THE MANAGEMENT OF LOW AND MEDIUM LEVEL RADIOACTIVE WASTE IN FRANCE

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THE ORGANISATION OF RADIOACTIVE WASTE MANAGEMENT IN FRANCE

The long-term industrial management of radioactive waste which is or will be produced, mainly by the electronuclear industry, is handled in France by a national agency, l'Agence Nationale pour la Gestion des Déchets Radioactifs (ANDRA), which was formed in 1979 within the C.E.A. by an interministerial order.

ANDRA is responsible for long-term management operations. ANDRA's goals are:

- design, siting and building of radioactive waste disposal centers,
- management of radioactive waste disposal centers,
- establishment of radioactive waste conditioning and storage specifications,
- contribution to research and development (R & D).

ANDRA's first priority has been the disposal of low and medium activity wastes whose volume, although considerably below that of other industrial wastes (below 1/1000), nevertheless creates storage problems on the sites where they are produced.

The aim of this paper is to present ANDRA's industrial policy for the disposal of low and medium activity wastes, its work schedule, the principles for safety in "subsurface" disposal, the Centre de la Manche which has been in operation since 1969, the cost and financing of this management and the steps taken by ANDRA to ensure assistance as regards R & D, engineering and industrial operation.

ANDRA'S WORK-SCHEDULE AND POLICY

ANDRA's work-schedule is directly linked to France's electronuclear program which was put forward by the Government and adopted by a large majority in the Parliament last October; it is expected (Table I) that by 1990, 59 electronuclear reactors with a total output of 60 gigawatts will be providing 70 % of the electric power, that is to say 27 % of the overall power (supplied) in France.

TABLE I

NUCLEAR POWER

	1981	1990
NUCLEAR POWER PLANTS IN OPERATION	30	59
NET POWER (MWe)	21.806	59.700
% / ELECTRIC ENERGY	38	69
% / TOTAL ENERGY USES	10,3	27

Furthermore, two extensions of the existing reprocessing plant will be built at LA HAGUE, one of which will be used in its first year to reprocess foreign fuel.

On the basis of this electronuclear program we can forecast production and delivery to ANDRA of wastes in the three categories normally taken into consideration when dealing with the problems of long-term disposal : (Tables II, III, IV)

Category A or Beta-Gamma wastes:

Low and medium activity, short-lived (less than 30 years) wastes. The wastes mainly come from the everyday running of nuclear reactors, and the fuel cycle (90 %), and from various users of radioisotopes (10 %). They will represent a total volume of 480,000 m3 in 1,992 and 800,000 m3 in 2,000.

Category B or alpha wastes:

Low and medium activity wastes containing a significant amount of long-lived radioisotopes, in particular, alpha emitting radioisotopes. These wastes come mainly from the fuel cycle and, in particular, from reprocessing. The forecast for delivery of alpha wastes to ANDRA is as follows:

. 8,000 m3 in 1,992 considering present stocks
. 35,000 m3 in 2,000

Category C or vitrified wastes:

High activity from reprocessing which are or will be vitrified. The forecast for delivery to ANDRA is as follows :

. 800 m3 in 1,992 considering present stocks
. 2,000 m3 in 2,000

The French policy of long-term disposal, like that of many other countries, takes into consideration different factors including :

- the advantage of decreasing radioactivity,
- the risk of human intervention or of the effects of water,
- the length of time during which the artificial barriers remain effective,
- the total cost of the operation.

After optimization of these differents factors, the French policy has been : (Table V)

- Subsurface disposal of Beta-Gamma wastes, since barriers are available which are guarenteed to remain effective for at least 300 years. The site is supervised throughout this period.

Table II. "Low and Intermediate Activity" Wastes Cumulated Production 1981 to 1990 and 2000.

Table III. Previsions of Waste Deliveries.

	1982	1992	1995	2000
L.I.A.	25,000 / 170,000*	35,000 / 490,000	40,000 / 600,000	41,000 / 800,000
ALPHA	0 / 0	2000 / 8000	3000 / 17,000	3000 / 35,000
VITRIFIED	0 / 0	700 / 700	100 / 850	200 / 1700

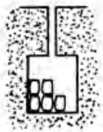
*Previous deliveries included

ANNUAL DELIVERIES ◣ CUMULATED ◢ IN M3

Table IV. January 1981 - Waste Deliveries - (Volume in m^3 delivered in 1981).

	DRUMS	BLOCKS	CONTAINERS	FILTERS	TOTAL
C.E.A.	1,406	100	380	-	1,886
COGEMA	3,590	301	1,899	136	5,926
ARMY	1,300	-	-	-	1,300
E.D.F.	3,280	3,849	1,187	69	8,385
OTHERS	2,743	-	-	111	2,854
TOTAL	12,319	4,250	3,466	316	20,351

TABLE V RADIOACTIVE WASTE CLASSIFICATION VOLUME MANAGEMENT

CATEGORY "A"	CATEGORY "B"	CATEGORY "C"
BETA-GAMMA WASTES	ALPHA WASTES	VITRIFIED WASTES
SHORT HALF-LIVES* LOW AND INTERMEDIATE ACTIVITY ^{137}Cs 30 Years ^{90}Sr 30 Years ^{60}Co 5 Years ^{55}Fe 2.5 Years	LONG HALF-LIVES* LOW AND INTERMEDIATE ACTIVITY Ex^{237}Np 210^6 Years ^{239}Pu 2.410^4 Years ^{243}Am 8.10^3 Years ^{241}Am 4.10^2 Years	LONG HALF-LIVES* HIGH ACTIVITY* Ex^{237}Np ^{60}Co ^{239}Pu ^{90}Sr ^{243}Am ^{241}Am ^{243}Am
 SUB-SURFACE STORAGE	 DEEP STORAGE	 COOLING DEEP STORAGE
TRANSPORT-HANDLING NON-IRRADIATING <200mrad/h IRRADIATING >200mrad/h	TRANSPORT-HANDLING NON-IRRADIATING <200mrad/h IRRADIATING >200mrad/h	TRANSPORT-HANDLING IRRADIATING >>200mrad/h
CUMULATED PRODUCTION IN THE YEAR 2000 ~800.000m^3	CUMULATED PRODUCTION IN THE YEAR 2000 ~35.000m^3	CUMULATED PRODUCTION IN THE YEAR 2000 ~2.000m^3

*PRINCIPAL RADIOELEMENTS

- Disposal of alpha wastes in geological formations deep enough to avoid human intervention. Only the effects of water need be taken into consideration.

- Disposal in deep geological formations of vitrified wastes after a prior cooling period on the surface or "in situ".

On the basis of these forecasts and orientations, ANDRA will draw up a program for creation of disposal centers which will be submitted to the Government in 1,982.

SUBSURFACE DISPOSAL OF BETA-GAMMA WASTES (TECHNICAL SAFETY OPTIONS)

Let us return to our main subject : long-term Beta-Gamma waste disposal.

The only radioactive wastes whose final disposal is at present authorized in France are final disposal of Beta-Gamma wastes. This is carried out by means of land surface or subsurface disposal according to the following basic principle :

Protect operating staff, and the public in general from radiological hazards which may occur during normal operations or abnormal situations.

To reach this objective, the radionuclides must be kept isolated from the biosphere until they have sufficiently decreased and the residual potential risk can be considered negligible whatever may occur.

Since the wastes which can be accepted in a shallow land repository have, by definition, short radioactive half life, this isolation has to last no more than a few hundred years. History and archeology have shown us that this can be achieved.

As the wastes have been neutralized and immobilized and as they have an extremely low self dispersibility, the repository is intrinsically passive. Only action coming from the outside, such as by human beings or water could disperse the radioactivity into the biosphere.

To prevent human intervention, access to the repository must remain under the control of an official body for a long time. Only a Governmental organization would seem to be able to do this for a period lasting over 200 or 300 years.

To prevent water from reaching wastes and then transporting radionuclides, there are a series of possibilities :

- Selecting a site in an arid area to take advantage of the natural protection. In that case is not necessary to build facilities involving very sophisticated engineering.

- Designing and building elaborate, water and air-tight facilities. In that case the characteristics of the site are less important and the repository may be located almost anywhere.

Because of the climate in France, the solution chosen has been a multi-barriers system which does not need a site with particular characteristics.

For safety assessment, the repository itself and its environment are considered as a system which must be safe during its whole life time.

The different phases in the life of shallow-land repository :

- The operational period : period during which the repository is under a process of continuous building. The wastes are handled and disposed of either on surface areas or in pits or trenches.

The backfilling material is poured between the packages and a temporary cover or the final one is placed over the wastes.

The site is under permanent supervision and access is restricted.

During this period, which may last a few decades, the potential risks are essentially due to conventional operations as in other nuclear facilities.

At the end of this period the repository must have its permanent configuration with the definitive cover and all surveillance features and equipment installed.

- The surveillance period :

This period starts at the end of the previous one. At this stage nothing but surveillance and access control is provided on the site by the authority in charge on the repository.

Nevertheless, if any failure were to be detected in the repository mainly in the cover, it would be repaired in order to guarantee required isolation.

This period is anticipated to last about 200 or 300 years, the decision to end it being taken according to the safety analysis made with the final inventory of the wastes actually disposed of.

In fact, it is the risk evaluation scheduled for the end of this period which determines the acceptability of the waste during the operational period.

For short-lived nuclides the amount of activity which can be disposed of must be such that, at the end of surveillance period, whatever may happen after radioactive decrease will be negligible.

For the long-lived nuclides which may exist in low or intermediate level waste, the activity which may be disposed of, must be initially low enough to be considered negligible, whatever happens at the end of the period of surveillance.

- The unrestricted access period :

This starts at the end of the previous one, when it may be considered that the remaining risk is negligible.

It appears from on-going evaluations that the remaining theoretical risk during this period would be mainly a risk of ingestion through water for beta-gamma radionuclides, and mainly a risk of inhalation for alpha radionuclides in case of air-borne dust during unforeseen civil works.

In practice the limit of alpha emitters content in low or intermediate level wastes is determined by this last consideration.

The barriers concept (Table VI)

The barriers may either prevent water from entering the repository (these are called "preventive barriers"), or inhibit transportation or release into the biosphere (these are called "remedial barriers").

- Preventive barriers

As a protection against rain, one can generally find :

- a covering layer made of low permeability material such as clay, with an efficient drainage system, overcapped by a gently-sloping layer of soil,
- the backfilling material wich can be waterproof,
- the package,
- the waste form which has a low leaching rate.

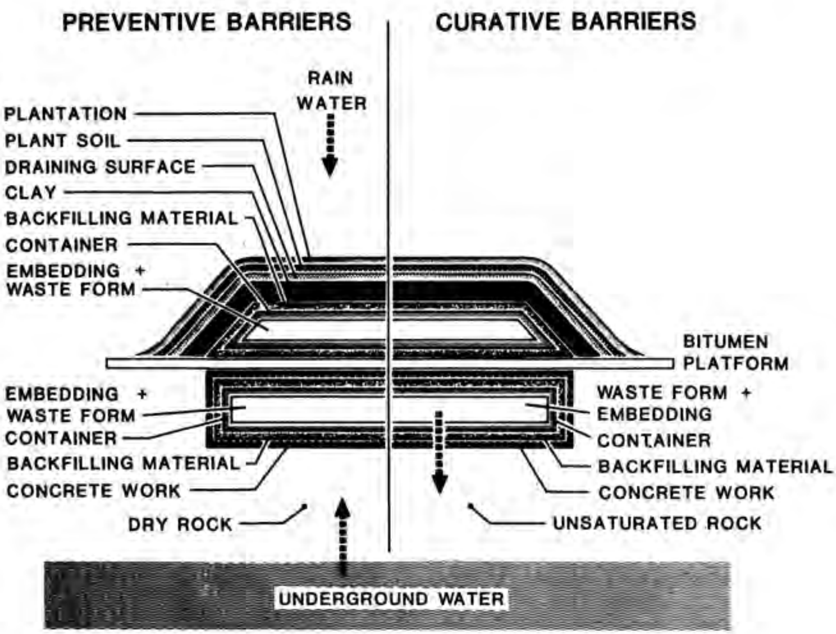
As a protection against ground water :

- a dry layer of soil between the bottom of the repository and the water-table,
- the tight bottom of the repository which may be either a concrete or a bitumen pad,
- the backfilling material,
- the waste form itself.

- Remedial barriers

In the very improbable case of water infiltration it is possible to collect it at a central check point, to remove it and to repair the cover where it leaked.

Table VI. Radioactive Materials Containment Barriers.



Although it is really difficult to imagine how a leak through the bottom of the repository could occur, other measures can contribute to reducing the risk for surrounding human beings :

- sorption properties of the previous barriers which may have already trapped the radionuclides,
- the dry layer of soil,
- the dilution either in the water-table or in the rivers which active material might reach.

THE FRENCH PRACTICE OF SHALLOW-LAND REPOSITORY

The first shallow-land repository has already been in operation for 12 years. It started in 1969 in the northwestern part of France just beside the second reprocessing plant. It is called the "Centre de la Manche".

At the beginning, the waters came mainly from research centers, from reprocessing plants, which were in an early stage fo development, and from hospitals and universities.

Since a large program of power reactors has been developped, reactor wastes are increasing sizeably. In 1,985 they will represent over 60 % of the total volume. Table IV gives the breakdown of the deliveries per category for 1,981. Most of these wastes are fully conditioned and packaged by the producers before they are sent to the repository.

Embedding materials are generally : concrete, thermo-setting resins, bitumen.

There are two main complementary possibilities for disposing of the wastes:

- putting them in trenches, dug under the original ground level,
- creating large tumuli on concrete or bitumen pads above the original ground level.

Trenches

According to our safety regulations, intermediate level wastes must be put in concrete arrangements.

To meet this specification, trenches are dug under the ground level above the water-table, a concrete pad is made and constitute bottom of the pit. Then the waste containers are placed in the trench. After each level in the trench is filled, it is backfilled with concrete. When the trench is full and reaches the ground level, the top is carefully sealed, covered with a layer of bitumen making a tight pad above which a tumulus will be built.

For contact handled-wastes, it is possible to build large trenches and to put the wastes inside with limited radioexposure for people working close to the packages.

Irradiating wastes are transported in shielded casks and placed in narrow trenches (less than two meters wide) formed by large concrete arrangement of non-irradiating wastes. This allows a continuous shielded process avoiding irradiation of workers.

These special trenches for remote handled wastes are also backfilled with concrete.

Tumuli

Two kinds of wastes may be accepted in tumuli :

- those whose activity is low enough to be considered as low level waste. That is, the activity concentration in a package (in Curies per cubic meter) must be lower than 1000 times the Maximum Permissible Concentration for drinkable water for the general public. In that case, it is not necessary to backfill them with concrete .

- those whose package is good enough to ensure containment on its own as good as that given concrete trenches. This is the case for large concrete blocks whose reinforced concrete walls are 10, 20 or 30 cm thick and inside which wastes are embedded either in concrete or in resins.

To build the monoliths, these large blocks are used to constitute huge walls. Between these walls drums or steel boxes are stacked.

During the operational period, all around the trenches or pads, gutters collect rainfall in order to ensure that no contamination has leaked out of containers or to detect and remove any contamination water.

After the underground concrete arrangement or the tumuli have been completed and overcapped by the final water-tight cover, these gutters are used for inspecting the repository. They allow the effectiveness of the cover to be checked.

At present, 150,000 m3 of wastes have already been received and safely disposed of at the Centre de la Manche.

The foreseeable overall capacity of this center is about 400,000 m3.

THE POLICY OF OPERATING, ENGINEERING AND R AND D ASSISTANCE

ANDRA the owner and prime operator of Centre de la Manche (CM), entrusts the management of the CM to an operator under its supervision. The operator is the Societe Industrielle de Stockage et d'Assainissement (SISA).

For engineering, ANDRA calls on the services of different industrial consulting engineers.

Furthermore, from the R and D standpoints, ANDRA relies on the operational units of the CEA and on the services of different organizations engaged in this field.

FRENCH EXPERIENCE IN LMW DISPOSAL AND CONCLUSIONS

Directly in charge of waste disposal since 1,979, ANDRA has already drawn some conclusions from the past experience obtained in shallow-land repositories.

- The regulations which exist in France for creating and operating a "Basic Nuclear Installation" provide a good framework for managing a shallow-land repository safely (Table VII).

- Almost all short-lived wastes produced in the French nuclear program may be disposed of in shallow-land repositories and only alpha wastes and high level waste need a geological repository.

- Some special kinds of wastes might be better disposed of by sea-dumping (tritium bearing wastes, for instance) or in geological formations (high level activated materials).

- ANDRA has to establish precise specifications for the acceptance of packages and must inspect them carefully to fulfill licensing requirements and to convince local authorities and the public of the quality of its management.

- Shallow-land repositories do not need a large surface of land, even if little is dedicated to reducing volume. For instance, only 30 to 40 hectares are needed to dispose of overall production of short-lived wastes in the year 2,000.

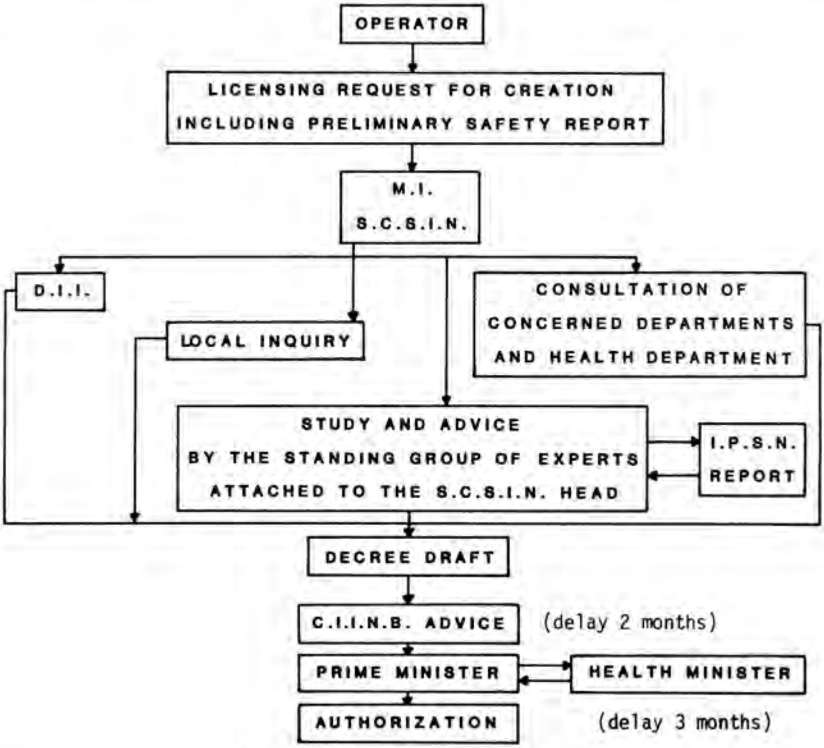
- The use of shielded transportation casks instead of concrete integrated drums will reduce the volume of waste to be stored from the new electronuclear plants.

- To improve the management of waste transportation, particularly by train, ANDRA, EDF and SNCF have created a "Waste Transportation Management Office". The geographical position of each waste carriage can be known at any moment.

- All the operations (deliveries, transportation, treatment, packaging), concerning the waste of the small producers are managed by a special management office under the control of ANDRA. A unique bill is delivered covering the total cost.

TABLE VII

PROCEDURE RELATED TO CREATION AUTHORIZATION OF BASIC NUCLEAR FACILITIES



M.I.:	Ministère de l'Industrie (Industry Department)
S.C.S.I.N.:	Service Central de Sûreté des Installations Nucleaires (Safety Central Division of Nuclear Facilities)
D.I.I.:	Direction Interdépartementale de l'Industrie (Industry Interregional Management)
I.P.S.N.:	Institut de Protection et de Sûreté Nucléaire (Nuclear Protection and Safety Institute)
C.I.I.N.B.:	Commission Interministérielle des Installations Nucléaires de Ba (Interdepartmental Commission of Basic Nuclear Facilities)

- The cost of disposal charged to ANDRA's customers is not too expensive : each given type of package has its own cost disposal which takes into account many parameters, such as :

Size, class of activity, irradiation level.

The average disposal costs for standardized packages in 1,981 are about :

. $ 300/m3 for wastes disposed in tumuli,
. $ 500/m3 for contact waste disposed in normal concrete arrangements,
. $1000/m3 for remote handled wastes disposed of in special trenches.

Although all technical aspects of shallow-land repositories are satisfactory, and while few problems arise with the population living around a repository already operational for a long time, some public opposition still remains to the creation of a new disposal facilities just as will any new nuclear installation. Basically, public opinion acceptance remains the only true bottleneck in the radwaste disposal.