Visitor’s Guide

Treatment of low and intermediate level radioactive waste using Plasma Melting Process, and Performance Analysis

SERAW (Kozloduy NPP)
A visit aimed at sharing knowledge with EU Operators

The visit has been organised as part of a EU effort to spread the knowledge gained over the course of decommissioning and radioactive waste management activities across all EU Member States.

SERAW has collected relevant experience related to the design, construction and operation of a Plasma Melting Facility with the goal of making their knowledge available to other EU decommissioning Operators that may be interested in this technology.
Facility Description

Construction

Operation

Project Feasibility
Facility Description
Technology

The facility is based on high-energy technology, creating a thermal plasma field by directing an electric current through a gas flow, which is able to process a wide range of waste – organic and inorganic. The temperature of the arc reaches 5,000÷15,000°C, where the working temperature in the furnace reaches 1,500°C. Processing throughput is 250 t/year. Treatment rate is up to 65 kg/h.
Benefits

- WASTE VOLUME
- WASTE STABILITY
- COST SAVING
Drawbacks

- LIQUID WASTE
- METALLIC WASTE
- POLYMERS PRESENCE

Facility Description
Construction
Timeline

- Signing of the...
- Design
- Equipment m...
- EIA permission
- Technical Des...
- Construction
- Functional te...
- Utilisation Per...
- Commissioni...
- RAW tests
- Operational ...

Years: 2009 to 2023
Adaptation of the infrastructure to the new facility

The design of the PMF was consistent with the use of the existing infrastructure at the Kozloduy NPP site.

The decision to install the PMF in the existing building of AB-2 required some design modifications.

Building structure
The dimensions of the PMF required some modifications of the structure of the building

Ventilation Systems
Existing ventilation systems required reconfiguration given the new PMF design requirements

Power Supply & Cabling
Existing cabling was insufficient for the new PMF installation

Diesel supply
The new PMF facility required the installation of diesel supply to the existing building

Water Supply
There was a new need for water supply and wastewater evacuation from the PMF

Air Supply
New need for air and nitrogen supply to the PMF to ensure function and safety
Operation
The type of packaging to process over the four campaigns for the received radioactive waste (RAW) included:

- RAW in super-pressed drums (super-compacted)
- RAW in pressed drums (compacted)
- RAW in polyethylene bags (non-compacted)

Processing sorted RAW without pretreatment in polyethylene bags achieves the highest Volume Reduction Factor (VFR) and extends the life of the feed auger. Resources are also saved by eliminating the need for pre-treatment (pressing, super-pressing) of the RAW.
Total RAW Treated (kg)  
442,835.58  
Across all four campaigns

Total RAW Treated (m³)  
3,400.41  
Across all four campaigns

Average processing speed (kg/h)  
45.06  
Across all four campaigns
**Generated molten slag (kg)**

Across all four campaigns

- **215,372.22**

**Generated molten slag (m³)**

Across all four campaigns

- **67.49**

**Volume Reduction Factor (VFR)**

Across all four campaigns

- **50.38**
LESSONS LEARNED

CAMPAIGN 1
CAMPAIGN 2
CAMPAIGN 3
CAMPAIGN 4
Project Feasibility
When preparing a feasibility study for a RAW treatment facility, the key factors for decision-making are summarised below.

1. The expected amount of the RAW to be treated in the facility during the exploitation period.
2. Assessment of the price for treatment of this inventory through alternative technologies: PMF against other suitable choices.
3. Assessment of the price for disposal of the final amount of the conditioned waste in the chosen alternatives.
4. Overall assessment of the treatment and disposal price per unit of the selected inventory in each of the selected alternatives.
Assumptions

Lifetime
The expected lifetime used in the analysis is 25 years.

Technologies
The analysis compares plasma melting and super-compaction technologies.

Estimated RAW
In this period, the estimated amount of RAW to be treated is 44,000 m³.

Cost estimation
The calculation of costs has been made from the data obtained during the 4 campaigns.
Expenses

Investment cost
The investment cost made for the PMF is estimated to be €39,397,663.61.

Operational costs
The PMF operational costs for the four periods are estimated at €4,404,988.13 (including costs for Personnel, Depreciation, Consultant services (JV Support) and used spare parts, energy and consumables)

The super-compaction operational costs during this period for the same amount of RAW treatment are estimated to be €4,264,414.64.

Disposal costs
Based on the design information for NDF, the estimated price for disposal of 1 package of waste (RCC) is €16,230.78.
Evaluation of the costs of treatment of RAW through PMF and AB

<table>
<thead>
<tr>
<th>Input data for calculation of 1 RCC package produced in PNF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment cost</td>
</tr>
<tr>
<td>Operational cost for the analysis period</td>
</tr>
<tr>
<td>Generated RCC</td>
</tr>
<tr>
<td>Cost for production of 1 empty RCC</td>
</tr>
<tr>
<td>Operational cost for treatment for 1 tonne of RAW during the analysis period</td>
</tr>
<tr>
<td>RAW in 1 RCC</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>39 397 663.61</td>
</tr>
<tr>
<td>20.82</td>
</tr>
<tr>
<td>9 947.24</td>
</tr>
<tr>
<td>21.27</td>
</tr>
</tbody>
</table>
## Calculation of costs for the production of 1 package of RCC with processed RAW

<table>
<thead>
<tr>
<th>Description</th>
<th>PMF costs</th>
<th>SC costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational cost for treatment RAW [t]</td>
<td>€/RCC</td>
<td>211,538.98</td>
</tr>
<tr>
<td>Operational cost for treatment RAW [m³]</td>
<td>€/RCC</td>
<td>211,538.98</td>
</tr>
<tr>
<td>Disposal of 1 RCC in NDF</td>
<td>€</td>
<td>16,230.78</td>
</tr>
<tr>
<td>Total operational and disposal cost for 1 RCC</td>
<td>€</td>
<td>230,588.37</td>
</tr>
<tr>
<td>Investment costs per 1 RCC package</td>
<td>€</td>
<td>145,917.27</td>
</tr>
<tr>
<td>Total Cost per RCC (Including Investment Costs)</td>
<td>€</td>
<td>376,505.65</td>
</tr>
</tbody>
</table>
Cost calculation for the treatment and disposal of total RAW

As a consequence of the treatment of 3,400 m³ of RAW using the PMF, 67.49 m³ of final RAW volume was generated. This resulted in the generation of 20.82 RCCs for disposal.

Taking into consideration the technical parameters of the super-compaction technology as a result of the treatment of 3,400 m³ of RAW would lead to the creation of 154.21 RCCs for disposal.

<table>
<thead>
<tr>
<th>Costs for treatment and disposal of 3 400 m³ of RAW through SC and PMF</th>
<th>Costs (RCC x Operational and disposal costs for 1 RCC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through SC</td>
<td>€ 7 890 365.02</td>
</tr>
<tr>
<td>Through PMF</td>
<td>€ 4 801 663.80</td>
</tr>
</tbody>
</table>
Cost calculation for the treatment and disposal of total RAW

Taking into account that a total of 270 RCCs will be generated through the PMF technology for the lifetime of the facility and the coefficient calculated in the previous slide. 2,000.7 RCCs from SC would be generated during the lifetime of the facility.

According to that, the following calculations can be made:

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Cost (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMF Ops Lifetime Costs (Assume assessment period as average)</td>
<td>62,588,611.18</td>
</tr>
<tr>
<td>Calculation for processing of the same waste using super-compaction (SC)</td>
<td>102,307,275.20</td>
</tr>
<tr>
<td>Savings over the operational lifetime comparing the PMF vs. SC</td>
<td>40,048,414.02</td>
</tr>
<tr>
<td>Recovery period for Capital Investment in years</td>
<td>24.59</td>
</tr>
</tbody>
</table>
Thank you for your visit