MANAGEMENT SOLUTIONS FOR SPENT ION EXCHANGE RESINS AT NPP SITES IN GERMANY

AN EXAMPLE OF THE DEVELOPMENT OF ALTERNATIVE WASTE MANAGEMENT SOLUTIONS

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MANAGEMENT SOLUTIONS FOR SPENT ION EXCHANGE RESINS AT NPP SITES IN GERMANY
PART 1: CONTEXT

Ion exchange resins (IER) utilised for water treatment in light water reactors

- Material: porous micro beads (usually organic polymers), large inner surface
- Principle: capture of solved ions under release of previously bound ions of likely charge
- Two types: powder (BWR), nodular (PWR)
- Purification of primary and secondary cooling water circuits:
  - Radioactive contaminants (fission & activation products)
  - Demineralisation
  - Condensate polishing
- Typically contain rather short-lived radionuclides: ^{137}Cs, ^{60}Co, ^{134}Cs, ^{90}Sr, ^{54}Mn, ^{3}H (all $T_{1/2}$ < 40 a)
  - Exception: ^{129}I ($T_{1/2} = 1{,}7 \times 10^{7}$ a), but: < 10^{-4} % of total activity
- Challenges:
  - Residual water (WAC: < 1 mass %)
  - Flammable
- **Strategy**: drying & unfixed packaging, deep geological disposal at Shaft Konrad facility for LILW (non-heat-generating waste), expected to become operational in 2027.

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PART 1: CONTEXT

- **After retirement: packaging spent IER (SIER) in 200 l drums at NPP**
- **Powder SIER:**
  - Approx. 184 m^3/a from six BWR-NPP (as of 1991)[1]
  - $1{,}9 \times 10^{10} - 1{,}5 \times 10^{12}$ Bq/m^3, ~10^{-5} % α activity[1]
  - Residual water 45-55 % (mass) [1]
  - Vacuum transfer to pre-evacuated Gusscontainer Type VI or MOSAIK® II by PUSA facility (GNS)
  - Vibration compactors for condensation and even distribution, remain in container
- **Nodular SIER:**
  - Approx. 38 m^3/a from 13 PWR-NPP (as of 1988) [1]
  - $3{,}7 \times 10^{11} - 1{,}5 \times 10^{13}$ Bq/m^3, ~10^{-4} % α activity[1]
  - Residual water 40-55 % (mass) [1]
  - Vacuum transfer to pre-evacuated MOSAIK® II cask by FAFNIR facility (GNS)

[1] A. Bohlender, Experimentelle Untersuchungen zur Charakterisierung des Fließ- und Zerstäubungsverhaltens von Pulverharz-Suspensionen im Hinblick auf eine Sprühinjektions-Verbrennung, FZ Jülich (1993)

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Challenge: Residual water < 1 mass % (WAC)

- Exact amount of residual water not directly accessible
- Post-transfer drying required
- Procedure:
    - MOSAIK® II: At least one week standing time (deposition of fluids)
    - Two-step drainage (coarse and fine) by vacuum drying
    - Cask considered dry when water collecting rate < 0,1 l/h after 1 h standing time
    - Exact threshold value depends on facility (same magnitude)
    - Drained water is collected and emptied into buffer tank
- NEWA facility: simultaneous conditioning of up to four MOSAIK® II drums

GNS NEWA & FAFNIR facilities in operation for drying of MOSAIK ® II drums (source: gns.de)

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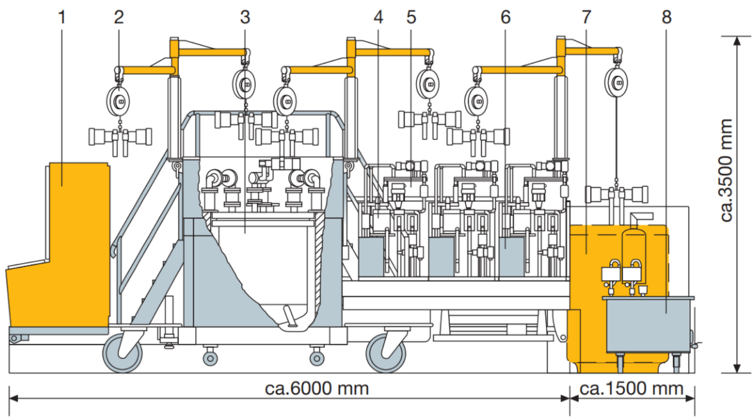
Principle of vacuum drying procedure at the example of GNS FAVORIT

- Modular design, mobile use on site
- Extraction of free liquids
- Decreasing pressure inside casket (vacuum pump), reduces boiling point, removes fluid from system
- Jacket heating increases temperature of fluid, induces transition into gas phase
- Volume reduction depends on solid content of liquid waste
- Conditioned product & packaging ready for intermediate or final disposal

GNS FAVORIT (source: gns.de)



1. Control panel
2. Coupling station for waste casks
3. Dosing tank
4. Vacuum pump
5. Vapor condensor
6. Compressed air supply
7. MOSAIK® cask with jacket heating
8. Condensate collecting tank

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WAC for final disposal at Schacht Konrad

- Assignment to waste product group (APG, *Abfallproduktgruppe*)
  - APG01, prerequisites: solid state, non-rotting/fermenting, no free liquids…
  - APG02, additional criteria: no leakage of flammable wastes, < 1% total activity of waste product
- Assignment to waste container class (ABK, *Abfallbehälterklasse*)
  - Prerequisites: dimensions, volume, stackability, anticorrosive
  - ABK I: basic mechanical (fall, impact) and thermal stability
  - ABK II: more rigid requirements concerning mechanical & thermal stability, max. leakage rate in case of fire
  - MOSAIK® II meets ABK II requirements → suitable for final disposal without cementation
  - In fact, even higher standards are put on cemented wastes
- WAC met by combining conditioning (vacuum drying) & packaging (MOSAIK® II)

DEVELOPMENT OF DIFFERENT MANAGEMENT SOLUTIONS FOR SPENT ION EXCHANGE RESINS AT INDIVIDUAL NPP SITES

PART 2: DESCRIPTION OF CASE STUDY

GNS drying facilities for conditioning of SIERs
(source: GNS.de)

Questions	Answers
What type / degree of waste management was deployed? What was the resulting product?	Primary strategy: drying and unfixed packaging. Every NPP is managing SIERs by performing primary characterisation and water separation (heating & vacuum). For this purpose, unconditioned SIERs are packed in standard 200 l drums and are stored in intermediate storage facilities at NPP sites. Drying and transfer procedures are conducted on site using mobile facilities provided by GNS. Drained SIERs can be considered as solids (powders or nodular). In principal, technological facilities for incineration are also available (JÜV 50/2 oven at Jülich Research Centre), but not in use for conditioning of SIERs.

DEVELOPMENT OF DIFFERENT MANAGEMENT SOLUTIONS FOR SPENT ION EXCHANGE RESINS AT INDIVIDUAL NPP SITES

PART 2: DESCRIPTION OF CASE STUDY (CONTINUED)

Questions	Answers
What subsequent management steps are envisaged?	Containment for intermediate storage occurs unfixed, typically in GNS Gusscontainer® Type VI (cubic) or MOSAIK® II (cylindrical), meeting requirements (mechanical and thermal stability) for final disposal at Konrad repository. SIERs are condensed and evenly distributed in the containers using vibration compactors, which remain inside the container. While a true standardized waste management strategy is still missing, this procedure has been developed and is routinely recommended by GNS.

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PART 2: DESCRIPTION OF CASE STUDY (CONTINUED)

Questions	Answers
In the timeframe relevant to the case study, what was the status of: ➢ The envisaged disposal route? ➢ WAC (or equivalent requirements) for waste management, transport (if applicable) and disposal? ➢ The technical solution / facility?	• Conditioning and intermediate storage, final disposal at Konrad (not before 2027) • WAC: residual water (<1 % of mass), mechanical and thermal stability of containers for final disposal • Mobile in-cask draining and drying facilities used at NPPs • each conditioning step is documented (flow chart), reviewed and approved by BGE and respective regulators, product control carried out by surveyer (TÜV)
Were there any other uncertainties or challenges relating to management of the waste?	• Exact amount of residual water remains unknown, though limit of 1 % (mass) needs to be adhered to for final disposal • Conditioned SIERs are flammable and organic, posing potential safety risks
Why was a decision taken to implement this waste management initiative at this time, despite these uncertainties / challenges? What were the anticipated benefits?	• Reliable methods for draining of SIERs available • MOSAIK II meet mechanical and thermal stability criteria for final disposal **even without cementation** of SIER → classified as lower waste product group with fewer criteria

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PART 3: EVALUATION & LESSONS LEARNED

Questions	Answers
Please describe the approach(es) taken to manage / resolve issues or challenges associated with the case study. For example, how were ongoing uncertainties about the requirements for disposal and the scope of associated WAC addressed?	• Double-stage drying procedure (coarse and fine drain) using heating & vacuum • Criterion: water collection rate after 1 h standing time • < ≈0,1 l/h, exact value depending on facility • If criterion met → container considered as dry
What experience can be taken from this case study? *What went well / not so well? Were the anticipated benefits realised? Were there any unexpected challenges or additional benefits? What ongoing uncertainties persist?*	• Fixation/cementation not always method of choice, as for cemented/concreted waste products, additional (more rigid) criteria are to be met for final disposal at Konrad repository
Will the decisions taken constrain future waste management activities?	Not the case based on present knowledge.
Based on this experience and/or more recent activities elsewhere, would anything be done differently if repeated?	Procedure relies on WAC for Shaft Konrad, older wastes were not necessarily handled in the same manner.