DISPOSAL OF CREYS MALVILLE SODIUM

P. ALPHONSE
EDF/CIDEN, D.O. RN, Creys Malville, France

Abstract

When the IAEA dismantling level 1 is reached, the fissile materials have to be removed and the plant fluids and products treated. This document describes the fate decided for the sodium wastes from Superphénix and succinctly describes the method adopted for treating reactor sodium.

1. BACKGROUND - RECAP OF THE CONTEXT (1997/2001)

After the declaration to the French National Assembly on 19 June 1997, of the decision to finally shut down the Creys power plant, and after 6 months of alternating hopes and disappointments as to a possible restart in order to complete the use of the 1st core, and perhaps even the 2^{nd} core, the first structured strategic reflection for definitive shutdown began in February 1998. One of the main aims of this reflection was to prove the technical feasibility of this dismantling based on the assumption of reasonable costs and time limits. In this context of 'technical doubt', fuelled by the media, a very determined attitude had to be adopted.

At the beginning of 1998, it was decided to make a total commitment to this project (fast studies and execution of sodium treatment and dismantling) while at the same time observing the safety and regulatory aspects. This option also met a keen requirement of the Department of the Environment for a technically irreversible operation so that reactor restart would no longer be an option.

The decree of the 31^{st} December 1998 finalized the immediate and definitive shutdown of Creys nuclear power station and authorized unloading of the fuel. It also covers sodium removal and storage operations and the dismantling of the non-nuclear installations within the framework of a safety report and general rules for monitoring and maintenance approved by the DSIN (French Nuclear Installations Safety Authority).

At the EDF-CIDEN, a so-called reference scenario based on the discharge of sodium sulphate salts to the Rhone river (reflecting the Scottish approach used in the sodium disposal process, which is economically less expensive but 'sensitive' in terms of its acceptance by the media and the environmental lobby) has been developed and alternative solutions put forward.

This scenario requires the installation of a primary sodium draining system as well as the treatment of certain significant retentions in the vessel, and the construction of a 'reactor' to transform the sodium into caustic soda. This reactor would be of the same type as on the Sodium Disposal Process for PFR on DOUNREAY site, based on the principle developed by the CEA for the Rapsodie programme (NOAH process). An early commitment to sodium draining before the very specific competences for this complex operation are lost was another strong additional incentive drawn from the experience feedback from other sites.

Faced with the risk relating to the discharge into the Rhone which this scenario involves, a fallback scenario for treatment involving caustic soda cementation and long-term storage was chosen (with several possible technical options). The possibility of intermediate storage of all sodium products, which would release the reactor from the monitoring requirements related to the liquid sodium, was not retained since the cost of this solution would cancel out the indirect gains made on the operating costs.

In 2001, the scenario of sodium sulphate discharge into the Rhone was abandoned in favour of the scenario known as treatment by cementation. In spite of a significant difference in the cost, due to the climate surrounding the Public Inquiry File, it is no longer certain that a new application to discharge to water in this first solution would be looked at favourably or that it would be authorized within reasonable delays. This decision is consolidated by the desire on the part of EDF General Management to proceed to "immediate" dismantling of the nine definitively shutdown nuclear sites, thereby reducing the programming for Creys Malville to a total duration of 25 years. The risk involved in an uncontrollable administrative delay therefore became unacceptable.

To conclude this first part, the choice of the sodium treatment solution for Creys Malville is based on a so-called on-line drainage system (no buffer storage) using tools fabricated for this operation, followed in real time by treatment at 6 metric tonnes/day in two caustic soda transformation reactors (NOAH process) nearly identical to the SDP ones. A total of 13 860 m^3 of caustic soda from primary sodium will be mixed with cement to make packages (26 400 cubes of 1 m^3) that will be stored on the surface since they are only very slightly radioactive (< 100 Bq/g), and this in less than 2 years.

2. TECHNICAL CHOICES FOR PRIMARY SODIUM DRAINING

The pool-type Superphénix reactor (larger version of Phénix) consists of a main vessel filled with 3300 metric tonnes of sodium subjected to only 320 JEPP of radiation and currently maintained at 180°C by an external electric heating system on the security vessel, permissing shut down the primary pumps.

As no clad failure happened the radioactivity of this sodium is relatively low, thereby simplifying the problems of pollution and radiation protection.

The main primary sodium is extracted using an immersed electro-magnetic pump able to output up to 20 metric tonnes/hour into the head tanks upstream of the treatment process (tanks currently store the secondary loop sodium which will have been previously destroyed by the same process). This pump is installed in place of a fuel transfer machine through the upper slab. Special drainage piping is also fabricated for this operation. An alternative gravity run-off solution by drilling through the reactor vessels bottom was examined from the technical and economic standpoints, and rejected.

Prior to this main drainage process, a certain number of additional items of equipment (5 planned to date) will be introduced into the vessel inner structures in order to pump or siphon off the main retention sodium.

An end piece adaptable onto the electromagnetic pump suction line will clean the bottom of the vessel (target: to leave only 40 L maximum). Another end piece will clean the retentions from the double bottom of the recovery plates, themselves drilled prior to draining so that the sodium runs out towards the bottom of the vessel.

Two self-priming siphon systems will eliminate the retentions from the bottom support of the reactor and the connection of the stepped walls and shell located above by gravity flow of the sodium at the bottom of the vessel during draining. Models of these systems are under development or testing with water in order to validate the dimensional and hydraulic data.

All the retentions described above represent a volume of approximately 38 m^3 (1% of the total volume) which once treated will be reduced to 1.4 m^3 (< 0.1% of total volume), except for the residual sodium wetting the surfaces.

Studies to obtain even better results are in hand.

The target is to eliminate as much as possible the sodium after integral carbonation (treatment of approximately 10 to 20 mm sodium thickness).

Sodium draining is accompanied by methods for checking its operation, in particular a periscope, close-circuit TV and bubble-type level gauge installed in the hot sodium manifold.

Means of inspection after draining have also been envisaged. These are probes equipped with ultrasonic sensor or fibroscope to ensure that no retention remains for a good carbonatation and perhaps water filling.

The main identified risks for these operations are the possible escape of sodium (with fire risk — although the sodium is 'low-temperature' which reduces this risk), and the hydrogen risk generated by the transformation into caustic soda. A safety report evaluating these risks in detail and the counter-measures implemented to reduce their occurrence and consequences has been prepared in order to obtain the necessary authorizations from the DSIN.

To conclude, Superphénix vessel sodium draining is entirely carried out using the tools installed on the reactor slab, as envisaged by the design for all the reactor operation equipment. An immersed electromagnetic pump with adjustable flow up to 20 metric tonnes/hour has been manufactured for this operation, which will last less than two years (mid-2007/2009).

Drainage takes place into the head tanks currently used to store the sodium from the secondary loops to be treated in priority (2006/mid-2007), the sodium being transformed into caustic soda then cemented for surface storage of 26 400 m^3 in very low radioactive packages.