DELIVERABLE REPORT

Thermal treatment for radioactive waste minimisation and hazard reduction

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THERAMIN Project Partners

Andra	Agence nationale pour la gestion des déchets radioactifs – France
AREVA	AREVA – France
CEA	Commissariat à l'énergie atomique et aux énergies alternatives – France
GSL	Galson Sciences Limited – UK
FZJ	Forschungszentrum Juelich GmbH – Germany
LEI	Lithuanian Energy Institute – Lithuania
NNL	National Nuclear Laboratory – UK
ONDRAF/NIRAS	Organisme National des Déchets RAdioactifs et des matières Fissiles enrichies – Belgium
SCK•CEN	The Belgian Nuclear Research Centre – Belgium
USFD	University of Sheffield – UK
VTT	Teknologian Tutkimuskeskus VTT Oy (VTT Technical Research Centre of Finland Ltd)
VUJE	VUJE a.s. – Slovakia

THERAMIN End User Group

Andra	Agence nationale pour la gestion des déchets radioactifs – France
CEA	Commissariat à l'énergie atomique et aux énergies alternatives – France
EDF	Electricité de France – France
Fortum	Fortum Oyj – Finland
IGD-TP	Implementing Geological Disposal of Radioactive Waste Technology Platform
Nagra	Die Nationale Genossenschaft für die Lagerung Radioaktiver Abfälle – Switzerland
ONDRAF/NIRAS	Organisme National des Déchets RAdioactifs et des matières Fissiles enrichies – Belgium
RWM	Radioactive Waste Management Ltd – UK
Sellafield	Sellafied Ltd – UK
TVO	Teollisuuden Voima Oyj – Finland

List of acronyms

EC	European Commission
ILW	Intermediate Level Waste
LLW	Low Level Waste
WP	Work Package
PVC	Polyvinyl Chloride
PCM	Plutonium Contaminated Material
HIP	Hot Isostatic Pressing
PIVIC	Procédé d'Incinération Vitrification In Can
IRIS	Installation de Recherche en Incinération des Solides
ELIPSE	Elimination de Liquide par Incinération en Plasma Sous Eau
SHIVA	Système Hybride d'Incinération Vitrification Avancé

1 Introduction

1.1 Background

The **Ther**mal treatment for **ra**dioactive waste **min**imisation and hazard reduction (THERAMIN) project is a European Commission (EC) programme of work jointly funded by the Horizon 2020 Euratom research and innovation programme and European nuclear waste management organisations (WMOs). The THERAMIN project is running in the period June 2017 – May 2020. Twelve European WMOs and research and consultancy institutions from seven European countries are participating in THERAMIN.

The overall objective of THERAMIN is to demonstrate the efficacy of thermal treatment in providing improved safe long-term storage and disposal of intermediate-level wastes (ILW) and low-level wastes (LLW). The work programme provides a vehicle for coordinated EU-wide research and technology demonstration designed to provide improved understanding and optimisation of the application of thermal treatment in radioactive waste management programmes across Europe, and will move technologies higher up the Technology Readiness Level (TRL) scale. The THERAMIN project is being carried out in five work packages (WPs). WP1 includes project management and coordination and is being led by VTT. WP2 evaluates the potential for thermal treatment of particular waste streams across Europe; this WP is led by GSL. In WP3, the application of selected thermal treatment technologies to radioactive waste management is demonstrated and evaluated; this WP is led by NNL. In WP4, the disposability of the thermally treated waste products is assessed; this WP is led by Andra. WP5 concerns synthesis of the project outcomes and their dissemination to other interested organisations.

1.2 Scope of this Report

To record the decisions taken in matching generic wastestreams selected from WP2 to demonstrations to be carried out on the facilities made available by participating organisations. The report identifies the technology demonstrators, references the waste stream types for demonstration as agreed in WP2 and notes the decisions taken at the WP3 kick off meeting allocating waste streams to demonstrators.

Description of the individual demonstrators and their attributes are being drafted as part of work package 2.3 and will be included for each demonstration as part of the report on the demonstration itself.

2 Recommended Feed streams from WP2

Following the WP2 discussion on 2/10/17 in Paris [1] (Meeting minutes from Work Package 2 meeting 02/10/2017 Andra Paris) the following groups were recommended to Work Package 3 at the WP3 kick off meetings on 13th October 2017 [2].

- Conditioned Waste
    - Cemented (including cemented concentrates, concrete-lined drums, degraded packages, etc.)
    - Bitumen (including various types of bituminised waste).
- Unconditioned Waste
    - Metals (pure or high content)
    - Alpha waste (including PCM)
    - Inorganic resin
    - Organic resin
    - Sludges
    - PVC
- Liquid waste
    - Organic
    - Oily
    - Chrompik

The technology owners have assessed the generic streams outlined above and made an assessment as to the viability of using the available demonstrators to treat surrogate streams.

3 Matching streams to demonstrators

From the outset it is understood that any thermal treatment demonstration could only be carried out on rigs and in facilities that are already available in the collaboration, thus avoiding the prohibitive expense and time that would be required to set up and operate bespoke equipment. As such it has been important to identify which demonstrators amongst the participating countries are most suited to waste streams arising from those countries and which streams might be out of scope due to unsuitability of existing technologies or inability to achieve an operational safety case in the time available.

It should also be considered that replication of all aspects of a particular stream may not be possible and that the succesful demonstration of generic aspects of a particular stream may be more valuable to the consortium as a whole, for example the ability of a particular technology to handle dilute liquids or organic feeds.

Described below are the key facets of the technologies that are available for demonstration and the waste streams they have been matched to.

The matching of waste streams to demonstrators was outlined in the WP3 kick off meeting of 13th October 2017 in Manchester. The output is tabulated below.

	WASTESTREAMS IDENTIFIED BY WP2											
	Conditioned Wastes			Unconditioned wastes					Liquid Wastes			
TECHNOLOGY/DEMONSTRATOR	Bitumen	Cemented	Metals	Alpha/PCM	Inorganic	IX (organic)	Sludges	PVC	Organic	Oily	Chrompik	Comments
Geomelt (NNL)	x	√ Could make a surrogate and add radionuclides. Simulant of sea drums/degrading packages, would be of interest to UK and Belg in particular.	in small quantities	√	√	√	√ + additive (% water and specific nuclides TBC)	not as major feed	√	√	x	
HIP (NNL)	x	√	small quantities	x	√	x	√ + uranium surrogate	x	x	x	x	Need to calcine first, could tolerate small amounts of water, U contaminant, mirror large scale HIP with small scale, talc?
HIP (UoS)	x	√	small quantities	x	√	x	√ sludge + U	x	x	x	x	Potential to use VTT ash
SHIVA (CEA)	√ Info available from historic trials	x	x	√	√	√ (resins + other minerals, graphite etc)	√	√	not prefered	not prefered	x	no metal feeds
In Can Melting (CEA)	x	x	√ small quantities	√ inorganic only	√	x	√	x	x	x	√	High active, good for ashes
PIVIC (CEA)				√	√	√	√	√	√			
IRIS (CEA) - PCM incincerator	x	x	x	√	x	√	√	√	√	√ small % feed only	x	Produces ash
ELIPSE (CEA)	x	x	x	x	x	x	x	x	√	x	x	Liquids only (organic)
Thermal Gasification (VTT)	?	x	x	x	√	√	?	x	√	√	x	Could provide immobilised ash - organic IX
VICHR (VUJE)	x	x	x	x	x	x	x	x	x	x	√	Make samples from inactive simulant, and some active samples

Key	
√	Can be processed
√	Can be processed - selected wastestream for treatment in THERAMIN WP3
x	Cannot be processed
?	TBC

Table 1 Allocation of Wastestream to Demonstration Technology based on disucssions at WP3 kick off meeting

3.1 SHIVA demonstration (CEA/AREVA)

The SHIVA process is well adapted to organic and/or mineral, low and intermediate level waste such as ion exchange resins, zeolites etc. It allows, in a single reactor, waste incineration and ashes vitrification. The objective is to produce a glass wasteform following incineration of the organic fraction of the waste through mixing and conditioning the resulting material with glass frit/formers.

SHIVA will be used to demonstrate the processing of a waste stream containing organic ion exchange resins. SHIVA has been chosen on account of the organic content of the feed and the capability of the plasma treatment facility on the rig to destroy the organic component followed by the induction heating facility in the rig to vitrify the resulting phases into an homogenous product.

3.2 In Can Melting test CEA/AREVA

In-can can be used to produce a glass form package after in situ calcination of a liquid effluent. This process is simple and compact, and very well adapted for decommissioning waste: direct liquid feeding of the canister inside the furnace (without a separate calcination step).

The In-can melting rig at CEA Marcoule will be used to demonstrate the immobilisation of a dilute sludge stream.

3.3 Thermal treatment process based on thermal gasification, gas conditioning and flue glass cleaning – (VTT)

VTT has developed, constructed and tested a thermal gasification based treatment method, especially for spent ion exchange resins. Technically the method can also be used for reduction of volume of low level operational waste containing organic matter but waste has to be crushed before treatment. The existing test facility has been designed for treatment of spent ion exchange resins and thus the feeding systems have to be modified in order to enable treatment of other types of waste.

For the purpose of this demonstration the rig will be used to demonstrate the treatment and immobilisation of a wastestream containing organic ion exchange resins.

3.4 GeoMelt ICV (NNL)

NNL and Kurion have recently actively commissioned an In Container Vitrification (ICV) system, GeoMelt, in NNL's active rig hall in the Central Laboratory on the Sellafield site. The system is configured to take active feeds.

Melts are carried out on a 200L/500kg scale rig. Glass forming components are mixed with feeds and staged in the cast refractory box (CRB). A starter path is put in place and the melt initiated. As the melt progresses further material is added through the feed while melt (FWM) system. The melt is taken to completion over a period of around 24 hours and then allowed to cool.

On completion of the melt the product is sampled for analysis and characterisation. Samples will also be taken form the off gas train. Both mass and activity balances are derived from analysis data. In cases where active components are added, activity in the product and the off gas system is determined by gamma spec.

The first GeoMelt trial will be carried out on a simulated cemented package representing conditioned wastes such as failing cemented packages and sea dump drums as outlined.

The second Geomelt demonstration will be trialled on a heterogenous sludge stream.

For both streams the feeds will be doped with Cs-137 to allow an assessment to be made as to the caesium retention capability of the glass melts.

3.5 Hot Isotopic Pressing (NNL and UFSD)

Hot Isostatic Pressing presents a potential alternative for the treatment of some waste feeds. The demonstration of hot isostatic pressing will be carried out on two facilities. Firstly the HIP installed at UFSD which has a hot zone of 125mm by 75mm has the capacity to treat feeds containing uranium oxide/metal. The HIP installed at the NNL Workington facility has a hot zone of 400mm by 250mm and can be used to process non active feeds only. The use of the two facilities will enable the demonstration of alpha containing feeds and demonstrate scalability.

For immobilisation using HIP the feed materials must first be dried or calcined to remove moisture prior to the feeds being mixed with precursors and sealed inside a HIP can. The can is then hot isostatically pressed to enable a ceramic or glass ceramic wasteform to be formed, thus producing a wasteform suitable for storage and ultimate disposal.

For the purposes of this programme of work, HIP will be demonstrated on a uranium containing sludge stream containing metal and oxide at small scale at UFSD. A similar stream using surrogates for uranium will be demonstrated at larger scale at NNL demonstrating the scale up from small to larger scale.

3.6 VICHR vitrification process (VUJE)

Operation of the vitrification line VICHR is discontinuous that means that chrompik liquors are processed in batches; processing one charge of 50 dm^3 takes 24 hours. Concentration of liquid radioactive waste takes place in evaporator of a boiler type. Vitrification of mixture of glass melt and radioactive concentrate is performed in a middle-frequency induction furnace. The vitrified product is retained in metallic shell cartridge and is transported in containers to intermediary storage.

The VICHR facility will be used to demonstrate the vitrification of liquid RAW arising from the cooling of fuel elements after their removal from reactor of A1 NPP. The demonstration by means of practical operation of the vitrification plant will be executed in the full scale operation tests with simulates prepared based on analysis of the particular waste streams.

4 Table of demonstration options

Demonstrator	Waste stream	Waste Category	Product
Shiva (CEA/AREVA)	Organic ion exchange material	Unconditioned wastes	Vitrified
In Can (CEA/AREVA)	Sludges	Unconditioned wastes	Vitrified
GeoMelt 1	Cementitous wastes	Conditioned wastes	Vitrified
GeoMelt 2	Heterogeneous sludges	Unconditioned wastes	Vitrified
VTT	Organic ion exchange material	Unconditioned wastes	Solid residue
VICHR	Chrompik	Liquid wastes	Vitrified
HIP USFD	Uranium containing feeds	Unconditioned wastes	Vitrified/Ceramic
HIP NNL	Uranium surrogate containing feed	Unconditioned wastes	Vitrified/Ceramic

Table 2 Summary of demonstration technology vs waste streams

5 References

1 Minutes Work Package 2 Meeting, 02/10/2017, Andra, Paris

2 THERAMIN WP3 Kick-off Meeting, Friday 13th October 2017, Manchester Airport UK