DESIGN, MANUFACTURING AND COMMISSIONING OF MOBILE UNIT FOR EDF (DOW CHEMICAL PROCESS)

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ABSTRACT

To process their spent ion exchange resins and the liquid wastes, EDF has ordered to PEC a mobile unit using the DOW CHEMICAL binder.

This paper is presenting the EDF's design requirements as well as the new French regulation for waste embedding.

The mobile unit was started in January 1983 and commissioned successfully in January 1985 in the TRICASTIN EDF's power plant.

FRENCH ELECTRO-NUCLEAR DEVELOPMENT PROGRAM

The French electro-nuclear development program began many years ago with the entry into service of the "graphite-gas-natural uranium" system (CHINON A - SAINT LAURENT A).

The PWR System was introduced at the beginning of the 1970's. FRESSEHNEIM 1 started up in 1977, and up to the end of 1984, 31 (900 MWe) PWR units have been commissioned. The program of 900 MWe units is to be continued until 1987 with three new units starting up.

The first PWR 1300 MWe unit (PALUEL 1) has been coupled with the grid during the last year (1984) and by 1990, 19 units 1300 MWe shall be in operation. The fast breeder reactor SUPER PHENIX shall be commissioned in 1985.

The discussion below covers only wastes coming from PWR units.

MOBILE CONDITIONNING UNIT

The French regulations being stronger and stronger, EDF, in conjunction with PEC, has initiated a research program to define an efficient matrix.

PEC Engineering has proposed the DOW CHEMICAL binder, and has been in charge of a first evaluation program (summer 1982).

The process requirements set up by EDF are discussed later in this paper.

The first program being successful, EDF decided in January 1983, to order from PEC Engineering a mobile unit using the DOW CHEMICAL polymer.

The design criteria has been defined together with EDF in order to fulfill as completely as possible all their requirements.

EDF decided also to use a mobile unit expecting to gain the advantages listed below:

- Use of the most efficient industrial process.
- Reduction of the investment costs by using one unit for many power plants.
- Availability of a specialized team to operate the unit.

The PEC Engineering's mobile unit was started in January 1983; the manufacturing and assembly was completed in May 1984 and preliminary tests have been proceeded from June 1984 to September 1984.

In November 1984, commissioning test at the TRICASTIN Power Station started. The commissioning tests have been jointly done by PEC Engineering and STMI, our EDF subsidiary.

DESIGN CRITERIA

The design criteria of such a unit can be divided in several families which are:

1° - The safety requirements

2° - The process requirements

3° - The EDF's specific requirements

We will explain below below some of the requirements and solutions we have brought.

SAFETY REQUIREMENTS

The safety study related to the mobile unit has taken into account not only nuclear hazard but also health hazard due to the handling of some CHEMICAL products typical to the DOW CHEMICAL process.

Radiation & Contamination

The dose rate to the operators has been minimized as much as possible by :

- Using biological shielding of the main components or components handling medium activity products. The design activity was 300 Ci/m^3 of Co 60 and the contact dose rate of the vertical panels of the unit less than 10 mR/h.
- Locating the operator outside the radioactive room. All the operations are actuated remotely and controlled from the control board by TV cameras.
- The crane operators are located in a protected area and does not need to be close to the unit for normal operation.
- The unit, being a full processing one, with its own pumps, ion exchange dewatering device..., does not produce any secondary wastes. All the wastes are processed by the unit itself.

Chemical Hazard

The handling of the DOW CHEMICAL binder has been assimilated for the handling of styrene, with all the consequences regarding:

- health safety of the operators,
- fire detection and fighting

A full detailed study has been completed to define the hazardous areas and to establish the means to reach maximum safety. Some of the systems are listed below:

- ventilation system,
- styrene detectors with alarms,
- flame and smoke detectors with extinguishing systems.

Others

In addition to radiation and health safety, but related to, the design and the choice of the equipment has been made having in mind the consequences for radiation and health in case of mechanical and electrical failures.

For example, it is always possible to empty and flush any equipment to decrease the maximum radiation dose rate the operator could receive.

For some difficult equipment, sepcial procedures have been defined to minimize the exposure time.

The main items, or considered as major safety items, are maintained in service in the event of a power failure by using batteries.

The process control of the unit is controlled by a microprocessor preventing operators mishandling.

PROCESS REQUIREMENTS

The process criterias have been defined by EDF on one side and by the French authorities in charge of the waste burial site on the other side.

EDF Requirements

The EDF requirements were:

- The process must be able to solidify either liquid waste and spent ion exchange resins.
- The volume of waste for ion exchange resins. must be minimized (dewatering).
- The process must be controlled to ensure a perfect reproduceability.
- The capacity must be as high as possible.

French Authorities Requirements

The French authorities requirements were related to the quality of the solidified products. The final regulations not yet divulged will be published soon. The following values are extracted from a project of this regulation.

Leaching resistance: The leaching criterias are the function of solid specific activity and given below.

Specific Activity $\beta\gamma$(Ci/T)	Leaching Rate (cm.d^1)
10	2.10^{-3}
10	5.10^{-4}

If they are some α radio-isotopes, the leaching rate has to drop down to 10^{-7} cm.d^{-1}

Mechanical strength: The mechanical strength must be over 50-psi.

Thermal chocks resitance: A temperature cycling test, between +5°C and - 20°C and + 5°C and + 40°C with water spray must not affect the mechanical strength more than 30% and the leaching rate no more than 50%.

Test Procedure

Four stages must be followed to specify a type of embedded substance and, if appropriate, to determine its eligibility for disposal.

Stage 1: Non radioactive laboratory tests

To determine the mechanical characteristics of the coated substance, homogeneity, exfoliation, withdrawal and to correct the method followed.

Stage 2: Radioactive laboratory tests

To verify the resistance of the embedded substance to leaching.

Stage 3: Scale 1 radioactive tests

For industrial development of the process, the verification of homogeneity, mechanical characteristics and temperature rises.

Stage 4: Scale 1 radioactive tests

To check the resistance of the embedded substance to leaching and its behaviour under irradiation.

OTHER EQUIPMENT

Some special requirements have also been taken into account which are specific to EDF such as:

- The unit must be able to handle EDF containers already approved by the burial center.
- Any container leaving the unit must be fully capped ready for shipping without any local assistance of the operators.
- The unit should be able to be modified later for using steel casks instead of concrete liners.
- The size of the unit must be such that it can be located in existing EDF power stations.

THE PROCESS

A first preliminary evaluation program using different matrices has been initiated in 1981/1982.

As a consequence of this first program, EDF decided to start with PEC an evaluation program using the DOW CHEMICAL binder.

Because of very promising results, EDF ordered from PEC a first unit, and in the same time gave to PEC the charge to proceed the qualification program as described earlier.

All the tests purpose was to adapt the DOW CHEMICAL process to the French wastes and regulations.

Describing in details such program would be too long. So let us summarize the points which have been examined.

Laboratory Tests

Ion exhange resins:

- embedding ratio
- impact of ion exchange quality (steam
- generator, blowdown, RCV, mixture).
- difference between clean ion exchange resins and loaded one (Fe, Co, Ci,...),
- impact of products feeding sequence,
- impact of borates,
- impact of cruds.

Concentrate:

- embedding ratio,
- impact of boron concentration,
- influence of embedding ratio on reaction parameters,
- impact of concentrate temperature,
- impact of reagents feeding sequence.

Pilot Tests

The first purpose of the pilot test was to define the relation between laboratory test and pilot test (55 gal. - 100 gal.), regarding the reaction parameters.

The second purpose was to complete the design parameters such as:

- mixing paddles design
- rotation speed with the mixer selected,
- feeding rate of
  - catalyst
  - promoter
- mixing time for
  - ion exchange resins
  - concentrate
  - catalyst
  - promoter

Additional Tests

In addition to the tests listed above, PEC and EDF are looking after the possibility to complete the test program by the following studies.

- Leach rate modification according:
  - embedding ratio
  - solidification parameters (gel time, temperature)
  - irradiation
- Mechanical strength modification with irradiation dose.

The DOW CHEMICAL binder contains styrene, which is a dangerous product, EDF and PEC are also looking after the possibility to replace the styrene by a less toxic and higher flash point solvent. This program was started in 1983, but being very complex, it is still running, ans is considered by EDF as a "must".

COMMISSIONNING

The manufacturing of the unit was completed in May 1984 and the first non active commissioning tests have been proceeded at the work-shop.

Those tests were undertaken from June to September 1984 where final adjustments were made.

During this period the unit produced:

- 16 containers of ion exchange resins,
- 4 containers of concentrates

with no major problems.

A problem was observed on the completion of the final plug; the DOW polymer binder being very reactive, and gave some cracks on the surface. A study program was initiated immediately and the problem has been solved today.

In November 1984, the unit has been moved to one EDF site, namely TRICASTIN, to start the radioactive commissioning program as well as operators training.

To test all the circuits, a first series of 18 containers (from 250 to 300 one useful volume) has been made with low level radioactive steam generator blow down spent ion exchange resins.

End of January, this test being satisfactory, the unit has been starting to solidify ion exchange resins (40 Ci/m^3 eq Co 60) from chemical and volume control system and from reactor cavity and spend such pit cooling system.

There were no process difficulties during those tests. All the containers have been solidified without problems.