ACTIVITY MEASUREMENT ON LARGE SIZE WASTE PACKAGES

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RÉSUMÉ

Lors de la mesure de l'activité gamma d'un colis de déchets de gros volume (par exemple un caisson ANDRA de 5 m^3) par une méthode globale (par exemple une mesure spectrométrique de l'ensemble du colis), des incertitudes importantes résultent des inconnues sur la distribution de masse et d'activité dans ces colis.
Nous avons mis au point et validé par des mesures en vraie grandeur une méthodologie permettant de réduire significativement ces incertitudes. En effet, ces incertitudes sont essentiellement dues au fait que l'atténuation que subit le rayonnement entre son émission et sa détection est en général inconnue ; la méthode proposée évalue l'atténuation subie pour en tenir compte dans l'exploitation du résultat.
L'atténuation peut être évaluée, à partir d'un résultat de spectrométrie gamma, en exploitant soit le rapport des surfaces de deux raies d'énergies différentes émises par le même radioélément, soit l'importance relative du fond de spectre par rapport au pic.

SUMMARY

When measuring gamma activity located inside a large size waste package (France's 5 m^3 container for example) using a global approach method such as a spectrometric measure, large uncertainties arise from the fact that the mass and activity distribution inside the package are unknown.

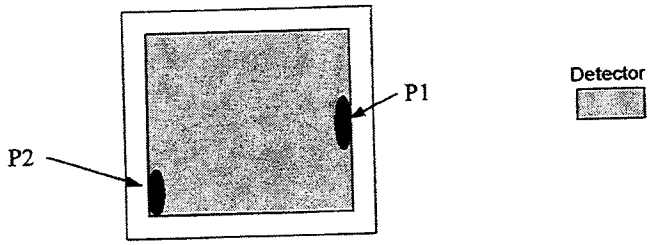
ONECTRA designed and validated by actual site testing a method to reduce significantly these uncertainties. This error in interpretation result mainly from the unknown attenuation undergone by the gamma rays, from the emitting point in the source to the detector. The ONECTRA method evaluates this attenuation when calculating the activity inside the package.

The key to evaluating the attenuation relies on either surface ratio between two peaks emitted by the same isotope (at different energies), or on the relative importance of the degraded energies in the spectrum with respect to the raw peak.

PROBLEM DESCRIPTION

Let us examine the case of a LLW 5 m^3 French waste package filled with metallic scraps that holds an apparent density of 800 kg/m^3 in the useful volume of 3 m^3.

In order to assess the global gamma activity of this package, one possible solution would be to perform one or several near spectrometric measurements around the package.



The detector is generally calibrated for a homogeneous mass and activity distribution inside the useful volume of the package. The reading found by 1 GBq of ^{60}Co homogeneously distributed inside the package will be 1 GBq but would rise to 10 GBq if the activity is concentrated at P1 (most favourable point), and fall to as low as 0,002 GBq if it is concentrated at P2 (less favourable point) and the mass is not homogeneously distributed.

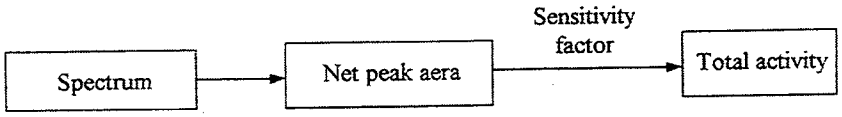
This activity assessment with unknown mass and activity distribution leads to an Uncertainty Factor (UF) exceeding 500. It is possible to reduce this UF with 2 or 4 spectrometric measurements (2 on opposite sides, or on the 4 sides of the geometry).

The ONECTRA measurement method is able to reduce dramatically this UF, using the same spectrometric detector, the same measure configuration the same geometry. In addition, the ONECTRA method can also be combined with the multiple detector method.

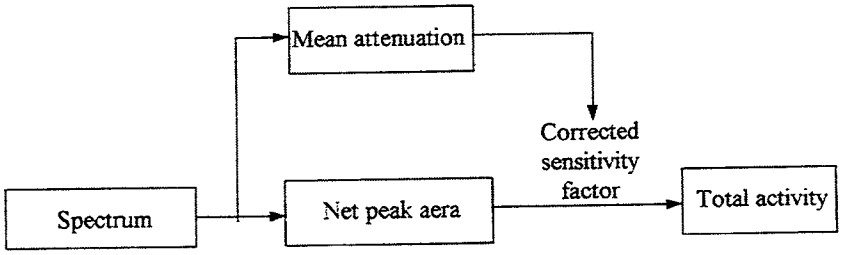
PRINCIPLE

The important uncertainties arise from the unknown attenuation of the gamma rays (γ), that occurs in the path of flight. The ONECTRA method consists in evaluating the mean attenuation through the examination of the measured spectrum and then to take into account this evaluated attenuation in a re-calculated sensitivity factor. There are 2 methods for evaluating the mean attenuation, these are explained later on:

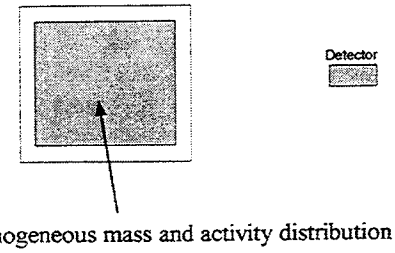
Activity evaluation without attenuation correction:



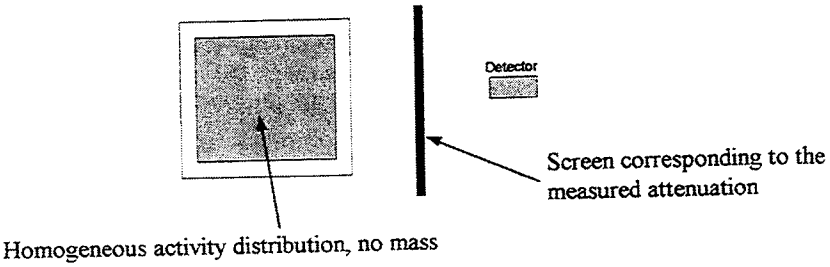
Activity evaluation with attenuation correction:



The sensitivity factor for activity evaluation without attenuation correction is generally computed once for all, assuming that the mass and activity are homogeneously distributed:



For evaluating the activity with attenuation correction, the sensitivity factor is computed for each waste package using a screen corresponding to the measured attenuation:



This attenuation correction method uses standard spectrometric detectors and it's software with the addition of an extra software for the assessment of the mean attenuation and the calculation of the corrected sensitivity factor.

ONECTRA ATTENUATION ASSESSMENT

Peak to Peak ratio:

Some 'radionucleides' like ^{60}Co, ^{110m}Ag, ^{152}Eu, etc. emit several gamma rays at different energies: ^{60}Co (at 1173 and 1332 keV), ^{110m}Ag (at 658, 1384 keV and others). The high energy photons undergo less attenuations than low energy photons, one will, for example see more 1332 keV ^{60}Co photons emerging from a large size package than 1173 keV ^{60}Co energy photons if the source contains ^{60}Co.

Measuring on the spectrum the ratio between 1132 keV and 1173 keV photon peaks enables ONECTRA to evaluate the average attenuation undergone by the gamma rays. This is performed through computation of the peak ratio versus mean attenuation using specific calculation software. It may also be performed, or checked by measurements using calibrated multi-gamma sources.

Peak to Compton ratio:

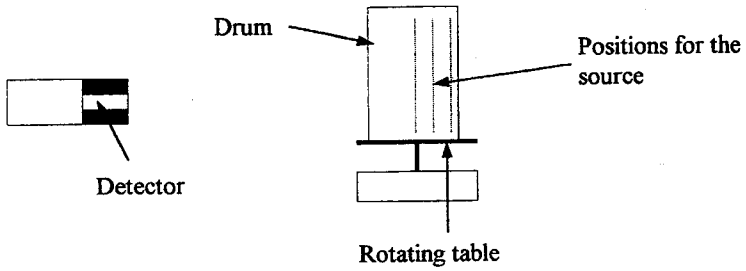
When the main radionucleide emits only one gamma ray like ^{137}Cs (at 662 keV) or ^{54}Mn (at 835 keV) or when the low energy X-rays are not detectable, the peak to peak ratio cannot be applied. It is then possible to assess the mean attenuation through the proportion of photons with degraded energy levels emerging from the waste package. The stronger the attenuation of the initial mono-energetic photon, the more numerous the generation of photons. The main process generating degraded energy photons is called the Compton effect, which is an elastic scattering of photons by electrons.

Measuring on the spectrum the ratio between the full energy peak and the degraded energies enables ONECTRA to assess the average attenuation undergone by the gamma rays. This is achieved through computation of the peak to Compton ratio versus mean attenuation, using specific calculation software based on the Monte-Carlo calculus method. It may also be performed, or checked by measurements using calibrated mono-gamma sources.

VALIDATION

The method has been tested by ONECTRA at the Joint Research Center of ISPRA (Italy), using several geometry.

The first test used a drum filled with concrete with three cylindrical vertical inserts. A calibrated linear ^{152}Eu source was inserted successively in each hole and the drum was rotated during measurements.



Without attenuation correction, the measured value at the fixed external position can vary up to 10 times from the middle position. Using ONECTRA's attenuation correction, the 3 values were found to be within 20% of the real value.

A second test consisted of the measurement of a group of waste drums (up to 40). Each source having been measured individually by the activity evaluation system on site. The activity in the drums was mainly ^{60}Co, a multi-gamma source. The activity values for each group of drums, assessed using attenuation correction, was within 30% of the sum of the individual activity.