

METROLOGY ASSURANCE OF RADEYE SERIES SURFACE CONTAMINATION MONITORS

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Summary: The report describes the main tasks of the metrology assurance of RadEye Series Contamination Monitors at Kozloduy NPP plc, the activities which are performed in order to provide the expected high quality in this area and compliance with the national and international requirements. The report is based on the documents developed and approved according to the established order by the Ionizing Radiation Measurement Laboratory at the Metrology Assurance Department at Kozloduy NPP plc based on the acquired long term, experience and in compliance with the regulations and legal requirements.

Key words: metrology assurance, metrology, calibration, check

1. INTRODUCTION

The measurement of ionizing radiation is performed in many areas of the production and monitoring activities carried out at Kozloduy NPP plc as the area of radiation protection is being of special importance for these measurements.

The RadEye series contamination monitors is a widely used equipment for radiation contamination measurement. They are part of the radiation monitoring equipment at Kozloduy NPP plc, as well as the departments of the State Enterprise for Radioactive Waste Management: Units 1-4 Decommissioning Department and RAW Department.

Depending on the detection unit, they are used for:

- surface contamination monitoring of objects, surface of the rooms and equipment in the controlled area with beta alpha radioactive nuclides.

- radioactive contamination monitoring according to the method for determination of the total alpha/beta activity, which is to determine the concentration of the beta active radionuclides in the plant process waters, concentration of the radioactive aerosols and airborne radioactive isotopes of iodine in gaseous form in the unrestricted access rooms in the controlled area (CA), at the inlet and outlet of the ventilation systems in the controlled area and discharges through the ventilation stacks and undermined surface contamination of the surfaces in the rooms, objects and equipment in the controlled area.

2. GOAL OF METROLOGY ASSURANCE

In order to provide anticipated high quality and reliability of the measurement results in compliance with the national and international requirements at Kozlodut NPP plc, metrology assurance activities

for the measurement equipment are carried.

Ionizing Radiation Measurement Laboratory provides for metrology assurance of the ionizing radiation measurement equipment, which defines the development in the following directions:

- maintaining and development of reference sources
- arrangement and performance of metrology monitoring of measurement equipment
- implementation of the international codes and standards for check and calibration
- personnel training and qualification

3. SCOPE

The metrology assurance of the Rad Eye series contamination monitors includes the following main activities:

- metrology check of the measurement equipment
- calibration of measurement equipment
- quality control of the measurements.

4. TECHNICAL CHARACTERISTICS

The RadEye series Contamination Monitors are devices for measurement of radioactive contamination with excellent resolution according to the radiation type - α , β .

RadEye AB100 is equipped with a detection unit having the area of 100 cm², which is a plastic scintillation detector covered with zinc sulphide and a photomultiplier. The radiometer is designed to measure alpha and beta contamination of the surfaces in the rooms and equipment in the controlled area with alpha and beta radioactive nuclides.

RadEye SX is equipped with the FLP3B and FLP3D detector unit. The detector is a scintillator with an active area of 600 cm², covered with zinc

sulphide and a photomultiplier. The monitor is designed to measure the surface contamination with alpha and beta radionuclides of the floors in the controlled area.

RadEye HEC is a radiometric system to measure the total alpha and beta activity. The system includes 2" double phosphorous scintillators built in a protective body made of strong plastic which can resist to rough handling. The body has a small size and a handle, which enables using the device in a battery mode. The detector is positioned above the pushing mechanism where the samples are placed. The space for the samples in the pulling rack is suitable for samples with different thickness and size up to two inches (50,8 mm) in diameter of the configuration

The radiometric system is designed for measurement of the radioactive contamination according to the method for determination of the total alpha and beta activity, which defines the concentration of the beta active radionuclides in the process waters, concentration of the radioactive aerosols and radioactive isotopes of iodine in the gaseous form and unfixed surface contamination in the rooms, objects and equipment of the controlled area.

All radiometers of the RadEye series has the option for connection to a personal computer. This provides for the administration of functions, measuring modes, nuclide table and introduction of calibration factors and alarm levels.

5. METROLOGICAL CHECK OF THE RADEYE MONITORS

The check provides for proper measurement with a given measurement equipment in compliance with the requirements for its use in the frames of the certain period of time.

Depending on the objectives and requirements, which are set, the following metrological checks are carried out:

- check during dedicated receiving inspection
- initial check
- follow-up periodic check
- special check.

The operations while performing metrological check are as follows:

- visual inspection and functional check
- check of the equipment background
- check of the efficiency of ionizing radiation recording
- review of the linearity of recording within the

measuring range

- determination of the measuring error
- check of the dependence of the recording efficiency of the maximum energy of beta radiation in the range from 150 keV to 2,3 MeV
- check of the repeatability of the efficiency of the recording using a reference source.

The metrological checks of the radiometers are performed in compliance with the approved according to the established order documents developed by the Ionizing Radiation Measurement Laboratory complying with the regulatory and legal requirements.

The results of these activities are documented according to the requirements of the internal procedures, which regulate this activity.

In the event of non-conformities of the received results with the conditions for fitness, actions are take in terms of repair and /or recalibration of the equipment.

5.1. Check during dedicated receiving inspection

Check during dedicated receiving inspection is carried out by the brand new measurement equipment upon delivery after bringing it up to operable condition prior to commissioning. Every radiometer is accompanied by a report containing the data from the check of the main characteristics performed by the manufacturer.

The objective is to confirm the values of the metrological characteristics of the equipment stated by the manufacturer and their compliance with the regulatory requirements and requirements of the owner. This check certifies to what extend the brand new equipment will be capable of fulfilling a given measurement of a proper quality.

5.2. Initial check

The initial check is carried out by a new measurement equipment in the Ionizing Radiation Measurement Laboratory and /or at the place of operation after bringing it up to working condition. The purpose is to study the metrological characteristics indicated in the documentation and define the allowable limits.

The check is carried out for all modes of operation and geometries of calibration.

5.3. Follow-up periodic check

The follow-up period check is performed of the measurement equipment in operation, whose initial

check has already been performed. The goal of the check is ensure that the equipment is operable, well set up and its metrological characteristics are within the allowable limits.

5.4. Special check

The check is carried out in the between the check interval, on a special occasion after repair or if there are some doubts about the deviations in the metrological characteristics.

6. CALIBRATION OF RADEYE

The calibration is an important activity in terms of methrology assurance when measuring alpha / beta activity. For calibration solid knowledge about the specifics of the measurement, its performance and result assessment is required. Compared to the review, the calibration provides for qualitative assessment, which show to what extend a certain objective is feasible with a given equipment when applying a specific measuring method.

The calibration is carried out by trained specialists who are well familiar with

- measurement equipment
- calibration methods
- applied software

The calibration is carried out

- upon delivery
- after repair of the equipment
- periodically in compliance with the working documents of the relevant units
- after unsatisfactory result of the review of the basic error
- upon deviations from the requirements identified during external laboratory monitoring.

The main parameters defined during the calibration are as follows:

- efficiency of recording with its extended uncertainty
- minimum detectable activity for each of the geometries of measurements under certain conditions.

The performed operations after the performance of calibration, for each of the measurement geometries, are as follow:

- preparation for calibration
- visual inspection and functional check
- review of equipment technical parameters
- performance of the calibration
- background measurement
- identification of the recording efficiency

- calculation of the calibration factor
- assessment of the expanded uncertainty of efficiency of recording
- MDA determination
- identification of the range of allowable values of the equipment background
- connection of the calibration results to the indications of reference source.

The calibration activities are performed in compliance with the calibration techniques prepared by the Ionization Radiation Measurement Laboratory in compliance with the directions provided by the equipment manufacturer and in compliance with the regulatory requirements.

The calibration results are given in the calibration certificate and calibration report in compliance with the procedure requirements.

7. SOURCES OF IONIZING RADIATION USED DURING THE METROLOGICAL CHECK ACTIVITIES

In order to perform the activities for check, calibration and quality control of the measuring equipment, the Ionizing Radiation Measurement Laboratory has and maintains a broad range of reference sources:

- reference radioactive sources
- certified standard specimen
- test radioactive sources.

There are a number of requirements to reference sources depending on their purpose.

7.1. Reference sources for calibration of RadEye AB100 and RadEye SX

The RadEye AB100 and RadEye SX are calibrated with thin wide-area reference sources having the area of the active surface of 100 cm² or 150 cm².

For the needs of radiation monitoring, Kozloduy NPP plc uses the nuclides of ²⁴¹Am, ⁶⁰Co и ¹³⁷Cs.

The characteristics of the reference wide-area radioactive sources should be in compliance with the recommendations of [4].

7.2. Calibration reference source for RadEye HEC

The calibration of **RadEye HEC** is carried out with activity reference sources which are certified comparative materials whose geometry, activity and nuclide content depend on their specific pur-

pose, thus their variety is relatively big.

The radioactive sources used for calibration should comply with the following requirements:

- precise reproduction of the sample matrix and measurement geometry during routine measurements

- contain just one radionuclide

- the radioactive substance shall be well fixed and of uniform distribution

- the uncertainty of the activity shall be less than 3%

- fading and scattering of the radiation in the volume and protective cover of the source shall be considered (if required)

- have a valid calibration certificate.

In Kozloduy NPP plc, for the needs of radiation monitoring, the calibration is carried out using nuclides ^{241}Am , ^{60}Co и ^{137}Cs .

The type and the number of the required CRM is established in the calibration methods.

7.3. Reference source for metrological check of RadEye AB100 and RadEye SX

For check of the basic error, reference sources having the same geometry and nuclide like those used for calibration are applied.

When checking the efficiency and dependence of the efficiency of the maximum energy on the beta spectra, a set of reference wide area source having the area $>100\text{ cm}^2$ is used.

A set of beta reference sources, which should have the same geometry, design and radionuclides with maximum energies of the beta spectra proving monitoring in the points of three energy intervals is used. $E_{\text{max}} \leq 0,2\text{ MeV}$, $0,2\text{ MeV} < E_{\text{max}} < 0,5\text{ MeV}$, $E_{\text{max}} > 0,5\text{ MeV}$.

The suitable radionuclides are :

^{14}C ($E_{\text{max}} = 0,155\text{ MeV}$) for the first interval

^{60}Co ($E_{\text{max}} = 0,318\text{ MeV}$) and /or

^{137}Cs ($E_{\text{max}} = 0,512\text{ MeV}$) for the second

interval

^{36}Cl ($E_{\text{max}} = 0,714\text{ MeV}$) и/или

^{204}Tl ($E_{\text{max}} = 0,77\text{ MeV}$) and /or

$^{90}\text{Sr}/^{90}\text{Y}$ ($E_{\text{max,Sr}} = 0,546\text{ MeV}$, $E_{\text{max,Y}} = 2,28\text{ MeV}$) for the third interval.

The reference source in the set should comply with the criteria set in [4].

When checking the dependence of the sensitivity on the position of the source of ionizing radiation, radioactive sources, type 1CO and 1П9 having the area of 1 cm^2 , certified by emission rate of particles with nuclides $^{90}\text{Sr}/^{90}\text{Y}$ и ^{239}Pu are used.

When checking the linearity in the measuring range, a set of reference wide range sources of the ^{60}Co type having the area $>160\text{ cm}^2$ certified according to particle emission rate is used.

7.4. Reference sources to check RadEye HEC

For the needs of the check, the reference radioactive sources should comply with the following requirements:

- contain just one radionuclide

- if the used radionuclide has daughter products then all components should be in equilibrium

- the radioactive substance is well fixed and of uniform distributed so that a good repeatability during measurement is obtained.

- the activity or external exposure of the reference source is selected so that when measuring for a suitable period of time, the statistical uncertainty of the number of impulses should be less than 2%

- the geometric dimensions shall comply with the options of the holder and geometry of the measurement

- variance of the beta nuclides in the range from 150 keV to $2,3\text{ MeV}$.

When checking the linearity of the measuring range, radioactive sources of type CO and П9 with nuclide $^{90}\text{Sr}/^{90}\text{Y}$ и ^{239}Pu , certified according to the particle emission rate will be used.

When checking the basic error, certified comparative materials having geometry and characteristics repeating the real samples used for calibration are applied. Every CRM contains only one nuclide (^{241}Am , ^{137}Cs , ^{60}Co) with activity ranging from 10 to 1500 Bq and uncertainty of $\leq 4\%$.

The Ionizing Radiation Measurement Laboratory maintains a big variety for reference sources complying with these requirements, which are required to provide for the check activities.

7.5. Radioactive sources used for quality control of the measurements

For the needs of internal laboratory monitoring, a reference source stored by the operating unit is used.

It may be different from the one used for calibration of the device and it is not necessary to be certified.

8. CONCLUSION

Laboratories for sources of ionizing radiation at Kozloduy NPP plc are responsible for the metrology assurance of a large number of measurements and measurement means in the industrial and legal metrology. The principles and methods for metrology assurance which are applied by the laboratory comply with the modern international and national trends for development of metrology assurance.

The laboratory has focused its efforts on the the harmonization of the metrology assurance of the technological measurements with the legislation of the Republic of Bulgaria and the European Union through the creation of programmes for quality assurance of the different measurements, calibration of the measurement equipment, improvement and development of the reference sources, improvement of the quality of the quality of the metrology checks, preparation of the measurement methods, receiving inspection, etc.

9. REFERENCE

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