Project supported by Andra under the
Investments for the Future Programme

PIVIC

In-Can incineration, melting and vitrification process

Duration: 25 years, including 15 years of R&D (2011-2026), supported under France's Investments for the Future Programme

Project launch: 04/2011

Total cost of the R&D program: €85 million

Including funding under the Investments for the Future Programme: €19.7 million

Type of financial support: Subsidy with ROI guarantees for the State

Locations: Bagnols-sur-Cèze, La Défense, Chatenay-Malabry

Coordinator: Orano

Partners:
- CEA
- Andra

Contact: Sylvain Pelletier, sylvain.pelletier@orano.group

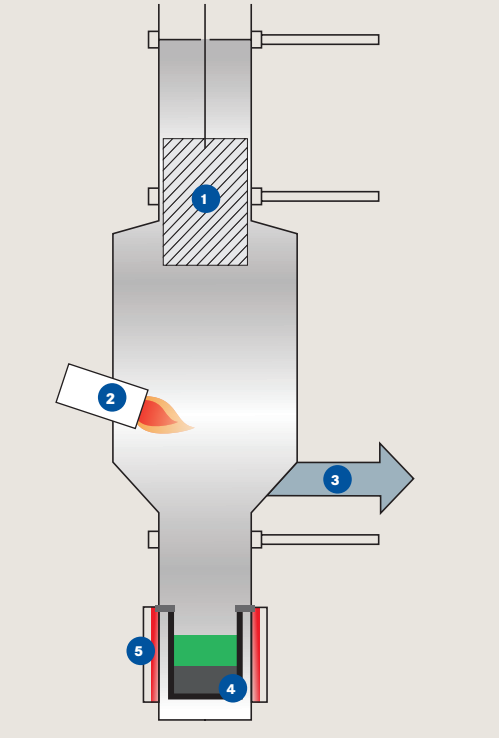
BACKGROUND

MOX fuel is used in around twenty nuclear power plants in France. It is a mixture of uranium oxide and plutonium oxide, produced by reprocessing spent fuel. During the operations carried out by Orano to make MOX fuel, filters, cables and protective clothing become contaminated by radioactive matter, mainly from the plutonium. This intermediate-level long-lived radioactive waste (ILW-LL), made up of metal, glass and organic matter (plastic), is to be conditioned in metal containers for disposal in the planned Industrial Centre for Geological Disposal (Cigeo). The total volume will be around 3,000 m³. This type of waste does however present certain problems: due to the effects of irradiation, the organic matter it contains produces gas, primarily hydrogen gas, with the related risk of explosion, as well as corrosive compounds that impact on the durability of the metal containers containing the waste.

OBJECTIVES

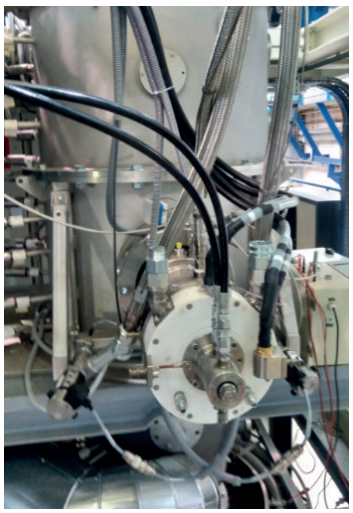
For disposal of this type of waste at Cigeo, the PIVIC process of In-Can incineration, melting and vitrification has been adopted. This process, a combination of processing by incineration and conditioning by melting/vitrification, should make it possible to:

- incinerate the organic matter contained in the waste using a plasma torch (Incineration);
- stabilise and condition the residue resulting from incineration in a glass matrix (Vitrification) ;
- melt the metal fraction by direct induction heating (Melting);
- perform the last two operations "In Can", i.e. the crucible in which melting and vitrification operations are carried out also serves as the waste container ("Can"). The Cans are thus replaced after every processing operation.

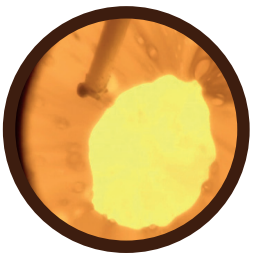


1. Radioactive waste, made up of metal, glass and organic matter, is fed into the upper section of the process unit (furnace).
2. In this upper section, a plasma torch heats the waste to a temperature of approximately 800°C. At this temperature, organic matter burns and is reduced to gas and ashes.
3. The gas is removed and sent to a treatment system.
4. The lower part of the process system (melting) is a metal canister (the *can*) which is heated by direct induction. Waste from the upper part (metal, glass and ashes from incinerating the organic matter) is placed in the can. Glass frit is also added.
5. The heat directly melts the metal, which in turn causes the glass frit to melt and the ash to be incorporated in the molten glass frit.

PIVIC: In-Can incineration, melting and vitrification process



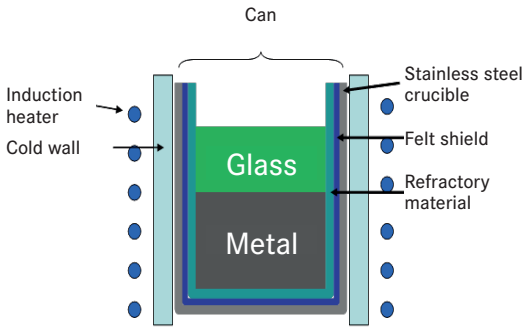
Plasma torch



Molten glass and metal:
- the part in dark yellow is glass;
- and the pale yellow part is metal.

Inside a "Can"

The final waste contained in the "Can" is thus made up of two layers: a layer of metal at the bottom (denser, resulting from melting metal waste), and a layer of vitrified product above (resulting from vitrifying ash). Prior to disposal, each Can is placed in a stainless steel overpack.



TWO-PHASE WASTE PACKAGE

PROJECT SEQUENCE

Orano, CEA and Andra began collaborating on this project in 2011. With a view to commissioning an industrial facility by around 2035, the PIVIC project has been divided into different stages over several years, including:

- up to 2016, an initial R&D stage on the sub-modules for the facility: the glass-metal melting module (lower part of the PIVIC process), and reduced-scale incineration/ vitrification tests;
- from 2016 to 2018, construction of the full-scale complete PIVIC pilot system, followed by a first stage of tests to check feasibility, up to 2020;
- from 2020 to 2023, a series of further tests and modifications of the pilot system as required in light of feedback from these tests. At the same time, industrial feasibility studies will be carried out;
- from 2023 to 2026, qualification of the process (primarily to verify operating in degraded conditions);
- from 2026, industrialisation of the process and its adaptation to nuclear constraints, up to commissioning in around 2035 at Orano's La Hague site.

EXPECTED RESULTS

Innovation

The PIVIC process is based on tried and tested technology blocks developed at CEA over many years: incineration (IRIS), gas treatment, metal melting, vitrification by direct induction (Advanced Cold Crucible Induced Melter), processing directly in the container (In-Can Melter), together with incineration and vitrification using plasma torches (SHIVA). The key innovation entailed in PIVIC is thus the fact of combining and adapting these different complex technologies to form a single process. Since the beginning of R&D studies, three patent families have been filed.

Impact on radioactive waste management

The PIVIC process will facilitate the disposal of waste the management of which, until completion of the project, is complicated. It will do this by:

- improving safety at the disposal facility since organic matter will be destroyed and a stable containment matrix produced (vitrified product related to a metal phase);
- conserving disposal capacity by reducing the volume of waste by a factor of eight.