Solidification Technology for Low Level Organic Liquid Waste from Cernavoda NPP

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Presentation outline

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2. The Nochar polymer
3. Management of the Cernavoda NPP organic liquid waste – project performed by Mate-Fin
4. Solidification at a small (laboratory) scale
5. Solidification at a large scale
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Cernavoda NPP radioactive waste streams (1)

- Spent resins
- Spent filter cartridges
- Solid waste
  - Type 1 solid waste (contact gamma dose rate < 2 mSv h\(^{-1}\))
  - Type 2 solid waste (contact gamma dose rate between 2 mSv h\(^{-1}\) and 125 mSv h\(^{-1}\))
  - Type 3 solid waste (contact gamma dose rate higher than 125 mSv h\(^{-1}\))
- Liquid radioactive wastes
  - Aqueous liquid wastes
  - Organic liquid wastes
Cernavoda NPP radioactive waste streams (2)

- Organic liquid wastes
  - Lubricating oil from pumps and turbines
    - In contact with the reactor primary coolant and moderator
    - Tritium up to about $10^9$ Bq kg$^{-1}$
    - Small quantities of radionuclides such as Co-60, Nb-95, Zr-95, Cs-137
  - Spent solvents from decontamination area, laboratories and maintenance activities
    - White spirit, ethylene glycol, alcohol ethyl, toluene, chloroform, and acetone
Organic liquid wastes (contd.)

- Liquid scintillation cocktails
  - Sampling of the Moderator and PHT system and their auxiliary systems, liquid effluent systems
    - Mainly contaminated with tritium, segregated by tritium content
- Spent solvents from decontamination area, laboratories and maintenance activities
  - white spirit, ethylene glycol, alcohol ethyl, toluene, chloroform, and acetone
Cernavoda NPP radioactive waste streams (4)

Organic liquid wastes (contd.)
- Radioactive sludge
  - from maintenance activities on the active drainage system
  - contaminated with gamma nuclides
- Flammable solids
  - mixture of solid materials (textile and plastic) and oils from maintenance activities
  - contaminated with gamma nuclides and $^3$H
- Collected at waste collection points in special canisters
- Placed for intermediary storage in specially constructed 220l stainless steel drums
The Nochar® polymer (1)

• Synthetic absorbent system
  • consists of a range of granulated polymer - immobilize liquid materials through a combined absorption and inter-molecular bonding process
  • bonds the organic liquid into a soft, spongy, rubber-like material
  • the polymer crystals can be specifically designed to address the characteristics of given mixed organic liquid waste
  • fast solidification: varies between 1 hour and 48 hours, depending on the type of waste
The Nochar® polymer (2)

- Stability of Nochar
  - no chemical reaction
  - no heat build-up or heat release from the resulted solid waste
  - no leaching; organic liquids are linked and secure in the polymer structure
- Possibility to blend polymers to solidify various types of liquid waste; polymers are hydrophobic an hydrophilic
- Polymerized solid waste reduce the risk of fire
  - The resulted product is not inflammable but incinerable
- Acceptable volume increase – a factor of 1.3-1.5
- It can immobilize LLW, ILW and HLW
- It remains solid for more than 10,000 years
Solidification of all organic liquid waste by absorbing the liquid into the organic polymer structure.
- The main reason is a requirement of the regulatory body not authorising the existence of inflamable liquid waste in the interim solid waste storage facility.

- The polymers used for this purpose are NOCHAR Petrobond® for organic liquid waste and NOCHAR Acidbond® for aqueous wastes.

- Why NOCHAR polymer?
  - Bound the water, prevent migration of HTO or $T_2O$
  - Permit further treatment (ex. incineration).
Management of the Cernavoda NPP organic liquid waste – project performed by Mate-Fin (2)

- Solid-liquid mixtures are treated with NOCHAR Petrobond® organic polymer, the organic liquid (mainly oil) is solidified and separated mechanically from the solids.
- The remaining solids (plastics and/or textiles) do not contain organic liquid and can be treated as “normal” solid waste.
- The technology developed by MATE-FIN at Cernavoda to perform the separation is based on a "sandwich" structure of solid and absorbent polymer.
Solidification at a Small Scale (1)

- A total of about 30 organic liquid waste sub streams (oils, scintillation liquids and solvents) have been tested by MATE-FIN in the experimental campaign.
- The polymers used were Nochar N910 Petrobond® and N960 Acidbond®.
  - N910 is suitable for hydrocarbon waste streams and N960 for acid, alkali and aqueous waste stream.
  - The polymers are blended if a mixed hydrocarbon/aqueous waste stream is encountered.
- Average volume increase after solidification was between 1.3-1.5 depending on the liquid to be solidified.
Solidification at a Small Scale (2)

A stratificated structure was realized to assure higher contact between the polymer and the liquid to be solidified.
Solidification at a Small Scale (3)
Solidification at a Small Scale (4)  
Experimental results

Test 1
- Type of waste: Pump oil
- Formula for polymers: Petrobond (95%) and Acidbond (5%); polymers are blended manually
- Bonding ratio = 1:2,5
- Time for solidification: 24 hours
- Result = good solidification

Test 2
- Type of waste: oil (80%) with water (20%)
- Formula for polymers: Petrobond (84%) and Acidbond (16%); polymers are blended manually
- Bonding ratio: 1:2,2
- Time for solidification: 24 hours
- Result = good solidification
Solidification at a Small Scale (5)
Experimental results

Test 3
- Type of waste: Scintillation fluid
- Formula for polymers: Petrobond (10%) and Acidbond (90%); polymers are blended manually
- Bonding ratio: 1:2
- Time for solidification: 24 hours
- Result = good solidification

Test 4
- Type of waste: Solvents
- Formula for polymers: Petrobond (10-12%) and Acidbond (90-88%); polymers are blended manually
- Bonding ratio: 1:2,1
- Time for solidification: 48 hours
- Result: good solidification
Solidification at a Small Scale (6)

Conclusions

- The results of the experimental campaign illustrate that the Nochar N910/N960® polymer systems have proved to be effective in the immobilization of organic liquid waste streams into a solid polymeric product, with no leakage of liquid at compression.

- A key point arising from this experimental campaign:
  - For the large scale project there is the need to test for compatibility and to assess the correct organic liquid waste/polymer ratio on a case by case basis.
On the basis of the results of this experimental campaign, MATE-FIN started the solidification of organic liquid waste from Cernavoda NPP at the beginning of 2009. The method used by MATE-FIN’s specialists consist of the following important steps:

- The contaminated organic liquid waste and the polymer was pre-weighted, to obtain the proper bonding ratio;
- The materials (organic liquid and polymer) were mixed at a pre-determined slow speed in order to avoid polymer breaking;
- The solidified organic liquid was packed into drums and allowed to cure for 24-48 hours;
- The solidified organic liquid was packed in PE bags (10-12kg) and re-packed in 220L drums, type A containers, ready for transport to incineration operator.
Solidification at a Large Scale (2)
Solidification at a Large Scale (3)
Solidification at a Large Scale (4)
Lessons learned

- A safety layer of N910 (6-7 cm) and N960 (3cm) at bottom of the drum is very important.
- A safety layer at top of the drum (N910 and N960) have to be placed.
- The mixture of N910 and N960 should be blended well prior to loading into the drum.
- The speed of mixing of the organic liquid and polymer is critical, the optimal mixing speed is up to 15-20rpm. The key point is to have good liquid and polymer touch, over mixing can damage the polymer.
- Loading the 1st layer of polymer (on top of the safety layer) avoid to compress the polymer.
- Check the 1st batch of oil (even it seems to be from pumps), if there is a water phase at the bottom of the oil drum the polymer formula have to be changed for the 1st layer of polymer.
Solidification at a Large Scale (5)
Lessons learned

- The composition of liquid scintillation cocktails is about 10% water and 90% Ultima Gold, there is a possibility the water is phasing out, as older the scintillation liquid is, the more likely is the appearance of bi-phase streams.

- There are two possibilities:
  - stir/mix (emulsify) the entire drum of scintillation fluid prior to solidification,
  - add more N960 in the 1st layer of polymer, 75% - N910 and 25% - N960 is optimal (more N960 is required to immobilize the water).

- Mixing will be required in the case of scintillation liquid, solidification occurs very quickly, causing a “skin” or top layer solidification, the “skin” does not allow the liquid to penetrate the polymers on its own (via gravity).

- The best is to solidify in small batches and after mixing in the final drum.
Organic liquid separation from solid-liquid mixture
CONCLUSIONS

➢ Nochar® polymer systems were effective in the immobilization of organic liquid and inflammable waste from NPP Cernavoda resulting a stable non inflammable solid;

➢ During the experimental campaign MATE-FIN established the appropriate organic liquid to polymer ratios depending on type of the waste (oil, solvents, scintillation liquid);

➢ During 2 years of project all inflammable liquid wastes were removed from the Intermediate Radioactive Waste Storage Facilities from Cernavoda NPP, without significant waste volume increase.
THANK YOU FOR YOUR ATTENTION!

QUESTIONS