Method MMK 606

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In-situ method for determination of Activity Index (AI) of construction materials indoors of existing buildings.

1. Scope

The method is intended for measuring construction materials, for the determination of the concentration of naturally occurring radioactive radionuclides K-40, Ra-226 (Uranium 238/235) and Th-232.

The measurement result of these radionuclides is used for the determination of activity index (AI) for the construction material.

2. Definitions

Activity index (AI) is a sum of the weighted concentrations of K-40, Ra-226 (U238 / 235) and Th-232 and a measure of the concentration of nuclides.

AI is a tool for determining the suitability for a material with respect to established national regulation on the effective dose caused by construction materials.

3. Principle for the method

The activity concentration of gamma emitting radionuclides in construction materials is determined by gamma spectrometry. The activity concentration is a property of the material and not a function of the physical form of the construction product.

The activity concentration is measured in a room directly on a surface of the building material.

The activity index is calculated and documented in the report to the client.

The measurement is instantaneous and can be performed at all times during the year.

4. Measurement method

4.1 Measurement instrument

The measurement of gamma spectra must be done with a gamma spectrometer.

The following functions of the measurement instrument are recommended:

- A detector (BGO crystal) with a volume exceeding 100 cm^3, shielded by steel mantled lead as required;
- Detection limit of the measurement instrument must be known so that the obtained measurement result can be compared to it for the quality assurance purposes;
- The instrument shall be equipped with an efficient and continuous operating compensation for spectrum positioning. The instrument shall use the radioactivity of the measurement object for this purpose;
- Equipped with memory function and automatic transfer of measurement data to defined network;
- Calibration function programme for background checks.

The table below shows the internationally recommended channels, which shall be used for the measurement.

Analyzed element	Isotope used	Gamma energy, MeV	Energy interval, MeV
Potassium	K-40	1,46	1,33 – 1,59
Uranium	Bi-214	1,76	1,63 – 1,89
Thorium	Tl-208	2,61	2,46 – 2,77

4.2 Calibration

The calibration must be performed by the instrument manufacturer or another authorized party and must be carried out with at least a two-year interval.

The calibration certificate must show traceability to the primary calibration source for NORM according to IAEA/AL/148.

4.3 Principle for the measurement

The measurement shall be carried out directly on the surface of the construction material with a measurement instrument.

The measurement is performed on c/c dimensions of the area (walls/floor/ceiling = 6 measurement points) in a room.

If the area has interruptions for windows, doors or alike, a measurement point should be selected in the middle of the largest uninterrupted part of the surface.

4.4 Measurement place and measurement time

4.4.1 Measurement place

Measurement in dwellings shall be carried out in rooms where inhabitants stay more than temporarily ex. living rooms, bedrooms, and eating/cooking areas.

Measurements at workplaces should be carried out in rooms/facilities where staff stays more than temporarily ex., facilities/rooms where daily operations are carried out, as well as other staff-spaces and dining rooms.

4.4.2 Measurement time

Measurement time minimum = 300 seconds per measurement point.

The measurements shall be carried out at least twice on each point.

4.5 Background correction

A required collimated gamma spectrometer provides possibility of a 2π measurement to be performed at a measuring point within a 4π situation. This only is possible if is the distance to the nearest surface exceeds 1 meter.

No correction of the reported values is needed other than within the measurement uncertainty calculation.

5. Table for calculation of activity concentration

The element U-Uranium in the calculations (C_{Ra}) refers to the content of radium or equivalent amount of uranium

Element	Content	Activity, Bq/kg
K – Potassium	1 %	313
U – Uranium 238/235	1 ppm	12,35*
T – Thorium	1 ppm	4,06*

6. Calculation of mean activity concentration

The result is given in the mean value for all measurements (measuring points).

The calculation is performed in 3 steps as follows:

Step 1 Measurement of individual measurement points = Mean activity concentration value of individual measurement point.

Step 2 Measuring mean value measuring point no (1 + 2 + 3 + 4 + 5 + 6) ÷ 6 = measured average value.

Step 3 The activity index is calculated and document in the report.

The activity index of the material is calculated as follows:
$AI = (C_K \times 313) \div 3000 + (C_{Ra} \times 12{,}35) \div 300 + (C_{Th} \times 4{,}06) \div 200;$

where
C_K = content of potassium in the unit %.
C_{Ra} = content of radium (uranium 238/235) in the unit ppm.
C_{Th} = content of thorium in the unit ppm.

7. Measurement uncertainty

Is based on the following:

Measurement time uncertainty 300 seconds	$*X_t$
Activity concentration	$*X_a$
Calibration uncertainty	$*X_c$
Cosmic background radiation	$*X_s$
Required shielded 2π measurement within a 4π measurement	$*X_b$

Measurement reliability for individual components (K, U and Th) increases with the level of activity. The reliability for the level that corresponds to their minimum determinable activity shall be taken as minimal level. See instrumental detection limit.

Total measurement uncertainty calculation (K2):

$$K2 = \sqrt{(X_t^2 + *X_a^2 + *X_c^2 + *X_s^2 + *X_b^2)}, (\%)$$

8. Report

Final report to the client shall document the following:

- Requesting organisation (client)
- Place and responsible person for the measurement
- Time of the measurement
- Identification of measurement points and construction
- Institution or company that performed the measurement
- Measurement method
- Type of measurement instrument
- Date of calibration
- Measured activity concentration, calculated activity index value with associated measurement uncertainty limit (K2 = increased measurement uncertainty)
- Detection limit of the measurement instrument
- Signature measurement responsible person and the quality controller.

References
**1. Naturally Occurring Radioactivity in the Nordic Countries – Recommendations the Radiation Protection Authorities in Denmark, Finland, Iceland, Norway and Sweden, 2000 ISBN 91-89230-00-0.*
**2. Radiological Protection Principles concerning the Natural Radioactivity of Building Materials, EC RP 112 (1999), 1999.*
**3. IAEA-TECDOC-1363 Guidelines for Radioelement Mapping Using Gamma Ray Spectrometry Data (ISBN:92-0-108303-3).*
**4. IAEA-RL-148 Preparation and Certification of IAEA Gamma-Ray Spectrometry Reference Materials.Swedish Radiation.*