

# Regulations on management of NORM residues in Belgium: lessons and challenges

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# Belgian NORM industries

## Phosphate industry from the 1920s



## Titaniumdioxide production



## Non-ferrous metal



## Groundwater treatment



## Belgian NORM regulations: overview

Belgian NORM regulations => Royal Decree of July, 20 2001

**Art.4** : list “*work activities involving natural radiation sources*”

**Art.9** : industries are submitted to **declaration**

**Objective of declaration:** dose-impact assessment (workers and population)

⇒ if possibility to exceed **1 mSv/a** , **corrective measures** or **licensing**

| Royal Decree 20/07/2001 | GSR – Part 3 |
|-------------------------|--------------|
| Declaration             | Notification |
| Corrective measures     | Registration |
| Authorization           | Licensing    |

# Overview declarations

| Sector  | # declarations | # notification (no corrective measures) | # registration (corrective measures) | # license |
|---|----------------|---|--------------------------------------|-----------|
| <b>Groundwater treatment</b> facilities                                 | 31             | 30                                      | 1                                    | 0         |
| Storage, handling and processing of <b>zircon and zirconia</b>          | 17             | 17                                      | 0                                    | 0         |
| Storage, handling and processing of <b>phosphate ores</b>               | 10             | 1                                       | 8                                    | 1         |
| Production of <b>non-ferrous metals</b>                                 | 10             | 7                                       | 3                                    | 0         |
| <b>processing, valorization and recycling of NORM residues</b>          | 8              | 0                                       | 8                                    | 0         |
| Production, storage, use and handling of <b>thorium-based materials</b> | 6              | 2                                       | 4                                    | 0         |
| Extraction and transport of <b>natural gas</b> and <b>shale-gas</b>     | 2              | 0                                       | 2                                    | 0         |
| <b>Oil refineries</b>   | 2              | 0                                       | 2                                    | 0         |
| <b>Geothermal energy</b> – including exploration phase                  | 4              | 3                                       | 1                                    | 0         |
| <b>Titaniumdioxide</b> production                                       | 1              | 0                                       | 1                                    | 0         |
| Primary production of <b>rare earths</b>                                | 1              | 0                                       | 1                                    | 0         |
| <b>Coal-fired</b> power plant   | 1              | 0                                       | 1                                    | 0         |
| Distribution of <b>consumer products</b> with AC > RP 122 II            | 2              | 2                                       | 0                                    | 0         |
| Primary <b>iron</b> production  | 1              | 0                                       | 1                                    | 0         |
| <b>TOTAL</b>  | <b>96</b>      | <b>62</b>                               | <b>33</b>                            | <b>1</b>  |

| Corrective measures apply to : | Occupational exposure | discharges | Residue management |
|--------------------------------|-----------------------|------------|--------------------|
|                                | 25                    | 10         | 31                 |

# Generic clearance levels for NORM residues

⇒ Use of clearance/exemption levels of EC document “Radiation Protection 122 II”

Derived from a dose criterion of **0.3 mSv/a**

| Radionuclide              | Clearance/exemption levels (Bq/g) |
|---------------------------|-----------------------------------|
| U-238sec (incl. U-235sec) | 0.5                               |
|                           | 0.1 (mono-landfill)               |
| U nat                     | 5                                 |
| Th-230                    | 10                                |
| Ra-226+                   | 0.5                               |
|                           | 0.1 (mono-landfill)               |
| Pb-210+                   | 5                                 |
| Po-210                    | 5                                 |
| Th-232sec                 | 0.5                               |
|                           | 0.1 (mono-landfill)               |
| Th-232                    | 5                                 |
| Ra-228+                   | 1                                 |
| Th-228+                   | 0.5                               |
| K-40                      | 5                                 |

If **AC < clearance**: no additional constraints for residue management (**exception**: mono-landfill):  
clearance from further surveillance

If **AC > clearance**: follow-up necessary

⇒ NORM residues treatment facilities must notify FANC

⇒ **Acceptance criteria** in function of type of treatment

## Acceptance criteria: reference values

| Tye of treatment                          | Activity concentration              |   |   |
|---|-------------------------------------|---|---|
|   | Input<br>(single batch of residues) | Output<br>(after processing)                  |   |
| Landfill for hazardous waste              | $C_{\text{exemption}}$              | RP 122 II                                     | $C_{\text{average}} < 0.2 \text{ Bq/g}$ |
|   | $C_{\text{max}}$                    | 50 Bq/g                                       |   |
| Landfill for non hazardous or inert waste | $C_{\text{exemption}}$              | RP 122 II                                     | $C_{\text{average}} < 0.2 \text{ Bq/g}$ |
|   | $C_{\text{max}}$                    | 10 Bq/g                                       |   |
| Mono-landfill                             |                                     | $< 0.1 \text{ Bq/g}$ : no restrictions        |   |
|   |                                     | $> 0.1 \text{ Bq/g}$ : site-specific approach |   |

## Current situation

⇒ **2019: 11** sites authorized for disposal of NORM residues

6 “mono-landfill” (4 related to phosphate industry, 1 titaniumdioxide, 1 non ferrous)

2 landfills for hazardous waste

1 landfill for non-hazardous waste

1 incinerator for hazardous waste

1 facility for pre-treatment of hazardous waste

⇒ Environmental monitoring

⇒ Inventories of NORM – record-keeping

### Quantities:

|                                       |   |
|---------------------------------------|---|
| Phosphate 1 (PG stack)                | 110 000 m <sup>3</sup> /yr – capacity 7 560 000 m <sup>3</sup>                                |
| Phosphate 2 (CaF <sub>2</sub> sludge) | 2012-2017 : 337 000 m <sup>3</sup> from remediation<br>(capacity : 2 400 000 m <sup>3</sup> ) |
| Phosphate 3 (remediation material)    | Capacity : ~ 1 500 000 m <sup>3</sup>   |
| Phosphate 4 (PG stack)                | (2013 – 2017) 139 254 m <sup>3</sup>  |
| TiO <sub>2</sub> landfill             | 40 000 ton/yr filtercake (capacity ~ 900 000 ton)   |
| Non ferrous metal production          | Capacity 550 000 m <sup>3</sup>   |
| Landfills                             | (2013 – 2017) 1479 tons   |

# NORM residue management: inspection campaign

**2018**: FANC inspection campaign in most of NORM residues facilities

## Objectives:

- verification and discussion NORM inventory
- identification of key-points and caveats
- operational difficulties
- discussion results environmental monitoring

## Environmental monitoring

- ⇒ **Measurements on leachate and groundwater**
- ⇒ **Measurements on fly and bottom ashes from incineration**

## Main conclusion:

- ⇒ impact of NORM disposal sites on groundwater/leachate not significantly different from “ordinary” landfills



# NORM residue management: operational caveats

## 1) Difficult for operator to correctly interpret analysis reports !

License condition:  
 $U-238_{sec} + Th-232_{sec} < 50 \text{ Bq/g}$

| Your Sample ID | Nuclide            | Activity | Unc | Unit   |
|----------------|--------------------|----------|-----|--------|
| }              | <sup>40</sup> K    | < 23     |     | Bq/ kg |
| }              | <sup>208</sup> Tl  | < 1.4    |     | Bq/ kg |
| }              | <sup>212</sup> Bi  | < 16     |     | Bq/ kg |
| }              | <sup>212</sup> Pb  | < 2.4    |     | Bq/ kg |
| }              | <sup>214</sup> Bi  | 8        | 4   | Bq/ kg |
| }              | <sup>214</sup> Pb  | 10.7     | 1.8 | Bq/ kg |
| }              | <sup>228</sup> Ac  | < 6      |     | Bq/ kg |
| }              | <sup>234m</sup> Pa | < 140    |     | Bq/ kg |
| }              | <sup>234</sup> Th  | < 31     |     | Bq/ kg |
| }              | <sup>238</sup> U*  | < 31     |     | Bq/ kg |
| }              | <sup>226</sup> Ra* | 9.4      | 2.2 | Bq/ kg |
| }              | <sup>228</sup> Ra* | < 6      |     | Bq/ kg |
| }              | <sup>228</sup> Th* | < 2.4    |     | Bq/ kg |
| }              | <sup>232</sup> Th* | < 6      |     | Bq/ kg |

| Méthode        | Analyse | Date de référence | Date de mesure | Résultat (Incert, 2s) | Unité |
|----------------|---------|-------------------|----------------|-----------------------|-------|
| SEM.M0062 (a)  | Bi-7    | 05/10/2018        | 11/10/2018     | < 1.79E-02            | Bq/g  |
| SEM.M0062 (a)  | K-40    | 05/10/2018        | 11/10/2018     | 4.72E-01 ± 1.07E-01   | Bq/g  |
| SEM.M0062 (a)  | Mn-54   | 05/10/2018        | 11/10/2018     | < 2.02E-03            | Bq/g  |
| SEM.M0062 (a)  | Co-57   | 05/10/2018        | 11/10/2018     | < 2.17E-03            | Bq/g  |
| SEM.M0062 (a)  | Co-58   | 05/10/2018        | 11/10/2018     | < 2.01E-03            | Bq/g  |
| SEM.M0062 (a)  | Fe-59   | 05/10/2018        | 11/10/2018     | < 4.22E-03            | Bq/g  |
| SEM.M0062 (a)  | Co-60   | 05/10/2018        | 11/10/2018     | < 2.09E-03            | Bq/g  |
| SEM.M0062 (a)  | Zn-65   | 05/10/2018        | 11/10/2018     | < 5.12E-03            | Bq/g  |
| SEM.M0062 (a)  | Nb-95   | 05/10/2018        | 11/10/2018     | < 3.65E-01            | Bq/g  |
| SEM.M0062 (a)  | Zr-95   | 05/10/2018        | 11/10/2018     | < 3.75E-03            | Bq/g  |
| SEM.M0062 (a)  | Ru-103  | 05/10/2018        | 11/10/2018     | < 2.10E-03            | Bq/g  |
| SEM.M0062 (a)  | Ru-106  | 05/10/2018        | 11/10/2018     | < 1.81E-02            | Bq/g  |
| SEM.M0062 (a)  | Ag-110m | 05/10/2018        | 11/10/2018     | < 3.31E-03            | Bq/g  |
| SEM.M0062 (a)  | Sb-124  | 05/10/2018        | 11/10/2018     | < 2.38E-03            | Bq/g  |
| SEM.M0062 (a)  | Sb-125  | 05/10/2018        | 11/10/2018     | < 6.20E-03            | Bq/g  |
| SEM.M0062 (a)  | I-131   | 05/10/2018        | 11/10/2018     | < 3.56E-03            | Bq/g  |
| SEM.M0062 (a)  | Ba-133  | 05/10/2018        | 11/10/2018     | < 2.83E-03            | Bq/g  |
| SEM.M0062 (a)  | Cs-134  | 05/10/2018        | 11/10/2018     | 2.33E-03 ± 8.93E-04   | Bq/g  |
| SEM.M0062 (a)  | Cs-137  | 05/10/2018        | 11/10/2018     | 2.55E-02 ± 3.29E-03   | Bq/g  |
| SEM.M0062 (a)  | Ce-141  | 05/10/2018        | 11/10/2018     | < 4.35E-03            | Bq/g  |
| SEM.M0062 (a)  | Ce-144  | 05/10/2018        | 11/10/2018     | < 1.63E-02            | Bq/g  |
| SEM.M0062 (na) | Pb-210  | 05/10/2018        | 11/10/2018     | 1.37E+01 ± 4.27E+00   | Bq/g  |
| SEM.M00778 (a) | Po-210  | 05/10/2018        | 17/10/2018     | 3.88E+01 ± 6.61E+00   | Bq/g  |
| SEM.M0062 (a)  | Ra-228  | 05/10/2018        | 11/10/2018     | 8.25E-03 ± 4.78E-03   | Bq/g  |
| SEM.M0062 (a)  | Th-228  | 05/10/2018        | 11/10/2018     | < 4.96E-03            | Bq/g  |
| SEM.M0062 (a)  | U-235   | 05/10/2018        | 11/10/2018     | < 1.65E-02            | Bq/g  |
| SEM.M0062 (a)  | U-238EQ | 05/10/2018        | 11/10/2018     | < 4.86E-02            | Bq/g  |
| SEM.M0062 (a)  | Am-241  | 05/10/2018        | 11/10/2018     | < 1.18E-02            | Bq/g  |

## 2) How to deal with *marginal quantities* of NORM (e.g. from scrap yards) ?

=> Either exemption or collection through authorised companies

## 3) **Conflicting** *authorisation schemes* for radiation protection and environmental authorities (e.g. transportation ADR-7)

# NORM residue management: caveats

4) *Specific exemption or acceptance criterias* when U-238 or Th-232 **not in secular equilibrium** (e.g. case of Pb-210/Po-210)

5) How to deal with ***liquid*** NORM waste ?  
⇒ Definition of exemption levels for liquids

⇒ which *acceptance criterias* ?

| Nuclide | Exemption level (Bq/l) |
|---------|------------------------|
| U-238   | 22                     |
| Ra-226  | 3,6                    |
| Pb-210  | 1,4                    |
| Po-210  | 0,8                    |
| Ra-228  | 1,4                    |

6) *Reluctance of acceptance* of NORM waste for ***incineration***

# Conclusions

1) Importance of **graded-approach** => **NORM** ≠ radioactive waste

⇒ Belgian National report on the implementation of Council Directive **2011/70/Euratom**  
“...**NORM substances are currently managed according to the provisions of the environmental protection framework,...** with appropriate control of the radiological risks by FANC”

2) NORM inventory is dynamic ...

Up to 2010 : NORM essentially **production** waste  
Currently : NORM essentially **remediation** waste



2010



2014



3) NORM regulations are worth it but **humility and dialogue** needed

⇒ they achieve results when they are part of integral approach to H&S / environmental management