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Legal and administrative control measures to limit the exposure of the public to ionizing radiation due to coal ash utilization in the concrete industry in Israel

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Abstract

Raw materials used in the building industry in Israel (e.g. gravel, sand, and other aggregates), contain low concentrations of natural radioactive elements, e.g. ^{40}K, ^{232}Th and ^{238}U and their decay products. The same elements are found in enhanced concentrations in fly ash and bottom ash produced in the process of burning coal in power stations. Coal ash is utilized as a constituent of cement and concrete and thermal building blocks in Israel (mainly as a replacement of sand).

Typical values of the concentrations of radio nuclides of natural origin in concrete samples in Israel, as measured in the period 2007-2008 are presented in **Table 1**. The presence of these radionuclides in building products can cause exposure of workers and members of the public (e.g. people who live in dwellings constructed of these building products) to ionizing radiation. This anticipated exposure, albeit relatively low, cause in Israel, as in many other countries, public health concerns. The legal health authorities in these countries feel therefore that there is a need to apply some legal and /or administrative measures to keep these exposures under control.

The scope of these measures has to be proportional to the risks and should be harmonized with the general framework of radiation protection legislation, based on the requirements of international radiation protection standards. In this presentation the updated recommendations of the IAEA related to the ***exclusion*** and **exemption** of certain natural sources (and related exposures) from radiation protection requirements are presented. These recommendations are based on the recommendations of the ICRP as presented in ICRP Pub.103 **(ICRP 2007a)**.

The consequences that can be drawn from these recommendations for establishing the scope and nature of the administrative and legal control measures to limit the exposure of the public to ionizing radiation due the presence, in building products, of radionuclides of natural origin are discussed. The actual administrative control measures applied in Israel in order to achieve this goal are then presented.

Exclusion, Exemption and release of Radionuclides of Natural Origin

Exclusion and ***exemption*** levels of *radionuclides of natural origin* recommended by the IAEA are presented in ***Schedule I*** of the *International Basic Safety Standards for Radiation Protection and Safety of Radiation Sources – the new BSS* **(IAEA 2011)**. ***Table I-3*** in this Schedule is presented in ***Annex 1*** below.

The guidance given in the new BSS is based on the 2007 recommendations of the ICRP **(ICRP 2007a)** and the committee's elaborated general guidelines related to the scope of radiological protection control measures as presented in ICRP Pub.104 **(ICRP 2007b)**.

In IAEA Safety Guide RSG 1.7 **(IAEA 2004)**, an earlier publication of the Agency, the IAEA set detailed guidelines for the ***exclusion*** and ***exemption*** of bulk amounts of radioactive material containing radionuclides of natural origin (i.e. ^{40}K, ^{232}Th, ^{238}U, in equilibrium with their decay products). This safety guide includes also instructions related to the practical implementation of the guidelines.

Some paragraphs from these guidelines are presented in ***Annex 2*** below.

The Scope of Legal and Administrative Control Measures

Coal ashes like other raw materials used in the concrete industry in Israel include ***radionuclides of natural origin*** (i.e. ^{40}K and members of the ^{232}Th and ^{238} U series). However, the activity concentrations of these radio nuclides in the ash are well below the ***exclusion***, ***exemption*** and **clearance** levels recommended by the ICRP and the IAEA as outlined in the new BSS (**IAEA 2011)** and in IAEA Safety Guide RSG 1.7 **(IAEA 2004).**

The *radionuclides of natural origin* present in low activity concentrations in construction materials such as sand, aggregates, coal ash etc. are, therefore, either *excluded* or exempted from administrative control measures (e.g. registration and/or licensing)**.**

Practically some administrative measures are indeed required, since the utilization of these raw materials in the building industry can result in significant radiation exposure to members of the public who dwell in buildings constructed from these materials. In view of this, the ICRP and IAEA recommend to the authorities of member states to set constraints on the dose to members of the public due to these specific applications.

However these constraints relate to the **dose** to workers and members of the public and not to the **raw materials or coal ashes** themselves.

One conventional method to apply such dose constraints is by means construction standards. In Israel such a standard is I.S 5098 which was published in its updated version in 2009 **(IS 2009)**. This Standard sets a constraint on the anticipated additional dose (above background dose levels) to inhabitants of dwellings due to the presence of radionuclides of natural origin in construction materials. Implicitly this dose constraint excludes some construction raw materials rich in radioactivity from broad use in the building industry and sets also limits on the amount of coal ashes that can be put into the concrete mixtures.

References

IAEA 2004 - Application of the Concepts of Exclusion, Exemption and Clearance, Safety Standard Series No. RS-G-1.7, IAEA, Vienna (2004).

IAEA 2011 - Radiation Protection and Safety of Radiation Sources: International Basic safety Standards, General Safety Requirements part, no. GSR part 3 (interim). IAEA, Nov. 2011.

ICRP 2007a - The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann. ICRP Vol. 37 No. 2-4, Elsevier 2007.

ICRP 2007b - Scope of Radiological Protection Control Measures, Annals of the ICRP Vol. 37 No.6, ICRP Pub. 4, Pergammon Press 2007.

IS 2009 – SI 5098, Content of natural radioactive elements in building products, ICS CODE 13.020.99, Israel Standard Institute December 2009.

Peled 2009 - O. Peled, Analysis of the results of a survey to evaluate the radiation dose due to natural radioactivity in concrete in Israel NRS 2009.

Table -1 Activity concentration (range) of radionuclides of natural origin as measured in 2007 by two independent laboratories in 44 samples of concrete mixtures in Israel **(Peled 2009**).

^{40}K	^{232}Th	^{226}Ra	
33-84	**5-24**	**22-55**	**Activity Concentration Bq/kg**
5-10	**2-5.5**	**3-5**	**SD (%)**

Annex 1

Table 1-3 in Schedule I of the new BSS for Radiation Protection and Safety of Radiation Sources (IAEA 2011).

TABLE I-3: LEVELS FOR CLEARANCE OF MATERIAL: ACTIVITY CONCENTRATIONS OF RADIONUCLIDES OF NATURAL ORIGIN

Radionuclide	Activity concentration (Bq/g)
K-40	10
Each radionuclide in the uranium and thorium decay chains	1

Annex 2- Recommendations of the IAEA for the exclusion, exemption and clearance pertaining to exposures from bulk amounts of radionuclides of natural origin (i.e. ^{40}K and the natural decay chains in secular equilibrium headed by ^{238}U, ^{235}U and ^{232}Th. These recommendations are presented in Pas: 4.1, 4.2, 4.3 and 4.6 in chapter 4 of ref. **(IAEA 2004)**.

RS-G-1.7, IAEA

4. VALUES OF ACTIVITY CONCENTRATION

GENERAL

4.1. This section provides the values of activity concentration that may be used, with account taken of a graded approach (see paras 5.11–5.13), for exclusion, exemption and clearance pertaining to exposures from radionuclides of natural origin and bulk amounts of material containing radionuclides of artificial origin. The details of the calculations that yielded these values are provided in a Safety Report [11].

RADIONUCLIDES OF NATURAL ORIGIN

4.2. The values of activity concentration for radionuclides of natural origin, derived using the exclusion concept (paras 3.2–3.3), are given in Table 1.

4.3. The values have been determined on the basis of consideration of the worldwide distribution of activity concentrations for these radionuclides. Consequently, they are valid for the natural decay chains in secular equilibrium; that is, those decay chains headed by ^{238}U, ^{235}U or ^{232}Th, with the value given to be applied to the parent of the decay chain. The values can also

Annex 2 (cont)

TABLE 1. VALUES OF ACTIVITY CONCENTRATION FOR RADIONUCLIDES OF NATURAL ORIGIN (see para. 4.2)

Radionuclide	Activity concentration (Bq/g)
^{40}K	10
All other radionuclides of natural origin	1

be used individually for each decay product in the chains or for the head of subsets of the chains, such as the subset with ^{226}Ra as its parent.

RADIONUCLIDES OF ARTIFICIAL ORIGIN

4.4. The values of activity concentration for bulk amounts of material containing radionuclides of artificial origin, derived using the exemption concept (paras 3.4–3.7), are given in Table 2.

4.5. For noble gases, the exemption levels provided in Schedule I of the BSS [1] should be used. Further discussion is provided in Ref. [11].

MIXTURES OF RADIONUCLIDES

4.6. For mixtures of radionuclides of natural origin, the concentration of each radionuclide should be less than the relevant value of the activity concentration given in Table I.

4.7. For material containing a mixture of radionuclides of artificial origin, the following formula should be used:

$$\sum_{i=1}^{n} \frac{C_i}{(\text{activity concentration})_i} \leq 1$$

where C_i is the concentration (Bq/g) of the i^{th} radionuclide of artificial origin in the material, $(\text{activity concentration})_i$ is the value of activity concentration for the radionuclide i in the material and n is the number of radionuclides present.

4.8. For a mixture of radionuclides of both natural and artificial origin, both conditions presented in paras 4.6 and 4.7 should be satisfied.