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Gel formation in conditioned waste drums: overview of the issue and lessons learned by the Regulatory Body.

OUTLINE

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Introduction

Who are the actors?

FANC:	Nuclear Safety Authority
Bel V:	Technical Support Organisation
FANC and Bel V	form the Regulatory Body (RB)
ONDRAF/NIRAS:	Agency for Radioactive Waste and Enriched Fissile Material
Belgoprocess:	Licensee of waste storage and processing facilities
ENGIE Electrabel:	Licensee of Nuclear Power Plants

Introduction

Discovery of the issue

- What:**
- A small volume of a radioactive gel-like substance was found at the outside of a 400-liter drum.
 - The drum contains evaporator concentrates immobilized in concrete.
 - It was conditioned by ENGIE Electrabel at the Doel NPP.
- Where:** In a storage facility of Belgoprocess for conditioned waste drums.
- How:** By a visual check during a routine inspection by Belgoprocess.
- When:** February 2013

Introduction

Extent of the issue

- Visual inspections of this drum and of additional drums were performed by Belgoprocess and ONDRAF/NIRAS.
- These inspections revealed that:
 - several drums containing evaporator concentrates (produced with the same conditioning process) showed either gel spots or a layer of gel on the surface of their concrete matrix.
 - several of drums containing spent ion exchange resins conditioned in concrete are also affected by this issue.
 - a large heterogeneity in the gel formation and quantities inside each production campaign and from one campaign to another.

Introduction

Extent of the issue



Drum containing a layer of gel on the concrete surface. Taken from <https://www.stora.org/fr/node/602>

- As a conclusion, all the drums containing evaporate concentrates or ion exchange resins conditioned with concrete at the Doel NPP are possibly affected.
- In total about 9000 waste drums are potentially affected (about 3500 m³).
- The 2 incriminated conditioning processes were stopped (and their qualifications were withdrawn by NIRAS/ONDRAF).

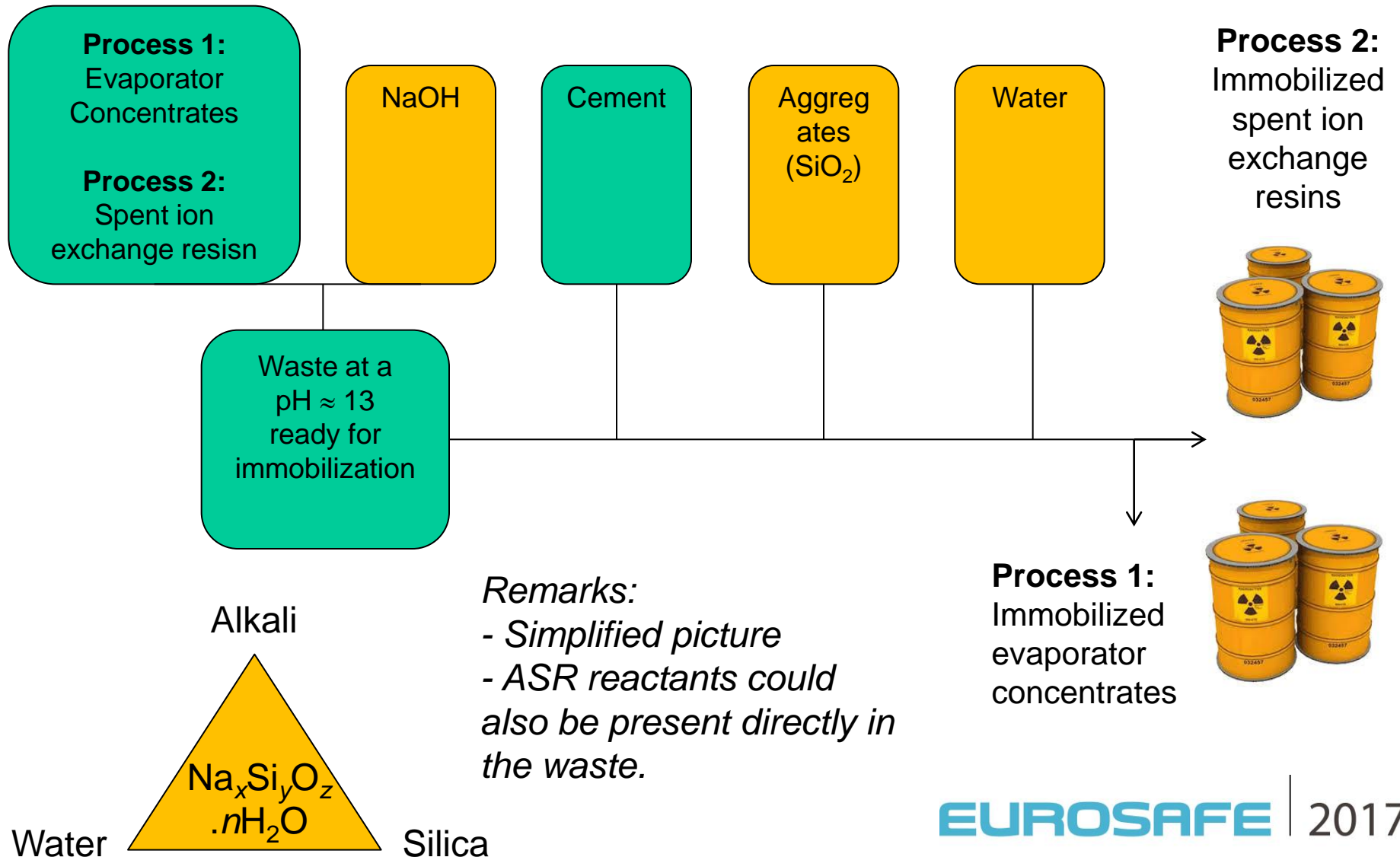
Root cause analysis

The Alkali Silica Reaction

- Based on radio-chemical analyses performed by ENGIE Electrabel, Belgoprocess and ENGIE Laborelec: it is a sodium silicate gel.
- Postulated forming reaction: Alkali-Silica-Reaction (ASR).
- Gel is hydrophilic and its water absorption causes its expansion. This could cause its escape from the drums.
- Analysis confirmed by an international expert panel (set up under the auspices of NIRAS/ONDRAF).
- Additional evidences are still needed to exclude other processes that might influence the gel formation (investigated by NIRAS/ONDRAF).

Root cause analysis

ASR reactants in the conditioning processes



Safety implications

Impact on operational safety

- Operational safety issues:
 - Risk of surface contamination in storage facilities;
 - Risk of cross contamination of drums not affected by this issue (but which are stored with the potentially ASR affected drums);
 - Potential risk of air contamination (not detected up to now).
- The RB requested to take the necessary measures to ensure safety in the concerned storage facilities.
- E.g.: action plan developed by Belgoprocess (in collaboration with NIRAS/ONDRAF):
 - Walkdowns and controls of air contamination were intensified;
 - Systematic wearing of protective equipment when manipulating the affected drums;

Safety implications

Impact on operational safety

- Segregation of the potentially ASR affected drums at one single location to prevent cross contamination of non affected drums;
 - Visual inspection of the outside of each potentially ASR affected drum to detect a possible non conformity;
 - The development of a specific storage facility for the ASR affected drums.
- Actions of this plan induce a radiation exposure of workers. Optimization of these actions is a concern for the RB.
 - Beside this radiation protection issue, up to now: no other safety impact for the personnel of Belgoprocess or for the public and the environment.

Safety implications

Impact on long term safety

- Long term safety issues (if disposed of in a repository as such):
 - Risk of mechanical constraints in the near-field;
 - Mobility of radionuclides could be increased.
- Thus, as of today, NIRAS/ONDRAF does not intend to dispose of the potentially ASR affected drums as such in a surface repository (as initially planned).
- RB agrees with this position.
- Interactions started with NIRAS/ONDRAF about the identification of long-term management options for the potentially ASR affected drums.

Safety implications

Impact on long term safety

- An R&D programme investigating the following options was started by NIRAS/ONDRAF:
 1. Gel formation can be excluded: disposal in a surface disposal facility.
 2. One of the ASR reactants is consumed and the reaction is stopped: disposal in a surface disposal facility with a specific waste package.
 3. It can be demonstrated that the gel will not compromise the safety of a disposal facility.
 4. Evaluation of possible options for the reprocessing of the drums.
- The RB will continue to follow these investigations and to verify the safety of the considered long term management options.

Lessons learned by the RB

Key lesson learned

- This issue is a problem of interdependence between several steps of waste management.
 - Waste processing steps resulted in chemically unstable waste forms.
 - These waste forms cause safety issues at the storage step.
 - Issues for the long term management of these waste forms are also identified.



Lessons learned by the RB

Key lesson learned

- This stresses the importance of following the IAEA general safety requirement:

Requirement 6 from IAEA GSR Part 5

“Interdependences among all steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option, shall be appropriately taken into account“

- This interdependence among the waste management steps is a key principle in the EC directive 2011/70/EURATOM, implemented in the Belgian law.
- Key lesson learned: **the control of these interdependences needs to be strengthened.**

Lessons learned by the RB

How to strengthen the control of interdependences

- This could be achieved by strengthening:
 - the definition of Waste Acceptance Criteria (WAC) that need to be respected along the waste management steps. E.g. by including specific criteria on raw materials to avoid detrimental reactions such as ASR.
 - the control that operators of waste conditioning facilities properly verify the quality and conformity to WAC of raw materials (e.g. by chemical analysis, existence of QA certificates, destructive analyses,...).
 - the on-site controls with RB members having a broad view on all the waste management steps (from waste generation to disposal).

Lessons learned by the RB

Actions taken

- Based on these lessons learned, actions are being taken by the RB, in compliance with its missions, to strengthen the control that waste management activities do not compromise the safety of their subsequent management steps.
- Actions are also taken in this way by the other actors, and in particular by NIRAS/ONDRAF who has notably taken initiatives to improve its waste acceptance process.

Lessons learned by the RB

Actions taken

- Interactions occurred between the RB and NIRAS/ONDRAF about the strengthening of the WAC.
 - ONDRAF/NIRAS is responsible for WAC definition;
 - Strengthened WAC now require that operators verify (based on ASTM standards) that aggregates used in immobilizing matrixes will not cause deleterious expansions due to a potential ASR.
- The control programme of the RB on predisposal waste management and its possible impact in long term safety is being strengthened.
- Trainings are given to the RB staff involved in such controls to stress the importance for safety of the interdependences between the waste management steps.

Conclusions

- Waste conditioning processed for evaporator concentrates and spent ion exchange resins have resulted in the production of about 9000 drums potentially affected by an ASR.
- This issue has implications both on operational and long-term safety.
- Appropriate actions were taken by the RB and the other concerned actors to ensure safety.
- The key lesson learned is that the control of interdependences among all waste management steps needs to be strengthened.
- Actions are taken this way by the RB and the other actors, in compliance with their respective missions.

Acknowledgment

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For more information about the actions taken specifically by these organisations, the reader can respectively contact: steven.vanierssel@engie.com, S.BenHadjHassine@nirond.be and rudydresselaers@belgoprocess.be.