Zircon and Zirconia under the U.S. System of TENORM Regulation

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Zircon and Zirconia

Zircon : Zirconium Silicate (ZrSiO$_4$)

Zirconia : Zirconium Oxide (ZrO$_2$)

“Fused Zirconia:”

ZrSiO$_4$ $\rightarrow$ ZrO$_2$ + SiO$_2$ (amorphous)

$2600^\circ$C
"Technologically Enhanced Naturally Occurring Radioactive Material (TENORM)" means naturally occurring radioactive material whose radionuclide concentrations are increased by or as a result of past or present human practices. TENORM does not include background radiation or the natural radioactivity of rocks or soils. TENORM does not include "source material" and "byproduct material" as both are defined in the Atomic Energy Act of 1954, as amended (AEA 42 USC §2011 et seq.) and relevant regulations implemented by the NRC.
"TENORM" means any naturally occurring radioactive materials whose radionuclide concentrations or potential for human exposure have been increased by any human activities.

N.J.A.C. 7:28-1.4
Uranium or Thorium, in any combination, in any physical or chemical form;

Ores, materials containing by weight 0.05% (500 ppm) or more Uranium or Thorium or any combination is LICENSABLE Source Material

**BUT:** Unimportant Quantity Source Material <500 ppm U+Th is EXEMPT from Licensing

**NOT** Health-based number; technology based

**Pre-Empts** Contrary State Regulations
Consider U-238 Series in Zircon
U, Th, He
Within the Zircon Crystal
Significance of U, Th Inclusions in Zircon

ALL decay chain elements exist within the zircon crystal lattice – a condition known as “SECULAR EQUILIBRIUM”

Importance: Transport Exemption of U, Th parent

Environmental Mobility of radionuclides is de minimis

- Low Radon emanation
- No Leaching of radioactivity into water / groundwater
- Not Bioavailable? No data.
- Zircon as U-Th-Pb Geochronometer: world’s oldest rock
Reduced Environmental Mobility = Reduced Exposure
Some Dis-Equilibrium of U, Th decay chains apparent, because:

- **Pb-214 b.p. = 1755 °C**
- **Bi-214 b.p. = 1560 °C**
- **Po-210 b.p. = 962 °C**
- **Electric Arc Furnace T > 2600 °C**

Expectations: downchain disequilibrium;

Po-210 presence in EAF dust;

*Some* radionuclides in amorphous SiO2

Problems with γ-spectroscopy analysis (U, Th underestimates)
TENORM Regulatory Interaction
Waste Disposal

- Increased Landfill Radiation Monitoring
- Rejection of “traditional” foundry (shell) wastes; spent refractory; crucibles, etc.
- Mandatory investigation by radiation authority
- TENORM Licensing; Disposal Restrictions
## Regulatory Issues

- Regulations prohibiting landfill disposal of any radioactive waste aimed against hydraulic fracturing wastes but over-broad.

- Concentration-based TENORM standard (5 pCi/g or 0.185 Bq/g) Ra-226+Ra-228 developed for U mill tailings not applicable to zircon / zirconia

- Need for US system of radiation protection to update dosimetry models from ICRP-26, 30.
Hazard Communication Issues

- Civil Liability FAILURE TO WARN
- California Proposition 65: ALL RADIONUCLIDES ARE PROP-65 LISTED
- OSHA Hazard Communication: Safety Data Sheet Disclosure or Not?
Future of Unimportant Quantity S/M?

CURRENTLY: “No License” AEA § 62

FUTURE? AEA “source material” = “intentionally extracted” for use of U, Th

Requires legislative change to “Source Material” definition

Who regulates non-Nuclear U, Th?

Opens up other regulatory schemes: TSCA, RCRA, CWA
Notable Exemption

zirconia, zircon, ... are exempt from this chapter provided that the radioactive constituent is consistent with the radioactive levels stated in the material safety data sheet.

O.A.C. 3701:1-43-07(D)
... zirconia, zircon, and products of zirconia and zircon containing TENORM are exempt from this Part.
... manufactures zirconia or zircon from ore is not exempt from this Part.
... chemically processes ... resulting in increased environmental mobility of TENORM is not exempt from this Part.

Part N Currently Under Revision!
Case History: New Jersey Foundry

- Landfill monitor alarms at waste shell material
- Regulators arrive, take samples, measurements
- Zircon flour > 5 pCi/g total Ra; TENORM license!
- Request Dose-Based Exemption: < 1 mSv/y
- Analytical: γ-, α-spectroscopy; personal air monitoring
- Workplace γ survey, including BACKGROUND
- Worker occupancy time study;
- TEDE for foundry and landfill workers << 1 mSv/y
- NO LICENSE REQUIRED
Conclusions

“Source material” complicates U.S. TENORM regulation

Concentration-Based Standards (easy)

Dose-Based Standards (hard)

Both are DESIRABLE:
Concentration = Surrogate for Dose
Zircon and Zirconia ideal candidates for “generic dose modeling”