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De NORM problematiek

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NEW REGULATORY APPROACH TO NORM INDUSTRIES AND TO RADIOACTIVITY IN BUILDING MATERIALS

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Abstract
Natural radiation sources are within the scope of the present Euratom Basic Safety Standards Directive (96/29/Euratom). The European Directive has more specific radiation protection requirements with regard to natural radiation sources, for "work activities" involving NORM, for radon at work and for the exposure of aircrew to cosmic radiation. However, the Directive does not prescribe how the protection of workers and members of the public should be regulated. This was left to Member States along with the identification of industries of concern. Both the international and the Euratom standards reflected ICRP publication 60 (1990) and in principle regarded the exposure to natural radiation sources as an "intervention" situation, even though the concept of "work activities" in the European Standards is somehow in-between practices and interventions. The new ICRP Recommendations (Publication 103, 2007) have introduced a distinction between three exposure situations (existing, planned and emergency exposure situations) and clarified the application of the basic principles of radiation protection to the different exposure situations. The new recommendations have prompted a revision of the international standards and a revision of the Euratom BSS together with a consolidation with other Euratom radiation protection Directives. Building materials were not explicitly addressed in the 1996 Directive, but the Group of Experts established under Article 31 Euratom set up guidance for the control of radioactivity in building materials and defined a radioactivity index for this purpose (Radiation Protection 112, 2000). The Experts also defined exemption and clearance levels for materials processed in NORM industries and for residues from these industries (Radiation Protection 122 part II, 2001). Building materials and radon in dwellings will now explicitly be included in the scope of the new Euratom Basic Safety Standards and NORM industries will have the same set of requirements as for planned exposure situations. This approach has been implemented in the draft proposal for new, consolidated and revised, Euratom Basic Safety Standards, adopted by the Commission in September 2011. The relevant details of this new Directive are discussed in this paper.

1. EURATOM BASIC SAFETY STANDARDS

1.1 Consolidation

The European Commission has consolidated five Euratom Council Directives: Basic Safety Standards Directive [1], Medical Directive [2], Directive on High Activity Sealed Sources [3], Directive on Outside Workers [4] and Directive on Public Information [5]. A Council Directive is binding and Member States are obliged to transpose the requirements into national legislation. The aim of the consolidation was to merge the five Directives into one while keeping as much of the present texts as possible, even though formally the consolidation is not a "recast" in terms of legislative simplification. Indeed, the Commission had taken this opportunity to clarify and strengthen legal requirements, based on the new ICRP Recommendations published in 2007 [6] and on experience gained by Member States and the Commission since the adoption of the current standards in 1996. The revision of the EU BSS coincided with the revision of the international BSS, adopted by the Board of Governors in September 2011. The Commission actively participated in this process in order to achieve a high degree of harmonisation between the international standards.

1.2 Exposure situations

The revision of the EU BSS takes into account the new ICRP Recommendations. Unfortunately ICRP offers nothing but a rather loose descriptive formulation of the distinction between exposures situations, which is not appropriate in a regulatory context. This introduces confusion between the concept of a "planned exposure situation" and the planned operation of a new radiation source. While the latter needs to be considered specifically in the context of the application of the principle of justification, this is not relevant to decisions on the appropriate mode and level of regulatory control. Some have concluded that "sources that already exists when a decision on control has to be taken" should always be managed as an existing exposure situation. The Commission holds the view that when an activity significantly affects or alters an exposure pathway in a situation caused by existing sources, such as naturally occurring radioactive material (NORM) or cosmic radiation, this is a planned exposure situation. Hence NORM industries and the operation of air- or space-crafts are planned exposure situations and the activities are labelled as "practices".

Another issue is how to manage commodities; these obviously can be part of an activity, at the time of manufacture or import or once they are placed on the market. However, if the radioactive substances arise from an existing exposure situation, it is more convenient to manage such commodities in the same context. Hence, building materials are managed as an existing exposure situation.

1.3 Natural radiation sources

1.3.1 Present BSS

Natural radiation sources are within the scope of both the present international standards [7] and of the present EU BSS. The European Directive introduced more specific radiation protection requirements with regard to natural radiation sources, for "work activities" involving NORM (see Title VII of the Directive). However, the Directive does not prescribe how the protection of workers and members of the public should be regulated. This, as well as the identification of which industries were cause of concern, was left to Member States. Radon in dwellings was excluded from the scope of the Directive (but addressed in Commission Recommendation 90/143/Euratom [8]). The requirements reflect ICRP Publication 60 [9] and in principle regard the management of natural radiation sources as an "intervention", even though the concept of "work activities" in the European Standards is somehow in-between practices and interventions.

The 1996 BSS Directive offered flexibility for the Member States to take into account national circumstances for the identification of "work activities" that would be of concern. Soon after the Directive was adopted, Member States thought that there was merit in using the concepts of exemption and clearance as tools for the identification of NORM industries and for establishing the need for regulatory control. The Article 31 Group of Experts drew the following main conclusions:

– as a result of the large volumes of material processed and released by NORM industries, the concepts of exemption and clearance merge, and it is appropriate to lay down a single set of levels both for exemption and clearance;

– while the basic concept and criteria for exemption-clearance for "work activities" are very similar to those for practices, it is not meaningful to define the levels on the basis of the individual dose criterion for practices (10 μSv per year); instead a dose increment, in addition to background exposure from natural radiation sources, of the order of 300 μSv is appropriate.

Similar to the approach for artificial radionuclides, on the basis of scenarios for public and occupational exposure, exemption-clearance levels for NORM have been calculated. The calculated values were rounded to the value of 0.5 kBq/kg for Uranium and Thorium in secular equilibrium (5 kBq/kg for K-40). Some individual elements in the decay chain, e.g. Po-210 or Pb-210, warrant the use of significantly higher values, by up to two orders of magnitude. Numerical values can be found in the EC guidance Radiation Protection 122, part II [10].

1.3.2 Revision of the BSS

In 2005 the Group of Experts established under article 31 of the Euratom Treaty set up a number of Working Parties to examine different parts of the regulatory framework. One of these Working Parties was dedicated to the management of natural radiation sources.

The WP Natural Sources worked in three steps, taking into account existing Commission Recommendations and earlier guidance. The first step was to look into present requirements for natural radiation sources, in particular NORM; the second step was related to radon in dwellings, taking Commission Recommendation 90/143/Euratom into account, and workplaces; the third step was to establish new requirements for building materials containing naturally occurring radionuclides. As a result, the natural radiation sources that are now explicitly incorporated in the draft EU BSS are:

– naturally occurring radioactive materials used or processed in specific industries (NORM industries) or used as building materials;
– indoor exposure to radon (Rn-222) in dwellings and workplaces;
– exposure of aircrew and space crew to cosmic radiation.

This paper is essentially concerned with the new developments with regard to NORM industries and building materials.

2. REQUIREMENTS FOR NORM INDUSTRIES

2.1 Identifying exposure situations

The regulatory framework for NORM industries should essentially be the same as for other practices dealing with "artificial" radionuclides. In the draft EU BSS, NORM industries have been integrated in the regulatory system as practices. However, as is shown further down, allowance is made for the fact that natural radiation sources are ubiquitous. It is also most unlikely that severe radiological accidents would occur and the existence of other industrial hygiene controls should be taken into account in the case of occupational exposure to NORM.

An important step towards harmonisation of the regulatory framework for NORM is the introduction of a specific list of industrial activities of concern in the draft EU BSS. The so-called "positive list" covers industrial activities known to require regulatory consideration[1] and is to a large extent similar to those listed by IAEA [11]:

- extraction of rare earths from monazite;
- production of thorium compounds and manufacture of thorium-containing products;
- processing of niobium/tantalum ore;
- oil and gas production;
- geothermal energy production;
- TiO_2 pigment production;
- thermal phosphorus production;
- zircon and zirconium industry;
- production of phosphate fertilisers;
- cement production, maintenance of clinker ovens;
- coal-fired power plants, maintenance of boilers;
- phosphoric acid production;
- primary iron production;
- tin/lead/copper smelting;
- ground water treatment facilities;
- mining of ores other than uranium ore.

Member States may add industrial activities to the list if the national authorities conclude that they deserve regulatory attention.

[1] Uranium mining and uranium milling are part of the nuclear fuel cycle and require licensing.

2.2 Materials of concern

For the sake of international harmonisation the draft EU BSS introduce the same values for exemption and clearance as in the new international Standards, while keeping the exemption criteria for natural radiation sources: annual doses of 1 mSv for workers and 0.3 mSv for members of the public. The values in the international standards are based on earlier work leading to IAEA Safety Guide RS-G-1.7 [12]. For naturally occurring radionuclides this work was based on the concept of "amenability to control", underlying the concept of exclusion. Values were eventually chosen at the upper end of the distribution of concentrations in soils around the world (UNSCEAR data [13]): 1 kBq/kg for the U- and Th-decay series and 10 kBq/kg for K-40, see Table I. This is a factor two higher than the values derived in RP122, Part II (see chapter 1.3.1). The difference of a factor two may be viewed as small, but has caused a lot of concern. Although ICRP Publication 75 [14] confirms that workers or members of the public will generally not receive doses higher than 1 or 0.3 mSv per year respectively if the activity concentrations are lower than the values in Table I, this is not the case for building materials. These are now regulated in their own right in the draft EU BSS and special consideration is given to NORM industries on the "positive list" producing residues used in building materials (see chapters 3 and 4.3).

Table I: Values for natural radionuclides in secular equilibrium in solid materials[2]

Radionuclide	Amount (kBq/kg)
Natural radionuclides from the U-238 series	1
Natural radionuclides from the Th-232 series	1
K-40	10

[2] Values in Table I has been proposed in IAEA Safety Guide RS-G-1.7 on the concept of exclusion, exemption and clearance, and are based essentially on the distribution of concentrations in the earth's crust.

2.3 A graded approach to occupational exposure

For industries on the so-called "positive list", the regulatory authorities should be notified by the undertaking if, at any point in the industrial process, the activity concentration in any materials exceeds the values indicated in Table I. The notification should include information on the materials processed, radionuclide concentrations, products, by-products and residues. Based on this information the authorities will decide on the level of regulatory control and can impose requirements for the initial assessment of the exposure of workers. When the assessed exposure of workers is expected to be less than 1 mSv per year, the practice may be exempted from further regulatory control. If the assessed exposure of workers in a group of identical industrial processes is consistently less than 1 mSv per year, these processes could be exempted on a generic basis.

If the exposure of workers can exceed 1 mSv per year but is less than 6 mSv per year, Member States shall consider authorisation, i.e. either registration or licensing, or consider whether circumstances are such that the practice should be exempted from further regulation. Member States shall require the employers to regularly assess whether doses could effectively be further reduced and whether there is a potential for doses to increase over time or as a result of changes in the work practice. Where appropriate, the authorities shall request a formal implementation of the principle of optimisation as it would for any other practice. When the exposure of workers exceeds or is likely to exceed 6 mSv per year in normal operation, Member States shall require that the practice be licensed.

3. REQUIREMENTS FOR BUILDING MATERIALS

The present EU BSS do not include specific requirements related to radionuclide concentrations in building materials. By introducing such requirements in the draft EU BSS, the Commission on the one hand complements the Council Directive on construction products [15], on the other hand pursues further harmonisation of the regulatory approaches by Member States to allow free movement of building materials within the European Union.

3.1 List of building materials and components

The Member States will be required to insert in their legislation a list of the different types of building materials which need to be controlled with

regard to their emitted gamma radiation. When setting up this list, an indicative list in an Annex to the BSS shall be taken into account. The list of materials contains:

1. Natural materials:
   – Alum-shale;
   – Building materials or additives from natural igneous origin, such as granite, gneiss, porphyries, syenite, basalt, tuff, pozzolana and lava.
2. Materials incorporating residues from NORM industries such as fly ash, phosphogypsum, phosphorus slag, tin slag, copper slag, red mud (residue from aluminium production) and residues from steel production.

The requirements will offer the possibility for Member States to add or withdraw certain categories of materials when there is evidence of them being a cause for concern or not being of concern.

3.2 Measurements and activity concentration index

For the materials of concern the industries placing such materials on the market the activity concentration index (I), as defined in EC guidance Radiation Protection 112 [16], has to be calculated[3]. The industry is required to provide information to the national authority on the results of the measurements.

3.3 Reference level and classification

A reference level of 1 mSv per year is proposed for indoor external exposure from building materials, in excess of the background outdoor external exposure. When assessing compliance with the reference level the doses from the exposure to local prevailing activity concentrations in the undisturbed earth's crust should be subtracted.

If the building material is found to yield doses not exceeding the reference level, then the material should be exempted from requirements, except for

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[3] $I = C_{Ra226}/300\ Bq/kg + C_{Th232}/200\ Bq/kg + C_{K40}/3000\ Bq/kg$.
where C_{Ra226}, C_{Th232} and C_{K40} are the activity concentrations in Bq/kg of the corresponding radionuclides in the building material. For practical purposes the measurement of Th-232 can be replaced by that of Ra-228 which is more readily measured.

appropriate further monitoring of activity concentrations if so required. If the material is liable to give doses exceeding the reference level, the authority should consider appropriate control measures ranging from registration and general application of relevant building codes, to specific restrictions on the use of such material. Building materials not exceeding the reference level shall be exempted from any restrictions on the market in the European Union.

Two groups of building materials should be considered:
– materials used in bulk amounts;
– superficial and other materials with restricted use.

For this purpose the activity concentration index I could be used for the classification of the materials into four classes leading to two categories of building materials (A and B):

Table II: Values for the activity concentration index I in building materials

	Category (corresponding default dose)	
Use	A (≤ 1 mSv)	B (> 1 mSv)
(1) materials used in bulk amounts	A1 I≤1	B1 I>1
(2) superficial and other materials with restricted use.	A2 I≤6	B2 I>6

The distinction of materials into (1) or (2) should be defined in national building codes.

The information relevant to the implementation of building codes should be made available before the materials are placed on the market: radionuclide concentrations, activity concentration index and corresponding classification. The practical implementation of these requirements in terms of monitoring and classification is presently subject to CEN/TC standardisation (as construction products under the corresponding EC Directive [15]).

4. REQUIREMENTS FOR NORM EFFLUENTS AND RESIDUES

4.1 Waste disposal

NORM industries may give rise to residues that qualify for disposal, in specific radioactive waste repositories, but this is exceptional (e.g. oil scales). In most case residues from NORM industries will be disposed of in industrial landfills, provided they comply with the criteria for clearance. It should be emphasised that the values laid down in Table I do not allow for leaching and possible contamination of drinking water as an exposure pathway. The generic, conservative, inclusion of a drinking water pathway in the assessment of doses to members of the public from landfill sites could lead to very low activity concentration values. It is thus necessary to monitor drinking water for such possible contamination and for compliance with drinking water standards (as required under Council Directive 98/83/EC [17]). In any situation where there is indication that such contamination may arise, a NORM industry may be subject to authorisation even if the concentration values in Table I are complied with.

4.2 Recycling of NORM residues in building materials

As explained in chapter 2.2 the draft EU BSS incorporate the activity concentration values proposed in IAEA RS-G-1.7, but nevertheless keep the exemption criteria for natural radiation sources: annual doses of 1 mSv for workers and 0.3 mSv for members of the public (to be compared to 10 μSv for artificial radionuclides). Reuse and recycling of residues from any authorised practice (involving in general artificial radionuclides) is subject to authorisation. Clearance levels for artificial radionuclides and for naturally occurring radionuclides are now equal to the exemption values for large amounts of material. The clearance of residues for the manufacture of building materials however, in general warrants lower values than those proposed in Table I. The building materials should be tested against the index value in Table II. Industries known to produce residues liable to cause the index for building materials to exceed 1 shall be notified to the regulatory authority. The reference level of 1 mSv applies to the building material as a whole, the clearance criterion of 0.3 mSv only to the dose resulting from the incorporation of specific residues. Notified NORM industries are subject to authorisation if doses to workers exceed 1 mSv or doses to members of the public exceed 0.3 mSv per year. The authority may impose specific

licensing conditions on an industry exceeding either the dose criterion of 0.3 mSv or the activity concentration index for building materials, while still allowing the recycling of residues, where this is justified. They may even authorise the mixing of residues with other materials in order to reduce the value of the index, again, if this type of practice is justified.

4.3 Effluent

The criterion of 0.3 mSv per year also applies to industrial facilities discharging liquid and gaseous effluents. If this dose is exceeded, the practice is subject to authorisation. Guidance on the establishment of discharge authorisations in terms of total annual activity has been offered in Radiation Protection 135 [18].

5. CONCLUSIONS

The Commission proposal for a new Basic Safety Directive[4] has been submitted to the Economic and Social Committee, and is already being examined in the WP on Atomic Questions of the Council. The Commission anticipates no major changes to the delicate architecture of requirements on NORM materials. The architecture may nevertheless be strengthened where further discussion shows that there may be loopholes or ambiguities in the system. Hence one should expect that within a few years NORM industries will be managed as a fully regulated practice. The main feature of this architecture is nevertheless its flexibility (in particular the approach to occupational exposure) and proportionality (graded approach to regulatory control). The Directive is intended to have a balanced and coherent approach to the management of residues from NORM industries, considering the different options: discharge of effluent, management as radioactive waste (taking possible water contamination into account), recycling (in particular into building materials). The approach of the Euratom Basic Safety Standards is similar to, but more explicit, than the corresponding requirements in the international Basic Safety Standards[5]. The Commission undertakes to provide further guidance on the

[4] http://ec.europa.eu/energy/nuclear/radiation_protection/doc/com_2011_0593.pdf.

[5] http://www-pub.iaea.org/books/IAEABooks/8736/Radiation-Protection-and-Safety-of-Radiation-Sources-International-Basic-Safety-Standards-Interim-Edition.

transposition and implementation of these requirements, based on feedback from regulatory experience in industry and from competent authorities.

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Belgian regulations for NORM: current status and perspectives

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Abstract

The Belgian radiation protection regulations list the NORM sectors which are subject to declaration: the goal of the declaration is to evaluate possible risks of exposure for the workers and the population and to verify whether the limit of exposure for members of public (1 mSv/yr) may be exceeded. This paper gives an overview of the declarations, which have been processed by FANC and explains the assessment-methodology. Planned developments in the regulations will also be described, in particular with respect to management of NORM waste and residues.

1. Introduction

Title VII of the European Basic Safety Standards (Directive 96/29/EURATOM) [1] addresses the issue of *significant increase in exposure due to natural radiation sources*. It requests Member states of the European Union to identify the work activities which are of concern and to enforce the *setting up of appropriate means for monitoring exposure*. Title VII has been implemented into Belgian law with the Royal Decree of July 20, 2001 setting forth the general regulation for the protection of the population, the workers and the environment against the danger of ionizing radiation [2]. The issue of NORM work activities is addressed in articles 4 and 9 of this Royal Decree.

2. Current Belgian regulations with respect to NORM

Article 4 of the Royal Decree of July 20, 2001 lists the work activities of concern:
- phosphate production;
- use of zircon sand;
- tin foundries;
- rare earths extraction;
- manufacture of thoriated welding rods.

Article 4 gives also the possibility to FANC of adding new sectors to the list. Note that the regulations do not refer to any exemption level in term of activity concentration for these work activities.

According to article 9 of the Royal Decree, the companies belonging to one of the listed sectors must submit a declaration to FANC containing the following information:
- administrative data of the facility;
- type of facility;
- type and characteristics of the natural sources of radiation which are present or processed in the facility and, if applicable, the physical state of these natural sources, their quantities, their level of radioactivity, their destination, the places where they are stored or processed;
- description of the processes which may lead to an enrichment of the natural radionuclides;
- number of people concerned in the facility;
- protection measures which are already taken or foreseen;
- description of the measures concerning the characterisation, the treatment, the storage and elimination of the produced residues.

The objective of the declaration is to identify possible risks of exposure. The information contained in the declaration forms the basis for a dose-assessment. The reference dose level is the dose limit for public - 1 mSv/yr. If this dose level is exceeded or likely to be exceeded, FANC may impose to the facility some corrective measures. If, in spite of these corrective measures, the dose level of 1 mSv/yr is still exceeded, the NORM facility may become a licensed facility.

3. Content of the declaration and overview of submitted declarations

FANC issued guidelines giving a general scheme for the declaration. The essential elements are a flowchart (see Fig. 1) of the production processes in the facility, so that all concerned working tasks may be easily identified. The description of the processes must include maintenance operations. The flowchart helps also to distinguish between the various input (raw materials, additives,…), intermediary and output (final products and residues) products of the processes.

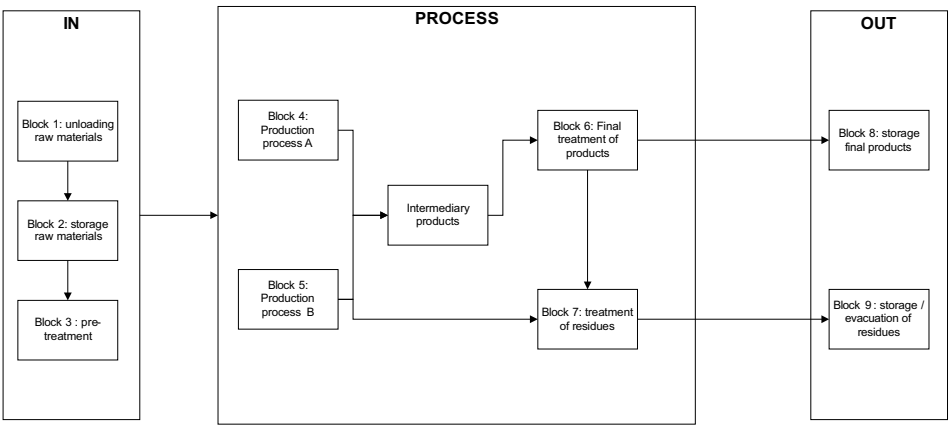

Fig 1. Generic example of a production flowchart.

The second element is a grid with a set of data relevant for assessing the risk of exposure: listing of concerned materials with their activity concentration, duration of exposure of the operators, dust concentration in the workplace, etc.

FANC received 20 declarations: 5 declarations from the phosphate production sector, 1 from tin production and 14 related to zircon sand (5 foundries, 6 ceramic industries and 3 handling and packaging companies). Maintenance operations and waste management are generally the most critical operations. In 5 cases, corrective or surveillance measures were prescribed to the facility. Corrective measures include the wearing of individual protective equipments especially during maintenance operations; surveillance measures consist essentially in an environmental monitoring of the mono-landfills (phosphogypsum or calcium fluoride stacks) operated by

some phosphate industries. This environmental monitoring consists in radon measurement in and around the landfills and groundwater monitoring.

Identification of concerned companies may be a tedious task as there is generally no direct match between the denomination of the "NORM" work activity (like "use of zircon sand") and the commonly used classification of economic activities (NACE codes). In other cases, like "tin foundries", the denomination is very generic: many tin foundries process only tin ingots or recycled tin, which are of no concern regarding NORM. Therefore, FANC organized a mailing to potentially concerned companies in the sectors of foundries, ceramics and refractories. The companies were asked to fill a questionnaire so that the ones which actually use zirconium sand or other NORM could be identified. It appeared that ~20 % of the contacted companies were actually concerned by the obligation of submitting a declaration.

4. Future regulations

There are several gaps in the current regulatory framework for NORM in Belgium. The current list of work activities in article 4 of the Royal Decree of July 20, 2001 is very limited and does not cover all sectors of concern in Belgium. To remediate this situation, FANC plans to extend this list – taking into account national and international experiences. The identification of these new sectors takes into account the list of potentially concerned sectors as published by the IAEA [3] and the EC [4]. Specific data were collected e.g. in the sectors of coal-fired power plants and groundwater treatment. The radioactivity monitoring of containers passing through Antwerp and Zeebrugge harbours and performed by Belgian customs also provide information about the actual flow of NORM in Belgium. The extension of the list of work activities will occur in two stages: first in 2012 and second in 2013.

Moreover there is also a need to define clearer rules for the management of NORM residues. Up to now, decisions on management of specific flow or batches of NORM residues (e.g. acceptance on industrial landfills) is taken on a case-by-case basis, which prevents to have a global view on the NORM residues flow in the non radioactive waste management sector. Applications for disposal or processing of NORM residues as non radioactive waste do not only come from the known NORM industries which are sub-

ject to the obligation of declaration. Often it concerns small batches of NORM residues which have been tracked down for example via detection at a portal monitor: isolation wool, refractory materials, scalings, etc.

FANC established a working group to develop regulations related to the management of NORM residues. The proposals of this working group were inspired by German regulations with respect to NORM residues and contain two essential elements:

– facilities where NORM residues are disposed or processed will be considered as a NORM work activity in the sense of the Royal Decree, which means that they will also be subject to a compulsory declaration;
– specific acceptance criteria will be defined for these facilities in function of the type of disposal or treatment (landfilling, incineration, processing in building materials, …). The acceptance criteria consist in a maximum activity concentration per accepted batch combined with a limit either on the average activity concentration in the total volume of disposed waste (landfills) or on the activity concentration in the final products or waste of the process (incineration, building materials,…).

Derogation to the acceptance criteria may possibly be asked on basis of a specific risk-assessment.

Definition of acceptance criteria provides a regulatory basis for the processing of NORM residues, while the integration of NORM residues processing facilities into the category of work activities gives to the radiation protection authority the necessary means for the follow-up, control and monitoring of the flow of NORM residues.
Table 1 gives an overview of the proposed acceptance criteria.

<table>
<tr><th rowspan="2"><u>Processing type</u></th><th colspan="3"><u>Activity concentration</u></th></tr>
<tr><th colspan="2">Concentration in ingoing NORM residues</th><th>« output » : concentration in the final product / in the waste</th></tr>
<tr><td rowspan="2">Landfill for hazardous waste</td><td>Exemption</td><td>RP 122 II</td><td rowspan="2">$C_{yearly\ average} < 0.2$ Bq/g</td></tr>
<tr><td>C_{max}</td><td>50 Bq/g</td></tr>
<tr><td rowspan="2">Landfill for non hazardous waste</td><td>Exemption</td><td>RP 122 II</td><td rowspan="2">$C_{yearly\ average} < 0.2$ Bq/g</td></tr>
<tr><td>C_{max}</td><td>10 Bq/g</td></tr>
<tr><td rowspan="2">Landfill for inert waste</td><td>Exemption</td><td>RP 122 II</td><td rowspan="2">$C_{yearly\ average} < 0.2$ Bq/g</td></tr>
<tr><td>C_{max}</td><td>10 Bq/g</td></tr>
<tr><td>Mono-landfill</td><td colspan="3">< 0.2 Bq/g : no restrictions

> 0.2 Bq/g : monitoring + remediation plan and/or restrictions on use of site;</td></tr>
<tr><td rowspan="2">Incineration and co-incineration (cement industry)</td><td>Exemption</td><td>RP 122 II</td><td rowspan="2">+ Control final products and waste

- RP 122 II : if material intended for road construction or similar applications.

- activity index: if material may be used in building construction.</td></tr>
<tr><td>C_{max}</td><td>10 Bq/g</td></tr>
<tr><td rowspan="2">Building materials (all applications: buildings, infrastructure work, road basement)</td><td>Exemption</td><td>RP 122 II</td><td rowspan="2">+ Control final products

- RP 122 II: if material intended for road construction or similar applications.

- activity index: if material may be used in building construction.</td></tr>
<tr><td>C_{max}</td><td>10 Bq/g</td></tr>
<tr><td>Other use</td><td colspan="3">Case by case</td></tr>
</table>

Table 1. Proposed acceptance criteria for NORM residues

"RP 122 II" refers to the exemption/clearance levels defined in the report from the European Commission "*Radiation Protection 122 Part II*" [5]. "$C_{\text{yearly average}}$" refers to the average activity concentration in the total volume of waste which are disposed on the landfill.

FANC plans to implement these acceptance criteria in 2013.

5. Legacy sites with NORM

Next to current "NORM" activities, several disused NORM sites are scattered throughout Belgium. Many of these NORM-contaminated sites are legacies of the phosphate industry, such as phosphogypsum stacks. The Belgian Royal Decree of July 20, 2001 addresses the issue of legacy sites as an **intervention situation** (more precisely intervention in cases of **lasting exposure**). Article 72bis of the Royal Decree is a transposition of article 53 of the Directive 96/29/EURATOM. It gives a general regulatory framework to the issue but leaves open several key-points such as liabilities, administrative procedure to be followed, etc. In order to fill these gaps, FANC wrote down a proposal of new regulations with a clear definition of responsibilities and a stepwise decision-making process. Although this regulation has not yet been approved at political level, its methodological approach may already be applied. The main steps of this methodology are the following:

- identification of possible NORM legacy sites on basis of measurements and/or historical data;
- screening of the contamination;
- detailed study in order to quantify the radiological impact;
- assessment of the various possible management options of the site with a process of stakeholder consultation;
- remediation project or so-called risk-management plan to either remediate the situation or to control the risk (e.g. through restrictions on the use of the site);

This approach is inspired by the existing environmental regulations with respect to the remediation of chemically contaminated sites. As in most cases the radioactive component of the contamination is not the main trigger for remediation, collaboration between the radiation protection authority and the environmental authorities is needed to insure a coherent approach of all components of contamination, both chemical and radioactive.

For most of these NORM contaminated sites, radon is the most important exposure pathway. Parallel to the above mentioned approach, FANC has classified these sites as *anthropogenic radon-prone areas*. The list of the corresponding cadastral parcels has been published as a FANC decree in the official journal of Belgium [6]. According to article 4 of the Royal Decree of July 20, 2001, all workplaces located on a radon-prone area are subject to monitoring and control regarding exposure to radon. Therefore, classification of NORM contaminated sites as anthropogenic radon-prone areas allows some institutional control of these sites: it gives notably the possibility to FANC of enforcing preventive measures against radon infiltration if construction of buildings would be carried out on these sites.

6. Conclusions

NORM regulations in Belgium are based on a graded approach where the assessment of the radiological impact is the key decision-criteria. 1 mSv/yr is the action-level both for workers and public exposed to NORM. The list of concerned industrial sectors is currently limited but it is planned to extend this list at short-term. A detailed regulatory framework for the management of NORM residues is also under development.

The methodology for occupational risk-assessment in NORM industries does not fundamentally differ from the methodology used in other fields of occupational safety (like e.g. the protection against crystalline silica or asbestos). In many cases, the standards rules of occupational safety are sufficient to cover the radiological risk.

Also for NORM residues management, radiation protection considerations are not necessarily the driving factor in the decision process (like, for instance, for the management of NORM containing asbestos cement). Cross-interactions between fields of expertise in environmental management, dialogue between the various stakeholders and authorities are necessary elements in a sound and coherent management of NORM.

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NORM-WETGEVING IN DE NEDERLANDSE E&P PRAKTIJK

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Samenvatting
De E&P-industrie (E&P is een afkorting van Exploratie & Productie van aardgas en aardolie) wordt al langere tijd geconfronteerd met de afzettingen van Natuurlijke Radioactieve stoffen als gevolg van de productie van aardgas of aardolie in de productie installaties. Deze afzettingen bevatten varierende concentraties van nucliden uit de ^{238}U- en ^{232}Th-reeks, welke grenswaarden voor Meldingsplicht (zie MR-NaBiS) of Vergunningplicht (zie BS) kunnen overschrijden. Dit artikel beschrijft werkwijze met betrekking tot NORM zoals door NAM toegepast.

Inleiding

De Nederlandse Aardolie Maatschappij (NAM) is grootste producent van aardgas in Nederland; in 80 gas productieinstallaties is de aanwezigheid van Meldingsplichtige of Vergunningplichtige concentraties van natuurlijke radioactieve stoffen (NORM) geconstateerd. Dit heeft ertoe geleid dat aan NAM een vergunning in het kader van de Kernenergiewet (NL) is verstrekt.

Vanwege het grote aantal betrokken NAM productie-installaties is deze vergunning uitgevoerd als zogenaamde Complex-vergunning.

Een dergelijke vergunning vereist een organisatie voor stralingsbescherming met ondermeer een Stralingsdeskundige niveau-2 en twee Stralingsdeskundigen niveau-3 en adequate bedrijfregel-geving op het gebied van stralingsbescherming. De complex-vergunning verschaf de vergunninghouder een redelijke mate van handelingsvrijheid.

Radioactieve stoffen van natuurlijke oorsprong [NORM]

Deze stoffen komen in zeer lage concentraties voor in de gas/olie-voerende formatielagen en worden het in de formatie aanwezige water in de productstroom naar de gas/olie productie put getransporteerd.

Na verloop van tijd neemt de kans toe dat deze natuurlijke radioactieve stoffen zich in meetbare concentraties op gaan zamelen in bovengrondse productieinstallaties.
Door het uitvoeren van besmettingsmetingen op inwendige oppervlakken van installaties, waarbij het gemeten stralingsniveau (actueel teltempo) wordt vergeleken met het lokale achtergrond stralingsniveau (teltempo) kunnen afzettingen van natuurlijke radioactieve stoffen worden vastgesteld. Door bemonstering van de gevonden afzettingen, gevolgd door gammaspectrometrische analyse kunnen activiteitsconcentraties in de afzettingen worden bepaald.
Voor de besmettingsmetingen wordt door NAM gebruik gemaakt van de RADOS Microcont met (losse) RPD-1 probe (NORM-1).
Aan de hand van de analyseresultaten kan worden bepaald of de gevonden radioactieve afzetting Meldingsplichtige (MP) danwel Vergunningplichtig (VP) is [zie tabel1].

Tabel 1 Overzicht grenswaarden

Nuclide	MP [Bq/g]	Totaal [Bq]	VP [Bq/g]
^{226}Ra	1	10000	10
^{210}Pb	100	10000	1000
^{228}Ra	1	100000	10
^{228}Th	1	10000	10

Omdat in de E&P industrie bijna altijd sprake is van een combinatie van radionucliden, in variërende samenstelling, wordt de volgende formule voor de gewogen gesommeerde waarde (G2-waarde) toegepast.

G2-waarde = $^{226}Ra_{act.}/^{226}Ra_{lim.} + (^{210}Pb_{act.} - ^{226}Ra_{act.})*/^{210}Pb_{lim.} + (^{228}Ra_{act.}/^{228}Ra_{lim.})**$

*: mits $^{210}Pb_{act.} > ^{226}Ra_{act.}$, anders: 0

**: mits $^{228}Ra_{act.} > ^{228}Th_{act.}$, anders: $^{228}Th_{act.}/^{228}Th_{lim.}$

act. : werkelijke concentratie [Bq/g]
lim. : grenswaarde uit “Besluit st4ralingsbescherming [Bq/g].

Indien deze G2 >1 maar < 10, dan is er sprake van Meldingsplichtige radioactieve stoffen;
indien de G2-waarde > 10, dan is er sprake van Vergunningplichtige radioactieve stoffen.
Het begrip Meldingsplicht houdt in, dat het bedrijf officieel meldt, in het kader van de Ministeriële Regeling Natuurlijke Bronnen van Ioniserende Straling (MR-NaBiS) aan de overheid, dat er bij het bedrijf radioactieve stoffen met Meldingsplichtige activiteitsconcentraties aanwezig (kunnen) zijn.
Deze melding brengt een beperkt aantal eisen met zich mee.
Het begrip Vergunningplicht spreekt voor zich, het bedrijf is in het bezit van een vergunning in het kader van de Kernenergiewet (KeW) en voldoet aan de in de vergunning gestelde eisen.

De NAM maakt qua werkprocedures geen onderscheid tussen Meldingsplicht en Vergunningplicht; besmette installatiedelen worden op dezelfde wijze behandeld.
Voor de verwerking van vrijgekomen radioactieve besmette reststoffen wordt wel een onderscheid gemaakt tussen Meldingsplichtige en Vergunningplichtige stoffen.
De beoogde verwerker dient namelijk ook te voldoen aan de voor Meldingsplicht of Vergunningplicht gestelde eisen. Het NAM-beleid is erop gericht dat er geen radioactief besmette installatiedelen of - reststoffen (zoals sludges of scales) worden overgebracht buiten NAM tenzij het betrokken bedrijf een goedgekeurde MR-NaBiS melding heeft uitgevoerd of in het bezit is van een geldige KeW-vergunning. **Reputatie schade, veroorzaakt door straling gerelateerde onderwerpen, moet worden vermeden.**

Radioactief besmette installatiedelen

Er is sprake van radioactief besmette installatiedelen wanneer bij besmettingsmetingen het gemeten teltempo de volgende grenzen overschrijdt:
“onshore locaties”: > 2x lokaal achtergrond teltempo
“offshore locaties”: > 3x lokaal achtergrond teltempo

Deze grenswaarden omvatten voldoende marges om variaties ten gevolge van de electronische instabiliteit van het meetinstrument, de kwaliteit van de metingen en eventuele interne afschermingseffecten in de radioactieve afzettingen te kunnen compenseren.

Opties mbt. besmette installatiedelen zijn:

– hergebruik in dezelfde of in een andere radioactief besmette installatie;
– decontaminatie door gespecialiseerde en vergund service bedrijf (NRG-Petten);
– omsmelten van radioactief besmet schroot door gespecialiseerd bedrijf (Siempelkamp Krefeld) tijdens het smeltproces verzamelen de natuurlijke radioactieve stoffen zich in de slakken boven op het smeltbad; deze slak kan dan eenvoudig gescheiden worden van het staal; het staal kan daarna zonder beperking worden gebruikt;

Radioactief besmette reststoffen

Deze bevatten naast NORM vaak ook lichte koolwaterstoffen (C_xH_y) en kwik in wisselende concentraties; deze combinatie van probleemstoffen beperkt het aantal mogelijkheden voor bewerking en/of eindberging.

Daarom worden deze reststoffen bijvoorkeur door middel van een vacuumdestillatie proces ontdaan van de vluchtige bestanddelen zoals ondermeer C_xH_y en kwik; het residue is inert.

De beoogde eindberging dient voor MP residuen in het bezit te zijn van een geaccepteerde MR-NaBiS melding en voor VP residuen in het bezit van een KeW-vergunning.

De bewerking van kwik-houdende reststoffen is door NAM Europees aanbesteed; bij dit proces is uiteindelijk DELA GmbH Essen geselekteerd als officieel vergunde reststof bewerker.

Complicerende factor hierbij blijkt bij nader inzien dat in Duitsland andere grenswaarden voor verschillende categorieen radioactief besmette reststoffen worden gehanteerd.

– niet-radioactief, concentratie per nuclide $< 0{,}2$ Bq/g
– notificatie vereist (I) $0{,}2 < x < 5$ Bq/g
  (II) $5 < x < 50$ Bq/g
  (III) $x > 50$ Bq/g

De bij de bewerking vrijkomende residuen dienen voor eindberging terug te worden getransporteerd naar Nederland. De volgende eindbergings locaties zijn hiervoor beschikbaar:

MP-residuen	Nauerna Assendelft
MP en VP-residuen (G2-waarde < 100)	A&G Maasvlakte
VP residuen	COVRA Vlissingen

Toekomstige aanpassingen in de BSS

De grenswaarden voor alle in de praktijk voorkomende nucliden worden op 1 Bq/g gesteld; individuele landen kunnen op basis van risico-evaluaties ervoor kiezen om van deze grenswaarden af te wijken: hiermee blijft het effect van de beoogde aanpassingen op de wijze van werken beperkt.
Het verlagen van de grenswaarden voor radioactieve reststoffen brengt echter wel hogere operationele kosten voor het verwerken van deze stoffen met zich mee, omdat meer reststoffen als radioactieve stoffen moeten worden verwerkt.

Andere NAM-wensen

– BSS en de Kernenergiewet dienen beter op elkaar afgestemd te zijn; grenswaarden zouden overal in Europa hetzelfde;
– ADR regelgeving dient in lijn te zijn met Euratom 2006/117; NORM dient opnieuw opgenomen te worden in deze richtlijn;
– Nationale regelgeving in Europese (aan elkaar grenzende) landen dient beter te worden afgestemd; vergelijk hiervoor de verschillen tussen Nederlandse en Duitse regelgeving.

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RADIATION PROTECTION CONTROL ON A FORMER FERRO-NIOBIUM PRODUCTION SITE

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1. Introduction

The airborne gamma survey conducted by the Geological Service of Belgium in the nineties, revealed in the harbour of Ghent a hotspot in thorium window. Based upon current industrial activities no explanation could be given to this increased thorium signal.
In the MIRA-report of 2002[1], it is mentioned that on the location of the hotspot some ferro-niobium production took place in the period 1965-1980 and that some slag was found on the site with resp. Ra-226 and Th-232 specific activities of the order of 4-5 Bq/g and 60-70 Bq/g.
This was confirmed by the current proprietor, who mentioned at the same time that on the site some 6000 tons of excavated material was stored with residues of the former FeNb production starting from pyrochlore.
The proprietor mentioned his intention to characterise the material stored and to send it to an appropriate final storage place.
As the material stored was a mixture of all kind of residues, first of all building debris, wood, iron were separated from the remaining. Secondly the remaining material was put on heaps according to a rough classification upon diameter and the " more active fraction" (18 ton) was stored in 200l drums. The dose-rate at 0,3m from these drums varied between 1 and 7 µSv/h and the Ra-226 (resp.Th-232) specific activity of the selected material varied between 2-12 Bq/g,(resp. 2-62 Bq/g), what is quite in range with the values mentioned in the MIRA-report.

[1] See MIRA/2002/08 at www.milieurapport.be/nl/publicaties/onderzoeksrapporten.

The handling of this excavated material (split up in a more and less active fraction) as well as the detailed investigations done – in close collaboration between FANC and the current operator - on the site of the former FeNb production will be described.

2. Clean-up of the excavated material

2.1 Handling of the more active fraction

As up to now the final destination for residues of former NORM industries with increased content of thorium and radium, is not unequivocally defined, it was decided to evaluate the possibility of transporting the drums to a landfill for dangerous waste (class 1), under the condition that no worker or member of the public get a dosis of more that 1 mSv/y.
Therefore different scenario calculations were made for the workers at former production site (storing the residues in the drums, preparing the material for transport), the workers at the final destination (handling and storing), exposure during transport and exposure of the members of the public living nearby both sites.
In Table 1 the exposure pathways taken into account in the scenario calculations are summarized.

The scenarios calculations did indicate that even under very conservative conditions the incurred dose was never greater than some tenths of a mSv, with the filling of the drums as most critical pathway (0,18 mSv). Therefore from radiological point of view, the final storage at the class 1 landfill seemed fully justified.
As the leaching tests showed that particular attention should be given to barium, the drums were physico-chemically treated (solidification) before final storage.
Due to the relatively high radium and thorium content of the material, transport of the slag is subject to ADR class 7 and the lorry had to be labelled appropriately during the transport to the landfill.

Table 1: Exposure pathways considered in the scenario calculations

Pathway	Workers	Public
Gamma exposure	x	-
Dust inhalation	x	-
Ingestion	x	-
Radon exposure		x
Food intake	-	x
Drinking water	-	x

2.2 Handling of the less active fraction

Initially it was hoped that for the "less active fraction" some application in the building industry (road construction) should be found.
As the barium leaching made a use in the building industry very problematic, it was finally decided to transport also this less active fraction to the same landfill as the so-called "more active fraction".

3. Site investigation

3.1. Mapping

As no historical documents exist as to the formerly used process for FeNb extraction and as the residues may be spread all over the site, the composition of a general GIS map by means of a portable NaI detector coupled to a precise GPS was the first step in the site investigation.
Some areas with significant higher count rate did show up and the 24 "hotspots" (cps> 5xBG) were investigated and documented in detail (see picture 1)

3.2. Depth profiles and groundwater contamination

At different hot spot it was evaluated to what depth radioactive slag is present.
It could be concluded that slag is generally spread in the layer up to -0,75 m and occasionally in the layer -0,75 up to -1,5 m. Below that depth there is no slag present anymore. Drills made at places outside the hotspot areas didn't reveal the presence of slag.

Total alpha groundwater analysis was performed at 19 shallow (-1 to -4 m) and deep (-5 to -8m) locations.
As the results in Table 2 indicate, the total alpha value in the deep groundwater is often above 0,1 Bq/l.
Above this level isotopic analysis is recommended. This will be performed (as well as the total beta determination) in the groundwater measuring campaign that will be repeated in February 2012.

Table 2: Total alpha analysis (Bq/l) of the groundwater

Total alpha	< 0,05	0,05 – 0,1	> 0,1
Shallow	66 %	17 %	17 %
Deep	43 %	10 %	47 %

Picture 1: GIS map of the site with the hotspot areas

3.3 Risk analysis for the critical working areas

Based upon the GIS map with the hotspot areas, the exposure risk analysis was performed under very conservative assumptions for the 3 most critical workplaces (filler of the silo in the raw material hall, supervisor of the transport on the site and sorter of slag material)
The expected annual doses were resp. 0,6, 0,8 and 0,3 mSv. In this analysis the results of the indoor (< 40 Bq/m³) and outdoor (< 10 Bq/m³) radon campaign were taken into account.

4. Conclusions

The gamma mapping of the site and the high specific activity – especially thorium - of the slag samples analysed, indicate clearly that radiological protection measures have to been taken in every future excavation work. Therefore a detailed work scheme has been set up.
Although there is no immediate risk for workers, public and environment due to the presence of the (buried) slag, a systematic clean-up of the site is highly recommendable as long term strategy.