Remote-Controlled Collimated System Gamma Locator for Remote Measurements of Radioactivity Distribution – 10388

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ABSTRACT

Preliminary work has started for the decommissioning of the research reactor MR at the RRC «Kurchatov Institute». One of stages of preliminary work for the decommissioning of a research reactor is the carrying out of radiation survey. An automatic system Gamma locator for the remote measurement of radioactivity in the reactor areas was developed.

The «gamma locator» is a spectrometric system designed for remote measurement of radioactive contamination. The system consists of a collimated gamma detector, color CCD video camera и control block all is fastened to a rotator mounted on a stand (tripod).

The instrument is connected to compact computer fastened to a rotator too. The instrument and rotator are controlled by operator from computer connected with system via wireless Wi-Fi line or by twisted-pair cable. Operator works at a safe position. First, system will be used for radiation survey, and when works with radwaste will be started (next year) it will be used for control of operations.

INTRODUCTION

The works on preparation for a decommissioning of research reactor MR are spent in RRC Kurchatov Institute. Reactor MR was shutdown in 1992. It works is continuation by works on rehabilitation of objects in RRC «Kurchatov institute» site begun in 2003. In the period from 2003 to 2006 the activities have been spent on liquidation of the historical radwaste storages and rehabilitation of a site of their placing [1]. At carrying out of these works there were various non-standard problems in the field of radiating measurements. Some new devices have been developed for carrying out of such measurements [2-4]. The results received at application of new devices developed for use in rehabilitation works, have shown their efficiency at the decision of non-standard problems.

The research complex "Reactor MR" includes research reactor MR with nine pipelines installations, various systems and the equipment, placed in a set of buildings and premises.

The most contaminated premises are that where the equipment of loops of the reactor is placed. There are more than 30 premises where EDR from the contaminated equipment is from 20μSv/h to 3mSv/h.

Reactor MR was used mainly for test of fuel assemblies and materials for new nuclear power installations of different types.

Main objectives of the decommissioning works of research reactor MR are:

- dismantle of the equipment of primary contour and loopback installations of reactor MR,
- removal of the formed radioactive waste from RCC Kurchatov Institute site,

- the subsequent rehabilitation of buildings and constructions of reactor MR taking into account the further use of these objects.

THE RADIOLOGICAL SURVEY

The important stage of preliminary works for a decommissioning of research reactor MP is the carrying out of radiological survey.
For scheduling on equipment dismantling it is necessary to know what the radioactive sources and in what parity give the contribution in EDR in this premise. This knowledge allows managing of the work with radioactivity in such a way that to reduce a personnel dose.
Previously, remote measurements of radioactivity distribution were carried out in conditions of high dose rate, when this was the only save way to solve the problem. The works [5-8] describe application of collimated detector technique for investigation of radioactive contamination inside rooms of unit #4 of Chernobyl NPP after accident there in 1986. In first works [5] simple handle collimated radiometer was applied for radioactivity mapping on the walls, roof and floor. These maps and calculated dose rate maps helped to select optimal ways of decontamination measures in rooms. The measurements with computer controlled scanning spectrometric detector at destroyed reactor hall have given estimation of radioactive contamination in inaccessible heaps. After measurements 3-D dose EDR map inside hall was calculated. That was the only way to solve problem, as estimated EDR in some areas was more then 100R/h.
Different instruments for remote radioactivity mapping -- gamma-imagers of AIL - GammaCam [9] and Areva - Cartogam [10], gamma-scanner of BNFL - RadScan [11] were used for measurements of radioactivity distribution at object of nuclear industry in USA [12]. After these measurements EDR maps were calculated too.
During activity for rehabilitation of the temporal radwaste storage site of RRC "Kurchatove Institute" the prototype of new collimated gamma-locator system was used for remote measurements of radiological conditions. The data of measurement of gamma-field characteristics (gamma-ray spectra registered with detector from different directions) was used for calculation of dose rate.
Further the construction and parameters of gamma-locator are presented. The procedure of measurements are shortly described.

GAMMA LOCATOR DESCRIPTION.

The Gamma locator is a spectrometric system designed for remote measurement of radioactive contamination. The system consists of a collimated gamma detector 1, color USB video camera and control block, all is fastened to a rotator mounted on a stand (tripod) and controlling PC
The scanning head is a spectrometric detector, placed in collimated lead shielding. Maximum shielding thickness is 35 mm. Angle resolution of the collimated detector can change from 10 to 20^o. For the given system three interchangeable detectors have been made changing which it is possible to vary sensitivity of the device. Two detectors is a CsI(Tl) scintillator (volume ~20 cm^3 and 5cm^3) coupled to Si PIN (area 1 cm^2) photodiode and CdZnTe detector with volume 20 or 60 mm^3 was also used.

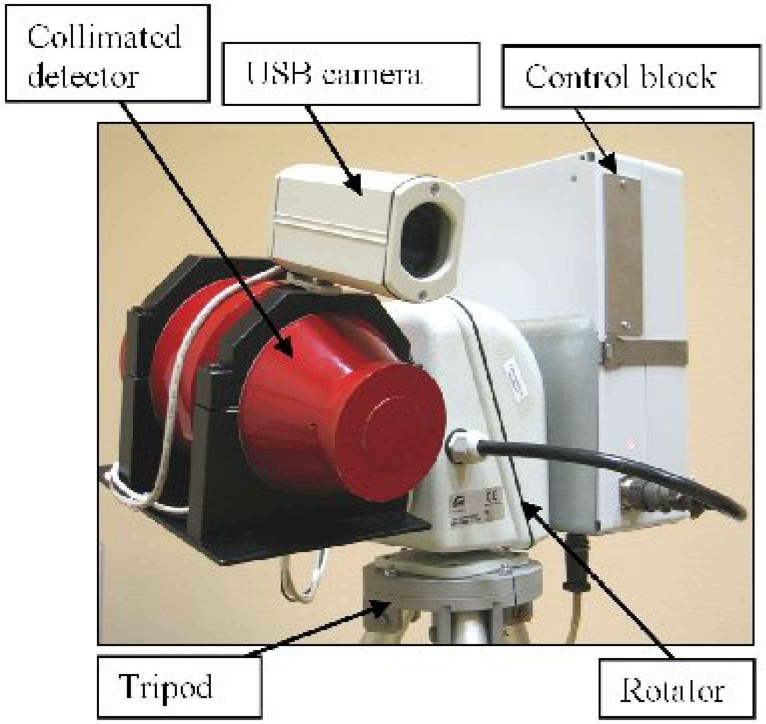

Fig.1 The gamma locator mounted on tripod

Photo of CsI(Tl) scintillator-photodiode detectors is shown in fig.2

Fig.2 The detectors scintillator CsI(Tl) – PIN photodiode

The control block, the rotary device and detector head are made in a tight variant, easily deactivated that is important at its use in the polluted premises. Photo of the control block is shown on fig.3

In the control block are placed the onboard computer, spectrum analyzer SKS-08 "Kolibri", a power unit of the device and a control board of the rotary device.
As the onboard personal computer it is used of industrial computer on the basis mainboard VIA EPIA LN10000EG. This mainboard does not demand active cooling and can be located in tight boxing.
Detector signals received by pre-amplifier go to the shape amplifier and finally are transferred on spectrum analyzer SKS-08 "Kolibri" which is connected and controlled from onboard PC. The signal from a videocamera arrives on USB port of the onboard personal computer.

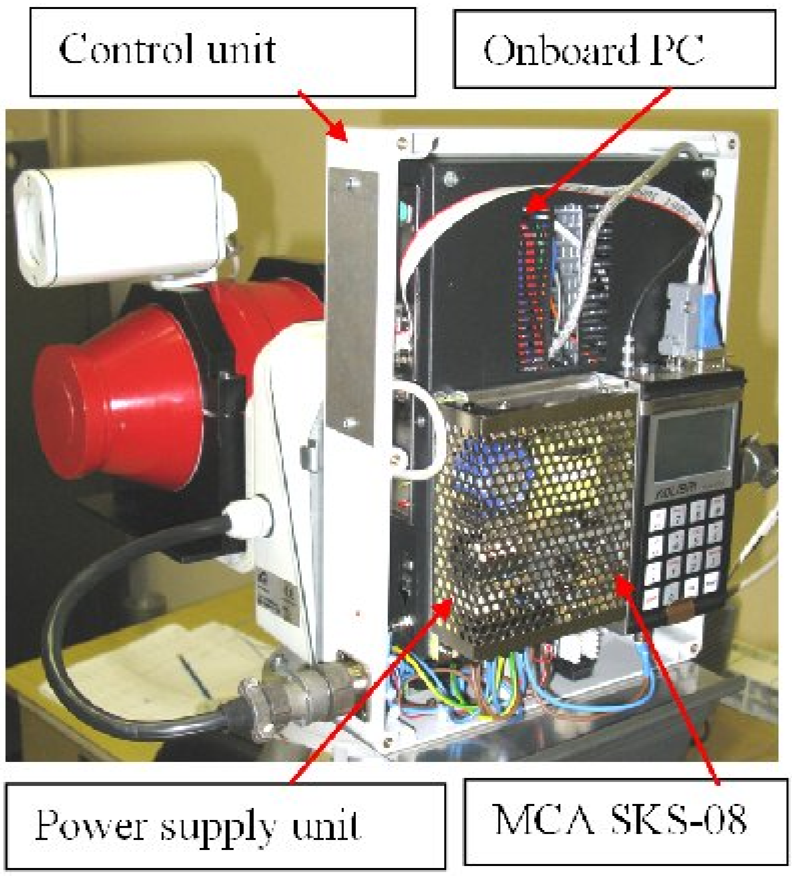

Fig.3 Photo of the control block

A USB video camera is placed on the scanning head, so that its axis of symmetry is parallel to collimator axis of symmetry. This video camera represents a field of view (FOV) of the detector.
The pan and title table is also controlled by бортовой PC via COM-port (RS-485 interface).
The instrument and rotator are controlled by operator from computer connected with system via wireless Wi-Fi line or by twisted-pair cable (a distance from the scanning head to the PC may be up to 200 meters). Operator works at a safe position.

<u>The system parameters are as follows</u>: Sensitivity – 36 pulses/s from a Cs-137 source with the activity of 70.0 kBk at 5 cm. Angular resolution – 10 degrees. Detector - scintillator CsI(Tl) (V=20cm^3)+photodiode. Spectral resolution - 9%. Spectrum analyzer – 4096 channels.

The gamma locator can control the operator both manually and automatically under the scenario. In manual control mode the operator directs the device under the video image at investigated object spends measurement of a spectrum of radiation and writes down the obtained data and the video image in memory of the computer. The software for these operation was developed and tested. The view of the main menu of the device control software is shown on fig.4

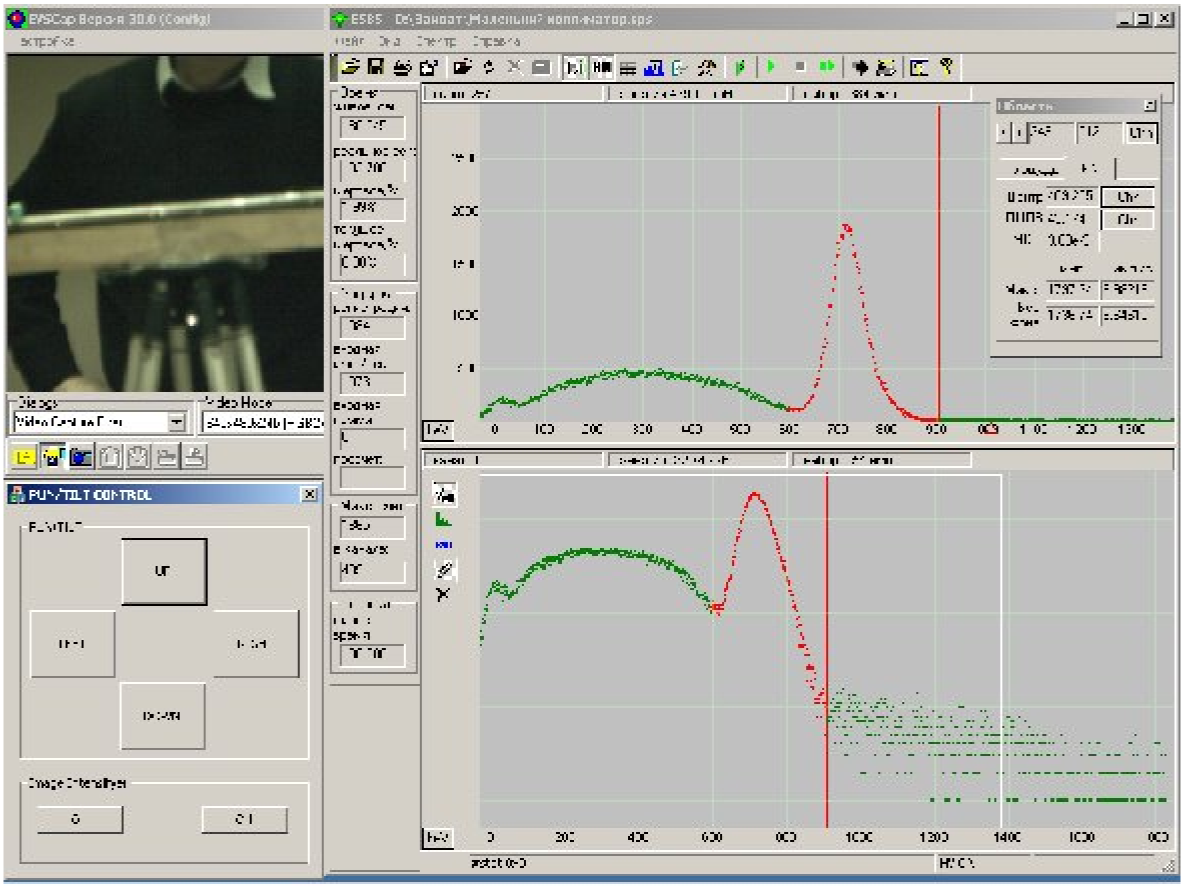

Fig.4 View of main menu of the device is shown on

The gamma-locator controlling program has different scenarios of gamma-locator operation. The scenario consists of series of movements in specified direction, measurements of spectra and video frames recording. A trajectory of movement, gamma-locator and video camera settings are set up interactive or read from settings file in the PC.
The data of measurement of gamma-field characteristics (spectra of gammas registered by detector from different directions) was used for calculation of dose rate.
The device will be used for control of position radioactive sources, sorting of radwaste, mapping of radioactive contamination of installation and rooms.

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