French experience and plans

From mounds and monoliths to deeper exploration

by J.J. Lefèvre

Experience acquired over 40 years through an extensive nuclear power programme has enabled France to develop a corresponding comprehensive waste management policy. It covers rules and regulations, health and safety aspects for both the short and long terms, technologies (from installation design to decommissioning), and the conditioning, transport, and disposal of wastes.

Who does what: The structure

In France, the Government carries the responsibility for the broad outline of waste management policy, national rules, regulations, and control, as well as authorization and licensing of nuclear installations. (At this time, the Ministry of Industrial Redeployment and Foreign Trade is the main body concerned.) Waste management policy is proposed to the Government for approval by the Commissariat à l'énergie atomique (CEA).

Waste producers themselves mainly carry out short-term waste management, including temporary storage at the production site. Long-term disposal is the responsibility of a specialized agency – Agence nationale pour la gestion des déchets radioactifs (ANDRA). It was set up by the Government in 1978 within the CEA.

ANDRA's mission covers:

- Selection, installation, and management of long-term disposal sites
- Establishing specifications (to ensure observance of Government safety standards) for the system of barriers between the waste and the environment
- Ensuring quality assurance and control at sites of production, treatment, conditioning, and disposal (apart from usual inspections and controls carried out by specialized regulatory authorities)
- Forecasting production of waste volumes to ensure timely programming of disposal sites.

Funding for ANDRA comes from waste producers on a cost basis, according to volume and nature of the delivered wastes. Pre-funding for future disposal sites also is charged to producers, based on future delivery forecasts. Waste producers include power plants of Electricité de France (these produce the greatest volume); Cogéma, the fuel cycle CEA subsidiary; CEA civil and military research centres; and the usual miscellaneous producers, such as universities, hospitals, and industry.*

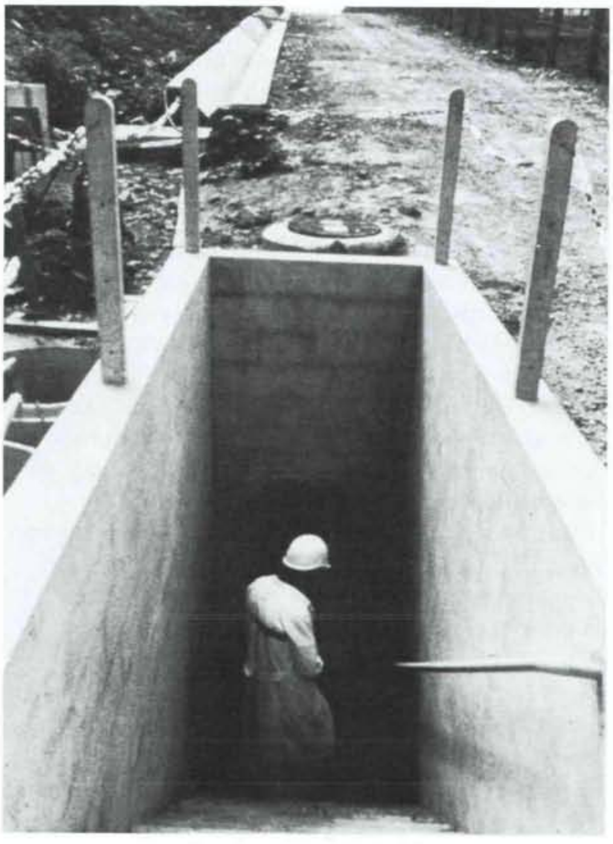
Research and development mainly is carried out and funded by CEA, with some contribution from the European Community and waste producers (through ANDRA). Waste producers, mainly Electricité de France (EdF), conduct some research in their own laboratories, as do various universities and institutes either under contract to CEA or through their own funds.

Technology transfer from CEA to industry is ensured through equipment and service suppliers, many of them subsidiaries of CEA or EdF that also conduct some research on their own.

Waste management policy

Waste management policy was defined in a programme prepared by CEA, approved by Government, and published in 1984. Nuclear wastes have been divided into three categories, according to both the technological problem posed by radioactivity levels and to the health-protection problem posed by long-term potential hazards.

Entering a monolith's "inspection gallery", which contains a system to catch and drain water.



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(All photos courtesy of CEA)

* Cogéma is the Compagnie générale des matières nucléaires.

The adopted policy is to ensure total isolation of waste from the environment for the short-term (the first few centuries). This is achieved through successive barriers: the waste form and packaging, the disposal site, and engineered barriers. For long-lived wastes, this isolation period, which can only be guaranteed for a limited time period, is followed by delayed transport and dilution of remaining radionuclides through the natural geological barrier.

In other words, short-lived wastes can be disposed of in surface or near-surface sites, provided total containment is ensured until radioactive decay has brought down potential hazards to acceptable levels. This stipulation limits the total quantity of short- and long-lived activity that any site can take in, as well as the content (long-lived or alpha emitters) of each package. Above this alpha limit, all other wastes must be further protected by a sufficiently stable and efficient natural barrier, such as deep geological formations, to reduce to an acceptable value the radioactivity levels that might reach people in the distant future.

Mounds and monoliths for LILW

Three waste categories have been established, the first of which is:

• *Category-A.* This covers low- and intermediate-level wastes (LILW) containing mainly beta and gamma emitters whose half-lives do not exceed 30 years, and with an alpha-emitter content no higher than 0.01 curie per tonne (Ci/t) averaged over the site. (The maximum alpha emitter for an individual package must not normally exceed 0.1 Ci/t. This can be extended, on a case-by-case basis, to 0.5 Ci/t.) These limits take into account radioactive decay from short- or mean-lived beta emitters to long-lived alpha emitters (such as plutonium-241, americium-241, neptunium-237). Therefore, they are computed for the end of the monitoring period – 300 years after site closure. They have been set on the basis of maximum credible risk scenarios over the long term. These include construction of a major road through the abandoned site (with corresponding exposure of the labour crew), or housing construction on the site (including children's playgrounds) and the resulting public exposure. Acceptable exposure limits are those recommended by the International Commission on Radiological Protection (ICRP) for an individual's lifetime.

Waste forms can be cement grouts, bitumen, polymer resins, or mixed forms. The engineered site barriers developed by ANDRA are the now technically well-known tumulus, or mound, and monolith concept. Short-lived waste of relatively high radioactivity, or whose packaging does not provide adequate containment in itself, are lowered into concrete compartments. Cement is poured over each layer and steel is laid over the last layer as reinforcement. The completely filled and cemented compartments constitute the monoliths. These are built in pairs, separated by a two-metre gap to house any radiating packages. The entire structure rests on a layer of concrete, with a built-in drainage system that collects any rain or water infiltration by gravity.

Very low-level and suitably conditioned wastes are stacked on the platform top of the monoliths. Concrete waste containers are placed along the sides and across the platform, again to make up compartments that house less-resistant drums. Backfilling material is poured over the entire pile, which is finally covered with a layer of clay. Again, a system collects any rain or water that might infiltrate. The pile makes up the tumulus, or mound, which is then covered with topsoil and vegetation.

The one available disposal site of this sort has been operating for 16 years in the northwest of France, close to the La Hague reprocessing plant. It will be filled to capacity (400 000 cubic metres) in a few years. Total volume of category-A waste is expected to reach about 800 000 cubic metres by the year 2000.

Transuranic wastes

The second grouping of wastes is:

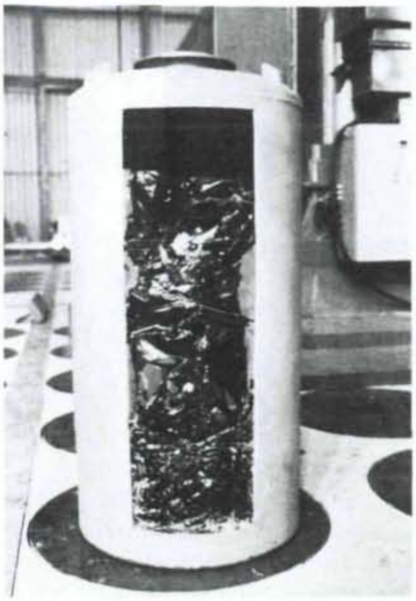
• *Category-B.* These are transuranic (TRU) wastes that stem mainly from reprocessing activities and some military and research wastes. A great effort has been made, and still is in progress, to reduce their quantity through sorting; separation and recycling; and combining or adding to volume reduction by incineration, crushing, or leaching, for example. Embedded in cement grouts, polymer resins, bitumen, or mixed matrices, all TRU wastes are placed in temporary storage, awaiting availability of deep geological disposal. The volume is expected to reach 60 000 to 80 000 cubic metres by the year 2000.

High-level wastes

The third grouping is:

• *Category-C.* These are high-level wastes (HLW); that is, liquid reprocessing wastes of very high radioactivity. The policy is to vitrify them, as has been done since 1978 at the AVM industrial plant at Marcoule. (The AVM vitrification process has been adopted by British Nuclear Fuels for its Thorp reprocessing plant at Sellafield.) By 1985, over 1000 steel containers had been produced at Marcoule that contain about 400 tonnes of glass, representing the equivalent of about 12 000 tonnes of fuel.

Two larger size plants are being built for the vitrification of liquid HLW from the reprocessing of enriched fuel at La Hague. (The first, called R7, will be available for non-active tests in 1986.) Each of these two plants will have three vitrification lines, each with a capacity of 50 litres per hour, producing 25 kilograms of glass per hour. Total capacity will be sufficient to service both reprocessing plants – that is, liquid HLW from reprocessing 1600 tonnes of light-water fuel per



Mock-up of a glass container in the AVM vitrification plant's storage hall at Marcoule.

The bottom layer of a monolith at the La Manche disposal site: re-inforced walls and room for concrete grout.

Inside the vitrification cell of the R7 facility being built at the Cogéma reprocessing plant in La Hague.

year. Each step of this process has been tested in a prototype (AVH, a proposed plant similar to AVM) at Marcoule.

Research now is aimed at improving knowledge of long-term behaviour of the glass and its container in real disposal conditions; improving the flexibility of the process; and improving reliability, thereby reducing the quantity of secondary wastes, for example.

The glass containers will be stored for cooling for a probable minimum period of 30 years, which leaves some time for preparing a final disposal site – but not much – since real disposal conditions must be known beforehand to optimize the overall barrier system.

Programme for disposal sites

Since the existing low-level waste disposal site will be full within a few years, the Government has given ANDRA the go-ahead to submit two further sites for approval, so that one or both could be commissioned in 1990. Preliminary work done by the Bureau of Mines (BRGM) for ANDRA made it possible to narrow down the search to three counties. At least one site has been identified as probably suitable and qualification work now is in progress. For ANDRA, this has entailed an intensive information campaign among all sectors of the population, starting with local authorities and the media.

As far as deep geological disposal is concerned, the Government has requested CEA to submit a proposal for a site for an underground laboratory by the end of 1987. It is hoped that the site will be good enough to qualify as a repository. No specific geological formation has been named: The choice is open to salt, granite, clay, or shale. Announcement of where the explanatory work will be done will be made in 1986. Should the laboratory findings prove that the site is not suitable, another laboratory would be built at another site that would be developed into a final repository.

Although some options still may be open, the general lines of France's waste management policy are laid and most techniques are available here and now.