

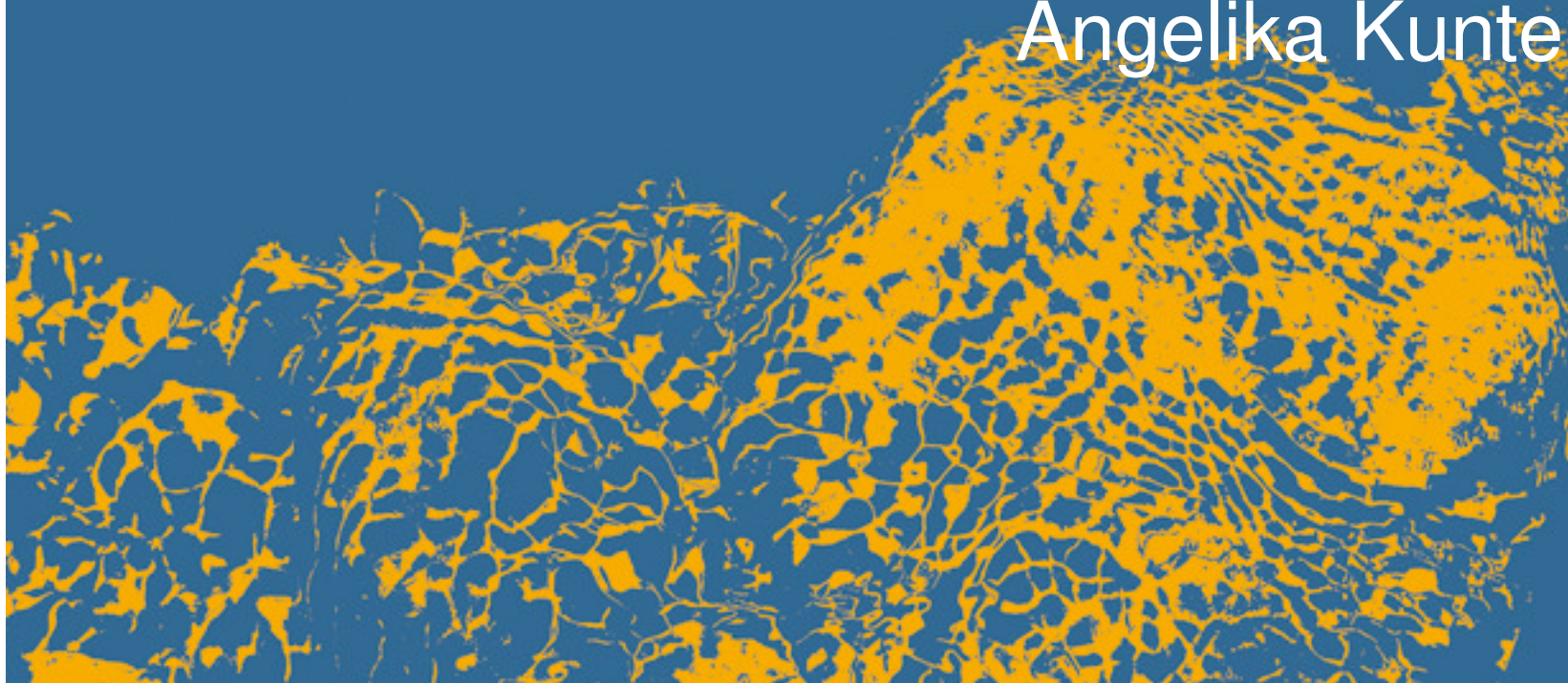


Bayerisches Landesamt für
Umwelt



The use of zircon and zirconia in Bavaria and related exposure situations

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Overview

- **Introduction**
- Applied Methods
- Results
- Conclusions



Regulation for NORM in Germany

German radiation protection ordinance

- Part 3 § § 97 – 102 regulates the protection of the public from NORM.
- Annex XII, Part A : Positive List that contains residues that have to be monitored
- NORM materials that are not listed in Part A can be regulated according to § 102: authorities can order appropriate action for other NORM if the effective dose is „significant“ (according to § 97: > 1 mSv/a)
- Currently Zircon and Zirconia are not included in the positive list – but according to the EU BSS draft it will be added in the near future
- Inclusion in the german „positive list“ is currently discussed.

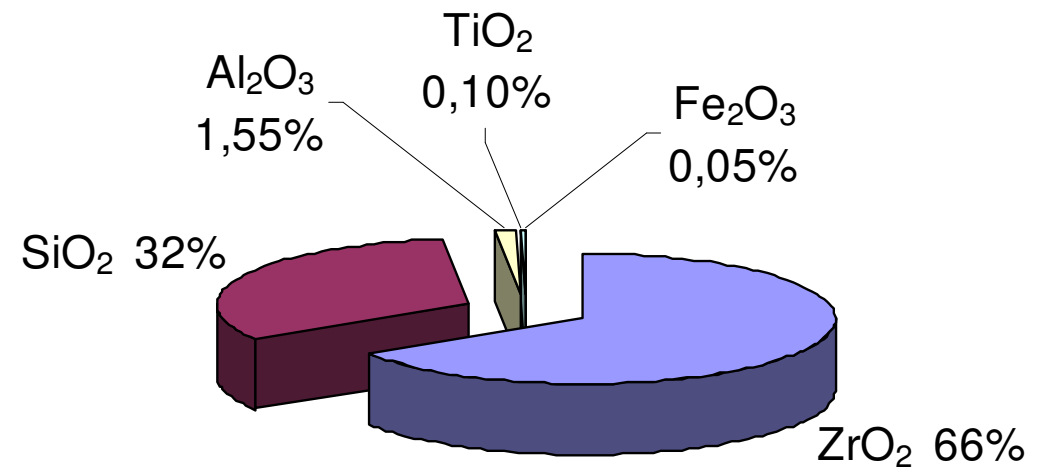
It's important to distinguish:

- **Zircon $ZrSiO_4$** : occurs as a an accessory mineral of igneous rocks or in secondary deposits, Mining: ~ 1 Mio. t / a; mainly in Australia, South Africa, USA
- **Zirconium Zr-40**: chemical Element, metal made out of zircon
- **Zirconium oxide ZrO_2** :
 - Naturally occurring: **baddeleyit** – nowadays only mined in Russia
 - Artificially produced out of zircon: **zirconia**

Material properties of zircon ZrSiO_4

- Density: 4200–4800 kg/m³
- Melting point: ~3000°
- Refraction index: 1.80–1.98
- Hardness: 6,5 – 7,75 mohs
- Particle size: 110-130 μm

Typical consistence of zircon sand



Material properties of zirconia ZrO_2

- excellent tribological properties
- outstanding stability
- very low thermal conductivity
- high resistance to corrosion
- high abrasion resistance
- very high fracture toughness
- high thermal expansion
- Depending on consistence good oxygen ionic conductivity
- very high surface quality



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Industries that have been contacted in Bavaria:



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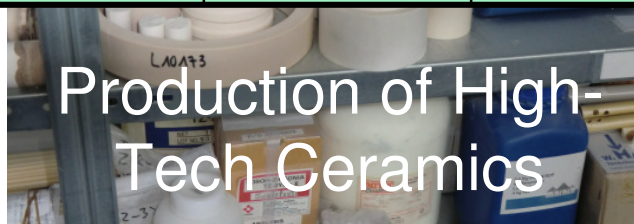


Foundries

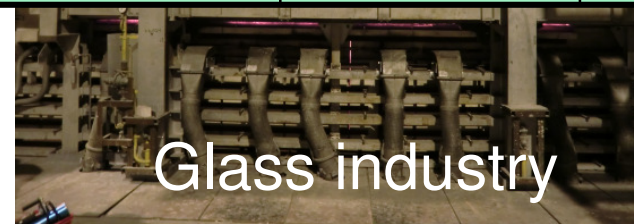


Refractories

	# cont. industries	# that use Zircon	# samples analyzed	# industries visited	# exposure exam.
Foundries	82	24	17	4	15
Refractories	33	5	1	0	0
Glass prod.	90	17	1	1	2
Ceramics	71	24	32	6	8
Total	276	70	51	11	25



Production of High-Tech Ceramics



Glass industry

Approach :

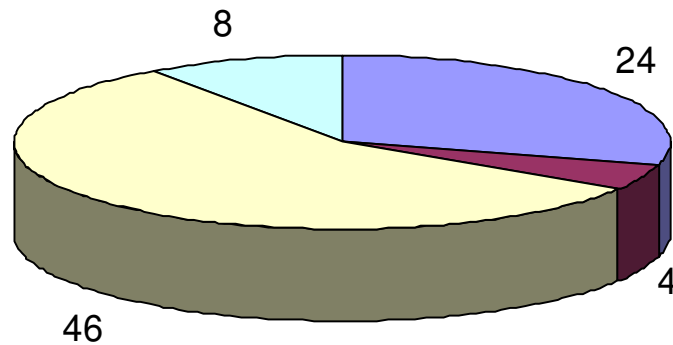
- Relevant local dose rates (ODL)
 - storage areas of NORM
 - at workplaces
- Relevant samples of NORM: raw materials, residues, final products, intermediate products, waste materials
- Dust samples
- Standardized questionnaire
- Measurement report
- Photo documentation
- Gamma analysis
- Dose estimations



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Use of zircon or zirconia in foundries in Bavaria

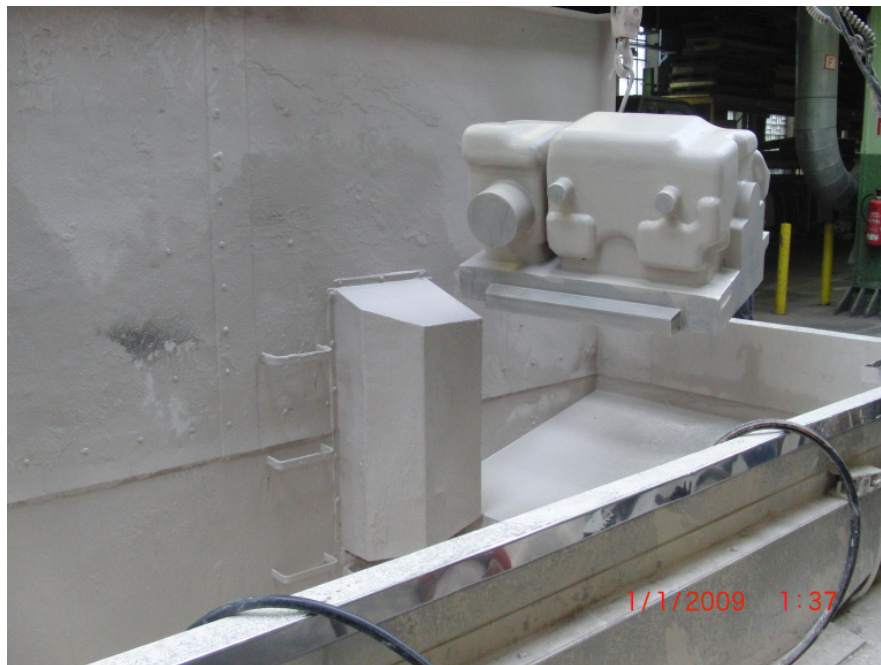


- Zircon is not in use
- Zircon is in use
- Company is insolvent
- No answer received

70 % iron castings

- Facings containing zircon (15)
- Some refractories are used for the lining of melting furnaces (3)
- Zircon sand for casting moulds (3)
- Others (6)

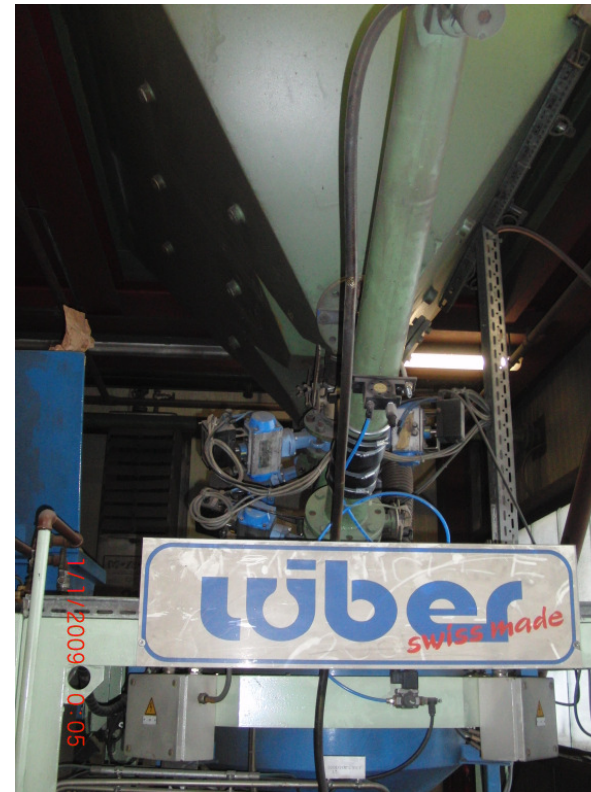
**Exposure situation 1: Sprinkling of a mould or plunging it into a basin containing the facing:
exposure time: 2 h / day (equals 500 h / year)
dose rate: 0,3 μ Sv/h**



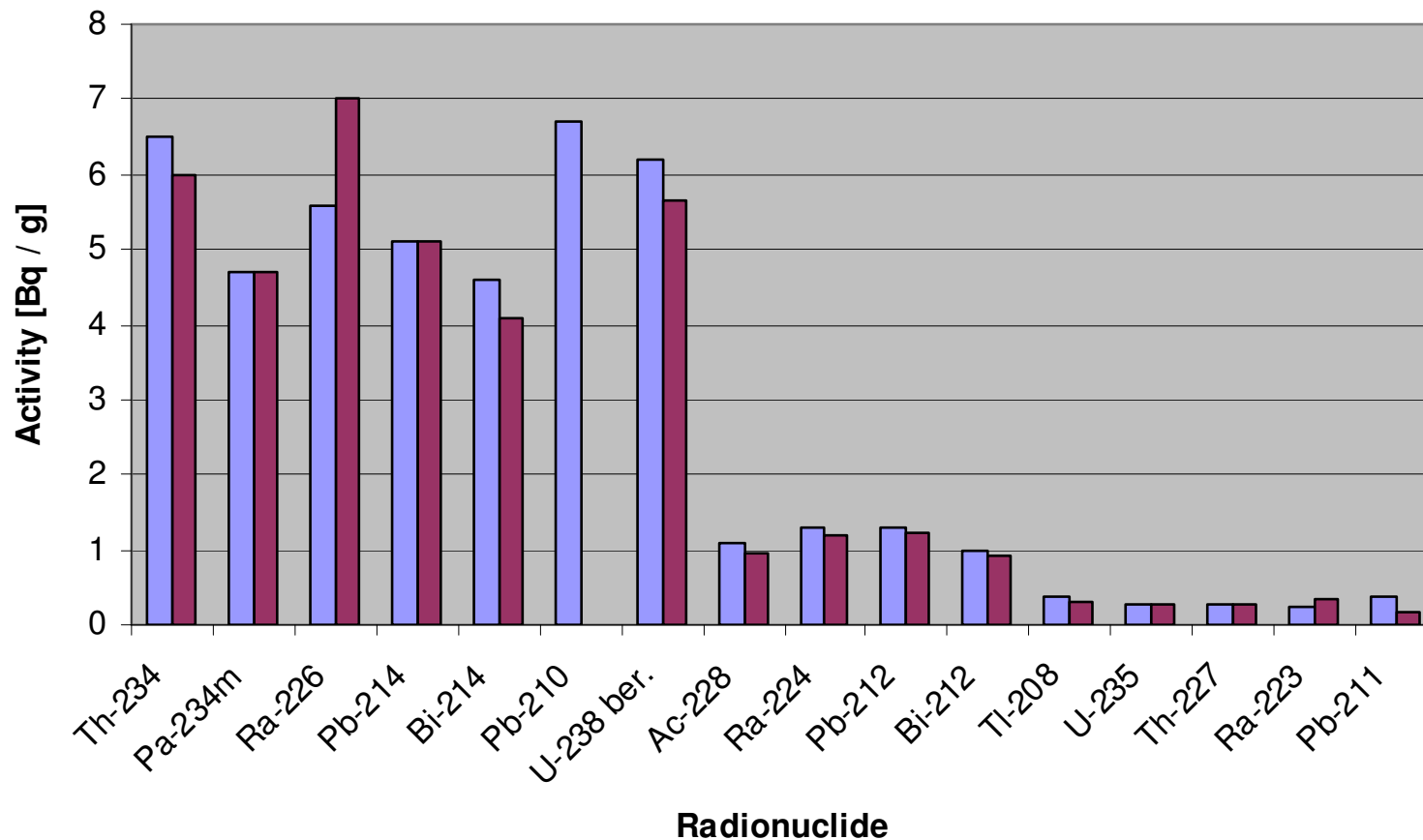
Exposure situation 2: Filling the zirconsand into the mixing equipment:

exposure time: 10 min/day (equals approx. 42 h / year)

dose rate: 0,5 μ Sv/h



Comparison of specific activities of zircon sand used in foundries



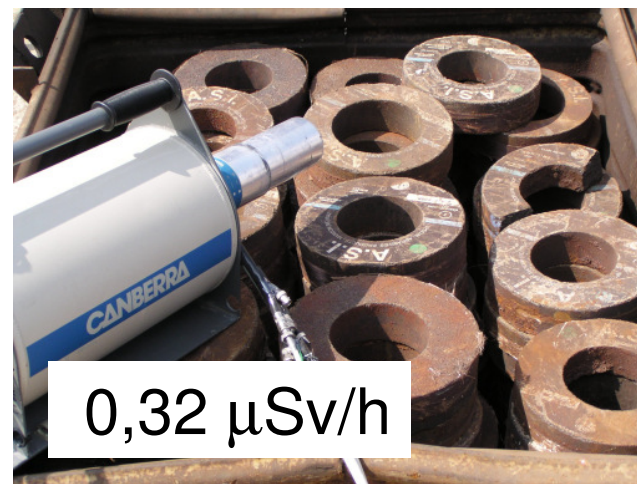
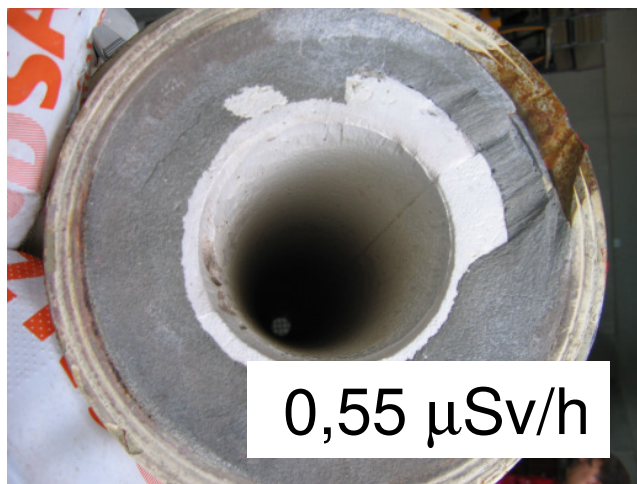
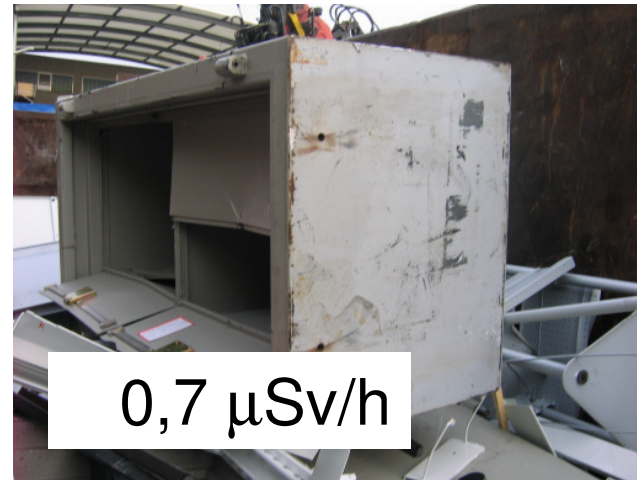
**Exposure situation 3: Occasional stays next to the storage area of the zircon sand line-up or passing by:
exposure time: 6 min / day (equals 25 h / year)
dose rate: 2,3 μ Sv/h**



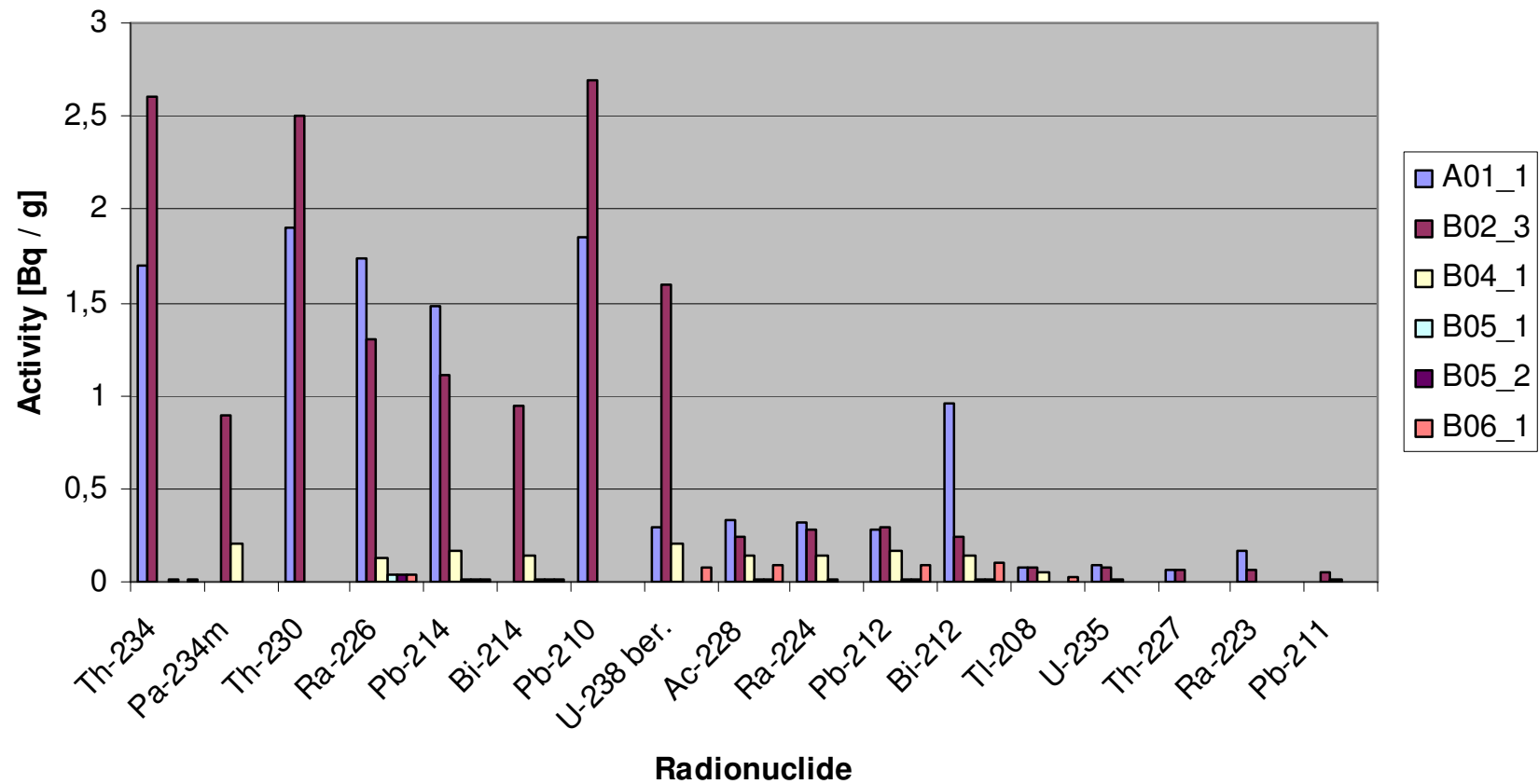
Conservative dose estimation for a worker in a foundry

	Exp.sit.1: Facing	Exp.sit.2: Zircon sand	Exp.sit.3: Storage area
Exposure time [h/a]	500	42	25
Dust concentration [g/m ³]	0,001	0,006	0,001
Rate of inhalation [m ³ /h]	0,93	0,93	0,93
Ingestion [g/h]	0,001	0,006	0,001
Dose rate [μSv/h]	0,3	0,5	2,3
Dose [mSv/a]	0,191	0,043	0,058
Effective dose [mSv/a]	0,292		

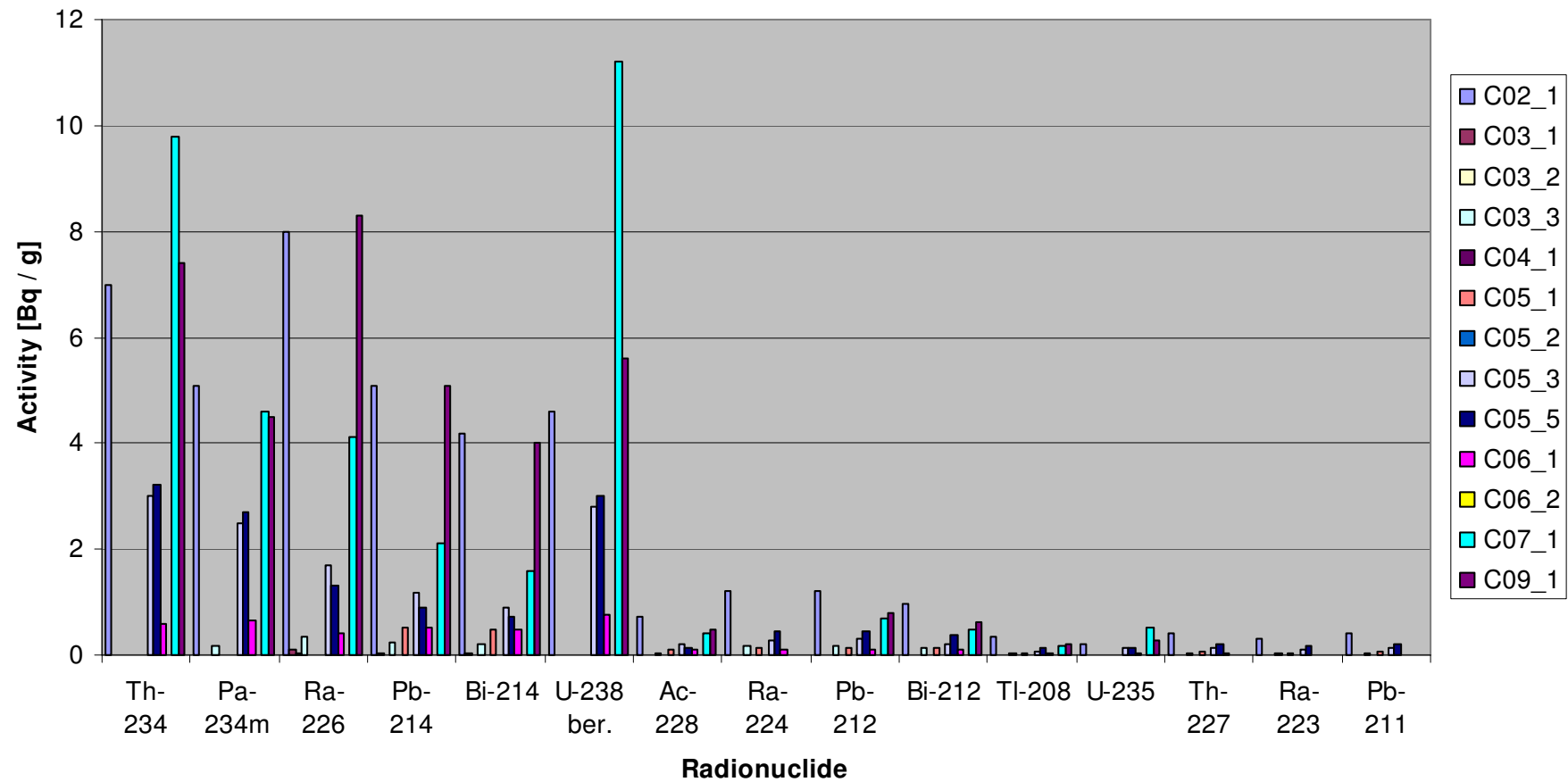
Problems concerning the disposal of products containing zircon or zirconia at scrap metal yards



Zircon containing residues out of melting furnaces



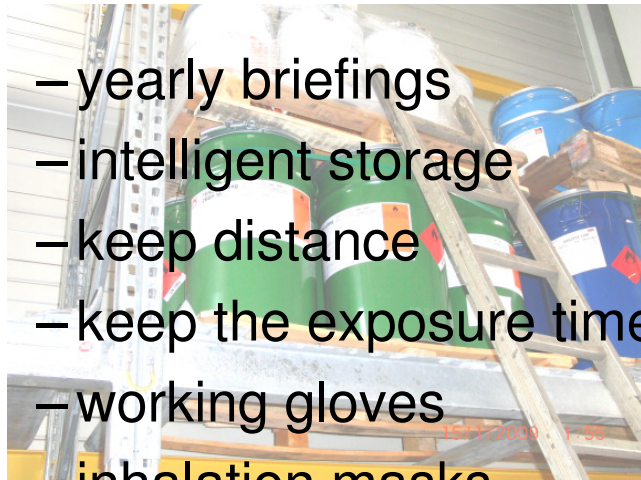
Specific activities of different kinds of zirconia powder



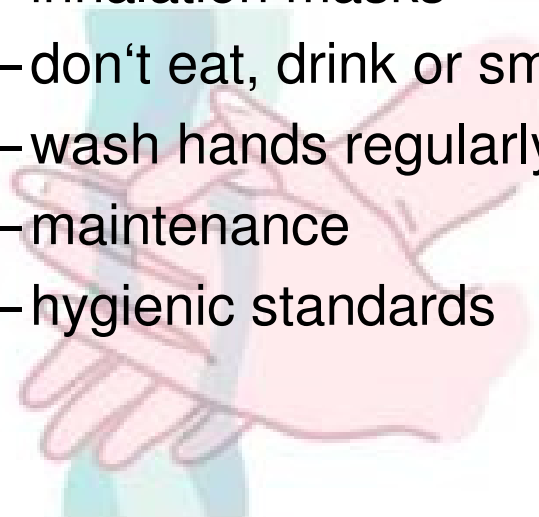
Summary of the results

	# samples analyzed	Max. Act. U-238 chain [Bq/g]	Max. Act. Th-232 chain [Bq/g]	Est. Exp. sit. max. [mSv/a]	Est. Exp. sit. average [mSv/a]
Foundries	17	5,6 - 7	0,95 – 1,3	0,292	0,19
Refractor.	1	0,57	0,12	-	-
Glass	1	1,9	0,96	0,245	0,245
Ceramics	32	0,007 - 8	0,002 – 1,2	0,219	0,1

Good practices:



- yearly briefings
- intelligent storage
- keep distance
- keep the exposure time low
- working gloves
- inhalation masks
- don't eat, drink or smoke next to it
- wash hands regularly
- maintenance
- hygienic standards



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Conclusions

- No companies in Bavaria, that deal with high amounts of zircon
- Residues that would be considered as NORM are manageable
- Dose estimations were made for diverse working scenarios :
 - ▶ No Effective doses above 1 mSv/a
- They do not need radiation regulations according to § 102 StrlSchV
- Most of the zirconia used in Bavaria has a high purity level – so that the U-238 and Th-232 inclosures are negligible
- Specific activities of zircon sand used in Bavaria are in accordance to literature:
 - U-238 decay chain: 4 – 7 Bq/g
 - Th-232 decay chain: 0,5 – 1,3 Bq/g
 - U-235 decay chain: negligible

