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Laboratory Installation for Preparation of Students for Professional Activities

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Abstract: This study consider research installation project, designed to study laws Neutron Physics by students of Institution Nuclear Energy and Technical Physics Nizhny Novgorod State Technical University named after R.E. Alekseev. The study presents design of installation, stages of creation and scientific and practical value. Described used neutron sources and scientific research that can be implemented on installation. Main purpose of a universal neutron converter is calibration (efficiency of registration) of different types of detectors in flow of heat and slowing of neutrons.

Key words: Neutron Physics, detector, ionizing radiation, laws neutron, calibration, registration

INTRODUCTION

Institute Nuclear Energy and Technical Physics is basic educational institution that trains personnel for nuclear industry in Nizhny Novgorod. In order to improve experimental test facilities for training of engineers tasked to develop a versatile neutron converter. Device is designed to convert flux neutron spectrum fission, emitted from isotope sources, in thermal neutron flux with specified parameters.

Purpose of described laboratory setup:

- Training of laboratory works in disciplines stipulated in curriculum INETP
- Experimental study of regularities in distribution of neutron fluxes from local sources in a decelerating environment and also influence of neutron flux on structural materials
- Research and works infield of calibration of instruments for neutron flux monitoring

Using this setup can performed other work: Determination of isotopic composition offissile materials activation method and method of illumination by neutrons and low-energy spectrum and other works. In design of neutron converter were taken into account that device must meet security requirements.

Construction: Design contain several important parts (Abramov *et al*., 1970) described.

Neutron converter is contain:

- Region in which neutrons are slowed
- Biological protection
- Case construction
- Control system

Converter device is contain:

- Inner shell
- Internal support
- Paraffin assembly which is a camera with an internal cavity. Internal cavity is a research camera installation

Biological protect is contain: Protective composition. This is homogeneous substance in which neutrons are slowed down and absorbed.

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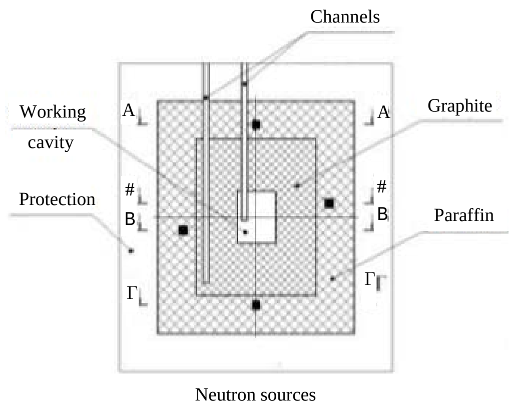

Fig. 1: Principal scheme of neutron converter

Protective lid: An additional element of biological protection lead nest which host neutron sources (Broder *et al*., 1967). Two materials were considered for protective composition.

Paraffin and graphite: First version of design biological protection is contain only graphite. Second construction of biological protection contains two layers: paraffin and graphite. But biological protect with graphite is heavy. Last construction of biological protect contain only paraffin. Wax melts and is poured into design during installation. Case of neutron converter made in form of a modular design. Thickness of paraffin was calculated to ensure a safety of background (Dmitriev *et al*., 2010).

Control system consists of a straight stroke mechanism with remote control and manual backups. Actuators designed for remote extraction and introduction of a measurement system in research chamber of neutron converter. Principal scheme of neutron converter is present in Fig. 1.

Paraffin is environment in which fast neutron flux is slow down. Neutron source is placed symmetrically in hydrogen-containing component. As materials of biological protection used materials with additives of boron. Case performs the function of carrier construction. All assistive elements of devices located on case 1. Measures are undertaken to reduce the background radiation following:

- Each of the sources shielded by a layer of lead
- Lead shield mounted in fixed points in hydrogen-containing component (Bolozdnya and Obodovsky, 2012)

Principle of operation installation is described. Research block is located on center of design. This block is removable. Block moves with use of lifting mechanism. Removable block contain cuvette. Research materials are placed in this cuvette and lowered into design. Research materials can be metals, material protect, products and other. Six neutron sources are located in volume of installation. Neutron sources are located on circle on two different heights. Neutron sources are located, thus, that neutron field is considered as sphere. It is therefore, considered that test materials are irradiated to evenly. Neutron sources are located in canals. There are six canals. Three channels of same depth and three channels of different depths. Canals are closed with plugs. Loading and unloading of neutron sources is performed using lifting mechanism. Used neutron source is source plutonium-beryllium (Pu239-Be) type. Energy of neutron in this source about 10 MeV. Neutron sources are cylinders of steel. Active component located inside cylinder. Active component is plutonium-beryllium mixture (Obodovsky, 2014).

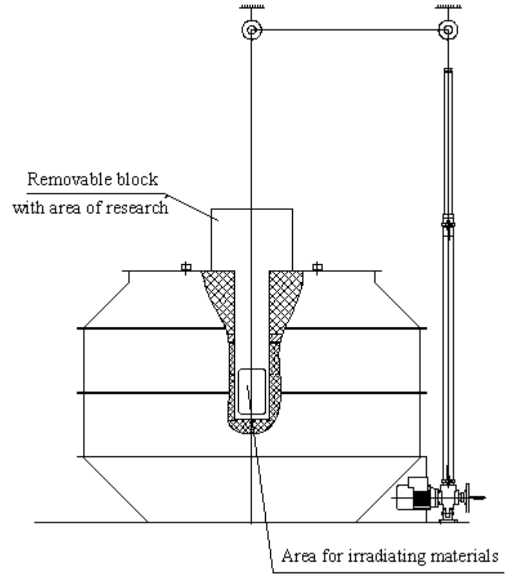

Fig. 2: Construction of neutron converter: front view

Measuring stand: Measuring stand is cylinder divided by height into 4 sections with a step of 50 mm (Fig. 2). In each section there are cells where can place activation detector. Detector is a cylinder. Radius of detector 10 mm, thickness of detector is 1.5 mm. Materials for detector rhodium foil and indium foil. Step in the plane 14 mm (equilateral triangle).

MATERIALS AND METHODS

Neutron sources are located in canals in special container. Before measurements and after it is necessary to measure counting installation background within 10 min. Detector isloaded in measuring stand. Detector used in installation is a rhodium-indium detectors. Recorded height on which was placed detector and cell number in which it is placed. Measuring stand is loaded in middle of design. Pinpoint time on which detector is placed inside. After irradiation time detector is removed from design and placed on counting installation. Radioactivity detector is measured several times at intervals of 10 min. Student should paint graph of changes in radioactivity of the detector in time.

Change height of detector or cell and conduct experiment again. Interval between end of irradiation and beginning of count radioactivity must be constant for every measurement radioactivity. By varying number of neutron sources, removing or adding them, it is possible to investigate influence of fields of various shapes on radioactivity of material.

Thus, it is possible to study change radioactivity of detector depending on time and position in measuring stand. Later it is planned to measure radioactivity of other materials such as metal, food, materials for biological protection and other.

RESULTS AND DISCUSSION

Data processing: As result of processing obtained data it is necessary to change radioactivity of detector in time depending on its location in measuring stand. Methods of data processing are given as (Obodovsky, 2014). Counting installation background:

$$F = \frac{N}{\tau_0}$$

Where:

F = Average counting installation background at 1 min

N = Number of counts in measurement without detector

t_0 = Time of measuring counting installation background, min

Radioactivity without a background:

$$A = N_0 - F \cdot \tau$$

Where:

A = Radioactivity of detector

N_0 = Number of counts in measurement with detector

F = Averag ecounting installation background at 1 min

τ = Time of measuring radioactivity of detector

Measures to ensure safety of personnel: Protection of personnel against radiation is provided by the implementation at all stages of operation of the neutron.

Converter the basic principles of radiation safety:

- Presence of a biological protection
- Restricting access to neutrons converter
- The restriction of access to sources of radiation
- Periodic (at least twice per year) monitoring of equivalent dose rate of radiation on the surface of the neutron converter
- Do not exceed the prescribed radiation dose limit
- Ventilation system in the room containing converter
- Regulation of actions of personnel at radiation-hazardous work and accidents
- Strict adherence to radiation safety rules

CONCLUSION

Multifunctional installation of neutron converter is developed. Neutron converter is allowing to solve educational, research and practical tasks. Use of neutron converter will allow students to acquire practical skills of neutron-physical measurements, apply obtained theoretical knowledge in practice in learning process and will provide an opportunity for in-depth study of means and methods of measurements related to Neutron Physics and Physics of nuclear reactors.

Skills acquired inuse of product will be useful to professionals operating organizations and design engineers and overall use of product will form a new competence of specialists for nuclear industry. Complex of laboratory works and methods of data processing are developing in present.

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