

Option "Thorium Therapy" for Aer5xxx

This document is an add-on to the manual of the standard version of the instrument!

Version: 25/09/2023

SARAD GmbH
Wiesbadener Straße 10
01159 Dresden
Germany

www.sarad.de
info@sarad.de

Scope

Radioactive substances may be released during production and application of ^{227}Th preparations (Xofigo). In that case, the resulting activity concentration in the air cannot be determined by standard algorithms used for long-living radionuclides by Aer5xxx air samplers.

The decay chain of ^{227}Th contains a number of short-living alpha emitters reaching very soon the radioactive equilibrium with the mother nuclide. However, the main problem results from the appearance of the radon isotope ^{219}Rn (Actinon) within the decay chain. The rare gas emanates very easily from the preparation and will be distributed quickly in a room by diffusion. In practice, the concentration of radon daughter products is always above the ones of $^{227}\text{Th}/^{223}\text{Ra}$ — in most cases by magnitudes of order. In case of promptly analysis of the activity collected by the air sampler on a filter, the alpha spectrum will be dominated by the decay products of the various radon isotopes. The requested detection limit for $^{227}\text{Th}/^{223}\text{Ra}$ in the range of a few mBq/m^3 cannot be obtained by spectroscopic analysis due to the limited resolution of filter spectra and emission energies very close to each other.

For that purpose, SARAD in cooperation with the Bayer AG has developed a time and energy spectroscopic procedure which is based on a sampling cycle of 24 hours. The activity concentration off Actinon (^{219}Rn) will be determined during the leading eight hours exposure period using the alpha emission of the daughter nuclide ^{211}Bi . A subsequent interval allows the complete decay of short-living daughters of the radon isotopes ^{222}Rn and ^{219}Rn on the filter. Within a third interval, the activity of the remaining thorium and radium will be measured. The probably occurring activity of thoron daughters will be compensated by alpha spectroscopy. Thoron daughters are also accumulated on the filter due to the half-life of ^{212}Pb .

Predefined cycles

The original measurement cycles of the instruments have been replaced by the following:

| | |
|---------------|---|
| “Actinon 1h” | Measures the activity concentration (EEC) of the daughter products of Rn-222 (Radon), Rn-220 (Thoron) and Rn-219 (Actinon) with a sampling interval of 1 hour. |
| “Th/Ra + Rn” | 24 hours cycle with 8 hours exposure, six hours decay interval and 10 hours filter analysis. The instrument measures the activity concentration of Radon, Thoron and Actinon as well as the one of Th-227 and Ra-223. |
| “Alert test”: | Test of all available alert signals. |

The Thorium/Radium (Th/Ra + Rn) cycle

The cycle must be started at begin of the exposure period. The results (Radium/Thorium as well as Actinon) will be present after 24 hours. The cycle must not be interrupted in between. After 24 hours the filter will be replaced (only for instruments with filter stepping unit) and a new exposure period will be started. It is also possible to stop the measurement after 24 hours and start a new exposure period at any time

Results

- EEC Radon (Rn-222 daughter products)
- EEC Thoron (Rn-220 daughter products)
- EEC Actinon (Rn-219 daughter products)
- Activity concentration of Thorium and Radium (Th-227, Ra-223)
- Detection limit for Thorium and Radium activity concentration (to generate a warning if the detection limit exceeds a pre-set value)
- Flow rate
- Speed of the pump motor (to detect malfunction)
- Filter exhaustion (0...15 % fresh filter, > 90% exhausted filter)
- Filter movement (>0 if filter has been moved)
- End of filter (generates a warning if the end of the filter tape is reached)
- Motor timeout (used as alert for stopping the cycle at the end of the filter tape)
- Temperature, humidity and barometric pressure(internal sensors)
- Charge status of the internal battery

The Actinon (Actinon 1h) cycle

This cycle can be used for continuous monitoring of the Actinon (Rn-219) activity concentration in the air. The results are stored hourly.

- EEC Radon (Rn-222 daughter products)
- EEC Thoron (Rn-220 daughter products)
- EEC Actinon (Rn-219 daughter products)
- Gross alpha count rate of the detector
- Flow rate
- Speed of the pump motor (to detect malfunction)

- Filter exhaustion (0...15 % fresh filter, > 90% exhausted filter)
- Filter movement (>0 if filter has been moved)
- End of filter (generates a warning if the end of the filter tape is reached)
- Motor timeout (used as alert for stopping the cycle at the end of the filter tape)
- Temperature, humidity and barometric pressure(internal sensors)
- Charge status of the internal battery

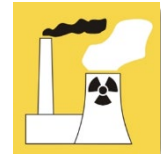
Alarm settings

Alert thresholds are set by factory to 20mBq/m³ for activity concentrations of Th/Ra, Actinon and the detection limit for Ra/Th. The thresholds can be changed by the user as described in the manual.

Compatibility

The hardware of the air samplers is compatible with the standard version. However, a special instrument configuration is used. The configuration may be changed but requires additional calibrations and parameter settings. Configurations can be saved as file on a PC and transferred to the instrument. Such files can be provided by SARAD on request. The cycle "Th/Ra + Rn" can be used only if the configuration "Thorium Therapy" is installed on the instrument.

225Ac

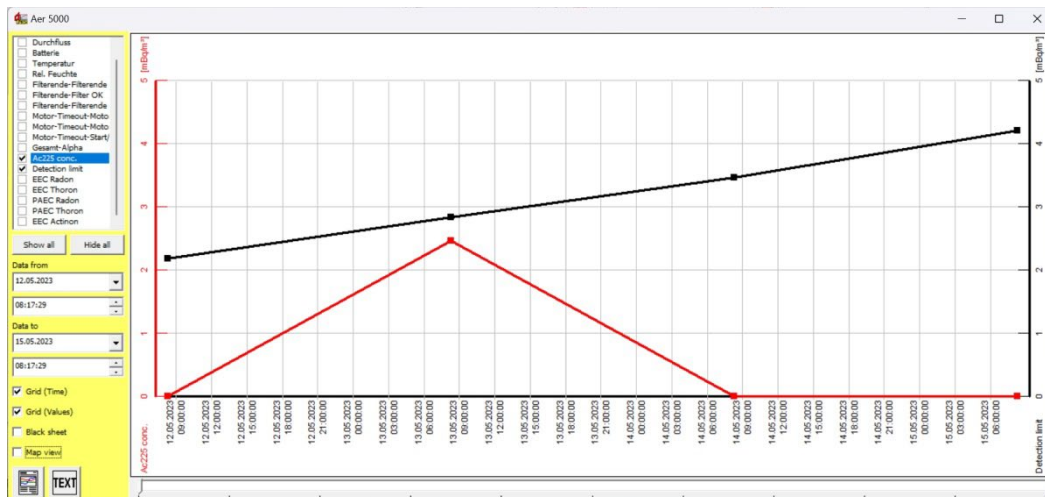


Radiation protection for Actinium therapy

In nuclear medicine, the Actinium isotope ^{225}Ac is becoming more and more important. As with the use of $^{227}\text{Th}/^{223}\text{Ra}$, it is necessary to monitor the breathing air during the production and application of the preparations.

The measuring method for $^{227}\text{Th}/^{223}\text{Ra}$ developed in cooperation with Bayer AG was adapted to the specific characteristics of the decay chain of ^{225}Ac . Both algorithms are implemented in the Aer series instruments, so that either $^{227}\text{Th}/^{223}\text{Ra}$ or ^{225}Ac can be measured, selectable by the user. The 24-hour measurement cycle with adjustable exposure period also allows detection limits for ^{225}Ac in the range of a few milli-Becquerels per cubic metre.

The following figure shows a four-day measurement series, with ^{225}Ac being used on the second day. In that case, the activity measured (red line) of approximately 2.5 mBq/m³ is in the order of the detection limit also indicated by the instrument (black line).



The alpha spectrum of day 2 (left) shows the contribution of the ^{225}Ac decay products while the spectrum of day 3 (right) contains only the ^{220}Rn daughter products.

