



EU-project TENORMHARM

Contract-No. FIGM-CT-2001-00174

“New approach to assessment and reduction of health risk and environmental impact originating from TENORM according to requirements of EU directive 96/29”

Deliverable No. 5

## **2.2. Dose assessment related to workers and members of the public according to the type of industry**

[Nature: Re; Dissemination level: PU]

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## **Deliverable No. 5**

Compilation and ranking of exposure to workers and members  
of the public by type of industry

[Nature: Re; Dissemination level: PU]

Prepared by

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## **1. Compilation and ranking of exposure to workers and members of the public by type of industry**

### **1.1 Introduction**

In general, a ranking of exposure scenarios can be undertaken in different ways by using different parameters. The ranking presented in this study is guided by three parameters as follows:

1. max. activity concentration
2. effective dose rate
3. amount of persons affected (workers and members of the public),

The max. activity concentration is ranked on the basis of the very first national report deliverable No. 1 “1.1 German national report to levels and inventory of TENORM” by LEOPOLD et al. (2002). This means that all relevant types of German TENORM-industries are taken into account, whereas the effective dose ranking is mainly focused on the special calculations done for the deliverable 2, especially in the summary “Comparison of exposure scenarios used by contractors to scenarios described in Radiation Protection 107” (MICHALIK & WEISS, 2003), “2.1 National report to radiation risk assessment” (LEOPOLD, 2003) and (WEISS, 2003) concerning the radiation hazards resulting from coal mining and oil & gas extraction. The third one should be taken just as a clue due to no detailed information about exact numbers of employees by category.

### **1.2 Ranking by max. activity concentrations**

The German ranking of TENORM guided by max. activity concentrations (table 1) is dominated by rare earth elements (REE) processing and the thorium compound manufacturing due to radionuclide concentrations exceeding the 1,000,000 Bq/kg limit. But the number of workers of these two industries is very low in comparison to the third type, the gas and oil extraction employing many hundreds of workers. Concerning the iron and steel processing the German National Report (Deliverable 1) contained Pb-210 concentrations up to 200,000 Bq/kg which were reported for Great-Britain and The Netherlands, because no data for Germany had been available at that time. New information provided by the German iron & steel industry indicate a maximum Pb-210 concentration of 8,500 Bq/kg in dust from blast furnaces. An extra attention to be paid for is the Mansfeld area in the Eastern part of Germany, where copper slag is heaped up containing Ra-226 concentrations up to 2,000 Bq/kg as well as the so called Theisenschlamm, which shows Pb-210 concentrations of 8,000 Bq/kg. And last but not least, waterworks and mineral water plants can sometimes be affected by enhanced radionuclide concentrations in the residuals from water treatment depending on the geological underground the water is extracted from. Water treatment sludge from a waterwork situated in Kassel contained 7,500 Bq/kg Ra-226 due to young igneous rocks, while 14,500 Bq/kg Ra-228 were measured in a manganese dioxide filter of a mineral water facility.

Table 1: Ranking of German TENORM guided by max. activity concentrations.

Ranking	Type of industry	Kind of material	Max. activity concentration
1.	Rare earth elements processing	Radiobarite (by-product)	3,150,000 Bq/kg Ra-226 450,000 Bq/kg Ra-228
		Monazite as raw material	3,000,000 Bq/kg Th-232 40,000 Bq/kg U-238
2.	Manufacture of thorium compounds	Gas mantles	1,000,000 Bq/kg Th-232 1,000,000 Bq/kg Th-228
		Thoriated tungsten welding electrodes	100,000 Bq/kg Th-232 100,000 Bq/kg Th-228
		Alloys	70,000 Bq/kg Th-232
3.	Oil- and gas exploitation	Natural gas scales	1,000,000 Bq/kg Ra-226 360,000 Bq/kg Ra-228 320,000 Bq/kg Pb-210 205,000 Bq/kg Th-228
		Crude oil scales	390,000 Bq/kg Ra-228 300,000 Bq/kg Ra-226 230,000 Bq/kg Pb-210 200,000 Bq/kg Th-228
		Natural gas deposits	70,000 Bq/kg Pb-210 7,400 Bq/kg Ra-226 5,900 Bq/kg Ra-228
4.	Processing of zirconium sands	Fume of arc furnaces	500,000 Bq/kg Pb-210
		Residues of chlorinating process	50,000 Bq/kg undifferentiated
		Zircon-based refractory material	30,000 Bq/kg U-238-decay-chain
5.	Coal mining	Sediments/crusts from mining	56,000 Bq/kg Ra-226
		Pit water	12,000 Bq/l Ra-226
		Flood plain soils affected by pit water discharge (radiobarite)	32,000 Bq/kg Ra-226 6,500 Bq/kg Ra-228
		Fly-ash of dry combustion	1,950 Bq/kg U-238-decay-chain 1,150 Bq/kg Th-232-decay-chain
		Furnace chamber combustion	1,100 Bq/kg U-238-decay-chain 755 Bq/kg Th-232-decay-chain
		Ashes from fluidised bed combustion	960 Bq/kg U-238-decay-chain 730 Bq/kg Th-232-decay-chain
6.	Processing of niobium	Columbit as raw material	30,000 Bq/kg U-238-decay-chain 10,000 Bq/kg Th-232-decay-chain
		Tin slag as starting substance	7,000-20,000 Bq/kg undifferentiated
7.	Processing of tin	Tin melting slag	15,000 Bq/kg Th-232 (dry matter) 5,500 Bq/kg Ra-226 (dry matter)
		Smelting slag	15,000 Bq/kg Th-232 (dry matter) 5,500 Bq/kg Ra-226 (dry matter)
		Tin slag	1,100 Bq/kg Ra-226 (dry matter)

<b>8.</b>	<b>Iron &amp; steel industry</b>	Fume of blast furnace	8,500 Bq/kg Pb-210 (dry matter)
<b>9.</b>	<b>Phosphate industry</b>	Phosphorite	1,700 Bq/kg Ra-226
		Phosphogypsum	1,000 Bq/kg Ra-226
		Fertiliser	2,300 Bq/kg U-238-decay-chain

### 1.3 Ranking by effective dose rates

According to the very poor data-set of effective doses, the ranking of German TENORM guided by effective dose rates mainly concerns the environmental impact caused by hard coal mining (table 2), which means in detail flood plain soils are affected by pit water discharge. This scenario can be separated into two exposure pathways: on the one hand the external exposure and on the other the factor of ingestion especially concerning playing children. Both are divided into a likely (50h/a) and unlikely (400h/a) exposure time, whereas the latter is further split due to the children's age as an important factor for the amount of ingested soil material. The ranking displays the highest effective dose rates are provided by Ra-228 in flood affected plain soils for the youngest children.

For the oil & gas industry some scenarios (s. summary of Deliverable 2) were considered which may lead to an enhanced exposure of workers only. The local population is not influenced by these activities.

Table 2: Ranking of German TENORM guided by max. effective dose rates, separated into members of the public and workers.

Ranking	Scenario	Exposure pathway	Effective dose
<b>Members of the public</b>	<b>1. Flood plain soils affected by pit water discharge</b>	Ingestion, unlikely situation, children's age given as indices (exposure time: 400h/a; ingested soil amount: 200 mg/d; duration of stay: 240 d/a)	Ra-228 <sub>2-7</sub> : max. 15.5 mSv/a Ra-226 <sub>2-7</sub> : max 12.28 mSv/a Ra-228 <sub>7-12</sub> : max. 10.2 mSv/a Ra-226 <sub>7-12</sub> : max. 8.1 mSv/a Ra-228 <sub>12-17</sub> : max. 7.7 mSv/a Ra-226 <sub>12-17</sub> : max. 6.1 mSv/a Ra-228 <sub>ad</sub> : max. 4.35 mSv/a Ra-226 <sub>ad</sub> : max. 3.07 mSv/a
		External exposure, unlikely situation (400h/a)	max. 2.4 mSv/a
		Ingestion, likely situation, children's age given as indices (exposure time: 50h/a; ingested soil amount: 40 mg/d; duration of stay: 48 d/a)	Ra-228 <sub>2-7</sub> : max. 0.62 mSv/a Ra-226 <sub>2-7</sub> : max. 0.49 mSv/a Ra-228 <sub>7-12</sub> : max. 0.41 mSv/a Ra-226 <sub>7-12</sub> : max. 0.32 mSv/a Ra-228 <sub>12-17</sub> : max. 0.31 mSv/a Ra-226 <sub>12-17</sub> : max. 0.24 mSv/a Ra-228 <sub>ad</sub> : max. 0.17 mSv/a Ra-226 <sub>ad</sub> : max. 0.12 mSv/a
		External exposure, likely situation (50h/a)	max. 0.3 mSv/a
<b>Workers</b>	<b>1. Oil &amp; gas industry</b>	Cutting of pipes by wet sawing or punching, external exposure (500 h/a)	max. 1.5 mSv/a
	<b>2. Oil &amp; gas industry</b>	Work at drilling platform or pipe storage site, external exposure (400 h/a)	max. 1.2 mSv/a
	<b>3. Oil &amp; gas industry</b>	Removal of scales with high pressure water jet, external exposure and inhalation of dust (500 h/a)	max. 0.7 mSv/a
	<b>4. Oil &amp; gas industry</b>	Disposal of scrap, interim storage in warehouse, external exposure and radon-inhalation (2,000 h/a)	max. 0.6 mSv/yr
	<b>5. Oil &amp; gas industry</b>	Disposal of scrap, underground storage gallerye, external exposure and radon-inhalation (2,000 h/a)	max. 0.4 mSv/yr
	<b>6. Manufacture and use of thorium compounds</b>	Persons being intensively occupied with welding thorium electrodes	0.14 mSv/a
	<b>7. Phosphate industry</b>	Fertiliser application	0.002 mSv/a

### 1.4 Ranking by amount of persons affected

The ranking of German TENORM according to the number of workers / members of the public affected by enhanced radionuclide concentrations is mainly based on publications by the Federal Statistical Agency (2002), individual annual reports, some specific industry associations or general information from some official homepages. The author feels also forced to point out that not all persons mentioned in table 3 are affected, especially since the quantities must be regarded as the total amount of people working in that category or living in the area concerned. It should be rather taken as a clue to be able to estimate the potential hazard dimensions. The companies without a ranking position can not be searched for an exact number of employees by category, but they are too important to be neglected.

**Table 3:** Ranking of German TENORM guided by amount of persons affected, separated into members of the public and workers.

Ranking	Type of industry	Kind of material	Amount of persons affected
<b>Members of the Public</b>	<b>1.</b>	<b>Pit waters discharged in rivers/tributaries</b>	Sediments and soils along the river Lippe and its tributaries Marl: 93,256 inhabitants (2003) Dorsten: 81,063 inhabitants (2003) Wesel: 62,063 inhabitants (2003) $\Sigma$ inhabitants along river Lippe: <b>236,382</b> [ <a href="http://www.meinestadt.de">http://www.meinestadt.de</a> ]
	<b>2.</b>	<b>Copper processing</b>	Slag and Theisenschlamm heaped up near Mansfeld Mansfeld: 3.754 inhabitants (2003) [ <a href="http://www.meinestadt.de/mansfeld-suedharz/home">http://www.meinestadt.de/mansfeld-suedharz/home</a> ]
<b>Workers</b>	<b>1.</b>	<b>Coal mining</b>	Sediments/crusts 47,000 (2001) [ <a href="#">RAG, 2002</a> ]
	<b>2.</b>	<b>Iron and steel</b>	by-products (Pb-210 up to 200,000 Bq/kg) 30,185 in 247 companies (2002) [Economy metal union, 2003]
	<b>3.</b>	<b>Oil-/gas exploitation, installation, maintenance</b>	Scales in pipelines and installations 5,186 in 44 companies (Sept. 2000) [ <a href="#">Federal Statistical Office, 2002</a> ]
			Removal of scales 4 (2 per shift) at one high pressure water jet device
<b>-</b>	<b>Rare earth elements (REE) processing</b>	Raw materials, precipitated by-products (radiobarite) 12 (2 per shift, interim storage and underground gallery, each)	
			1. <a href="#">Rhodia GmbH</a> Staedelstrasse 10, D-60596 Frankfurt/Main; 2. <a href="#">Wagener, E., GmbH</a> Kauslerweg 3A, D-70567 Stuttgart; 3. a.m.p.e.r.e. GmbH D-60598 Frankfurt; [ <a href="http://web.wlwonline.de">http://web.wlwonline.de</a> ]

	-	<b>Thorium compounds</b>	Manufacture of gas mantles and thoriated welding electrodes; Removal/disposal of Thorium-containing residues	<ol style="list-style-type: none"> <li>1. <a href="#">Gesellschaft für Wolfram Industrie mbH</a>, Permanederstr 34, D-83278 Traunstein;</li> <li>2. <a href="#">MSA AUER GmbH</a>, Thiemannstrasse 1, D-12059 Berlin;</li> <li>3. <a href="#">AEA Technology QSA GmbH</a>, Gieselweg 1, D-38110 Braunschweig; [<a href="http://web.wlwoonline.de">http://web.wlwoonline.de</a>]</li> </ol>
<b>Ranking</b>		<b>Type of industry</b>	<b>Kind of material</b>	<b>Amount of persons affected</b>
<b>Workers</b>	-	<b>Zirconium sands</b>	Grinding plants milling zirconium sands, producing fused zirconia mullite for refractories	<ol style="list-style-type: none"> <li>1. &lt;588 employees [annual report 2002] in <a href="#">Possehl Erzkontor</a>, Beckergrube 38-52, D-23552 Lübeck;</li> <li>2. <a href="#">Mineralmühle Leun, Rau GmbH &amp; Co. KG</a>, Braunfelser Straße 8-12, D-35638 Leun;</li> <li>3. <a href="#">Treibacher Schleifmittel Zschornowitz GmbH &amp; Co KG</a>, Burgkemnitzer Str. 17, D-06791 Zschornowitz [<a href="http://web.wlwoonline.de">http://web.wlwoonline.de</a>]</li> </ol>

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