


The case of the French mineral and concrete sectors

A methodological guide to assess natural radioactivity of building products

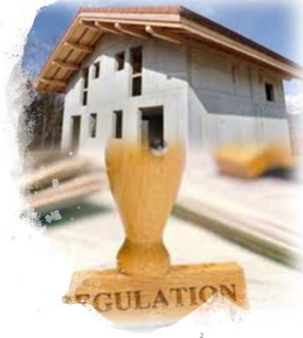
Raphael Bodet, UNICEM/UNPG



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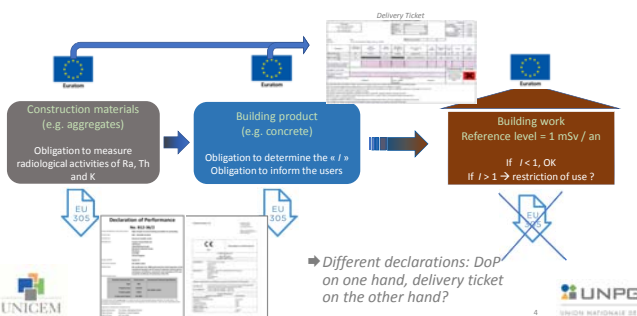
1. Objectives of the methodological guide for the French Concrete & Mineral Industry

- To be proactive
- To set up a declaration scheme for the suppliers of NORM materials & construction products
- To develop a practical approach for cement, concrete & ornamental stones
- To define the best way to declare what the client needs
- To be ready on the 1st July 2020 (French Decree)

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2. Regulatory framework



Construction materials (e.g. aggregates) → Building product (e.g. concrete) → Building work (Reference level = 1 mSv / an)

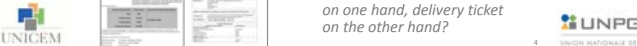
Obligation to measure radiological activities of Ra, Th and K → Obligation to determine the « I » → Obligation to inform the users

Building work Reference level = 1 mSv / an
If I < 1, OK
If I > 1 → restriction of use?

EU 305: Declaration of Performance (DoP)
EU 308: Declaration of Conformity (DoC)

Delivery Ticket

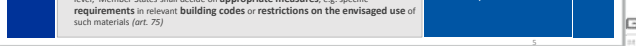
⇒ Different declarations: DoP on one hand, delivery ticket on the other hand?



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2. Regulatory framework

Council Directive 2013/59/Euratom	French Decree
Reference level shall be 1 mSv/y in addition to outdoor external exposure (art. 75)	Same reference level
Set values of compliance to exempt practices from notification or authorization , i.e. the incorporation of NORM into building materials (art. 75, Annex VII)	Same exemption criteria
Building materials of concern are identified by the Member States (art. 75) Examples NORM materials given in Annex XIII	Same list of NORM constituents
Activity concentrations of Ra-226, Th-232 (or its decay product Ra-228) and K-40 are measured and the competent authority is informed (art. 75, Annex VIII)	Declaration for the client's needs
Results of measurements and the corresponding activity concentration index "I" are provided, if requested by the competent authority (art. 75)	Declaration for the client's needs
"I" applies to the building material , not to its constituents except they are building materials themselves and are separately assessed as such (Annex VIII)	This distinction applies
A value of I = 1 can be used as a conservative screening tool (Annex VIII)	Same screening tool & level
Dose calculation needs to take into account other parameters : e.g. density, thickness, bulk or superficial (Annex VIII)	Other parameters not taken into account
For types of building materials which are liable to give doses exceeding the reference level, Member States shall decide on appropriate measures , e.g. specific requirements in relevant building codes or restrictions on the envisaged use of such materials (art. 75)	Currently under discussion



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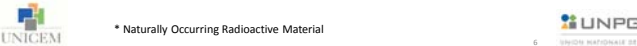
3. Materials with natural radioactivity (NORM*)



Annex XIII of the EURATOM Directive provides an indicative list of building materials to be taken into account with regard to the γ radiation they emit (Art. 75)

This Directive has been transposed and this list is set in French Decree No. 2018-434 of 4 June 2018

* Naturally Occurring Radioactive Material



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3. Materials with natural radioactivity (NORM)

French Decree 2018-434 of 4 June 2018	Aggregates EN 932-3 "simplified petrographic description"			Ornamental Stones EN 12670 "terminology of natural stones"		
	Rocks concerned		Rocks not concerned	Rocks concerned		Rocks not concerned
	Granitoids such as granites, syenites, ...	A.1.1.1 granite A.1.1.2 syenite A.1.1.3 granodiorite	A.1.1.4 diorite A.1.1.5 gabbro A.3.10 mylonite	A.1.2.1 dolere A.1.2.2 diabase	3.1.196 granite 3.1.483 syenite 3.1.199 granodiorite	3.1.127 diorite 3.1.182 gabbro 3.1.326 mylonite
Porphyries Tuff Pozzolana Lava	A.1.3.3 andesite A.1.3.1 rhyolite A.1.3.2 trachyte	A.1.3.4 dacite A.1.3.5 basalt and tuff and pumice stone	A.1.3.5 scoria, volcanic breccia	3.1.21 andesite 3.1.430 rhyolite 3.1.503 trachyte	3.1.116 dacite 3.1.45 basalt	
Orthogneiss	A.3.2 gneiss A.3.3 granulite	A.3.1 amphibolite A.3.4 horny A.3.5 Calcium / dolomitic marble A.3.8 shale A.3.9 slate	A.3.6 quartzite A.3.7 serpentine A.3.189 gneiss 3.1.204 granulite			3.1.17 amphibolite 3.1.422 quartzite 3.1.449 serpentine 3.1.291 calcium / dolomitic marble 3.1.441 shale 3.1.466 slate
		A.2 Sedimentary rocks				3.1.445 Sedimentary rocks

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3. Materials with natural radioactivity (NORM)

Fly ash
artificial mineral material generated during the combustion of coal in a thermal power plant and recovered by dedusting the fumes

Residues from the primary production of metals (steel slags)
- steel slags are the mineral materials co-generated during the smelting processes in the iron and steel industries
- only blast-furnace slags concentrate natural radioactivity and are covered

Phosphogypsum
calcium sulphate resulting from the neutralization of phosphoric acid; it is an occasional constituent whose use remains linked to its availability at the local level

Phosphoric scoria
not used in the industry in France

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4. Material test protocol

- **Sampling of natural materials at the deposit by rock facies to obtain a laboratory sample**
 - The sampling is carried out according to the standard EN ISO 18589-2 (March 2018)
 - A minimum mass of 2 kg is required and may consist of several individual samples
- **Sampling of natural or industrial materials on stocks of finished products**
 - Sampling according to EN 932-1
 - Reduction according to EN 932-2 so as to obtain a composite laboratory sample with a minimum mass of 2 kg

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4. Material test protocol

- **Preparation of the test portion**
 - Crush all the dry material using a laboratory mill until the 200 µm sieve rejection is zero
 - Homogenize the powder obtained
 - Repeat grinding and sieving operations until the entire sample has been processed

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4. Material test protocol

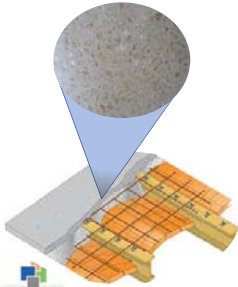
- **Radiological characterization**
 - The measurement is carried out in accordance with the provisions of standard EN ISO 18589-3 (March 2018) using gamma spectrometry
 - The duration of the measurement is to be evaluated according to the expected accuracy, which varies according to the concentration

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5. Information to the customer (concrete manufacturer)

- **Information to the client**
 - Activity concentration values for Ra-226, Th-232 and K-40 are made available on a contractual or regulatory basis
 - The declaration can be done through the Declaration of Performance or any other document transmitted to the user

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6. Building products

- ◆ Products made of a single material
- ◆ Products made of several materials or products

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6. Building products

Products made of a single material

- **Ornamental and Construction Rocks** which are natural stones, cut or shaped (in blocks, slices ...) and used for the construction of buildings
 - Ex: Granite: 102 000 m³ (25 % of the French market)

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6. Building products

Products made of several constituents

- **Cement**
 - 7 types of common cements which generate 27 products of different compositions
 - **main constituents** other than clinker (EN 197-1); they can be classified as "NORM" or not:
 - Granulated blast furnace slag (noted S)
 - Natural pozzolan (noted P)
 - Natural pozzolana burned (noted Q)
 - The siliceous fly ash from the combustion of coal, (noted V)
 - Calcium fly ash from the combustion of coal (denoted W)
 - Calcined shales (noted T)
 - Limestones (noted L or LL for Limestone)
 - Silica fume (noted D)
 - **Secondary constituents**

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6. Building products

Products made of several constituents

- **Cement**
 - The activity index I must be provided to the customer when it contains a NORM constituent
 - I calculated by means of:
 - Activity values provided by its suppliers, after characterization of their NORM materials (values in Bq/kg rounded to the nearest unit)
 - Activity values for non-NORM materials
 - I index values, estimated or calculated to the nearest 0,01
 - The contribution of each constituent is weighted by its mass fraction
 - The index I of the cement is rounded to the nearest 0,01

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6. Building products

Products made of several constituents

- **Concrete and concrete products**
 - Made of aggregates, cement, mineral additions, admixtures...
 - May contain one or several NORM materials
 - When the concrete contains one or more NORM materials, its activity index must be calculated or measured
 - I calculated by means of:
 - Activity values provided by its suppliers, after characterization of their NORM materials (values in Bq/kg rounded to the nearest unit)
 - Activity values for non-NORM materials
 - I index values, estimated or calculated to the nearest 0,01
 - The contribution of each constituent is weighted by its mass fraction
 - The result of I is rounded to the nearest 0,01

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6. Building products

Determining the index I for products incorporating NORM materials or products

- **By calculation using the data from the suppliers**


$$I = \frac{\sum_{\text{constituent } i=1}^{\text{constituent } n} \text{mass}_{\text{constituent } i} \left(\frac{C_{Ra226i}}{300} + \frac{C_{Rn222i}}{200} + \frac{C_{K40i}}{3000} \right)}{\text{total mass building product}}$$

- or

$$I = \sum_{\text{constituent } i=1}^{\text{constituent } n} \frac{\text{mass}_{\text{constituent } i}}{\text{total mass building product}} \times I_i$$

- or a mixture of both

C_{Ra226i} , C_{Rn222i} , and C_{K40i} : activities in radium 226, thorium 232 and potassium 40 of the constituent i
 I_i : activity index of the constituent i
- **By calculation after determination of the activity concentrations of the concrete**



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6. Building products

Tabulated values for non NORM cements

◆ For cements containing no NORM constituents, tabulated values can be used to calculate the I of the concrete

Name	Main Constituent	Secondary Constituent	Activity Index
CEM I	Clinker	-	0,18 – 0,55
CEM II/A-D		Silica fume	Measurements in progress
CEM II/A-T		Calcined shale	
CEM II/B-T			
CEM II/A-L			
CEM II/B-L			
CEM II/A-LL		Limestone	0,12 – 0,30
CEM II/B-LL			

* Calculated from activity concentrations



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6. Building products


Tabulated values for other non NORM constituents

◆ For non-NORM constituents, tabulated values may be used to calculate the I of the concrete

◆ In case of doubt for a given constituent or for constituents not mentioned, it is necessary to carry out its radiological characterization

Non NORM component not having a radiological characterization	Estimated value for index I
Total water of concrete	0
Alluvial aggregates	0,39*
Limestone aggregates	0,12*
Recycled aggregates	0,52*
Non-NORM eruptive aggregates	0,49*
Admixture	0
Cement containing no NORM component	0,12-0,55 (to be confirmed)
Siliceous filler	Measurements in progress
Limestone filler	0,12*

* Calculated from average values of activity concentrations by UNPG



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6. Building products

Example of calculation


◆ Case of a density concrete 2.350 kg/m³ formulated from:

- gravel (granitoid)
- alluvial sand
- CEM II cement
- fly ash
- water and admixtures

◆ The values in the previous Table are used to calculate the concrete activity index

Component	C ₉₀₋₂₃₀	C ₁₇₀₋₂₃₂	C ₉₀₋₄₀	I	Dosing (kg/m ³ of fresh concrete)
Gravel (granitoid)	84,	20,	1260,	/	945
alluvial sand	25,	25,	550,	/	750
CEM II cement	/	/	/	0,50 ₁	300
Fly ashes	100,	56,	1390,	/	150
Water	/	/	/	0,00,	200
Admixture	/	/	/	0,00,	5
Total	/	/	/	0,578 rounded to 0,58	2350

t: tabulated value
s: data from supplier



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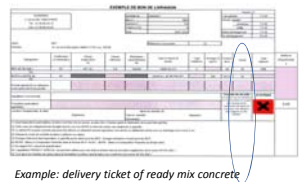

6. Building products

Information to the customer

The value of the "I" is indicated at least on one of the information document communicated to the customer

- Ornamental stones: "I" is indicated on the Product Characterization Sheet
- Cements: "I" of the cement is indicated on the Product Data Sheet
- Concretes and concrete products: "I" is indicated on the delivery ticket or any other media communicated to the customer




Example: delivery ticket of ready mix concrete

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7. Next steps

- The establishment of the conditions for restriction of use of construction products incorporating NORM
- The validation of the methodological guide by the French regulators
- The entry into force on 1 July 2020 of the French regulation

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