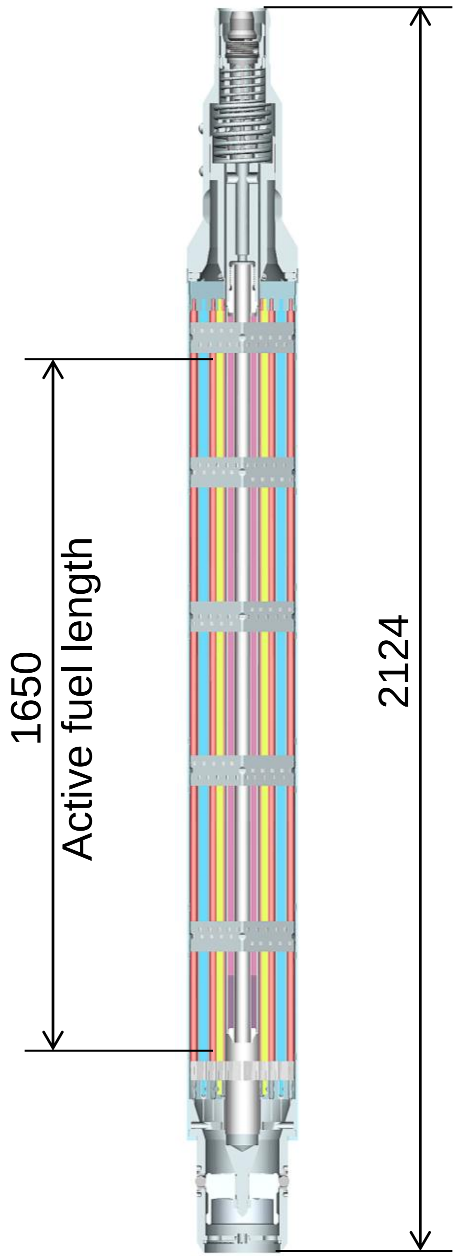
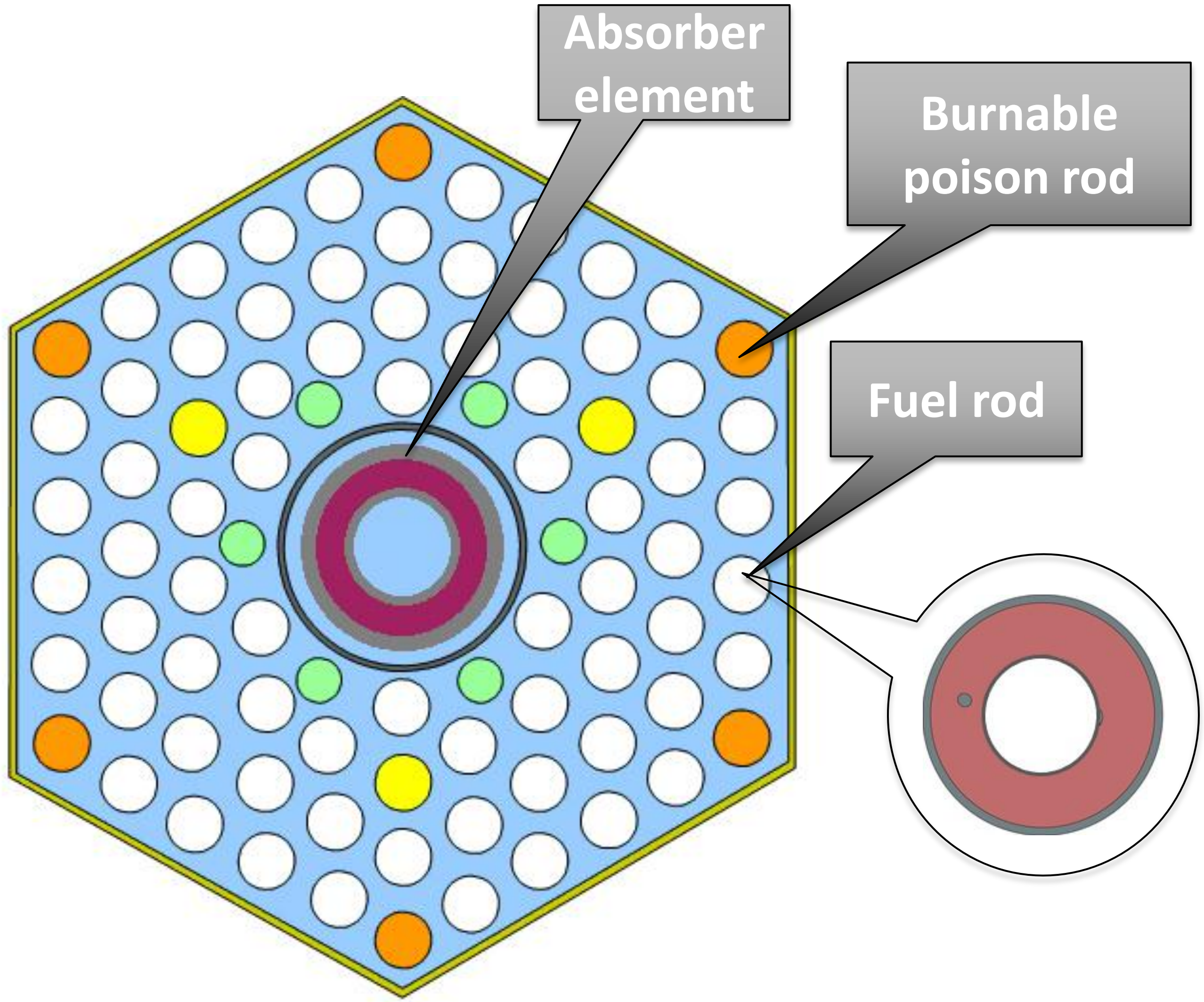


Characteristics of SNPP Reactor Core

Characteristics	Value	
	Option 1	Option 2
Number of fuel rods, pcs.	13692	13638
Uranium-235 load, kg	563.2	697.8
Mass fraction of Uranium-235 in Uranium, %: - maximum - average	 19.4 19.0	 19.6 19.3
Maximum fission-product build-up, g/cm^3	1.01…1.05	1.04
Maximum neutron flux with E≥0.1 MeV, 10^{22} N/cm^2	2.31	2.6
Maximum linear heat rate, W/cm	180	195
Coolant pressure, MPa	15.7	
Coolant temperature at core inlet/outlet, °C	277/313	277/313

Fuel Assembly

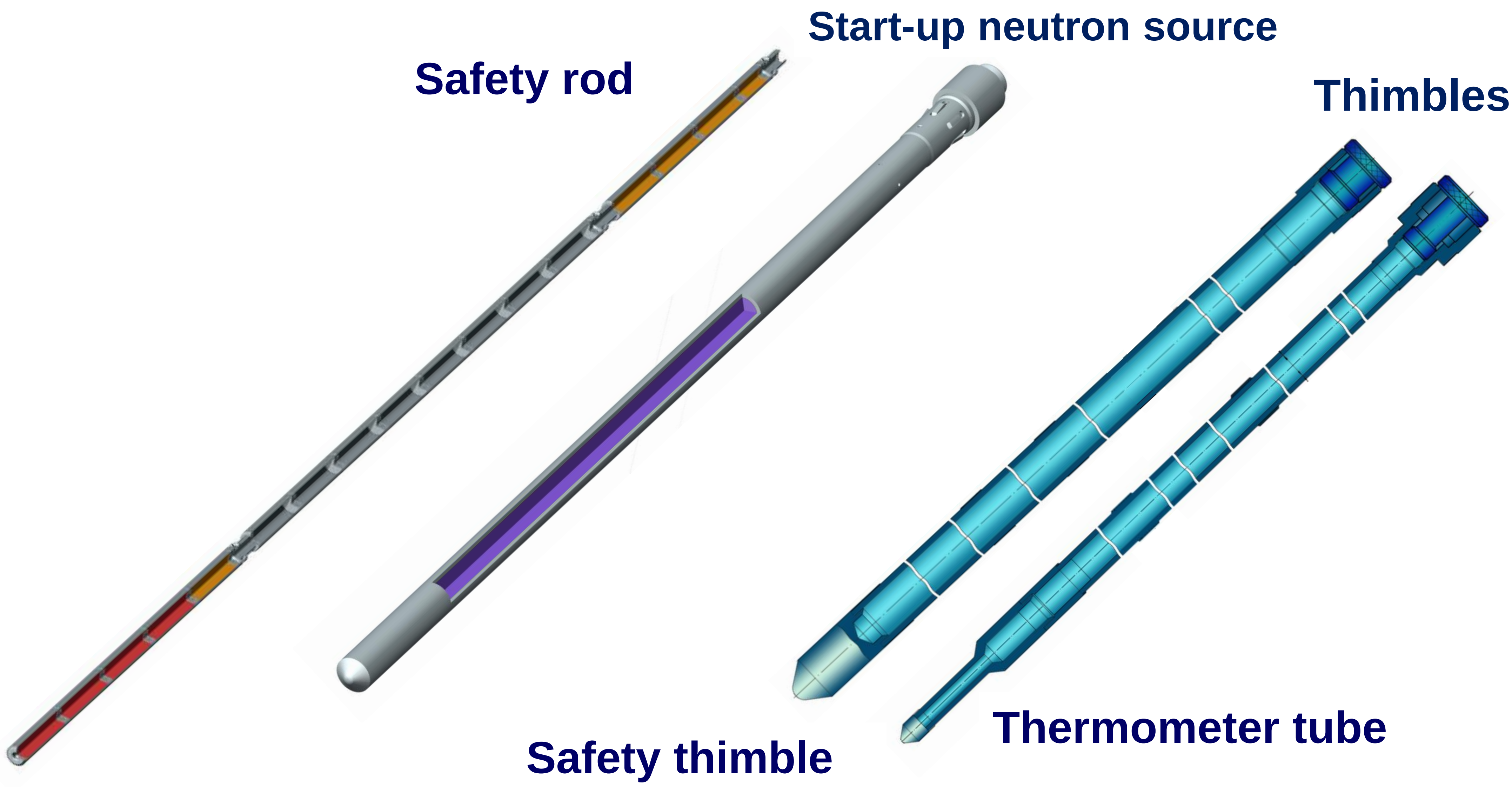




Element Inventory

Characteristics	SNPP	MNI	FPU
Overall length, mm	2124	1674	
Shroud Width across flats, mm thickness, mm material	 98.5 1.65 E110		
Fuel type	Cermet fuel	Intermetallic fuel	Cermet fuel
Fuel rod and burnable poison rod overall length, mm fuel rod diameter/clad thickness, mm clad material	 1725 6.9/0.3 42CrNiMo	 1275 6.9/0.25 42CrNiMo	 1275 6.8/0.5 E110
Absorber of burnable poison rod	Gd-Nb-Zr composition		
Absorber element design clad material absorber	 Ring-type 42CrNiMo Born carbide/ Dysprosium titanate		 Cluster-type

Reactor Core. Component Parts



Design Base

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Fuel assembly

14-14
- Lifetime – 21000 hours;
- Burnup – 0.75 g/cm^3*;
- Linear heat rate – 298 W/cm*;
- Fluence – $1.4 \cdot 10^{22}$ cm^{-2}
- Fuel – cermet
- Fuel rod with cladding of E110 alloy with swell compensator

Mechanics, Physics, Thermal Hydraulics

14-15-1
- Lifetime – 75000 hours;
- Burnup – 1.12 g/cm^3*;
- Linear heat rate – 379 W/cm*;
- Fluence – $1.77 \cdot 10^{22}$ cm^{-2}
- Fuel – intermetallic
- Fuel rod with cladding of 42CrNiMo alloy with swell compensator

SNPP with RITM-200 Reactor

- Lifetime – 48500 hours;
- Burnup – 1.04 g/cm^3;
- Linear heat rate – 195 W/cm;
- Fluence – $2.6 \cdot 10^{22}$ cm^{-2}
- Fuel – cermet
- Fuel rod with cladding of 42CrNiMo alloy with swell compensator

Fuel

PTVS 31-M
- Burnup – 1.05 g/cm^3;
- Linear heat rate – 280 W/cm;
- Fuel – cermet
- Fuel rod with cladding of 42CrNiMo alloy with swell compensator

Fuel Irradiation Facility
- Burnup – 1.02 g/cm^3;
- Linear heat rate – 270 W/cm;
- Fuel – cermet
- Fuel rod with cladding of E110 with swell compensator

PTVS 14-14
- Burnup – 0.82 g/cm^3;
- Linear heat rate – 250 W/cm;
- Fuel – cermet
- Fuel rod with cladding of E110 alloy with swell compensator

Cladding

14-15-1

PTVS 31-M

* Justified in the Fuel Rod Final Design

Fuel Rod of Extended Length

Fuel rods designed for FPU

Fuel rods designed for SNPP

Fuel rods designed for MNI

Optimization of production processes aimed at fuel charging into the fuel rod with increased active fuel length

- Equipment has been purchased
- Production line has been mounted
- WDD on fuel rod mockups has been developed
- Fuel rod charging process starts in May 2019

- Optimization of component parts manufacturing process
- Optimization of fuel rod manufacturing
- Optimization of fuel rod inspection
- Manufacturing of fuel rod mockups
- Manufacturing of pilot fuel rods

Irradiation Testing in the MIR Reactor and Post-Irradiation Examination

1

- The GIRLYANDA irradiation device and PTVS 14-14 charged with cermet fuel have made the way for the cermet fuel composition (the performed materials research activities and the test results have justified that the cermet fuel erosion-corrosion resistance is at any rate no worse than that of the intermetallic fuel)

2

- The loop fuel assembly PTVS-75 has demonstrated that it is impossible to arrange fuel rods in the angular cells behind the spacing angle piece in fuel assembly structure

3

- The loop fuel assembly PTVS-31M has demonstrated:
  - that it is possible to achieve the maximum burnup of at least 1.05 g/cm^3 in cermet fuel composition
  - a number of advantages of the steel compensator over the zirconium one.

SSC RIAR Objectives

1

•Post-Irradiation Examination of PTVS-31M have raised a number of issues which require additional studies.

2

•Examination of irradiated fuel rods in PTVS-31M under emergency conditions.

3

- Pilot-scale irradiation testing aimed at:
  - selecting optimal fuel rod cladding;
  - selecting optimal compensator;
  - switching over to higher fuel burnup.

R&D List

Optimize manufacturing technology of long fuel rods and FA component parts

Conduct FA tests:
- Mechanical tests
- Life time and hydraulic tests
- Thermal tests
- Irradiation-mechanical tests
- Thermal cyclic tests

Verify and validate neutronic analysis codes and thermal hydraulic analysis codes

Develop final designs of the reactor core fuel elements

Develop the reactor core final design

Thank You For Your Attention!