A. Appendix – Guidance on NORM blending

Typically, mining and mineral processing waste not containing environmentally mobile radionuclides can be blended with other materials to ensure that in the long term the use of the disposal site is not restricted [1]. The concentrations of radionuclides must be such that the final material is not classified as radioactive.

Ideally, the concentrations of uranium and throrium in the 'final waste' material should be the same as they were prior to mining and/or processing. The maximum acceptable concentrations that radionuclides could be diluted to and then dispersed in the ground without institutional control being considered are detailed in the Code of Practice [3] and are 1 Bq/g of thorium and/or uranium.

Some types of tailings generated by mining and mineral processing industry and containing naturally occurring radionuclides can be re-utilised for different applications, including those in the building and construction industry, in accordance with the following recommendations.

Several international documents provide guidance on the allowable levels of naturally occurring radionuclides in building materials. It is recommended that the values suggested in the EU publication RadPro-112 [6] are used as a basis for the guidance on levels of NORM in different materials, with additions from the documents from Poland [7] and China [8].

Two indexes are established:

a) External exposure index: $f_1 = \frac{C_{Ra}}{300} + \frac{C_{Th}}{200} + \frac{C_K}{3000}$

b) Internal exposure index: $f_2 = \frac{C_{Ra}}{200}$

Where: C_{Ra}, C_{Th} and C_K are the concentrations of radium-226, thorium-232 and potassium-40, respectively, expressed in Bq/kg. If both uranium and thorium decay chains in the material are in a secular equilibrium, the value for the concentration of radium-226 can be replaced by uranium-238, and the value for thorium-232 can be replaced by radium-228.

The index $f_1$describes the content of NORM in a particular material and is calculated on the basis of concenrtaions of radium-226, thorium-232 and potassium-40.

The index $f_2$limits the concentration of radium-226 due to the potential internal radiation exposure to radon-222 and its decay products.

Index $f_1$is used in all cases, index f_2 – only in situations when it is known that radon exhalation rate from a particular material cannot be disregarded from the radiation protection point of view.

These indexes should be used only as screening tools for identifying of the likely use for particualr materials. Additional approvals from an Appropriate Authority will be required in each case – based on a separate dose assessment carried out for scenarios where the material is used in a typical way.

Potential use of NORM has been classified in five groups and the limiting factors are as follows:

1. Material for buildings for human habitation. Application of the material is not restricted: $f_1 \leq 1$, $f_2 \leq 1$.
2. *Decorative* material (tiles, boards, etc) for buildings for human habitation. Application of the *decorative* material is not restricted: $f_1 \leq 1$, $f_2 \leq 2$.
3. *Decorative* material (tiles, boards, etc) for buildings for human habitation. Application of the *decorative* material is restricted to the external walls of a building: $f_1 \leq 3$, $f_2 \leq 5$.

4. Material is not recommended for buildings for human habitation. Application of the material is restricted to the underground parts of a building, including road and rail tunnels: $f_1 \leq 5$, $f_2 \leq 7$, and a thorough assessment of potential exposures will be required. The material can also be used as a base in road construction.

5. Material with values of $f_1 > 5$ and $f_2 > 7$ can only be used after a comprehensive dose assessment *and* a detailed environmental impact study – and only in situations where *both* the exposure of the members of the general public *and* the release of radionuclides into the environment are extremely unlikely. Examples of such situations are the construction of central parts of large bridge piers and sea shore erosion control applications (such as the construction of sea walls and/or artificial reefs – preferably in and around industrial ports).