ENEEP Member: The Czech Technical University in Prague

Shortlist of novel education and training activities

February 2024

Contents

1. Study of thermal neutron flux tilt by insertion of a control rod

Basic information

Main topic: Experimental reactor physics
Subtopic: Thermal neutron flux distribution at a reactor, control rod

Level of exercise ☛Basic ☛Advanced Complex
Level of education ☛BSc ☛MSc ☛PhD
Keywords: VR-1 reactor, neutron flux distribution, thermal neutron flux distribution, control rod, thermal neutron flux tilt

1.1. Purpose of experiment

During Neutron flux distribution measurement (CTU03) thermal neutron flux distribution is studied and during Control rod calibration (CTU09) basic properties of control rod is studied. In real reactor operation position of a control rod may significantly affect thermal neutron flux distribution in a reactor core. During CTU03 experiment influence of position of control rod/rods are neglected. In this subsequent experiment measurement of neutron flux tilt, or neutron flux deformation, caused by partially or fully inserted control rod is studied.

1.2. What you will learn

Learning objective of the experiment is to learn and to understand the influence of control rod position to thermal neutron flux tilt, i.e. neutron flux deformation. A clear understanding of thermal neutron flux tilt is a prerequisite for all who are directly involved in the reactor operation, design or reactor safety analysis, and nuclear education. Experiments related to thermal neutron flux tilt are highly suitable for students studying nuclear engineering as the major curriculum and it is suitable for students studying various major engineering curricula as such as power engineering, mechanical engineering, electrical engineering with future assignment in various nuclear curricula.

1.3. Pre-knowledge required

The students should be familiar with introduction to reactor physics, particularly with theory of thermal neutron flux distribution at a reactor, control rod calibration, and with neutron detection. Prior to this experiment, CTU02 - Neutron detection and CTU09 - Control rod calibration should be performed.

1.4. Facilities and instruments

For performance of the experiment a training reactor VR-1 in critical state is required.

Required instruments for exercise: TBD (to be decided) and TBA (to be announced) when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

1.5. Experimental procedure

TBD and TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

1.6. Additional information

1.6..1 Limitations

TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

1.6..2 Procedure to sign up for experiment

TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

1.6..3 Other

Launching of this experiment to regular experimental education at the VR-1 Reactor is expected in 2022.

2. Cherenkov radiation in a nuclear reactor

Basic information

Main topic: Experimental reactor physics
Subtopic: Cherenkov radiation detection

Level of exercise ☛Basic ☛Advanced Complex
Level of education ☛BSc ☛MSc ☛PhD
Keywords: VR-1 reactor, Cherenkov radiation, radiation detection, reactor power

2.1. Purpose of experiment

At almost all light water reactors or wet spent fuel storages Cherenkov radiation, i.e. Cherenkov light, easily can be observed by visitors by their eyes. This amazing blue light discovered and described by the 1958 Nobel Prize winner Pavel Cherenkov is not only very attractive visual effect during a reactor operation, but also it can be seriously studied and use in reactor power monitoring. In this specific experiment detection of Cherenkov radiation is carried out and relation between Cherenkov radiation intensity and reactor power are studied.

2.2. What you will learn

Learning objective of the experiment is to learn and to understand the Cherenkov radiation detection and capability of Cherenkov radiation in a reactor power monitoring. Experiments related to Cherenkov radiation are suitable for students studying nuclear engineering as the major curriculum.

2.3. Pre-knowledge required

The students should be familiar with introduction to nuclear basic physics.

2.4. Facilities and instruments

For performance of the experiment a training VR-1 reactor in critical state is required.

Required instruments for exercise: TBD (to be decided) and TBA (to be announced) when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

2.5. Experimental procedure

TBD and TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

2.6. Additional information

2.6..1 Limitations

TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

2.6..2 Procedure to sign up for experiment

TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

2.6..3 Other

Launching of this experiment to regular experimental education at the VR-1 Reactor is expected in 2022-2023.

3. Experiments with D-D neutron generator

Basic information

Main topic: Experimental reactor physics, experimental neutron physics
Subtopic: Experimental reactor physics, experimental neutron physics

Level of exercise Basic ☛Advanced Complex
Level of education BSc ☛MSc ☛PhD
Keywords: VR-1 reactor, D-D neutron generator

3.1. Purpose of experiment

Coupling of the reactor and the neutron generator significantly increases the utilisation of the VR-1 reactor and enhances educational experiments. The D-D neutron generator in the reactor allows to study of subcritical, critical and supercritical systems with an external neutron source (i.e. neutron generator). Subsequently, the VR-1 reactor will be in various states and exposed to various neutron pulses or continuous neutron beam from the generator. In addition, it also allows determination of kinetics parameters of the reactor core by various methods (e.g. Rossi-, Feynman-, Sjöstrand-Gozani method) when reactor is in deep subcriticality and the reactor core is driven by neutrons from the neutron generator. The D-D neutron generator allows to study the neutron transport through matter. Here, the neutron generator as a stand-alone device produces neutron pulses or continuous neutron beam penetrating through moderator (e.g. water, graphite or polyethylene). This arrangement allows easily measurement of several basic diffusion parameters such as diffusion length, diffusion coefficient, macroscopic absorption cross section, etc. In the future, it will also allow to use it for neutron activation analysis and potentially neutron imaging for educational and training purposes.

3.2. What you will learn

Learning objective of the experiment is to learn and to understand the role of the D-D neutron generator as a source of 2.4 MeV neutrons and capabilities of the D-D neutron generator in study of reactor transients. These advanced experiments related to the D-D neutron generator are suitable for students studying nuclear engineering as the major curriculum.

3.3. Pre-knowledge required

The students should be familiar with various aspects of experimental reactor physics. Prior to this advanced experiment 11 standard experiments CTU02 - CTU12 should be performed.

3.4. Facilities and instruments

For performance of the experiment a training reactor VR-1 in critical or subcritical states and D-D neutron generator is required. Required instruments for exercise: TBD (to be decided) and TBA (to be announced) when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

3.5. Experimental procedure

TBD and TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

3.6. Additional information

3.6..1 Limitations

TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

3.6..2 Procedure to sign up for experiment

TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

3.6..3 Other

Launching of this experiment to regular experimental education at the VR-1 Reactor is expected in 2022-2023.

4. Experiments with D-T neutron generator

Basic information

Main topic: Experimental reactor physics, experimental neutron physics
Subtopic: Experimental reactor physics, experimental neutron physics

Level of exercise Basic ☛Advanced Complex
Level of education BSc ☛MSc ☛PhD
Keywords: VR-1 reactor, D-T neutron generator

4.1. Purpose of experiment

Portable D-T neutron generator MP320 from Thermo-Fisher Scientific company was purchased at the end of year 2020. The generator, which produces fast neutrons with the energy 14 MeV, will be used for various research and educational purposes. Experiments for students will be focused on study of properties of the generator as source of fast neutrons and demonstration of its use in reactor and neutron physics.

4.2. What you will learn

Learning objectives of the experiments are to learn and to understand the role of the D-T neutron generator as a source of 14 MeV neutrons for various neutron applications. These advanced experiments related to the D-T neutron generator are suitable for students studying nuclear engineering as the major curriculum.

4.3. Pre-knowledge required

TBD (to be decided) and TBA (to be announced) when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

4.4. Facilities and instruments

For performance of the experiment D-T neutron generator is required.

Required instruments for exercise: TBD and TBA when experiments will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

4.5. Experimental procedure

TBD and TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

4.6. Additional information

4.6..1 Limitations

TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

4.6..2 Procedure to sign up for experiment

TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

4.6..3 Other

Launching of these experiments to regular experimental education at the VR-1 Reactor is expected in 2023-2024.

5. Experiments with subcritical reactor VR-2

basic information

Main topic: Experimental reactor physics
Subtopic: Experimental reactor physics, lattice physics, core physics

Level of exercise ☛Basic ☛Advanced Complex
Level of education ☛BSc ☛MSc ☛PhD
Keywords: VR-2 reactor, subcritical assembly, lattice physics, core physics

5.1. Purpose of experiment

The VR-2 subcritical reactor (subcritical assembly) is an ongoing project that will ultimately build and operate a new nuclear reactor in the Czech Republic. The VR-2 reactor will bring new educational, training and research capabilities which will satisfy users' needs. The unique feature of the assembly will be its maximal flexibility and modularity - variability in lattice geometry (square or hexagonal), fuel pins pitch, neutron sources, moderator level and moderator temperature as well as fuel pin type itself. The construction will allow reaching effective multiplication factor up to 0.97. There also will be a variability in external neutron sources which can be used in order to keep steady-state chain reaction. The sitting license was obtained on November 3, 2020, and nowadays the VR-2 reactor is design and construction stage. Expected commissioning of the VR-2 reactor is at the end on 2022 / beginning of 2023. Planned education experiments at the VR-2 reactor: reactivity measurement by Source Jerk method; neutron flux mapping; determination of half-lives of delayed-neutron group; determination of reflector savings; neutron noise experiments; pulsed source experiments; etc.

5.2. What you will learn

Learning objectives of the experiments with subcritical reactor VR-2 are to learn and to understand the basic lattice physics / core physics principles and phenomena. The experiments with subcritical reactor VR-2 are highly suitable for students studying nuclear engineering as the major curriculum and it is suitable for students studying various major engineering curricula as such as power engineering, mechanical engineering, electrical engineering with future assignment in various nuclear curricula.

5.3. Pre-knowledge required

TBD (to be decided) and TBA (to be announced) when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Nuclear Experimental Hub.

5.4. Facilities and instruments

For performance of the experiment a subcritical VR-2 reactor is required.

Required instruments for exercise: TBD and TBA when experiments will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Nuclear Experimental Hub.

5.5. Experimental procedure

TBD and TBA when experiments will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Nuclear Experimental Hub.

5.6. Additional information

5.6..1 Limitations

Rudimentary detector module is not suitable for imaging of extended sources or complex TBA when experiments will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Nuclear Experimental Hub.

5.6..2 Procedure to sign up for experiment

TBA when experiments will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Nuclear Experimental Hub.

5.6..3 Other

Launching of these experiments to regular experimental education at the VR-1 Nuclear Experimental Hub is expected in 2024-2025.

6. Neutron radiography in practice

Basic information

Main topic: Neutron physics, neutron applications
Subtopic: Neutron radiography, neutron imaging

Level of exercise ☛Basic ☛Advanced Complex
Level of education ☛BSc ☛MSc ☛PhD
Keywords: VR-1 reactor, neutron physics, neutron applications, neutron radiography, neutron imaging

6.1. Purpose of experiment

Neutron radiography, also called neutron imaging, is a non-destructive technique for studying the structure of objects. Neutron radiography is widely used in various industrial applications, in earth and environmental studies, in culture heritage preservation, archaeology, palaeontology, biology and medicine as well as in various research and scientific applications. Neutron radiography allows analysis of a very varied range of samples, such as cultural or archaeological artefacts, various industrial products, plants, wood samples, etc. Building of neutron radiography facility at the VR-1 reactor is an ongoing research project, expected commissioning of the neutron radiography facility is at the end on 2023 / beginning of 2024.

6.2. What you will learn

Learning objective of the experiment is to learn and to understand the basic principles of neutron radiography and its role in non-destructive investigation of various objects in various fields of human activities. Experiments related to the application of neutron radiography in various fields of human activities are highly suitable for students studying neutron sciences, neutron applications or non-destructive techniques. Neutron radiography experiments are also suitable for students studying various fields of human activities such archaeology, biology, medicine, earth or environmental sciences as the major curriculum in conjunction with the minor curriculum in use of nuclear analytical techniques in master and doctoral study programs.

6.3. Pre-knowledge required

TBD (to be decided) and TBA (to be announced) when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

6.4. Facilities and instruments

For performance of the experiment a VR-1 reactor is required.

Required instruments for exercise: TBD and TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

6.5. Experimental procedure

TBD and TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

6.6. Additional information

6.6..1 Limitations

TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

6.6..2 Procedure to sign up for experiment

TBA when experiment will be fully developed, tested and validated for launching to regular experimental education at the VR-1 Reactor.

6.6..3 Other

Launching of this experiment to regular experimental education at the VR-1 Reactor is expected in 2024-2025.