Recent Activity of VNIIM Neutron Group in 2007 – 2009

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The main directions of VNIIMs neutron group during 2007 - 2009 were the following;

1. Usual work for primary standards laboratory:
   - modernization of the standard equipment and techniques for neutron sources and fields parameters measurements;
   - participating in key-comparisons arranged by CCRI;
   - certification of secondary standards used in research institutes, instrument-producing and shipbuilding enterprises, nuclear power stations, defense ministry etc;
   - testing and certification of new types of measuring system;
   - calibration and verification of measuring instruments for users and manufacturers;
   - elaboration of the normative documents.

2. New investigations
- final phase of long-year investigation of possibility to use graphite moderator for measurements of neutron sources emission rate without calibration
- development of transportable device for radionuclide neutron sources comparing
- investigation of beam-like thermal neutrons field especially for key-comparisons K8
- comparative investigation of neutron devices in view to use one of them as comparison instrument in COOMET comparisons.

Neutron source emission rate measurement.
4 m spherical graphite moderator is used as comparator for measuring of radionuclide neuron sources emission rate. Primary standard in this case is a neutron generator with a special target chamber design which allows us to measure the monoenergetic neutrons emission rate from the reactions $T(d,n)^4He$ and $D(d,n)^3He$ using the associated particles method with uncertainty not more than 1%.
The proposed measurement technique is like a water-bath technique.
The radionuclide neutron source emission rate ***B*** is determined by the following equation

$$\Phi = 4\pi K_{n,\alpha} l_f l_{th} N \sigma_{th}(r) \int_0^R \varphi_{th}(r) r^2 dr$$

where $K_{n,\alpha}$ – neutron capture due to (n,α)-reaction, is determined experimentally;
l_f – fast neutrons leakage, is determined experimentally;
l_{th} – thermal neutrons leakage, is determined experimentally;
$N_c = 1.13 \cdot 10^{23}$ – carbon concentration (Kurchatov report, 1944);
$\sigma_c = 4.0$ *mb* –thermal neutrons cross-section (report, 1944);
$\int_0^R \varphi_{th}(r) r^2 dr = 7.409 \cdot 10^9$ is measured by gold activation detectors.
As our graphite ball is made of the same graphite what the first Russian research reactor we used for calculation the N_c and σ_c obtained by I. Kurchatov with collaborators in 1944.

The result obtained by described technique is $(4.29 \pm 0.13) \cdot 10^7 s^{-1}$.
The result obtained by Mn-bath-technique is $(4.31 \pm 0.07) \cdot 10^7 s^{-1}$.
The main source of uncertainty of new result is uncertainty of σ_c value.

Portable device for radionuclide neutron sources comparing

Parallelepiped (40×23×14) cm made of organic glass with spherical cavity 12 cm diam. in the centre. A special gadget makes it possible to fix a neutron source in the centre of cavity. Four He-3 counters (two pairs) are fixed at two different distances at four different directions from the centre of cavity. The main characteristics of comparator are presented in Table.1.

	Channel A	Channel B	Channel C	Channel D
Warming time	10 min	10 min	10 min	10 min
Long-term stability	< 0.1 %	< 0.1 %	< 0.1 %	< 0.1 %
Reproducibility after turning of	<0.2 %	<0.2 %	<0.2 %	<0.2 %
Dead-time	1.09 μs	1.51 μs	1.55 μs	1.98 μs
Gamma-sensitivity	$< 10^{-4}$	$< 10^{-4}$	$< 10^{-4}$	$< 10^{-4}$
Efficiency for Cf-252	0.120 %	0.315 %	0.128 %	0.313 %
Emission rate	10^3 to 10^7 s^{-1}	10^3 to 10^7 s^{-1}	10^3 to 10^7 s^{-1}	10^3 to 10^7 s^{-1}

Table 1.

Investigation of different neutron devices in view to use one of them as comparison instrument in COOMET comparisons

Three devices of different manufacturers were investigated.

- MAP VNIIM design, was used in CCRI(III)-K10 key-comparisons
- AT1117 produced by ATOMTECH, Belarus
- LB6411 produced by BERTHOLD, Germany

The main characteristics of comparator are presented in Table.2 and Fig. 1.

	MAP	AT1117	LB6411
Warming time	10 min	10 min	
Long-term stability	± 0.1 %	± 0.1 %	
Reproducibility after turning of	± 0.2 %	± 0.3 %	± 2 %
Temperature dependence	$< 5.10^{-4}$/°C	$< 5.10^{-3}$/°C	
Dead-time	2.33 μs	autocorrection	~3.5 μs
Gamma-sensitivity	$< 3.10^{-5}$	$< 2.10^{-4}$	$< 2.10^{-4}$
Efficiency for bare Cf-252	3.23 cm^2	1.68 cm^2	1.1 cm^2
Counting rate	$> 10^5$	$> 10^5$	$> 10^5$

Table 2.

The only shortage of AT1117 is no spherical moderator and therefore asymmetry of sensitivity. The LB 6411 problem is long-term instability (Fig.1.).

We contacted with Dr Alfred Klett, Business Element Manager and were very surprised to know it is good device according to Berthold quality system.

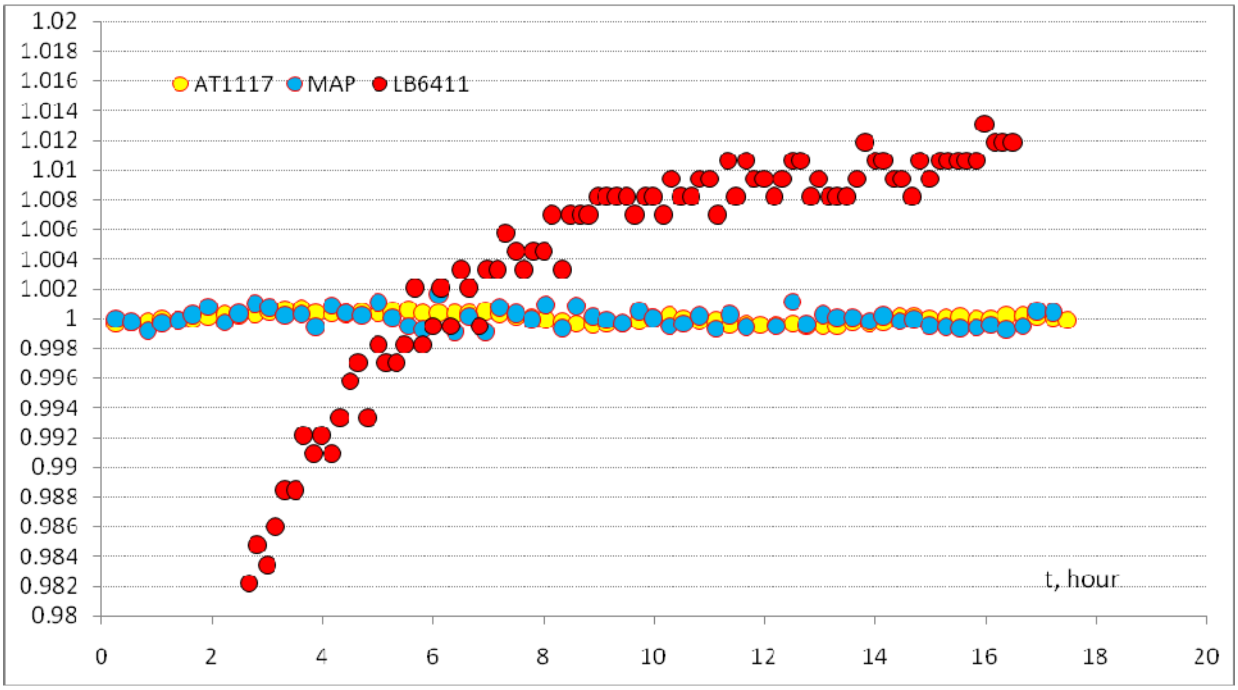

Fig.1. Comparator stability