2.18. TAGGED NEUTRON METHOD FOR DETECTION OF HIGH EXPLOSIVES

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Prototype of measuring inspection system created in VNIIA and intended for active interrogation of cargo containers to detect high explosives (HE) is presented. The system is based on 14 MeV tagged neutrons (API) method.

API method is based on using inelastic scattering of fast neutrons, accompanied by characteristic gamma-radiation. Identification of separate nuclei inside an object is based on registration of energy spectrum of emitted gamma-quanta. This radiation provides information concerning presence of nitrogen, oxygen and carbon, entering HE composition, in a cargo. Gamma-radiation energy of inelastic neutron scattering on carbon, nitrogen and oxygen nuclei exceeds sufficiently energy of gamma-quanta, emitted during inelastic neutron scattering on nuclei of other elements, thus enabling one to select them with high efficiency.

API method is using a continuous neutron flux, and direction of "tagged neutron" is determined by registration of associated alpha-particle. T(d,n) ^{4}He reaction with emission of ~ 14 MeV neutrons is used for neutron production. Neutrons and alpha-particles are emitted when tritium target is bombarded by deuteron beam. Position- and time-sensitive alpha-detector is measuring time and a coordinate of associated alpha-particle, thus enabling one to specify angle and time of neutron escape. Gamma-detectors detect gamma-quanta produced from interaction of "tagged" neutrons with container material. Information processing and data acquisition system enables to follow coordinate and time of registration of gamma-quanta and alpha-particles and provides time reference of detector signals. Computer processes the obtained data and sends information on elemental composition of container to the terminal.

As a result key chemical elements entering HE composition – carbon, nitrogen, oxygen – are determined. This allows one to improve sufficiently the detection probability and decrease false alarm probability, as compared to methods aimed at determination of nitrogen only (for example, TNA method – Thermal Neutron Analysis).

The system (fig. 1) includes:

– VNIIA portable neutron generator ING-27 with built-in segmented 9-pixel semiconductor alpha-detector (30 × 30) mm^2;

– 12 scintillation gamma-detectors based on bismuth germanate crystal (BGO) with size of ∅63 × 63 mm;

– gamma-detector shielding from primary neutron flux (borated polyethylene + iron);

– electronics for data acquisition and processing system.

The system was tested on identification of HE simulators. The obtained experimental spectra from several dangerous and not dangerous materials were approximated by template spectra of C, N and O elements. The comparison of obtained values of C/O and C/N ratios with theoretical ones is shown in fig. 2. Approximation of experimental spectra shows good agreement with obtained values of C/N, C/O ratios and theoretical expectations.

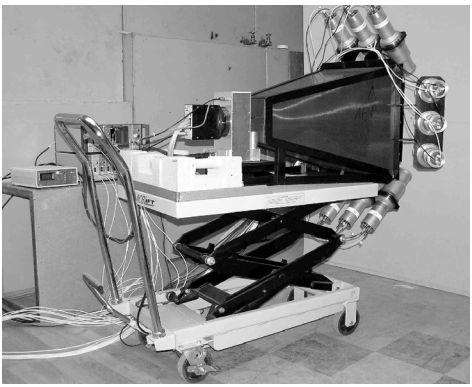

Fig.1. View of system

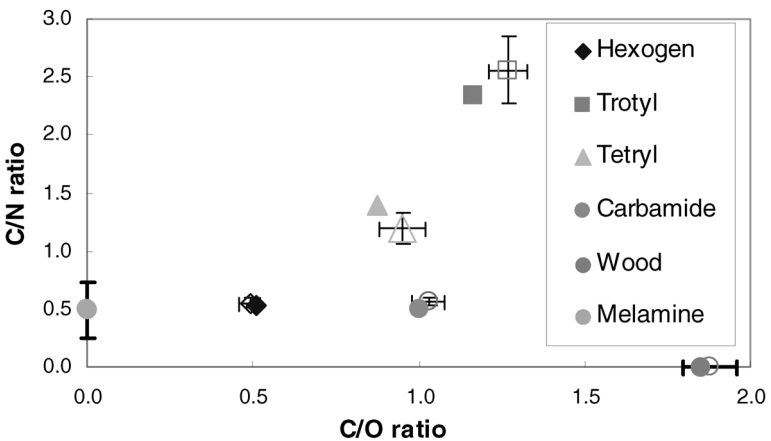

Fig.2. Comparison of experimental and theoretical values in C/O vs C/N coordinates

Next step of system testing was detection and identification of 50 kg of HE simulator (melamine – $C_3H_6N_6$) in wood matrix as container mock-up with average density of 0.4 g/cm^3 and for different distances of HE simulator from container front wall.

With increase of distance from container wall to melamine the excess of signal over background decreases. This is conditioned both by measurement geometry and attenuation of probe neutron beam and produced inelastic gamma-quanta by container filling. For identification melamine new analytical approach to creation of template spectra, corresponding to each chemical element, with individual account of all main gamma-lines is used. The results demonstrate efficiency of this approach. It should be noted that presence of 30 cm thick wood layer in front of identified object, absence of collimators on gamma-detectors, the system geometry (neutron generator and gamma-detector arranged on one side from exposed object) and time resolution of gamma-detectors (3.7 ns) result, how-

ever, in sufficient overlapping of gamma-responses from different layers of container. In this case it is possible to recognize just the presence of anomaly in the place under inspection (occurrence of nitrogen, change of C/O ratio typical for wood). To provide further identification of an object by unfolding of experimental gamma-spectrum it is advisable to use gamma-spectrum of shielding material, obtained for the previous layer.

Later on we propose to create a new system, being under development now, with additional collimation of gamma-detectors.