TREATMENT OF SOLID WASTE HIGHLY CONTAMINATED BY ALPHA

EMITTERS: LOW-TEMPERATURE IMPACT CRUSHING, LEACHING AND INCINERATION

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ABSTRACT

Reprocessing plants, hot laboratories and fuel fabrication plants produce solid wastes containing residual amounts of plutonium and uranium in nitrate and oxide form at concentrations up to several tens of grams per m^3. Dismantling of nuclear facilities having handled these radioelements also generates large volumes of solid wastes highly contaminated with alpha emitters.

It is desirable to process these alpha wastes to recover valuable fissile materials and/or permit surface storage.

Solid waste treatment by low-temperature impact crushing and then leaching, after minimal sorting and classifying at the sites of production, meets the corresponding requirements for high volume reduction plus fissile material recovery or waste decontamination.

Additional volume reduction of crushed wastes containing mainly combustible materials can be obtained by incineration. This is facilitated by the low fissile material content after low-temperature impact crushing and leaching.

Sorted wastes can also be leached or incinerated directly after, in most cases, crushing by more conventional techniques.

LOW-TEMPERATURE IMPACT CRUSHING

The CEA Group in France has developed a highly efficient low-temperature impact crushing process using equipment proven in other industrial areas.

The reliability, safety and performances of the system have been verified during over two years of hot operation by a unit at the CEA's Cadarache nuclear research center in the South of France. This unit processes twelve 100-liter drums of solid wastes in a single operation, reducing their volume by a factor of about four. It can also directly process fully-equipped glove boxes, then delivering an approximately tenfold reduction in volume.

The crushing process accommodates a very wide diversity of solid wastes, including :

- glove boxes,
- laboratory glassware,
- low and medium strength metals (except stainless steel),
- vinyl, neoprene and polyethylene,
- ventilation filter cartridges and frames.

Process description (Fig. 1)

After sorting and neutron counting to quantify the contained fissile materials, the wastes are fed by an elevator to a cryogenic tunnel.

The maximum allowable size of each waste package or item is 1.8 x 1.5 x 1 meters, with a weight limit per batch of about 400 kilograms. This limit corresponds to twenty 100-liter drums.

The wastes are held in the cryogenic tunnel for about three hours on average to reduce their core temperature. Actual residence time is adjusted according to the density of the wastes and the chosen core temperature (which depends on waste type and can be as low as -150°C).

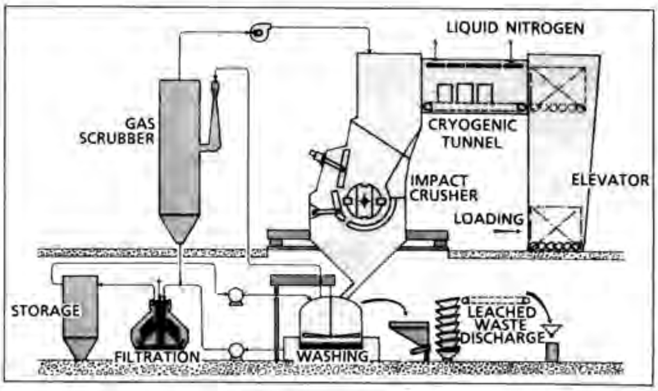

Fig. 1. Cryogenic Crushing and Leaching Principle Cadarache Facility.

Cooldown is obtained by heat transfer to liquid nitrogen circulating in heat exchangers.

The wastes are brittle to the core following this cryogenic treatment, making crushing very easy and also producing a smaller product that is easier to leach.

When removed from the cryogenic tunnel, the wastes are fed to a hammer mill with a 12-tonne rotor that rotates at a speed of 580 rpm. Disintegration is immediate and produces a product about 1 to 2 cm^2 in size. The rotor casing is made of sheet steel with replaceable liners in wear zones. Hydraulic jacks are used to open the casing for maintenance.

The low-temperature impact crushing unit at Cadarache also has a facility for leaching the crushed wastes (of a type different to that described herein).

LEACHING

Regulations in France, as in other countries, place strict limits on the alpha emitter content of wastes when intended for final disposal to a surface storage (or shallow subsurface storage) site, and highly sensitive measuring methods have therefore been developed for waste classification.

Given the very high costs of deep storage, any method that reduces alpha contamination to levels compatible with surface or shallow storage is of great interest. The CEA has therefore developed the PROLIXE waste leaching system and commissioned a first unit at its Fontenay-aux-Roses nuclear research center near Paris.

The system treats batches of about 30 kg of crushed material, which is equivalent to about 240 liters of uncrushed wastes. The feed can be produced by the low-temperature impact crushing method described above or by more conventional crushing techniques.

The PROLIXE unit at Fontenay-aux-Roses handles alpha wastes that are sometimes also strong emitters of beta and gamma radiation. It employs the oxidizing acid leaching process described below (Fig. 2).

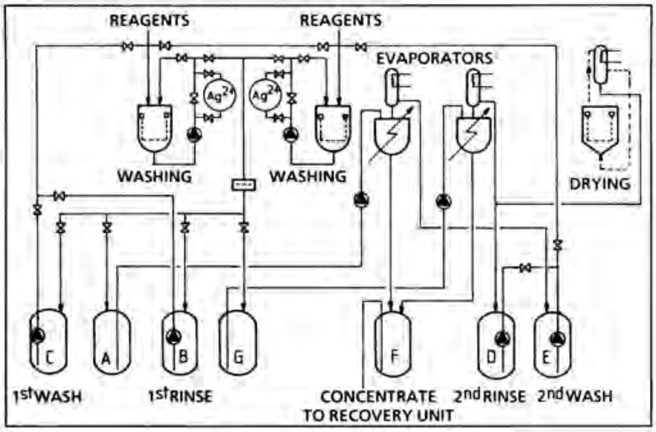

Fig. 2. Solid Waste Leaching Process.

Process description

The alpha emitters in wastes are usually in the form of oxides or nitrates. Although the nitrates are easily placed in solution, this is much more difficult for the oxides, especially those of plutonium. Research has shown that best results are obtained with a solution of Ag^{2+} ions in nitric acid. This solution has the additional advantage that leaching products can be recycled.

In the PROLIXE process, the Ag^{2+} ions are continuously generated in a reactor by electrolysis. The silver solution is then transferred to a leaching vessel, where it is placed in contact with the wastes before being returned to the reactor for Ag^{2+} regeneration (Fig. 3). After decontamination of wastes, the solution is sent to an evaporator and the resulting distillate recovered for reuse in leaching.

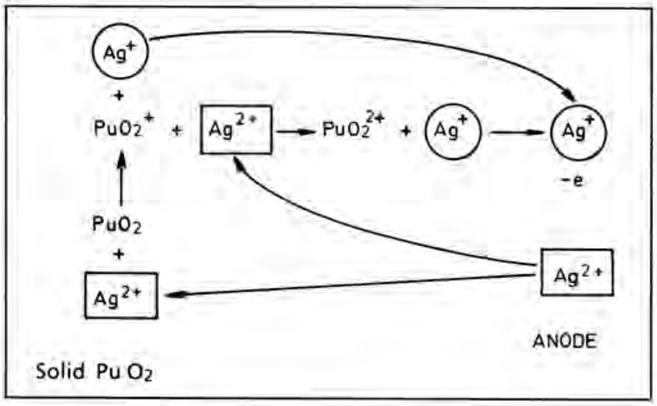

Fig. 3. PU O^2 Dissolution by AG^{2+} with Continuous Electrolytic Regeneration.

Leached wastes are rinsed with a neutralizing solution and then with water. After several rinsing cycles, the rinsing liquids are routed to an evaporator, from which the distillates are recycled and the bottoms grouped with those from the leaching stage.

The grouped evaporator bottoms are sent for additional processing to extract valuable materials such as plutonium (Fig. 4).

The alpha decontamination factor in the PROLIXE system is about 20 to 30.

The system also drys the wastes and packages them in 200-liter drums with encapsulation in a thermo-setting resin.

INCINERATION

Wastes from the processing operations described above and wastes with low alpha contamination received directly from the sites of production can be incinerated for maximum volume reduction. This is preceded, when necessary, by sorting to separate combustible from non-combustible materials.

When there is no risk of criticality and when it is not required to recover fissile materials from ashes, the standard high-capacity (25 to 100 kg/hour) excess air incinerators marketed by SGN are, in their "enhanced alpha containment" versions, suitable for this purpose. These incinerators are described elsewhere (1) and a unit of the sort will be commissioned in 1987 in Japan to process wastes from the Tokaï-Mura reprocessing plant.

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(1) See Proceedings of the 1984 Tucson Waste Management Symposium, Vol. 2, p. 235.

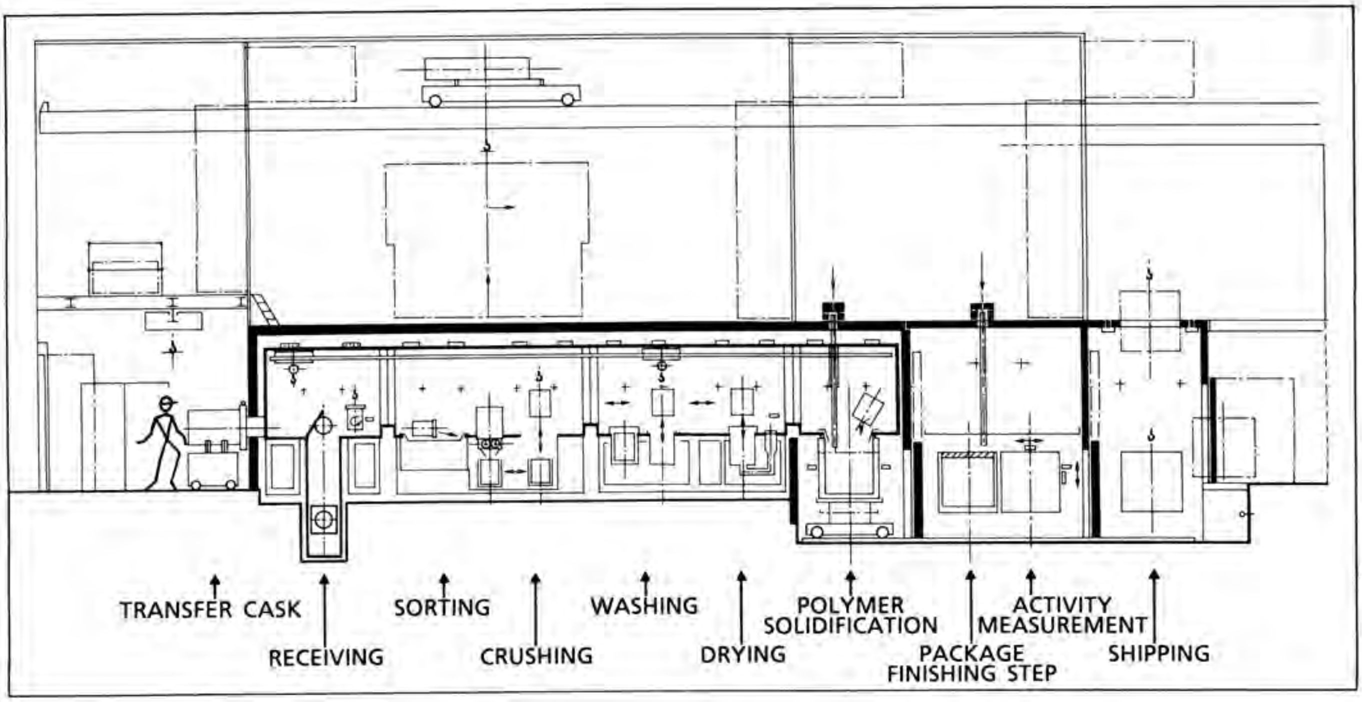

Fig. 4. Prolixe Cell.

The following description is instead concerned with special incinerators for combustible wastes with high fissile material content, development of which has benefited from the CEA's and Cogema's long experience with such wastes.

These special units employ excess air incineration or pyrolizing incineration and their required capacity is much lower than for the standard incinerators mentioned above. The incinerated solid wastes, which in the case of a reprocessing plant are usually in 100-liter drums, contain at least 1.5 grams of plutonium per drum and exceptionally as much as 250 grams. They consist mainly of cotton, rubber and plastics and have a net calorific value of about 30,000 kJ/kg.

Excess-air incineration (Fig. 5)

Excess air incineration units for wastes with high fissile material content incorporate lessons from the Marcoule reprocessing plant in France. A typical unit has the following main functions and is installed in glove boxes within a hot cell at subatmospheric pressure :

- waste feeding,
- crushing,
- separation of heavy fragments by elutriation,
- incineration furnace loading and waste combustion,
- ash recovery,
- offgas postcombustion,
- hot gas filtering,
- cooling by dilution,
- high-efficiency final filtration,
- process control and monitoring.

Features include :

- 1 or 5 kg/h standard capacity,
- electric heating of furnace and postcombustion chamber,
- temperature of 600/700°C in the furnace and about 1,000°C in the postcombustion chamber,
- waste reduction factors :
  . 40 to 60 fold reduction in volume,
  . 20 fold reduction in mass,
- distribution of ashes by weight :
  . 95.5 % in the incineration furnace,
  . 2 % in the postcombustion chamber,
  . 2.5 % in rest of unit,
- criticality prevention by controlling the mass of fissile materials.

Pyrolizing incineration

The CEA is developing special incinerators of higher capacity with a front-end pyrolyzing furnace, offgas burning in a postcombustion chamber, and reduction of the solid or pasty pyrolysis products to ashes in a separate calciner.

An incinerator based on these principles is expected to the marketed in the near future with a capacity of 7 kg/h.

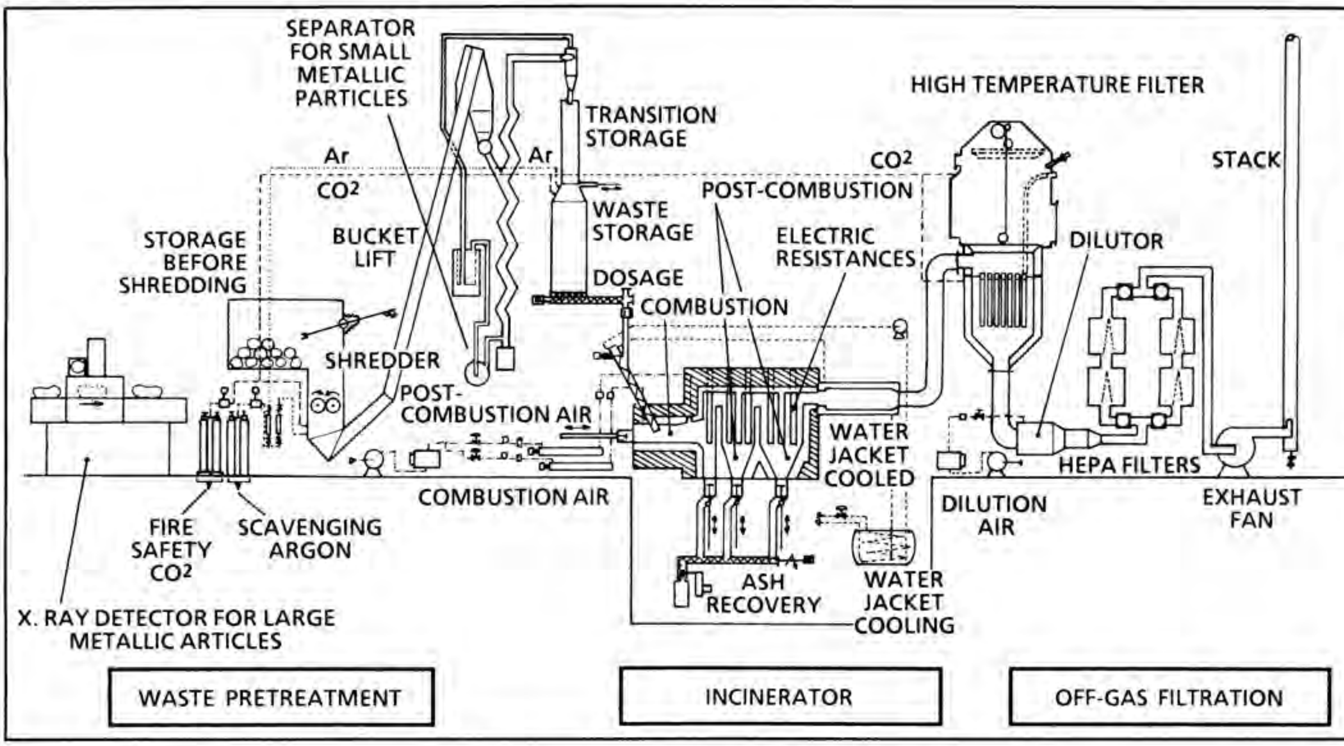

Fig. 5. Incineration Process Flow-Sheet.

CONCLUSION

The described processes and systems for treating solid wastes highly contaminated with alpha emitters represent only some of the developments underway within the CEA Group for improved handling and management of such wastes.

They stand apart, however, because they are all solutions of proven flexibility, ease of operation and very high safety that have demonstrated their efficiency in units operating under hot conditions. In some cases, the corresponding industrial experience is very long. Cogema's incinerator at Marcoule, for example, out of which all the described incineration systems have been developed, has a nominal capacity of 1 kg/h but has already processed over 20 tonnes of wastes with an observed actual capacity of 1.2 kg/1.

As a result of such experience, all waste treatment systems can be supplied with fully automatic control.

The described arrangements and features are not obligatory and the various processes are easily adapted and/or combined to provide the best solution in each waste treatment application.

Low-temperature impact crushing, for example, can be combined with leaching or used by itself simply as a method of volume reduction. It has the great advantage of accepting solid wastes directly and with minimal handling, including relatively very large items (of particular interest for dismantling wastes).

When waste treatment includes leaching, the purpose can be to recover fissile materials, or to reduce the alpha content of wastes to levels compatible with surface storage, or both.

The corresponding choices are made on a case-by-case basis as part of an overall study that integrates cost factors, including the costs of final waste disposal.