

NATIONAL SCIENTIFIC EVALUATION COMMISSION
REPORT N° 10 – JUNE 2004
SUMMARIES OF THE CHAPTERS

LINE 1 OF THE 1991 LAW

RESEARCH ON SEPARATION AND TRANSMUTATION

SUMMARY

Research on **advanced separation** aim at going beyond the separation of U and Pu of spent fuels (CU). The separation of Np, Am and Cm (the only elements on which the Commission had information in 2003-2004) has reached the stage of technical feasibility through aqueous processes. For the I and Tc elements, the technique is accepted and for the Cs it is being tested. This research could be followed by the making of a demonstration pilot, essential before any industrialization. Although the research and development suffered from a few ups and downs in 2003, the Commission is confident on the fact that the demonstration programme on the technical feasibility planned by the CEA will be completed by the end of 2005. Studies in pyro-chemistry went on normally at the CEA and within the framework of numerous collaborations with these countries that have done pyro-chemical separations on CU at the pilot stage. The scope of this research exceeds the framework of the law and mobilizes the international community.

Concerning **transmutation** in ADS sub-critical systems (*Accelerator Driven Systems*), the year 2004 is marked by the end of the 5th FP (largely devoted to AD Systems) and the formulating of the proposals for the second call for tenders of the 6th FP. The Commission realizes that a change in the orientation of the propositions formulated for the EUROTRANS integrated project of the 6th FP which form a break with the research strategy defined earlier at the time of the 5th FP and an important modification on the specifications and the realization calendar of the ADS European demonstrator.

Concerning the transmutation in critical reactors, the CEA has completed the synthesis of the studies it has been conducting for several years on transmutation in critical reactors with current technologies (PWR and FBR - sodium) within the framework of three scenarios, two with one type from reactor (PWR or FBR), the other with two types (PWR and FBR); the feasibility, the difficulties and the performances of these three categories of scenarios are being clearly analysed.

The CEA, partly as a conclusion of these studies, abandons the idea to suggest using pressurized water reactors for transmutation as it clearly appeared during the audit on March 10th 2004. This position is akin to the one of EDF. It questions the interest and the feasibility of a double strata based on AD Systems and tends today to transfer all of the transmutation to the fast neutron reactors like those kept by the *Generation IV* Forum and which could be industrially deployed around 2035, according to the CEA.

Research on targets and fuels for transmutation concerns mainly the preparation of needles that have to be irradiated to test various Am and Pu based materials. The irradiation programmes will spread over several years after 2006. At an experimental level, we must underline that the irradiation programme as it was planned and presented in 2003 has not been called into question in spite of the fact that the Phénix reactor was only operated continuously since the beginning of 2004.

LINE 2 OF THE 1991 LAW

RESEARCH ON DEEP GEOLOGICAL FORMATION DISPOSAL

SUMMARY

In spite of the delays met by the surveying process in Bure, we should have, in 2006, enough scientific data to decide or not to go on to the next step of this process, as soon as the research programme defined by the Andra will have been achieved, a programme that the commission finds judicious and relevant. The elements already put together enhance favourable characteristics and the absence of prohibitive unfavourable characteristics. These elements make it possible to establish a list of vital issues on which future studies must focus. In this context, the results of the preliminary drillings done or being done, in the Bure area and site, significantly contribute to the knowledge of the surrounding formations and the control of the continuity and the horizontal homogeneity of the host layer.

The tests conducted by the Andra in Mont Terri underground laboratory in Switzerland, in a formation showing analogies with the one in Bure, provide precious information for the test campaign that will take place in situ before 2006 in the experimental niche and drifts in Bure. This campaign is characterized by an ambitious and very tight programme which underwent a careful scientific and technical preparation.

The Commission paid particular attention to three open scientific issues : the existence of overpressures in the Callovo-Oxfordian formation for which some elements of explanation are beginning to see the light; the geo-mechanical behaviour at various time scales of a disposal life, difficult to understand because of the lack of direct observation at the required depth, and finally the issue of the genesis, evolution and migration of gases in the repository and the rock during disposal time.

The modelling of a possible disposal has been the subject of research aiming at improving the level of analysis and understanding reached in the 2001 file. This research will only be presented completely by the Andra at the end of 2004. The combined simulation tools have been substantially improved.

The CNRS is usefully taking part in the works conducted by the Andra, with a more fundamental direction in accordance to its vocation, through the GdR FORPRO.

The Andra continues to study granite via generic studies on the French massifs and its participation to experiments made in foreign underground laboratories. However, because of the lack of a concrete study site in France, the programme has made far less progress than the one related to the Bure argillite.

LINE 3 OF THE 1991 LAW

RESEARCH ON WASTE CONDITIONING AND ON WASTE AND SPENT FUEL LONG-TERM STORAGE

SUMMARY

The conditioning of MLW and HLW nuclear waste in primary packages, suitable for storage and disposal, is an industrial operation supported by research, in particular in terms of the radiological characterization and the short or long term package behaviour, in an environment saturated or not with water. The CEA has developed gamma and neutronic counting facilities, which allow to sort out the packages to be kept for storage for the time being. The CEA has developed operational models on long-term behaviour of waste packages (MOP) in disposal conditions. The MOP parameters combined to the bitumen matrix in presence of water, have been refined. The MOP predicts that packages will last for a very long time. The translation into MOP of the knowledge acquired to date on vitrified packages behaviour in a repository is correct. The "vitrified residues" MOP has now been simplified to take into account vital phenomena regarding the long life of vitrified waste. It is important to establish even better the value of certain parameters that characterize these two systems, but, as the Commission said in its report N° 9, the "vitrified residues" MOP allows to give reasonable forecasts on the evolution of the long-term R7T7 nuclear glass in a disposal environment.

The conditioning of separate elements, actinides and some fission products, has reached the stage of the technical feasibility of processes aiming at elaborating ceramics, in other words far from the stage of making packages. In order to do that, research must be pursued, particularly to confirm the exceptional retention capacity of ceramics under lixiviation. It will provide important results in 2006, but research will have to be continued after 2006 to agree on a possible industrialization, if this strategy was selected. In this respect, the consequences on a geological disposal of an advanced reprocessing, followed by a specific conditioning should be assessed before the date given by law expires. Besides, in 2006 it will be difficult to fully compare the confinement properties of ceramics with vitrified objects in a repository.

UOX and MOX spent fuels are the object of totally new research in the PRECCI programme. Many results have been obtained, both on the fuel pellets and their cladding. The microscopic localization of the elements in the pellets has been established and the associated activities assessed at different moments of a fuel life span. A MOP of activity leakage following cladding rupture has been established. No major difficulty has been identified over the periods of time envisaged for the storage. The phenomenology of fuel lixiviation has been considerably enriched. It appears that we cannot neglect the oxidizing dissolution caused by radiolysis in the forecast of long-term behaviour in a globally reductive environment. PRECCI is an excellent programme which must continue and supply results beyond 2006.

Two important decisions have been made in 2003 for the storage concepts of MLW waste. The first one is to place all the primary packages of this kind in concrete containers. The second one is to adopt ordinary parallelepipedic containers for storage and disposal. The widespread use of concrete containers allows to do away with the maintenance of an atmosphere ensuring a dry corrosion activity (i.e. absence of water film) for the storage of MLW waste packages.

Since the envelopes for HLW waste packages and containers are all metallic, they have to be placed in storages where the atmosphere must ensure a dry corrosion activity, therefore ventilation must be controlled.

In all the storage possibilities that are examined, it is essential to have a permanent surveillance and an important maintenance. This follow-up is also necessary to control the evolution of the facilities in reinforced concrete which, to date, are guaranteed to last only 100 to 120 years. Uncertainties which still exist concerning longer durations, must be lifted. It is a major problem because it is the same for all types of long term (surface or sub-surface) storage or for any industrial storage. These common uncertainties on storage durability leads us to bring closer the two strategies conceivable for long-term storage: either a storage directly designed for the long-term (research object of the law), or prolonging

and planning a series of industrial storages (by periods of 100 years). The debate on these two strategies cannot be settled without having lifted the uncertainties on the durability of the elements that form the storage facilities. Economic and socio-political factors will be determining in that choice.

Studies on sub-surface storage are still at a preliminary stage and will only get substance when they will be applied to real sites.

Globally, we can consider that the problems created by long-term storage have been largely clarified. The inventory of the major problems that still remain to be studied, has been established.

STATE OF RESEARCH AND ACHIEVEMENTS ABROAD

SUMMARY

Research on the separation and transmutation of radionuclides and research on waste geological disposal fall within the context of international co-operation. The European long-term framework-programmes support the efforts of the member States of the European Union. In 2004, the projects of the 5th Euratom FP will come to an end and several of them are being extended in the new wide scope "integrated projects" of the 6th Euratom FP. The first integrated projects have just been launched in the fields of separation and geological disposal engineering.

Research in the fields of the first two lines of the 1991 law are actively pursued by all the countries where the nuclear industry has been developed, particularly those where there is an industrial activity contributing to the nuclear fuel cycle. The Global 2003 biennial conference gave rise to an overall presentation of the activities related to chemical separation and transmutation, including in particular research to do with the development of 4th generation reactors. The United States and Japan's involvement remains high, since the United States have initiated a new strategic orientation of research on the fuel cycle, to better correspond to the research shared within the "Generation IV" International Forum. Research on waste geological disposal, which depends on many scientific disciplines, is the object of specialists' conferences. One of the most important ones, *Migration 03*, has shown the recent improvements of characterization and of the study of the properties of the various forms under which radionuclides are transported or retained in the natural environment, as well as the transport and retention (diffusion, sorption, colloidal transport...). These break-through are the results of particularly improved experimental methods, especially spectroscopic methods.

The year 2003 was marked by the publication, in Switzerland, of the synthesis file demonstration of geological disposal feasibility in an argillaceous formation (*Opalinus clay*). This file is an important step of a programme that started in 1988. The file is backed up by the results of a quantity of research, particularly the one presently carried out in Mont Terri underground laboratory, and by a survey, from the surface, of the Zurich Weinland, where a reversible geological repository could be realized.