

**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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Background

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**.

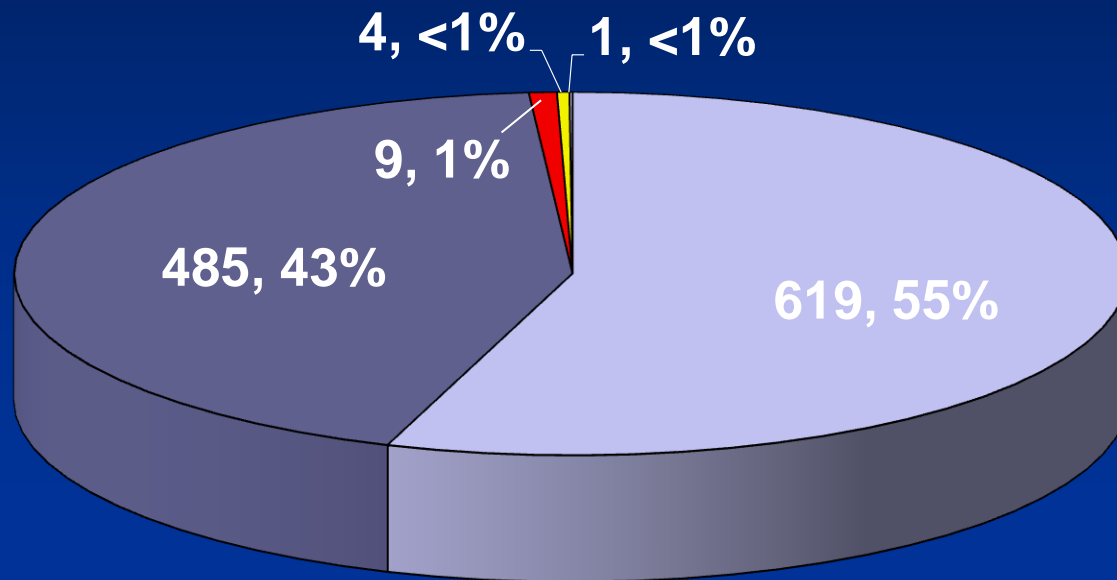
Radio nuclides of natural origin in concrete samples in Israel (2007)

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 (%) |

The extent of the utilization of fly ash in the production of cement, concrete and building products in Israel (2008)

Fly ash uses (thousands tons) in 2011

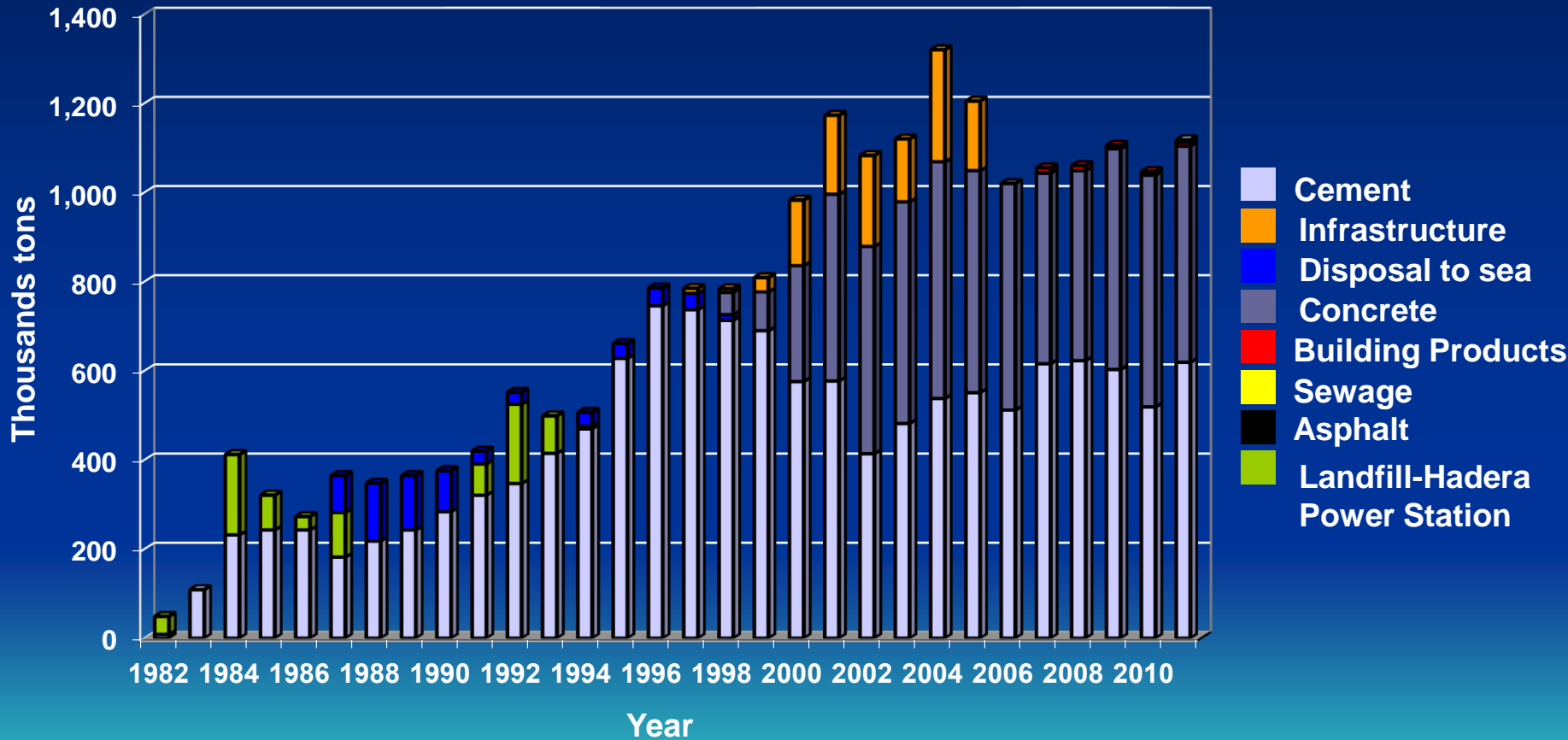


■ Cement ■ Concrete ■ Building Products ■ Sewage ■ Asphalt

The extent of the utilization of fly ash in the production of cement, concrete and building products in Israel (2008)

The extent and distribution of fly ash utilization in Israel

Fly ash




Background (cont.)

The presence of these radio nuclides 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 have 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.



Background (cont.)

In this presentation we will discuss the updated Guidance of the **IAEA** related to the ***exclusion*** and ***exemption*** of certain natural radiation sources (and related exposures) from radiation protection requirements. This Guidance is based on the recent recommendations of the **ICRP** as presented in **ICRP Pub.103 (ICRP 2007a)**.

The consequences that can be drawn from the updated Guidance issued by the **IAEA** for establishing the scope and nature of the administrative and legal control measures to be applied in Israel to limit the exposure of the workers and members of the public to ionizing radiation due the presence (in building products) of radio nuclides 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 radio nuclides of Natural Origin

Updated quantitative guidance of *the IAEA* related to the **exclusion** and **exemption** levels of radio nuclides of natural origin from radiation protection requirements is presented in **Schedule I** of the *International Basic safety Standards for Radiation Protection and Safety of Radiation Sources (IAEA 2011)*. **Table I-3** in this Schedule is presented below.

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

A stylized, low-poly mountain range graphic in shades of brown and tan, positioned at the bottom of the slide against a dark blue background.

The new 2011 BSS

IAEA Safety Standards

for protecting people and the environment

Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

INTERIM EDITION

General Safety Requirements Part 3
No. GSR Part 3 (Interim)



IAEA

International Atomic Energy Agency

Table I- 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 |

Exclusion, Exemption and release of radio nuclides of Natural Origin

In IAEA Safety Guide RS-G-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 and ^{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 below.



IAEA Safety Guide RS- G 1.7 (IAEA 2004)

IAEA SAFETY STANDARDS SERIES

Application of the Concepts of Exclusion, Exemption and Clearance

SAFETY GUIDE

No. RS-G-1.7



IAEA
International Atomic Energy Agency

Recommendations of the IAEA for the exclusion, exemption and clearance pertaining to exposures from bulk amounts of radio nuclides of natural origin (i.e. ^{40}K and the natural decay chains in secular equilibrium headed by ^{238}U , ^{235}U and ^{232}Th (RS-G-1.7, IAEA 2004)..

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

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.

The Scope of Legal and Administrative Control Measures for Coal Ash

Coal ash like other raw materials (e.g. sand, aggregates etc.) used in the concrete industry in Israel contain ***radio nuclides 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 and in these raw materials are well below the ***exclusion, exemption*** and **clearance** levels recommended by the ICRP and the IAEA as outlined in the new BSS and in IAEA Safety Guide RSG 1.7 (IAEA 2004).

The *radio nuclides of natural origin* present in low activity concentrations in the ash and in other construction materials. and in concrete are, therefore, either *excluded* or exempted from administrative control measures (e.g. registration and/or licensing).



Radiological characteristics of coal ash produced in Israel (2009)

Radioactivity concentrations (Bq/kg):

| | | |
|--------------------------------------|----------------------------|----------------------------|
| Fly ash - ^{40}K : 130- 450 | ^{238}U : 100-220 | ^{232}Th : 80-230 |
| (av) av-290 | av-150 | av-150 |
| 1.1 mgK / kg ash | 12 mgU / kg ash | 37 mgTh / kg ash |
| Bot. ash - ^{40}K : 80-560 | ^{238}U : 80-190 | ^{232}Th : 75-190 |
| (av) av-230 | av-130 | av-130 |
| 0.9 mgK / kg ash | 11 mgU / kg ash | 32 mgTh / kg ash |

^{238}U and ^{232}Th in the ash are in equilibrium with all their daughters


Exclusion and exemption level (RS-G-1.7, IAEA 2004): 1.000 Bq/kg of ^{40}K and ^{232}Th , ^{238}U , in equilibrium with their decay products.



Practical Administrative Control Measures for Coal Ash in Israel

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.




Practical Administrative Control Measures (cont.)

One conventional method to apply dose constraints related to the use of raw materials containing radio nuclides of natural origin is by means of 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 dose increment (above background dose levels) to inhabitants of dwelling anticipated due to the presence of radio nuclides of natural origin in construction materials. Implicitly this dose constraint exclude some construction raw materials rich in radioactivity from broad use in the building industry and sets also limits on the amount of coal ash that can be put into the concrete mixtures.



Israeli Standard 5098, 2009 Version

SI 5098

תקן ישראלי ת"י 5098

December 2009

טבת התש"ע – דצמבר 2009

ICS CODE: 13.020.99

91.100.01

תכולת יסודות רדיואקטיביים טבעיים במוצרי בנייה

Content of natural radioactive elements in building products

Table 3 in IS 5098

טבלה 3 - קבועי הריכוז $A(^{40}\text{K})$, $A(^{232}\text{Th})$, $A(^{226}\text{Ra})$, $A(^{222}\text{Rn})$ לחישוב מדדי הקרינה

| $A(^{226}\text{Ra})$ | $A(^{222}\text{Rn})$ | $A(^{232}\text{Th})$ | $A(^{40}\text{K})$ | מסה משטחית ממוצעת P_{SA} |
|----------------------|----------------------|----------------------|--------------------|-------------------------------|
| בק"ג לק"ג | | | | ק"ג למ"ר |
| 10400 | 522 | 7480 | 109000 | 10 |
| 5240 | 261 | 3760 | 55100 | 20 |
| 3520 | 174 | 2520 | 37000 | 30 |
| 2650 | 131 | 1900 | 28000 | 40 |
| 2140 | 104 | 1540 | 22400 | 50 |
| 1130 | 52.2 | 811 | 11900 | 100 |
| 804 | 34.8 | 577 | 8400 | 150 |
| 649 | 26.1 | 465 | 6700 | 200 |
| 560 | 20.9 | 400 | 5720 | 250 |
| 504 | 17.4 | 359 | 5090 | 300 |
| 466 | 14.9 | 332 | 4660 | 350 |
| 440 | 13.1 | 312 | 4360 | 400 |
| 421 | 11.6 | 298 | 4150 | 450 |
| 407 | 10.4 | 287 | 3990 | 500 |
| 397 | 9.5 | 279 | 3860 | 550 |
| 389 | 8.7 | 272 | 3770 | 600 |
| 378 | 7.5 | 264 | 3640 | 700 |
| 371 | 6.5 | 258 | 3570 | 800 |

הערה:
עבור ערכי ביניים של מסה שטחית ממוצעת מחשבים את קבועי הריכוז על ידי ביון לינארי (אינטרפולציה לינארית).

concrete

The net dose increment to residents of a Standard concrete dwelling due to the incorporation of coal ash in the concrete (7%) is evaluated to reach :

30 -100 $\mu\text{Sv/ y}$ (7000 h)

