The innovative plasma tilting furnace for treatment of radioactive and problematic chemical waste

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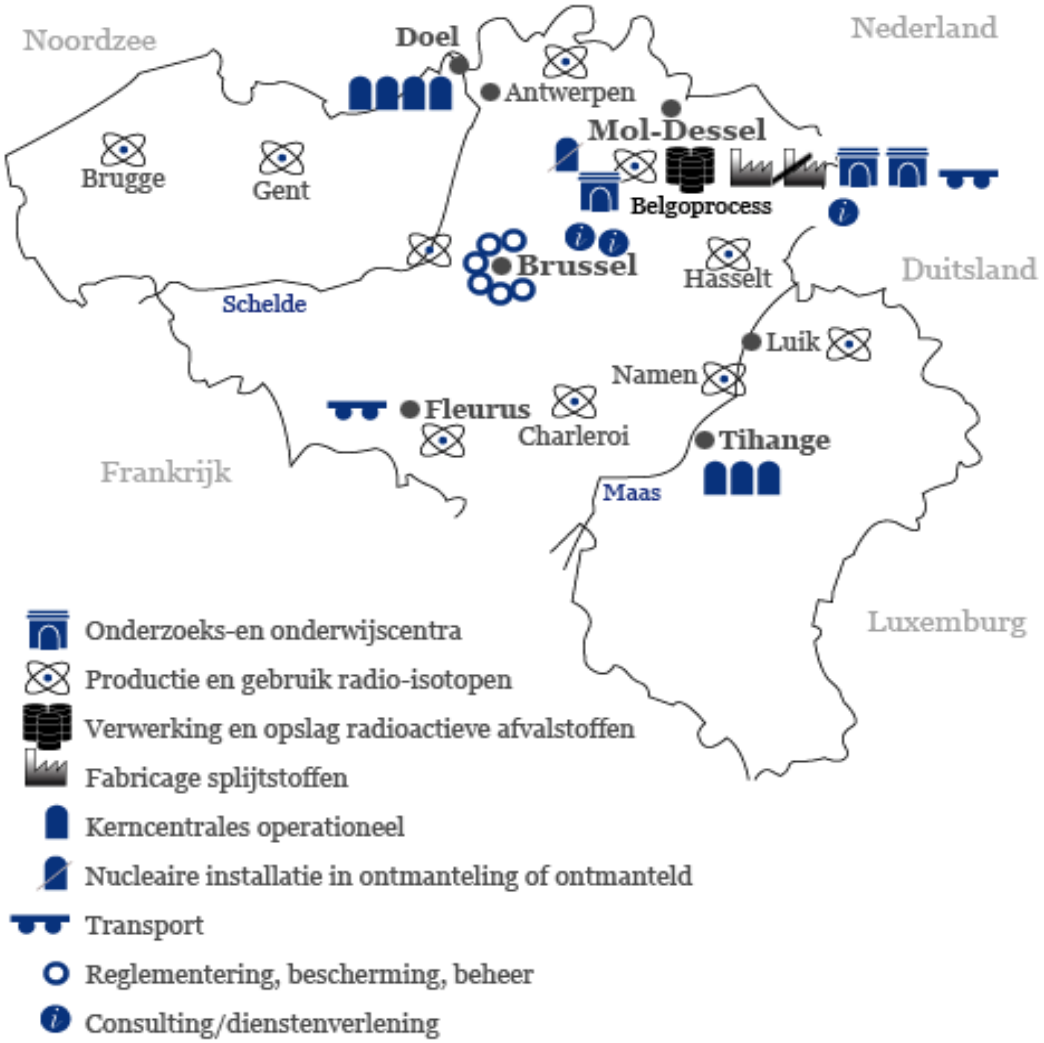
Belgoprocess

- Private company
- Established in 1984
- Operations for 2 sites
- 330 employees
- Turnover: € 50 million

Location



- Processing and temporary storage of radioactive waste: LW, ILW, HLW
- Decommissioning, dismantling & decontamination of obsolete nuclear facilities
- Integrated safety, environment and quality management
- Valorization of know-how

Plasma technology

Features of plasma technology

- ✓ Developed in the 60's for making high intense heat source for testing heat shields for the space industry
- ✓ Used for melting into metallurgical industry
- ✓ Used as heat source for treatment/melting hazardous waste. Typical temp is 5000°C
- ✓ After more than 4 decades first application for radioactive waste treatment was taken into operation in 2004
- ✓ With plasma, the organic material is vaporised in volatile hydrocarbons, carbon monoxide, etc. while non-combustible and other inorganic constituents are melted and transformed into **glassy slag**

Introduction Plasma

- Due to the higher temperature of the plasma the range of applicable complex waste types is much greater →organic material is gasified and iron, concrete, glass and other inorganic material is melted to form a slag

Applicability of thermal technologies to common waste types

Technology	Waste type						
	Organic Liquids	Inorganic Liquids	Organic Solids	Inorganic Solids	Mixed Organic-inorganic solids	Mixed organic-inorganic liquids	Spent resins
Calcination	NA	A	NA	NA	NA	NA	NA
High temperature incineration	A	A	A	NA*	A*	A	A
Incineration	A	A	A	NA*	A*	A	A
Melting	NA	NA	NA	A	NA	NA	NA
Molten salt oxidation	A	NA	A	LA	LA	LA	A
Plasma	**A**	**A**	**A**	**A**	**A**	**A**	**A**
Pyrolysis	A	NA	A**	A**	A**	A	A
Synroc	NA	NA	A	A	A	NA	NA
Thermo-chemical treatment	NA	NA	A	A	A	NA	A
Vitrification	NA	A	A**	A**	A**	NA	A
Wet combustion	A	NA	A	NA	NA	NA	A***

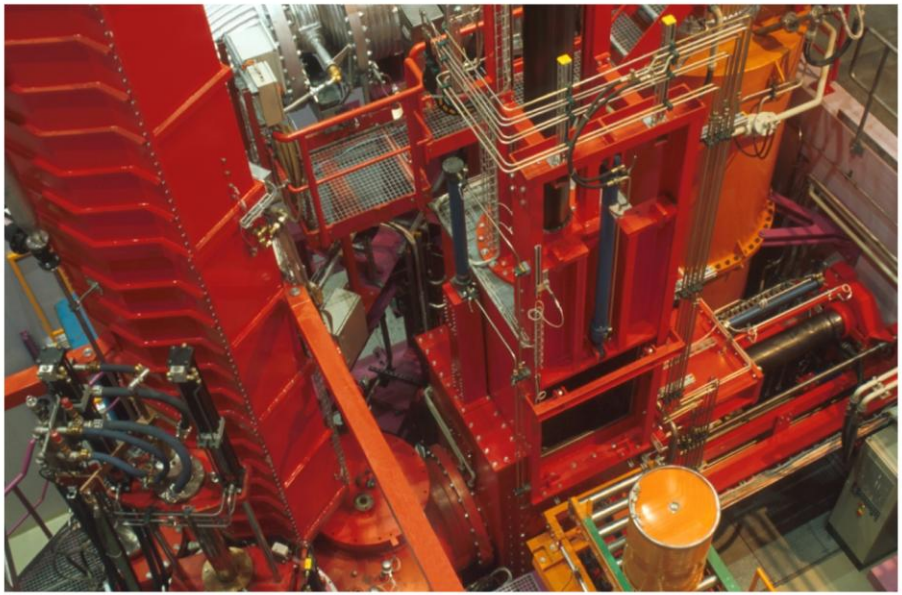
A Technology is applicable to this waste type.
NA Technology is not applicable to this waste type.
LA Technology has limited applicability to this waste type.
* Small pieces of inorganic are acceptable without causing damage or plugging of the system
** Applicable only for the granular or powder form of this waste type.
*** Applicable only to organic spent resins

IAEA TECDOC 1527

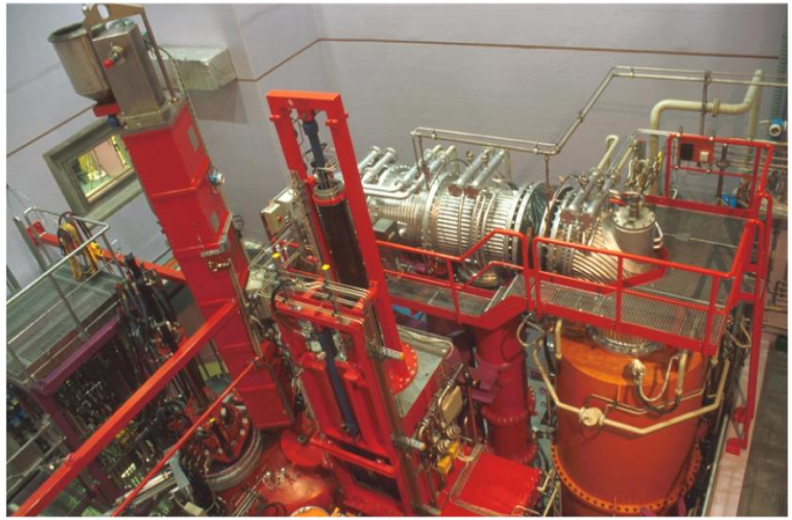
Plasma technology: Technological benefits

- One single process can treat many RAW streams
  - Applicable to solid organic and inorganic wastes, including asbestos
  - drummed spent resins and liquid wastes
- Process fulfils ALARA principles.
  - Waste packages can be treated “as is” and fed unopened without needed of pre-treatment or sorting out
  - Eliminating risks for contamination and limitation of dose uptake
- A robust waste form is obtained (similar as the vitrification)
  - free from any organic material and liquid/sludge
  - In accordance with the most stringent WAC for long term storage and disposal.
  - Suitable to recondition historical waste which do not fulfil WAC
- High volume reduction factor that minimises the overall cost for storage and final disposal

Industrial facility: Plasma plant ZWILAG in Switzerland



Successfully operated by ZWILAG from mid 2004



- Nowadays: 2 campaigns of 10 weeks per year
- About 500 drums or 100 ton per campaign
- About 140 pours per campaign
- End 2013: Total 8000 drums or 1300 ton
- Run on a commercial base

Industrial facility under construction PMF at Kozloduy NPP

Key project figures

- EPC Turn key project funded by EBRD & KNPP
- Signature of Contract: April 2009
- Supplier: Joint Venture (Iberdrola Ingeniería S.A.U Belgoprocess N.V.)
- Basic project data:
  - Treatment of Low and Intermediate Level Radioactive waste (Category 2a)
  - Inlet throughput: 65 kg/h , yearly: 250 ton/year
  - VRFs:
    - Un-compacted ≈ 80
    - Compacted ≈ 20
    - Supercompacted ≈ 2

Kozloduy NPP area

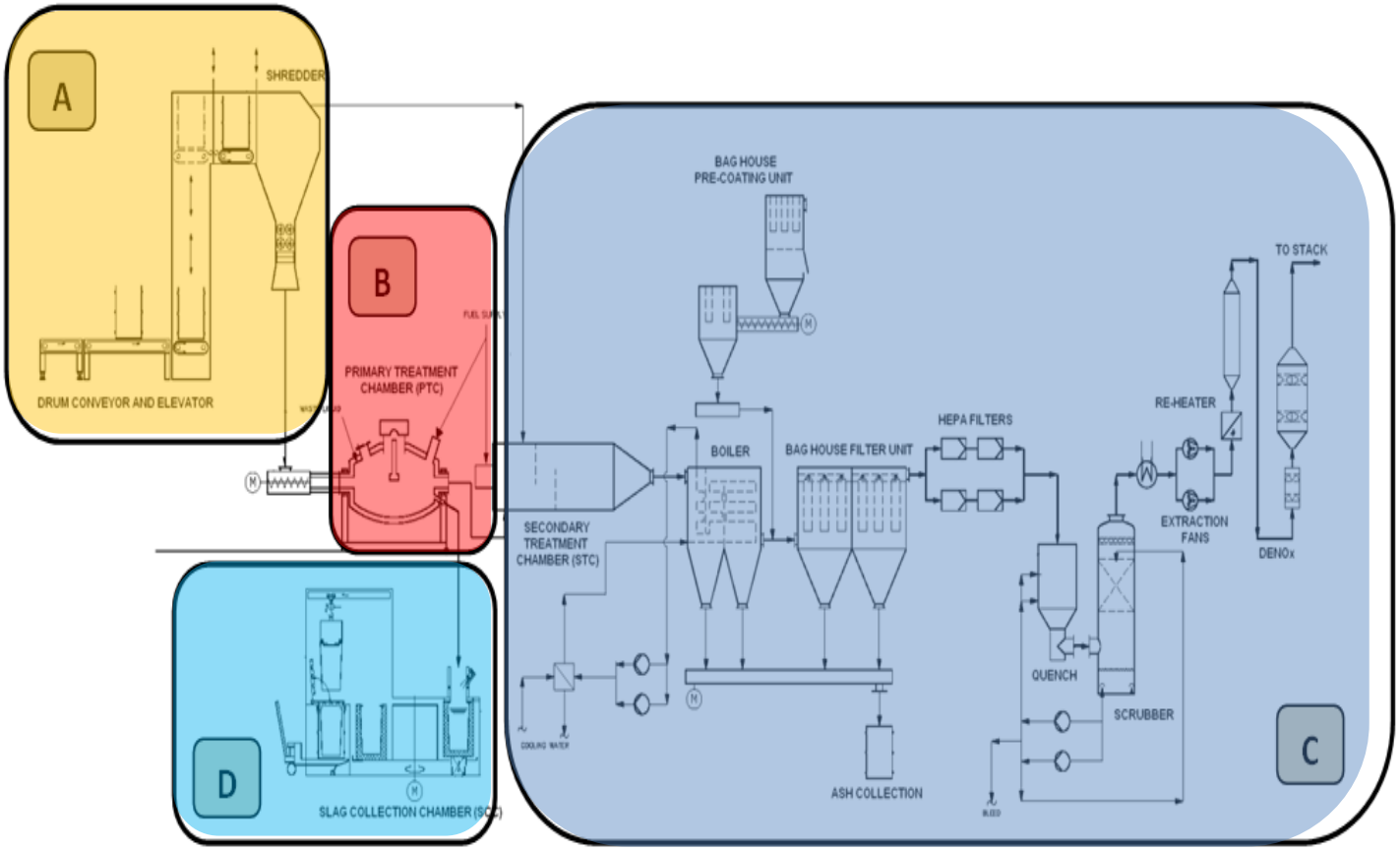
BELGO PROCESS IBERDROLA Ingeniería y Construcción

Waste to be treated

KNPP Radwaste types to be treated:

- Untreated waste: Organic waste in bags
- Pre-compacted waste: Mixture of organic / inorganic in 200 l steel drums
- Supercompacted waste (organic, wood, concrete)
- Liquid waste such as oils
- Spent resins
- Category 2a (*) 3,23E+05 Bq/kg (Co60: 57%, Cs137: 20%, others: 23%)
- Difficult to sort out (pre-compacted and supercompacted)

Flow diagram PMF

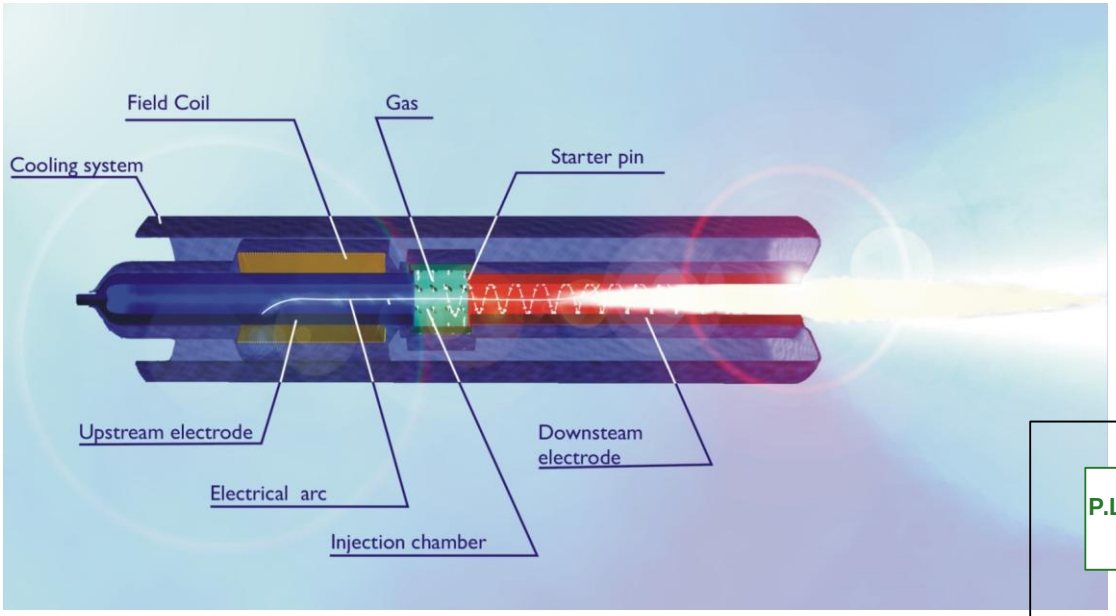


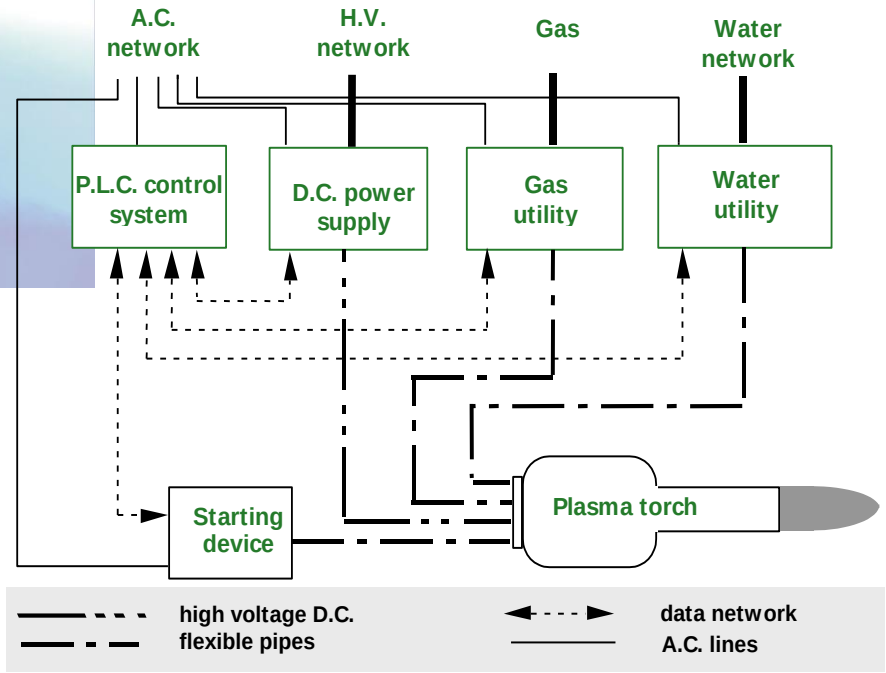
- Conveying, shredding and feeding system (A)
- Primary Treatment chamber with Plasma system (B)
- Off-gas cooling and cleaning system (C)
- Slag collection and cooling system (D)

Most significant equipment in KNPP PMF

- **Plasma treatment chamber** > fix furnace with tilt design
- **Torch** > 500 kW non-transferred arc plasma torch; temp 5000°C
- **Feeding system** > continuos through a 2 stage shredder
- **Off-gas system** > based on CILVA facility at Belgoprocess site
- **Slag collection chamber** > based on ZWILAG design

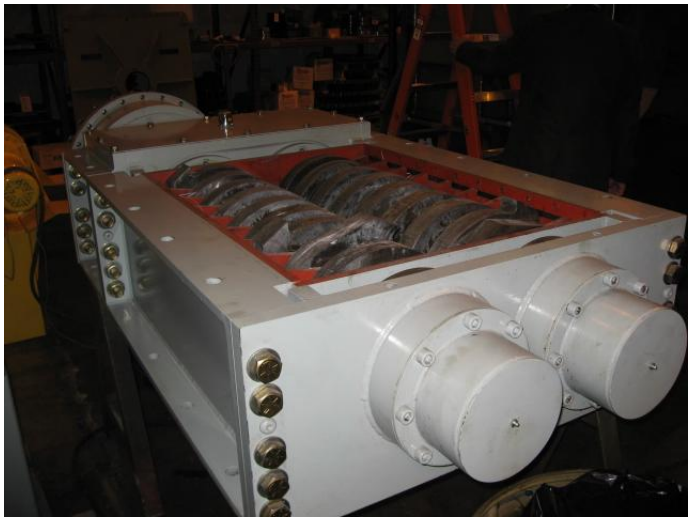
Main equipment: Non tranferrable torch





Main equipment: Shredder components

- Primary and secondary shredder
- Screw feeder
- Driving force is system has to accept 200 L Drums



Main equipment: Secondary Chamber (STC) and Off Gas System

- STC and off gas similar as conventional radwaste incinerators (based on CILVA incinertor at BP site))
- STC →the syngas, hydrocarbons containing Cl and S are oxidized to primary components such as CO2, H20, SO2 and HCl
- Off gas:
  - Boiler
  - Bag filter and HEPA filters
  - Srubber unit
  - Extraction fans
  - DENOX
- Released gases→Directive 2000/76/EC

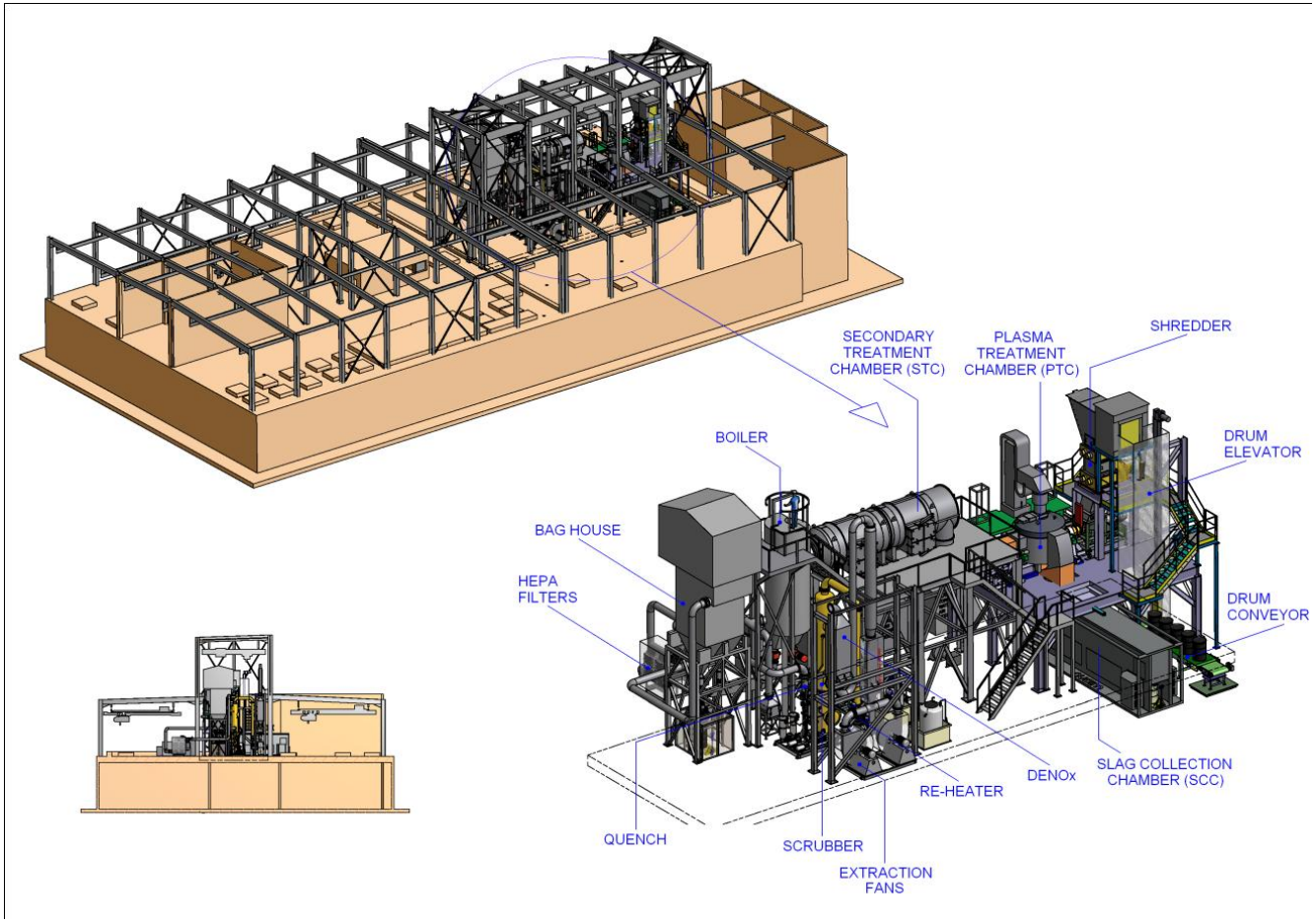
Main equipment: Secondary chamber (STC) and off gas system

Emissions level

mg/Nm³ (1) corrected to 11% O2	EC Directive 2000/76/EC	
	Daily average values	typical measurement results
Total dust	10	<1
CO	50	16
TOC	10	<2
HCl	10	1
HF	1	0,18
SO_2	50	15
NOX	400	<200
Heavy metals ▫ ∑ Cd, Tl ▫ Hg ▫ ∑ Sb, As, Pb, Cr, Cu, Mn, Ni V, Sn	 0,05 (2) 0,05 (2) 0,5 (2)	 <0,037 <0,01 <0,028
Dioxins and furanen : ng/Nm³	0,1 (3)	0,04

(1) Emissions are standardized at the following conditions: temperature: 273 °K; pressure: 101,3 kPa; 11 % O_2; dry gas
(2) average values over sample period min. 30 min. – max. 8 hours
(3) average values over sample period min. 6 hours – max. 8 hours

Inplantation in building AB-2



Project Planning PMF facility

- EIA (environmental report) 2010
- ISAR (safety report) Rev1 2010
- Approval Technical Design: 10/11/2011
- Approval Detailed Design: 07/05/2012
- FAT testing major equipment: April-June 2013
- Transport equipment to Kozloduy: Sept - Dec 2013
- Civil works : Aug 2015
- Commissioning and SAT in KNPP: mid 2016

FAT Slag Collection Chamber

FAT Shredder

FAT Shredder

- Purpose is shredding:
  - bagged waste,
  - drummed organic /inorganic waste (metal, concrete, building material, brics)
  - Supercompacted wood and concrete
- Total shredded: at least 50drums
- Shredded metals and concrete, brics send to Morcenx for intergration test

Video drum 5655.

Video feeder tube 5654.

FAT Off Gas

- Biggest mechanical and PLC part of the PMF facility
- Tests were carried on particulary:
  - PLC program
  - Simulation alarms
  - Control algorithm such as underpressure control, temperature control
  - Taking over redundant equipment

FAT and integration test Plasma furnace and feeder

Integration test with srew feeder July 2013

FAT and integration test Plasma furnace and feeder

- Testing with only inorganic waste
- Test with different compositions which are representative for the real RA waste:
  - Concrete, soil, sand, Al, Steel (with and without additives)
  - Concrete, steel, brick (with and without additives)
  - Concrete, building debries, steel, additives
- Prepare batches of 500kg→ about 200 L of slag;
  170 L is poured rest stays in furnace
- Torch has operated for about 200h; easily another 200h→ far above guaranteed lifetime of 100h of the upstream electrode

FAT and integration test Plasma furnace and feeder

Conclusions

- FAT test of major equipment and different compositions was succesfully carried out and is an important milestone for the project.
- Intregration test with plasma furnace and screw feeder give good confidence into the future operation of the PMF facility and shows the system is proven technology.
- We are acting as a process provider and take care for full integration of the radioactive waste treatment and use plasma torches as a tool.