

I.Bilodid - O. Kukhotskyi - Sv.Nemtsova - Iu.Ovdiienko - Iu.Kovbasenko

Expert Safety Assessment to Support the Licensing of Accelerator – Driven Nuclear Facility in Ukraine



Neutron Source facility

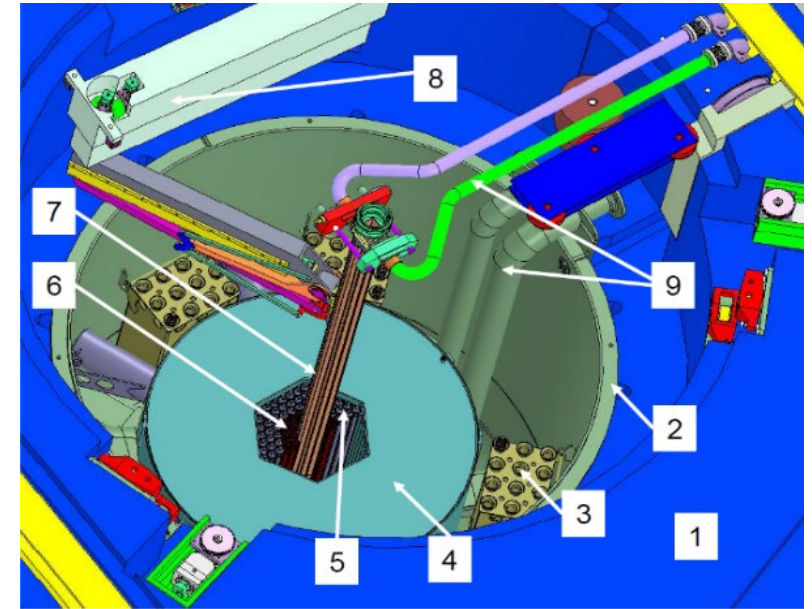
- provide capabilities for performing scientific and applied research
- perform material experiments inside the subcritical assembly
- produce medical isotopes
- train young specialists
- scientific study of ADS



Neutron Source facility

Main components:

- subcritical assembly: pool-type, water moderated
 - 37-38 VVR-M2 fuel assemblies, 19.7% enrichment
 - radial reflector: beryllium units and an annular graphite reflector
 - neutron-generating target: W or natural U
- linear electron accelerator: 100 kW, 100MeV
- neutron channels for nuclear research
- $k_{\text{eff}} \leq 0.98$
- core thermal power < 250 kW



- 1 - biological shielding;
- 2 - tank;
- 3 - hinged racks;
- 4 - graphite reflector;
- 5 - beryllium reflector;
- 6 - core;
- 7 - target;
- 8 - refueling machine;
- 9 - cooling system



Neutron Source facility

- In compliance with the agreements reached at the Washington Security Summit and set forth in the Joint Statement by the Presidents of Ukraine and the United States of America in April 2010 and in the Memorandum of Understanding on Nuclear Security Cooperation between the Governments of Ukraine and the United States signed on 26 September 2011, a subcritical neutron source facility is being constructed on site of the Kharkov Institute of Physics and Technology
- 10 November 2013, SNRIU issued License No.001018 for the Neutron Source construction and commissioning
- 3 July 2014, SNRIU approved the Neutron Source Commissioning Program

Neutron Source facility

The construction and licensing of the state-of-the-art nuclear research facility – Neutron Source was a challenge for:

- Operating organization:
 - technical challenges caused by unique design features of the facility;
 - lack of the operator's experience in the development of licensing, operational, technical and maintenance documents

- SNRIU & SSTC NRS:
 - no regulatory framework to govern nuclear and radiation safety of such type of facilities
 - no experience in assessing the nuclear and radiation safety of such type of facilities

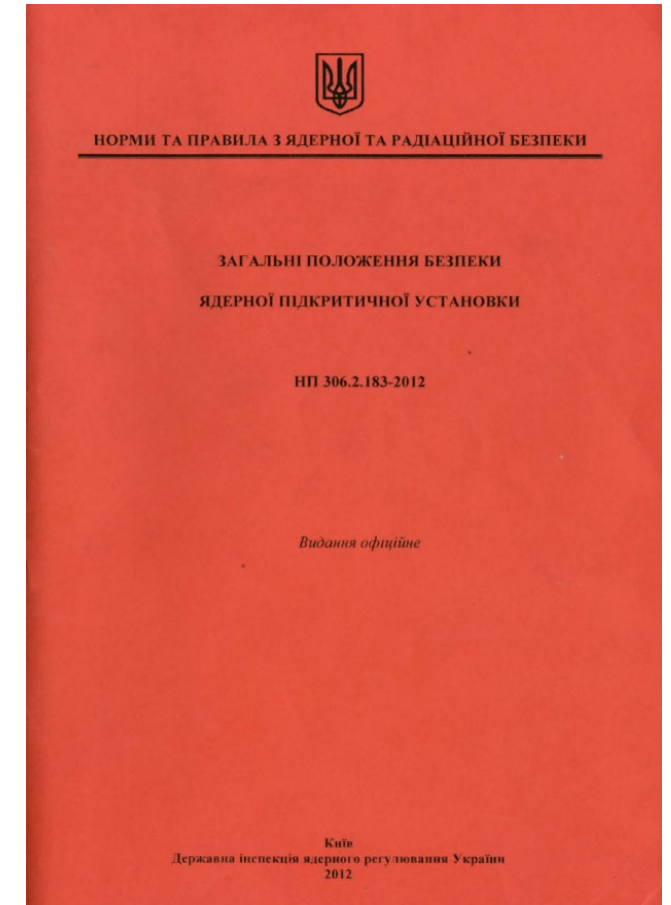
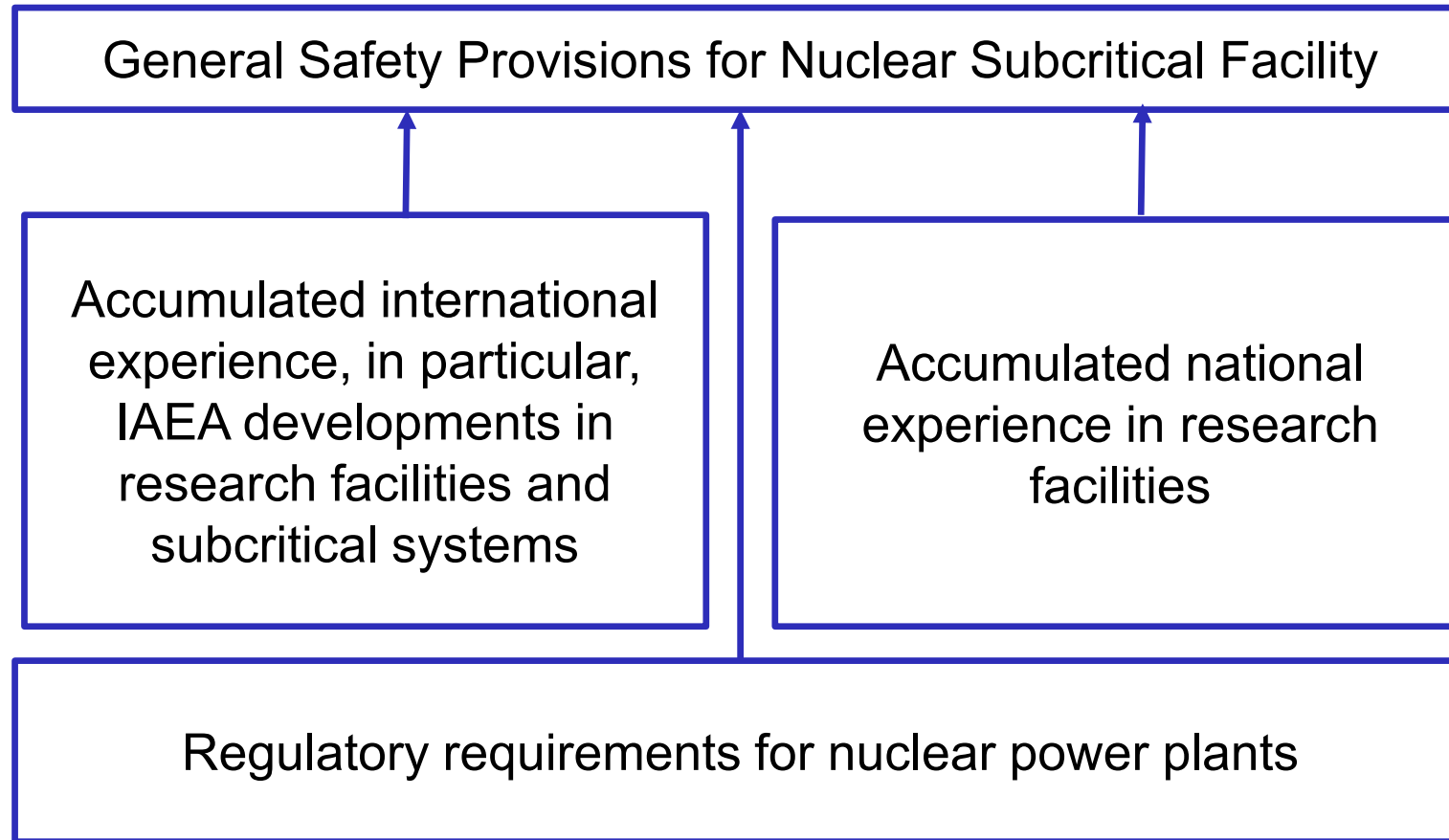


Regulatory framework

At the beginning of the Neutron Source design, the Ukrainian regulatory framework included three former USSR regulations in force:

- Nuclear Safety Rules for Subcritical Benches (PBYa-01-75);
 - Safety Rules for Research Reactors (PBYa-03-75);
 - General Safety Provisions for Research Reactors in Design, Construction and Operation (OPB IR)
- General Safety Provisions for Nuclear Subcritical Facility, 2012

Regulatory framework



International collaborations in Neutron source's licensing



European Commission

INSC projects with support of the European Commission



“Licensing of new nuclear subcritical facility – neutron source based on an electron accelerator-driven subcritical assembly” (UK/TS/49)
(3 unique tasks)

Strengthening of SNRIU capabilities in licensing of new nuclear installations (except NPPs)” (UK/TS/51)
(2 unique tasks)

SSITC NRS | STATE ENTERPRISE
STATE SCIENTIFIC AND TECHNICAL
CENTER FOR NUCLEAR AND
RADIATION SAFETY

← *completed
successfully*

SSITC NRS | STATE ENTERPRISE
STATE SCIENTIFIC AND TECHNICAL
CENTER FOR NUCLEAR AND
RADIATION SAFETY

← *on-going*



International collaborations in Neutron source's licensing



“Licensing of new nuclear subcritical facility – neutron source based on an electron accelerator-driven subcritical assembly”
(UK/TS/49)

Gaining new experience

Strengthening of SNRIU capabilities in licensing of new nuclear installations (except NPPs)”
(UK/TS/51)

Familiarization with EU experience in design, construction, licensing and operation of accelerator driven subcritical Assemblies

Improvement regulatory framework

on-going
Enhancement of the regulatory oversight for the Neutron Source

Development of regulations and methodologies on Neutron Source Safety

Support in expert safety assessment

Development of the safety cases for Neutron Source

Development of models and the Validation & Verification methodology for the regulatory review



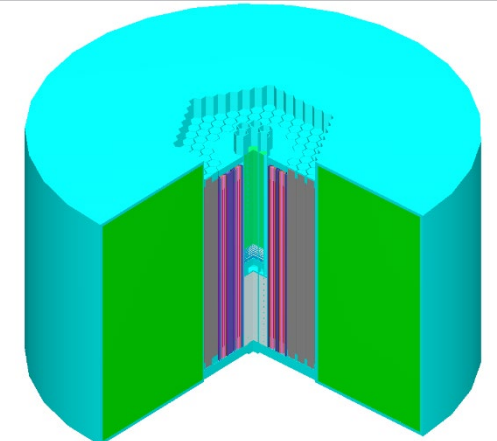
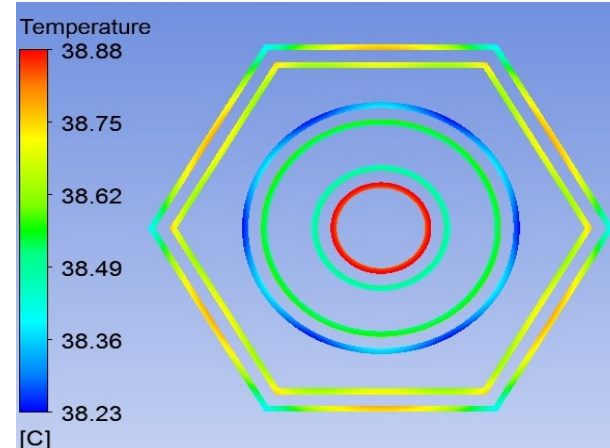
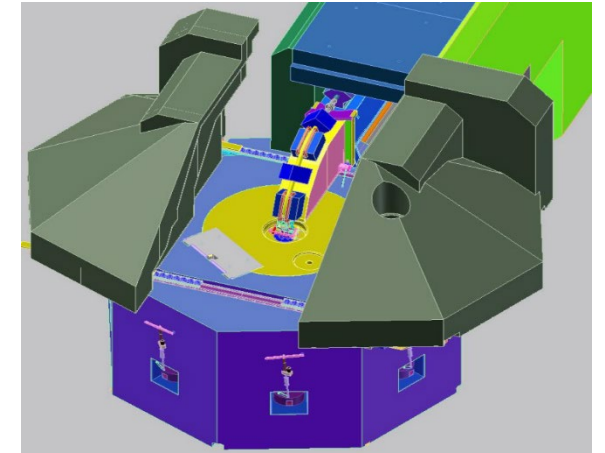
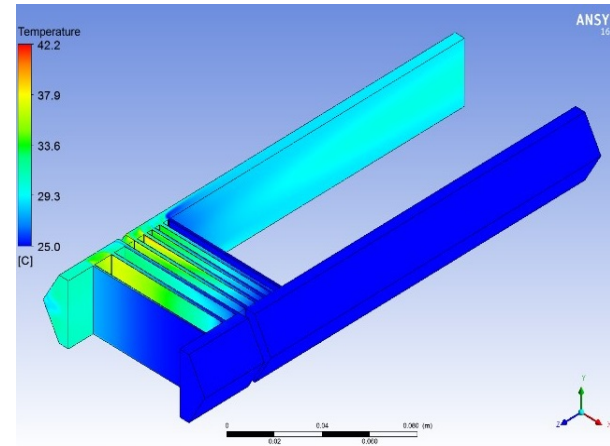
Expert safety assessment

Areas of verification calculations:

- Neutron physics (SCALE)
- Thermal hydraulics (ANSYS CFX)
- Radiation protection (MCNPX)

Approaches to verification calculations:

- independent models
- different computational tools



Expert safety assessment

Model	$k_{\text{eff}} \pm \sigma$
PSAR (MCNPX), average design parameters	0.97739 ± 0.00012
SSTC NRS calculation (SCALE), average design parameters	0.97533 ± 0.00016
SSTC NRS calculation (SCALE), consideration of fuel enrichment and density tolerances	0.98477 ± 0.00020 $k_{\text{eff}} > 0.98$

- 1) first loading of 35 FAs; justification performed on real FA data
- 2) report on the results of initial startup with 35 FAs
- 3) final stage - loading of 36-38 FAs

Expert safety assessment

Neutron physics

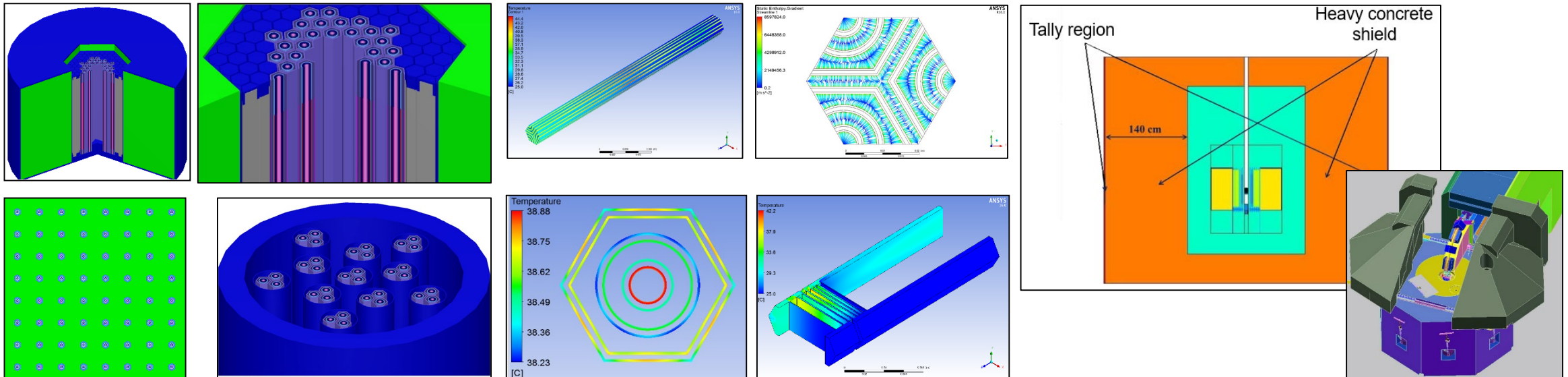
- subcritical assembly
- transport cask
- fresh fuel storage facility
- spent fuel storage facility

Thermal hydraulics


- VVR-M2 fuel assembly
- neutron generating target and
- steady-state and transient scenarios

Radiation protection

- biological shielding
- source term estimation for LOCA



Recent activities

- all construction activities, installation and functional tests of equipment and systems important to safety have been completed;
- necessary technical and operational documentation developed, passed state review and agreed with SNRIU;
- an individual permit for the first nuclear fuel delivery to the NSC KIPT industrial site was issued by SNRIU on 12 April 2019;
 - fuel was delivered to the NSC KIPT site in May 2019 and placed for storage
- obtaining an individual permit for the initial startup:  *we are here*
 - updating the PSAR based on the construction activities and tests;
 - ❖ performing criticality calculations to justify the safety of the first core loading

Recent activities

Significant design changes were made to the NSF design:

- number of FAs to be loaded into the core with a tungsten target was reduced (38 FAs versus 43/42 FAs prior to modification);
- two absorbing safety rods were introduced;
- biological shielding design was modified;
- number of hinged racks in the NSF tank was reduced from five to three;
- internal reflector material was changed to two-component beryllium–graphite material instead of single graphite



Summary

- SSTC NRS participates in the state review of the Neutron Source upon request of the regulatory body throughout the facility life cycle
- construction of the Neutron Source has become a challenge not only for the operator and regulatory body but also for SSTC NRS
- SSTC NRS experts gained extensive new knowledge and became acquainted with the latest international experience in safety justifications of ADS, which was immediately applied in review activities
- SSTC NRS continues to ensure an appropriate level of technical support to the regulatory body



Thank you for your attention!

-  sstc.com.ua
-  sstc.com.ua
-  [SSTC_NRS](#)
-  [SSTC NRS](#)
-  nrs@sstc.com.ua

